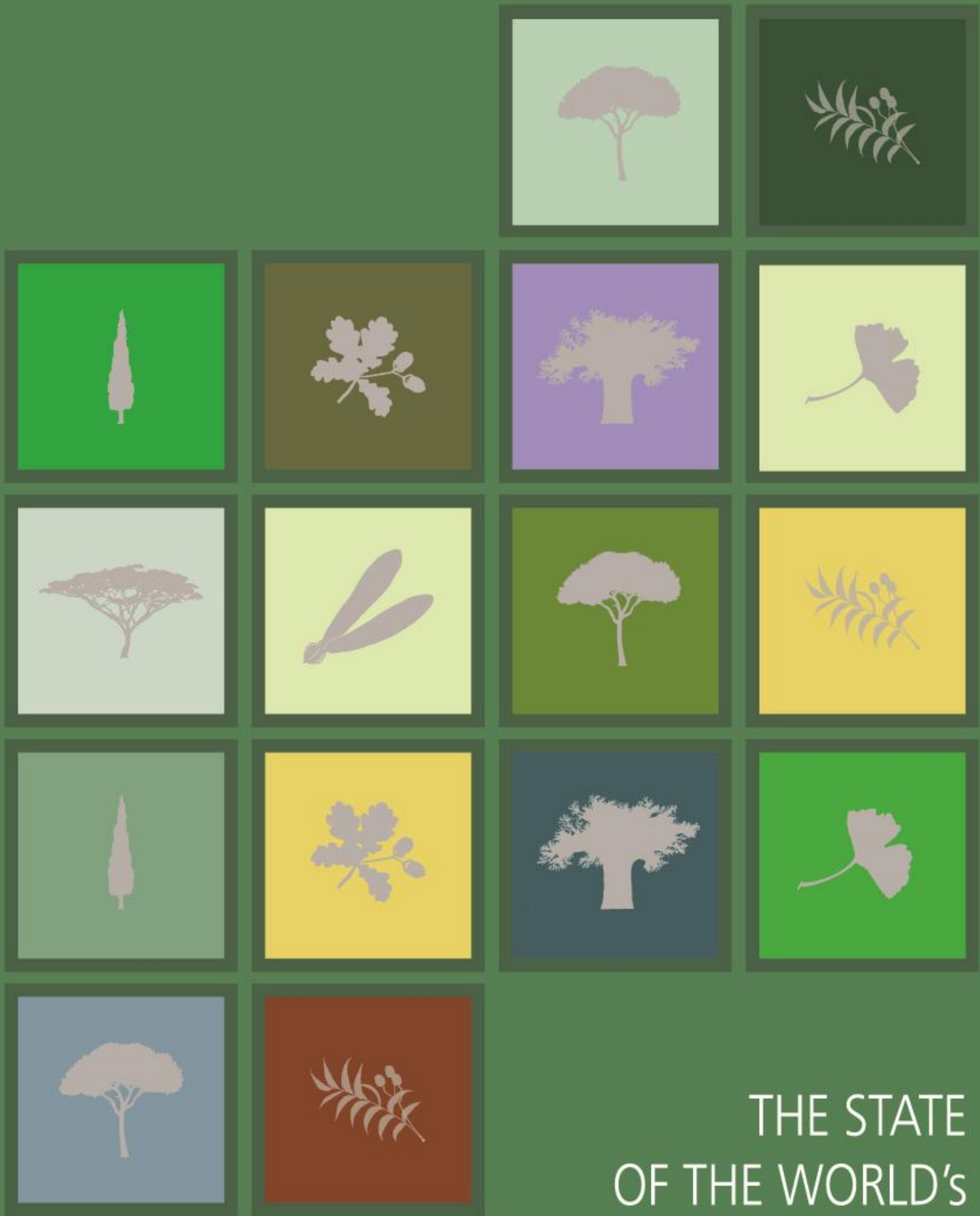

THE STATE
OF THE WORLD's
FOREST GENETIC RESOURCES

COUNTRY REPORT

NORWAY

This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

Country Report

STATE OF FOREST GENETIC RESOURCES IN NORWAY

for

The State of the World's Forest Genetic Resources

2011

Content

EXECUTIVE SUMMARY

Forests and wooded land cover 39 % of the land area of Norway and productive forest amounts to 8.3 million hectares. Two conifer species, *Picea abies* and *Pinus sylvestris,* dominate the forest area; they cover 71 % of the forest area and 84 % of total volume. The annual harvest is at present less than 50 % of the annual increment. Forestry and the wood industry have great financial importance in Norway, and timber and wood products have a gross value of 5 % of the total gross domestic product. Forestry is characterized by small-scale properties which to a large extent are privately owned.

The main objective of the forest policy is to promote sustainable forest management with a view to promote active, local and economic development, and to secure biological diversity, considerations for the landscape, outdoor recreation and the cultural values associated with the forest. Forest management plans are important instruments to obtain these goals. Three targeted programmes have high priority in the present forest policy: forests and climate, increased use of wood and bioenergy. Active use of the forest genetic resources may contribute to the success of these programmes.

Species composition and distribution of forest trees in Norway is largely determined by the following factors: the invasion of tree species after the Ice Age, subsequent climatic changes and human activities. Twenty-five of the 34 native forest tree species have their northern limit in this country. The genetic resources of 18 species are considered to be exposed or threatened either at the local or national level. Genetic information is provided at some level for either morphological, adaptive or production traits or by molecular characterization, for 11 of the native and for 11 exotic tree species. *Picea abies* is the species that is best characterized both at provenance, family and clonal level. There is a lack of knowledge of the implications of factors that may influence the genetic diversity of the forest tree species.

In situ conservation of genetic resources of forest tree species is done in nature reserves, and 22 gene conservation units in such reserves, comprising nine species, have been identified and included in the European database EUFGIS. More species should be included in the *in situ* conservation programme in nature reserves, and a better co-operation is needed between local and regional managers of both protected areas and forests.

Ex situ conservation of forest genetic resources in Norway is performed by collections in arboreta and botanical gardens; long-term tests of clones, families and provenances in research plantations; progeny tests, clonal archives and seed orchards belonging to the national breeding programme; and storage of seed lots for forest regeneration. NordGen is assessing the possibilities for seed samples of selected forest tree species to be deposited and stored in Svalbard Global Seed Vault. Evaluations should be made to assess which material should have highest priority in *ex situ* conservation, and strategies should be developed for long-term maintenance of *ex situ* conservation field plantations.

The Norwegian forests are regenerated both by natural and artificial regeneration. The number of seedlings planted, of which 80 % are *Picea abies*, has been strongly reduced during the last eight years, and more than 75 % of the seeds sold of this species is produced in seed orchards. Regulations are given for regional transfer of seed lots. A revised tree breeding strategy has been developed, with emphasis on *Picea abies.* All seed orchards are first generation, and their breeding objectives are to improve climatic adaptation, growth and quality, without decreasing the genetic variation in future forests. Most breeding populations consist of local material. The national strategy to increase CO_2 sequestration by greatly

augmenting the number of genetically improved seedlings planted will require a considerable increase in resources invested into tree breeding and associated breeding research.

The national programme on forest genetic resources is administered by the Norwegian Genetic Resource Centre, based on advice from the advisory committee on forest genetic resources. In the present period, planned actions are in four major areas: generate knowledge and monitor processes influencing genetic resources; e*x situ* and *in situ* conservation activities; sustainable use and development of forest genetic resources and networking, coordination and dissemination of knowledge about forest genetic resources and raising public awareness. A network of partner institutions contributes to the activities. No specific courses are given at the universities on management and conservation of forest genetic resources. Public awareness of the values related to forest genetic resources has increased significantly in Norway during the last five year period. However, it will be continuously necessary to educate managers of forests and natural resources about the importance of forest genetic resources, and in particular, how to choose adapted reproductive materials under the changing climate conditions.

Norway takes actively part in regional and global cooperative programs on forest genetic resources. The Nordic Genetic Resource Center is important at the regional level, and its forest sector, NordGen Forest, is located in Norway. In the period 2008-2011, Norway held the chairmanship and secretariat (Liaison Unit) of FOREST EUROPE and is from 2011 a bureau member of the Intergovernmental Negotiating Committee for a Legally Binding Agreement on Forests in Europe. Further cooperation both at the regional and European level is needed in the management of forest genetic resources under climate change. It is then important to maintain the networks that have been established in common research and development projects.

Significant legislation regulating conservation and use of forest genetic resources in Norway is the Forestry Act of 2005 and the Nature Diversity Act of 2009. A regulation mandated in the Forestry Act assures that reproductive material of high quality and adapted to planting site is being used in regeneration and that a high level of genetic diversity is maintained in the forest. The Nature Diversity Act regulates the import and planting of alien tree species and also access, property rights and exchange of genetic resources. At present, there is a policy of free access to forest genetic material for seed production and tree breeding, and also a free exchange of forest reproductive material between the neighboring countries. This is recommended to be continued.

Promoting sustainable development and poverty reduction is an overriding objective of Norwegian foreign and development policy. One major element of this policy is the Government of Norway's International Climate and Forest Initiative, in which Norway is prepared to allocate up to NOK three billion per year to efforts to reduce greenhouse gas emissions from deforestation in developing countries.

0. Introduction to the Forest Sector in Norway

0.1. Natural conditions

Norway is Europe's northernmost country, ranging over some 1750 km between 58 °N and 71 °N. The country's total area is 323,787 km^2 (excluding the islands of Svalbard and Jan Mayen). Its population is 4.9 million, with a population density of 15 people per km^2.

The total area covered by forests and wooded land is 13.4 million hectares and constitutes 39 % of the land area in Norway. Of this 8.3 million hectares are productive forest land, that is to say forest areas that can produce more than 1 m^3 per hectare per year. Mountains, extensive grazing and other outlying land, lakes and built-up areas account for 57 % of the land area.

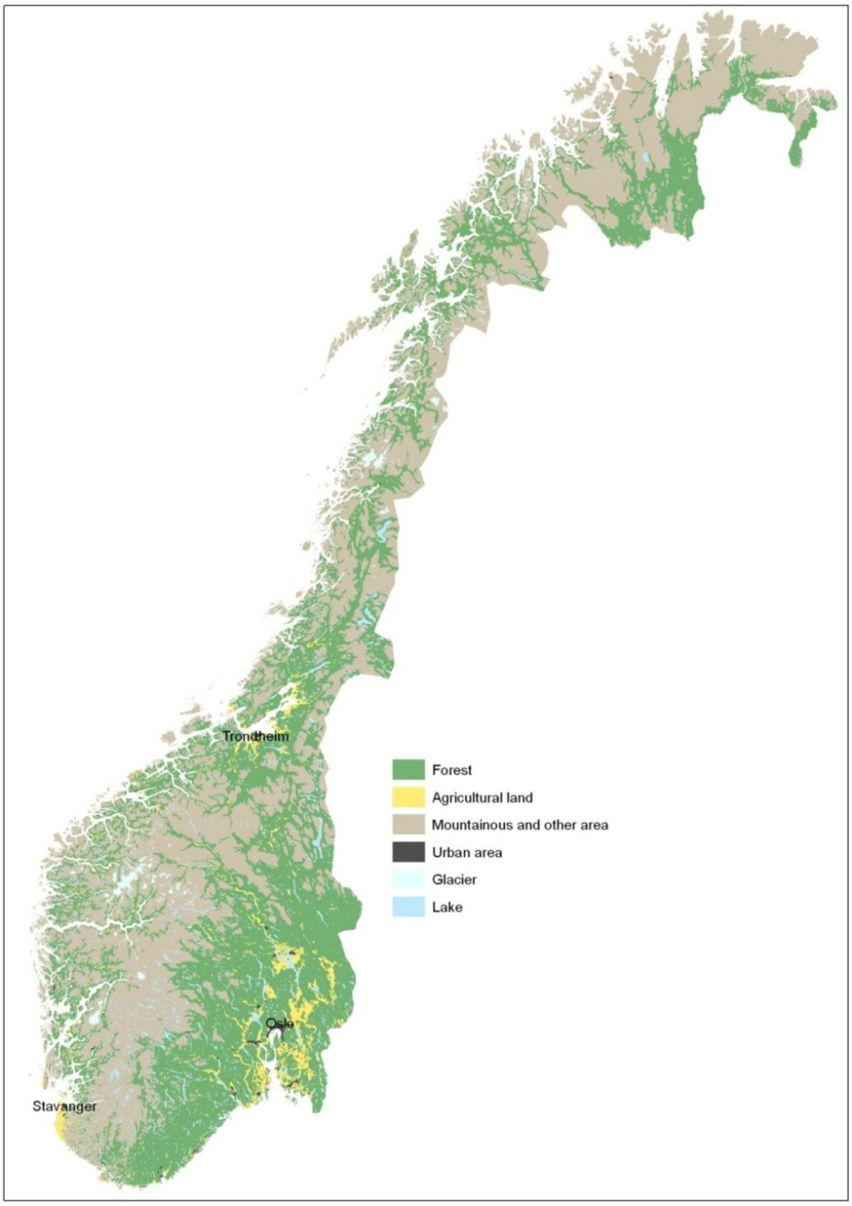

Figure 1. Map showing the forest area and other types of land in Norway.
Source of map: Norwegian Forest and Landscape Institute.

Norway has substantial north-south and east-west climate gradients. Inland areas in northern and eastern Norway have a typical continental climate, with warm summers and cold winters. The entire coastline is characterised by a maritime climate, with relatively cool summers and mild winters.

Annual precipitation also varies. The zone with the highest annual rainfall lies about 30-40 km inland from the coast. The driest areas are the inland regions of Finnmark (in the far north), as well as parts of the valleys of eastern Norway. The length of the growing season, defined as the number of days with a mean temperature of more than 5 °C, varies between 200 days in south-western Norway and 100 days along the coast of eastern Finnmark. In the alpine regions, the growing season is even shorter.

The soil and topography of the Norwegian land area has, in addition to the climatic conditions, had a great impact on the extent of the forests, species composition and growth. The far largest portion of the forests is boreal coniferous forest with principal species Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*), and with downy birch (*Betula pubescens*) and silver birch (*B. pendula*) as the dominating deciduous tree species. Boreal deciduous forests are an important component of the forests at high altitudes and in the northern areas. Hardwood forests which constitute, only 1 % of the forest area, occur in the southern part of the country and in particular along the coast, while the coniferous forests dominate in the inland.

The current forest composition is greatly influenced by different human-forest interactions. During several centuries the forests have suffered from deforestation, and much of the present forests are the results of human-induced regeneration and various silvicultural treatments. The species composition and structure of the present forests in all ecological zones is thus significantly different from primeval forests.

Image 1. A Norwegian forest landscape. Photo: Bård Løken, Samfoto.

0.2. Forestry in Norway

The forests are of great importance for the Norwegian society. They provide a whole range of ecosystem services that contribute to the living environment and social welfare as well as economic development. The forest resources are of great historical importance and have played a major role in developing trade and industry.

In 2009, the total growing stock in Norwegian forests was 823 million m^3, with a yearly increment of 25 million m^3. Over the last 90 years the total annual harvest has been between 8 and 11 million m^3. This is considerably lower than the yearly increment, as shown in Figure 2. With the existing level of timber harvest and forest management, the growing stock and its increment in 2011 is more than twice the level documented by the first National Forest Inventory in 1932. The amount of dead wood, old forest and deciduous trees, which is important for biological diversity, has increased considerably during the same period.

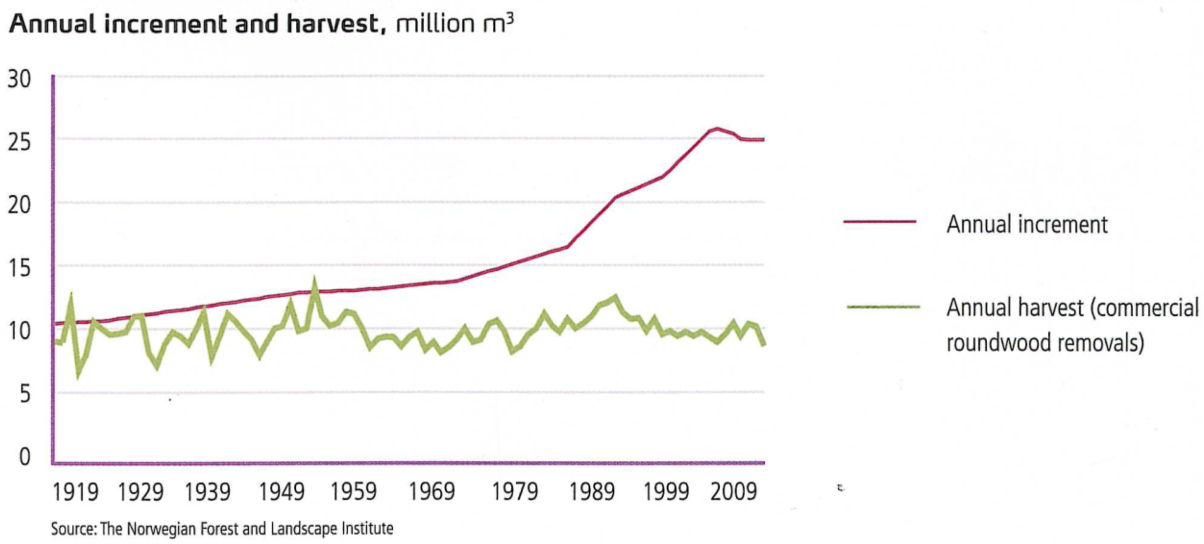

Figure 2. Annual increment and harvest in Norwegian forests 1919-2009.

Norwegian forestry and the wood industry continue to have great financial importance today, at a national, regional and local level. The primary value of Norwegian timber was 3 billion NOK (US$ 535 million) in 2008. The same year timber and wood products had a gross value of approximately 48 billion NOK (US$ 8.6 billion), corresponding to 5 % of the total gross domestic product in Norway. Approximately 50 % of the wood of the two conifers harvested is sold to the timber and wood industry and 50 % to the pulp and paper industry. Biomass and timber from Norwegian forests will continue to play an important role in the years to come, as renewable resources that can help us meet the challenges of climate change.

Forestry in Norway is characterized by small-scale properties, combining forestry and agriculture. This structure is based on the Norwegian topography, varying production conditions and the ownership structure of Norwegian forests. In 2009, Norway had 120.000 forest owners with more than 2.5 hectares of forest. Of these properties, 97 % are privately owned, and constitute 80 % of the total productive forest area. The average size of privately owned farms with forest resources is 45 hectares. Figure 3 shows the percentage distribution of forest ownership by area.

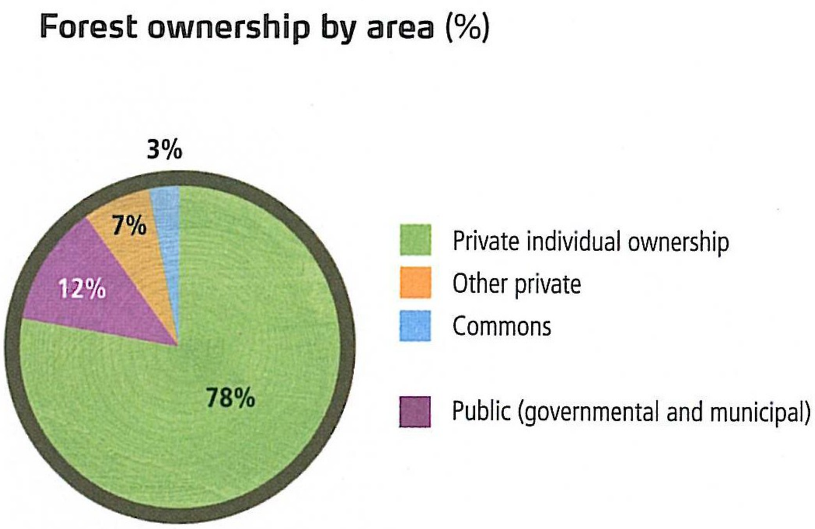

Figure 3. The percentage distribution of forest ownership by area.

The Norwegian Ministry of Agriculture and Food is the national authority responsible for the Norwegian forest policy which is based on a wide range of measures, including legislation, taxation, financial support schemes, research and advisory bodies. The main objectives of the Forestry Act of 2005 are to promote sustainable forest management with a view to promote active local and economic development, and to secure biological diversity, consideration for the landscape, outdoor recreation and the cultural values associated with the forest. The Forestry Act applies to all categories of forest ownership. Protective forests, which comprise approximately 20 % of the Norwegian forest area, are regulated in the Forestry Act. The main function of a protective forest is to protect climatically vulnerable forests and other forests against damage, and includes mainly the forest bordering mountain areas.

The National Forest Inventory has been an important basis for the development of forest policy since the beginning of the last century, and is repeated for every county in Norway at five year intervals.

A regulation under the Forestry Act requires forest owners to reinvest a part of the revenue from forestry into a government administrated fund; the Forest Trust Fund. This fund was established to secure long term investment in sustainable forest management such as silviculture, building and maintenance of infrastructure, forest management planning and environmental measures. From the genetic resource point of view, this fund has in particular been important for contributing to the reestablishment of forests after harvest with proper reproductive material.

Norwegian forest policy, as well as the environmental standards that forest owners are committed to follow, emphasise environmental considerations, such as maintaining and developing biological diversity, and the social and cultural functions of forests. The share of virgin forests is small in Norway. Today there are therefore strong concerns that Norwegian forestry is environmentally sustainable and takes sufficient consideration of biological diversity and threatened habitats. Biodiversity rich habitats are registered and mapped in forest management plans. This registration is done according to a standardized and well documented system.

Forest management plans are important tools for the forest owner, in order to promote sustainable forest management. This includes both active commercial use of the forest resources as well as the forest owner's responsibility for the protection of biological diversity, landscapes, recreation and cultural values in the forest. Forest management plans are offered to all forest owners in Norway every 10th to 15th year according to plans at county level. Today, forest management plans are developed through analysis and descriptions based on aerial photography supported by field inventories on ground and laser scanning. Field registrations are also important. The final product is customized to the individual forest owner and can give him or her recommendations for forestry measures. Providing an inventory of forest resources and environmental values on the property is a precondition for the allocation of grants.

Important areas for biological diversity are being inventoried on the basis of knowledge about species and their habitat requirements. The environmental inventories developed through the forest management planning process are made publicly available. The forest owner must ensure that all activities in the forest are carried out in compliance with laws and regulations. Under the Forestry Act, every forest owner must have an overall view of the environmental values and pay regard to them when carrying out activities in the forest.

The right of public access to outlying land, including forests, is an old and important principle in Norway. The general public may use the forests for recreational activities and sports at any time of year. The principle of public access is underlined by the forest policy and the environmental standards used by forest owners. Traditional activities such as skiing, hunting, fishing, berry picking and mushrooming are still important, while modern activities such as off-road biking are increasingly popular. Norwegian forests are often mentioned as important for public health and as an educational arena for children and youth. Using the forests for recreation and sports is considered to have a positive impact on both physical and mental health.

Image 2. Cross country skiing is a popular recreation activity in the Norwegian forests. Photo: Svein Skøien, Norwegian Institute of Agricultural and Environmental Research.

Forest genetic resources are considered important both as an element of the biological diversity that should be conserved for future generations and as the basis for the supply of forest reproductive material for the regeneration of forest after harvest. In the present Norwegian forest policy the genetic resources may contribute to the success of targeted programmes that have high priority: Forests and climate; increased use of wood and bioenergy.

Growing forests capture CO_2, and active management of forests resources may play an increasing part in reducing CO_2 emission. The Norwegian forests annually capture and store more than 50 % of the national CO_2 emissions. A Governmental White Paper in 2009 proposes climate policy instruments with a view to increase the use of forest resources to mitigate CO_2 emissions by means of sustainable, active forestry, including forest tree breeding and planting of genetically superior reproductive material.

An important goal for both the Government and the wood processing industry is to increase the use of wood wherever it can replace materials with more negative environmental impact. The Norwegian Wood-based Innovation Scheme is an important initiative that addresses different parts of the market: Companies, decision-makers, architects, entrepreneurs, traders, research and innovation. The Bio-energy Scheme was established in 2003 and its budget has been tripled to increase awareness of climate change and forests as a source of carbon-neutral energy. The forest genetic resources can make contributions to both initiatives.

The Norwegian Government will adapt a proactive and integrated approach to forestry issues in international forestry and environmental policy work, taking as a point of departure that a more central place must be given to forestry in future international legislation on climate-related issues.

Image 3. The forests are an important source for bioenergy. Photo: Arne Steffenrem, Norwegian Forest and Landscape Institute.

1. The Current State of Forest Genetic Resources

The Norwegian forests can be broadly classified into three major types: coniferous evergreen boreal forest, broadleaved forest and mixed forest (Table 1). In addition to the 12 mill hectares of forests, other wooded land amounts to 1.4 mill hectares. The forests are to a large extent formed by two conifers, *Picea abies* (Norway spruce), and *Pinus sylvestris* (Scots pine), and the two birch species *Betula pendula* and *B. pubescens*. The two conifers are economically the most important species and are the only species actively managed for wood production in the commercial forestry; together they cover 71 % of the forest area and 97 % of the annual harvest. Actual data related to the distribution of tree species in Norway is presented in Table 1.

Pinus sylvestris is mainly naturally regenerated, while *Picea abies* is planted on approximately 50 % of the harvested forest area. The number of seedlings planted of this species annually is at present 23 million, which is only a third of the number planted 30 years ago. The major part of spruce seedlings planted is of native origin. Exotic conifer species have been tested in experiments since the beginning of the 20th century, but except for the planting of *Picea sitchensis* and the hybrid *P. sitchensis* x *P. glauca* along the coast in central and northern Norway, no exotic species are used to any large extent in the commercial forestry. Very few broadleaved trees are planted for wood production. However, several of these species are used for landscaping, along roads and in parks and gardens.

Table 1. Major forest type categories and main tree species.

Major Forest Types	Area covered hectares	Main species
Coniferous evergreen forest	5.5 mill	*Picea abies,* *Pinus sylvestris*
Broadleaved forest	4.5 mill	*Betula pubescens,* *B. pendula*
Mixed forest	2.0 mill	*P. abies, P. sylvestris,* *B. sp.*

Image 4. A Scots pine production stand in Norway. Photo: Norwegian Forest and Landscape Institute.

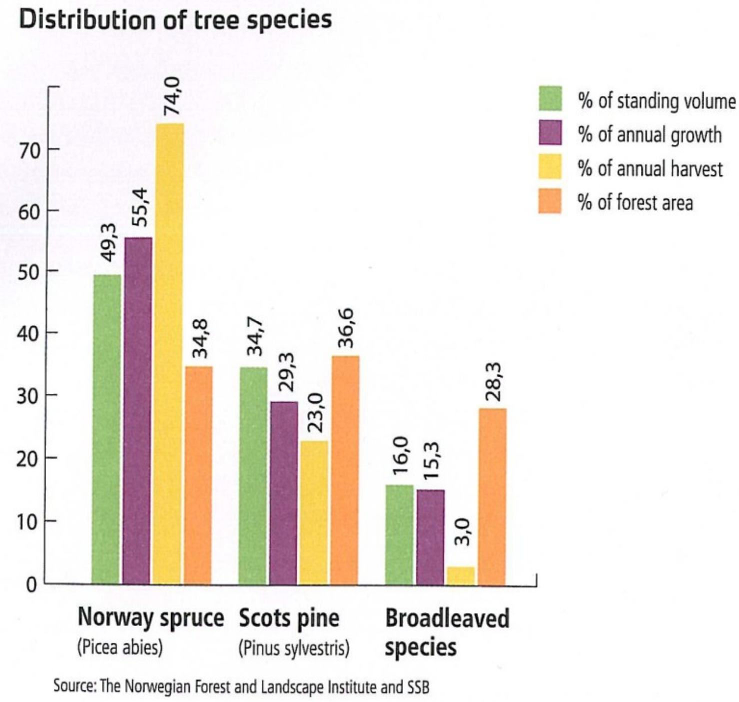

Figure 4. Distribution of tree species in Norway.

1.1 Native forest tree species

Species composition and distribution of forest trees in Norway are largely determined by the following factors: the invasion of tree species after the Ice Age, subsequent climatic changes and human activities. The first tree species to establish after the ice retreated more than 10,000 years ago were birch (*Betula pubescens*), poplar (*Populus tremula*) and Scots pine (*Pinus sylvestris*). These species spread fast and to altitudes 200-300 m higher than the present timber line. During the warm and dry period that later followed high temperature demanding species such as lime (*Tilia cordata*), ash (*Fraxinus exelsior*) and oak (*Querqus robur, Q. petrea*) spread and formed forests in the southern and southwestern part of the country. Small remnants of these forests still exist. These and other deciduous tree species that occur as scattered trees in mixed stands with other species (e.g. *Fagus silvatica, Ulmus glabra, Acer platanoides, Prunus avium)* have their main distribution in warmer climates at more southern latitudes and occur in Norway today at the northernmost border of their natural range.

Image 5. Most likely the northernmost population of Fraxinus excelsior in the world, lat. 63°40'. Photo: Arne Steffenrem, Norwegian Forest and Landscape Institute.

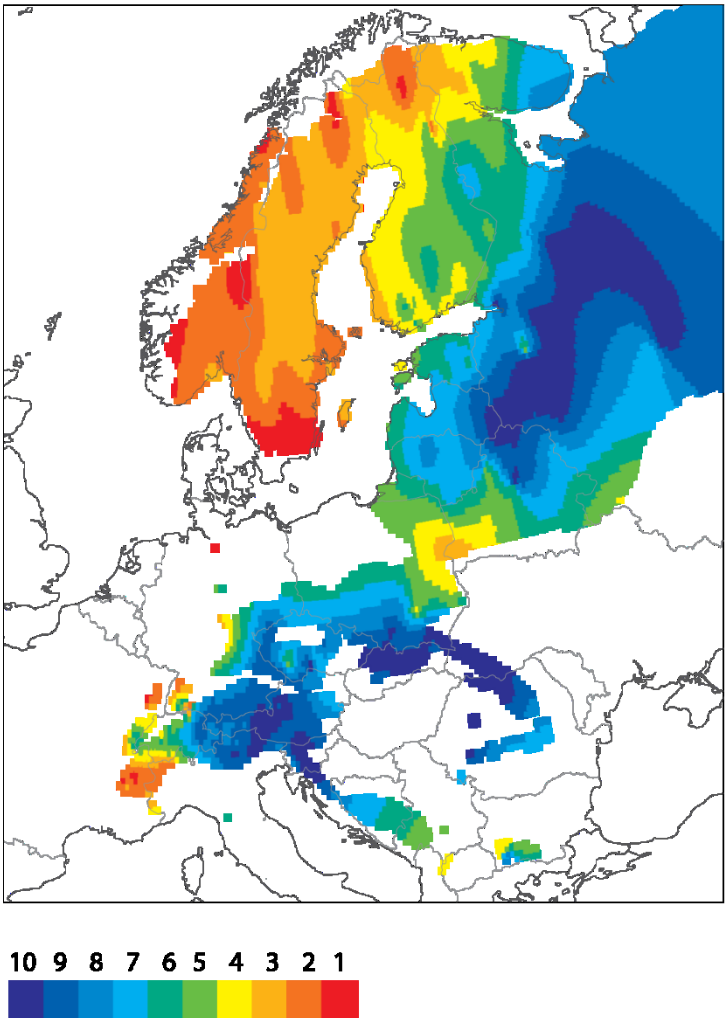

Figure 5. Map of fossil pollen for the inference of Holocene expansion in Picea abies. The map show interpolated age (in time intervals of 1000 years before present) of Picea abies fossil pollen (threshold >= 2%). Map developed by Christoph Sperisen, Federal Institute for Forest, Switzerland.

It was not until approximately 2,500 years ago, during a cooler and more humid period, that the conifer *Picea abi*es started to form forest in Norwegian landscape (Figure 5). The *Picea abies* spruce populations have their origin in the Russian planes, and most likely also from the Baltic area. During a period of 7,000 years the species spread through Finland and northern Sweden, and also from the Baltic area through southern Sweden to southern Norway. The invasion of the south-eastern lowland area started 3,000 years ago, but the migration up the valleys to the species' present altitudinal boundary was not completed until the period 1,000-1,500 AD. The coastal spruce forest in Central Norway established rather late (approx. 1,300 AD). The present natural occurrence of Norway spruce is in south-eastern Norway from the sea level and up to 1000 m, and in Central and North Norway, north to lat. 67°N, at decreasing altitudes in the north. Outside this area the species has been planted both in western Norway and north of its natural boundary in northern Norway in the last century. In both regions it has become an important timber species.

An evaluation has been made of the native forest trees species in Norway with a description of life history traits such as geographic range, occurrence, pollination vector and seed dispersal. Based on this information, and known genetic knowledge, of the species their genetic resources were characterised as *vital*, *uncertain*, *exposed* and *threatened*. This information is presented in Table 2. Special for Norway is that 25 of the 34 native species have their northern limit in this country. Of the *Sorbus* species, seven are endemic in Norway. Eight of these species characterised as exposed or threatened are included in the Norwegian Red List for Species.

Twelve widely distributed species with generally effective dispersal of pollen and seeds were considered *vital* (e.g. *Betula* spp., *Alnus* in*cana*, *P*inus *sylvestris*, *Picea abies*) and have as such no particular conservation requirements. Five species were considered *uncerta*in (*Quercus* spp, *Fraxi*nus *excelsior*, *Acer platanoides*, *Fagus sylvatica*) because of limited ranges, scattered occurrences and possibly less effective dispersal of seeds and/ or pollen than the former group. Fifteen species were considered *exposed* (10 *Sorbus* spp., *Malus sylvestris*, *Prunus avium*, *Tilia cordata*, *Taxus baccata*, *Ilex aquifolium*) owing to marginal occurrences, a great proportion of insect-pollination (all except for *Taxus baccata* and *Ilex aquifolium*), limited sexual reproduction (*Tilia cordata*), and endemism (some *Sorbus* spp.). Only *Ulmus glabra* was classified as *endangered* because of the Dutch Elm disease that may reduce the genetic variability at the population level. Human influence has minor impact on the above classification.

Image 6. One of the endemic Sorbus species in Norway, Sorbus meinichii (Lindeberg ex. C. Hartman) Hedlund). It has probably originated through one or several hybridization events between (Sorbus aucuparia L. and Sorbus hybrida L). Photo: Per Salvesen, University of Bergen.

Table 2. Native forest tree species in Norway and their characteristics.

Species Scientific name	Geographic range	Occurrence	Pollination vector	Seed dispersal	Northern limit in Norway?	Genetic resource category
Picea abies	Widespread	stand	wind	Wind		vital
Pinus sylvestris	Widespread	stand	wind	Wind	yes	vital[2)]
Juniperus communis	Widespread	scattered	wind	Birds	yes	vital
Taxus baccata	Limited	scattered	wind	Birds	yes	exposed
Salix caprea	Widespread	scattered	insect	Wind	yes	vital
Populus tremula	Widespread	stand/scattered	wind	Wind		vital
Betula pendula	Widespread	stand/scattered	wind	Wind		vital
Betula pubescens	Widespread	stand/scattered	wind	Wind		vital
Alnus incana	Widespread	stand/scattered	wind	water/wind		vital
Alnus glutinosa	Medium	stand/scattered	wind	water/wind		vital
Coryllus avellana	Medium	stand/scattered	wind	mammals	yes	vital
Prunus padus	Widespread	scattered	insect	Birds	yes	vital
Fagus sylvatica	Marginal	stand/scattered	wind	Birds	yes	uncertain
Quercus robur	Limited	stand/scattered	wind	mammals/ birds	yes	uncertain
Quercus petraea	Limited	stand/scattered	wind	mammals/ birds	yes	uncertain
Acer platanoides	Limited	scattered	insect	Wind	yes	uncertain
Fraxinus excelsior	limited	stand/scattered	wind	Wind	yes	exposed
Ilex aquifolium	limited	scattered	wind	Birds	yes	exposed
Malus sylvestris	limited	scattered	insect	mammals/ birds	yes	exposed
Prunus avium	marginal	scattered	insect	Birds	yes	exposed
Tilia cordata	limited	stand/scattered	insect	Wind	yes	exposed
Ulmus glabra	medium	stand/scattered	wind	Wind	yes	threatened
Sorbus aucuparia	widespread	scattered	insect	Birds		vital
Sorbus hybrida	limited	scattered	insect	Birds	yes	exposed
Sorbus meinichii [1)]	marginal	scattered	insect	Birds	yes	exposed
Sorbus subsimilis[1)]	marginal	scattered	insect	Birds	yes	exposed
Sorbus subpinnata[1)]	marginal	scattered	insect	Birds	yes	exposed
Sorbus subarranensis[1)]	marginal	scattered	insect	Birds	yes	exposed
Sorbus neglécta[1)]	marginal	scattered	insect	Birds	yes	threatened
Sorbus lancifólia[1)]	marginal	scattered	insect	Birds	yes	threatened
Sorbus norvegica[1)]	marginal	scattered	insect	Birds	yes	exposed
Sorbus rupicola	limited	scattered	insect	Birds	yes	exposed
Sorbus intermedia	marginal	scattered	insect	Birds	yes	exposed
Sorbus aria	marginal	scattered	insect	Birds	yes	exposed

[1)] Species that are considered to endemic in Norway
[2)] *Pinus sylvestris* ssp. *lapponica* is rated as near threatened in The Norwegian Red List for Species

1.2 Genetic knowledge

The first provenance and species trials with both native and introduced tree species, in particular conifers, were planted in Norway approximately 100 years ago. Since then, short and long term field tests with both native and introduced species have provided knowledge about genetic differences between species and of the within-species genetic variability among provenances, populations within provenances and within populations. Studies have in particular been made of traits that characterise adaptation to the climatic conditions. More recently, molecular genetic studies have been initiated, at present in eight native and one introduced species (Table 3). Forest tree species, both native and introduced, from which genetic knowledge is available, are listed in Table 3. Norway spruce is the only species that has a sufficient genetic characterisation at the provenance, family and individual level.

Genetic diversity in Picea abies

Recent molecular studies confirm that the vast northern range of *Picea abies* was colonized from a single Russian refugium and that the expansion westward took place along two main migration routes. Populations in southern Norway show relatively high levels of diversity compared to those of the northern one. In the north, limited seed and pollen production may have caused decreased diversity and increased inbreeding, reflecting the marginality of the species in the north.

Genetic information characterising adaptation of Norway spruce to the climatic conditions is available from provenance, progeny and clonal trials. Measurements have in particular been made of annual growth rhythm traits: the timing and duration of the annual growth period, frost hardiness development in the autumn and dehardening in the spring, and the occurrence of climatic damage under field conditions. All studies demonstrate a clinal variation in growth rhythm traits in natural populations from the south to the north and from low to high altitudes. The southern and lowland populations have the longest duration of growth season, and as a consequence, the highest growth potential. They also develop latest autumn frost hardiness. The only well-known characterisations of the adaptive process of spruce populations are the responses to temperature and photoperiod. Within natural populations, a large genetic variation is present, also for traits that show clinal variation at the provenance level and in populations at the geographic margin of the species.
In addition, a number of studies have shown that trees of *Picea abies* can adjust the performance in adaptive traits by a rapid and likely epigenetic mechanism, through a kind of a long-term memory of temperature sum and photoperiod during seed production. These effects may have important implications for both gene conservation and for practical forest tree breeding. The research on epigenetic effects on adaptive traits in *Picea abies* has high priority.

The genetic knowledge of intraspecific genetic variation patterns obtained in research is published in international and national research journals and in more popular national forest journals. It is also regularly disseminated at meeting and conferences for foresters. Major users are the national tree breeding organisations and advisors in forestry and natural resource management at the regional and national level.

Image 7. Clouds of pollen from Picea abies stands. Photo: Ragnar Johnskås, The Norwegian Forest Seed Center.

Table 3. Forest species for which genetic variability has been evaluated at different genetic levels.

Species		Type of material evaluated, genetic level	Morphological traits	Adaptive and production characters assessed	Molecular characterization
Scientific name	Native (N) or exotic(E)				
Picea abies	N	provenances, families, clones	X	X	X
Pinus sylvestris	N	provenances, families	X	X	
Betula pendula	N	provenances, families	X	X	X
Alnus glutinosa	N	provenances, families	X	X	
Acer platanoides	N	provenances, families	X	X	X
Fraxinus excelsior	N	provenances, individuals			X
Sorbus aucuparia	N	provenances, families	X	X	
Ulmus glabra	N	provenances, families	X	X	X
Malus sylvestris	N	individuals			X
Taxus baccata	N	provenances			X
Fagus sylvatica	N	provenances			X
Picea sitchensis	E	provenances, families	X	X	
Picea lutzii	E	provenances, families	X	X	
Picea engelmanni	E	provenances	X	X	
Picea glauca	E	provenances	X	X	
Picea mariana	E	provenances	X	X	
Pinus contorta	E	provenances, families	X	X	
Abies lasiocarpa	E	provenances, families	X	X	X
Abies nordmanniana	E	provenances,	X	X	
Abies amabilis	E	provenances	X	X	
Abies procera	E	provenances	X	X	
Pseudotsuga menziesii	E	provenances	X	X	

1.3 Factors influencing the genetic diversity and lack of knowledge

Generally, there is a lack of knowledge of the importance and implications of factors that may influence the genetic diversity of the forest tree species. **Fragmentation** of the landscape reduces the gene flow among individuals and populations which may lead to a smaller effective population size and increased degree of inbreeding. The gene flow among populations has been characterised for very few tree species with a fragmented distribution in Norway. For many tree species **regeneration** is hindered by browsing of increasing population sizes of wild animals such as moose and red deer, e. g. browsing on Tax*us baccata*. **Change in land use** and **clogging** influence the growth conditions, in particular for the hardwood broadleaved species, and may change the competitive environment. **Pests** and **diseases**, which may be more common due to warmer climate at northern latitudes, may lead to loss of populations and thereby reduced diversity for some species. The implications of **climate change** on the forest genetic resources are not well understood, in particular as the prediction of the future climatic conditions is uncertain. More information should be generated about the influence of these factors, and their interactive effects, on the forest genetic diversity. In general, prospects for future conditions are good, but pest and diseases (e. g. ash decline), perhaps associated with climate change, and browsing pressure appear to be the main obstacles today.

During the period 1950 -1980 Central European provenances of *Picea abies* spruce were planted to a large extent in southern Norway. Both practical experience and results from surveys showed that this was a bad choice of provenances for south-eastern Norway, resulting in plantations with climatic damage and reduced saw timber qualities. It was feared that gene flow from such stands would lead to a reduced adaptedness in the next generation. Research results have shown that this may not be the case, as there seems to be a rapid change in adaptive performance from one generation to the next in Norway spruce due to an epigenetic mechanism.

The use of *Picea sitchensis* and the hybrid *P. sitchensis* x *P. glauca* along the coast of central and northern Norway have resulted in the natural regeneration of these species on several sites. However, this does not seem to be a threat to the native forest trees. The use of exotic tree species in the commercial forestry is restricted and no other exotic tree species are used to any large extent in the commercial forestry.

A survey was conducted in five counties as part of the periodic national forest assessment to monitor the extent and regeneration of eleven selected tree species. It was found that there has been an increase in the standing volume and area of several of the deciduous tree species. The data obtained from the survey will be a good baseline for future monitoring of the change in the resources of these species.

Tree species that are listed on the Norwegian Red List for Species will be revaluated when the regular updating of the list takes place, approximately every five years.

2. The State of *in situ* Genetic Conservation

In situ conservation of forest tree species comprises the conservation of viable populations in their natural environment, whether it is a production forest or a protected area. The term is often applied to naturally regenerating wild populations, and can be integrated into managed production and multiple-use forests. The aim of *in situ* conservation is often to conserve the function of an ecosystem and the evolutionary processes rather than just species. Under certain conditions, nature-protected areas provide a significant potential for *in situ* conservation of forest genetic resources. Norway has chosen a strategy to establish *in situ* conservation units in protected areas for some target species. This is done as part of our national contribution to the common European project EUFGIS (www.eufgis.org) which created an online information system for forest genetic resources inventories in Europe, focusing on improving documentation and management of dynamic conservation units of forest trees.

Protected areas in Norway

Protected areas in Norway are protected through The Nature Diversity Act. Excluding the marine reserves, there are four different types of protected areas, which differ in size, objectives (i.e. what is protected) and management regulations.

The four types of protected areas are:

1. National parks which are established to prevent activities that could disturb unspoiled areas of significant size, and also to protect landscapes and habitats for plants and animals. National parks also safeguard areas for outdoor activities, nature experience and recreation. Traditional farming and mountain dairy farming are usually allowed in a national park.

2. Nature reserves which have the strictest protection regime among Norwegian protected areas. Some reserves cover untouched nature, while others are former cultivated land. A stated goal for these reserves is to conserve biodiversity, and vascular plants in particular, present at the time the reserves were established. However, when areas change as a result of succession, biodiversity will be affected and management actions may be necessary to prevent loss of the species that initially were used for the selection of reserves. Activities that can impact the targeted protection objectives are strictly forbidden. Moreover, there should be management operations that can contribute to fulfill the objective for conservation of the specific area.

3. Protected landscape areas comprising distinctive and/or beautiful natural or agricultural countryside which are often used to maintain actively used farming landscapes. Restrictions are less severe than in other protected areas and farming and forestry can usually be continued, though with greater attention as to not reducing landscape qualities.

4. The final type of protected area, biotope reserves, protects the ecological environment of specific plant or animal species, without protecting the corresponding area as a nature reserve.

Altogether 3.1 % of the total forest area is protected through one of the first two types of protected area. This allows the possibility to combine *in situ* conservation of genetic resources with other protection objectives in already protected areas. Nature reserves was considered to form the most relevant option for *in situ* conservation of forest genetic resources because such areas are quite well documented as regards species content, size of area, the conservation regime is quite strict, development in such areas is to some extent monitored and some management can be allowed. Of the 2012 nature reserves in Norway, 759 reserves are in forests, covering 281 550 hectares, see Table 4. The number of reserves in forests has increased from 412 in the last ten year period. An on-line searchable database of all protected areas in forests, and a listing of the tree species growing there, has been established by the Norwegian Genetic Resource Centre. It is based on, and linked to, the database of all protected areas managed by the Norwegian Directorate for Nature Management (Naturbase).

Table 4. Nature reserves in Norway 2010 and 2000 in forests. Source: The Directorate for Nature Management.

Forest type	2010		2000	
	Number of reserves	Size hectares	Number of reserves	Size hectares
Coniferous forest	438	261 554	189	79 086
Broadleaved deciduous forest	283	19 214	187	5 178
Taxus/Ilex forest	38	782	36	740

Gene conservation units in nature reserves

Certain requirements have to be fulfilled on order for a nature reserve to qualify for being defined as a gene conservation unit. Minimum requirements for a given species will depend heavily on a number of factors including its reproductive biology and growth, ecology and kind of genetic threats it is currently facing or will most likely face in the near future. The requirements relate to population size, number of reproducing trees, sex ratio and whether trees are growing in stands or scattered. Conservation of the genetic resources of the specific species must be in accordance with the original objectives for establishing the nature reserve. In cooperation with the Directorate for Nature Management and the environmental units with the County Governor, the Genetic Resource Centre has selected candidate nature reserves for being considered as *in situ* gene conservation areas for specific species and to be part of the EUFGIS network. Assessments have been made in the field of the suitability of the selected reserves.

Image 8. From the nature reserve containing the northernmost population of Fagus sylvatica in the world. Photo: Bernt-Håvard Øyen, Norwegian Forest and Landscape Institute.

During the last five years, 22 gene conservation units, comprising nine forest trees species on a total of 13 682 hectares have been registered and are included in the EUFGIS database. They are shown in Table 5. The species occur differently in the nature reserves and they have different requirements for long term existence. As an example, *Picea abies* is a highly competitive species that occurs in large stands and with a sufficient sexual reproduction and natural regeneration capacity. Other species occur as scattered single trees that may have low competitive ability or may not have a sufficient sexual reproduction, e. g. *Tilia cordata*. Management plans for the genetic resource are therefore needed, which could be included in the management and conservation plan for the nature reserve.

Table 5. Target forest species included within the in situ conservation programmes. All conservation units established as part of the European EUFGIS project.

Species	Number of conservation units	Total area hectares
Picea abies	5	13 151
Ilex aquifolium	1	9
Ulmus glabra	4	189.3
Fraxinus excelsior	3	74.2
Tilia cordata	2	72.1
Fagus sylvatica	2	25.9
Quercus petraea, Q. robur	3	104.5
Acer platanoides	2	46.7

The genetic resources for a number of the Norwegian tree species are considered to be vital, e. g. *Pinus sylvestris*, *Populus tremula*, *Betula pendula and Alnus glutinosa* (Table 1.2); they have a wide and continuous occurrence and reproduce easily. It is thus assumed that there is an extensive gene flow among populations and that they maintain a large genetic variation on a large scale. For such species, with the exception of *Picea abies*, it has not been found necessary to establish specific gene conservation units.

Several *Sorbus* species are endemic to Norway; they often have marginal geographic ranges and some are considered threatened or exposed (Table 2). Many species comprise a large and often unique variation that needs special concern. Specific conservation activities are needed to manage and conserve these unique genetic resources. Based on former field studies 43 localities where these species occur with high variability or where rare taxa are found, have been identified and described. Some of these are in protected areas, some of which are designated for other purposes, but most are not. Protection and management are proposed for these localities, in some cases in a combination of *in situ* and *ex situ* conservation. Other species for which such strategies should be proposed are *Taxus baccata, Ilex aquifolium* and *Malus sylvestris.*

Priorities in in situ conservation

It is important to obtain full acceptance from the nature reserve managers that the genetic resources of selected forest tree species should be conserved in nature reserves and that management may be needed to fulfil also this objective of the reserve. Such management should be an integrated part of the management plan of reserves that are selected for this purpose. More gene conservation units and more species should be evaluated to be included in the *in situ* conservation programme in nature reserves. A better co-operation is needed between local and regional managers of both protected areas and forests.

Greater public awareness is needed about *in situ* conservation of vulnerable tree species and the role of protected areas for such conservation. Information about this function of each specific reserve should be given, and the on-line databases of protected areas should be updated with this information. It is important that the Norwegian *in situ* conservation units at the marginal range of several tree species, is considered as an integrated part of the gene conservation efforts across their whole natural range.

Image 9. Taxus baccata trees growing in a nature reserve in West-Norway.
Photo: Tor Myking, Norwegian Forest and Landscape Institute.

3. The State of *ex situ* Genetic Conservation

Ex situ conservation of forest genetic resources in Norway is carried out in several different ways: Collections in arboreta and botanical gardens; long-term tests of clones, families and provenances in research plantations; progeny tests, clonal archives and seed orchards belonging to the national breeding programme; and seed lots stored at The Norwegian Forest Seed Center. No *in vitro* storage for conservation purpose of forest genetic material is performed in Norway. Facilities for such storage are available, however, both at research institutions and private companies.

Arboreta and botanical gardens

Several arboreta and botanical gardens possess collections of forest trees, of both native and exotic species. In most cases these collections contain a small number of individuals of each species and do not have a strategy for long term regeneration. Therefore, they are not considered as the main elements of the national conservation strategy. Such collections often contribute to the maintenance of unique and rare genotypes, but may also contain locally adapted populations of native species and individuals from transferred provenances of native or exotic species. Collections of trees in arboreta often have a role as public parks and are important for raising public awareness. They are therefore valuable for demonstration and education. A collection of endemic *Sorbus* species covering nearly 200 accessions has been established in a cooperative project between arboreta and botanical gardens. With a few exceptions, collections in arboreta and botanical gardens are not discussed further in this report.

Image 10. Columnar forms of Juniperus communis of Norwegian origin in the collection at the Norwegian University of Life Science. Photo: Jeanette Brun, The Norwegian University of Life Science.

Collections for landscaping purposes

A substantial number of trees of both native and exotic origins are planted in the landscape; in parks, along the roadside and in private gardens. Cultivars and clones with specific aesthetic values have been developed, tested and propagated for use in such plantings. For Norwegian conditions, testing for frost hardiness is of specific importance. Collections of such materials, intended both for testing and demonstration purpose, contain valuable genetic resources. They offer a large variety of genetic materials and contribute towards increasing the diversity of tree plantings in the landscape. The largest collection, located at the Norwegian University of Life Sciences, contains trees of approximately 120 different species of the genera *Acer, Alnus, Betula, Carpinus, Fraxinus, Prunus, Quercus, Sorbus, Tilia* and *Ulmus*. However, only a small number of trees of each genetic unit has been planted, in most cases four, and the long term conservation of the materials is not secured. Smaller collections exist in other parts of the country.

Long-term tests of clones, families and provenances in research plantations

The first provenance and species trials with both native and introduced tree species, in particular conifers, were planted in Norway approximately 100 years ago. They have given valuable information about the use of species and provenances. Research plantations were often planted in experimental designs that were not suitable for long term studies, and few of the old trials exist to-day. During the last 50 years, most field trials have dealt with the most important native conifer, *Picea abies*, and many of these tests are kept and constitute valuable genetic resources containing genetic units from which genetic information on phenotypic traits is available. In years with abundant flowering, seed lots were obtained from several individual trees in a number of natural populations that often were distributed along climatic gradients, and progeny tests were established. Several such collections were made by the Norwegian Forest and Landscape Institute, formerly Norwegian Forest Research Institute, during the period 1951-97. The more recent trials with *Picea abies* were based on families from controlled crosses, and also some with clones, with the objectives of characterizing the genetic variability and inheritance patterns of the species, both within natural and in breeding populations. A Nordic database of research field experiments with forest trees (http://noltfox.metla.fi) lists 230 field trials in genetics and tree breeding in Norway, of which 160 are species or provenance trials, 63 are progeny tests and 4 are clonal tests. Three institutions are responsible for the field tests in forest genetic research: The Norwegian Forest and Landscape Institute, The Norwegian University of Life Sciences and The Norwegian Forest Seed Center. Table 6 presents species that are contained in *ex situ* collections that are not part of the tree breeding activities. A large number of short term tests, often on agricultural soil and with an expected duration of less than 10 years are not included.

Table 6. Species stored in field collections in research or clone banks that are not part of the breeding programmes.

Species	Field collections 1)				
Scientific name	Native (N) or exotic (E)	Collections, provenance or progeny tests, arboreta or conservation stands		Clone banks	
		No. stands	No. accessions	No. banks	No. clones
Picea abies	N	114	> 600		
Pinus sylvestris	N	6	20		
Picea sitchensis	E	11	> 100		
Pinus contorta	E	37	> 60		
Picea engelmannii	E	3	20		
Picea glauca	E	4	20		
Picea mariana	E	4	20		
Abies lasiocarpa	E	7	20		
Abies grandis	E	1	16		
Abies procera	E	2	20		
Pseudotsuga menziesii	E	7	75		
Betula pendula, B. pubescens	N	6	70		
Querqus petraea	N	1	17		
Tilia cordata	N			1	103
Sorbus meinichii	N	2	40		

1) Materials and field tests in tree breeding are listed in Table 12 and should be added to those listed here to obtain the total number of *ex situ* collections.

Clonal archives and seed orchards

Forest tree breeding with *Picea abies* started in the mid 1950's with the selection of plus trees in natural populations. These plus trees were grafted in clonal archives and seed orchards. Seed lots were collected from the selected trees, either in the forest or in the clone collections, or controlled crosses were made on the grafts. The resulting families were planted in progeny tests at multiple sites. Altogether, 5186 plus trees of *Picea abies* were selected and kept as grafts in clonal archives or seed orchards, and 3832 families are being tested in progeny tests. The The Norwegian Forest Seed Center is responsible for all breeding materials. More information about materials conserved *ex situ* in tree breeding is given in Chapter 4.

Seed lots in storage

The Norwegian Forest Seed Center is responsible for the procurement, storage and trade of seeds for the forest sector. Seeds of recommended seed sources and of both native and imported species are stored, with main emphasis on a wide selection of native *Picea abies* provenance and seed orchard seed lots and *Pinus sylvestris* provenances, as shown in Table 7. Long term seed storage is needed as seed years are scarce at northern latitudes and at high altitudes. Seed lots are therefore kept as long as 20-30 years until new representative seed crops become available. Optimal storage conditions will guarantee a high germination rate even after several decades of storage. This seed storage is an important component in the management of the forest tree genetic resources in artificial regeneration. Samples of some seed lots of native species are saved for long term storage.

Table 7. Accessions of forest tree species stored at The Norwegian Forest Seed Center. Source: The Norwegian Forest Seed Center.

Native species	Number of accessions	Exotic species	Number of accessions
Acer platanoides	3	*Abies amabilis*	1
Alnus glutinosa	2	*Abies balsamea*	1
Alnus incana	2	*Abies bornmulleriana*	1
Betula pendula	10	*Abies concolor*	2
Betula pendula carelica	1	*Abies fraseri*	2
Fraxinus excelsior	3	*Abies homolepis*	1
Picea abies	359	*Abies koreana*	3
Pinus sylvestris	196	*Abies lasiocarpa*	24
		Abies nordmanniana	3
		Abies procera	11
		Abies sachalinensis	2
		Abies sibirica	1
		Abies veichi	1
		Chamaecyparis lawsoniana	1
		Larix kermpferi	3
		Larix sibirica	2
		Picea engelmanii	1
		Picea glauca	1
		Picea lutzii	2
		Picea mariana	1
		Picea omorika	4
		Picea pungens	2
		Picea sitchensis	9
		Pinus aristata	1
		Pinus cembra	1
		Pinus contorta	5
		Pinus mugo	9
		Pinus pumila	1
		Pseudotsuga menziesii	3
		Thuja occidentalis	1
		Thuja plicata	1
		Tsuga heterophylla	1
		Tsuga mertensiana	1

Image 11. Seed lots stored at the Norwegian Forest Seed Center. Photo: Ragnar Johnskås, The Norwegian Forest Seed Center.

Documentation and characterisation

Information about the genetic units tested in research and breeding plantations and records of traits measured are kept in databases at the institutions that established these plantations. A common database of all genetic units available in research and tree breeding is being developed as a common project between The Norwegian Forest Seed Center and the Norwegian Forest and Landscape Institute. Documentation and discussion of the genetic knowledge obtained in research is presented in articles and reports published both in international and national journals.

Documentation and information about available seed lots stored at The Norwegian Forest Seed Center is available at the home page of the institution (www.skogfroverket.no) for registered users.

Priorities for future ex situ conservation actions

Svalbard Global Seed Vault (Seed Vault), the long time global back-up storage for seeds is owned by the Norwegian government and managed by the Nordic Genetic Resource Center. This Center is assessing the possibilities of deposit and store forest tree species in the Seed Vault. Initially, accessions whould be of *Picea abies* and *Pinus sylvestris* of Nordic origin provided by Nordic seed banks, breeding, research or gene conservation organisations. Such storage could serve three main objectives:

- Conservation of seed samples from natural populations to secure back-up storage for future monitoring of long-term changes in genetic diversity

- Conservation of seed samples from different stages and generations of breeding populations or seed orchards to monitor changes in genetic diversity taking place during breeding operations
- Conservation of back-up seed samples of threatened populations, of gene reserve forests or other in situ conservation units.

Further plans for such storage at the Seed Vault are being developed.

Depending on results from inventories made *in situ* of species growing as scattered trees, e. g. *Sorbus* species, *Taxus baccata*, *Ilex aquifolium* and *Malus sylvestris*, proposals will be made for establishing *ex situ* collections, as mentioned in Chapter 2.

Challenges in ex situ conservation

There is no complete catalogue of all the materials contained in *ex situ* collections and no evaluation has been made to assess which material should have highest priority in *ex situ* conservation. Management is required in order to maintain collections in long term field trials. At the time field trials must be thinned and finally harvested, decisions must be made for further conservation of the genetic materials. Strategies for *ex situ* conservation of the genetic resources of species threatened by diseases, the present ash decline taken as an example, should be developed.

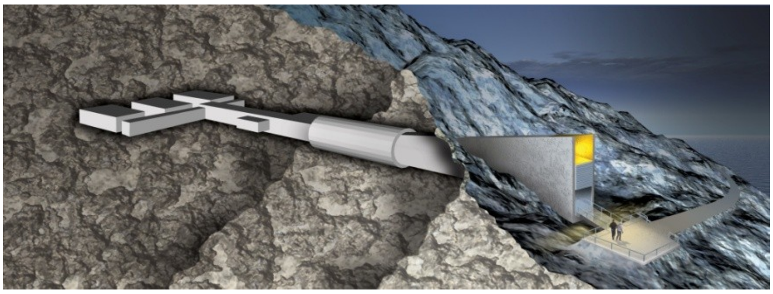

Image 12. Svalbard Global Seed Vault is located in a mountain at latitude 78 degrees north.

Image 13. Seed lots are stored in closed boxes at minus 18 degrees Celsius in the Seed Vault.

4. The State of Use and Sustainable Management of Forest Genetic Resources

Forest genetic resources in Norway are used in production forestry when forests are regenerated after harvest, in afforestation on treeless land or for the replacement of other tree species. They are also used for Christmas tree and greenery production, for landscaping purposes or for ornamental use in gardens.

The Forestry Act requires that regeneration generally should take place within three to five years after harvest, depending on environmental conditions. The local forest authority is mandated to demand that the forest owner takes actions to establish a commercially viable stand within a reasonable period of time. Regulations are given for silvicultural and environmental actions in the regeneration, such as change of tree species, the introduction of exotic species, the transfer of provenances and the recommended number of seedlings planted per hectare.

In production forestry, regeneration after harvest is executed differently for the two major commercial species, *Pinus sylvestris* and *Picea abies. Pinus sylvestris* is to a large extent naturally regenerated, using the seed-tree method. In the regeneration fellings, 30-150 seed trees are retained per hectare, depending on site conditions. On sites with difficult regeneration conditions due to. e. g. harsh climate and/or thick humus layers, soil scarification may be used to improve seedling establishment. The use of soil scarification is, however, less common in Norway than in the other Nordic countries.

Image 14. Seed trees of Pinus sylvestris left for natural regeneration. Photo: Sverre Skoklefald, Norwegian Forest and Landscape Institute.

Picea abies is regenerated both naturally and artificially by planting. When natural regeneration is planned, the use of patch clear-cuts and shelterwood fellings are common. When using the latter method, 150-400 trees are retained per hectare for seed dispersal and to provide shelter. The shelter trees can also be other tree species than *Picea abies*. At higher elevations, a significant proportion of the spruce forest is also harvested by means of mountain forest selective cutting, where subsequent recruitment is initiated by either natural regeneration or planting, or a combination of both. However, clear-cut fellings and subsequent planting of seedlings is most common in *Picea abies* and is considered to be the fastest regeneration method on most forest sites.

National assessments are annually made of the regeneration methods used and the results of the regeneration three years after harvest. In the assessment made in 2010 of the areas harvested in 2007, planting was the used regeneration method on 52.5 % of the area, while 10.2 % was regenerated by a combination of planting and natural regeneration. On 26.6 % of the harvested areas treatments were initiated to favour natural regeneration. No actions were initiated to re-establish the forest on 10.6 of the area, which is a reduction compared to earlier years. Approximately 75 % of the planted areas had a seedling density equal to or higher than that recommended in the legal regulations.

4.1 Reproductive material in use

The number of seedlings delivered from Norwegian forest nurseries and planted in production forestry has been strongly reduced during the last 20 year period. From a level of close to 50 million seedlings 20 years ago it has been reduced to an average of 23 million during the last five–year period, as shown in Figure 6. As seen from the figure, more than 90 % of the seedlings are *Picea abies*.

The seedlings are produced in 15 forest nurseries which are located in different parts of the country. In general, each nursery produces seedlings for its local region. Most of the seedlings are one- or two year-old container plants.

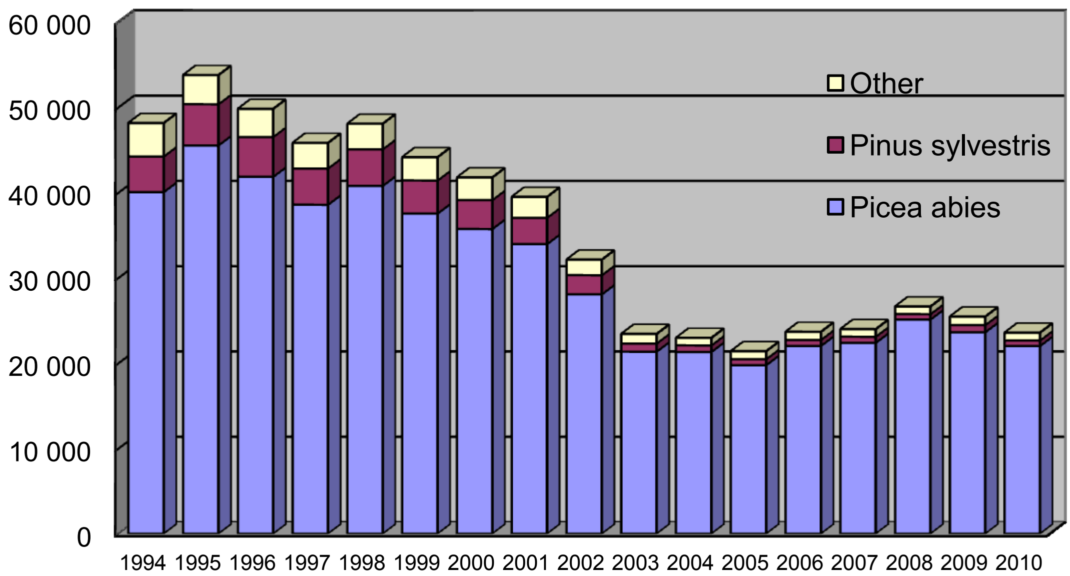

Figure 6. Number of seedlings delivered from Norwegian forest nurseries 1994-2010. Source: The Norwegian Forest Seed Center.

Image 15. Production of two-year old container seedlings in a Norwegian nursery. Photo: Ola Gram Dæhlen, Oppland Forestry Society.

The seeds used in the forest nurseries are delivered by the Norwegian Forest Seed Center. Table 8 presents the mean annual weights of seeds sold, by species, of domestic sources and imported and exported, as an average of the five-year period 2005-2009. The dominating species is Norway spruce, covering 81 % of the overall domestic seed sale, and 90 % of seed sold for the purpose of timber and pulpwood production.

Table 8. Seed sold domestically and transferred internationally annually for the period 2005-2009. Source: The Norwegian Forest Seed Center.

Species		Weight of seed Kg			Purpose (relates to columns domestic seed sale and import, not export)
Scientific name	Native (N) or exotic (E)	Domestic seed sale	International transfer		
			Import	Export	
Picea abies	N	290.8	0.5	4.4	Forestry; timber and pulpwood
Pinus sylvestris	N	15.6		1.6	Forestry; timber and pulpwood
Picea sitchensis	E	1.2	0.3	1.9	Forestry; timber and pulpwood
Picea lutzii 1)	E	0.01	1.1	1.7	Forestry; timber and pulpwood
Larix kaempferi	E	2.0	2.8		Forestry; timber and pulpwood
Larix sibirica	E	2.4	0.6	0.4	Forestry; timber and pulpwood
Abies lasiocarpa	E	24.7	14.2	11.2	Non-woods forest product, Christmas trees
Abies nordmanniana	E	10.9	9.6		Non-woods forest product, greenery
Other conifers	E	10.6	37.1	32.7	Forestry; timber and pulpwood
Broadleaves, except Q. petraea and Q. robur	N	4.1	0.5	0.5	Forestry and landscaping
Q. petraea and Q. robur	N			18 475	

1) *Picea lutzii* is the hybrid between *P. sitchensis* x *P. glauca,* from uncontrolled hybridization.

Forest reproductive materials are in Norway classified in the categories of the OECD Forest Seed and Plant Scheme: *source-identified*, *selected* and *qualified*. Recently, seeds have also been available of the *tested* category. Import of seeds of *Picea abies*, which was quite high 50 years ago, is now at a low level. Figure 7 shows the development in the sale of seeds from source identified and selected (stand seed) and seed orchards (qualified). The percentage of seeds from seed orchards has increased considerably during the last five years, in particular in the southern part of the country, where seed orchard seed sold during the last two years amounted to 75 % of the *Picea abies* seed sold, and with a percentage close to 100 in south-eastern Norway.

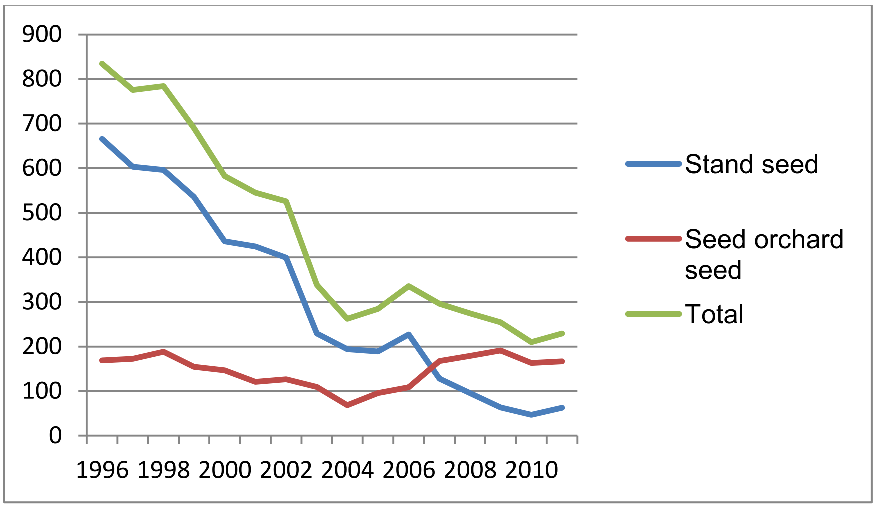

Figure 7. Sale of seed in kg of Picea abies 1996-2011distributed in classes of stand seed and seed orchard seed. Source: The Norwegian Forest Seed Center.

Regions of provenance and transfer rules

Formerly, most reproductive material of *Picea abies* was of the category source identified, collected in natural stands and characterized by its region of provenance (Figure 8). According to regulations mandated in the Forestry Act, transfers within the country should not be made more than 200 km north or south and less than 300 m in altitude. In addition to the national seed sources of Norway spruce, up to the 1980s transfers were made of provenances from Central Europe. During the last 20-year period, the far largest part of *Picea abies* seed used has been from sources of native origin. However, in western Norway, where *Picea abies* did not occur naturally, provenances from Central Europe are recommended due to their superior volume growth in the coastal areas.

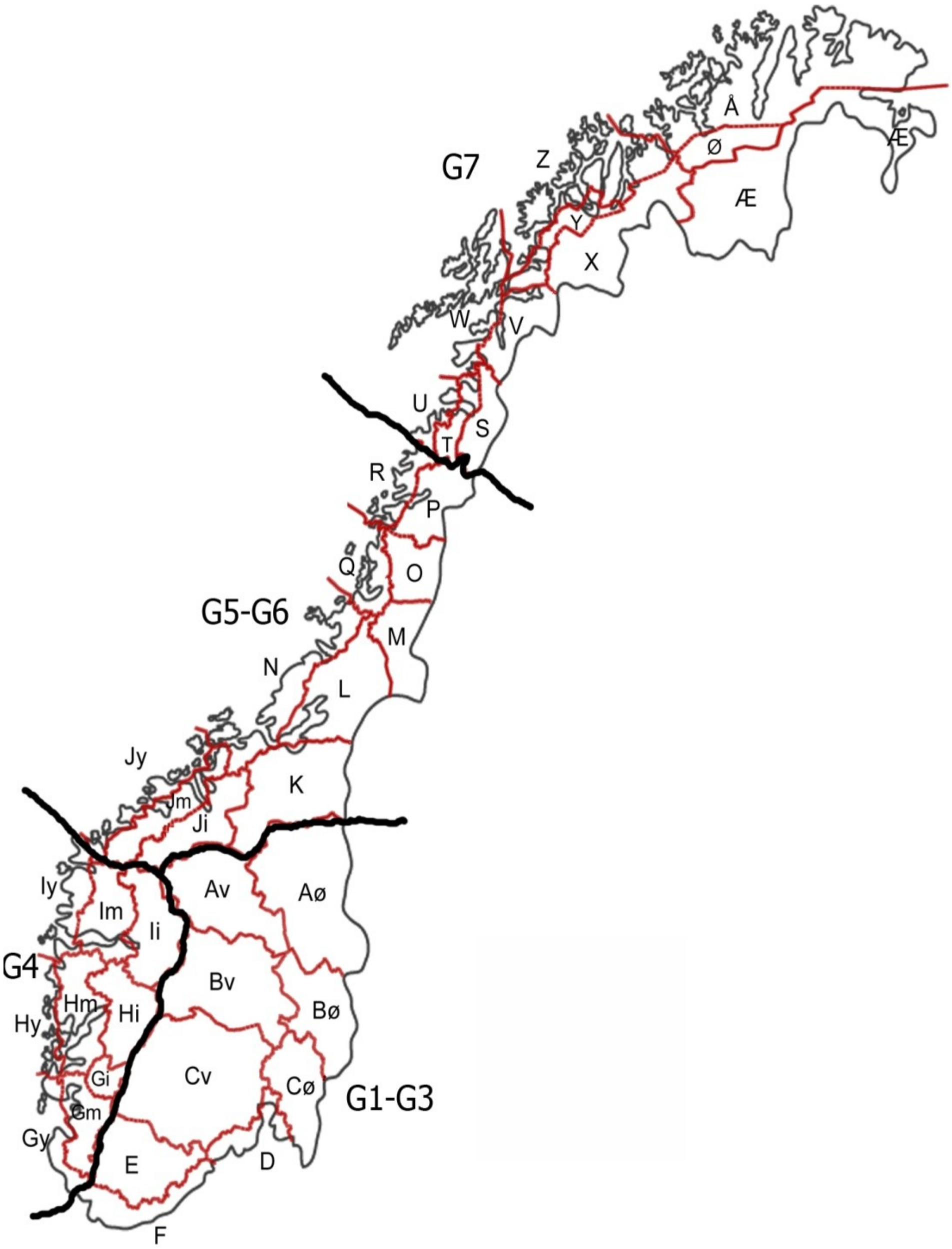

Figure 8. Regions of provenance in Norway (red borders) and breeding zones according to the revised breeding strategy from 2010. The regions of provenance are in addition characterised by the altitude in 100 m intervals. Source: The Norwegian Forest Seed Center.

Reproductive materials available

All reproductive materials are available at The Norwegian Forest Seed Center for both national and international requests, both for commercial use and for research (Table 9). If there is lack of seeds of specific seed lots, Norwegian buyers will have first priority.

Table 9. Types of reproductive material (seed lots) available.

Species (scientific name)	Type of reproductive material according to OECD Scheme[1)]	Available for both national and international requests	
		Commercial	Research
Picea abies	Source identified, qualified and tested	X	X
Pinus sylvestris	Source identified and qualified	X	X
Pinus contorta	Qualified	X	X
Picea sitchensis	Qualified	X	X
Abies lasiocarpa	Qualified	X	X
Betula pendula	Qualified	X	X

[1)] Categories according to the OECD Scheme;
Source identified: seeds from forest stands in known region of provenance
Qualified: seeds from untested seed orchards that may be under test.
Tested: seeds from tested seed orchards.

4.2 Tree improvement programmes and their implementation

Tree breeding activities in *Picea abies* started in Norway more than 60 years ago with the selection of plus trees in natural stands, and grafted seed orchards were established in the 1960s and 1970s. Breeding activities were also initiated with other species (*Pinus sylvestris, Picea sitchensis*), but with a lower intensity than for Norway spruce. The selected plus trees were kept as grafts in the seed orchards or clonal archives, and a progeny testing programme was slowly initiated. The earliest established seed orchards are now terminated or are re-established with parents that are being tested in progeny tests. The species involved in the breeding, their priority and the number of seed orchards are listed in Table 10. In addition to breeding for timber and pulpwood, Christmas tree production is an important objective. All Norwegian seed orchards are still of first generation breeding populations, but with an increasing number of the tested category. The orchards for *Pinus contorta* and *Betula pendula* are seedling seed orchards, the rest are grafted clonal orchards. In addition to the clonal seed orchards listed for *Picea abies* spruce, two seedling seed orchards intended for producing seeds for Central Norway and three seedlings seed orchards for Northern Norway were recently established. These are not included in Table 10 as they will not produce seeds until 30-40 years from now.

A revised tree breeding strategy

A new national tree breeding strategy for the period 2010-2040 has been developed during the last four years and submitted to a hearing process involving organisations in practical forestry, environmental management, forest authorities at national and local level, research organisations and universities. The strategy will be revised at ten year intervals, and five-year action plans will be made for each breeding zone.

Table 10. Forest improvement programmes in Norway. All seed orchards are first generation. Source: The Norwegian Forest Seed Center.

Species	Native (N) or Exotic (E)	Improvement programme objective	Priority	Seed orchards Number	Area (ha)
Picea abies	N	Timber and pulpwood, Christmas trees	High	15	146.8
Abies lasiocarpa	E	Non-woods forest product, Christmas trees	High	3	1
Alnus glutinosa	N	Timber and pulpwood	Medium	2	1
Pinus sylvestris	N	Timber and pulpwood	Low	2	5
Picea sitchensis	E	Timber and pulpwood	Low	2	10
Picea lutzii	E	Timber and pulpwood	Low	1	0.7
Picea engelmanni	E	Christmas tree	Low	1	2.2
Pinus contorta	E	Timber and pulpwood	Low	1	7
Larix sibirica	E	Timber and pulpwood	Low	1	0.5
Betula pendula	N	Timber and pulpwood, landscaping	Low	1	1

Main priority in breeding is given to *Picea abies* and *Abies lasiocarpa* (Table 10). The proposed breeding objectives for *Picea abies* are to improve climatic adaptation, growth and quality, without decreasing the genetic variation in future forests. Bred material should provide higher survival and be possible to use over a larger area then material from natural stands. The bred material should also be robust to future climatic changes. The increased growth should contribute to mitigate the effect of CO_2 from the atmosphere. Breeding should not decrease, and preferably increase, wood density, improve form stability and reduce the frequencies of defects that cause reduced value production. Except for one breeding zone, G0 for the mildest climatic conditions along the coast, breeding is performed on material from native provenances. A high level of genetic diversity is kept in the breeding programme of *Picea abies* by having several breeding zones, several subpopulations within each zone and a sufficient number of individuals within each population.

Image 16. A Picea abies seed orchard. Photo: Ragnar Johnskås, The Norwegian Forest Seed Center.

Breeding and deployment zones

Norway is divided into eight breeding zones (Table 11) based on latitude, altitude, and known climatic gradients, both for administrative reasons and optimal use of adapted reproductive materials from the seed orchards. Breeding efforts and objectives differ between zones depending on whether there are specific issues in the wood production that have to be focused, and also on the importance of forestry in the region. In each zone the breeding population is divided into one or more sub-populations each containing 50 unrelated individuals. Breeding zone G0 will contain one sub-population with individuals selected from more southern provenances adapted to climatic conditions corresponding to a 2º C increase in mean annual temperature in zones G1 and G4. The other zones will contain sub-populations with individuals from a limited geographic area within the zone. Hence, the populations should then be adapted to the present climate in the zone, but may also be ranked according to climatic gradients within the zone. They should provide the basic material for reproductive material from seed orchards that could be used in a wide area, but also be flexible for transfer if climate change. All individuals in the sub-populations should be tested in progeny tests planted at several sites. The importance of traits in selection will vary among zones, but will generally characterise annual growth rhythm, height growth and wood quality traits. The timing of flushing in spring is a key trait in regions where spring frosts frequently occur and early flushing will be avoided. The recommendations for the deployment of reproductive material should be revised as more fields test information become available.

It is important to note that breeding zones and deployment zones for seed orchards are different and that there can be several deployment zones within each breeding zone. The deployment zones are defined by the adaptive properties of the seedlings from each seed orchard which have to be tested. Their performance will to some extent be influenced by the seed orchard locality due to both pollen contamination from surrounding forests and by epigenetic effects caused by the climatic conditions at the seed orchard site.

Table 11. Breeding zones and regions of deployment for *Picea abies* in Norway. In each breeding zone there are one or more sub-populations each containing 50 unrelated individuals from a limited geographic area within the zone.

Breeding zone	**Region of deployment**	**Altitude**	**Number of sub-populations**
G0	Same as G1 and G4 with a 2º C increase in mean annual temperature	0 – 250 m	1
G1	Interior south-eastern Norway Lat. 58º - 62º N	0 – 350 m	5
G2	Interior south-eastern Norway Lat. 58º - 62º N	350 – 650 m	4
G3	Interior south-eastern Norway Lat. 58º - 62 ºN	650 – 950 m	4
G4	Western Norway Lat. 58º - 62 ºN	0 – 350 m	2
G5	Central and northern Norway Lat. 62º - 66º30‘N	0 – 250 m	3
G6	Central and northern Norway Lat. 62º - 66º30‘ N	250 – 550 m	3
G7	Northern Norway Lat. 66º30’ - 70ºN	0 – 250 m	1

Genetic improvement materials and trials

Table 12 presents field plantings containing materials that are part of the breeding programmes. The most extensive breeding material exists for *Picea abies* with more than 5000 plus trees grafted in clonal archives and seed orchards, and a large number of progeny trials of different ages. With this species and with *Pinus sylvestris* and *P. contorta* provenance trials were formerly done as part of the genetic research programme. For the other species with high priority, *Abies lasiocarpa*, the trials were established more recently.

Table 12. Tree improvement materials and trials that are part of the breeding populations. Source: The Norwegian Forest Seed Center.

Species		Plus trees	Clonal archives	Provenance trials		Progeny trials	
Scientific name	Native (N) or exotic (E)	Number	Number	Number of trials	Number of prov.	Number of trials	Number of families
Picea abies	N	5186	15			148	3832
Abies lasiocarpa	E		1		76	6	20
Alnus glutinosa	N	100		9	11	1	121
Pinus sylvestris	N	150	3				
Picea sitchensis	E	168				2	6
Picea lutzii	E	50				17	213
Picea engelmanni	E	76				1	15
Pinus contorta	E			1	11	1	99
Larix sibirica	E	22					
Betula pendula	N	200		5	15	1	225

Image 17. Short term progeny test with Picea abies on cultivated soil. Photo: Norwegian Forest and Landscape institute.

Benefits from breeding

Results from field trials suggest that seedlings of *Picea abies* from seeds produced in untested seed orchards will have 10-15 % better height growth when the stand closes, and similar or better quality, compared to seedlings from stand seed. The gain from seed orchards with material tested in progeny tests will increase with additional 10 %. This will contribute to an increase in the value of the forest, and it has been estimated that the planting of 40 million seedlings from seed orchard seed will result in an extra uptake of one million tons of CO_2.

Information system on tree breeding and choice of reproductive material

The use of high quality reproductive seeds and seedlings is highly recommended and measures are taken to ensure that the tree planters actually use the materials. All information about reproductive materials available is presented at the website of the Norwegian Forest Seed Center: www.skogfroverket.no. At this page advice is given on recommended materials for a planting site defined by region and community, latitude and altitude. It is planned that nurseries producing seedlings of the different seed lots for sale will be listed. Another web site, www.skogplanteforedling.no, presents information about the national tree breeding programme, its strategies, objectives and seed orchards. Research results important for the breeding and also for motivating the foresters to use the materials are presented in a popular form.

Challenges in the use of forest genetic resources

Ten years ago there was a substantial decrease in the number of seedlings planted in Norwegian forestry. The main reason for this was the removal of subsidies given to the forest owner for planting. The number of seedlings planted has remained at this low level during the last ten year period. The national strategy to increase CO_2 sequestration by greatly augmenting the number of genetically improved seedlings planted will require a considerable increase in resources invested into tree breeding and associated breeding research. In addition to governmental funding, a substantial increase in the contributions from forest organisations and forest industry will be required. It will be necessary to educate tree breeders and scientists in forest genetics. An increased cooperation among the Nordic tree breeding organisations will be beneficial for obtaining better adaptation to the changing climate in the future forest and for higher production.

5. The State of National Programmes, Research, Education, Training and Legislation

Norway does not have one single formalized national forestry programme, but several parallel processes and documents jointly constitute the national forest programme. The most important elements are the Forestry Act (2005), the white paper on climate challenges in the agricultural sector (2009), the white paper on forest policy (1999), the annual national budget, the forest policy instruments and the Living Forest Standard, which is a national standard for sustainable management in Norway. Since June 2010 the Living Forest Standard has been suspended, pending an unsolved disagreement in the Living Forest Council related to reforestation and afforestation involving the use of new and introduced tree species. Although formally suspended, the forestry sector continues to follow the rules and guidelines of the standard. Forest genetic resources, and their conservation and use, are explicitly mentioned in several of these policy documents, both in general terms and in recommendations related to the production and use of forest reproductive material and in the implementation of important measures to mitigate climate change. Genetic resources are also specifically treated in the Nature Diversity Act adopted by the Parliament in 2009. This act regulates the conservation, access and use of genetic resources from nature, and also the import and release of alien organisms in Norwegian nature. The Government has recently presented a white paper on agriculture and food in Norway in which it is proposed to produce an annual report on sustainable forestry from 2013. This report will possibly also include use of forest genetic resources.

5.1 National programme on forest genetic resources

The Norwegian programme on forest genetic resources was initiated in 2001 when a national FGR advisory committee was appointed by the Ministry of Agriculture and Food and with a secretariat hosted at the Norwegian Forest Research Institute (which later was merged into the Norwegian Forest and Landscape Institute).

The first advisory committee consisted of representatives from research institutions, the tree breeding organisation, the forest owners' organisation and national and regional authorities within forest and nature management. This secured a broad scope and anchoring of the national FGR-activities to user groups and stakeholders. A national programme for 2003-2006 was approved by the committee.

An evaluation of the national management of genetic resources for food and agriculture resulted in the establishment of the Norwegian Genetic Resource Centre in 2006 as a department of the Norwegian Forest and Landscape Institute. National programmes for animal, plant and forest genetic resources were merged in the centre.

The Norwegian Genetic Resource Centre

The Norwegian Genetic Resource Centre promotes the conservation and sustainable use of national genetic resources in farm animals, crop plants and forest trees. It is the national centre of expertise on genetic resources in agriculture, advisory to the Ministry of Agriculture and Food, and coordinates a wide range of activities.

The Centre is the secretariat for advisory committees within each of the three sectors for farm animals, crop plants and forest trees. Together with these bodies, the Centre conducts national programmes for conservation and sustainable use of genetic resources in agriculture and is responsible for the execution of the national programmes for animal, plant and forest genetic resources.

The Centre initiates and administrates activities within the three sectors, but depends on cooperation within gene conservation networks for practical implementation of the programmes. It contributes towards increasing the information flow on genetic resources and general public awareness. It is also the national participant in Nordic and international programmes.

The Genetic Resource Centre is financed under the budget of the Norwegian Forest and Landscape Institute by the Norwegian Ministry of Agriculture and Food, amounting to approximately 10.5 million NOK per year. Of this amount, 2 million NOK is provided to activities related to forest genetic resources.

The main responsibilities for the FGR advisory committee, to be followed up by the forest section at the centre are:

1. Carry out The Norwegian Action Plan for Conservation and Use of Forest Genetic Resources 2011-2014
2. Coordinate national activities and initiate new projects aimed at conservation and use of FGR
3. Develop further cooperation with institutions, organisations and individuals regarding FGR
4. Ensure dissemination of knowledge, promote capacity building and raise public awareness about FGR.

Priorities of the national FGR programme

The national programme for forest genetic resources runs in four-year cycles. In the first two periods from 2003 the following activities were given high priority:

- Organisation and establishment of a national network
- Documentation of knowledge about national FGR
- Establish databases of protected areas containing populations of forest trees species
- Monitoring the genetic resources of selected broadleaved tree species in the regular sample plots of the National Forest Inventory
- Initiate research on characterization of genetic variability of forest tree species
- *Ex situ* conservation in collections and in breeding populations
- *In situ* conservation in protected areas
- Public awareness activities
- Promoting new enterprises based on FGR
- Questions related to legal rights to FGR.

In the current action plan for the period 2011-2013 the planned actions are in four major areas:

- Generate knowledge and monitor processes influencing genetic resources
- *Ex situ* and *in situ* conservation activities
- Sustainable use and development of FGR
- Networking, coordination and dissemination of knowledge about FGR and raising public awareness.

Main activities are presented in Table 5.1.

Major challenges in the national programme

For most of the national tree species genetic characterisation is scarce and the generation of better genetic information should have high priority. This is in particular important in view of the changing climate conditions, both for the development of adapted reproductive material for the commercial species and for the management of forest tree genetic resources in general. Monitoring of the development of changes in genetic diversity to be able to actuate specific conservation activities when needed, is another challenge. This is in particular important for rarer forest trees species and for their conservation *in situ*, which requires sustainable management in nature reserves, or specific *ex situ* conservation actions.

A large number of actors collaborate in the national programme; in nature and forest management and administration, research, tree breeding and the users of the genetic resources. Agreements on common objectives and how to achieve these objectives are needed for the success of the programme.

5.2. Partners in the national FGR programme

The staff of the Norwegian Genetic Resources Centre comprises five persons, of which 0.5 of a man-year is dedicated to the forest sector. Implementation of the national program is therefore highly dependent on synergies and close cooperation with a broad range of partners. The partners can be grouped into two categories, those that have FGR activities as a main activity and cooperative partners on specific activities. The partners and their related tasks can be summarised in the Table 13. National coordination of activities is done by the Norwegian Genetic Resource Centre, at the Norwegian Forest and Landscape Institute.

The main actors with specific responsibilities in the conservation of FGR, in addition to the Norwegian Genetic Resource Centre, are the Directorate for Nature Management for maintaining natural populations and the Norwegian Forest Seed Center for the utilisation of FGR. The national seed bank is located at the latter institution and performs activities related to seed collections, seed cleaning and processing, seed sales to nurseries and forest owners, import and export, official statistics, seed certificates and tree improvement and seed orchard management.

The national programme supports every year projects carried out in partner institutions based on funding by the Ministry of Agriculture. The average annual programme budget for such projects has amounted to approximately 1.1 million NOK during the last four-year period.

Table 13. Activities and cooperating partners in the Norwegian FGR programme.

Cooperative tasks/activities	**Partner**
In-situ conservation of FGR in natural populations, management included	Directorate for Nature Management; Regional authorities within forest and environmental management
Ex-situ conservation in collections	Department of Plant and Environmental Sciences, Norwegian University of Life Sciences; botanical gardens; arboreta; museums; Nordic Genetic Resource Center , Norwegian Forest Seed Center , Svalbard Global Seed Vault
Ex-situ conservation in research and tree breeding	Norwegian Forest and Landscape Institute; Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences; Norwegian Forest Seed Center
Development of climatically adapted forest reproductive materials	Norwegian Forest and Landscape Institute; Norwegian Forest Seed Center; University of Life Sciences; Norwegian Institute of Agricultural and Environmental Research; arboreta and botanical gardens; forest nurseries and forest plant societies
Monitoring of rare and threatened species and populations	Norwegian Forest and Landscape Institute; universities; Norwegian Biodiversity Information Centre; Norwegian Institute for Nature Research
Documentation and databases	Norwegian Forest and Landscape Institute; Norwegian Forest Seed Center; owners of collections; forest owners
Research in forest genetics and FGR	Norwegian Research Council; Norwegian Forest and Landscape Institute; Norwegian Institute of Agricultural and Environmental Research; Norwegian Institute for Nature Research; universities
Teaching in forest genetics and FGR	Norwegian University of Life Sciences
Business enterprise based on FGR	Norwegian Forest Seed Center; other R & D institutions; forest nurseries; economical organisations in forestry and private enterprises
National legislation and legal questions related to FGR, import/export, including access and benefit sharing	Ministry of Agriculture and Food; Ministry of the Environment; Directorate for Nature Management; Committee for the Control of Forest Reproductive Materials; Norwegian Food Safety Authority; Fridtjof Nansen Institute
Information and public awareness	Cooperative R & D institutions and project partners

5.3. Research, education and training

The major part of the research on forest genetic resources is performed by the Section on forest genetics at the Norwegian Forest and Landscape Institute. Some research projects are also performed at the Norwegian Institute of Agricultural and Environmental Research and at the universities. The projects are finances either by the institution’s own budget or by research grants given by the Norwegian Research Council, the Nordic Council of Ministers and the European Union. At the Norwegian Forest and Landscape Institute the budget for forest genetics research amounts approximately NOK 7.5 million (2011), which is close to 10 % of the total budget for forest research at the institute.

Advanced education in topics related to agriculture and forestry at university level is the responsibility of the Norwegian University of Life Sciences. Their courses include basic genetics, population and quantitative genetics, molecular genetics and plant breeding. Forest genetics and tree breeding is included as part of the basic course in silviculture and in the general course at the master level. In the basic course students visit the Norwegian Forest Seed Center and a seed orchard. No national course is given in forest genetics or forest genetic resources at the doctorate level. However, PhD students in this field could follow courses given in plant breeding and conservation of plant genetic resources. At the Nordic level, a doctorate course in plant breeding, which includes forest tree breeding, is given regularly.

Forest tree breeding and the importance of choosing proper forest reproductive materials is regularly highlighted at regional and national meetings for nursery managers, the regional forest extension service and forest owners with contributors from the Norwegian Forest and Landscape Institute and the Norwegian Forest Seed Center.

In Norway, no specific university courses are offered in forest genetics or management of forest genetic resources. Therefore foresters and managers of natural resources often do not understand the values of the conservation and sustainable use of forest genetic resources. Such courses are therefore needed.

5.4. National legislation

Significant legislation regulating conservation and use of forest genetic resources in Norway is the Forestry Act and the Nature Diversity Act. A regulation mandated in the Forestry Act (Regulation on forest seeds and plants) assures that reproductive material of high quality and adapted to planting site is being used in regeneration and that a high level of genetic diversity is maintained in the forest. A phytosanitary regulation aims to prevent introduction of pests and diseases and assures a healthy reproductive material. International trade of forest reproductive material is regulated by the OECD Forest Seed and Plant Scheme.

The Nature Diversity Act of 2009 contains provisions on forest conservation and on prioritized species and selected habitats in forests that are important for specific groups of species. Voluntary protection is now the main strategy for forest conservation. A regulation under this act will regulate the import and planting of alien plant species, in particular non-native forest trees. The Nature Diversity Act also regulates access, property rights and exchange of genetic resources, as further discussed in Chapter 7.

Norway is a member of the UPOV convention of 1978 and the European Patent Organisation (EPO). At present there are no known cases of plant variety protection being applied for in the forestry sector, nor are there any patents so far. It is foreseen that such protection can be relevant at least in four cases: Christmas tree production, breeding new trees for biofuel production, plantations of tree varieties to capture and store carbon and breeding tree varieties for making them more tolerant to climate change conditions.

A major challenge as regards legislation is to ensure that knowledge generated from research is taken into account when laws and regulations are decided, and that both such knowledge and practical experience are used in the management of genetic resources. It is increasingly important to maintain a legal system that facilitates exchange of forest reproductive material between countries, not least taking climate adaptation and mitigation into consideration.

5.5 Public awareness

The national FGR programme has, since its establishment in 2001, emphasised dissemination of data about forest genetic resources and information about the importance of their conservation and sustainable use. Several methods and information channels in use:

- Website of the Norwegian Genetic Resource Centre; www.genressurser.no or www.skogoglandskap.no/genressurser which disseminates information about activities in the national FGR programme including project information and a news service
- Website of the Norwegian Forest Seed Center, www.skogfroverket.no, which contains information about available forest reproductive materials and recommendations for use, in addition to statistical information
- Website related to forest tree breeding, www.skogplanteforedling.no, maintained by the Norwegian Forest Seed Center, providing knowledge and information about forest tree breeding in Norway
- Conferences, seminars, lectures and meetings targeted at specific stakeholders and user groups
- Interviews and participation in radio programmes, articles in professional magazines, technical and scientific journals and general media
- Production and distribution of posters, brochures and other printed material for the public.

The public awareness of the values related to forest genetic resources has increased significantly in Norway during the last five year period. However, it will be continuously necessary to educate managers of forests and natural resources about the importance of forest genetic resources, and in particular how to choose adapted reproductive materials under the changing climate conditions. A major challenge is to promote awareness that long term considerations are necessary for the management of forest genetic resources. It is also a challenge to make the results from forest genetic research and their implications known to the general public.

6. The State of Regional and International Agreements and Collaboration

According to governmental policy Norway has supported regional and international agreements and cooperative programs on forest genetic resources and has played an active role in multilateral bodies and different actions. Regionally, cooperation has been at the Nordic and Baltic level, and internationally both at the European and global level.

6.1 Nordic cooperation

Nordic collaboration on research, conservation and use of forest genetic resources is an important component of the cooperation organized and financed by the Nordic Council of Ministers and its research body the Nordic Forest Research Co-operation Committee (SNS). From the start in 1972, Norwegian scientists have initiated and been partners in research and breeding projects in forest genetics and tree breeding.

The Nordic Council for Forest Reproductive Material, established in 1970, organised cooperative activities to increase the availability of suitable forest reproductive material and to promote successful forest regeneration in the Nordic countries. In 2008, this body was merged with the Nordic Gene Bank for agricultural plants and the Nordic Gene Bank Farm Animals to form the Nordic Genetic Resource Center (NordGen) with the aim to strengthen and coordinate genetic resource activities in the agricultural sector in the Nordic countries.

The forest sector of NordGen, NordGen Forest, is located at the Norwegian Forest and Landscape Institute and receives additional economic support from Norway. It serves as a Nordic forum in the fields of forest genetics and genetic resources, supply of seeds and plants, and methods for regeneration. The main goal is to contribute to the establishment of the best possible Nordic forests for the future by organising thematic days, conferences, seminars and meetings. NordGen Forest monitors and initiates research and development, and disseminates information. The NordGen Forest network contains two external bodies, the Council and the Working Group on Genetic Resources, each with members from all Nordic countries. Information and news related to the forestry activities are presented on the web page of NordGen (www.nordgen.org) and in publications.

The Council seeks to increase the availability of suitable forest reproductive material and to promote successful forest regeneration in the Nordic countries. This includes both practical and administrative parts of seed and plant supply, regeneration methods, genetics and tree breeding. Its members exchange information on regeneration issues, discuss different topics of interest to Nordic forestry, and plan coming events.

The Working Group on Genetic Resources ensures co-operation in conservation and use of genetic resources of forest trees among the Nordic countries. It forms an interface between conservation activities at the national and the European levels (EUFORGEN), and initiates and implements activities that can improve or guide the conservation and use of forest genetic resources.

NordGen Forest carries out projects in the field of forest genetic resources. Titles of projects funded by the Nordic Council of Ministers are: *Seeking Appropriate Legislation Regulating Access and Exclusive Rights to Forest Genetic Resources in the Nordic Region* and *Cooperation in breeding of Picea abies*. An upcoming project is to establish long term storage of seeds of forest tree species at Svalbard Global Seed Vault.

6.2 European Networks

Norway has been a member of the European Forest Genetic Resources Programme (EUFORGEN) since its start in 1994. The programme aims at promoting conservation and sustainable use of forest genetic resources as well as serving as a platform for pan-European collaboration in this area, bringing together scientists, managers, policy-makers and other stakeholders.

EUFORGEN was originally structured in networks for species or groups of species, later thematic networks were added. In the last phase the mode of operation is based on expert working groups and workshops to carry our specific tasks related to FGR in Europe. Norway has actively participated in most of these activities. The country has also contributed data on 24 dynamic gene conservation units of forest trees in Norway to the European Information System on Forest Genetic Resources in Europe (EUFGIS), developed in close cooperation with EUFORGEN.

EUFORGEN was established as an implementing mechanism for the resolution on conservation of forest genetic resources of the first Ministerial Conference on the Protection of Forests in Europe (MCPFE). Norway has continued to play an active role in MCPFE, later named FOREST EUROPE, through which the European ministers of forestry have committed themselves to conserve and enhance forest genetic resources as part of sustainable forest management. In the period 2008-2011, Norway held the chairmanship and secretariat (Liaison Unit) of FOREST EUROPE, and is from 2011 a bureau member of the Intergovernmental Negotiating Committee for a Legally Binding Agreement on Forests in Europe.

Norway has participated in the EU funded Co-ordination Action Treebreedex with participants from 18 countries and has co-ordinated the activity: *Geographic structure of genetic diversity*. The main aim of the project was to develop a scientific and technical research framework in forest genetics and tree breeding and a virtual tree breeding centre at the European level.

6.3 International programmes and agreements

Norway has signed international agreements and takes part in international processes relevant to the sustainable use, development and conservation of forests. The United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) are of particular importance relative to forest genetic resources. The country has been an active force in the negotiations in United Nations Forum on Forests (UNFF) leading to a voluntary agreement at the global level for sustainable management of forests, and for reducing deforestation of the tropical forests.

Norway participates actively in the Commission of Genetic Resources for Food and Agriculture in FAO. The country has been a member of the Intergovernmental Technical Working Group of Forest Genetic Resources and chaired the first session of this body.

Norway takes an active part in research activities on forest genetic resources initiated by the International Union of Forest Research Organisations (IUFRO), and Norwegian scientists have established and maintained tests as part of the international provenance trials with Norway spruce and Western American conifers. In IUFRO, Norway recently chaired the Working Party *Norway spruce genetic resources* for two periods.

6.4 Benefits from and needs in regional and international cooperation

Being a small country with a limited number of actors involved in activities related to the conservation of forest genetic resources, Norway has benefited from both regional and international cooperation. At the Nordic level, both forest genetic research and development projects have dealt with species sharing more or less the same gene pool, and breeding is based on similar strategies, in particular for Norway spruce. Establishing field trials with the same materials in several countries and common analyses of data from such experiments, have strengthened the generality of the results obtained. Some joint Nordic research projects have further developed into common projects at the European level that have generated new knowledge. Information exchange, development of technical guidelines and establishment of gene conservation strategies are activities that have been beneficial in the EUFORGEN collaboration.

Further cooperation both at the regional and European level is needed in the management of forest genetic resources under climate change. It is then important to maintain the networks that have been established in common research and development projects.

7. Access to Forest Genetic Resources and Sharing of Benefits Arising out of their Use

In 2003, the Nordic Council of Ministers adopted a Nordic Ministerial Declaration on access and right to genetic resources, in which they declared that the legal status of their forest tree genetic resources should be evaluated, but did not identify any reasons to recommend regulations of access.

According to the Convention on Biological Diversity (CBD), each country has a sovereign right over its genetic resources, including the competence to regulate ownership and access to its genetic resources. Norway has introduced a specific legal regulation of rights to genetic resources in general in the Nature Diversity Act of 2009, in which § 57 says: “Genetic material obtained from the natural environment is a common resource belonging to Norwegian society as a whole and managed by the state. It shall be utilised to the greatest possible benefit of the environment and human beings in both a national and an international context, also attaching importance to appropriate measures for sharing the benefits arising out of the utilisation of genetic material and in such a way as to safeguard the interests of indigenous peoples and local communities.” The Act requires issue of a permit prior to collecting material from nature for the purpose of utilizing its genetic resources.

Even though this Act also includes forest genetic resources, its provisions give an exception for forest genetic resources and states that “Collection for use in public collections and for use and further breeding or cultivation in agriculture or forestry does not require a permit.” Therefore access to propagative material of forest trees may be collected as before for the purpose of forestry as long as the property rights of the land-owner is respected.

The Public Right of Access *allemannsretten* ensures by law everyone access to public and private non-cultivated land and also to forests. This right hold a strong position, closely related to recreation activities. It provides access to non-cultivated forested land and to some extent to the forest genetic resources. Forthcoming administrative regulations of the Nature Diversity Act will further determine regulations which may clarify how far the common rights to the genetic material extends. This may have implications for the ownership of collected cones, seeds and breeding material.

Practical cone collection of conifers is organised by local forestry extension officers after logging in the forest, after an agreement with the forest owner and in most cases without economic settlements. Breeding materials such as scions for the grafting of plus trees are collected after permit given by the forest owner. Such permits do not involve economical compensation to the forest owners. Seeds from the breeding programme are sold without any restrictions for further use. Tree breeding is partly funded by the income from seed lots sold to the nurseries and partly subsidised by the Government, and is generally a non-profit business. Thus, it is the forest owner who obtains the benefits arising from the use of the forest genetic resources when harvesting the forest 60-100 years after its establishment.

The principle of fair and equitable sharing of the benefits from the use of genetic resources is established in the Convention on Biological diversity adopted in 1992, and further elaborated in the Nagoya protocol that was adopted in 2010. A paragraph in the Nature Diversity Act of 2009 requires that this principle shall be complied with when imported genetic material is used in Norway. However, except for the purpose of Christmas tree production, international trade with forest reproductive material has been low in Norway for the last 10 year period and in particular for the last two years.

It is the policy of the Government that native forest genetic resources should be preferred for use both in forestry and in landscaping, and that the use of exotic trees species should be restricted in forestry. A proposal to require a permit before establishing stands based on forest reproductive material not originating from Norway, Sweden or Finland is under consideration. This restriction towards transfers of forest reproductive material is based on environmental considerations. It may prevent an optimal choice of reproductive material under the changing climate conditions.

Both forest seed companies and tree breeders desire to continue the policy of non-restricted access to forest genetic material for seed production and tree breeding. It is believed that non-restricted access produces benefits which gains in the whole forestry chain and contributes to keep seed and plant cost at low levels. It is recommended that flexible exchange of forest genetic resources among the Nordic countries should continue. So far, no legal regulations have restricted such exchange and will most likely not do so in the next ten year period unless new biotechnological methods appear which might introduce the use of exclusive property rights also on forest genetic resources. An assessment is planned to find out if it is necessary to take legal steps to assure that improved forest reproductive material developed in the national tree improvement programmes will remain in the public domain, also in the future.

8. Contribution of Forest Genetic Resources to Food Security, Poverty Alleviation and Sustainable Development

Nationally

No forest tree species are important for food security in Norway. However, the income from harvesting the forest contributes to the total revenue for many active farmers. The forest resources are thus important for maintaining a sustainable level of agriculture and food production across the country. It is an expressed political aim to strengthen the contribution from the forests to the economic value creation in agriculture and to reach important goals related to energy, climate and environmental values. The forests are important for recreational activities and thus for public health. The Ministry of Agriculture and Food has decided that a report on sustainable forestry should be published annually from 2013, presenting information and new knowledge related to forest resources, their use and development and contribution to the climate, in addition to environmental values. A monitoring will thus be made of the development of the whole forestry sector, forest genetic resources included.

Globally

Promoting sustainable development and poverty reduction is an overriding objective of Norwegian foreign and development policy. One major element of this policy is the Government of Norway's International Climate and Forest Initiative, in which Norway is prepared to allocate up to NOK three billion per year to efforts to reduce greenhouse gas emissions from deforestation in developing countries. The initiative applies to all types of tropical forests. One of the main goals of this initiative is to promote the conservation of natural forests to maintain their carbon storage capacity. This initiative will thus contribute to the maintenance of species and genetic diversity, ecosystem services and livelihoods of forest dependent indigenous peoples and local communities. It contributes to the UN Millennium Development Goal 7 on ensuring environmental sustainability and the target aiming to reverse the loss of forests.

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