Icelandic Forest Service
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FORESTRY
IN A TREELESS LAND
2017

skógræktin

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Among the first things that visitors to Iceland usually notice are that it is not as warm as where they came from and there is a lack of forests in the landscape. Logically, they connect these two facts and come to the conclusion that Iceland is too cold for forests. This impression is often reinforced when they see the "forests" of low-growing and crooked native birch. However, over a century of forestry has proven that this is not the case, that it is past land-use and not climate that explains the treeless landscape. In fact, forests grow as well in Iceland as they do in parts of the world where forestry is a major industry.

As much of Iceland was before settlement.

Forest history

Fossil evidence indicates that Iceland was generally forested during the mid to late Tertiary (5-15 million years ago), with tree genera including Sequoia, Magnolia, Sassafras, Pterocarya and many others, indicating that the climate was warm-temperate. Beech (*Fagus sp.*) forests were very common for a time. By the late Pliocene, shortly before the onset of Pleistocene glaciations, boreal-type forests of pine, spruce, birch and alder predominated, indicative of a cooler climate. The fossil evidence for these forests is found in West and East Iceland but the forests, in their time, grew in the central volcanic belt, where they were preserved and fossilised between layers of lava. Tectonic movement has since brought them to where they are now, the oldest being farthest east and west.

With succeeding glaciations, the Icelandic flora became ever more species-poor. Pines survived the first few glacial periods up to about 1.1 million years ago and fossil evidence of alder is found during interglacials to about 500,000 years ago. The only forest forming tree species to return to the present interglacial is downy birch (*Betula pubescens*). Other native tree species found in Icelandic forests are rowan (*Sorbus aucuparia*), which is uncommon, and the extremely rare aspen (*Populus tremula*) found naturally in only 6 locations, along with abundant tea-leaved willow *(Salix phylicifolia*), which is usually a shrub but occasionally reaches tree size. In fact, all of these species more often grow as shrubs rather than trees in Iceland and none of them ever get very big, roughly 15 meters in height being the maximum for the birch, rowan and aspen.

At the time of human settlement almost 1150 years ago, birch forest and woodland covered 25-40% of Iceland's land area. The relatively tall (to 15 m) birch forests of sheltered valleys graded to birch and willow scrub toward the coast, on exposed sites and in wetland areas and to willow tundra at high elevations.

As in agrarian societies everywhere, the settlers began by cutting down the forests to create fields and grazing land. Sheep were important as a source of wool from the outset, but by about 1300 they had become a staple source of food for Icelanders as well. At the same time, the Catholic Church (also the political power at the time) started obtaining woodland remnants, a clear indication that they had become valuable resources because of their increasing rarity. Sheep grazing prevented regeneration of the birchwoods after cutting and the area of woodland continued to decline. A cooling climate (the little ice age) is sometimes cited as a possible cause for woodland decline as are volcanic eruptions and other types of disturbance, but on closer inspection they can not explain the overall deforestation that took place. Cooling temperatures might have lowered tree line elevation, but they do not explain deforestation of the lowlands, where temperatures have been sufficient for birchwoods throughout historical times. Natural disturbance is sporadic and limited in area and thus cannot account for the permanent destruction of 95% of the original forest cover. In Iceland as elsewhere, regeneration failure due to livestock grazing is the principal cause of deforestation.

Traditional forest use and forest decline

The birchwoods were important as a source of fuel wood, building material and livestock fodder, but the most important forest product was charcoal, needed to smelt iron and make iron tools. The need for charcoal was finally alleviated in the latter half of the 19th century, when steel tools and farming implements began to be imported. However, wood was used for fuel until as late as the 1940s, both for cooking and heating the new wood frame and concrete houses, which were colder than the sod homes that Icelanders lived in before.

Birch fuelwood ready to bake pizzas.

However, the main use of the woodland remnants still found in Iceland in the 19th and 20th centuries was for livestock (mostly sheep) grazing and fodder production. Increased cultivation of hay fields during the mid 20th century led to a reduction in winter browsing of woodlands but summer browsing pressure continue to increase. It wasn't until the late 1970s that overproduction finally led to a quota system for sheep and dairy production and a reduction in sheep numbers.

The extent of Icelandic birchwoods probably reached a post-glacial minimum of less than 1% of total land area around the mid 20th century, perhaps even less than 0.5%. By that time, several woodland remnants had been protected from grazing and birch had started to spread within the enclosures. Afforestation by planting had also started. It is difficult to state exactly when net deforestation changed to net afforestation but it was probably some time between 1950 and 1980.

Today, birchwoods are not economically important as a source of wood or fodder, although over 200 tonnes of fireplace logs are produced annually. Again, after a 70 year hiatus, birch is being used as cooking fuel as well, this time in restaurants for baking pizzas. Some birch forests are popular recreation areas and they are recognised as being important form an ecological perspective as remnants of an ecosystem that once covered much of Iceland. They also act as sources of forest-related plants, animals and fungi to colonise afforestation areas.

One of the first tree nurseries in Iceland, established in 1903. The photo was taken by Christian Flensborg in 1905-1907.

Forestry

Beginnings and protection 1899-1950

Organised forestry is considered to have started in Iceland in 1899 with the planting of the Pine Stand at Thingvellir. Three Danes; merchant marine captain Carl H. Ryder who perceived the problems inherent in having no forest resource, forestry professor Carl V. Prytz who provided expertise and Christian E. Flensborg, a young forester who did most of the work, were instrumental in initiating forestry efforts in Iceland and lobbying the parliament to adopt a forestry and soil conservation act. It was adopted in 1907 and the Icelandic Forest Service (IFS) was established in 1908.

After an early phase of experiments with exotic tree species, forestry efforts largely focused on protecting birch woodland remnants during the first half of the 20th century, with several forest areas being acquired by the IFS for that purpose. They, along with more recently acquired afforestation areas comprise the National Forest system today. Protection entailed enclosing the woodland areas in a fence to exclude sheep, a practice still necessary today for all afforestation areas, due to uncontrolled summer grazing.

Gaining experience with planting 1950-1990

Since about 1950, emphasis has been on afforestation through planting trees. Planting by forestry societies and the IFS increased greatly during the 1950's, reaching over 1.5 million seedlings per year during 1960-1962. The principal species planted were exotic spruces, pines and larch: *Picea abies*, *Picea sitchensis*, *Pinus sylvestris*, *Pinus contorta* and *Larix sibirica*. Planting declined after 1963 and remained at 500,000 to 1 million seedlings annually to 1989. From 1950 to 1990, a great deal of experience was gained through experimenting with different exotic species and provenances. It soon became clear that scientific research was essential to progress in identifying the best species and provenances and developing afforestation methods. The IFS initiated research and established a research station in 1967 with aid from Norway.

Increased afforestation 1990-2009

Afforestation through planting increased again to roughly 4 million seedlings annually throughout most of the 1990s, reaching a high of about 6 million seedlings per year during 2007-2009. Planting of native birch increased proportionate to the total, comprising as much as 30% of seedlings planted in some years. *Larix sukaczewii* (syn. *L. sibirica* var. *sukaczewii*) was planted to roughly the same extent and planting of *Picea sitchensis* increased as older stands showed very good growth.

The crash 2009-2015

Public funding for forestry reached a maximum in 2005, after which it started to wane slightly in real terms (rated against inflation). After the financial crisis of 2008-2009, funding for forestry was cut drastically. In real terms, public funding for forestry in 2013 was only half of what it was 2005. This resulted in a drastic reduction in planting, down to about 3 million seedlings in 2015. Among the consequences were tree nurseries going out of business and educated foresters moving abroad to find work.

The IFS research station at Mógilsá near Reykjavík. Celebrating 50 years of forest research in 2017.

On the other hand, the collapse of the Icelandic Krona meant that wood imports became much more expensive, providing opportunities for greater use of domestic wood. Plantations from the 1950s-´70s were in need of thinning and had been for some time. Now for the first time there was a possibility that thinning could be economically sustainable. Thinning and timber sales by the IFS increased greatly in 2009 and continued to increase during the following years. Since then, timber production from thinnings has become a new, major activity within the Icelandic forestry sector.

Historically, there have been three relatively short-lived upswings in forestry in Iceland with longer periods of less activity in between. The upswings were the beginnings of forestry 1899-1908, the beginnings of planting 1950-1963 and the recent increase in afforestation 1990-2009. The causes of the current decline are partly financial and partly social, both of which translate into less political support for forestry. If history is any indication, we might be in the early years of a period of less forestry activity that could last 30-40 years. Despite rapid economic recovery in Iceland during 2014-2016, funding for forestry has only increased slightly. However, Iceland now has a developing commercial forest resource that is already starting to generate significant income. That income should spur interest in investing in forestry, hopefully resulting in a shorter downswing. Other factors, such as increased afforestation for carbon sequestration could also aid in revitalising forestry, but that hasn't happened yet despite 20 years of talking about it.

The forestry sector

The Icelandic ministerial structure went through major reshuffling in 2007 and again in 2012. In two steps, responsibility for forestry was moved from the Ministry of Agriculture to the Ministry of Environment and Resources. From 2007 to 2012, the IFS was under the Ministry of Environment while the Regional Afforestation Projects (RAPs), responsible for providing grants for farm afforestation, remained under the Agriculture Ministry. In 2016 the IFS and the RAPs were merged into a new agency, Skógræktin, which is nevertheless still translated into English as the Icelandic Forest Service.

One of the early IFS afforestation areas at Kirkjubæjarklaustur in SE Iceland. The tallest tree in Iceland is in the Sitka spruce stand on the left; 27 m in 2016.

The IFS

The Icelandic Forest Service (IFS) was established according to the forestry and soil conservation act of 1907. It is the state forestry authority in Iceland and is under the Ministry of Environment and *Resources.* The IFS manages the National Forests, totalling about 7000 ha or 5% of Icelandic forests and woodlands. The majority of forest and woodland area within the National Forests is protected native birch woodland, but there are also cultivated forests of various species, experimental forests and arboreta. All National Forests are open to the public year-round and some are among the most visited outdoor recreation areas in Iceland. Their status with respect to outdoor recreation varies from barely accessible wilderness to considerably developed, with marked footpaths, picnic areas and campgrounds. The National Forests employ a full-time staff of around 30 people.

Between 1950 and 1990 the main emphasis of the IFS was on afforestation through planting. The IFS planted roughly half the trees planted in Iceland up to 1990, mostly in the National Forests. To this end, the IFS built and ran as many as six tree nurseries in various parts of Iceland. After 1990, seedling production was gradually privatised and other actors took the lead in planting. Tree planting is now a relatively minor part of IFS activities but continues at a rate of 50-100 hectares per year.

Besides planting, the IFS promoted increased woodland area through direct seeding and self seeding of birch. Most IFS enclosures were established around remnants of birchwoods where natural regeneration was usually abundant. For example, the area of birch cover within the original Hallormsstaður National Forest enclosure increased by 330 ha from 1906 to 1995 without any birch being planted, or an average of 3.7 ha per year, more than doubling the original forest area in 90 years.

The IFS Research Station is located at Mógilsá near Reykjavik. Tree improvement (species and provenance trials and tree breeding) along with research on seedling production and establishment are the mainstay of forest research in Iceland. In recent years, forest ecology research has become increasingly important,

with a wide range of topics being looked at, including carbon and nutrient cycles, insect pests and pathogens and the effects of afforestation on plant and animal communities. Forest inventory has also increased in importance, not the least due to the need for knowledge about carbon stocks and sequestration. Other recent research topics include growth and yield studies and social aspects of forestry. For the majority of research projects, emphasis is placed on applicability to forest management planning and practice.

From its limited beginnings as a pilot project by the IFS on four farms in 1970, state supported afforestation on farms has grown to become the main channel for afforestation activity in Iceland. Since 1970, the grants scheme has gone through several institutional changes and a great deal of development has taken place. Between 1990 and 2016 the grants scheme was managed by Regional Afforestation Projects (RAPs) that were independent of the IFS, but the IFS and RAPs were merged in 2016. State funding of farm afforestation grants reached a maximum during 2005-2009 but has since then suffered severe cut-backs.

Within the farm afforestation grants scheme, contracts are made with landowners, afforestation plans are drawn up for each participating farm, seedling production and distribution are co-ordinated, education and extension services are provided and grants are distributed. Recently, methodology and provision of grants has been developed for spacing and pre-commercial thinning.

Each farm afforestation grant covers 97% of establishment costs, including fencing, roads, site preparation, planting and the first thinning. The individual landowner owns the resulting forest and bears all legal responsibility. The landowners often do part of the work themselves but other parts of the work are usually done by contractors. Thus, the grants scheme has led to establishment of small businesses providing services to forest owners, such as fence maintenance, road work, site preparation, planting and thinning.

After the merger in 2016, the IFS is set up in four divisions:

- **Forest resources**
  - *National Forests*
  - *Afforestation grants scheme*
  - *Seed supply and cutting production*
  - *Outreach and advisory services*
- **Forest research**
  - *Tree improvement*
  - *Forest inventory*
  - *Forest pests and diseases*
  - *Forest establishment*
- **Forest strategy**
  - *National forestry programme*
  - *Forest recreation*
  - *Education*
  - *Public relations*
  - *Marketing*
- **Finance**
  - *Day-to-day operations*
  - *Fiscal planning*
  - *Contracts*

Hekluskógar (Hekla forests project)

A very large area north, west and south of the volcano Hekla consists mostly of desertified land at fairly low elevation. It was wooded for the most part at the time of settlement, but the forests were felled and grazing along with blowing volcanic tephra caused severe erosion. Tephra is not only a problem immediately after an eruption, since in an open landscape it is blown back and forth for years and can be the source of dust storms for decades. In the shelter of a forest however, the ash quickly settles and becomes covered by vegetation.

An ambitious effort to reclaim forest and woodland around Hekla was initiated in 2005. The aim is to afforest up to 100,000 hectares of land, primarily with native birch, in the hope of reducing disturbance from future eruptions of Hekla. The Hekluskógar project is a joint effort of the Soil Conservation Service and the IFS with special funding from the state budget.

As of 2016, other similar projects are being prepared, principally on lands managed by the Soil Conservation Service. These are often disturbance prone sand dune areas that have been at least partially stabilised by lyme grass, other grasses or lupine but succession toward a more stable vegetation cover is slow. The aim is to afforest these areas for soil conservation, carbon sequestration and other forest benefits such as recreation and timber production. These will hopefully be cooperative projects between the Soil Conservation Service, the IFS, local municipalities and others.

Forestry Societies

The Icelandic Forestry Association (IFA) was founded in 1930 and is an umbrella organisation for 57 local forestry societies. These are non-governmental volunteer organisations of people interested in afforestation. Their efforts are mostly concentrated around towns and villages, but some own quite large tracts of forest land and some of the oldest cultivated forests originally grown on treeless land belong to forestry societies.

Since 1990, forestry societies have been the main actors in the Land Reclamation Forest project, originally a co-operative project between the IFA, the IFS and the Soil Conservation Service but now by contract between the IFA and the Ministry of Environment and Resources. This project has been responsible for 10-30% of annual planting in Iceland. The aim is to afforest eroded or degraded land and 40-75% of seedlings planted annually have been native birch. Besides the Land Reclamation Forests project, local forestry societies are mostly concerned with managing forests and woodlands for outdoor recreation, some grow Christmas trees and some have small tree nurseries.

The IFA publishes the journal Icelandic Forestry, which comes out in two volumes annually. It is the main forestry publication in Iceland and contains a mix of scientific papers and more general articles. The IFA has roughly 7000 members, or about 2% of the Icelandic population, making it by far the largest environmental NGO in Iceland.

The Forest Owners Association

The Icelandic Forest Owners Association (FOA) was formed in 1998 as a union to represent the views and concerns of forest owners. It has a membership of over 700, consisting mostly of forest owners participating in the farm afforestation grants scheme. The FOA has a volunteer board of directors, a very small budget, one part-time employee and no permanent headquarters. Outreach, in the form of meetings, conferences and publication of the magazine Við Skógareigendur (We Forest Owners), is an increasing part of FOA activities.

Forestry education at the Agricultural University of Iceland

The Agricultural University of Iceland, with its main campus at Hvanneyri in West Iceland, started a forestry degree programme in 2004. This marked the first time that university level education in forestry was offered in Iceland and was a milestone for Icelandic forestry. The first foresters with an Icelandic BSc in forestry graduated in spring 2007 and the first MSc degree was awarded in autumn of 2008. The Agricultural University also offers sub-university level courses and continuing education in forestry, where forest owners and others can improve their knowledge and technical competence.

The Icelandic Forestry Association is the largest environmental NGO in Iceland.

The beginnings of forest industry

Icelanders use the same amount of forest products per capita as other nations with a comparable standard of living, but they are almost all imported due to Iceland's very small forest resource. However, there are niche markets that can be supplied with wood from selection felling in the largest birch forests and thinning in plantations of various species. Examples include:

- Birch fireplace logs
- Fuel wood for heating buildings in non-geothermal areas
- Larch fenceposts
- Birch, larch and other species for handicrafts
- Larch, spruce, pine and poplar lumber in small quantities
- Spruce poles for fish drying racks
- Spruce and pine shavings for bedding for livestock
- Wood chips used in footpaths, as mulch, etc.

It is perhaps inappropriate to use the term forest industry in Iceland, but there are several small businesses that use wood from Icelandic forests in their production. As the forest resource grows and more wood from thinnings in plantations becomes available, these businesses and others will be able to rely on domestic sources of wood rather than imports to an increasing extent.

Silicon smelting has become a sizeable industry in Iceland because it is an arc smelting process requiring a great deal of electricity. A source of carbon is also required in the smelting process and wood chips are more climate friendly than fossil carbon (coal or coke). Since 2012, the IFS has provided wood chips from Icelandic forests to the Elkem-Iceland silicon smelter at a price that more or less covers the costs of thinning, transport and chipping. This has resulted in a greatly needed increase in thinning of middle-aged stands in both the National Forests and forests owned by others. However, the Icelandic forest resource can as yet only provide a small part of the wood chips needed in the smelting process, so most are imported.

Chipping of Siberian larch thinned from young stands.

A new silicon smelter near Keflavík started operations in late 2016 and another one near Húsavík will start in 2017. Both will use wood chips as a carbon source, mostly imported. Together, these three smelters will require well over 100,000 tonnes of wood chips annually, whereas the potential annual production of chips from Icelandic forests is currently less than 10,000 tonnes. This will increase as the forest resource grows, but it will still be some decades before we can provide the wood needed by the silicon industry.

This is only one example of the need for wood as a raw material in Iceland. This is also a need that could easily be met domestically, while both creating jobs and reducing the carbon cost of importing chips. If we only had a larger forest resource. This underscores the need to plant more trees, to build up the resource.

Afforestation objectives

In general, Icelandic afforestation is planned and cultivated forests managed with multiple-use objectives. These objectives can best be described based on the three principle aspects of forest sustainability: economic (wood production, non-wood products), ecological (ecosystem processes, habitats, wildlife, soil and water conservation, sequestering CO_2) and social (recreation, spiritual, public health).

In forest planning and management, greater emphasis is often placed on one or two of these functions and less emphasis on others, without ignoring them entirely. In farm afforestation the majority of plans to date emphasise timber production as a primary goal, the main timber species being Siberian larch, Sitka spruce, lodgepole pine and black cottonwood.

The management goal for the greatest area within the National Forests (IFS lands) is simply protection of native forest and woodland ecosystems. Because the IFS was first to plant extensive areas with productive conifers, it is now the main timber producer in Iceland as well. In large areas, emphasis is on soil erosion control, reclamation of productivity and in some cases ecological restoration, where native birch plays a major role.

The realisation is increasing that urban and peri-urban forestry serves very important social and health-related functions. Forestry societies have been most active in this regard, placing emphasis on opening forests to the public. Two forest areas originally cultivated on treeless land in the 1950's and 60's, one near Reykjavik and the other near Akureyri, annually receive over 500,000 visits, well over the entire population of Iceland.

Forestry Legislation

Laws pertaining to forestry reflect the fact that forests form a very small part of the Icelandic landscape, the main policy points being that existing forests should be protected and afforestation of treeless land is encouraged. To this end, the IFS also has a mandate to educate and advise the public in forestry matters, which requires research. These goals have been in effect since the first Forestry Act of 1907. The current forestry act is from 1955 and is for the most part out of date and useless. However, the goal of increasing forest cover through afforestation is re-affirmed in the Farm Afforestation Act of 2006, where for the first time a concrete goal of 5% forest and woodland cover of lowlands is set.

In recent years, checks have been put into place regarding certain aspects of forestry through the Planning Act, the Environmental Impact Assessment Act and a regulation regarding use of exotic plant species. These legal instruments are the results of EU directives; in other words not the result of a perceived need within Iceland to put checks on forestry, although forestry in Iceland as elsewhere is not without its detractors.

Work on drafting a new forestry act commenced in 2014. If passed, the new forestry act will support and legitimise developments that have already taken place and lead to some much needed changes.

Forestry strategy and a national forestry programme

Influenced principally by outcomes of the Ministerial Conferences for the Protection of Forests in Europe (Forest Europe) and a recent forestry strategy for Scotland, a strategy was developed for Icelandic forestry looking forward to the end of the 21st century. It was published in 2013.

The strategy is divided into five main areas of emphasis:

- Building up a forest resource
- Forest utilisation, value and innovation
- Society, access and health
- Environmental quality and biodiversity
- Climate change

Under each of these headings are goals and means to achieve them. Included among these goals are:

- That at least 12% of Iceland be afforested by the year 2100 through both planting and natural forest extension
- To develop sustainable forest utilisation and forest industry
- To improve public access to forests and increase the recognition and role of forests in public health
- To increase the role of afforestation in soil and water conservation, enhancement of biodiversity and amelioration of the environment
- To enhance the role of forests as carbon sinks and to adapt forestry to climate change

The main tool for achieving these goals will be the National Forestry Programme. In order to be effective, it must be based in law, be developed and updated regularly and have a great deal of public and political support. The IFS will start work on the first national forestry programme for Iceland in 2017 in the hope that parliament will pass the new forestry act soon. With legal status, the national forestry programme will be an official instrument detailing strategic goals and means to achieve them. Even without legal status, it will be a useful tool in building consensus on the way forward in Icelandic forestry.

Afforestation of eroded land, in this case using Siberian larch, is one of the best ways of sequestering carbon, both in trees and soil, thereby mitigating climate change.

Forestry and climate change

There are many connections between forestry and climate change. Among them are questions regarding how afforestation, forest management and wood utilisation can help to mitigate global warming. Another group of questions concerns how trees and forests and forestry will react to climate change. These have to do with genetic adaptation of trees, changes in forest ecosystems and adaptive management.

For over 20 years, the IFS has maintained that afforestation of treeless land can be effective in sequestering carbon, a position now backed up by a great deal of research. Using afforestation, we have the possibility of sequestering a significant part, or even all of the CO_2 released by Icelanders, depending on how much people are willing to invest. Afforestation has been

named as part of Iceland´s climate strategy, along with soil conservation and reclamation of wetlands, but at the same time, funding for afforestation was among the parts of the state budget cut most after 2008.

As regards adaptation of tree species, most concern has been with continued use of Siberian larch, which is not well enough adapted to mild winters. As winters continue to become milder, it seems likely that Siberian larch will cease to be a viable option at some point, at least in the lowlands. The other main tree species seem better able to tolerate mild winters.

Breeding and testing programmes are ongoing for European x Siberian hybrid larch, black cottonwood and Sitka spruce, as well as for Icelandic birch to straighten it out a little and subalpine fir (*Abies lasiocarpa*) for Christmas tree production. Such tree improvement programmes are essential in dealing with adaptation in the face of climate change, both because of the knowledge gained about the trees in the course of breeding and testing and also because of the capacity to react relatively rapidly to changing conditions, for example by selecting better genetic material and getting it into seed or cutting production fairly quickly.

Adaptation of existing forests to new insects and pathogens is another challenge and more difficult to deal with. As elsewhere, new forest pathogens and damaging insects regularly become established in Iceland, aided by global warming or global trade or both. The way to deal with them is through selection and breeding of tolerant trees. That way, damaged forests can theoretically be replaced by better material. However, that is expensive from a practical standpoint unless it can be paid for by timber sales as part of regular forest harvesting and regeneration.

On the other hand, a warming climate is not all bad. One of the effects will be to increase the potential forest area in Iceland. Already, the maximum elevation for productive forestry has increased by about 100 m since the 1980s, creating the potential for afforestation of large areas on mountainsides and the periphery of the central highlands. Of course, conditions for forestry are more complex than simply looking at annual or growing season temperatures. Wind exposure increases with elevation and radiative frost during the summer increases with distance from the coast, both making forest establishment more difficult. Nevertheless, it seems likely that large areas in the lower parts of the central highlands will become potential forest land within this century.

So how is it going?

In over a century of forestry in Iceland, we prevented the destruction of the last remnants of natural forests. We gained experience in forest management and cultivation of a number of tree species. We gained scientifically based knowledge of the best provenances to use, where to plant them and how to get them to live and grow. We have a great deal of knowledge and experience with afforestation of treeless land. We are beginning to develop a real multiple-use forest resource. Without a doubt, the most important outcome is that there has been a slow realisation among the Icelandic people that we can actually grow forests and reap the resulting benefits. A century ago, most Icelanders had never even seen a tree and knew that trees could not grow in Iceland. Sixty years ago, few Icelanders believed that trees of any size to speak of could grow in Iceland. Planting trees was the harmless hobby of a few eccentrics, but forests for timber production were out of the question. Today, forestry for timber production, land reclamation and amenity is being carried out by thousands of people all over Iceland. Growing forests are both an outcome of and cause for optimism.

As cultivated forests get older and a growing number of them are becoming noticeable in the landscape, it has become obvious to most that a forest resource is developing in Iceland, still small but growing in area. The trees are growing well too. Spacing of young stands has become common and commercial thinning is increasing from year to year. Realisation is increasing of the importance of forests for outdoor recreation, especially around urban areas, resulting in increased emphasis on developing and maintaining the social functions of forests. Last but not least, afforestation is by far the best means to reclaim and rehabilitate the abundance of eroded and degraded land that characterises much of the Icelandic landscape, changing it to productive and functioning ecosystems, providing habitats for a great variety of life and mitigating climate change in the process.

There are of course still some detractors. They point to potential loss of scenery, nature conservation concerns and a variety of other reasons for being against afforestation. The concerns are usually sincere on the part of the people who hold them and some have merit, at least on a local scale in specific places, but any potential negative impacts of afforestation must be balanced against the positive outcomes. For this reason, good forest planning and management are no less important in Iceland than in countries where forests form a much larger part of the landscape.

The good growth of several tree species has probably been most important in changing people's attitude towards forestry. Several exotic species not much used in afforestation because they don't grow well enough have nevertheless reached between 18 to 22 m in height. Besides the native birch, the major species used in forestry (Siberian larch, Sitka spruce, lodgepole pine and black cottonwood) have all reached at least 22 m in height and show mean annual increments ranging from 5 to 20 m^3/ha/yr. Black cottonwood has reached 25 m in height and Sitka spruce is at 27 m as of 2016 and growing fast. Based on growth curves, Siberian larch and lodgepole pine will certainly reach 25 m height on good sites by age 100 years and black cottonwood at least 30 m. Who knows how tall Sitka spruce will get in Iceland? Perhaps 50 meters? In addition to these, roughly 150 species of trees and large shrubs are in regular cultivation in forestry, shelterbelts or for amenity.

A small population in a big land can only plant so many trees.

The total area of forest and woodland in Iceland has at least doubled, possibly quadrupled, since 1950. Whether this should be considered a large or small increase depends on the comparison. It is large in comparison to the woodland area in 1950, but very small indeed compared to Iceland's land area and to the woodland area at the time of settlement. Native birch woodlands have expanded through natural regeneration within fenced areas but much less in areas not specifically protected from grazing until recently. A recent (2015) remapping of natural woodland extent by the IFS Research Station indicates for the first time that birchwoods are generally expanding and now cover 130 km^2 more than in 1990 or a total of roughly 1.5% of Iceland. Cultivated forests cover another 0.4% bringing the total forest and woodland cover to very nearly 2% of Iceland's land area.

For several reasons, planting has not resulted in large land areas being afforested, compared to the area of potential forest land in Iceland. Up to the mid 1980s, land was not available for afforestation because of competition by other land use, especially grazing. Forest establishment is expensive and few individuals have the financial resources to invest in afforesting large tracts of land. Planting by forestry societies was always constrained by lack of money as was planting by the IFS. Afforestation grants to farmers were first offered in the early 1970s but were extremely limited until the 1990s. Due to these constraints, afforestation

of relatively large areas has only started within the last 25 years or so.

Iceland has a very small population (330,000) compared to the area of the country (103,000 km^2, of which at least 40,000 km^2 can potentially be afforested). In other words, there are fewer taxpayers per km^2 of land than in neighbouring countries with a similar deforestation/afforestation history such as Denmark, the UK and Ireland. For this reason alone, afforestation through planting, as a proportion of total land area, will likely continue to proceed slowly. Total afforestation planting has been on the order of 1000-1500 ha per year during most of the last 26 years. At that rate, it takes at least 70 years to plant trees on 1% of Iceland's land area.

Since 2005, funding for forestry has been cut in half in real terms, resulting in a proportionately similar reduction in total planting. At the same time, the need for spacing (pre-commercial thinning) is increasing as well as demand for better infrastructure, especially forest roads, foot paths and other things having to do with recreation. Among other effects of downsizing forestry are a greater emphasis by the IFS on increasing other income, such as from timber sales, and proportionately less emphasis on afforestation for land reclamation, erosion control and amenity and less money for research. The dream of afforesting a significant part of Iceland has, for the past 8 years, seemed more distant than it did in the decade before. But, the economy has recovered and forestry is finally seeing an increase in state funding in 2016 and 2017.

In a treeless land, developing a forest resource is obviously beneficial, a no-brainer as some would say. From a historical perspective, it can be seen as rebuilding a resource that was lost and doing it in a way that meets society's current needs. From an ecological perspective, it is a way of reclaiming biological productivity, preventing soil erosion, enhancing ecosystem resilience and much more. From an economic perspective, it can be a way of meeting certain needs in a sustainable manner and decreasing dependence on imports. But developing such a resource requires investment that will not be repaid within the 1-2 years required by impatient (normal) investors. Therefore, it is appropriate that society as a whole make the investment. It is after all not the individual forest owner who will reap most of the benefits, but society as a whole, in the form of jobs, better health, fewer dust storms, better water quality and much more. For today´s society to invest in afforestation that will benefit our grandchildren is the very definition of sustainability.

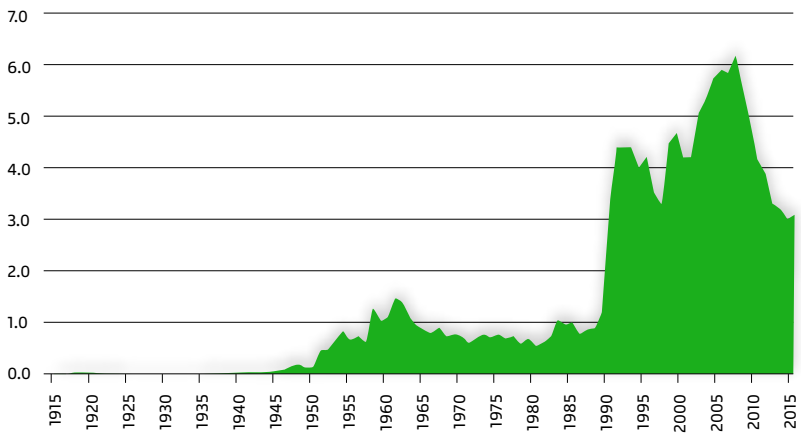
Society primarily funds what it does through paying taxes, with the government appropriating them. In order to get society to invest in forestry, a widespread understanding of the benefits is required, but mostly it is vital for forestry to have political support, which has recently been lacking. The job ahead for the Icelandic forestry sector is to regain political support for forestry.

Icelandic forestry by the numbers 2016

The following table and figures include some of the latest available statistics in Icelandic forestry. They were provided by Arnór Snorrason and Björn Traustason at the IFS Research Station Mógilsá, Einar Gunnarsson at the Icelandic Forestry Association and the author.

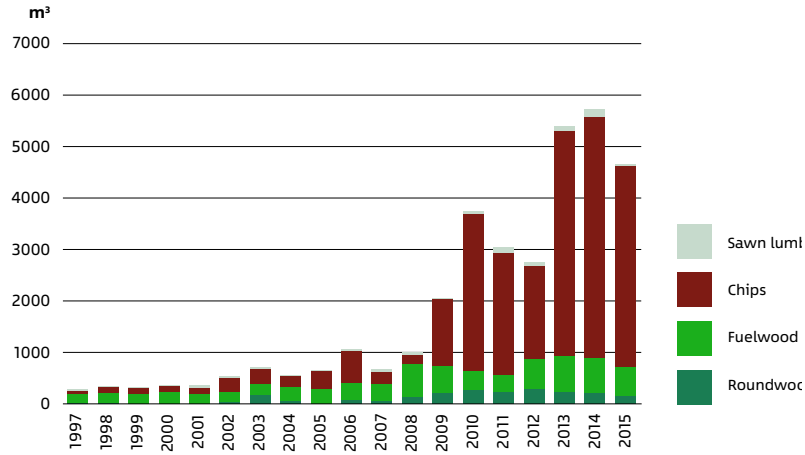
Native birch forest and woodland cover	1506 km^2
Cultivated forest cover	400 km^2
Total forest and woodland cover	1906 km^2 (1.9% of Iceland)
Trees planted 2015	3.1 million (~1000 ha)
Carbon sequestration in forests planted after 1990	210 000 tonnes CO_2 per year
Timber sales 2015	4680 m^3
Annual increase in forest extent 1990-2015	4.58%

Seedlings planted annually (millions)



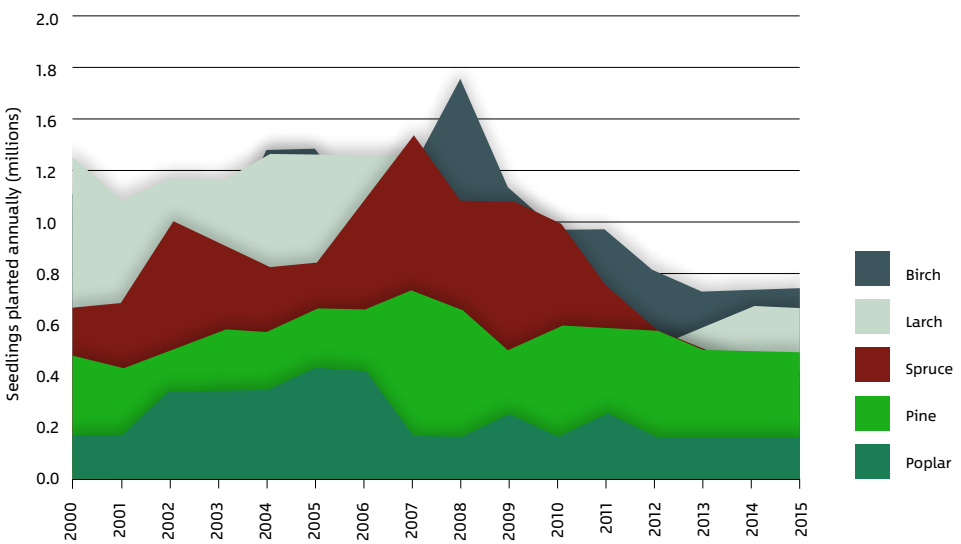
The above figure shows the development of tree planting for afforestation over the past century. After a slow start during the 1940s, planting picked up in the 1950s and reached a maximum around 1960, followed by a 30-year long period of reduced activity. During that time, afforestation took place on state-owned land (the National Forests) and in areas obtained by forestry societies. The increase around 1990 marks the beginning of farm afforestation grants and the Land Reclamation Forests project. The drop after 2009 is partly due to the financial crash of 2008, after which forestry was among the sectors that sustained the greatest cuts in government spending. (Reference: Statistics collected by the Icelandic Forestry Association and published in their journal Icelandic Forestry).

Timber sales from Icelandic forests



The above figure shows the development of wood sales from Icelandic Forests and in fact the beginnings of a timber market. "Roundwood" reflects a variety of products but the increase since 2007 is mostly due to sale of spruce poles for fish drying racks, an indication that Icelandic forests are now tall enough in stature to produce such poles. "Fuelwood", mostly fireplace logs of native birch, was the main wood product from Icelandic forests until about 2008. The increase since 2012 reflects increased use of wood in cooking, i.e. wood fired pizza ovens in restaurants, and is connected to increased tourism. "Chips" are principally used as bedding for livestock, in household heating and since 2009 as a carbon source in silicon smelting. That market finally resulted in much needed thinning in older forests and drove wood sales into the thousands of cubic meters. That is still a very small amount compared to other countries, but a beginning nevertheless. Sales of sawn lumber have increased in recent years, but are still miniscule and will continue to be small for some time to come, or until the forests are on average older and larger in area and final felling commences. (References: Statistics from the Icelandic Forest Service and Icelandic Forestry Association).

Planting by genus



The above figure shows total annual planting of the five main tree genera used in Icelandic forestry. The decrease in planting since 2009 affected all species but not equally. Birch planting declined but roughly maintained its proportion of total planting. Larch dipped to low levels due to production problems but is back at a similar proportion as before. Spruce planting sustained the greatest reduction because spruce seedlings are more expensive to produce than birch, pine or larch and in times of cut-backs the tendency is to reduce the costliest production. Pine planting remained more stable and has been gradually increasing as a proportion of total planting since 2001. This is a long term trend resulting from increasing acceptance of lodgepole pine as a timber species in Icelandic forestry. Poplar planting is also more stable but still at a low level for a variety of reasons including concerns about poplar rust, low availability of suitable land and nursery production problems. This figure shows instability in total seedling production and species selection, both of which are reflections of the smallness of Icelandic forestry (small year-to-year changes readily show up) and the fact that forestry is still in development. (References: Statistics from the Icelandic Forestry Association).

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