THE SECOND REPORT ON THE STATE OF THE WORLD'S FOREST GENETIC RESOURCES

COUNTRY REPORT

ICELAND

This country report was prepared as a contribution to the FAO publication, *The Second Report on the State of the World's Forest Genetic Resources*.

The country reports had two elements: (1) an online questionnaire to gather data and information on forest genetic resources; and (2) a complementary written report. For the written reports, countries were invited to follow the structure of the global report and reporting guidelines adopted by the Commission on Genetic Resources for Food and Agriculture at its Seventeenth Regular Session in 2019.

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Photo: Pétur Halldórsson

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skógræktin
ICELANDIC FOREST SERVICE

The Icelandic Forest Service is responsible for this country report which is prepared as a contribution to the FAO publication, The Second Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO.

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

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The Icelandic Forest Service

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Executive summary

The original Icelandic birch forest (forest and shrubs) covers about 152.000 ha and planted forest about 42.000 ha. The total forest and woodland cover is today slightly less than 2% of total land area and is only 5-8% of the original forest cover when the settlement took place. Other native tree species which belong to the birch forest are rowan (*Sorbus aucuparia*), aspen (*Populus tremula*), tea-leaved willow (*Salix phylicifolia*) and common juniper (Juniperus communis). The willow and the juniper are common all over the country and genetic variation is thought to be high. The rowan can be found in many places but usually only as single trees.

Downy birch (*Betula pubescens*) was the most planted species in 2019 and is together with rowan the only native species planted for forestry. Sitka spruce (*Picea sitchensis*), Siberian larch (*Larix sibirica*), lodgepole pine (*Pinus contorta*) and black cottonwood (*Populus balsamifera ssp. trichocarpa*) are the four other commercially important species. Those 6 most planted tree species will be prioritized for genetic conservation and breeding. Other tree species which are considered as important in the future are Douglas fir (*Pseudotsuga menziesii*), European larch (*Larix decidua*) and subalpine fir (*Abies lasiocarpa*). All exotic tree species mentioned above are preserved in provenance trials, clonal tests and archives or seed orchards.

An inventory of the Icelandic birch forest was completed in 2014. The area with natural birch forest is increasing, but the future expansion will depend on changes in the climate and land use. There is one in situ conservation unit for birch (Betula pubescens) which is in Skuggabjörg, North Iceland, registered in the EUFGIS database. Another important conservation unit for birch is Bæjarstaður in South-East Iceland. Bæjarstaður has been the most planted provenance in Iceland for a long time. Ex-situ conservation of the native birch is in provenance trials and in well documented stands with the most important provenances. The conservation is done by the Forest Service. All known Icelandic clones of aspen are conserved in clonal archives. Important exotic tree species are conserved in provenance trials and Black cottonwood is conserved also in clonal archives. Selected clones of Sitka spruce, subalpine fir, Siberian larch and European larch are conserved in seed orchards and that is the plan for lodgepole pine too.

Survival, fast growth, minimal frost damage and straightness are the most important traits in Icelandic breeding programs. Selection of clones is partly based on provenance trials but also on selected clones within stands with the best provenance. The breeding work is still in first generation for all tree species and progeny tests have only been realized for black cottonwood and Siberian x European larch.

The Nordic countries have cooperated formally in the forest genetics area for the last fifty years. Today this cooperation in forestry is in working groups within Nordic Genetic Resource Center (NordGen).

Both native and planted forest are well registered today with coordinates and information about origin. Documentation of provenance trials, clonal archives, orchards with rare genetic material and promising seed stands is ongoing. The overall goal is to have a conservation plan, clonal archives, and seed orchards/seed stands for at least the 10 most economically important tree species in Icelandic forestry in the year 2026.

Part 1: The contributions of forest genetic resources to sustainable development

Chapter 1. Value and importance of forest genetic resources

The forest cover in Iceland when the country was settled around the year 870 is estimated to have been 25-40 % with birch and willow. In the beginning of the 20th century only 1 % of Iceland was covered with degraded remnants of the original birch forest. The remaining forest was in poor condition and suffered from lack of regeneration. The first legislation to conserve remaining forest and to combat soil erosion was enacted in 1907. The original forest has value for recreation and is also an important ecosystem but its value as a timber resource is low. The forest is important in dry areas with frequent volcanic activity and ash fall to prevent soil erosion. Some provenances of Icelandic birch have been more important than others for general use in afforestation all over the country, especially those from the southeast of Iceland.

Exotic tree species have been planted in Iceland since the year 1899 and their importance in afforestation has been increasing. Genetic research and appropriate choice of adapted material, based on provenance trials, has always been important in Icelandic forestry. Since 1970 exotic tree species have been planted for timber production by farmers on former grazing land. This forest is now becoming a valuable timber resource and a timber industry will develop in coming years based on those forests and the continuous plantings of exotic tree species after 1990. New forests with various tree species have also been established close to urban areas for recreation purposes and have a high value as such.

The use of the Icelandic birch and the five most important exotic tree species is based on provenance trials. The genetic variation in the exotic species is conserved ex situ, usually well distributed around the country. Seed orchards with selected elite clones have only been established for four species but the aim is to offer seed from seed orchards with selected clones for all important tree species used in forestry. Good knowledge about the physiology of various genetic material will help to select well adapted material for both present and future climate. The genetic variation can be found in provenance trials and in well documented stands all over the country.

Part 2: State of diversity in forests and woodlands

Chapter 2. State of forests

The original Icelandic birch forest (forest and shrubs) covers about 152.000 ha and planted forest about 42.000 ha (data from 2017). Figure 1. shows how these two forest types are distributed within the country.

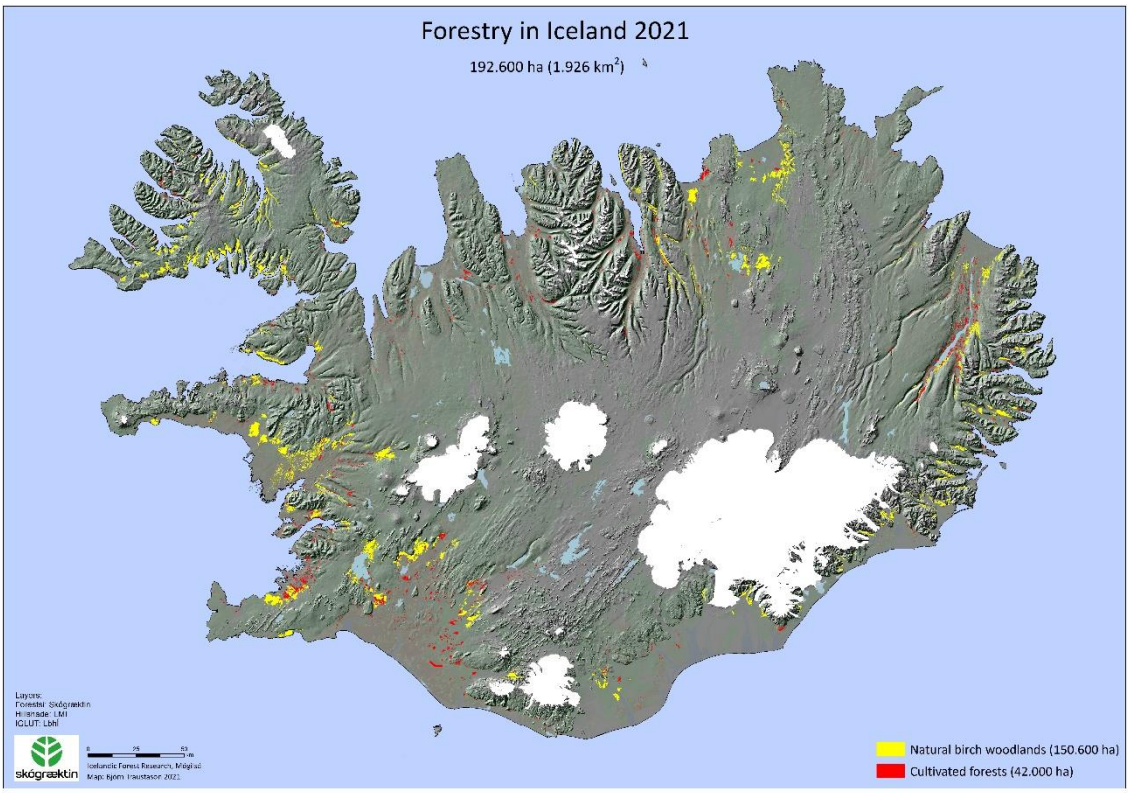

Figure 1. Distribution of natural (green) and planted (red) forest in Iceland in 2017.

The total forest and woodland cover is today slightly less than 2% of total land area and is only 5-8% of the original forest cover when the settlement took place. Deforestation resulted from various activity of the inhabitants, such as clearing to create grazing land, need for firewood/charcoal and free-roaming livestock grazing. Cold periods, in combination with intensive use of firewood and hard grazing stress on vegetation, led to soil erosion and only 1% forest cover today. The birch forest has the capacity to regenerate and spread by seeding from present forest where grazing is under control. Experience shows that even moderate grazing pressure is enough to exclude regeneration by seed in birch. The density and distribution of sheep will decide where and how fast the birch forest area will increase from present seed sources. Generally, the natural birch forest is now increasing in area and the genetic variation is probably stable.

Planted forest has mostly been financed by the state. Since 1970, farm forestry has been subsided by the state where the aim is to establish productive timber forest, mostly with exotic tree species. Other afforestation programs have also been initiated, subsidized by the state, to establish forests for recreation and soil protection. The aim of the afforestation has changed from timber production to be more focused on CO_2 sequestration in recent years. The state and companies/organizations will likely finance future afforestation programs with CO_2 sequestration as the main goal.

To meet the goal for high CO_2 sequestration and timber production, the emphasis will be on use of fast-growing genetic material of exotic species, especially at low elevations, and selected native birch provenances will be used on more marginal land for a combination of CO_2 sequestration and soil conservation/restoration benefits. The conifers are not so sensitive to sheep grazing and will not be as dependent on protection as the birch forest.

The public in Iceland is positive towards increasing forest cover and interest from authorities, companies and farmers is increasing, driven forward by the state policy to combat climate change.

The Icelandic Forest Service will strive to obtain genetic forest material of high quality with establishment of seed orchards with selected clones for present and future climate with emphasis on the healthy and productive material.

Chapter 3. State of other wooded lands

The birch forest is divided into three height classes, 0-2 m, 2-5 m and >5 m with areal size 107300 ha, 41300 ha and 2000 hectares respectively. The lower classes are mostly found in higher elevations and/or at windy and colder sites close to the ocean. All height classes can serve as protection for the soil and as birch forest ecosystems, but the highest forests are the most valuable for recreation. For all types, sheep grazing is the main threat to regeneration, and in time, risk of reduction of the genetic variation. Small and isolated birch populations might be at highest risk of being destroyed or disappearing over time, especially on private land where protection can be complicated for the authorities. Other native tree species which belong to the birch forest are rowan (*Sorbus aucuparia*), aspen (*Populus tremula*), tea-leaved willow (*Salix phylicifolia*) and common juniper (*Juniperus communis*). The willow and the juniper are common all over the country and genetic variation is thought to be high. The rowan can be found in many places but usually only as single trees, often regenerating by seed from gardens in the nearby village. Only some of the genetic material of rowan originates from Iceland, since the importation of seed was frequent and widespread during the early 20th century, and the genetic variation is not known. Only a few clones of aspen have been found and those are conserved in clonal archives. Those clones are too few to be base material for sustainable aspen forest.

Chapter 4. State of diversity between trees and other woody plant species

About 3.5 million seedlings were planted in Iceland in 2019 which is slightly more than during the last four years before (figure 2). In the Icelandic forested area, there are 10 native woody species, including both trees and shrubs. In addition, about 640 tree and shrub species have been included in experiments testing for their usability, 19 tree species have shown acceptable adaptation to be useful in forestry.

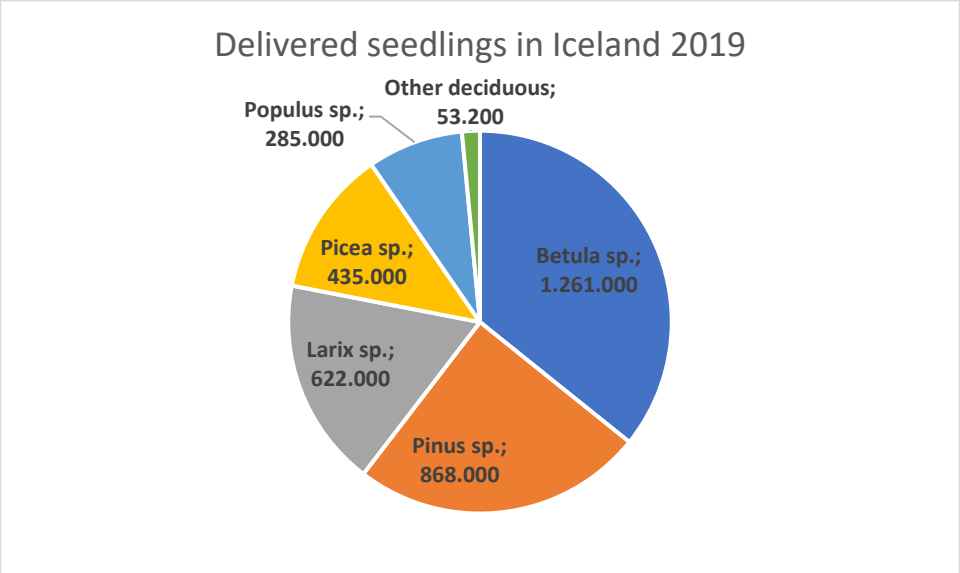

Figure 2. Number of seedlings of various genera, planted in Iceland 2019.

Downy birch (*Betula pubescens*) was the most planted species in 2019 and is together with rowan (*Sorbus aucuparia*) the only native species planted for forestry. Sitka spruce (*Picea sitchensis*), Siberian larch (*Larix sibirica*), lodgepole pine (*Pinus contorta*) and black cottonwood (*Populus*

balsamifera ssp. trichocarpa) are the four other commercially important species. Those 6 most planted tree species will be prioritized for genetic conservation and breeding. Other tree species which are considered as important in the future are Douglas fir (*Pseudotsuga menziesii*), European larch (*Larix decidua*) and subalpine fir (Abies *lasiocarpa*). All exotic tree species mentioned above are preserved in provenance trials, clonal tests and archives or seed orchards. A strategy on how to conserve the genetic variation of introduced species is to be made in the future. Old provenance trials can be thinned to preserve maximum genetic variation. Other alternatives are thinning to preserve the best genetic material as possible breeding populations for the future or thin it for temporary seed production.

Chapter 5. State of diversity within trees and other woody plants species

An inventory of the Icelandic birch forest was completed in 2014, and all natural or semi-natural stands are now known and mapped. The area with natural birch forest is increasing, but the future expansion will depend on changes in the climate and land use, as grazing by sheep is preventing their expansion. There is one in situ conservation unit for birch (*Betula pubescens*) which is in Skuggabjörg, North Iceland, registered in the EUFGIS database. Another important conservation unit for birch is Bæjarstaður in South-East Iceland. Bæjarstaður has been the most planted provenance in Iceland for a long time. Breeding material of birch, named Embla, is mostly based on parent material originated from Bæjarstaður. Nine provenance trials including 50 provenances have been established across the country. These are mainly established for breeding purposes but might be used as ex situ conservation units in the future. The distribution of rowan stands is currently not known, and they often appear as single trees in birch forest stands. Recently they are found more often in new larch and spruce forest stands, most likely spread by birds from gardens and shelterbelts. In horticulture, both Icelandic and Danish/Norwegian sources of rowan have been used, which pose difficulties if one would like to find the origin of the trees spreading from planted stands in the future. There is no ongoing systematic conservation in rowan, but selection of plus trees has been made for breeding, and progeny testing is ongoing. Inventory of rowan in Iceland will be carried out during next two years to get a better platform for an efficient conservation strategy. To date, five (+ possibly two more) natural clones of aspen (*Populus tremula*) have been discovered, as well as three clones of Danish origin. The natural clones are found on private or public properties and most of them have been vegetatively propagated by tissue culture and are today conserved ex situ in clonal archives. Most of the original clones are in areas with little or no pressure from grazing animals.

Part 3: State of forest genetic resources conservation

Chapter 6. In situ conservation of forest genetic resources

Monitoring of the present native birch forest gives opportunity to act if the forest is decreasing because of environmental stress, overgrazing or by construction projects. Most of forest land is in private ownership so it can be difficult to stop unsustainable use of the forest. A permit is needed for forest clearing. The native, Icelandic birch and important exotic tree species are conserved in provenance trials where clones for breeding and seed production are selected. The first protection of remaining forest started after 1900. Today, the authorities try to focus on small forest areas which are threatened by diverse stress and larger areas which are environmentally or economically important. Fencing and protection of birch forest has mostly been carried out by the Forest Service and forest associations (NGOs). Forest genetics and use of adapted genetic material has been an important part of Icelandic forestry since the afforestation started 120 years ago and will continue to be in the future.

Chapter 7. Ex situ conservation of forest genetic resources

Ex-situ conservation of the native birch is in provenance trials and in well documented stands with the most important provenances, often also used for seed collection. The conservation is done by the Forest Service but sometimes on private land. Other native tree species are not conserved as well as the birch. All known Icelandic clones of aspen are conserved in clonal archives. Some elite clones and their progenies of rowan can be found in clonal archives and in small trials but the genetic variation and the distribution of rowan is not well-known. Tea-leaved willow and common juniper are not conserved systematically because they are very common, of low economic importance and usually not forest trees. Important exotic tree species are conserved in provenance trials. Black cottonwood is conserved also in clonal archives. Selected clones of Sitka spruce, subalpine fir, Siberian larch and European larch are conserved in seed orchards and that is the plan for lodgepole pine too. Seed orchards of Sitka spruce, subalpine fir and lodgepole pine were established in Taraldsöy, West-Norway in 1974, based on elite material in Iceland.

Part 4: State of use, development and management of forest genetic resources

Chapter 8. The state of use

The forest conservation, breeding programs and development of improved forest material is carried out by the Icelandic Forest Service. Production of seedlings is done by private companies, using reproductive material, accepted by the Forest Service. Use of the best possible material for variable purposes and locations is important, considering the rather harsh and variable Icelandic environment. Good knowledge about the genetic material is therefore essential in Icelandic afforestation to secure success in survival of planted seedlings. A priority in the breeding work will be to develop well adapted genetic material of economically and environmentally important native and exotic tree species for both present and future climate. The capacity in genetic research and breeding might increase with increasing importance of CO_2 sequestration globally and growing industry, based on forest products, in Iceland. General recommendations on the use of forest genetic resource are given today to all actors in Icelandic forestry. Until fairly recently, a high proportion of the reproductive material has been imported as seed, mostly of provenances that have been doing well in Icelandic trials. The aim is to be self-sufficient in adapted forest reproductive material in the future for all main tree species. This will be done by collecting seed from seed orchards and from well thinned, selected stands.

Chapter 9. The state of genetic improvement and breeding programs

Survival, fast growth, minimal frost damage and straightness are the most important traits in Icelandic breeding programs. Selection of clones is partly based on provenance trials but also on selected clones within stands with the best provenance. The breeding work is still in its first generation for all tree species and progeny tests have only been realized for black cottonwood and Siberian x European larch. Because of the harsh, cool growing conditions in Iceland, survival always has the highest priority in breeding programs. Genetic research and breeding work are mostly done by the Icelandic Forest Service. Icelandic forestry is today moving from direct use of best provenances to use of first generation seed from orchards, based on selected clones. The next step will be to start progeny tests on the material from the seed orchards and then establish new orchards with updated clones. New accessible production technology might increase the possibilities to combine vegetative and seed propagation to lower the number of seed needed and maximize the result from the breeding work directly into the production.

Chapter 10. Management of forest genetic resources

Forest management in Iceland is not intensive and is not assumed to have significant effect on the genetic variation of the forests. Earlier, the largest trees in the birch forest might have been selected to be used for building or firewood. In thinned birch forest today, the largest individuals are usually conserved and kept as seed trees. Generally, in thinning, the largest and healthiest trees are saved to grow further so we assume that well treated and thinned stands will give progenies which are better adapted to local climate than the first generation of exotic tree species in Iceland. Over the coming years, Icelandic seed orchard material and well silviculturally thinned stands with tested and accepted provenances, will be prioritized as reproductive material.

Part 5: State of capacities and polices

Chapter 11. Institutional framework for the conservation, use and development of forest genetic resources

The Icelandic Forest Service is responsible for management of forest genetic resources in Iceland. Registration of all important forest genetic resource sites, such as provenance trials and valuable plantations with promising growth and health, is ongoing. The register is, among other things, based on information about origin of the plant material, the ownership of the forest and geographic coordinates. Most of the provenance trials and older plantations are in areas managed by the Forest Service. The purpose of the registration is to keep an overview of the genetic resources, continue with genetic research of the trials, make a conservation plan with emphasis on economic importance and to maximize genetic variation. Research and conservation of forest genetic material will continue to have high priority in Icelandic forestry.

Chapter 12. International and regional cooperation on forest genetic resources

The Nordic countries have cooperated formally in the forest genetics area for the last fifty years. Today this cooperation in forestry is in working groups within Nordic Genetic Resource Center (NordGen). The Icelandic interest has mostly been in testing of exotic tree species. Some Nordic joint provenance trials have been established with North American tree species. Iceland has also tested provenances of Scots pine, Norway spruce and silver birch from the Nordic countries. Buying forest seed from the Nordic countries has always been important for Icelandic forestry. Two programs started recently with seed orchard material from our Nordic neighbors, one with lodgepole pine and Scots pine from Sweden and second with silver birch from Finland. A field test was established in 2020 with about 30 clones of black cottonwood, selected in Iceland. The sites are in Iceland, Faroe Islands and Greenland in a joint trial. Iceland is member of Euforgen which gives important contacts and inspiration to the breeding- and conservation work of the forest material.

Part 6: Challenges and opportunities

Chapter 13. Recommended actions for the future

Both native and planted forest are well registered today with coordinates and information about origin. Documentation of provenance trials, clonal archives, orchards with rare genetic material and promising seed stands is ongoing. This information will soon be available for the forest sector in Iceland in 2021 and be the basis for a conservation plan. The conservation plan should aim to take care of the genetic variation in provenance trials for various exotic tree species and furthermore, take care of the most promising clones in seed orchards and clonal archives as reproductive material for Icelandic forestry. Conservation of the native birch forest should aim to secure the natural genetic variation in situ by protection of birch stands, threatened by grazing, erosion, or other stress, but also take care of the largest and environmentally most important forest areas. The economically most

important genetic material of birch should be kept in seed orchards and clonal archives for further use in breeding and for production of seed. The overall goal is to have a conservation plan, clonal archives, and seed orchards/seed stands for at least the 10 most economically important tree species in Icelandic forestry in the year 2026. There is good understanding in Iceland for the importance of well adapted forest material. The expertise in forest genetics at the Forest Service has been ample and the conservation work will continue there in foreseeable future.

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