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Deforestation and afforestation in Iceland

Islannin metsien hävitys ja palautus

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Downy birch (*Betula pubescens*) is the only tree species that has formed forests and woodlands in Iceland after the latest ice age. After the human settlement, forests and woodlands experienced extensive use. Woodlands were also cleared as farmland, and sheep and horses were allowed to graze freely. The situation was made worse by the extreme environmental and climatic conditions and loose, volcanic soils created a difficult environment for vegetation succession. Today, 35–45% of Iceland is desert prone to erosion. The main actors in Icelandic afforestation today are government-funded regional farm afforestation projects and non-governmental funded forestry societies. Both the native downy birch and exotic conifer species have been used to establish forests in Iceland. Afforestation is seen to improve environmental conditions and add ecosystem resilience. Especially the restoration of natural birch woodlands has increased in recent years. Bringing birch back helps in the restoration of degraded lands and brings other benefits to the ecosystem. However, large-scale sheep grazing remains to be a challenge for restoration during the first years after planting. Forestry in Iceland is on its early stages. There is work and research to be done in the future.

Introduction

Before human settlement in AD 870s, 25–40% of Iceland's land area was covered by forests and woodlands; nowadays the amount is only 1% (Fig. 1), after centuries of deforestation and ecosystem degradation driven by anthropogenic disturbances. Downy birch (*Betula pubescens*) is the only tree species that has formed forests and woodlands in Iceland after the last ice age, and in different parts of the island it takes on different forms: in the oceanic conditions and in higher altitudes of Western Iceland, birches are mostly 2-meter-high shrubs, whereas inland in low and mid-altitudes in Northern, Eastern and South-Eastern Iceland they are more tree-like, reaching over 10 meters in height. It is estimated that one-fourth of the land area was covered by birch woodlands at the time of human settlement, whereas today the total area is approximately 150 600 hectares. Other domestic tree species are aspen (*Populus tremula*), juniper (*Juniper communis*) and rowan (*Sorbus aucuparia*) along with several willow species (*Salix* sp.) (Aradóttir and Eysteinsson 2005).

Deforestation

After the human settlement, forests and woodlands experienced extensive use: wood was used for fuel, building material, and animal fodder as well as in charcoal production. Woodlands were also cleared as farmland, and sheep and horses were allowed to graze freely. There are no native large herbivores, like moose, in Iceland, so the slow-growing vegetation was not equipped to withstand such pressure, and especially the regeneration of trees was disturbed. The situation was made worse by the extreme environmental and climatic conditions: frequent volcanism and eruptions, repeated freeze-thaw cycles, strong winds, and loose, volcanic soils created a difficult

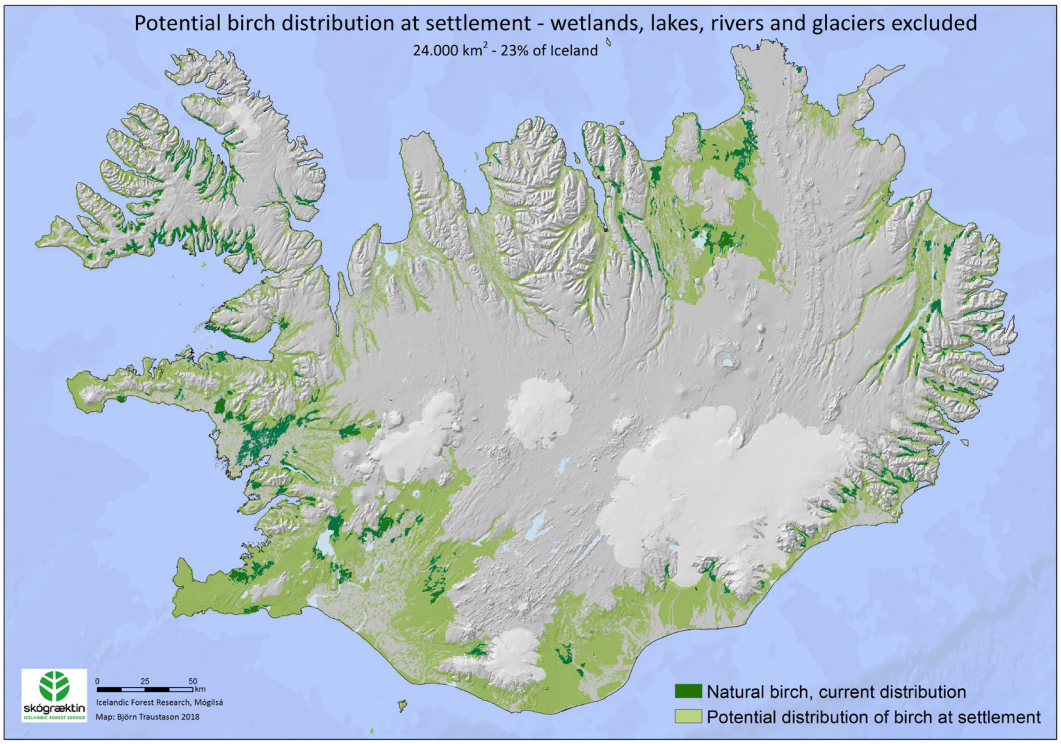

Fig. 1. The potential distribution of birch woodlands in Iceland at the time of settlement, A.D. 870, and the current distribution of birch woodlands. Author of map: Björn Traustason, Icelandic Forest Service, 2018 – published with permission from the author.

Kuva 1. Hieskoivun oletettu levinneisyys Islannissa asutuksen alussa v. 870 (vaalean vihreä) ja hieskoivun nykyinen levinneisyys (tumman vihreä). Kartan laatinut Björn Traustason, Islannin metsähallitus 2018. Julkaistu tekijän luvalla.

environment for vegetation succession. Today, 35–45% of Iceland is desert prone to erosion (Arnalds and Kimble 2001).

Soil

Icelandic mineral soils are characterized by volcanic and aeolian origin. Peat formation takes place in wetlands, in anoxic conditions; the main peat-forming plant species are *Sphagnum* mosses and sedges (*Carex* spp). Degraded mineral soils are highly unstable, and few native species can survive, let alone colonize them. During the first half of 1900s, the Nootka lupine (*Lupinus nootkatensis*) was introduced to Iceland to combat erosion, speed up land reclamation, and help with reforestation, but it has been since designated an invasive species, since it tends to dominate the areas where it grows and colonize already vegetated areas. Later, the Lyme grass (*Leymus arenarius*), as a native grass species, has been found to be a better option instead of lupine because it stabilizes the soil surface and creates suitable conditions for seedling establishments (Aradóttir and Eysteinsson 2005).

Reclamation and afforestation

The main actors in Icelandic afforestation today are government-funded regional farm afforestation projects and non-governmental funded forestry societies. Both the native downy birch and exotic conifer species have been used to establish forests in Iceland. Planting exotic conifers started in 1935, and they were even introduced to birch woodlands until 1980s (Aradóttir and Eysteinsson 2005). The conifer species mostly come from Alaska: the climatic conditions are

relatively similar and thus the trees can survive in Iceland. Common ones are, for example, Douglas fir (*Pseudotsuga menziesii*), Norway spruce (*Picea abies*) and Sitka spruce (*Picea sitchensis*). However, the interest in Norway spruce has declined due to the better growth rate of Sitka spruce (Tengberg 2005, Reynisson 2011). Other conifers used are Siberian larch (*Larix sibirica*) in eastern Iceland and Lodgepole pine (*Pinus contorta*) (Hlynur Óskarsson, pers. comm.).

Also, the black cottonwood (*Populus trichocarpa*), originating from western parts of North America, is the fifth most planted tree species in Iceland, and it is mostly planted to create urban and recreational forests and to the field edges to make windbreaks to prevent soil erosion (Jónsson et. al. 2006).

Noteworthy details about the Icelandic conifer forests are monocultures and dense stands. Often the conifer forests consist of one species only, and due to the lack of thinning, the stands are so dense that no vegetation grows on the forest floor. Such an ecosystem is extremely sensitive to disturbances: for now, Icelandic forests have been spared from insect damage, but it is only a question of time before, for example, bark beetles find their way there. A serious insect outbreak would be devastating to such forests.

Downy birch hybridization between *Betula nana* and *Betula pubescens* is common and widespread in Iceland. A genetic variation of that kind may be useful in subarctic regions (Anamthawat-Jónsson 2012). Birch woodlands, as the only native tree species, withstand well volcanic ash deposition. Also, wind speed at the soil surface is reduced due the woodland cover, stabilizing ash falling on woodland and enabling understory vegetation to regenerate. The shrub layer on the birch woodlands is often formed by willows, especially by tea-leaved willow (*Salix phylicifolia*), woolly willow (*Salix lanata*) and arctic willow (*Salix arctica*). The main threat for young and low birch woodlands in the east of Iceland are the domestic sheep and reindeer, which slow down afforestation through grazing. The restoration of birch woodlands is essential because it prevents erosion and brings various benefits to the ecosystem (Aradóttir and Eysteinsson 2005, see also Fig. 2).

Fig. 2. Birch woodland research site near Hveragerði. Photo: Belinda Mäki.

Kuva 2. Koivumetsän tutkimusalue Hveragerðin lähistöllä. Kuva: Belinda Mäki.

Effects of afforestation

Afforestation influences biodiversity and ecosystem functions in various ways, for example it causes a change in the field layer plant communities by reducing light availability (Arneberg et. al. 2007, see also Fig. 3). Afforestation can bring new fauna like birds and beetles to the afforestation site as the forest matures, even though some species can abandon the afforested area. Afforested sites can still offer more diverse habitats to accommodate new species (Jónsson et. al. 2006). Especially birch as an early colonizer is useful for the rehabilitation of degraded land because it adapts quite well in eroded sites. Also, birch plantations have potential to increase carbon sequestration, understory vegetation and bring better options for land use in the future (Aradóttir and Eysteinsson 2005).

According to Arneberg et. al. 2007, there was "a clear difference in decomposition rates of cotton strips among treeless pastures and stands of different tree species in Iceland". Mountain birch had the highest decomposition rate, Siberian larch following, then Sitka spruce, and Lodgepole pine had the lowest decomposition rate. In addition, decomposition decreased with stand age. The results are notable because it can help to choose the most ecologically favorable species and provenances, when considering future afforestation activities. It also promotes the yield and growth

Fig. 3. Skorradalur forest research site arboretum. Photo: Kari Minkkinen.

Kuva 3. Puustoa Skorradalurin metsäntutkimusaseman arboretumissa. Kuva: Kari Minkkinen.

of the forests and consequently economic profit (Reynisson 2011).

The restoration of birch woodlands is nowadays seen more and more important, despite of the general lack of interest among landowners and lack of specific goals in the afforestation projects. Various afforestation projects have been started recently, and the native birch is the most planted tree species in Iceland. Usually, the birch seedlings are planted (1.4 million per year) but sometimes direct seeding is also used along with natural regeneration. However, the restoration of birch woodlands can take a long period of time especially on eroded sites, where the establishment can be hard due to low nutrient status and low water holding capacity of the soil, frost heaving and active soil erosion. Still, the decrease in sheep farming can alleviate the problems caused by grazing and improve soil conditions for restoration. In the future, better methods need to be developed for large-scale restoration operations. In addition, further research of ecosystem functions of birch woodlands may help to find better ways for ecosystem restoration and species recovery (Aradóttir and Eysteinsson 2005).

Conclusions

All in all, human impact, volcanic activity, and extreme climate conditions among other factors have influenced the treeless scenery of Iceland today. The lack of trees furthers erosion and weakens vegetation establishment along with degraded mineral soils. There have been various attempts to introduce new plant species to the shrub layer to stabilize the vegetation growth, now the Lyme grass is the most promising.
Nowadays afforestation by planting native downy birch and exotic conifer tree species, mostly Sitka spruce, is seen to improve environmental conditions and add ecosystem resilience. Especially the restoration of natural birch woodlands, most of which were lost due to excessive nature resource utilization in the past, has increased in recent years. Bringing birch back helps in the restoration of degraded lands and brings other benefits to the ecosystem. However, large-scale sheep grazing remains to be a challenge for restoration during the first years after planting.

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Tiivistelmä

Asutuksen alkaessa Islannissa v. 870, 25–40 % Islannin maapinta-alasta oli erilaisia metsiä ja metsiköitä. Nykyisin niiden pinta-ala on vain 1 %. Hieskoivu (*Betula pubescens*) on ainoa puulaji, joka on muodostanut metsiköitä Islannissa viimeisimmän jääkauden jälkeen. On arvioitu, että neljännes maa-alasta oli koivikoiden peitossa ennen asutuksen alkamista. Nykyinen koivikoiden pinta-ala on n. 150 600 ha. Muita kotoperäisiä puulajeja ovat haapa (*Populus tremula*), kataja (*Juniper communis*) ja pihlaja (*Sorbus aucuparia*) sekä monet pajulajit (*Salix* sp.).

Saaren asuttamisen jälkeen metsiä ja puuta ruvettiin hyödyntämään monin tavoin: poltossa, rakentamisessa, puuhiilen tuotannossa ja eläinten rehuna. Metsiköitä raivattiin laitumiksi ja lampaiden ja hevosten annettiin laiduntaa vapaasti. Tämä teki puuston uudistumisen hyvin vaikeaksi. Kasvillisuuden sukkessiota vaikeuttavat myös ankarat ilmasto- ja ympäristöolot. Nykyisin 35–45 % Islannista on eroosiolle altista autiomaata.

Islannin metsittämisohjelmat ovat joko valtion rahoittamia maatilojen metsittämisohjelmia tai yksityisten metsäyhdistysten metsitysprojekteja. Metsittämisessä käytetään sekä paikallista hieskoivua että ulkomaisia havupuita. Havupuiden siemenet tulevat pääosin Alaskasta. Siellä ilmasto on samanlainen kuin Islannissa ja tuodut lajit pystyvät kasvamaan siellä.

Yleisiä kasvatettavia havupuita ovat douglaskuusi (*Pseudotsuga menziesii*), metsäkuusi (*Picea abies*) ja sitkankuusi (*Picea sitchensis*). Lisäksi Itä-Islantiin on istutettu jonkin verran Siperian lehtikuusta (*Larix sibirica*) ja koko maahan kontortamäntyä (*Pinus contorta*). Myös Pohjois-Amerikan länsiosista peräisin olevaa jättipoppelia (*Populus trichocarpa*) on istutettu kaupunkimetsiin ja ulkoilualueille sekä peltojen reunoillle tuulensuojiksi vähentämään maaperän eroosiota.

Islantilaiset istutetut havumetsät ovat yleensä yhden puulajin muodostamia tiheitä monokulttureja. Niitä ei harvenneta, jolloin ne ovat läpitunkemattomia rivistöjä, joiden pohjalla on pelkkä neulasmatto. Vielä ei Islannissa ole ollut hyönteistuhoja, mutta lienee vain ajan kysymys, milloin esim. kaarnakuoriaiset leviävät sinne tuulten mukana. Hyönteisten massaesiintyminen olisi kohtalokasta tuollaisille metsille.

Islannin metsätalous on kovin nuorta ja sen tavoitteet eroavat melkoisesti Suomessa harjoitettavan metsätalouden tavoitteista. Paljon on tehty, mutta työn ja tutkimuksen sarkaa on vielä runsaasti käännettäväksi.