Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany*)

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Summary

The aim of the "Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany" is to: estimate the extent of danger to the genetic resources of our tree and shrub species; propose preventive measures for the maintenance of genetic variability of these species; consider proposals for the organisational realization of this programme and give a cost-estimate.

The programme will help to reduce genetic losses due to anthropogenic environmental loads (immissions), but a basic precondition for this is a reduction of environmental load.

The mandate of the working party for the elaboration of this concept was derived from a resolution made at a meeting held on 10.1.1985 between representatives of the Federal Ministry for Food, Agriculture and Forestry and the Federal States. The political importance of the project is emphasized by the resolution of the Bundesrat (Upper House of Parliament) made on 13.2.1985 concerning measures for conserving genetic diversity of forest tree species and the second edition of the Federal Government's action programme "Save the Forests". The latter states that the Federal Government identifies the conservation of natural genetic resources to be of major importance and that it will try to establish a forest genebank.

The working party aims to compile all existing measures that either directly or indirectly aid the conservation of forest genetic resources, and to work out a framework, including cost-estimates, for conserving forest genetic resources.

Because of the immobility and the longevity of tree and shrub species, high genetic variation is the longterm base for adaptability and thus for survival of these species. For biological, economical and ethical reasons, forestry depends on the maintenance of high genetic diversity.

The forests and therefore the forest genetic resources were already endangered by the clearing of forests for cultivation and other diverse interventions into forest ecosystems. The survey of the damages caused by forest decline has shown that serious gene losses from anthropogenic environmental loads are continuing.

The influence of existing legal regulations on the conservation of forest genetic resources was evaluated. The Act on Forestry Seed and Planting Stock (Bundesgesetzblatt 1979) demands that forests be maintained because of their economic and environmental importance; the provision of habitat for other species is particularly important. Consequently, the high genetic variability of forests has to be maintained. However, no regulations exist for the realization of this aim either in the Federal Forest Law or in the respective laws of the states. In addition, the legal regulations concerning forest reproductive material and nature conservation do not offer such an instrumentation.

Existing measures within the Federal Republic which directly serve gene conservation are concentrated in public organisations such as Federal Research Institutes and State Forest Administrations with their research institutes and seed extractories. There is little activity in the private sector. Direct activities include: conservation of breeding material within the framework of breeding programmes; collection of provenances, families and clones in field tests and clonal archives; genebanks of seed, pollen and tissue cultures. Up to now, these conservation measures have been funded from the budgets of the research institutes, but these are insufficient for the additional activities which are needed.

The criteria for the selection of material "worthy of conservation" are for example: selected or comparable populations covered by the Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979), populations under specific ecological conditions, marginal populations and the "necessity for conservation" which results from the degree of current damage or from the rarity of the material.

Conservation is necessary for: 18 tree species and the genus *Populus* as covered by the Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979); 29 species not under the law, but with importance for forestry; 10 indigenous and introduced tree species important from a regional view; and 37 indigenous shrub species.

The measures for conservation depend on the biology, the developmental stage of the material, the technical feasability, and on the costs. The following can be applied with different prospects for success depending on the tree species: conservation of stands; natural regeneration; sowing and planting *in situ* and *ex situ*; seedling and clonal seed orchards; clone collections; conservation of seed, pollen, plants, parts of

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plants including tissue, and conservation by macro- and microvegetative propagation.

The individual measures are evaluated. In addition, the total work necessary in forest genetic conservation is presented. The current situation is discussed.

The fields to be covered in the frame of the programme can only be achieved by close cooperation between the Federal and State Forest Administrations and their institutions. The following principles for cooperation are proposed:

Activities for conservation of forest genetic resources are performed by the Federal Forest Research Centre and the State Forest Research Institutes including the respective seed extractories. These institutions have the professional capacity, the direct connection to forestry, the necessary technical facilities and the scientific background. In addition, they cover the interests of the States.

The selection of genetic resources to be conserved will be coordinated and the institutions responsible for the conservation of forest genetic resources in the Federal Republic of Germany will regularly exchange information about incoming and outgoing gene resource material.

To minimize the risk of loss, samples for *ex situ* conservation (seed, pollen, plants, parts of plants) will be stored at least at 2 locations.

Research necessary for gene conservation occurs in the institutes of the forestry faculties at the universities, and the respective federal and state institutes in close coordination.

Independent of the constitutional responsibilities for the single measures, Federal Government and States will coordinate the activities for conservation of forest genetic resources. It is proposed to give the responsibility for the coordination of the activities between Federal Government and States to the "Federal and State Working Group on Conservation of Forest Genetic Resources".

The Federal Government will maintain responsibility for its legal obligations, collective representation, resource orientated research and the safeguarding of important international relationships. Division of duties between Federal and States will be according to Article 30 of the constitution.

For the further procedures it is recommended that the programme should be discussed at the conference of Federal and State Ministers for Agriculture and Forestry with the aim to reach an agreement for cooperation in the field of conservation of forest genetic resources. The forest administrations and the Federal and State Research Institutes should be charged with implementing the programme.

In this paper, facts are presented, possibilities outlined and urgent recommendations given from a professional view. The realization of the necessary measures for the conservation of forest genetic resources needs the political decision.

Forests are ecologically and economically an important stabilizing factor in the Federal Republic of Germany. The forest genetic resources therefore have to be saved; actions for their conservation have to be started without delay. The present state of the conservation programme is described.

Key words: genetic resources, concept, conservation, *in situ,* conservation, *ex situ,* conservation.

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Preface

Conservation of plant genetic resources was, in the past, a major concern in agriculture because of intensive inbreeding and world-wide trade with seed of agricultural crops. Such activities were restricted to endangered forest tree species and a more general concept of gene conservation in forest tree species had not been clearly delineated.

This situation changed in Central Europe in the early 1980's due to forest decline by air pollution. Subsequently, forest decline became a global concern. A first general concept for the management of forest genetic resources in the world was outlined by the US National Research Council, Board of Agriculture, in 1991.

The Conference of European Ministers for protection of forests in Strasbourg, France (1990) and Helsinki, Finland (1993) as well as the United Nations Conference on Environment and Development, held in Rio de Janeiro, Brazil, in June 1992 developed guidelines for the conservation of biodiversity, including genetic diversity of forest trees, which were widely adopted by the European states. During the 4th Technical Conference of FAO on Plant Genetic Resources, held in Leipzig, Germany, in June 1996, a "Global Plan of Action" was accepted for the conservation of plant genetic resources. There were, however, a number of member states of FAO who had reservations regarding the inclusion of forestry issues in the "Global Plan of Action." On the other hand, many countries included forestry into their national reports (see, for example, OETMANN et al. 1995). During the past 10 years different national and international conferences were organized to discuss conservation of forest genetic resources (see ARBEZ 1987; STEPHAN, 1991; HATTEMER, 1991; MÜLLER-STARCK and ZIEHE 1991; KLEINSCHMIT and WEISBERGER 1993; BML, 1993; MUHS and VON WÜHLISCH 1993; BEGEMANN and HAMMER 1994; TUROK et al. 1995; FRISON, 1995).

In Germany a concept for the forest genetic resources was developed by a Federal and State Working Group following a resolution by the Federal Assembly in 1985. This concept has been implemented in the Federal Republic of Germany for 10 years. In spite of the fact that many modifications that seemed necessary for the practical application, the general frame of the concept, which was submitted to the Federal and State Ministries in 1987, is still valid to a large extent. The framework of this concept is presented in this paper, together with an updated description of the state of conservation of forest genetic resources in Germany. This seems to be worthwhile, as the activities of EUFORGEN (European Forest Genetic Resources Network) have been extended to include a broader base now, since the European Union unequivocally recommended the inclusion of forest genetic resources into the "Global Plan of Action." Subsequently many states in the world have started programmes for the conservation of forest genetic resources. The German concept refers to the specific situation of forests in Germany, which were influenced by the ice ages, clearing of land for agriculture on two-thirds of the land surface from forests, and 200 years of intensive forest management with extended plantations of conifers. This programme, therefore, cannot be directly applied in other countries. However, it may present some experience which might be useful for others also, and to stimulate new ideas for the global conservation of forest gene resources.

1. Introduction

The forests in Germany are presently exposed to extraordinarily strong environmental stress caused by immissions. This fact is reflected by the level of damage to the forests during the past ten years. There is reason to suspect that the forest ecosystem cannot fully serve its multiple functions in the future. Existing damage therefore has to be repaired and future damage has to be averted. Consequently all political and economical measures have to be taken which are suitable to secure the conservation of the forest and its ability to serve all functions.

They include
- reduction of the anthropogenic environmental stressors,
- stabilisation of the forest condition by all available means and
- conservation of the genetic resources.

The conservation of genetic resources is only efficient if accompanied by the reduction of the high environmental load. The damage already incurred calls for rapid action.

Conservation of forest genetic resources means, in this context, that with the aid of ecologically oriented forestry and technical means everything possible must be done to safely transfer genetic multiplicity of tree and shrub species to future generations. In the frame of this concept, the necessary measures are dealt with which have to be planned, carried out and monitored at the site of the resource (*in situ*) or at a different site (*ex situ*). Research is necessary as well as the collection of data and the transfer of data to interested persons.

Based on the conference of the Federal Ministry for Food, Agriculture and Forestry with the respective delegates of the States ("Länder") on 10.1.1985, a working group was established which was to develop a concept for the conservation of forest genetic resources. The Federal Minister for Food, Agriculture and Forestry has appointed the Federal Research Centre for Forestry and Forest Products to chair this working group. The Minister and the Federal States nominated members which were to develop a professional concept as a guideline for the Federal Government and the States.

The political importance of the project is emphasied by the resolution of the "Bundesrat" (Upper House of Parliament) on 13.2.1985 concerning measures for the conservation of genetic diversity of forest tree species and the second edition of the Federal Government's action programme "Save the Forests". The resolution states that the Federal Government identifies the conservation of natural genetic resources to be of major importance and that a forest genebank is to be established.

The working group thus has the responsibility to compile measures already taken in the Federal Republic of Germany which relate to the gene conservation directly or indirectly and to develop a concept for the conservation of forest genetic resources including a cost estimate.

The following concept of the working group represents a compromise between the members of the working group. It is supposed to be the basis for the quickest means possible for the conservation of forest genetic resources as well as for maintaining the genetic structures of the endangered tree species in the Federal Republic of Germany. The main goals are to:
- determine the scope of threat to the gene pools of our tree and shrub species,
- propose measures for the conservation of genetic multiplicity of our tree and shrub species,
- develop proposals for the organisational implementation of the concept and work out a cost estimate.

2. Importance of Genetic Multiplicity

Our tree and shrub species still consist mostly of wild populations. Their genetic multiplicity is a result of evolution and is of importance for the following reasons:

From a biological point of view, the genetic multiplicity represents the basis for adaptability and improves the chances for survival of a species. Human influences as well as the subsequent deterioriation of living conditions for tree and shrub species give cause for fear that the natural genetic mechanisms will not be sufficient to counteract the rapid loss in genetic multiplicity successfully. The described influences affecting the entire ecosystem presently cause threats in various degrees for all species in the forest ecosystem and may eventually lead to the extinction of entire species. Even if a species may not disappear completely, its genepool may be reduced to such an extent that its adaptive capacity is lost and that it will be threatened with extinction sooner or later. The process of reducing the genepool is accelerated, if genetic mechanisms are impeded in their effectiveness and the genetic structures of populations are modified to their disadvantage. During the past two decades, this process began to occur in several tree species. A significant loss in adaptive capacity of populations or species and their eventual disappearence is expected, for example in the higher altitudes of the middle mountains and in the Alps.

The genetic multiplicity has to be maintained for economic reasons also. In the future traits may gain importance which are looked at with indifference today. A large genetic multiplicity will be able to better meet demands and requirements of future generations under obviously changed environmental conditions. A high level genetic multiplicity amongst forest tree species today complies with the demands of forestry under regional and changing environmental conditions and thus improves their adaptive base. Genetic multiplicity serves as a buffer against biotic and abiotic influences, a necessity because of the long rotation age in forestry. Thus forestry is dependent upon a large genetic multiplicity.

The genetic multiplicity has to be maintained as well for ethical reasons in order to preserve the natural ecosystem with the highest possible species diversity and genetic multiplicity for passing intact populations and species on to future generations.

3. Threat to Genetic Multiplicity

When man started to use natural goods, he began to modify the forest ecosystem. Clearing of forests for agriculture, the use of timber for constructing ships and houses and mining as well as the entire industrialisation have repeatedly led to the destruction of forests over large areas in the past. In some regions this process has not been reversed. The increased use of forest land for human settlement and infrastructure brought about the same consequences. These activities have locally led to the loss of valuable and ecologically well adapted populations and consequently to a loss of genetic diversity. Although forestry has regained some of the lost forest areas by reforestation it is not possible, however, to reestablish any loss of genetic information.

Other impacts in the forest ecosystem have also resulted in the loss of species genetic diversity over centuries. Changes in species composition and the structure of mixed forests as well as the replacement of indigenous species by nonindigenous species or provenances for economic reasons have led to a reduction in the gene pool for many tree species. Other forestry activities may also influence the genetic structure of forest tree populations.

The danger of gradual contamination with non-adapted species or provenances may also lead to a change in the genetic composition of adapted wild populations. Particularly the use of non-adapted plant material in the open landscape (*e.g.* roadsides) poses a threat.

In combination with damage by immissions, unduly high populations of ungulates are yet another threat to genetic multiplicity since browsing may destroy the natural regeneration over large areas. In the Bavarian Alps there is a further threat by cattle browsing.

The fact that several tree and shrub species appear in the so-called "red list" of endangered species, indicates that losses have already occurred.

Industrialisation has brought another threat to the forest by air pollution. Immissions initially cause sensitive and exposed individuals of a population to drop out. By loosing them, genetic information may disappear which is not present in the remaining population. Forest decline has reached such a level that regionally adapted populations of species are in danger of becoming extinct. These influences lead to an irreparable loss in the genepool for the respective species and consequently to a severe and irreversible genetic deprivation. It is difficult to quantify the magnitude of the loss. If entire wild populations of species die out, the locally adapted genetic material which was selected naturally over long periods of evolution is generally lost forever.

Immissions may also cause selection processes during the reproductive phase. Research concerning this aspect has been started only recently. First results suggest serious negative impacts endangering the entire aspect of seed production.

The threat to the genepool of our forest trees cannot be solved by breeding trees being resistant to immissions. Positive results could only be expected under very low immission levels and only with respect to defined components of the immission. Considering the present level of immission, the multitude of components of the immission, their interaction as well as the long-term nature of forest tree breeding (several decades), breeding for gaining resistance would be neither technically, economically nor ecologically possible nor sensible. Breeding for resistance can also not be considered as an effective measure for the conservation of genetic multiplicity. Breeding for resistance towards natural damaging factors appears to be more meaningful, because the trees will also become more resistant towards influences of immissions and other abiotic factors if the resistance towards natural factors is improved (RUETZ et al., 1996).

4. Status Quo for the Conservation of Forest Genetic Resources

Since the early days of forest tree breeding, gene conservation has been an important goal and it represents a considerable part of the breeding activities performed. The fact that severe losses in genetic material have already occurred in the course of time and that these losses are enhanced by forest decline as a result of immissions, has led to specific activities on national and international levels.

Existing national regulations and measures therefore have been evaluated as to their effectiveness in conserving genetic resources.

Existing legal regulations and their effectiveness:

The following legal regulations relate to the protection and conservation of forest genetic resources:

Forest laws of the Federal and State Governments: § 1 of the Federal Forest Law and the respective regulations in the state laws include the objective to conserve the forest in its genetic multiplicity as well. It does not contain any explicit legal implementation of how this goal is to be attained.

Legal regulations concerning forest seeding and planting: These regulations deal with the trade of forest reproductive material. Consequently gene conservation is not the actual target of these regulations. However, the large number of seed collection stands, seed orchards, clones and mixtures of clones contribute efficiently to the conservation of genetic information as contained in this material. A satisfactory protection towards immission cannot be guaranteed.

Regulation on nature protection: The protection of biotopes serves mainly the protection of species. These measures assure only partially the maintenance of sufficient species diversity necessary for the conservation of forest genetic resources. In certain instances, they may complement the measures for gene conservation, however, a satisfactory protection against immission cannot be guaranteed here either.

Conservation of genetic resources can be guaranteed only indirectly by the above-mentioned regulations. A concept for the conservation of genetic multiplicity of a species is not subject to the existing legal regulations. If a species is to be effectively conserved in its genetic diversity, a concept needs to be developed which incorporates aspects of biology, ecology, of population genetics and plant breeding in these programmes. Species and nature protection may well become complementary measures of gene conservation.

5. Targets, Criteria and Measures for the Conservation of Forest Genetic Resources

5.1 Targets

The entire spectrum of gene conservation can be classified as follows:

- registration of populations and individuals of tree and shrub species which are endangered,
- development of programmes for the conservation of tree and shrub species,
- selection, identification and registration of the material to be conserved including data processing,
- detailed compilation of required investments, personnel and technical commodities,
- realisation of the conservation measures,
- realisation of the required research activities,
- coordination of national and international activities,
- provision of professional assistance for the legislative and political decision process, consulting and performance of public relations work.

Provisions for conserving forest genetic resources would be necessary even without the acute situation due to forest decline. The conservation of forest genetic resources is a continuing area of responsibility with changing priorities depending on the need. They must be kept updated. The environmental stress has aggravated the situation so that efforts to conserve forest genetic resources have to be significantly intensified during the next decades in order to keep losses at a minimum. After the necessary reduction of immissions to acceptable levels for the forest ecosystem, efforts can be scaled down. The costs can then be reduced to the necessitive conservation measures and by the implementation of less expensive results of research techniques.

5.2 Selection criteria for the material to be conserved

The rapid increase of forest decline due to immission demands immediate activities to preserve as large a genetic multiplicity of the forest tree species as possible. A basic assumption is that the genepool of approximately 2% of the total forest area is to be managed specifically as a gene pool for all tree species. This area does not include the areas preserved under the nature protection law or any other protection purpose, which altogether amount up to 50% of the total forest area. This corresponds to the area of the registered seed stands in Germany. For common principal tree species, this parameter may be less, for others it may be higher. Despite the relatively

small area involved, the measures required for conservation will be considerable. For financial und personnel reasons, setting priorities and a time table is a necessity. Special criteria are proposed to facilitate priority selection. They will be analyzed in the following chapters. The weighing of the criteria has to be decided upon from case to case. Regional differences must be considered.

5.2.1 Valuation of conservation

Adaptation and adaptive capacity of the material to be conserved under various ecological conditions of the respective sites are important conservation criteria. Within the natural range of a tree species it is an essential conservation criteria whether it is indigenous or not. Knowledge about the genetic constitution of populations is urgently required; this calls for intensive research for most tree species. As long as better selection criteria are missing, the stands registered as seed stands and stands which appear eligible for seed stands will be considered first. The stands to be conserved shall be distributed in such a way that the entire genetic multiplicity will be represented. Of great importance for conserving genetic multiplicity are marginal populations or populations surviving under special ecological conditions. Special provenances of non-indigenous tree species can also be eligible for gene conservation, if they are of proven value or if they are endangered at their origin or have disappeared from there. When research has defined the selection críteria, it can be decided to what extent a population has to be represented in measures of gene conservation.

5.2.2 Necessity of conservation

The degree of threat or of damage, the economic importance and rarity as well as the ecological, genetic and silvicultural importance of a population or species are basic criteria for the necessity of gene conservation. These criteria are the basis in setting priorities. The priorities are strongly influenced by the specific situation in the various regions.

5.3 Measures of conservation

The implementation of conservation measures depends upon the biology of the tree and shrub species (*i.e.* possible propagation by natural regeneration, cuttings, seed storage *etc.*), their state of development (*i.e.* age, fructification *etc.*) of the material to be conserved and on the available technical means.

In view of the present state of forest decline, it is urgently required to investigate all measures which aim at the conservation of a sufficient genetic base for all species. Since the further development of the immission load cannot be foreseen and since the propagation of tree and shrub species is not assured, research for all measures and all related basic questions is indispensable. The various forest institutions must take regional differences into account, rationalize the work and make use of existing experience and scientific knowledge.

In the following chapters possible measures of conservation are analyzed on the basis of their advantages and disadvantages. The interaction of the various measures is not considered. “Basically possible” means: regardless of the state of development and the costs. Generally several measures of conservation will be applied concurrently in order to increase efficiency, to reduce the risk and to fill the gap in times of risk.

5.3.1 *In situ*-measures

The conservation of genetic resources seems to be safeguarded best where a sufficiently large number of adapted populations exists and where these can be maintained and cultivated under respective site conditions (*in situ*). The existence of populations can best be safeguarded by conserving these stands and let natural regeneration take its course with the possibility of supplemental seeding and planting using local reproductive material. The respective techniques are wellknown and carried out in regular forest management practices. Considering the negative influences of air pollution, however, the *in situ*-conservation of forest genetic resources is difficult in many cases or even made impossible.

5.3.1.1 Conservation of stands

Depending on the size and the structure of the stands for the tree species in question, it must be decided whether populations can be saved by conserving the stands locally. Stand age and location are especially important. The conservation of stands must be assured by suitable silvicultural and administrative measures.

Advantages: Techniques are known and comparatively simple, a large genetic multiplicity can be conserved under conditions of natural selection. The link with forest management is given, no additional areas are required. Flowering may be induced and seed collection is facilitated. Under normal circumstances, a long-term conservation of the natural genetic structures in unpolluted areas is possible.

Disadvantages: Only partly satisfactory in areas of moderate air pollution, not possible in seriously polluted areas. Very much dependent on environmental change with only slight possibilities of improving the environment (site). Possibility of constricting effects on the selection process during the reproductive phase due to the environmental load. The measure may be impaired by poor silvicultural practices, difficult site conditions or lack of direct influence due to ownership.

5.3.1.2 Natural regeneration

Depending on the size and the structure of the range of the respective tree species, the stands have to be analyzed as to the possibility of successful natural regeneration.

Where natural regeneration of a stand has turned out to be successful, this material can be considered as more or less secured assuming that the immission load will be reduced drastically. Further conservation may be assisted by fertilization, protection and tending measures. The rapid increase in damage due to air pollution and changing site conditions, particularly the soil might make natural regeneration impossible in many cases.

Advantages: The technique is well-known and comparatively simple. A large genetic multiplicity can be conserved under natural selection. Close link to forest management practices remains: No additional forest areas are required. Recombination of genetic information in the naturally regenerated, succeeding generations.

Disadvantages: Under average immission load conditionally, under heavy immission load hardly possible. Very much dependent upon changes of the environment with only a slight possibility of improving the site. Restriction of the selection process during the reproductive phase of the parent stand cannot be excluded even in areas with low pollution levels. The measure may be impaired further by lacking or rare flowering of the parent stand, by inadequate silviculture, by a difficult site or by a lack of direct influences due to ownership.

5.3.1.3 Seeding and planting *in situ*

If natural regeneration fails a similar result can be achieved by seeding and planting *in situ* using seed or plants from the

stand, which is to be regenerated. In this case, one has to ascertain that the seed crop of the parent stand is completely harvested and that the genetic structure is well represented in the seed and the seedlings.

Advantages: Technique is known, conservation of a comparatively large genetic multiplicity under natural selection is possible. Close link with forest management remains, no additional areas required, the site can be improved more easily than under natural regeneration (*i.e.* melioration before establishment of the stand). Young plants are initially comparatively resistant to environmental load.

Disadvantages: Under moderate pollution levels conditionally acceptable, under heavy pollution levels unsuitable. Depending upon environmental change there is only a limited possibility of improving the site. Constraints on the selection process during the reproductive phase of the parent stand is possible even in regions with a low immission load. The measure may be impaired by lacking or sporadic seed production of the parent stand due to unsuitable silvicultural conditions, difficult site factors or by lack of direct influence due to land ownership.

5.3.2 *Ex situ*-measures

Ex situ conservation of genetic resources means relocation. Generally there are two possible ways: Conservation under natural site conditions or conservation under artifical conditions. In the first case, measures described below will be carried out using known and routine techniques. These measures offer the possibility of evacuation to areas with a low immission load. Influences on the genetic constitution of the evacuated population on the new site cannot be excluded.

Besides the *ex situ* conservation under natural conditions, conservation may also take place under controlled conditions. The facilities required to carry out such measures is called a "genebank". It serves the conservation of genetic resources under artificial conditions for as long a period as possible. It deals in particular with the storage of seed, pollen, plants, parts of plants and tissue. This concept of conservation also includes vegetative propagation.

5.3.2.1 Seeding and planting *ex situ*

This measure of conservation may be employed for specific threatened populations of all tree species. An early and detailed selection of sites is required which have conditions similar to that of the original population yet with a lower environmental load. Plantations should generally be established within the country where melioration measures of the soil is possible. Sites may also be selected outside the country if not sufficient suitable sites are available in the country, thus the risk can be divided. The basic material should be represented as complete as possible.

Advantages: Techniques are known. Conservation of a comparatively large genetic multiplicity under natural selection. Connection with practical forest management remains. Better possibilities of improvement of the site as in the aforementioned measures (*i.e.* melioration before stand establishment). The same advantages as mentioned under seeding and planting *in situ* with the exception that additional areas for planting are required. Possibility to evacuate into areas with less pollution. Stimulation of flowering and seed production may be possible.

Disadvantages: Limited possibilities in finding suitable sites, additional plots necessary. A change in conditions for natural selection is given in regions with lower immission which may show an effect during later generative propagation. Possibly impaired by lacking or rare seed production. For plantations outside Germany: Lack of direct control, long-term investment under political uncertainty, increased costs, suitability of sites not known.

5.3.2.2 Seedling seed orchards

The same as for planting *ex situ* applies to the establishment of seedling seed orchards.

a) Within the country

Advantages: Direct control of plantation is possible. Through intense measures of protection and tending the conditions of survival can be improved, site suitability is known, for several species a proven method, comparatively lower costs than with clonal seed orchards.

Disadvantages: With increasing immission the method becomes less suitable, depending on species, flowering may commence later than with clonal seed orchards, natural selection and reproduction conditions may change.

b) Outside the country

Advantages: Evacuation to regions with lower immission load, flowering and seed production may be enhanced by selection of the site.

Disadvantages: Lack of direct control, longterm investment under political uncertainty. Natural selection and reproduction conditions may change, in most cases it is not known whether or not the site is suitable, increased costs.

5.3.2.3 Clonal seed orchards and clone collections

The use of seeds from clonal seed orchards established for seed production may lead to a considerable reduction in the genetic base as compared to natural regeneration or seeding and planting. Nevertheless, this method is necessary if other measures for the conservation of genetic multiplicity fail as is the case with populations severely damaged by pollution.

If the number of selected clones of a population does not suffice for the establishment of a clonal seed orchard, the clones may be conserved in clonal collections or clone archives. They are suitable for later vegetative propagation as well, and it can serve as parent material for breeding purposes.

Clonal seed orchards and clone collections are comparatively more difficult to establish and more cost-intensive than the previously mentioned measures. Generally only a limited number of clones (genotypes) can be conserved. Depending on the species, they may however produce seeds in an early age and thus may pass on their genetic information relatively early. Clonal seed orchards and clone collections are established *ex situ*, they may be established within or outside the Federal Republic of Germany.

a) Clonal plantations within the country

Advantages: Direct control is possible, intensive protection and tending measures may increase the survival rate, it is a well-known technique for many species, suitable for the production of seed as well as plant material for vegetative propagation.

Disadvantages: Comparatively high costs limit the number of conserved genotypes. Physiological aging of the clones as well as increasing environmental loads may reduce the suitability for vegetative propagation. For some species there is limited knowledge of the biology (incompatibility, techniques of propagation, flowering, biology etc.). The selection and reproduction conditions may change.

b) Clonal plantations outside the country

Advantages: Evacuation to regions with less environmental load as well as improvement of flowering and seed production.

Disadvantages: Lack of direct control, long-term investment under political uncertainty. Site suitability not known, increased costs.

5.3.2.4 Storage of seed, pollen, plants and part of plants

By collecting and storing seed, the largest number of genotypes can theoretically be conserved. The seed can be conserved under conditions free of immissions and may be used at any suitable time for reforestation. For some tree species, particularly those producing heavy fruits, the duration of storage is limited.

In order to reduce risk and to have direct control, storage should be decentralized and carried out by federal and state institutions in genebanks. Additional capacities are required for storage, and the technical facilities have to be established at state seed extraction plants and the respective research institutes. Existing facilities have to be expanded. A permanent check of viability of the seed has to be guaranteed. Regulations need to be established for use during shortages and how the material is to be propagated and conserved.

Advantages: Conservation of a large genetic multiplicity in a small space under controlled conditions is possible, can be utilized simply and quickly. For numerous tree species the storage techniques are well known.

Disadvantages: Not suitable for some species, for others only limited storage possible. Restricting selection may take place under storage conditions. There is danger of technical failure and the risk of loss.

By storing *pollen* genetic information may be conserved in a very small space. For some species suitable techniques for storing pollen are known. The full utilization of the genetic information depends on the availability of female partners. Stored pollen is being used for controlled pollination.

Advantages: Conservation of a large genetic multiplicity in a small space under controlled conditions is possible. Very long storability of some tree species.

Disadvantages: Technique is only applicable if suitable female partners are available.

The storage of *plants* and *parts of plants* is possible in a small space. Genetic resources can be conserved by storing of plants and plant parts such as unrooted cuttings, scions and tissue. In practice this technique has only been applied for a few tree species over short periods of time (several years) with variable success. The storage of plant parts (*i.e.* buds, tissue) for later propagation through tissue culture techniques is possible.

Advantages: Easy collection of the basic material. Storage under controlled conditions for future rapid propagation of many individuals.

Disadvantages: Scarcely developed for tree species. Duration of storage is limited. Restricting selection may take place under storage conditions. Only a limited number of genotypes can be conserved. Danger of technical failure and risk of loss.

5.3.2.5 Conservation by vegetative propagation

Conservation of genotypes through *propagation by cuttings or scions* (cloning) may exceed the natural lifespan of the basic material, *i.e.* tree. For some tree species, these techniques have been developed. Numerous propagules may be obtained. The clones have to be propagated continuously to avoid aging.

Advantages: By vegetative propagation genotypes may be conserved which have already been tested, they can be propagated quickly. For some species this technique is routine.

Disadvantages: Cannot be implemented for all tree species. Only a limited number of genotypes can be propagated. Because of the need for continuous propagation, the number of genotypes which can be handled is limited.

The *microvegetative propagation* by means of tissue cultures is gaining importance for the conservation of many genotypes.

Table 1. – Possible measures for the conservation of genetic resources of tree species subject to the German Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979).

tree species	priority class	conservation of stands	natural regeneration	seeding / planting *in situ*	seeding / planting *ex situ*	seedling seedorchard	clonal seedorchard	clone collection	storage (years) seeds 1)	storage (years) pollen 2)	storage (years) plants + parts of -	conservation by vegetative propagation macro-vegetative	conservation by vegetative propagation micro-vegetative
Abies alba	1	++F	++F	++F	++I	+ I	++I	++I	3- 5F	3F	?F	+ F	- F
Abies grandis	4	++	+	++	++	+	+	+	3- 5F	3F	?F	- F	- F
Acer pseudoplatanus	2	++	++	++	++	++	++I	++I	2- 3F	-F	?F	+ F	- F
Alnus glutinosa	2	++	+	++	++	++	++	++	3- 5F	+F	?F	+ F	- F
Fagus sylvatica	1	++F	++F	++	++FI	++I	+ FI	+ FI	3- 6F	-F	?F	+ F	- F
Fraxinus excelsior	2	++	++	++	++	++	++FI	++I	2- 3F	-F	?F	+ F	- F
Larix decidua	2	++	++	++	++I	++I	++I	++I	10-20	10F	?F	+ F	- F
Larix kaempferi	4	++	++	++	++	++	+ F	++	10-20	10F	?F	+ F	- F
Picea abies	1	+ F	++F	++	++F	++F	++FI	++FI	10-20	10F	?F	++	- F
Picea sitchensis	4	+	+	++	++	+	+	+	10-20	5F	?F	+	- F
Pinus nigra	4	++	+	++	++	++	+	+	10-20	10F	?F	+ F	- F
Pinus strobus	4	+	++	++	++	++	++	++	10-20	10F	?F	+ F	- F
Pinus sylvestris	1	++	++	++	++I	++I	++I	++I	10-20	10F	?F	+ F	- F
Populus spp.	1/3	-	-/+	++	++	++	++	++	2- 3F	10F	?F	+/++F	-/+F
Pseudotsuga menziesii	2	++	++	++	++	++	+ FI	+ FI	5-10F	10F	?F	+ F	- F
Quercus petraea	1	++	++	++	++	++	+ I	+ FI	1- 2F	-F	?F	+ F	- F
Quercus robur	1	++	++	++	++	++	+ I	+ FI	1- 2F	-F	?F	+ F	- F
Quercus rubra	4	+	+	++	++	++	+	+ F	1- 2F	-F	?F	+ F	- F
Tilia cordata	2	++	++	++	++	++	++I	++I	2- 3F	-F	?F	++	+ F

Priority class (see Chap. 5.2).
Classification according to valuation and necessity of conservation of the tree species. Classification relates to the species as a whole. Regionally there may be significant shifts in classification.
Conservation measures to be performed are classified as: 1 = at once; 2 = urgent; 3 = necessary; 4 = desirable.

Further symbols and comments
++ = application possible on a wide scale and meaningful.
\+ = application possible to some extent; technical development more or less complete
– = measures not applicable at present
? = no experience in Germany
F = research is needed in methods and techniques, other questions excluded
I = realisable abroad through international cooperation
1) = number of years gives duration of storage under operational conditions
2) = presently only in the experimental stage

Table 2. – Possible measures for conservation of the genetic resources of tree species not subject to the German Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979), yet of significance for forestry.

tree species	priority class	conservation of stands	natural regeneration	seeding / planting		seedling seedorchard	clonal seedorchard	clone collection	storage (years)			conservation by vegetative propagation	
				in situ	*ex situ*				seeds 1)	pollen 2)	plants + parts of -	macro-vegetative	micro-vegetative
Abies procera	4	+	++	++	++	+	++	++	3- 5F	3F	?	- F	- F
Acer campestre	3	++	++	++	++	++	++	++	2- 3F	?	?	- F	- F
Acer platanoides	3	++	+	++	++	+	++	++	2- 3F	?	?	- F	- F
Alnus incana	3	++	+	++	++	+	++	++	2- 3F	?	?	- F	- F
Alnus viridis	2	++	+	+ F	+ F	++	++	++	2- 3F	?	?	- F	- F
Betula pendula	3	+	++	++	++	++	++	++	3- 5	5F	?	+F	+
Betula pubescens	3	+	++	++	++	++	++	++	3- 5	5F	?	+F	+
Carpinus betulus	2	++	++	++	++	++	++	++	2- 3F	?	?	+F	- F
Castanea sativa	4	+	++	++	++I	++	+ I	+ I	1- 2F	?	?	+F	-
Juglans nigra	4	+	+	++	++I	+	+ I	+ I	1- 2F	?	?	+F	- F
Juglans regia	4	+	+	++	++I	++	++I	++I	1- 2F	?	?	+F	- F
Picea omorika	4	+	?	++	++I	?	+ I	+ I	8-10F	+	?	+	-
Pinus cembra	2	+	+	+ F	++I	++	+ I	+ I	2- 3F	+	?	+	-
Pinus mugo	2	+	+	++	++	+	?	+	8-10	+	?	+	-
Prunus avium	3	+	+	++	++	++	++	++	1- 2F	?	?	++	++
Robinia pseudoacacia	2	++	++	++	++I	++	+ I	++I	10	?	?	+	+ F
Salix spp.	2	+	+	-/+	-/+	-	++	++	>3	?	?	++	-
Sequoiadendron giganteum	4	++	?	++	++I	++	++I	++I	5- 8F	+	?	++	+ F
Sorbus aria	2	++	++	++	++	++	++	++	2- 3F	?	?	+F	-
Sorbus aucuparia	2	++	++	++	++	++	++	++	2- 3F	?	?	+F	+F
Sorbus domestica	3	++	-	+ F	+ F	++	++	++	1- 2F	?	?	+F	+F
Sorbus torminalis	3	++	++	++	++	++	++	++	2- 3F	?	?	+F	+F
Taxus baccata	2	+	+	+ F	+ F	++	++	++	2- 3F	+	?	+F	-
Thuja plicata	4	+	++	++	++I	++	+ I	+ I	5- 8F	+	?	+F	-
Tilia platyphyllos	3	++	+	++	++	++	+	+	2- 3F	?	?	+F	-
Tsuga heterophylla	4	+	++	++	++I	++	+ I	+ I	5- 8F	+	?	++	-
Ulmus carpinifolia	2	+	+	++	++	++	+	+	2- 3F	?	?	+F	- F
Ulmus glabra	2	+	+	++	++	++	++	++	2- 3F	?	?	- F	+F
Ulmus laevis	3	+	+	++	++	?	?	?	2- 3F	?	?	- F	-

Symbols explained in the legend to *table 1.*

It requires the continuous propagation of the tissue. This technique is available only for a limited number of tree species.

Advantages: Can be carried out in the laboratory, cloning and propagation under controlled conditions.

Disadvantages: Techniques not fully developed for all tree species. Work and cost intensive. Undesirable variation may occur. Only a limited number of genotypes can be propagated. Because of the need of continuously propagating, the number of genotypes which can be handled is limited. Danger of technical failure and risk of loss.

5.4 Possible measures of conservation of individual tree species

The following tables show the possible measures of conservation for the respective tree species (see also chapter 5.3). The tables are divided into:

a) tree species which are covered by the German Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979) (*Table 1*),

b) tree species not being contained in the Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979) which are of importance to forestry, however (*Table 2*),

c) indigenous and introduced tree species which are worthwhile conserving from a regional point of view (*Table 3*),

d) indigenous shrub species *(Table 4*). Of the shrub species, only those are included which already appear in the "red list" (list of endangered species) and for which measures of conservation appear to be necessary. All other shrub species are not mentioned here, although for some of them their specific genetic variability may be endangered due to their regional scarcity and therefore they should also be included in a conservation programme. It is still more or less unknown to what extent tree species suffer from anthropogenic environmental loads.

The tables give information regarding important methological and technical research grouped according to tree species and measures. Research related to other questions is not considered here. Required research for measures relating to *in situ* conservation of stands, natural regeneration, seeding and planting *in situ* and *ex situ*, seedlings and clonal seed orchards as well as clone collection are only listed as examples for a number of species.

6. Measures of Conservation and Required Research for the Concept of Conserving Forest Genetic Resources

6.1 General principals

6.1.1 Priorities: Species and fields of concern

The 18 tree species and the genus *Populus* subject to the Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979) as well as the large number of other indigenous and introduced tree and shrub species cannot be handled simultaneously, consequently priorities have to be developed. The future development of forest decline may make it mandatory to change the priorities for individual tree species. At present 7 tree species have a high priority (*Table 1*). The measures are to be applied over the entire area of Germany. Due to different degrees of damage regional priorities have to be placed. The development of decline symptoms must be considered when carrying out and updating the programme. Due to the severity of damage in some areas it is necessary that some measures are commenced immediately. The measures concentrate primarily on stands registered according to the Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979) because:

– these stands are of specific significance for the seed supply,
– these stands are clearly delineated and measures can be directly and quickly applied to these stands, and
– measures and their duration and costs remain calculable.

Ecologically defined growing regions should serve as an orientation for the selection of the stands. Within the scope of the possibilities and financing, other stands (*e.g.* remnant populations) should be included in the measures of conservation.

Table 3. – Possible measures for the conservation of genetic resources of indigenous and introduced tree species considered worth conserving for regional purposes or rarity.

tree species	priority class	conservation of stands	natural regeneration	seeding / planting *in situ*	seeding / planting *ex situ*	seedling seedorchard	clonal seedorchard	clone collection	storage (years) seeds 1)	storage (years) pollen 2)	storage (years) plants + parts of -	conservation by vegetative propagation macro-vegetative	conservation by vegetative propagation micro-vegetative
Acer monspes-sulanum	3	+	+	+	+	++	+	+	2-3F	?	?	-	?
Aesculus hippocastanum	3	++	?	++	++I	++I	+ I	+ I	1-2F	?	?	+	?
Carya alba	4	+	?	++	++I	++I	- I	- I	?	?	?	- F	?
Chamaecyparis lawsoniana	4	+	?	++	++I	++I	++I	- I	5-8F	+	?	++	?
Liriodendron tulipifera	4	+	?	+	+ I	++I	+ I	+ I	?	?	?	+	?
Malus sylvestris	3	+	+	++	++	++	++	++	1-2F	?	?	+ F	?
Platanus x acerifolia	3	+	?	+	+ I	++I	+ I	+ I	?	?	?	++	?
Prunus padus	2	+	++	++	++	++	++	++	1-2F	?	?	++	?
Prunus serotina	4	+	+	++	++I	++I	++I	++I	1-2F	?	?	+ F	?
Pyrus communis	3	+	+	++	++	++	++	++	1-2F	?	?	+ F	?

Symbols explained in the legend to *table 1.*

Table 4. – Indigenous shrub species included in the "Red List" (list of endangered species) which require conservation measures due to their risk of loss.

Acer opalus
Andromeda polifolia
Arctostaphylos uva-ursi
Betula humilis
Betula nana
Colutea arborescens
Cornus suecica
Cotoneaster tomentosus
Daphne cneorum
Daphne laureola
Erica cinerea
Fumana procumbens
Helianthemum apenninum
Helianthemum canum
Ledum palustre
Linnaea borealis
Myrica gale
Myricaria germanica
Prunus fruticosa
Ribes nigrum
Ribes petraeum
Rosa elliptica
Rosa gallica
Rosa glauca
Rosa jundzillii
Rosa micrantha
Rosa obtusifolia
Rosa stylosa
Rosa villosa
Salix alpina
Salix daphnoides
Salix myrtilloides
Salix phylicifolia
Salix starkeana
Sorbus mougeotii
Staphylea pinnata
Vaccinium microcarpum

6.1.2 Duration of the measures

The proposed measures refer to the first 10 years. Because of the long-term nature of the conservation measures and because only part of the genetic resources can be conserved during the first 10 years, all measures have to be continued at a similar intensity.

6.1.3 Interconnecting measures

Various measures have to be carried out simultaneously for the same basic material in order to be successful in the conservation effort on one site and still have sufficient basic material for obtaining reproductive material to supply the normal forest operations on other sites.

Interconnecting the individual measures can be illustrated by the following example:

– If a stand can only be conserved for the next 10 to 30 years, it can only yield seed during this period.

– With the collected and stored seed the regeneration time may be extended up to 30 years depending on the species.

– In order to secure the supply beyond this time, seed orchards have to be established for the seed supply during the next 30 to 60 years on one hand, and

– natural regeneration has to be enhanced on the other hand and/or

– *ex situ* plantations have to be established for the long-term seed supply (beyond 60 years).

This example demonstrates in what way 5 measures of conservation have to be applied to guarantee the conservation of forest genetic resources.

6.1.4 Cost estimate

The cost estimate is guided by the following principles:

– The cost estimate differentiates between costs for measures and costs for research.

– The budgets are to be determined for the indispensably necessary measures of conservation and research tasks. It is assumed that the majority of the measures connected with *in situ* and *ex situ* conservation will have to be carried out by the forest land owner in addition to their normal expenditures.

All measures and research tasks pose a considerable increase in the work load of the institutions dealing with implementation and research. This supplemental work cannot be carried out without considerable increase in personnel and financing. Necessary funding for buildings, equipment, purchase of sites for seed orchards etc. as well as rent, administration and coordination have to be considered.

6.2 Tree nurseries, research plots and personnel

The substantial *in situ* and *ex situ* measures call for collaboration with efficient, competent tree nurseries in which seedling and transplant production and microvegetative propagation can be carried out. Trained personnel is required for these tasks. It is suitable to incorporate these tree nurseries into institutions which deal with measures of conservation. These are generally the federal and state forest research institutions. In some of these institutions, existing research nurseries can be enlarged if required.

6.3 Forestry genebanks

Measures and research for conserving forest genetic resources require expansion of existing facilities in order to

carry out the numerous activities *in situ* and *ex situ*. This includes additional storage capacity for seed, pollen etc., facilities for microvegetative propagation and further information systems. These institutions will be called genebanks.

6.3.1 Specification of the genebank

The construction of a genebank has to comply with the following criteria:

– suitable dry site not subject to flooding, solid, collapse-proof construction with maximum safety for the stored material,
– for storage best possible climate control, *i.e.* refrigeration, moisture, airfilter to avoid contamination *etc.*,
– secure water supply and drainage without danger of backup, emergency powerplant,
– optimal facilities for preparing, identifying, registration and regular sampling of the stored material, coordination, research, information systems and administration,
– good access to truck and transportation within the building (elevator),
– possibility for future extension.

6.3.2 Number of required genebanks

According to the principles of cooperation and distribution of tasks within the concept of conserving genetic resources, it follows that a national genebank will be established as a federal institution and regional genebanks at the level of the states. Genetic resources are to be stored at least at two locations. A forest genebank can only be operated efficiently if it is directly connected to existing forest research institutes.

6.4 Research needs

There is an obvious lack of knowledge about the present situation of most species. This includes knowledge about regional frequency, genetic structure, biological characteristics as well as knowledge about the efficiency of different conservation methods, *e.g.* long-term storage of seed. Methods for evaluation, identification, description of variability on different levels and with meaningful methods have to be developed. Mechanisms and characters of resistance, especially under the influence of immission, and physiological and genetic problems of reproduction have to be studied. In the concept a number of specific research topics is identified.

7. Organization to Implement the Concept of Conserving Forest Genetic Resources

7.1 Participating institutions and responsibilities

As a precautionary measure and because of the long-term nature of conservation measures, the governments (federal and state) have the obligation to plan, coordinate and implement the conservation of genetic resources. Private and corporate forest owners cannot be expected to do so. Activities of the private forest owners are welcomed and their collaboration in carrying out the concept is desired. The federal government has to maintain responsibility for legal obligations, collective representation, resource orientated research and in international relationships. Division of duties between federal and state government is covered by article 30 of the Constitution. The programme should be discussed at the conference of federal and state ministers for agriculture and forestry with the aim to reach an agreement for cooperation in the field of conserving forest genetic resources.

7.2 Coordination of activities

The activities necessary for conserving forest genetic resources in the Federal Republic of Germany have to be coordinated by the Federal and State Governments. A suitable information system has to be set up to store, handle and pass on data. It was proposed to give the responsibility for the coordination of activities between the Federal Government and the States to the "Federal and State Working Group on the Conservation of Forest Genetic Resources" which has been nominated in 1987.

8. Current Situation of the Programme

The activities for conservation of forest genetic resources cannot be clearly separated from the activities in forest tree breeding, which had a-fourty-years-history when the specific programme for the conservation of forest genetic resources was started. Conservation of genetic resources is a prerequisite for sustainable silviculture as well as for forest tree breeding.

In 1989 a total of 79,351 clones on 1,174 ha had been collected for species under the German Act on Forestry Seed and Planting Stock. Due to the economic interest, the majority of these were Norway spruce (60,548 clones), Douglas fir (11,152 clones), Scots pine (1,782 clones) and larch (1,710 clones). Hardwood species were represented with 4,390 clones.

Table 5. – Tree species subject to the German Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979) (status: 31. 12. 1995).

tree species	*ex situ* stands		seed orchards				clonal archives	
	number	area (ha)	number	area (ha)	number families	number clones	number	number clones
Abies alba	17	27.97	5	14.64		323	1	33
Abies grandis	19	25.69	1	0.75		14		
Acer pseudoplatanus	38	16.45	14	27.6		786	2	21
Alnus glutinosa	5	4.34	16	34.6		748	2	89
Fagus sylvatica	93	152.39	10	12.97	64	186	1	6
Fraxinus excelsior	10	17.28	9	21.8		619	1	52
Larix decidua	39	31.25	31	63.64		1,053	8	393
Larix kaempferi x decidua			4	6.7		89		
Larix kaempferi	3	2	5	9.4		230	5	163
Picea abies	402	416.08	31	94.95		1,342	13	2,783
Picea sitchensis	5	4.79						
Pinus nigra			1	2		35	1	32
Pinus strobus			2	4.77		26	2	92
Pinus sylvestris	82	36.51	61	233.87		1,726	9	2,716
Populus spec.			10	6.32	1	489	19	1,939
Pseudotsuga menziesii	580	1,252.5	26	79.76	73	3,088	6	791
Quercus petraea	81	96.3	7	8.4		222		
Quercus robur	55	76.5	11	20.1		158		
Quercus rubra	3	2.63	1	0.7		16		
Tilia cordata	19	15.64	19	39.36		917	2	102
Total	1,451	2,178.32	264	682.33	138	12,067	72	9,212

Table 6. – Tree species not subject to the German Act on Forestry Seed and Planting Stock (Bundesgesetzblatt, 1979), and shrub species (status: 31. 12. 1995).

tree species	*ex situ* stands		seed orchards				clonal archives	
	number	area (ha)	number	area (ha)	number families	number clones	number	number clones
Abies nordmanniana	3	2.72						
Abies procera	11	9.29	2	4.40		38		
Acer platanoides			2	4.40		110	1	
Alnus incana			2	0.99		86		
Betula pendula			2	1.40		138	4	545
Betula pubescens	3	4.73	3	2.14			3	141
Betula spec.	36	34.09	1	0.50			1	31
Calocedrus decurrens	1	0.18						
Carpinus betulus	12	9.07	1	1.00		50		
Castanea sativa							1	20
Juglans nigra	9	2.53						
Juglans regia	17	8.29	3	14.20		15		
Larix spec.	3	1.30						
Malus sylvestris	227	37.23	18	18.85	157	320		
Picea omorika	2	0.49						
Pinus contorta	2	0.53						
Pinus mugo			1	1.00				
Pinus spec.	1	0.30						
Prunus avium	46	30.65	19	33.60	1	748	4	120
Pyrus communis	3	0.34	13	10.57	53	336		
Robinia pseudoacacia			1	0.78			1	31
Sequoia sempervirens	2	0.18						
Sequoiadendron gigant.	19	15.59						
Sorbus aria	8	1.00	3	0.94	50	21		
Sorbus aucuparia	13	4.01	3	1.97	48	127		
Sorbus domestica	21	6.51	5	3.10	128	186	2	76
Sorbus torminalis	13	4.56	7	9.00		202	1	71
Sorbus spec.	1	0.10						
Taxus baccata	12	3.12	1	0.30		14	3	259
Tilia platyphyllos							1	11
Ulmus glabra	14	8.20	8	10.10		237	8	229
Ulmus laevis	54	5.60	2	2.70		151	1	9
Ulmus minor			1	2.50		50	1	21
Ulmus spec.	5	1.68						
Juniperus communis	4	0.20						
Prunus serotina	1	0.12						
Prunus spinosa	1	0.10						
Salix spec.							1	462
Total	544	192.71	98	124.44	437	2,594	33	2,026

For another 19 species not under the national law, additional 2,135 clones on 44 ha were collected. In this figure some of the activities of the first 4 years of joint efforts for the conservation of minor species in seed orchards are included.

Additionally material was included in provenance and progeny tests which serve to a certain extent the conservation of genetic variability too as did the seed and pollen in storage. A new component, added by the programme, are the *in situ* conservation stands for those species which still exist in sufficiently large population. For those natural reserves are included as one component, if the long-term survival of the species seemed to be guaranteed under the prevailing ecological conditions. Conservation and utilization of forest genetic resources are closely connected and can be handled in the same programmes as demonstrated by ERIKSSON et al. (1993). In a long-term, conservation can only be guaranteed on a broad base if tree species are included into regular forest management. This is especially true for many of the secondary species where reconstruction of breeding populations in seed orchards is one of the prerequisites to reintroduce these species into silviculture.

The current situation of the conservation programme is summarized in *tables 5* and *6*. It becomes apparent from these that in 1996 stands for conservation *in situ* with 2,370 ha area have been selected and the main activities during the last years were directed towards the secondary species.

Literature

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