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First National Report on Forest Genetic Resources for Food and Agriculture

The Netherlands

Country report for the FAO First State of the World's Forest Genetic Resources for Food and Agriculture

Ministry of Economic Affairs
The Hague, November 2012

CGN Report 23

Centre for Genetic Resources, the Netherlands (CGN)

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CGN, Centre for Genetic Resources, the Netherlands

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Foreword

This national report is the Netherlands' contribution to the first FAO assessment of the State of the World's Forest Genetic Resources for Food and Agriculture. The report has been compiled by a working group coordinated by the Centre for Genetic Resources, the Netherlands (CGN) and guided by a stakeholder group. The report provides a comprehensive overview of the management of trees and shrubs in the Netherlands, including of autochthonous populations (indigenous vegetation). In addition, information on forest management in overseas territories of the Netherlands is provided in Annex I.

On the one hand, the report shows that the importance of the Netherlands as a vital source of autochthonous trees and shrubs should obviously be put into perspective. Forests only occupy 10% of the small land area of the Netherlands (34,000 km^2), and compared to other European countries, this forest area is also highly fragmented: about 85% of all forest areas in the Netherlands are smaller than 5 hectares. Moreover, only 5% of all native and non-native trees and shrubs are recognized as autochthonous populations and no endemic species are known.
On the other hand, since the second half of the 20th century, forest management in the Netherlands has changed from a system mainly based on wood production to a multifunctional system in which biodiversity conservation and recreational functions have become increasingly important. Furthermore, in line with the strategy of EUFGIS, 10 *in situ* gene conservation units for 11 species have been established since 2011. Moreover, a living *ex situ* gene bank for trees and shrubs was established in 2006 and the number of accessions (i.e. samples) of trees and shrubs in this gene bank has been extended to about 3,735, belonging to 48 different species.

Today, the challenge will be to increase awareness and appreciation of the various ecosystem services and other values of forests, including in the Netherlands. In particular, this should also include awareness of values of autochthonous woody species, which are carefully safeguarded in the Netherlands by means of a living gene bank.
I hope that the present report, although intended first and foremost to be a contribution to the FAO assessment, will simultaneously raise domestic awareness in the Netherlands.

I would like to thank the members of the stakeholder group for their valuable input in the report and the Centre for Genetic Resources, the Netherlands for carrying out the survey and drafting the final report.

Annemie Burger
Director-General Nature and Regional Policy

Executive summary

In April 2010, the FAO invited the Dutch Government to prepare a first national report on forest genetic resources in connection with the preparation of the first Report on the State of the World's Forest Genetic Resources. The Dutch national report is designed to contribute to a regional and global synthesis of the state of forest genetic resources and in particular to examine trends over the past ten years. Therefore, this national report is also considered as a significant and strategic report for the Netherlands itself. After a general introduction to the Dutch forest sector and the historical background of today's forests, it describes the current state of forest genetic diversity in the Netherlands and the main factors influencing it. Chapters 2 and 3 describe the current situation of *in situ* and *ex situ* conservation of Dutch forest genetic resources, emphasizing the limited opportunities for *in situ* conservation and the need to establish an *ex situ* collection for the long term. Chapter 4 focuses on use and sustainable management and includes a description of the national tree improvement programmes of the past decades and trends in the use of and demand for forest reproductive material. Chapters 5, 6 and 7 address aspects such as national programmes for forest genetic resources, education and research, national legislation, public awareness, international cooperation, access to forest genetic resources and benefit-sharing arising from their use. The last chapter describes the contribution made by forest genetic resources to food security, poverty alleviation and sustainable development. Finally, some limited information is given in Annex I on the forest genetic resources of the Caribbean islands of Bonaire, St. Eustatius and Saba, which officially became municipalities of the Netherlands on 10 October 2010. The report is prepared by a working group representing the main stakeholders in the sector and is written in accordance with the guidelines provided by FAO.

Introduction

Nowadays forest occupies approximately 10.6% of the total land area of the Netherlands (34,000 km^2). Dutch forests are characterized by a long history of human intervention and excessive exploitation. By about 1800 the area of woodland had been drastically reduced and a stage was reached where only 4% of the Dutch landscape was covered by forests. Since then, our forests have increased steadily to the current level of approximately 360,000 ha. This was mainly achieved through planting Scots pine which was particularly suited to poor sandy soils. As a consequence of the consecutive periods of cultivation and reforestation, ancient woods are extremely rare in the Netherlands. In the second half of the 20th century the economic importance of forests declined, and since then forest management has changed from a system mainly based on wood production to a multifunctional system in which nature conservation and recreational functions are highly important. In line with this, management focuses on increasing the amount of dead wood, enhancing structural diversity and promoting native broadleaved trees species in the forests. The relatively limited harvest volumes imply that self-sufficiency for timber is less than 10%. Compared to other European countries the forest area of the Netherlands is small and highly fragmented. About 85% of all forest areas are smaller than 5 hectares. There have been no significant changes in the demand for forest products and services over the past 10 years. The main products from forests are still timber and fuelwood. Important services of forests are their water regulating function, recreation and cultural values.

The state of forest genetic resources

The ratification of the Convention on Biological Diversity in the early 1990s, the obligations under the Ministerial Conferences on the protection of forests in Europe, and Dutch membership of the European Forest Genetic Resources Programme have all helped raise awareness among the public and decision-makers of the importance of forest genetic resources. Another important development was the adoption of a new national genetic resources strategy, developed in the government policy document 'Sources of Existence: Conservation and the Sustainable Use of Genetic Resources' (2002). All this has resulted in concrete actions, ranging from surveys to *ex situ* gene conservation initiatives, carried out by different stakeholders.

There are only 12 main tree species in the Netherlands, which constitute almost all tree species in Dutch forests. Of these, Scots pine is still the most common and economically most important one. However, the proportion of native deciduous species, mainly native oak, has increased over the past decades at the expense of exotic conifers. The Netherlands is home to about 101 native woody species. Over the past 20 years knowledge of the distribution and rarity of these native trees and shrubs has increased. Today, an estimated 95% of all native and non-native trees and shrubs originate from other countries. This implies that only 5% are recognized as original vegetation, also called autochthonous populations. With regard to these autochthonous populations, many of these woody species are rare or threatened in all or part of their range. The main threats to their genetic diversity are forest ecosystem diversity reduction and degradation, management intensification and habitat fragmentation. Only eight native woody species are on the Dutch Red List, of which one of them, *Juniperus communis,* is protected legally.

The relative importance of most of the main utilized forest tree species has not significantly changed over the past ten years. The increasing demand for wood in general and energy production from wood may have increased the use of forest tree species as biofuel.

The state of *in situ* conservation

Ancient woodlands still contain original vegetation that has become rare elsewhere. Unfortunately, these *in situ* locations are often under heavy pressure. Consequently, the opportunities for *in situ* genetic resource conservation are limited. Efforts in the Netherlands rely mainly on the establishment of gene conservation units in line with the EUFGIS strategy. Since 2011, ten gene conservation units for 11 species have been established. The other strategy for *in situ* conservation, sustainable management of forests with respect to their genetic resources, is hardly practised. The Netherlands has established an extensive network of protected areas throughout the country. On the one hand, these protected areas offer appropriate genetic conservation for some woody species, since the strategy for these protected areas is to conserve the entire ecosystem. On the other hand, conserving the entire ecosystem is also the major bottleneck for conserving forest genetic resources in these areas. In particular, rare, competitively weak or light-demanding tree species need specific management methods to avoid too much shading or competition with neighbouring associate tree species. As these specific management interventions are often not permitted in protected areas, this also limits the opportunities for genetic conservation of these species in these areas.

There remains a need for better dissemination of knowledge regarding *in situ* conservation of forest genetic resources. The interest in conservation and use of genetic resources that are characteristic of Dutch nature and landscape and past land use, such as hedgerow landscapes and old oak coppice stools, has increased. At the same time, there are still knowledge gaps in respect of the occurrence of rare tree and shrub species and how to conserve and manage their genetic resources.

The state of *ex situ* conservation

The most important action over the last ten years was the establishment of a living gene bank for trees and shrubs in 2006. Since its establishment, the number of accessions (i.e. samples) of trees and shrubs in this gene bank has been extended to about 3,735, belonging to 48 different species. Responsibility for *ex situ* conservation of Dutch autochthonous trees and shrubs is shared between the State Forest Service (Staatsbosbeheer, SBB) and the Centre for Genetic Resources, the Netherlands (CGN). The corresponding activities by SBB and CGN are financed by the Dutch Ministry of Economic Affairs, Agriculture and Innovation. Knowledge of the collected accessions in relation to their value to users is still limited, and collecting more information about their use will therefore have priority in future over additional *ex situ* conservation actions. Additionally, botanical gardens, arboretums, and NGOs manage several field collections of forest genetic resources of a wide range of native and non-native tree species.

The state of use and sustainable management of forest genetic resources

Utilization is seen as an effective method to sustainably conserve forest genetic resources. For more than 50 years tree improvement programmes have been carried out utilizing both autochthonous and foreign germplasm. In the past, the emphasis was on breeding conifer species. However, most of these improvement programmes were discontinued in the 1990s, and nowadays efforts are focusing on provenance testing in broadleaved species, including noble hardwoods.

In the past ten years demand for autochthonous Forest Reproductive Material (FRM) has increased. Conserved autochthonous forest genetic resources, including the material in the living gene bank and basic material featured in the National Catalogue ('Source identified' category) are important sources for harvesting reproductive material. In general, the use of FRM has decreased over the past decades. Important trends such as the shift in species choice in the forest and the preference for small-scale forms of forest management with natural regeneration have influenced this.

The Netherlands is mainly a transit country for FRM, both for seeds and seedlings, and exhibits high self-sufficiency in reproductive material for most species, except for some noble hardwoods.

The state of national programmes, research, education, training and legislation

The trend in support for forest genetic resources has increased over the past ten years, and this is reinforced by the implementation of the policy document 'Sources of Existence'. Efforts to raise public awareness will continue. There is a need to establish a permanent National Gene Conservation Stakeholders group to coordinate and guide forest genetic resource conservation activities in the long term at the national level.

The state of regional and international collaboration

The Netherlands participates in various European and international networks. The Netherlands is responsible for conserving its own forest genetic resources. However, European collaboration is of utmost importance for strengthening its national conservation activities.

Access to forest genetic resources and sharing of benefits arising from their use

So far the Netherlands has not introduced legislation regulating access to genetic resources and benefit-sharing.
The Dutch policy is that in principle access to genetic resources found *in situ* within the Netherlands is free.
The Netherlands has been exchanging forest genetic resources with other countries within Europe and outside for many decades.

The contribution of forest genetic resources to food security, poverty alleviation and sustainable development

Forests and their forest genetic resources provide numerous ecosystem services, including habitats for plants and animals, wood production, soil and water catchment protection, provision of reliable high-quality water supplies, options for recreational opportunities, and provision of carbon sinks. Major concerns for the future are climate change, biodiversity loss and depletion of natural resources. Protection and sustainable use of forest genetic resources is the best possible solution for mitigating these major threats in the long run. The use of a large variety of species with a high genetic diversity can be considered as the backbone policy for the maintenance of the Dutch forest area.

Introduction: The Netherlands and the forest sector

Geography and demography

The Netherlands is situated in Western Europe, in the delta of the Rhine and Meuse rivers. It borders Belgium to the south, Germany to the east, and the North Sea to the west and north. It has a temperate climate as a result of the influence of the Gulf Stream, with even rainfall throughout the year (approx. 800 mm per year). The total area of the Netherlands is 41,526 km^2. About 18% of this area is water. The main land use types are agriculture and human habitation and infrastructure, which occupy about 60% and 30% of the total land area (34,000 km^2) respectively. Forest occupies 360,000 ha, which is equivalent to 10.6% of the total land area of the country. The total population is 16.7 million (2012). With 491 people per km^2 of land, the Netherlands is a densely populated country.

Historical background

From about 13,000 BC, after the Weichselian glaciation, plants and trees started to migrate northwards from southern Europe, where they had been able to survive the glacial period. Archaeological research has indicated that climatic warming from 10,000 BC onwards resulted in colonization of the Netherlands by various woody species. Scots pine (*Pinus sylvestris*), birch (*Betula pendula*, *B. pubescens*), juniper (*Juniperus communis*) and sea buckthorn (*Hippophae rhamnoides*) were among the first to arrive, soon followed by hazel (*Corylus avellana*), poplar (*Populus tremula*) and oak (*Quercus robur*, *Q. petraea*). Species that arrived later were elm (*Ulmus minor*, *U. glabra*, *U. laevis*), black alder (*Alnus glutinosa*), lime (*Tilia platyphyllos*, *T. cordata*) and ash (*Fraxinus excelsior*). Yew (*Taxus baccata*), beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*) entered the Netherlands in a later period (3000, 2000 and 1000 BC respectively)[1].

There are strong indications that in the period 7000-4000 BC (Atlantic) the Netherlands was covered by extensive deciduous forest dominated by species such as oak, elm, lime tree and alder. On poor sandy soils the forests predominantly consisted of oak and birch. Riverine forests consisted of various species including poplar, willow, alder, elm, ash and maple. The Scots pine, which used to be abundant in colder periods, occurred mainly at the edges of oligotrophic peat areas in later periods[2]. The relatively low species diversity in northern European forests is generally explained by the east-west orientation of all the large mountain ranges in Europe (Alps, Pyrenees and Carpathian Mountains), which form important barriers for south-north migration.

Around 5300 BC the first agricultural settlements were established in the southern loam soils, where forest was being cleared locally to be replaced by crop land and pastures. Timber was extracted from forests for firewood and to construct houses and boats. Timber extraction and cattle roaming resulted in an open forest area, especially on nutrient-poor, sandy soils. These areas became dominated by extensive heather fields and human settlement began to concentrate here. In Roman times the deforestation process continued to enable the establishment of large farms and the production of charcoal, which was widely used in the iron industry. After the Romans withdrew in the fifth century AD, the forest once again proliferated into agricultural areas[3].

However, in the Middle Ages the population density gradually increased again throughout the country, leading to increasing clearance of forest lands. Deforestation rates peaked in the 11th and 12th centuries. The rapid deforestation resulted in a general awareness of the importance to protect the country's wood resources. For that reason community forests were established, with strict regulations for their exploitation. Additionally, private forest estates

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1 Maes, B. (2007). *Inheemse bomen en struiken in Nederland en Vlaanderen: herkenning, verspreiding, geschiedenis en gebruik*, Uitgeverij Boom, Amsterdam.

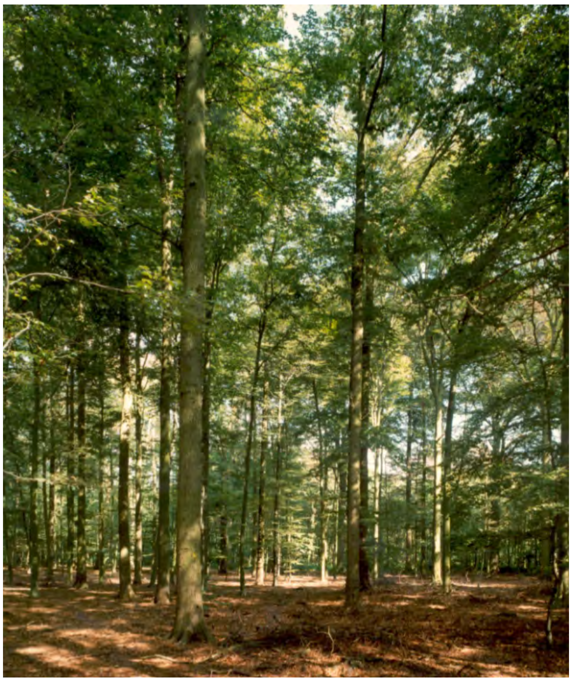
2 Lammerts van Bueren, E. M., E. P. L. Hessels, *et al.* (1988). *Holland Holtland. Voeten in de Aarde*. M. de Boo and R. Coops, Uitgeverij Terra, Zutphen.

3 Maes, B. (2007). *Inheemse bomen en struiken in Nederland en Vlaanderen- herkenning, verspreiding, geschiedenis en gebruik*, Uitgeverij Boom, Amsterdam.

or '*heerlijcke bossen*' were established by land owners, providing wood resources and hunting grounds. Despite these measures, forest management was not sustainable and many of the remaining forests disappeared[4].

By the 16th century the majority of the Netherlands had been deforested and the country had become a large importer of wood, mainly for the shipping industry[5]. The first reforestation event took place in 1514 to satisfy the large demand for wood. More plantings followed in subsequent centuries, but it was only in the late 18th century that afforestation took place on a larger scale. By that time, overgrazing of heather fields had resulted in large drift sands that had become a serious threat to surrounding villages. Forests were planted to restrict drift sands and large areas of unused land had to be brought into cultivation to meet the increased demands for agricultural products. In the second half of the 19th century substantial areas of agricultural land were cultivated for coppice production, which was used for firewood, charcoal and the tanning industry. Cultivation of abandoned land, which had highly impoverished soils, was led by the Heidemaatschappij (established in 1888) and the State Forest Service (Staatsbosbeheer (SBB), established in 1899). Within half a century tens of thousands of hectares of forest were planted. These forests mostly consisted of Scots pine, which was able to grow on the poor sandy soils. Large quantities of the produced pine wood were used by the mining industry. Non-native tree species such as Douglas fir (*Pseudotsuga menziesii*), black pine (*Pinus nigra var. corsicana*) and red oak (*Quercus rubra*) were also planted for commercial timber production. In general, these forests were planted with regular spacing and one or two species in even-aged stands. Wood production was their main purpose. Finally, in the second half of the 20th century the economic importance of forests declined rapidly, whereas their role for recreation and nature conservation increased[6]. Since the 1970s forest management has focused increasingly on the establishment of multiple purpose forests (e.g. nature, recreation and wood production). The aim of this management is to transform the even-aged monoculture forests into forests with higher species richness and structural diversity, allowing for natural processes such as regeneration and mortality.

Douglas fir seed stand.



Oak seed stand.

4 Lammerts van Bueren, E. M., E. P. L. Hessels, *et al.* (1988). *Holland Holtland. Voeten in de Aarde*. M. de Boo and R. Coops, Uitgeverij Terra, Zutphen.

5 Buis, J. (1993). Holland Houtland - *Een geschiedenis van het Nederlandse bos*, Prometheus, Amsterdam.

6 den Ouden, J., B. Muys, *et al.* (2010). *Bosecologie en bosbeheer*, Uitgeverij Acco, Leuven.

This functional change took place in parallel with the increasing efficiency in agricultural production. From the 1950s onwards, large-scale land consolidation took place, often at the cost of small-scale landscape elements such as hedgerows and riparian forests. These large-scale developments took place all over the Netherlands and resulted in great losses of autochthonous plant material[7].

Key aspects of the forest sector

During the last few decades forest management in the Netherlands has shifted from the purpose of wood production towards multi-purpose forest management with the focus on recreation and nature conservation. As a result, the forest area primarily assigned for wood production has declined from 31,000 ha in 1990 to only 4,000 ha (1% of forest area) in 2000 and has remained constant ever since. Conversely, the forest area managed for biodiversity conservation has increased from 19,000 ha to 90,000 ha (25% of forest area) within the same period. The remaining 74% of the forest area has a multi-use function (266,000 ha in 2000). Furthermore, 60 forest reserves totalling 3,500 ha had been established by 2000, ranging in size from 5 to 400 ha. These are managed primarily to conserve biodiversity. Some recreation does take place but timber harvesting is prohibited in the reserves. These 60 reserves are a good representation of the variety of forest types that occur throughout the Netherlands. The main tree species characterizing the Dutch forests are commercially exploited, mainly for the production of wood pulp, saw timber and particle board. However, as forest management becomes increasingly nature-oriented, the volume of roundwood removal has decreased since 1990. In line with the changed objectives in forestry, from a system aimed at wood production to a multifunctional system, management now focuses on increasing the amount of dead wood in the forest, increasing the number of large and thick trees, enhancing structural diversity, increasing the number of different age classes and promoting native tree species. Harvesting is most often carried out by selective thinning[8]. In 2005 the total timber stock including standing dead wood was estimated to be 65 million m^3. The net annual increment (in forest available for wood supply) was about 2.24 million m^3 (7.6 m^3/ha). With an estimated 1.55 million m^3 (5.3 m^3/ha), fellings corresponded to about 69% of the annual increment[9].

European White Elm.

7 Maes, B. (2007). *Inheemse bomen en struiken in Nederland en Vlaanderen- herkenning, verspreiding, geschiedenis en gebruik*, Uitgeverij Boom, Amsterdam.

8 FAO (2010). Global Forest Resources Assessment. Country Reports-Netherlands. FRA2010/145. Rome, Italy, Forestry Department, Food and Agricultural Organization of the United Nations.

9 FOREST EUROPE, UNECE and FAO (2011). State of Europe's Forests 2011. Status and Trends in Sustainable Forest Management in Europe.

The total biomass was estimated to be 58 million tonnes oven-dry weight in 2010[10] (Figure 1). In the period 1980-2010 the annual consumption of wood and wood products in the Netherlands varied between 11 and 17 million m^3, with peaks in 1990 and 2000[11]. The total forest area of the Netherlands is reported as 'planted forest', which is defined as forest predominantly composed of trees established through planting and/or deliberate seeding in the FAO Forest Resources Assessment 2010 (see Table 1)[12].

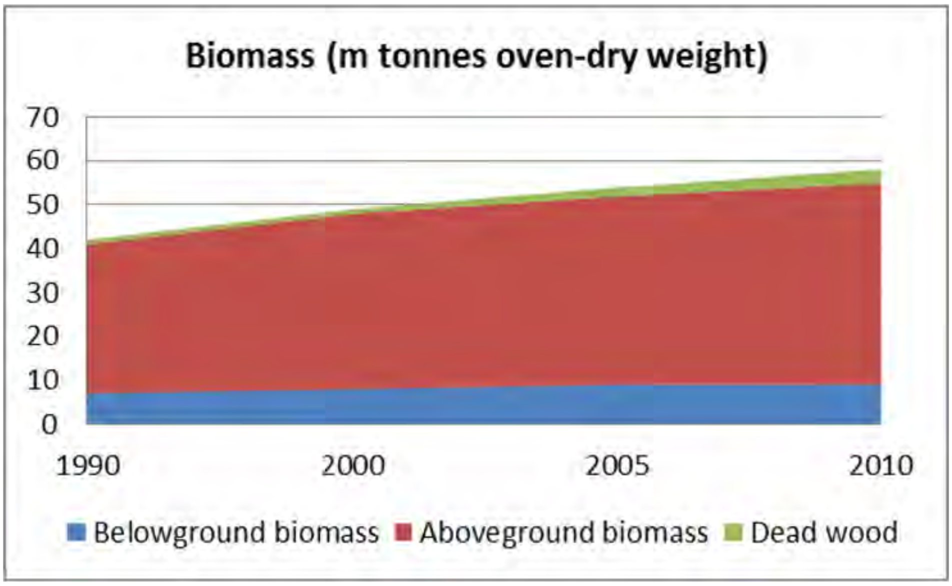


Figure 1. Development of estimated total biomass in Dutch forests in the period 1990-2010.

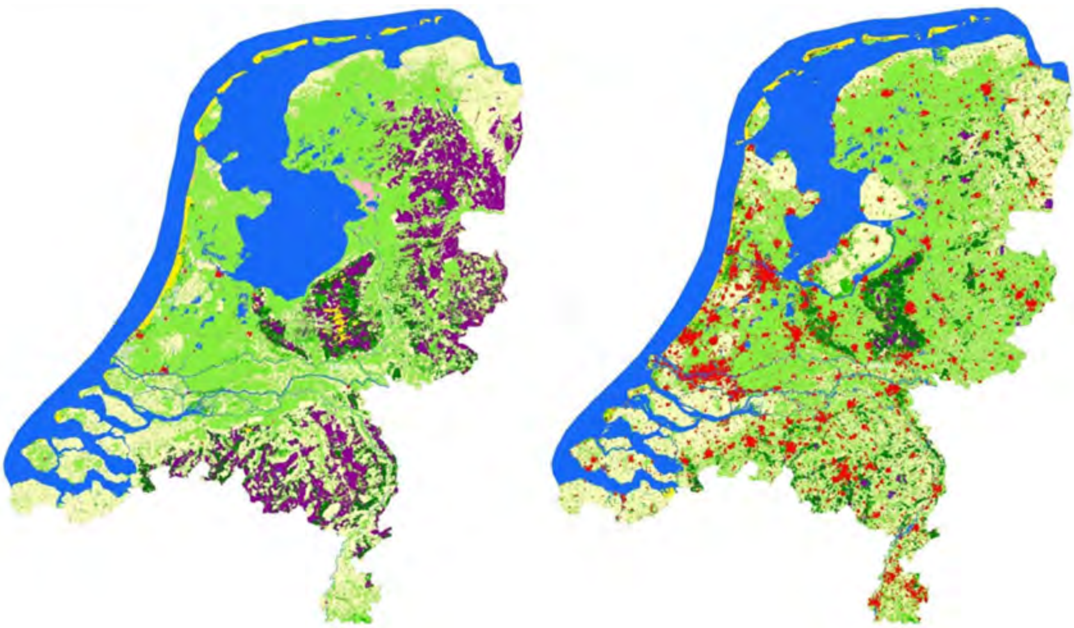


Figure 2. Land cover map of The Netherlands in 1900 (left) and 2000. Red=built area, purple=heathland, yellow= drift sand, pale green=pasture, dark green=forest and beige=crop land (source LGN, www.lgn.nl).

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10 FAO (2010). Global Forest Resources Assessment. Country Reports-Netherlands. FRA2010/145. Rome, Italy, Forestry Department, Food and Agricultural Organization of the United Nations.

11 PROBOS (2011). *Kerngegevens Bos en Hout in Nederland*, Stichting Probos, Wageningen.

12 FAO (2010). Global Forest Resources Assessment. Country Reports-Netherlands. FRA2010/145. Rome, Italy, Forestry Department, Food and Agricultural Organization of the United Nations.

However, a small part of the area consists of stands that have been cleared and re-established by natural regeneration, sometimes enhanced by planting. The total forest area has been increasing gradually over the last 130 years, mainly as a result of afforestation projects that were executed as part of government plans to increase the total forest area (Figure 2). In the 1990s the Dutch government aimed to increase the total forest area by 75,000 ha over the period 1990 -2020 to meet the increased societal demand for forest and nature areas[13]. Between 1990 and 2000 35% of this area was realized, largely in the province of Zuid-Holland and in the three northern provinces of Groningen, Drenthe en Friesland.

Compared to other European countries the forest area of the Netherlands is small and highly fragmented. About 85% of all forest areas are smaller than five hectares (Figure 3). The largest continuous forest areas are concentrated on the push moraines in the central part of the country (Veluwe and Utrechtse Heuvelrug). The remaining Dutch forest is highly fragmented and scattered throughout the Netherlands, mostly consisting of planted forests on former heathlands and drift sands in the provinces of Drenthe, Noord Brabant and Limburg.

Table 1. Forest characteristics and areas in 2000.

Main forest characteristics	Area (ha)
Primary forests	0
Naturally regenerated forests	0[a]
Planted forests	360,000
• Reforestation	
• Afforestation	

[a] *There are some areas with naturally regenerated forests, for example on heathlands, but no estimates of the number of hectares can be given.*

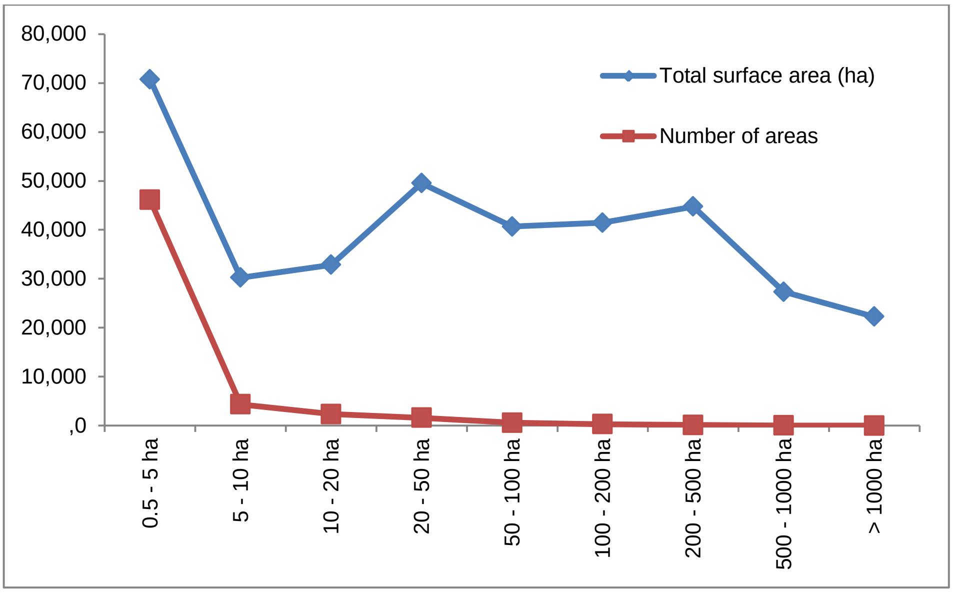

Figure 3. Surface area and number of forest areas per size class[14].

[13] MinLNV (1995). *Structuurschema Groene Ruimte*. Ministerie van Landbouw, Natuurbeheer en Visserij.
[14] Daamen, W. P., G. M. Dirkse, *et al.* (2007). *Het bos in statistieken : resultaten van het meetnet functievervulling bos 2001 - 2005*. Vakblad natuur bos landschap 4(4): 18-21.

The total number of people employed in forestry is not exactly known, since only employment in primary production of goods in forestry is registered by Statistics Netherlands. However, the forest sector is estimated to employ approximately 2,200 persons. With Rotterdam as one of the major trade ports, the Netherlands has an important position in the international timber market. The majority of timber traded on the Dutch market is imported and exported again. In the period 2003-2007 the average total value of traded wood from Dutch forests (including roundwood and fuelwood removals) amounted to EUR 36 million[15].

An estimated 179,000 ha of the forest area in the Netherlands is publicly owned (mainly by the State Forest Service and provinces, municipalities etc.) and 186,000 ha is private forest (Table 2)[16].

Table 2. Forest ownership and area in 2005.

Forest ownership	Area (ha)
Public	179,000
Private	186,000
Others	0

Trends

As a result of the European target to increase the share of sustainable energy in the total energy supply by 20% by 2020, an increase in the use of woodchips for energy production is expected. Due to relatively high prices for land and the shortage of available land there is no real interest in meeting the demand for bio-energy with short rotation production over large areas in the Netherlands. This would most likely result in increasing fuelwood removals from Dutch forests[17].

There have been no significant changes in the demand for forest products and services. The interest in forests for their climatic importance (CO_2 and fine dust reduction) may have increased. The main products obtained from Dutch forests are timber and fuelwood. Interest in these products has increased, as has the price of these products. Non-wood forest products such as wild meat are of minor importance to the Dutch forest sector. Only the earnings from hunting licences provide a reasonable income for the forest owners. Important services of forests are their water-regulating function, and recreational and cultural values. Forest genetic resources play a minor role in the demand for these goods and services. However, autochthonous *Populus nigra* plant material has been used in the development of commercial poplar hybrids, and autochthonous *Populus nigra* and *Ulmus laevis* clones have been used in the restoration of riparian forests in river catchments (*Plan Ooievaar* – the 'Stork Plan').

[15] FAO (2010). Global Forest Resources Assessment. Country Reports-Netherlands. FRA2010/145. Rome, Italy, Forestry Department, Food and Agricultural Organization of the United Nations.

[16] FAO (2010). Global Forest Resources Assessment. Country Reports-Netherlands. FRA2010/145. Rome, Italy, Forestry Department, Food and Agricultural Organization of the United Nations.

[17] Spijker, J. H., H. W. Elbersen, *et al.* (2007). *Biomassa voor energie uit de Nederlandse natuur*. Alterra report 1616. Wageningen, Alterra, Wageningen UR.

1. The current state of the forest genetic resources

Awareness in the Netherlands of the decline in the genetic resources of our native trees and shrubs has been increasing over the past 20 years. The Netherlands' obligations under the Convention on Biological Diversity (CBD) and the Ministerial Conferences on the protection of forests in Europe have contributed to this. Moreover, the Netherlands' membership of the European Forest Genetic Resources Programme (EUFORGEN) established in October 1994 was an important step towards taking action at the national level. In 1991, a project called 'Genetic quality of our native trees and shrubs' was launched with the aim of surveying the remaining indigenous vegetation, also called autochthonous populations[18]. Since then, knowledge of gene conservation and management of the forest genetic resources in the Netherlands has increased. Another positive factor for Dutch forest genetic resources was the development of a new national genetic resources strategy, developed in the government policy 'Sources of Existence: Conservation and the sustainable use of genetic resources'[19], which recognized the need to undertake action in the area of *ex situ* gene conservation.

State of diversity of the main tree species

The Netherlands is home to approximately 101 native woody species, including 78 trees, 3 conifers, 4 climbers and 16 dwarf shrubs (see also Table 7). The most common introduced tree species are: *Larix decidua, Larix kaempferi, Picea abies, Pinus strobus, Pinus nigra, Abies grandis, Picea omorika, Picea sitchensis, Pseudotsuga menziesii, Tsuga heterophylla, Robinia pseudoacacia, Quercus rubra, Acer platanoides* and all other *Populus* and *Salix* species (not mentioned in Table 7).

Only 12 tree species form the main species in Dutch forests. Of the total forest dominated by broadleaved species, 21% consists of one tree species, 15% is mixed with other broadleaved species and some 8% is mixed with coniferous species. A comparable pattern is observed in the coniferous forest area, where a majority (32%) consists of one tree species. Some 7% of the coniferous forest contains more than one coniferous species, whereas 13% is classified as mixed coniferous-broadleaved. The remaining 4% of the forest area is categorized as open or young forest (Table 3). The area of mixed coniferous-broadleaved forest has been increasing in recent decades as a result of the introduction of nature-oriented forest management. Scots pine is still the most common main tree species, although its proportion of the total area has substantially decreased over the years. One-third of Dutch forest is currently dominated by Scots pine. The proportion of native deciduous species has increased: in particular the area of native oaks (18% of the total forest area in 2005), the second main tree species in the Netherlands. The increase in deciduous forests has been at the expense of the exotic conifers (Douglas fir, larch and spruce). In terms of wood production, Scots pine is the most important species. Other important tree species for wood production are poplar, Douglas fir, spruce, larch, native oak, red oak and beech. Scots pine accounts for an estimated 23% of the timber volume[20].

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[18] An autochthonous population is defined as a stand or population which has normally been continuously regenerated by natural regeneration in accordance with EU Directive 1999/105/EC.

[19] LNV, VROM and OSW, 2002. Policy document: Sources of Existence: Conservation and the sustainable use of genetic diversity. Ministries of LNV, VROM and OSW, The Hague.

[20] PROBOS (2011). *Kerngegevens Bos en Hout in Nederland*, Stichting Probos, Wageningen.

Table 3. Major forest type categories and main tree species[21].

Major forest types	Area x1000 ha	Main species for each type	
		Trees	Other species if applicable
Temperate oceanic forest	360		
Temperate broadleaf	158	*Quercus petraea,* *Quercus robur* *Populus* spp. *Salix* spp. *Betula spp.* *Fagus sylvatica* *Quercus rubra*	
• Monoculture (<20%)	75		
• Mixed broadleaf species	54		
• Mixed broadleaf-coniferous	29		
Temperate coniferous	187	*Pinus sylvestris* *Pseudotsuga menziesii* *Larix* spp. *Pinus* spp. *Picea* spp.	
• Monoculture (<20%)	115		
• Mixed coniferous	24		
• Mixed coniferous-broadleaf	48		
Regeneration/young forest/cleared	15		

With the exception of Douglas fir, conifers are no longer priority species in the Netherlands. The current priority species are listed in Table 4, along with the reason for their priority, e.g. economic, social or cultural importance, or invasive. In the Dutch forests American black cherry (*Prunus serotina*) is currently the main invasive exotic species, both in terms of distribution, impact and management. The black cherry is abundantly present in half of the Dutch forests, complicating forest management and hindering the regeneration of native species[22].

[21] Dirkse, G.M., W.P. Daaman, H. Schoonderwoerd, M. Japink, M. van Jole, R. van Moorsel, P. Schnitger, W. Stouthamer, M. Vocks, 2006. *Meetnet Functievervulling bos 2001-2005, Vijfde Nederlandse Bosstatistiek*, Knowledge Directorate, no. DK065, Ministry of LNV, Knowledge Directorate#.

[22] den Ouden, J., B. Muys, *et al.* (2010). *Bosecologie en bosbeheer*, Uitgeverij Acco, Leuven.

Table 4. Priority species.

Priority species			Reasons for priority
Scientific name	Tree (T) or other (O)	Native (N) or exotic (E)	
Pseudotsuga menziesii	T	E	Economic importance
Juniperus communis	T	N	Protected species, natural value
Prunus serotina	O	E	Invasive, priority for removal
Fagus sylvatica	T	N	Economic importance, natural value
Quercus robur	T	N	Economic importance, natural value
Quercus petraea	T	N	Economic importance, natural value
Populus spp.	T	N/E	Economic importance, natural value
Fraxinus excelsior	T	N	Economic importance, natural value
Acer pseudoplatanus	T	N	Economic importance, natural value

The main tree species that are actively managed for productive purposes are presented in Table 5. About 54% of the Dutch forest area is dominated by coniferous tree species – mainly Scots pine (120,000 ha) but also European larch (21,000 ha), Douglas fir (20,000 ha) and Norway spruce (14,000 ha) – whereas some 21,000 ha is dominated by other conifers. The other 46% consists of broadleaved forest dominated by pedunculate oak (66,000 ha), poplar and willow (25,000 ha), birch (22,000 ha), beech (14,000 ha) and other broadleaved species (38,000 ha). Production is mainly for the purpose of industrial roundwood. In 2010 approximately 0.8 million m^3 of industrial roundwood (excluding firewood) was harvested. Industrial roundwood is used for pulpwood (46%), sawn timber and veneer (45%), and other purposes such as particle board and pallets (9%)[23]. Due to a change in forest management (nature-oriented forest management), the volume of roundwood removal has been decreasing since 1990. Harvesting is most often carried out by selective thinning. Firewood removal has risen slightly in recent years, mainly caused by an increase in the use of woodchips for energy production[24].

Seed collection of beech.

[23] PROBOS (2011). *Kerngegevens Bos en Hout in Nederland*, Stichting Probos, Wageningen.

[24] FAO (2010). Global Forest Resources Assessment. Country Reports-Netherlands. FRA2010/145. Rome, Italy, Forestry Department, Food and Agricultural Organization of the United Nations.

Table 6 shows the species providing environmental services or social values. In the past, specific plant material from certain tree species, varieties and clones was used for planting in parks, avenues, estates or hedges. Only part of this Dutch assortment of historical plant material (pre-1900) has been conserved. In particular, cultivars and historic clones of Dutch lime (*Tilia x europaea*), *Populus x canescens*, *Salix* and *Ulmus* species have a high cultural-historic value[25]. For example, willow cultures (coppice) occur in a typical Dutch landscape type (Osiers) and in specific agro-ecological regions of the Netherlands. In addition, if actively managed, they also have a specific ecological value.

Table 5. Forest species currently used and managed in the Netherlands[26].

Species (scientific name)	Native (N) or Exotic (E)	Current uses (code)*	If managed, type of management system (e.g. natural forest, plantation, agroforestry)	Area managed (ha) X 1000
Pinus sylvestris	N	1,2	Plantation, natural forest	120
Pseudotsuga menziesii	E	1	Plantation	20
Larix spp.	E	1,2	Plantation	21
Pinus nigra	E	1,2	Plantation	n.d.
Picea abies	E	1,2	Plantation	14
Betula spp.	N	1,2	Plantation, natural forest	22
Fagus sylvatica	N	1	Plantation, natural forest	14
Quercus robur	N	1	Plantation, natural forest	66
Quercus petraea	N	1	Plantation, natural forest	
Quercus rubra	E	1	Plantation	n.d.
Populus spp.	N/E	1,2,3	Plantation, natural forest	25
Salix spp.	N	2,3	Plantation, natural forest	

* *Current use: 1 solid wood products; 2 pulp and paper; 3 energy (fuel); 4 non wood forest products (food, fodder, medicine, etc.); 5 used in agroforestry systems.*

The common juniper is legally protected in the Netherlands.

25 Maes, N. C.M. 2011. *Betekenis en beheer van bomen en heesters als cultuurhistorisch erfgoed*. In: *Praktijkreeks Cultureel Erfgoed*. Sdu, The Hague.

26 PROBOS (2011). *Kerngegevens Bos en Hout in Nederland*, Stichting Probos, Wageningen.

Table 6. Main tree species providing environmental services or social values.

Species (scientific name)	Native (N) or exotic (E)	Environmental importance value
Pinus sylvestris	N	1,3,5
Pseudotsuga menziesii	E	5
Larix spp.	E	5
Fagus sylvatica	N	1,3,4,5
Quercus robur	N	1,3,4,5
Quercus petraea	N	1,3,4,5
Populus spp.	N	1,2,3
Salix spp.	N	1,2,3
Castanea sativa	E	4
Prunus avium	N	3,4,5
Malus sylvestris	N	3,4,5
Alnus glutinosa	N	1,2,5
Acer pseudoplatanus	N	1,2,3,5
Tilia spp.	N	2,3,4,6

1 soil and water conservation including watershed management; 2 soil fertility; 3 biodiversity conservation; 4 cultural values; 5 aesthetic values; 6 religious values.

Threatened species

As surveys and research over the past 20 years have indicated, knowledge of the distribution and rarity of the native trees and shrubs in the Netherlands has grown substantially. Results have shown that many of the native tree and shrub species are now rare or threatened (see Table 7). Among these are *Daphne mezereum*, *Juniperus communis*, *Rhamnus cathartica*, and *Ulex europaeus*. Other species appear to be so rare that only a few specimens can be found, such as *Viburnum lantana* and *Malus sylvestris*. Indeed, the autochthonous genetic material of a few species has completely disappeared (e.g. *Pinus sylvestris*). A number of species require protection as they have become rare and vulnerable. To meet the obligations of the Convention on the Conservation of European Wildlife and Natural Habitats, a Dutch Red List of vascular plants was compiled. The most recent list (2004)[27] contains eight native woody species, *Juniperus communis*, *Ulex europaeus*, *Genista pilosa*, *Andromeda polifolia*, *Vaccinium uliginosum*, *Daphne mezereum*, *Genista anglica* and *Rosa villosa*. All these species are threatened by extinction based on their rarity or declining occurrence. Of these woody species, *Juniperus communis* is the only species that is legally protected under the Flora and Fauna Act 1998. The act provides protection to a total of 96 plant species in the Netherlands.

Factors influencing the state of Dutch forest genetic diversity

Dutch forests have a long history of human intervention and excessive exploitation. In addition to the postglacial remigration history of the tree species from southern European refugia and subsequent natural selection processes resulting in adaptation to local conditions, these human interventions in the forest ecosystem have shaped the genetic composition of the present-day Dutch forests. As a consequence, ancient woods are extremely rare in the Netherlands. By the beginning of the 19th century the area of forest had been drastically reduced to only 4% of the total land area[28]. Although the forest area has since increased significantly due to heathland reclamation, this partly took place at the expense of remaining ancient woodlands and shrub vegetation. In the 20th century, due to the use

[27] LNV (2004). *Bijlage als bedoeld in artikel 1 van het besluit Rode lijsten flora en fauna (Staatscourant 11 november 2004, Nr. 218).*

[28] Dirkx, J (1998) Wood-pasture in Dutch common woodlands and the deforestation of the Dutch landscape, in Keith Kirby and Carl Watkins, eds, The ecological history of European forests, Wallingford.

of barbed wire and extensive land consolidation the area with hedges and hedgerows decreased by more than 50%. Hedgerows and windbreaks are particularly important sources of autochthonous trees and shrubs, since up to the end of the 19th century these elements were planted using local plant material. They were mainly used as cattle fences and to delineate property borders, but also, for example, to prevent sand-drift in coastal dune areas.

After 1950 reforestation with foreign and non-autochthonous plant material became common and this material was used on a large scale for planting new forests, hedges and other landscape elements. Today, an estimated 95% of all the trees and shrubs in the Netherlands originates from other countries, and often even from other continents[29]. This may have increased the total genetic diversity of the Dutch tree and shrub populations, but it has also brought with it associated risks related to growth, diseases and adaptability.

In addition, current human-induced changes, including through forest management, fragmentation through road construction, and introduction of foreign forest reproductive material, are impacting on the genetic diversity of the forests. Furthermore, forest genetic resources are threatened by logging, inappropriate thinning in old woodlands and hedges, and the use of herbicides and fertilizers that end up at the forest edges. Even non-intervention management in forests intended primarily as nature conservation can be disastrous for the survival of autochthonous genetic resources, especially for light-demanding rare species, as forests with a traditional open character are becoming increasingly shady. The use of foreign provenances to anticipate the consequences of climate change may become an interesting option to positively influence the genetic diversity of the Dutch forests and to allow tree populations to adapt to new climatic conditions. However, this is theory for the time being, as there are many pros and cons and uncertainties to this option.

Incidental diseases, storms or grazing and feeding by, for example, beaver, red deer and roe deer can cause damage to the Dutch forests. Furthermore, an example of a major threat to the genetic diversity of the native elm species (*U. minor, U. glabra*) in the country is Dutch Elm Disease. Other examples are watermark disease in willows (mainly *S. alba*), oak wilt, ash dieback (very recently) and poplar rust.

Table 7. List of tree and other woody species considered to be threatened in all or part of their range from a genetic conservation point of view (Only autochthonous populations are considered here).

Species (scientific name)	Area (km^2) of species' natural distribution	Proportion of species' natural distribution that is in the country (%)	Distribution in the country: widespread (W), rare (R), or local (L)	Type of threat (code)	Threat category		
					High	Medium	Low
Acer campestre	25500[a]	<5	L	2,4	x		
Acer pseudoplatanus	1700[a]	<5	L	2,4		x	
Alnus glutinosa	34000[a]	<5	W				x
Berberis vulgaris	3400[a]	<5	L	2,4,7	x		
Betula pendula	34000[a]	<5	W	2		x	
Betula pubescens	34000[b]	<5	L	2		x	
Carpinus betulus	3400[b]	<10	L	2			x
Clematis vitalba	1700[b]	<5	L	7			x
Cornus mas	340[b]	<5	R	2,4,7	x		
Cornus sanguinea		<10	L				x
Corylus avellana	6800[b]	<10	W	2,4			x

[29] Maes, B. (2007). *Inheemse bomen en struiken in Nederland en Vlaanderen- herkenning, verspreiding, geschiedenis en gebruik,* Uitgeverij Boom, Amsterdam.

Species (scientific name)	Area (km²) of species' natural distribution	Proportion of species' natural distribution that is in the country (%)	Distribution in the country: widespread (W), rare (R), or local (L)	Type of threat (code)	Threat category		
					High	Medium	Low
Crataegus laevigata	3400[b]	<5	R	2,4,7,		x	
Crataegus monogyna		<25	W	7			x
Crataegus rhipidophylla		<5	R	2,4,7	x		
Crataegus x macrocarpa	1700[b]	<5	R	2,4,7,	x		
Crataegus x subsphaerica	340[b]	<5	R	2,4,7,	x		
Daphne mezereum	<340[b]	<5	R	2,4,7,	x		
Euonymus europaea	13600[b]	<5	L	2,7		x	
Fagus sylvatica	17000[a]	<5	W	4,7		x	
Fraxinus excelsior	34000[a]	<5	W	4,7,11			x
Hedera helix	34000[b]	<10	W	7			x
Hippophae rhamnoides	340[b]	<5	L				x
Ilex aquifolium	3400[b]	<10	L				x
Juniperus communis	6800[b]	<5	R	2,4,7		x	
Ligustrum vulgare	1700[b]	<5	L	2			x
Lonicera periclymenum	34000[b]	<10	W				x
Lonicera xylosteum	<340[b]	<5	R	2,4,7	x		
Malus sylvestris	34000[a]	<5	R	2,4.7	x		
Myrica gale	8500[b]	<5	W	2			x
Populus nigra	17000[a]	<5	R	2,4,7,	x		
Populus tremula	34000[a]	<5	W				x
Prunus avium	30600[a]	5	L	4		x	
Prunus padus	8500[b]	<10	W				x
Prunus spinosa		<10	W				x
Pyrus pyraster	1700[a]	<5	R	2,4,7	x		
Quercus petraea	17000[a]	<5	L	4,7		x	
Quercus robur	32300[a]	<25	W	2		x	
Rhamnus cathartica		<5	R	2,4,7	x		
Rhamnus frangula		<15	W				x
Ribes nigrum		<5	L	2,13		x	
Ribes rubrum		<5	R	2,7,13		x	
Ribes uva-cripa		<5	L	7		x	
Rosa agrestis		<5	R	2,4,7	x		
Rosa arvensis		<5	R	2,4,7		x	
Rosa caesia		<5	R	2,4,7	x		
Rosa canina		<15	W				x
Rosa corymbifera		<5	L	2,4,7		x	
Rosa dumalis		<5	R	2,4,7	x		
Rosa gremlii(Rosa henkeri-schulzei)		<5	R	2,4,7		x	
Rosa inodora		<5	R	2,4,7	x		
Rosa micrantha		<5	R	2,4,7	x		
Rosa pseudoscabriuscula		<5	R	2,4,7	x		
Rosa rubiginosa		<5	R	2,4,7		x	
Rosa sherardii		<5	R	2,4,7	x		
Rosa spinosissima		<5	R	7			x

Species (scientific name)	Area (km²) of species' natural distribution	Proportion of species' natural distribution that is in the country (%)	Distribution in the country: widespread (W), rare (R), or local (L)	Type of threat (code)	Threat category		
					High	Medium	Low
Rosa subcanina		<5	R	2,4,7	x		
Rosa subcollina		<5	R	2,4,7	X		
Rosa balsamica		<5	R	2,4,7		x	
Rosa tomentosa		<5	R	2,4,7	x		
Salix alba		<25	W				x
Salix aurita		<5	L	2,7,13		x	
Salix caprea		<10	W				x
Salix cinerea		<25	W				x
Salix fragilis		<5	L	2,7,13		x	
Salix pentandra		<5	R	2,4,7		x	
Salix purpurea		<5	R	2,4,7		x	
Salix repens		<5	L	2,4,7	x		
Salix triandra		<5	L	7		x	
Sambucus nigra		<20	W				x
Sambucus racemosa		<5	L	7		x	
Sorbus aucuparia		<25	W				x
Taxus baccata		<5	R	4,7	x		
Tilia cordata	30600[a]	<5	R	4,7	x		
Tilia platyphyllos	6800[a]	<5	R	4,7	x		
Ulex europeus		<5	R	2,4,7		x	
Ulmus glabra		<5	R	4,7,11	x		
Ulmus laevis	340[a]	<5	R		x		
Ulmus minor		<10	L	4,7,11		x	
Viburnum lantana		<5	R	2,4,7	x		
Viburnum opulus	1700[b]	<25	L	2,4,7		x	

a: area estimated based on www.euforgen.org/distribution_maps.html, b: area estimated based on Maes, 2007. Inheemse bomen en struiken in Nederland en Vlaanderen. Utrecht, 376 pp.

Type of threat:
1 Forest cover reduction and degradation
2 Forest ecosystem diversity reduction and degradation
3 Unsustainable logging
4 Management intensification
5 Competition for land use
6 Urbanization
7 Habitat fragmentation
8 Uncontrolled introduction of alien species
9 Acidification of soil and water
10 Pollutant emissions
11 Pests and diseases
12 Forest fires
13 Drought and desertification
14 Rising sea level
15 Other (please specify)

State of forest reproductive material identification and utilization

For the purposes of identification and marketing of forest reproductive material (FRM), the Netherlands is considered to be one region of provenance according to Council Directive 1999/105/EC and the OECD scheme. There are no further defined areas within the country, as the ecological and climatic conditions are more or less the same throughout the country. Tables 8a and 8b provide an impression of the volumes of seeds harvested and numbers of seedlings planted at nurseries of the main species used. *Populus* is the only genus where vegetatively produced plant material from improvement programmes is used. The number of cuttings varies from year to year (5000 plants and 19,000 plants in 2010 and 2011 respectively).

Table 8a. Annual quantity of seed harvested and current state of identification of FRM of the main forest tree species (Data source: Naktuinbouw 5-year average 2007- 2011).

Species		Total quantity of seed harvested (kg)	Quantity of seed from documented sources (selected and source-identified)	Quantity of seed from tested provenances	Quantity genetically improved (from seed orchards)
Scientific name	Native (N) or Exotic (E)				
Alnus glutinosa	N	10.6	10.6	0	0
Acer platanoides	E	134	0	n/a	134
Acer pseudoplatanus	N	280	0	n/a	280
Betula pubescens	N	1.3	1.3	n/a	0
Betula pendula	N	24.8	6.3	n/a	18.5
Carpinus betulus	N	24.3	24.3	n/a	n/a
Castanea sativa	E	273.6	273.6	n/a	n/a
Fraxinus excelsior	N	737.3	370.7	n/a	366.6
Fagus sylvatica	N	3717.4	2923	794.4	n/a
Prunus avium	N	56.9	0	n/a	56.9
Pinus sylvestris	N	6.4	0	0	6.4
Quercus petraea	N	235	235	n/a	n/a
Quercus robur	N	96304.1	67831	28325	148.1
Quercus rubra	E	10586	10586	n/a	n/a

n/a = not applicable.

Table 8b. Annual number of seedlings (or vegetative propagules) produced for the main tree species (Data source: Naktuinbouw 2010).

Species		Total quantity of seedlings planted	Quantity of vegetative reproductive material used
Scientific name	Native (N) or Exotic (E)		
Acer platanoides	E	734500	n/a
Acer pseudoplatanus	N	1532500	n/a
Alnus glutinosa	N	2763850	n/a
Alnus incana	N	100000	n/a
Betula pendula	N	1806985	n/a
Betula pubescens	N	1272000	n/a
Carpinus betulus	N	1445050	n/a
Castanea sativa	E	165620	n/a
Fagus sylvatica	N	9468159	n/a
Fraxinus excelsior	N	2437385	n/a
Larix spp.[a]	E	111000	n/a
Picea abies	E	198000	n/a
Pinus sylvestris	N	82600	n/a
Populus spp.	N/E	n/a	5000
Prunus avium	N	1029700	n/a
Pseudotsuga menziesii	E	98700	n/a
Quercus petraea	N	1074180	n/a
Quercus robur	N	2820505	n/a
Quercus rubra	E	409700	n/a
Robinia pseudoacacia	E	601290	n/a
Tilia cordata	N	1087435	n/a
Tilia platyphyllos	N	222000	n/a

[a] *mainly Larix kaempferi. n/a = not applicable.*

The state of genetic characterization of the main forest tree and other woody plant species

The natural distribution range of the native tree and shrub species in the Netherlands covers large areas outside the country. For most species, less than 5% of their natural distribution lies within the country[30/31]. None of the native tree species found in the Netherlands is endemic. A major cause for the absence of endemics is the fact that all trees have been migrating northwards since the last ice age.

Although the Netherlands is considered as one region of provenance, surveys of autochthonous tree and shrub populations use ecological zonation based on 15 main flora districts.

Provenance experiments, carried out for over fifty years for the main tree species, have shown high levels of genetic diversity within and between populations and a diverse response of provenances to site conditions in the form of genetic adaptation. The aim of these trials is to identify the most suitable provenances in terms of adaptation, growth and quality, and to make recommendations for the use of planting material in the Netherlands. More recently,

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[30] http://www.euforgen.org/distribution_maps.html

[31] Maes, B. (2007). *Inheemse bomen en struiken in Nederland en Vlaanderen- herkenning, verspreiding, geschiedenis en gebruik*, Uitgeverij Boom, Amsterdam.

emerging molecular technologies have enabled us to characterize and evaluate the genetic diversity in a large number of species. Genetic characterization of genetic resources is an important step for designing conservation measures, especially for rare and endangered species. Table 9 lists the tree and shrub species for which adaptive and production traits are assessed or genetic variability has been investigated using molecular markers.

Table 9. Forest species (from Table 5 and 6) for which genetic variability has been evaluated.

Species		Morphological traits	Adaptive and production traits	Molecular characterization
Scientific name	Native (N) or exotic (E)			
Pinus sylvestris	N	n.d.	+	–
Pseudotsuga menziesii	E	+	+	–
Larix spp.	E	n.d.	+	–
Pinus nigra	E	n.d.	+	–
Picea abies	E	n.d.	+	–
Fagus sylvatica	N	n.d.	+	+
Quercus robur	N	+	+	+
Quercus petraea	N	+	–	+
Populus spp.	N/E	+	+	+
Salix spp.	N	n.d.	+	–
Castanea sativa	E	n.d.	–	–
Prunus avium	N	n.d.	+	+
Malus sylvestris	N	n.d.	–	+
Alnus glutinosa	N	n.d.	+	–
Acer pseudoplatanus	N	n.d.	+	–
Crataegus laevigata	N	n.d.	–	+
Crataegus monogyna	N	n.d.	–	+
Juniperus communis	N	n.d.	–	+
Ulmus laevis	N	n.d.	–	+
Ulmus minor	N	n.d.	–	+

n.d. = no data available.

Trends

The relative importance of most of the main forest tree species utilized has not significantly changed over the past ten years. Demand for wood in general has increased, and energy production from wood may have increased the use of forest tree species for biofuel purposes, although there is insufficient data to support this. Over the past ten years in particular, knowledge of the intraspecific variation in a number of forest species present in the Netherlands has increased by assessing production characteristics and molecular genetic diversity.

2. The state of *in situ* genetic conservation

The old forest remnants that have survived until today have acquired a high nature conservation status in recognition of their high historical and cultural values. These forests contain the original vegetation that has become rare elsewhere in the country. *In situ* maintenance of these populations is often under heavy pressure, especially from urban expansion, road construction and clay and sand mining. Consequently, the opportunities for *in situ* conservation are limited.

Surveys

It is estimated that more than 95% of the genetic resources of all Dutch trees and shrubs originate from abroad, including exotics such as American black cherry (*Prunus serotina*), introduced from North America around 1630, black locust (*Robinia pseudo-acacia*), imported from North America around 1625, and Douglas fir. In other words, less than 5% is recognized as consisting of autochthonous populations. Between 1991 and 2012 an extensive survey of the distribution of this autochthonous genetic material was carried out across the entire country, commissioned by the Dutch government. The outcome of this survey revealed that half of the Dutch tree and shrub species of autochthonous origin are extremely rare or partly threatened with extinction. Currently, about 60% of all *in situ* locations of Dutch trees and shrubs have been inventoried. The survey provided data on the occurrence of the species within the different floral districts, the number of existing populations, and their size. This information is essential for designating areas for genetic conservation activities.

Protected areas

There is no specific programme for *in situ* conservation of forest genetic resources in the Netherlands. The primary strategy for long-term conservation of Dutch biodiversity is to make use of an extensive network of protected areas that does not necessarily coincide with conservation of forest genetic resources. The driving force behind the establishment of this network of protected areas is the conservation of species and habitats. *In situ* conservation of forest genetic resources is not necessarily a goal within these protected areas. The Netherlands recognizes different types of protected areas with a different legal status, such as National Parks, National Landscapes, the National Ecological Network (EHS), Natura 2000 sites, exclusive protected Nature Monuments under the Nature Conservation Act (1998), and Forest Reserves. These protected areas have been established throughout the country and cover all major ecosystems. In 2011 the Netherlands designated 162 Natura 2000 areas, representing 1 Mha or 24.1% of the total area. The EHS is a coherent network of existing and developing forests and nature areas. It forms the basis and backbone of Dutch nature policy. The Ministry of Economic Affairs, Agriculture and Innovation (EL&I) aimed to have 750,000 ha of nature areas in the EHS by 2018, though in 2011 the last government declared that it would spend significantly less money on the EHS. The twenty National Landscapes (in total 90,000 ha) each exhibit a unique combination of cultural and natural elements. The different protected areas partly overlap: all National Parks (123,000 ha) core areas are within the EHS and all Natura 2000 areas will be included in the EHS. The Nature Monuments (in total 3,422 ha) are outside the Natura 2000 areas but most of them (3,310 ha) fall within the EHS[32]. The country has designated 60 forest reserves, of which 42 fall within Natura 2000 areas[33].

For most of the forest tree and shrub species, these protected areas meet the goal of conserving the genetic diversity of their populations, since the strategy for these protected areas is to conserve the entire ecosystem. Particularly vulnerable and precious habitats and species are being protected through the designation of the Natura 2000 areas under the EU Birds Directive and Habitats Directive. Several Natura 2000 areas are relevant for our native trees and shrubs such as buckthorn and juniper brushwoods and willow riparian forests. Moreover, so-called

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[32] Broekmeyer, M.E.A. R.J. Bijlsma and W. Nieuwenhuizen (2011). *Beschermde natuurmonumenten: stand van zaken en toekomstige bescherming*. Wageningen, Alterra, Alterra report 2131, 137 pp.

[33] Bijlsma, R.J. 2008. *Bosreservaten: Koplopers in de natuurlijke ontwikkeling van het Nederlands boslandschap.* Alterra, Alterra report 1680, 50pp.

habitat types are specifically protected by means of Natura 2000 areas, and these include types that are defined on the basis of the presence of tree or shrub species. Many autochthonous populations are also found in ancient woodlands (e.g. Veluwe), old hedgerows (e.g. the Maasheggen area), embankments or hollows. On the one hand, these forest and landscape elements are mainly situated in protected areas and owned by nature conservation organizations, some of which lands are part of the EHS. On the other hand, many of the native trees and shrubs are rare and competitively weak species, demanding special management or silvicultural treatment. For example, rare and light-demanding species such as wild rose, wild apple, wild medlar, eared willow, juniper, but also oaks, need proper management to avoid strong shading. As management interventions are often minimal ('close to nature' management) or not permitted, this limits the opportunities for genetic conservation of these species in these protected areas.

Activities for *in situ* genetic conservation

The Netherlands has established a number of *in situ* dynamic gene conservation units in line with the strategy of EUFGIS[34] (an EU project on the establishment of a European information system on forest genetic resources, co-ordinated by Bioversity International) for *in situ* conservation of forest trees. In 2011 a total of 10 gene conservation units for 11 target species were established (see also Table 10). Together they comprise an area of about 340.6 hectares. These gene conservation units consist mainly of one or two stands of rare species. The criteria used to establish these gene conservation units were derived from the minimum requirements for the dynamic conservation of forest trees agreed within the EUFGIS project and based on the work carried out by the EUFORGEN networks. The established units have a designated status as gene conservation areas of forest trees. The minimum size of the conservation units depends on the species: for the broadleaves oak and beech the population size should be at least 500 individuals; for black poplar the minimum number is about 50 reproducing trees; and for the other endangered tree species for which the objective is to conserve the remaining populations, the population size should be at least 30 individuals. The type and function of the conservation units differ. All are used as a gene reserve forest and registered seed stand ('Source identified' category) and function for biodiversity conservation. Nine of the conservation units (except the *Fagus sylvatica* unit) are located in protected areas (e.g. the Natura 2000 protected area Geuldal). Most of the gene conservation units are publicly owned. Different owners, including the state, NGOs and private owners, have different interests regarding the management and use of forest resources. The aim of the management strategies for these conservation units is to maintain and enhance the long-term evolutionary potential of tree populations. For this reason public owners are preferred, since long-term commitments with regard to the maintenance of the gene conservation units are required and can hardly be expected from private owners. However, in practice it is difficult to achieve the conservation aim. For example, management interventions such as thinning or cutting are not permitted in most of the conservation units, which will eventually be a problem for light-demanding species.

The selection and designation of gene conservation units was carried out by the Centre for Genetic Resources, the Netherlands (CGN). Currently there is no national forum for stakeholders involved in *in situ* conservation, so CGN is seeking collaboration with other interested or concerned parties such as the State Forest Service and NGOs.

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34 http://www.eufgis.org

Table 10. Target forest species included within in situ conservation programmes/units.

Species (scientific name)	Purpose of establishing conservation unit	Number of populations or stands conserved	Total area (ha)
Fagus sylvatica	Long-term gene conservation	1	250
Quercus robur	Long-term gene conservation	1	23
Quercus petraea	Long-term gene conservation	2	26
Populus nigra	Long-term gene conservation	1	0.6
Ulmus laevis	Long-term gene conservation	1	30
Prunus avium	Long-term gene conservation	1	7
Fraxinus excelsior	Long-term gene conservation	1	7
Taxus baccata	Long-term gene conservation	1	4
Juniperus communis	Long-term gene conservation	1	3
Carpinus betulus	Long-term gene conservation	1	20
Acer campestre	Long-term gene conservation	1	2

Sustainable forest management for forest genetic resources conservation within and outside protected areas

Currently, the focus for 20 to 30% of Dutch forests is on nature conservation, with priority being given to undisturbed forest development. In all protected areas the aim is sustainable biodiversity conservation, both species and habitats, under a 'no, unless' regime. This means that human interventions that have a negative impact on biodiversity are in principle prohibited, unless the Minister grants permission for good reasons. Such a regime could interfere with regular silvicultural treatments as well as specific management activities for forest genetic resources conservation. Examples are thinning for conservation of specific species or removing a species to initiate natural regeneration of another species.

Some tree and shrub species require maintenance of functions of traditional landscape elements associated with former land or agricultural use, such as hedgerows. These landscape elements are part of our bio-cultural heritage. The use of these elements has decreased as the economic function of the elements has decreased or disappeared. Responsible landscape management is important for the conservation of these tree and shrub species, but this is expensive and time and labour consuming. In practice, this means that management of these historic bio-cultural elements is primarily made possible by subsidies and volunteers. It would be better if a new or different economic function could be found for sustainable conservation of these elements. These elements certainly have added value for the area as they make it more attractive for recreation.

Constraints

The main constraints to improving *in situ* genetic conservation activities in the Netherlands include (1) inadequate knowledge of the biology of the species, particularly rare species; (2) limited public interest in gene conservation; and (3) lack of resources. Efficient *in situ* conservation requires sufficient knowledge of the individual tree species. These rare species are often of minor interest to forest managers. Many forest managers are ignorant of the existence of these species or the valuable populations in their terrain. Moreover, conservation of these rare species, which are often light-demanding, requires specific management measures such as ensuring regeneration and preventing shading. The resources available for *in situ* conservation are limited. There is normally no budget for *in situ* conservation in the framework of regular management activities. Although subsidies for management and maintenance of landscape elements exist (Nature and Landscape Management Grant Scheme), genetic conservation of native species is currently not included.

Priorities

Near-future *in situ* gene conservation actions by the Centre for Genetic Resources in the Netherlands will aim at identifying gene conservation units for more species. Such efforts will add information on new gene conservation units to the EUFGIS database and in the context of the EUFORGEN programme. Moreover, dissemination of information on *in situ* conservation to forest managers, including local governments, nature conservation organizations, water supply companies and private owners, can be considered as important. Forest owners and managers may well need better information, as their current knowledge of how to conserve, manage and utilize forest genetic resources in their terrains is limited. Therefore, public awareness and dissemination of results from the EUFORGEN programme will be considered as an important activity in this context.

Trends

Interest in conservation and use of genetic resources that are characteristic of Dutch nature and landscape is increasing. Examples of characteristic trees and shrubs that are associated with certain forms of land use in past centuries are hedgerow landscapes, old avenues of Dutch lime cultivars (*Tilia x europaea*), old oak coppice stools in ancient woodlands, and willow osiers. For example, coppicing was common from the Middle Ages until the early 20th century. Awareness and knowledge of this bio-cultural heritage is growing.

There are no on-farm conservation activities in the Netherlands. None of the native trees and shrubs have any importance in agroforestry systems or are used for food security or livelihoods. Many traditional agroforestry systems disappeared during the 20th century. Intensification, agricultural mechanization and land consolidation were the main driving forces behind removing trees from agricultural lands. Nowadays some farmers have a growing interest in agroforestry. In addition, some businesses have started planting walnuts, hazelnuts and common sea-buckthorn as a mixed culture of perennial crops. However, there is still a lack of awareness of the use of authentic plant material for this purpose, and higher-yielding modern varieties are preferred (walnuts).

Black poplar in situ gene conservation unit.

3. The state of *ex situ* genetic conservation

Ex situ conservation of forest trees in the Netherlands started as a secondary activity in several tree selection and breeding projects in the De Dorschkamp Forest Research Institute in Wageningen in 1947. Collections were established for larch, Scots pine, poplar, willow and elm in order to supply the breeding programme with a variety of genetic material. Currently, the State Forest Service (Staatsbosbeheer; SBB), botanical gardens and NGOs manage several field collections of forest genetic resources of both native and non-native trees species. There are no *in vitro* or seed banks for trees and shrubs. The Centre for Genetic Resources, the Netherlands (CGN) and Alterra manage a large collection of forest genetic resources (provenances, progenies, clones, plus trees and seed orchards) established as part of their provenance testing and improvement programmes; this is described in chapter 4.

Ex situ collections

In 2002, the Dutch government adopted the policy document 'Sources of Existence'[35], which recognized the importance of *ex situ* forest genetic resources and the need for their long term maintenance. In an effort to implement this policy document, SBB and CGN, together with two ecological consultancy firms, started to establish a new gene bank for native trees and shrubs, commissioned by the Ministry of Economic Affairs, Agriculture and Innovation (formerly the Ministry of Agriculture, Nature and Fisheries). A motive for this initiative was that *in situ* conservation was found to be no longer feasible for a number of Dutch tree and shrub species, as the remaining populations had become too small, fragmented or isolated. Bringing together the material from these isolated populations in a single gene bank site was considered the best solution to safeguard the genetic material in the long term and to use it sustainably. This gene bank, developed gradually since 2002, was officially opened by the Minister of Economic Affairs, Agriculture and Innovation in 2006. Today, this living collection contains 3,735 accessions of 48 species belonging to 25 genera. Noble hardwoods, such as *Tilia*, *Prunus*, *Ulmus*, *Fraxinus*, *Malus* and *Pyrus*, as well as willows, black poplar and two conifers, are among these species. See also Table 11 for target tree and shrub species included in this gene bank.

The State Forest Service is responsible for the management of the gene bank. The gene bank is located on state-owned forestland in different parts of the province of Flevoland, covering about 32 ha in total. Material for the collections has been gathered from about 400 *in situ* locations. The trees sampled for the collections were selected with the aim of collecting a broad sample of the existing genetic variation. CGN assists the State Forest Service with the exploitation and management of the gene bank by advising on acquisitions of new material to be included in the gene bank and by maintaining the documentation of the accessions in the gene bank in a database. Information on the accessions is accessible through a website that contains this database[36]. The accessions and collections are documented using a number of descriptors including accession number, genus, species, common name, and number of plants included in the gene bank, as well as descriptors related to the origin of the material, such as the floral district where the material was sampled, the location of the collection site, the landscape element of the collection site, and the collection date of the sample. The accessions are not yet fully described, but this minimal set of descriptors should at least be valuable for users looking for material from a specific floral district or locality.

The Netherlands follows two options for its *ex situ* conservation activities: clonal archives and clonal seed orchards. The biology (e.g. abundance) and current status of the target species is decisive in terms of choosing between these options. Many species (e.g. black poplar, wild apple) are under serious threat of extinction. In some cases only a few individuals remain, the relict populations are too small and isolated, or natural regeneration or seed production is limited, so that these populations are not able to survive as viable populations. Species to which these conditions applied needed immediate action, so the remaining individuals from different parts of the country were sampled and put together in one clonal archive. For others, where the number of individuals exceeded 30, clonal seed orchards were established. The individuals were vegetatively propagated and brought together, enabling outcrossing between

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[35] LNV, VROM and OSW, 2002. Policy document Sources of Existence: Conservation and the sustainable use of genetic diversity. Ministries of LNV, VROM and OSW, The Hague.

[36] www.genenbankbomenenstruiken.nl

the individuals and an easy seed harvest. If feasible, populations from different floral districts were kept separated in different seed orchards in the gene bank (provided >30 genotypes were available). For one species (*Ulmus laevis*) a duplicate clone collection was established in another locality.

Small-leaved lime in ex situ gene bank.

Apple in ex situ gene bank.

Table 11. Ex situ conservation.

Species		Field collections			
Scientific name	Native (N) or exotic (E)	Collections, arboreta		Clone banks	
		No. stands	No. acc.	No. banks	No. clones
Acer campestre	N	0	0	1	93
Alnus glutinosa	N	0	0	1	73
Berberis vulgaris	N	0	0	1	74
Carpinus betulus	N	0	0	1	83
Cornus mas	N	0	0	1	49
Cornus sanguinea	N	0	0	1	149
Corylus avellana	N	0	0	1	212
Crataegus laevigata	N	0	0	1	70
Crataegus x macrocarpa	N	0	0	1	4
Crataegus monogyna	N	0	0	1	246
Euonymus europaea	N	0	0	1	45
Fraxinus excelsior	N	0	0	1	233
Juniperus communis	N	0	0	1	94
Ligustrum vulgare	N	0	0	1	104
Lonicera xylosteum	N	0	0	1	51
Malus sylvestris	N	0	0	1	127
Mespilus germanica	N	0	0	1	38
Myrica gale	N	0	0	1	300 (trees)
Populus nigra	N	0	0	1	116
Prunus avium	N	0	0	1	86
Prunus padus	N	0	0	1	122
Prunus spinosa	N	0	0	1	58
Rhamnus cathartica	N	0	0	1	52
Ribes nigrum	N	0	0	1	78
Ribes rubrum	N	0	0	1	79
Ribes uva-crispa	N	0	0	1	68
Rosa agrestis	N	0	0	1	17
Rosa canina	N	0	0	1	45
Rosa corymbifera	N	0	0	1	41
Rosa columnifera	N	0	0	1	30
Rosa rubiginosa	N	0	0	1	39
Rosa spinosissima	N	0	0	1	14
Rosa balsamica (tomentella)	N	0	0	1	32
Rosa tomentosa	N	0	0	1	59
Salix alba	N	0	0	1	61
Salix aurita	N	0	0	1	130
Salix caprea	N	0	0	1	29
Salix cinerea	N	0	0	1	118
Salix fragilis	N	0	0	1	61
Salix pentandra	N	0	0	1	65
Salix purpurea	N	0	0	1	53
Salix triandra	N	0	0	1	59
Salix viminalis	N	0	0	1	74
Sorbus aucuparia	N	0	0	1	97
Tilia cordata	N	0	0	1	103

Species		Field collections			
Scientific name	Native (N) or exotic (E)	Collections, arboreta		Clone banks	
		No. stands	No. acc.	No. banks	No. clones
Tilia platyphyllos	N	0	0	1	35
Tilia spp.	N	1	120	0	0
Ulmus laevis	N	0	0	2	72
Ulmus spp.	N/E	1	32	0	0
Viburnum opulus	N	0	0	1	97

In addition to the gene bank of the State Forest Service funded by the Dutch Government, there are a number of specific collections of trees of both native and exotic species, including old monumental trees and historical cultivars, maintained by public or private organizations. The Lime Arboretum Foundation, for example, maintains a large collection of old cultivars of *Tilia,* including old Dutch lime hybrid clones (*Tilia x europaea*). The collection is used as a gene bank for scientific research and testing for cultivation and use value. An elm arboretum is held by the city of Amsterdam. Other tree and shrub collections are held by gardens of the Dutch Botanical Gardens Foundation (NVBT), including botanical gardens belonging to universities, arboretums and zoos with a botanical department. Many of these collections belong to the National Plant Collections. An overview of these collections (including more than 15 tree collections) is provided on the NVBT website (www.botanischetuinen.nl). Members of the Royal Boskoop Horticultural Society (KVBC) maintain collections of plants and trees with the aim of conserving a wide range of plants cultivated in the country and to provide a reference collection. Together, these almost 100 collections form the Dutch Plant Collections (www.plantencollecties.nl).

Constraints

The main constraints to extending *ex situ* conservation in the Netherlands are the lack of resources and the lack of a stakeholders' platform to support *ex situ* activities in the long term. Since its establishment in 2006, the gene bank has become the responsibility of the State Forest Service. The State Forest Service is an agency of the Ministry of Economic Affairs, Agriculture and Innovation (EL&I) and receives government funding for maintaining, managing and developing its 250,000 hectares of nature area and forests, covering only part of its budgetary needs. After an initial subsidy for founding the gene bank, the Ministry of EL&I has financed the subsequent management of the gene bank by the State Forest Service on a year-by-year basis (each year specifically tagged within the framework of the overall financing of the activities by the State Forest Service). Some stakeholders fear that this year-by-year financing may put the long-term continuation of the gene bank at risk. In addition, in order to render the gene bank more economically viable, it will be important to ensure that it is actively used.

The limited number of stakeholders involved in *ex situ* conservation may be a disadvantage in the long run. To ensure a sustainable *ex situ* conservation system, therefore, the participation of more stakeholders could be encouraged, preferably in the form of a National Gene Conservation Stakeholders Group. Such a formal platform could mobilize support for a national conservation plan, raise awareness and assist with fundraising, and could also be used to disseminate knowledge obtained within the EUFORGEN network or other international collaborations on gene conservation.

Future trends in *ex situ* conservation

The number of accessions and number of species included in the gene bank has grown steadily over the past five years (from 2,636 accessions in 2006 to 3,735 in 2012). However, knowledge of the collected accessions in relation to its value to users is still limited. Therefore, priorities in future *ex situ* conservation actions include increased research efforts to characterize the collected material, including through the use of molecular markers, as well as further support for acquisition activities related to the composition of the collections.

Ex situ conservation requires a long-term commitment in terms of funding and input of staff. The State Forest Service is aware that maintaining the gene bank is essential and that future use of the material in plantings and reforestation is an important prerequisite for the long-term sustainability of the gene bank. As there is scope for raising public awareness of the need for the gene bank, the State Forest Service is exploring ways of promoting the gene bank to the public and end-users. That includes options to make the gene bank accessible via footpaths and establishing information panels for the general public. Additionally, the State Forest Service is working on a marketing plan for increasing public interest in bio-cultural heritage.

4. The state of use and sustainable management of forest genetic resources

Forest genetic resources include the genetic resources of both native and introduced forest tree species available in *in situ* conditions and in the gene bank, as well as the material in the national tree improvement programmes. Conservation of these forest genetic resources is largely promoted through testing and research and through the use of FRM. Both the active seed trade sector and the FRM nursery sector in the Netherlands as well as the breeding and provenance testing activities in the past have demonstrated this.

The importance of sustainable management and use

Sustainable forest management is seen as multipurpose management of the forest in ways that will not diminish its overall capacity to provide goods and services. A forest managed in this way will provide timber on a sustainable basis and will continue to provide fuelwood, food and other goods and services for those living in and around it. Its role in the preservation of genetic resources and biodiversity as well as in the protection of the environment will also be sustainable[37]. The Netherlands is committed to implementing the CBD, and it is the CBD in particular that connects sustainable management of forests with conservation of its genetic resources.

The use of appropriate FRM and integration of genetic conservation activities in forest management practices should be key elements of sustainable forest management. These two aspects could be given even more attention in the Netherlands. In the past, large amounts of inappropriate FRM (conifers and more recently beech, ash, sycamore and wild cherry) have been imported from abroad[38]. This was initially due to the lack of good seed sources in certain years and the relatively low cost of seed imports compared to the cost of Dutch material. This material was often obtained from countries with different climatic and ecological conditions. Moreover, natural regeneration is seen as a preferred method for conserving the forest's genetic resources. Although natural regeneration is a common method in the Netherlands nowadays, this may not always be the most sustainable method. Natural regeneration from inferior seed stands will impact on the genetic quality of their offspring. In summary, this means that there is still a lot to be gained in terms of sustainable management of forest genetic resources in the Netherlands.

A number of organizations are involved in developing and managing forest genetic resources, including CGN (selection and testing of seed stands, gene bank), Alterra (tree improvement programmes), Board for Plant Varieties (National Register), the Ministry of Economic Affairs, Agriculture and Innovation, (EU FRM Directive and regulation of forest genetic resources, OECD scheme), Naktuinbouw (certification and EU Plant Health Directive), and the State Forest Service (management of seed stands, seed orchards and gene bank).

Utilization of conserved forest genetic resources and major constraints to their use

Conserved forest genetic resources are used for FRM purposes. FRM is used for planting trees for wood production, amenity and provision of environmental services (such as CO_2 sequestration and watershed protection) and restoration of forests for biodiversity conservation or restoration of hedges. Autochthonous plant material is used for the latter purposes in particular, derived from the gene bank and 'Source-identified' category basic material, for example in the use of autochthonous *Populus nigra* clones in restoration projects for riverine forests (e.g. along the

[37] FAO. 1993. Conservation of forest genetic resources in tropical forest management: principles and concepts (based on the work of R.H. Kemp, G. Namkoong and F.H. Wadsworth). FAO Forestry Paper No. 107. FAO of the United Nations, Rome, Italy.

[38] Kriek, W. 1981. *Natuurlijke verjonging en genetische kwaliteit van het Nederlandse bos.* Nederlands Bosbouw Tijdschrift 53 (9): 271 – 286.

Meuse)[39]. Since its establishment, the use of plant material from the gene bank in planting programmes has gradually increased. In the last three years production from the gene bank has increased to approximately 800,000 plants annually, and it is expected to increase further. Around 60% of these plantings comprise shrub species in forest edges.

The use of autochthonous germplasm derived from the gene bank in tree breeding is currently limited. As an exception, germplasm of *Populus nigra* has been used in hybrid poplar breeding since 1947. Examples of hybrid poplar clones that have native *P. nigra* as genitor are 'Degrosso', 'Koster', 'Polargo', 'Sanosol' and 'Spijk'.

Seventy-five per cent of the Dutch forest is multifunctional. Multifunctional forests fulfil various functions, such as recreation, biodiversity, biomass, wood production, CO_2 sequestration and watershed protection, although differences in emphasis occur from place to place. A major constraint in the use of conserved forest genetic resources in these forests is that not all functions are always compatible. For example, in forests with priority on nature development, the policy is no, or limited, management intervention, including harvesting activities. Such constraints to the use will vary from forest to forest, as the choice of the function of the forest is primarily a responsibility of the forest owner or manager.

Establishment of a birch provenance trial.

[39] Vanden Broeck, A.; Van Looy, K.; Jochems, H.; Storme, V. (2002) *Vlaams impulsprogramma natuurontwikkeling : mogelijkheden tot herstel van levensvatbare populaties zwarte populier (Populus nigra L.) langsheen de Grensmaas : VLINA 00/10 – Eindrapport*, Instituut voor Bosbouw en Wildbeheer: Brussels. 63, xvii pp.

Table 12. Seed and vegetative propagules transferred internationally per annum (Source: Naktuinbouw, 2010 data).

Species		Quantity of seed (Kg)		Number of vegetative propagules		Number of seedlings		Purpose
Scientific name	Native (N) or Exotic (E)	Import	Export	Import	Export	Import	Export	
Acer platanoides	E	185	60	n/a	n/a	11250	31050	FRM
Acer pseudoplatanus	N	700	10	n/a	n/a	40500	494250	FRM
Alnus glutinosa	N	40	14	n/a	n/a	105468	434350	FRM
Alnus incana	N	0	2	n/a	n/a	11500	0	FRM
Betula pendula	N	65	11	n/a	n/a	15500	179300	FRM
Betula pubescens	N	6	3	n/a	n/a	13750	247350	FRM
Carpinus betulus	N	587	321	n/a	n/a	537500	266100	FRM
Castanea sativa	E	1190	100	n/a	n/a	1500	95850	FRM
Fagus sylvatica	N	2148	100	n/a	n/a	135735	2454500	FRM
Fraxinus angustifolia	E	5	0	n/a	n/a	0	0	FRM
Fraxinus excelsior	N	148	123	n/a	n/a	417937	411190	FRM
Prunus avium	N	537	47	n/a	n/a	256275	383741	FRM
Robinia pseudoacacia	E	5	2	n/a	n/a	0	617830	FRM
Populus spp.	N/E	n/a	n/a	6384	0	n/a	n/a	FRM
Quercus robur	N	2560	40687	n/a	n/a	280025	2475390	FRM
Quercus rubra	E	3592	4961	n/a	n/a	109355	4150	FRM
Quercus petraea	N	4612	350	n/a	n/a	192765	1098825	FRM
Tilia cordata	N	229	52	n/a	n/a	41233	53025	FRM
Tilia platyphyllos	N	84	85	n/a	n/a	35015	21000	FRM
Abies alba	E	66	3	n/a	n/a	5000	0	FRM
Abies grandis	E	4	15	n/a	n/a	15950	0	FRM
Larix decidua	E	96	0	n/a	n/a	750	500	FRM
Larix x eurolepis	E	0	0	n/a	n/a	38760	0	FRM
Larix kaempferi	E	7	1	n/a	n/a	20501	0	FRM
Picea abies	E	69	7	n/a	n/a	80700	0	Christmas trees
Picea sitchensis	E	0	0	n/a	n/a	255	0	FRM
Pinus contorta	E	0	3	n/a	n/a	12035	0	FRM
Pinus nigra	E	6	14	n/a	n/a	12035	0	FRM
Pinus pinaster	E	0	0	n/a	n/a	2000	0	FRM
Pinus sylvestris	N	2	4	n/a	n/a	41625	0	FRM
Pseudotsuga menziesii	E	43	24	n/a	n/a	3150	0	FRM

n/a = not applicable.

The state of use and management of FRM: availability, demand and supply

Movement and trade of FRM between the Netherlands and other countries has a long history. The first import of Scots pine seed dates from the 16th century[40]. The main imports in the 17th and 18th centuries were conifer seeds. However, documentation on this is poor. After 1850 in particular there was great demand for planting material (Scots pine) needed for reforestation programmes. The current transfer of seeds and seedlings of the main species to and from the Netherlands is described in Table 12 based on import and export statistics. Information is based on data for 2010, which is representative of the past 5 years.

Table 12 shows that the Netherlands is predominantly a transit country for FRM, both for seeds and seedlings. This is clearly illustrated for the species sycamore, alder, birch, beech, sessile oak and sweet chestnut. Most of the seed for these species is imported, raised on nurseries and exported abroad again. For pedunculate oak, the Netherlands is predominantly an exporting country for seeds and seedlings, as is also the case for beech seedlings.

FRM in the Netherlands is traded under the Seeds and Plant Material Act 2005 (Zpw, 2005). This law implements Council Directive 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material within the EU. This directive ensures the supply of high quality FRM of the species concerned within the EU by stipulating that FRM may not be marketed unless the basic material from which it originates is in one of the four categories ('Source-identified', 'Selected', 'Qualified' and 'Tested') specified by the directive and that only approved basic material may be used for its production. All information on units of approved basic material in the Netherlands is held in the national register. A 'Catalogue of recommended varieties and provenances of trees' has been compiled, which includes the national list of basic material of species subject to Directive 1999/105/EC and the recommended list of basic material of so-called non-EU species. The main aim of this list is to inform users about the characteristics of the different varieties and provenances of trees that can be recommended. As a rule, reproductive material derived from basic material that is not listed in this catalogue cannot be certified and therefore cannot be marketed. Naktuinbouw is the designated authority responsible for issues concerning the regulation of marketing.

The most commonly used type of FRM, seed, is obtained from a variety of sources, including autochthonous stands, selected and tested seed stands or seed orchards. Most units of approved basic material for all 66 species currently listed in the catalogue are listed in the category 'Source-identified', followed by the category 'Selected'. Improved ('Qualified' or 'Tested') material is available for 14 tree species, mostly from seed orchards. Pedunculate oak is the only species for which a substantial amount of seed is sourced from tested stands. Hybrid larch is the only species for which 100% of the seeds are derived from seed orchards. Autochthonous populations are the only source of basic material for shrub species, and their reproductive material is certified in the category 'Source-identified'. Vegetative improved reproductive material (in the categories 'Qualified' and 'Tested') is only available for poplars (*Populus* spp.).

Table 15 gives an indication of the improved seed sources in the Netherlands. There are 36 seed orchards for 13 species. Sufficient material can be sourced from Dutch seed orchards, including for exotic species such as *Pinus sylvestris* and *Pseudotsuga menziesii*. No specific action is being taken to promote the use of improved FRM. The current seed production capacity is sufficient to meet the national and international demand for most species. Demand for the most important conifer species can be more than met by production from seed orchards. There is little demand for hybrid larch nowadays. There is a sufficient number of seed stands for the broadleaved species. Exceptions might be some noble hard wood species such as hornbeam, wild cherry and lime. No seed sources are available at all for *Tilia platyphyllos*, and only 'Source-identified' is available for *T. cordata*. For these species, seed from German or Belgian seed sources are also recommended for planting in the Netherlands. In the past ten years demand for autochthonous FRM has increased. A trend towards planting autochthonous trees and shrubs has emerged, especially among nature conservation organizations, water boards, provinces and municipalities. Lower demand for conifer species can currently be observed.

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[40] Tutein Nolthenius, C.E.H., 1891. *Handleiding voor het aanleggen en behandelen van grovedennenbossen*. Ned. Heidemij, Arnhem, 194 pp.

In general, seed from natural stands as well as from improved seed sources is harvested by private companies that sell the seed to local nurseries or internationally. There are about 2,700 tree nurseries that grow a wide variety of tree nursery products, of which only 50 specialize in raising forest planting material. The total export value of tree nursery products is about EUR 862 million, while the total import value is EUR 37 million (source: Productschap Tuinbouw, 2011). This shows that the international markets are more important for the Dutch tree nurseries than the relatively small domestic market. The main export countries are Germany, the UK and France.

There is no active deployment strategy for FRM in the Netherlands other than the listing of approved seed stands and seed orchards in the National Catalogue.

Trends in the development of FRM use

At present the preference is for small-scale forms of forest management, with a larger area left to natural regeneration, which unfortunately also occurs from seed sources of often inferior quality. Due to the increased focus on the nature function of the forest, many forest managers prefer minimal human intervention in forest management (e.g. planting) with the result that in general the demand for plant material is declining. The use of natural regeneration is also motivated by economic considerations, as replant subsidies are being abolished and natural regeneration is cheaper. Thus, on the one hand the availability of good quality FRM from seed orchards and seed stands for forestation has increased, while on the other a decrease in the use of FRM can be observed on account of the preference for natural regeneration. Forest managers have not yet adopted the view that different regeneration strategies could actually be very effectively combined, such as natural regeneration from a few seed trees together with seeding or planting from good quality FRM. Such an approach would have advantages both in terms of quality and quantity. Furthermore, the shift in species choice also plays an important role in changes in the use of FRM. Nowadays, planting of broadleaves such as beech and oak, preferably from local seed sources, is increasingly common, while the so-called 'forgotten' species such as sessile oak and lime are also being given more attention. A future trend could be a renewed interest in Douglas fir and larch for wood production.

The state of forest genetic improvement and breeding programmes

There was concern about the quality of the Dutch forests as early as the end of the 19th century. Around 1800 only about 4% of our land was forested and it was realized that this had to change. Large afforestation programmes were initiated. In particular, Scots pine from abroad (Latvia and Poland) was planted. These first plantings were very disappointing and the importance of a good seed source became apparent. In 1947 the De Dorschkamp Forest Research Institute was established under the auspices of the State Forest Service, with the aim of setting up forest research and tree breeding programmes. The aim of the breeding department at De Dorschkamp was to collect breeding material, mainly by selecting plus trees within existing forests, to test selected plus trees in progeny trials for the formation of seed orchards, to perform crossings and hybridization programmes in poplar, and to perform provenance tests. It established its first provenance trials for Larch and Scots pine in 1955. Since then over 110 provenance trials have been established for the major conifer and broadleaved species (Table 14). In the framework of IUFRO several series of international provenance experiments were established for a range of species in the 1960s and 1970s. The forerunner of CGN participated in these projects for Norway spruce, larch, Douglas fir, Scots pine, Sitka spruce, *Abies* spp. and poplar.

Collection of plus trees began in the 1950s. Between 1965 and 1990, 36 first generation seed orchards were planted with these phenotypically and genetically selected plus tree clones. In the 1960s, 1970s and early 1980s the emphasis was on conifer species. This changed in the second half of the 1980s, however, when the decision was taken to concentrate more on broadleaves: mainly oak, beech, alder and birch, with noble hardwood species such as wild cherry, sycamore and ash added shortly thereafter. The last seed orchard to be established in 1990 was for *Fraxinus excelsior*. Between 1960 and 1994, progeny trials were established mainly for the conifer species and some broadleaved species such as birch, ash, wild cherry and sycamore.

Besides provenance testing and seed orchard establishment, breeding for superior poplar clones was one of the main objectives. Selection within existing poplar material was common in the Netherlands even before World War II, but a breeding programme for poplar was started in 1948. Material was collected throughout the entire distribution range of *P. nigra*, *P. deltoides* and *P. trichocarpa* and controlled crosses were made. In total about 10,000 clones were tested in comparative trials all over the country, of which a number of clones were released.

However, in 1992 selection and breeding work was no longer one of the main objectives of the Institute, as biodiversity as such was receiving greater attention. Consequently, most improvement programmes stopped and nowadays selections are only carried out in earlier breeding material. However, provenance tests still continue today. As can be seen in Table 15, CGN has set up first-generation (clonal) seed orchards for a number of species. A clone bank for *Pinus sylvestris* (1 ha) was established in 1963.

A summary of the current status of the tree improvement programmes is given in Table 13. This is the result of about 50 years of research and development. In almost all species the breeding objectives are for good quality timber and adaptation to Dutch climatic conditions. Selection for timber quality and production capacity focuses on characteristics such as growth, stem straightness and good branching habits. Selection for adaptation takes survival and bud burst into account, as well as resistance against pests and diseases. In addition, clonal tests were established for a number of species (e.g. *Acer platanoides*, *Acer pseudoplatanus*, *Prunus avium*, *Ulmus* spp. and *Picea abies*) in order to test genotypes for non-forestry purposes such as their performance as roadside trees. More recently, a number of provenance tests have been established to compare autochthonous seed sources with regular used FRM.

Table 13. Forest improvement programmes for the major tree species in the Netherlands.

Species		Improvement programme objective					
Scientific name	Native (N) or exotic (E)	Timber	Pulpwood	Energy	MP*	NWFP**	Other
Abies alba	E	x					
Abies grandis	E	x					
Acer platanoides	E	x					Roadside trees
Acer pseudoplatanus	N	x					Roadside trees
Alnus cordata	E	x					
Alnus glutinosa	N	x					
Alnus incana	E	x					
Betula pendula	N	x					
Betula pubescens	N	x					
Fagus sylvatica	N	x					
Fraxinus excelsior	N	x					
Larix decidua	E	x					
Larix kaempferi	E	x					
Larix x eurolepis	E	x					
Picea abies	E	x	x				Christmas trees
Picea sitchensis	E	x					
Pinus contorta	E	x					
Pinus nigra ssp. laricio	E	x					
Pinus nigra ssp. nigra	E	x					
Pinus sylvestris	N	x	x				
Populus spp.	N/E	x	x	x			Roadside trees
Populus tremula	N	x					
Prunus avium	N	x					
Pseudotsuga menziesii	E	x	x				
Quercus petraea	N						
Quercus robur	N	x					
Quercus rubra	E	x					
Salix spp.	N	x					Roadside trees
Ulmus spp.	E						Roadside trees

* *MP: Multipurpose tree improvement programme.*
** *NWFP: Non-wood forest product.*

Table 14. Tree improvement trials.

Species		Plus trees	Provenance trials		Progeny trials		Clonal testing and development		
Scientific name	Native (N) or exotic (E)	Number	No. of trials	No. prov.	No. of trials	No. of families	No. of tests	No. of clones tested	No. of clones used
Abies alba	E		1	11					
Abies grandis	E		6	37					
Acer platanoides	N	36					2	26	
Acer pseudoplatanus	N	122	2	21	6	148	8	90	
Alnus cordata	E		2	3	5	41			
Alnus glutinosa	N	78	12	97	8	34			
Alnus incana	E		3	6	6	13			
Betula pendula	N	25	2	2	10	186			
Betula pubescens	N		2	16	5	18			
Fagus sylvatica	N		8	70	1	9			
Fraxinus excelsior	N	114	1	20	7	147	6	82	
Larix decidua	E	18					2	14	
Larix kaempferi	E	44					2	47	
Larix x eurolepis	E						1	1	
Picea abies	E	30	5	160	7	116	5	365	
Picea sitchensis	E		1	63	7	1			
Pinus contorta	E		4	129					
Pinus nigra ssp. laricio	E	30	4	11	1	14	1	13	
Pinus nigra ssp. nigra	E		4	7	1	11			
Pinus strobus	E						1	15	
Pinus sylvestris	N	204	10	90	19	563	2	339	
Populus spp.	E						109	6929	30
Populus tremula	N	12							
Prunus avium	N	28	1	11	4	25	12	72	1
Pseudotsuga menziesii	E	44	2	52			1	37	
Quercus petraea	N		7	27	3	7			
Quercus robur	N	56	30	127	15	49	1	61	
Quercus rubra	E		6	19					
Salix spp.	N		1	59			12	432	
Ulmus spp.	E						20	298	6

Table 15. Seed orchards.

Species	Seed orchards		
	Number	Generation *	Area (ha)
Acer platanoides	2	1	2.7
Acer pseudoplatanus	4	1	7.7
Betula pendula	1	1	0.2
Betula pubescens	1	1	1.5
Fraxinus excelsior	2	1	7.4
Larix x eurolepis	2	1	3
Picea abies	1	1	1.2
Pinus nigra ssp. laricio	1	1	1.4
Pinus sylvestris	15	1	14.8
Populus tremula	1	1	0.4
Prunus avium	2	1	1.6
Pseudotsuga menziesii	3	1	15
Quercus robur	1	1	4.5

* *Generation refers to the 1st, 2nd, 3rd, etc. breeding cycle.*

The clonal improvement programmes resulted in the selection of several clones both for forestry and non-forestry purposes, of which a few are now used as cultivars in the Netherlands and Europe. Plant Breeder's Rights have been granted for some of these cultivars. For example, Plant Breeder's Rights were recently granted for four Euramerican poplar clones: 'Polargo', 'Albello', 'Degrosso' and 'Sanosol'. An earlier released poplar clone from the Dutch breeding programme, 'Koster', was protected with Plant Breeder's Rights back in 1989 and is still successfully used in many European countries.

CGN has collected a large amount of data over the past decades of selection and breeding, such as on the origin and location of the plus trees and breeding material, and their performance in trials. For internal use, CGN manages a database of the field experimental trials including information on the locality and type of trial, the genetic resources tested and raw data on a range of traits measured. In this context, CGN has contributed to the EU-wide Treebreedex database, an online data management system which documents confidential metadata on the major tree breeding programmes for the EU tree breeding community (www.treebreedex.eu). This EU-funded project, which included 27 partners, aimed to start a pan-European virtual Forest Tree Breeding Centre focusing on conifers, poplar, ash, sycamore and wild cherry.

Table 16. Type of germplasm available (improved).

Species (scientific name)	Type of material	Available for national requests only		Available for international requests	
		Commercial	Research	Commercial	Research
Acer platanoides	Seed, scions	n/a	+	n/a	+
Acer pseudoplatanus	Seed, scions	n/a	+	n/a	+
Betula pendula	Seed, scions	n/a	+	n/a	+
Betula pubescens	Seed, scions	n/a	+	n/a	+
Fraxinus excelsior	Seed, scions	n/a	+	n/a	+
Larix x eurolepis	Seed	n/a	+	n/a	+
Larix decidua	Seed, scions	n/a	+	n/a	+
Larix kaempferi	Seed, scions	n/a	+	n/a	+
Picea abies	Seed, scions	n/a	+	n/a	+
Pinus nigra ssp. *laricio*	Seed, scions	n/a	+	n/a	+
Pinus sylvestris	Seed, scions	n/a	+	n/a	+
Populus tremula	Seed, scions	n/a	+	n/a	+
Prunus avium	Seed, scions	n/a	+	n/a	+
Pseudotsuga menziesii	Seed, scions	n/a	+	n/a	+
Quercus robur	Seed, scions	n/a	+	n/a	+
Populus ssp.	Cuttings	-	+	n/a	+

n/a = not applicable.

Both CGN and the State Forest Service can provide germplasm on request to researchers from the Netherlands or abroad for a number of species (see Table 16). The exchange of tree germplasm has increased during the past decades as a result of international collaboration and the establishment of EU trials. This international exchange is mostly based on bilateral agreements; however, in general, the movement of the material is poorly documented.

Needs and priorities

Awareness that planting stock should be genetically suited to the sites where it is planted is growing but could be further increased. A project supported by the government, about the importance of using good quality plant material, is currently under development. This agreement between producer organizations and users of FRM can be considered as an official ‘declaration of intention’ to improve the use of forest genetic resources in the short term. However, more initiatives to raise interest in the use of genetically appropriate plant material are needed. For example, the government requires suppliers to take the environment into account and is therefore developing criteria for sustainable procurement. One of these criteria is the use of approved material, which means that the government requires national and local government authorities to purchase at least 25% of their planting stock from the National Catalogue.

5. The state of national programmes, research, education, training and legislation

National programmes

No separate National Forest Programme exists in the Netherlands. However, a forest policy programme has been incorporated in the government's nature policy (see also below). Within the framework of the EU Forest Action Plan, a 'forest dialogue' has been initiated in the Netherlands. The 'forest dialogue' is intended to formulate a broadly supported national forest action plan in which actions are identified that will be undertaken by the different stakeholders. The stakeholders are the Ministry of Economic Affairs, Agriculture and Innovation, the Ministry of Housing, Spatial Planning and the Environment, provinces, municipalities and the forest sector itself.

As the Netherlands is a densely populated country, our forest policy is focused on multifunctional management to meet society's needs: nature conservation, recreation, landscape values and timber production. The other main objectives of the Dutch forest policy are sustainable management of the forests and expansion of the forested area. These policy objectives are outlined in a range of documents. Sustainable management of the forests is guaranteed by the Forest Act (1961). Under this law the forest area existing in 1961 must be maintained and, where possible, expanded. The other two objectives - multifunctionality and forest expansion - are not embedded in a legal framework. These are addressed in the most important policy document in terms of national forest policy, the 'Nature for People, People for Nature' programme[41]. This document confirms Dutch support for international commitments such as the Forest Principles, UNFF (United Nations Forum on Forests) and the Convention on Biological Diversity (CBD). Actions formulated in this document specifically for forests are as follows: forests must be managed in an economically feasible, sustainable manner, and long-term conservation of woodlands and further expansion of the forested area to more than 400,000 ha by 2020 will be continued. No explicit attention is given to timber harvesting policy in the 'Nature for People, People for Nature' programme, although the government indicates that timber harvesting is important within the framework of sustainable forest management and ensures that, in at least 70% of woodlands, sustainable timber production will be able to continue at levels similar to those of recent years. However, Dutch policy has evolved over the years and forests are now considered as an integral part of nature. In 2004 another policy document with relevance for nature – and thus also for forest policy – was published: the policy for rural areas ('*Agenda voor een vitaal platteland*, 2004) following the 'Nature for People, People for Nature' programme. The term 'forests' is no longer used in this policy document. The government's forest policy in relation to timber harvesting is also reflected in '*Visie op de Houtoogst*'[42], a document written in collaboration with the Wood Platform Netherlands. Their main conclusion is that timber harvesting and production should once again receive more attention.

The Dutch forest policy is facilitated by a few subsidies such as the nature management subsidy schemes 2000 (*Subsidie regelingen Natuurbeheer 2000*), based on the principle of multifunctionality, and the subsidy scheme for nature management by farmers (*Agrarisch natuurbeheer)*. Since the introduction of the Investment Budget for Rural Areas scheme (*Investeringsbudget Landelijk Gebied*, ILG) in 2007, nature policy, and thus forest policy, has been decentralized to the provinces. In the framework of the national policy, the 12 provinces have control over implementation and forest law enforcement, which they carry out together with other parties, including municipalities. The Ministry remains ultimately responsible.

In response to the requirements of the CBD, the Dutch government has developed a national policy on genetic resources entitled 'Sources of Existence', which was adopted by parliament in 2002[43]. The policy document covers the following topics: legislation and regulations, *in situ* and *ex situ* management, commercial and non-commercial

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41 LNV (2000), Nature for People for Nature, Policy document for nature, forest and landscape in the 21st century.

42 LNV/PHN (2005), *Visie op de houtoogst*. Wageningen, 25 pp.

43 LNV, VROM en OSW, 2002. Policy document Sources of Existence: Conservation and the sustainable use of genetic diversity. Ministries of LNV, VROM and OSW, The Hague.

applications of genetic resources, and international cooperation. In order to implement this policy, the government signed an agreement with the Centre for Genetic Resources, the Netherlands (CGN) to execute a work programme contributing to the conservation and utilization of genetic resources. These statutory research and other tasks cover crops, domestic animals and forest species. For forest genetic resources specifically, the programme provides for assistance with the management of the gene bank of forest trees and related documentation, support for *in situ* conservation of forest genetic resources, development of molecular characterization tools, policy support, and international collaboration within the European Forest Genetic Resources Programme (EUFORGEN).

The Netherlands has not established a formal national coordination mechanism that includes different institutions. The various actors actively engaged in conservation of forest genetic resources are listed below (Table 17). Traditionally, conserving forest genetic diversity was the responsibility of the State Forest Service, under which the De Dorschkamp Research Institute for Forestry and Landscape resided. This institute established working collections of genetically diverse material for a number of species for use in their selection and breeding work. In 2003, after adoption of the 'Sources of Existence' policy document, the conservation of forest genetic resources was integrated into the mandate of CGN, which was originally only responsible for plant genetic resources. Today both CGN and the State Forest Service are the main institutions actively engaged in the conservation of forest genetic resources.

CGN also functions as the National Focal Point for genetic resources within the CBD framework. CGN hosts a website providing an overview of genetic resources available in the Netherlands (www.absfocalpoint.nl).

Table 17. Institutions involved in conservation and use of forest genetic resources.

Name of institution	Type of institution	Activities or programmes	Contact information
CGN	Research	Research, collections, advisory and dissemination	www.cgn.wur.nl
Board for Plant Varieties	Independent governance body	Listing of basic material in national register	www.plantenrassen.nl
State Forest Service	(Semi) state	Collection management, *in situ* management	www.staatsbosbeheer.nl
Naktuinbouw	Independent governance body	Certification	www.naktuinbouw.nl
Bosschap	Industrial Board for Forest and Nature	Listing of forestry varieties and stands of non-EU species	www.bosschap.nl
Ecologisch Adviesbureau Maes	Private	Inventories, advisory	www.ecologischadviesburomaes.nl
Ecologisch Adviesbureau Van Loon	Private	Harvesting, advisory, inventories	-

The trend in support for forest genetic resources has become stronger over the past ten years. This has been accelerated by the implementation of the 'Sources of Existence' policy document and specific actions resulting from this policy such as the opening of the living gene bank for trees and shrubs in 2006. Today forest tree nurseries are increasingly using reproductive material derived from this gene bank to supply nature restoration projects.

Research, education and training

The budget spent on forest genetic resources research includes the State Forest Service's budget for maintaining the living gene bank and seed orchards (EUR 126,000 annually) and the forest genetic resource part of the Ministry's structural contribution to CGN for carrying out its statutory tasks (EUR 100,000 annually). Additionally, the Ministry finances the implementation of EU Directive 1999/105/EC regarding the movement of FRM through the production of the National List of Recommended Varieties and Provenances of Trees and related Value for Cultivation and Use (VCU) research with a total budget of EUR 177,000 per year. Other forest research financed by the Ministry is the Policy Supporting Research into nature, landscape and rural areas performed by the Wageningen University and Research Centre and the 'Multifunctional Forest Inventory Network' forest monitoring project (*Meetnet Functievervulling Bos*, MFV_{bos}).The MFV_{bos} collects data for answering international forest questionnaires published by bodies such as the EU and FAO.

Over the years part of the forest genetic research budget has been dedicated to the study of genetic diversity in autochthonous tree and shrub species using molecular and population genetic methods. Insight into the genetic diversity of the *ex situ* collections and the natural populations is used to support the main nature conservation organizations' management and conservation strategies. In the framework of EU-funded projects (Fairoak, Oakflow, Europop, Dynabeech and Evoltree), genetic diversity and the processes involved in maintaining genetic variation in natural populations have been studied within the species oak, poplar and beech. Alterra is currently coordinating the EU-funded project FORGER, which is focused on the sustainable management of forest genetic resources in Europe.

Wageningen University offers a three-year Bachelor course in Forestry and Nature Management and a two-year Masters programme in Forest and Nature Conservation. Both programmes focus on forests and natural areas in both an ecological and socio-economic context and address issues relating to nature conservation and natural resource management from related scientific fields. Forest genetic resources receive explicit attention in several courses, but are not addressed in courses specifically dedicated to the issue. Issues such as conservation of genetic resources in the Dutch context mostly relate to conservation of relict populations of trees and removal of unwanted (usually exotic) species and are currently properly addressed in courses within WUR programmes. No attention is paid to tree breeding aspects. Students who are interested in this topic may follow a minor programme at other universities.

The Van Hall Larenstein University of Applied Sciences offers a Bachelor course in Forestry and Nature management as a four-year programme, with a major in Forestry/Urban Forestry, International Timber Trade and Tropical Forestry. No specific modules on genetic resources are offered, but provenance issues are discussed in silviculture modules such as the Forest Management Plan in the second year. Genetic aspects of forest and nature management can be addressed in internship periods and the final thesis. Final theses on the major international timber trade sometimes address wood quality, sustainability and genetics (e.g. comparisons of different clones).

National legislation

To date, the Netherlands has not considered developing new legislation that regulates access and benefit sharing (ABS) of indigenous genetic resources in the Netherlands. Therefore, access to the country's genetic resources found *in situ* is essentially still unregulated and unrestricted.

Nature conservation in the Netherlands is defined in several laws: the Nature Conservation Act 1998, focusing on area protection; the Flora and Fauna Act 2002, protecting wild plants and animals; the Nature Protection Act 1928, created to maintain private estates; the Spatial Planning Act 2008, regulating the spatial component of the forest policy; and the Forest Act 1961, focusing on maintaining the forested area. Currently the government intends to simplify the nature conservation legislation by merging the Flora and Fauna Act, the Nature Conservation Act 1998 and the Forest Act into one act.

The Netherlands has implemented EU Directive 1999/105/EC, which sets out EU legislation on the marketing of forest reproductive material. Seed of the main forest species may only be marketed if it has been certified in accordance with the requirements of this directive and if the variety or stand in question appears on the National List of a Member State or in the EU Common Catalogue. The Netherlands has also adopted the Act of 1991 of the UPOV

Convention. Both the Forest Reproductive Material Directive and the protection of Plant Breeder's Rights are implemented in the National Seeds and Planting Material Act (2005). The Board of Plant Varieties is the responsible body for granting plant variety rights and approving basic material. There is also legislation on the subjects of intellectual property rights and biotechnology.

The Netherlands also participates in the Organisation for Economic Co-operation and Development (OECD) Scheme for the Certification of Forest Reproductive Material Moving in International Trade (2007) (www.oecd.org/tad/forest).

Additionally, the Netherlands Food and Consumer Product Safety Authority (nVWA) is responsible for implementing the forestry aspects of the EU Plant Health Directive (2000/29/EC) on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. Plant passports or phytosanitary certificates are issued by the designated inspection service, Naktuinbouw, under the responsibility of the nVWA. This Directive is implemented in Dutch legislation by the Regulation on the import, export and movement of plants (RIUVP) and the Regulation on the designation of harmful organisms 1998.
The needs for developing forest genetic resources legislation are prioritized as in Table 18.

Table 18. Needs for developing forest genetic resources legislation.

Needs	Priority level			
	Not applicable	Low	Moderate	High
Improve forest genetic resources legislation	x			
Improve reporting requirements	x			
Consider sanction for non-compliance	x			
Create forest genetic resources targeted regulations	x			
Improve effectiveness of forest genetic resources regulations	x			
Enhance cooperation between forest genetic resources' national authorities				x
Create a permanent national commission for conservation and management of forest genetic resources				x

Public awareness

Several initiatives have been taken in the past, including more recently, to give greater visibility to the forests and their genetic resources. In 1994 the former Ministry of Agriculture, Nature Management and Fisheries published a brochure entitled '*Inheemse bomen en struiken: geef ze een toekomst*' about the need to preserve Dutch indigenous tree and shrub species. CGN undertakes several activities designed to raise awareness among forest managers and the general public of the value of forest genetic resources. An example of this is the publication of the brochure '*Bomen aan den einder*' targeted specifically at the general public. This brochure highlights the history of the Dutch forests and reflects on the current conservation of the genetic material of Dutch indigenous trees and shrubs.

Other initiatives to share knowledge are implemented by various NGOs. Aequator, commissioned by the Board for Forests and Nature (Bosschap), regularly organizes field workshops to bring various experts including researchers, managers and policy makers together to exchange knowledge on nature management. Some of these field workshops are dedicated to identification and management of autochthonous trees and shrubs. Wikiforest, a group of members of the Royal Dutch Forestry Society (KNBV) and the Society for Tropical Forests (VTB), took the initiative to improve the information available on Wikipedia on forestry and nature. Topics that are addressed are the National

List of Recommended Varieties and Provenances of trees, autochthonous genetic resources, genetic quality of planting stock, and breeding of forest trees. The Seed and Plant Supply Committee of the Board for Forests and Nature is active in coordinating the balance between the demand and supply of good quality FRM.

Table 19. Awareness raising needs.

Needs	Priority level			
	Not applicable	Low	Moderate	High
Prepare targeted forest genetic resources information			x	
Prepare targeted forest genetic resources communication strategy			x	
Improve access to forest genetic resources information				x
Enhance forest genetic resources training and education			x	
Improve understanding of benefits and values of forest genetic resources				x

Needs and priorities

Knowledge transfer and public awareness of forest genetic resources deserve greater attention. At the same time, in today's urban society much knowledge about forests and their management has disappeared. Furthermore, forests can play an important role in plans resulting from the climate change debate and in meeting a larger part of the national demand for renewable resources in the future. Therefore, new ways of sharing knowledge and information should be better used, including with the aim of involving more stakeholders and communicating with them and the general public on the value, conservation and use of genetic diversity. Capacity building in the area of forest genetics in the form of training and education of forest managers needs more attention (see also Table 19).

Common hawthorn.

6. The state of regional and international collaboration

International agreements

The Netherlands has signed a number of legally binding agreements on the conservation and sustainable use of forest genetic resources. The most important of these are the international Convention on Biological Diversity (CBD), dealing with the conservation and sustainable use of biodiversity, including forest ecosystems; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); and the International Tropical Timber Agreement (ITTA 2006). The obligations arising from these conventions have been laid down in Dutch biodiversity policy.

At the EU and the pan-European level, several initiatives have been undertaken which are relevant to forest genetic resources. At the pan-European level, the Netherlands contributes to the Ministerial Conference on the Protection of Forests in Europe (MCPFE, now 'Forest Europe'). Forest Europe aims to develop common principles, criteria and guidelines for sustainable forest management.

The EU has launched the Action Plan 'Forest Law Enforcement, Governance and Trade – FLEGT'. This provides a number of measures to exclude illegal timber from markets, improve the supply of legal timber and increase the demand for responsible wood products. As an EU Member State the Netherlands is responsible for implementing Council Regulation (EC) No 2173/2005 and its implementing Commission Regulation (EC) No 1024/2008 on forest law enforcement governance and trade (FLEGT) regarding timber import controls to combat illegal logging. As a second step towards implementing the EU FLEGT action plan, the EU introduced legislation to ban illegally produced wood from the EU market, known as the EU Timber Regulation (Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010, laying down the obligations of operators who place timber and timber products on the market). The Regulation will enter into force on 3 March 2013 and will affect timber trade in all 27 EU Member States.

International collaboration

The Netherlands participates in a number of regional forest genetic resource based or thematic networks, which are listed in Table 20 below.

The Netherlands is currently participating in Phase IV (2010–2013) of the Bioversity European Forest Genetic Resources Programme (EUFORGEN). EUFORGEN is a collaborative programme among European countries to promote conservation and sustainable use of forest genetic resources. It serves as a platform for pan-European collaboration in this area, bringing together scientists, managers, policy-makers and other stakeholders. It was established in October 1994 as an implementation mechanism of Strasbourg Resolution S2 (Conservation of forest genetic resources) of the first Ministerial Conference on the Protection of Forests in Europe (MCPFE), held in France in 1990. The programme also helps implement other MCPFE commitments on forest genetic resources and relevant decisions of the Convention on Biological Diversity (CBD). The EUFORGEN Steering Committee, which is composed of National Coordinators from all member countries, is responsible for the programme. The Netherlands has been a member of EUFORGEN since the outset (1994). Its membership fees are included in CGN's statutory research tasks in respect of genetic resources. Within EUFORGEN the Netherlands has actively contributed to different networks and working groups. In particular, it has contributed to activities aimed at producing distribution maps and technical guidelines for a number of species. For the purpose of the EUFGIS information system it has provided data on Dutch autochthonous populations for the installation of a network of 'gene conservation units' within Europe and has contributed to producing minimum requirements and data standards for these dynamic gene conservation units.

The Netherlands is also represented in several IUFRO Working Parties such as ‘Poplars and Willows’, ‘Breeding and Genetic Resources of Pacific Northwest Conifers’, ‘Larch Breeding and Genetic Resources’ and ‘Genetics of *Quercus* and *Nothofagus*’.

Table 20. Overview of the main activities carried out through networks and their outputs.

Network name	Activities	Genus/species involved (scientific names)
Treebreedex	Information exchanges, development of technical guidelines, development of shared databases	*Pinus* spp., *Picea* spp., *Larix* spp., *Acer pseudoplatanus*, *Fraxinus* excelsior, *Prunus avium*, *Populus* spp.
Trees4future	Information exchanges, development of technical guidelines, development of shared databases	*Pinus* spp., *Picea* spp., *Larix* spp., *Acer pseudoplatanus*, *Fraxinus excelsior*, *Prunus avium*, *Populus* spp.
European Forest Genetic Resources Programme (EUFORGEN)	Information exchanges, development of technical guidelines, development of shared databases, establishment of gene conservation strategies, elaboration, submission and execution of joint research projects.	Forest tree species relevant to Europe
EUFGIS	Establishment of gene conservation units	Forest tree species relevant to Europe
Cost action E52	Information exchange, germplasm exchange	*Fagus sylvatica*
Cost action FP 1103 ‘FRAXBACK’	Information exchange	*Fraxinus excelsior*
IUFRO Working parties	Information exchange	*Populus* spp*., Salix* spp*., Larix* spp*., Quercus* spp*., Douglas fir, Abies grandis, Tsuga heterophylla, Thuja plicata, Pinus contorta*
International Poplar Commission (FAO)	Information exchange	*Populus* spp*. and Salix* spp.

Table 21. Needs for international collaboration and networking.

Needs	Level of priority			
	Not applicable	Low	Moderate	High
Understanding the state of diversity				x
Enhancing *in situ* management and conservation				x
Enhancing *ex situ* management and conservation				x
Enhancing use of forest genetic resources				x
Enhancing research				x
Enhancing education and training				x
Enhancing legislation				x
Enhancing information management and early warning systems for forest genetic resources			x	
Enhancing public awareness			x	

Needs

The Netherlands is responsible for the conservation of its own forest genetic resources, but international, and in particular European, collaboration delivers a great deal of added value for strengthening its national activities on conservation. Species that are native to the country receive priority for international collaboration and networking. Almost all of these species have natural distribution ranges that go beyond national borders, which makes European collaboration of utmost importance to understanding and conserving the existing genetic diversity of these species. Other needs for European collaboration relate to the use of genetic resources, including germplasm exchange or trade in FRM; research to assess the impact of climate change on the genetic diversity of tree populations; and delineation of provenance zones (see also Table 21).

International provenance trial of beech.

7. Access to forest genetic resources and sharing of benefits arising from their use

Access to forest genetic resources

Access to and equitable benefit-sharing in the use of genetic resources are important components of the Convention on Biological Diversity (CBD, Rio de Janeiro, 1992). The CBD emphasizes the fact that every country has sovereign rights to their genetic resources. Another agreement is that countries of origin will receive an equitable share of the benefits produced by the use of their genetic resources. The Dutch government supports the convention and ratified it in 1994. It has also ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The core element of the International Treaty is a multilateral system for access and benefit-sharing of genetic resources of approximately 60 cultivated plant species (Annex I of the International Treaty). CGN has brought all its Annex I collections into the Multilateral System of the International Treaty, including fruit tree (domesticated apple) collections. However, Dutch forest genetic resources are not within the scope of this multilateral system as these species are not listed in Annex I, which comprises only genera important for global food security. In October 2010, the 'Nagoya Protocol on access to genetic resources and fair and equitable sharing of benefits arising from their use' was established in addition to the Convention on Biological Diversity. The Netherlands signed the Protocol on 23 June 2011. The agreement aims at sharing the benefits arising from the use of genetic resources in a fair manner, including by providing appropriate access to genetic resources and by appropriate transfer of relevant technologies.

To date, the Netherlands has not introduced specific legislation that regulates access to genetic resources and benefit-sharing issues. The Dutch policy is that in principle, access to genetic resources found *in situ* in the Netherlands is free and that access, exchange and use of genetic resources can be based on existing public-law regulations, supplemented by private-law provisions. The EU is currently working on preparations for the implementation of the Nagoya Protocol and will probably soon introduce a proposal for legislative or regulatory action at the EU level. This will provide the Member States with a framework for meeting the requirements of the Nagoya Protocol. The Netherlands will implement this EU regulation and by that time the consequences for the forest sector in the Netherlands will be more evident.

The government promotes the development and use of codes of conduct, such as the code of conduct developed by the International Plant Exchange Network (IPEN) for botanical gardens. This IPEN network facilitates the exchange of plant material between the member gardens while respecting the Access and Benefit-Sharing regulations of the CBD. Gardens that wish to join the network must sign and abide by a code of conduct that sets out gardens' responsibilities for acquisition, maintenance and supply of living plant material and associated benefit-sharing. In the Netherlands over 21 botanical gardens, arboreta and zoological gardens have signed this code of conduct.

Sharing of benefits arising out of the use of forest genetic resources

The Netherlands has not established mechanisms for sharing benefits arising out of the use of forest genetic resources. The Netherlands has been exchanging forest genetic resources with other countries inside and outside Europe for many decades. An example is the exchange of a reference collection of poplar clones within the EUFORGEN poplar network in the 1990s. Exchange and access to germplasm was mainly intended for the purposes of research and establishing international (EU) trials. The exchange of material is poorly documented. However, this international transfer usually took place on the basis of bilateral agreements between research institutions or 'gentleman's agreements'. This non-bureaucratic attitude has certainly enhanced access to forest genetic resources within the forest tree breeding sector.

Trend

Breeding and selection strategies within the forest tree sector are changing over time, including in the Netherlands. For example, biomass production is becoming more important nowadays, while selection based on adaptation to climate change could enhance the use of material from southern European countries. Dutch forest genetic resources can and will be used in more northern European regions, for example material of several broadleaved species (e.g. oaks) in southern parts of Scandinavian countries (Sweden and Norway). Therefore, it is expected that the use of foreign forest genetic resources, and with that the need for agreed ABS arrangements, will increase.

Poplar clones.

8. The contribution of forest genetic resources to food security, poverty alleviation and sustainable development

Food security and poverty reduction

None of the Netherlands' native trees and shrubs are used for food security. The forestry sector in the Netherlands is not of great importance from either an economic point of view or for the labour market. The number of jobs in the forest sector is estimated to be approximately 2,200. When employment in supply companies and wood processing industry is included, the total number is estimated at 42,500. Turnover in the forestry sector directly related to harvesting and processing of wood from Dutch forests is approximately EUR 230 million[44]. However, forests play an important role in the recreation sector. Recreational activities in and around the forest are often essential for a tourist town or region and generate additional income for the local population.

Seed harvest in hedges.

44 http://www.probos.net/bosdigitaal/

Sustainable development

According to the Millennium Development Goals, the Netherlands can make progress in the field of sustainable development. Sustainable development pursues an ideal balance between environmental, economic and social interests, including the well-being of future generations. Forests and their forest genetic resources provide numerous ecosystem services, including habitats for plants and animals, wood production, soil and catchment protection, provision of reliable high-quality water supplies, recreational functions and provision of carbon sinks. Major concerns for the future are climate change, biodiversity loss and exhaustion of natural resources. Protection and sustainable use of forest genetic resources are the best possible solution for mitigating these major threats in the long run. The use of a large variety of species with high genetic diversity can be considered as the backbone policy for maintaining the Dutch forest area.

At the international level, the Netherlands supports the strengthening of cooperation in order to reach agreements on achieving sustainable management of forests worldwide. In particular, the Netherlands attaches importance to a sustainable wood chain by encouraging legal and sustainable timber logging and sustainability in international trade chains of natural resources in relation to deforestation.

Annex I
Bonaire, St. Eustatius and Saba

The Caribbean islands of Bonaire, St. Eustatius and Saba (BES islands) officially became municipalities of the Netherlands on 10 October 2010. The total land area of these islands is 328 km^2 (Bonaire: 294 km^2, St. Eustatius: 21 km^2, Saba: 13 km^2). They are covered by various land use types ranging from shrub land/thorny bushes to forest, agriculture and urban areas. The total population (2010) is 15,800 on Bonaire, 2,286 on St. Eustatius and 2,000 on Saba.

There is no well-developed forest sector on Bonaire, St. Eustatius or Saba. Trees have been exploited in the past for their timber and for firewood and charcoal production, resulting in nearly complete deforestation of the islands[45]. Today's forests are mainly used for recreation and are of ecological importance for their rich biodiversity.

The forests on the Windward Islands can be classified as secondary forests, showing signs of recovery from past exploitation and hurricane damage[46]. On Bonaire, large parts of the mangrove forest at Lac Bay are dying due to sedimentation of the bay and the forests are expanding further into the bay[47]. The low woody vegetation (thorny bushes, scrubs and cacti) is influenced mainly by grazing and clearing for development. Forests taller than 4 m occur only at higher elevations (above 250 m above sea level), mainly on The Quill (St. Eustatius) and Mount Scenery (Saba), reaching a total estimated area of 1,000 ha. Significant mangrove forest occurs only in Lac Bay, Bonaire, covering around 350 ha, with tree cover ranging from 15 to 95%[48]. Lower vegetation consisting of dry seasonal and dry evergreen formations cover most of the lower parts of all three islands.

The following forest types occur in the BES islands according to Stoffers (1956)[49] are:
- Rainforest (including pioneer forest and secondary forest) (E,S)
- Montane thicket (E,S)
- Elfin woodland (E,S)
- Evergreen seasonal forest (E,S)
- Semi-evergreen seasonal forest (E,S)
- Deciduous seasonal forest (E,S)
- Dry evergreen forest (E,S)
- Evergreen bush land (B,E,S)
- Thorny woodland (B,E,S)
- Croton thicket (E,S)
- Littoral bush land (E, S)
- Mangrove woodland (B)

Related to the prevalent climate, a range of forest types occurs on the BES islands. Bonaire is predominantly covered by dry bushy vegetation which is relatively low in stature. On the Windward Islands of St. Eustatius and Saba more moisture-loving forest types are found, especially on the higher parts of the volcanoes (The Quill on St. Eustatius and Mount Scenery on Saba).

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45 de Freitas, J., B. S. J. Nijhof, *et al.* (2005). Landscape ecological vegetation map of the island of Bonaire (Southern Caribbean). KNAW. Amsterdam, The Netherlands.

46 Rojer, A. (1997). Biological inventory of Sint Eustatius, Carmabi Foundation, Curacao.

47 Debrot, A., E. Meesters, *et al.* (2010). Assessment of Ramsar Site Lac Bonaire, June 2010. Report no. C066/10, IMARES, Wageningen UR.

48 de Freitas, J., B. S. J. Nijhof, *et al.* (2005). Landscape ecological vegetation map of the island of Bonaire (Southern Caribbean). KNAW. Amsterdam, The Netherlands.

49 Stoffers, A. L. (1956). The vegetation of the Netherlands Antilles. Doctoral thesis, Rijksuniversiteit Utrecht.

Bonaire

Bonaire's vegetation is heterogeneous in origin and includes many species from the 'tropical deciduous forest' and 'dry evergreen woodland'[50]. Nevertheless, the vegetation has changed dramatically with colonization by Europeans, who started to fell trees (mainly *Haematoxylon brasileto, Zanhoxylum flavum* and *Guaiacum officinale*) and introduced goats, donkeys, cattle and other grazing mammals. In the first half of the 19th century the forest cover had practically been reduced to zero[51]. For these reasons most of the current vegetation can be categorized as secondary and is dominated by a relatively small number of species, including thorny scrubs, low trees and cacti. Due to the high grazing pressure, many common grazing-resistant species have become more abundant on Bonaire: *Prosopis juliflora, Acacia tortuosa, Aristida adscensionis, Caesalpinia coriaria, Casearia tremula, Croton flavens*, and several species of *Euphorbia, Lantana* and *Opuntia*[52]. The salt/brackish mud flats in Lac Bay are to a large extent covered by a mangrove community represented by *Rhizophora mangle* and to a lesser extent by *Avicennia germinans* and *Laguncularia racemosa*.

Rare woody species on Bonaire include *Bursera simaruba, Convolvulus nodiflorus, Guaiacum sanctum, Guapira pacurero, Manihot carthaginensis, Maytenus tetragona, Pisonia fragrans, Serjania curassavica, Tabebuia billbergii, Tillandsia flexuosa* and *Zanthoxylum monophyllum*.

St. Eustatius

St. Eustatius has a diverse and species rich vegetation, ranging from dry thorny woodland dominated by drought tolerant species including mimosa (*Leucaena leucophala*) and casha (*Acacia* sp.) and cacti on the lower parts of the island to tall seasonal forest and cloud forest on the higher parts of the Quill volcano. Human influence is apparent in the form of remnant plantation trees and crops such as coffee (*Coffea arabica*), cinnamon (*Pimenta racemosa*) cacao (*Theobroma cacao*) and mamaya (*Mamea americana*). Dry evergreen forest is found on the outer rim of the crater above 350 m above sea level and includes genera like *Myrcia, Maytenus, Capparis* and *Guapira*. Between 250 and 350 m above sea level semi-evergreen and deciduous seasonal forests and montane thickets are found, depending on the location. The semi-evergreen seasonal forest occurs on the north-west slope of the Quill and is characterized by species like the cotton tree (*Ceiba pentandra*), white cedar (*Tabebuia heterophylla*), locust tree (*Hymenea courbaril*), yellow plum (*Spondias mombin*) and gum tree (*Bursera simaruba*). Deciduous seasonal forest occurs only on the southern and south western slopes. This type is dominated by mappo (*Pisonia subcordata*) and less frequently also mimosa (*Leucaena leucocephla*)[53].

Saba

Saba is covered by a wide variety of vegetation types including cloud forest, in which *Freziera undulate* and *Rapanea ferruginea* are the most common tree species, intermixed with tree ferns (*Cyathea* spp.) and the palm *Euterpe globosa*. In former times the greater part of the volcanic slopes between 420 and 650 m above sea level was covered by rainforest. Currently, these slopes are covered by secondary rainforest vegetation with typical rainforest species such as *Hirtella triandra, Psychotria undata, Chionanthus compactus, Cordia sulcata* and other remnants of the original forest. Relict species of past agriculture are common and include *Citrus limon, Persea americana, Annona* spp., *Artocarpus altilis, Coffea arabica, Theobroma cacao, Mammea americana* and *Psidium guajave*. Dry evergreen vegetation is found around the island from 0 up to 350 m above sea level, consisting of woodlands and croton thickets. Croton thickets form a low shrubby vegetation dominated by *Croton flavens*. Other species include *Lantana camara, L. involucrate, Jatropha gossypifolia, Urechites lutea, Opuntia dillenii* and *O. triacantha*. The zone slightly above these thickets in the western part of the island is occupied by dry evergreen woodland, with evergreen species from numerous genera (e.g. *Eugenia, Myrcia, Pithecellobium, Malpighia, Chiococca, Trema* and *Tabebuia*).

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[51] de Hullu, J. (1923). "Bonaire in 1816." West-Indische Gids 4: 505-511.

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[53] Rojer, A. (1997). Biological inventory of Sint Eustatius, Carmabi Foundation, Curacao.

Some remnant species indicating former human activities are also found, for example *Tamarindus indica* and *Annona muricate*[54 55].

Conservation of forest genetic resources

With regard to forest genetic resources, measures taken to safeguard genetic diversity on these islands tend to rely merely on species and habitat conservation. No information is available on specific *ex situ* conservation measures. In response to overexploitation, some small scale reforestation has taken place on the island of Bonaire using native plant material originating from Bonaire and Curacao.

[54] Augustinus, P. G. E. F., R. P. R. Mees, *et al.* (1985). Biotic and abiotic components of the landscapes of Saba (Netherlands Antilles) - Report of an integrated research in Botany and Physical Geography. Uitgaven 'Natuurwetenschappelijke Studiekring voor Suriname en de Nederlandse Antillen', no. 115.

[55] Stoffers, A. L. (1956). The vegetation of the Netherlands Antilles. Doctoraal proefschrift., Rijksuniversiteit Utrecht.

Abbreviations

ABS	Access and Benefit-Sharing
BES	Bonaire, St. Eustatius and Saba
CBD	Convention on Biological Diversity
CGN	Centre for Genetic Resources, the Netherlands
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
EHS	National Ecological Network
EL&I	Ministry of Economic Affairs, Agriculture and Innovation
EU	European Union
EUFGIS	European information System on Forest Genetic Resources
EUFORGEN	European Forest Genetic Resources Programme
FLEGT	Forest Law Enforcement Governance and Trade
FRM	Forest Reproductive Material
IPEN	International Plant Exchange Network
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
ITTA	International Tropical Timber Agreement
IUCN	International Union for the Conservation of Nature
IUFRO	International Union of Forest Research Organisations
KNBV	Royal Dutch Forestry Society
KVBC	Royal Boskoop Horticultural Society
MCPFE	Conference on the Protection of Forests in Europe
NGO	Non-Governmental Organization
NVBT	Dutch Botanical Gardens Foundation
nVWA	Netherlands Food and Consumer Product Safety Authority
OECD	Organisation for Economic Co-operation and Development
PGRFA	Plant Genetic Resources for Food and Agriculture
UNFF	United Nations Forum on Forests
VCU	Value for Cultivation and Use
VTB	Society for Tropical Forests

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