Restoring the North – Challenges and opportunities

International Restoration Conference, Iceland, October 20-22, 2011
Book of abstracts

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Restoring the North – Challenges and opportunities
Selfoss, Iceland, October 20-22, 2011

Thursday, October 20.

08:20 Registration
08:50 *Conference opening*, Guðmundur Halldórsson
09:00 *Address from the Minister for the Environment*

Session I: Restoration in the North – Challenges and opportunities

Session II: Setting objectives and evaluating success in restoration

Case studies

Friday, October 21.

Session III: Legislation, policy, implementation

Session IV: Posters

Session V: The role of theory in restoring ecosystem structure and function

Session VI: Achievements and future of ReNo

Saturday, October 22.

Field excursion to Þórsmörk. Theme: Resilience of degraded vs. restored ecosystems to natural hazards.

Posters

Special challenges and opportunities for restoration in the North

Bruce Forbes

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The presentation will consider special challenges and opportunities for restoration, and related forms of assisted and natural regeneration, in northern terrestrial ecosystems. First, terminology is important and a large number of 'R' words are reviewed. Besides Restoration, our respective sources of funding and we should ideally be versant in Reclamation, Revegetation, Rehabilitation, Recolonization and so on. These terms must be used properly among practitioners and with non-expert audiences carefully and consistently to avoid confusion. Second is a brief historical overview of restoration-relevant research in circumpolar arctic and sub-arctic regions from the 1960s until the present. Next, case studies are presented – mainly from north of latitudinal treeline in Alaska, Canada and Russia. Finally, we come to challenges and opportunities. Challenges include diminishing sources for local/regional seed, a general lack of controlled long-term studies, the increasing scale of impacts requiring active intervention, invasive plants, and climate change. Opportunities include climate change – a double-edged sword - new industries with (hopefully) more advanced efforts at mitigation, and more stringent regulations concerning reclamation in the vast Russian Arctic.

Peatland and forest restoration in Finnish conservation areas

Päivi Virnes

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Introduction

Boreal forests and peatlands in Finland have been under strong human influence for hundreds of years. Currently, the majority of the habitats in natural condition are protected. However, the marks of the past human activities are clearly visible in many protected areas. A substantial proportion of forests in conservation areas are even-aged with very low volumes of dead wood. Because of effective fire control also natural fires are rare. In peatlands the drainage for forestry has decreased the water table level and has affected the physical properties of soil, e.g. acidity, aeration of surface peat, microbial activity and nutrient conditions. These changes have had severe implications on the diversity of forest and mire habitats and species.

Restoration

Restoration is a useful and important tool for improving the quality of conservation areas when natural recovery is expected to be too slow or uncertain. The long-term goal of the restoration is to promote natural processes of biotopes and consequently to maintain viable populations characteristic for the ecosystem. In short term this usually means improving the habitat quality for the threatened and declined species.

Framework for habitat restoration includes planning, implementation and monitoring. Constant feedback between these is a way to continuous improvement of the restoration methods. It also ensures that possible problems are detected, solved and corrected as early as possible.

More than 15 000 ha of former commercial forests and 18 000 ha of peatlands drained mostly for forestry have been restored so far. The Metsähallitus Natural Heritage Services is responsible for all restoration work in state-owned conservation areas in Finland.

In forests the volume of decaying wood has been increased by damaging and felling trees. Gap dynamics has been initiated by creating small openings and controlled burning has been used as a disturbance factor in forests of protected areas. In peatlands the water table level has been raised and the natural flow paths of waters have been restored by filling in the ditches and by building dams. To recreate the landscape also all or part of the tree stand from originally open or semi-open mires has been harvested.

Short term restoration observations, monitoring and case studies show encouraging results on the restoration measures in Finnish nature conservation areas. However, long term monitoring is definitely required to ensure achievement of long term goals.

Restoration of forests and peatlands is financed mostly by Finnish national Forest Biodiversity Programme METSO (2008-2016) and tens of LIFE-projects.

Hekluskógar – large scale restoration of birch woodlands with minimum inputs

Hreinn Óskarsson[1], Guðmundur Halldórsson[2] and Ása L. Aradóttir[3]

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The main objective of Hekluskogar project is to reclaim woodlands of native birch (*Betula pubescens*) and willows (*Salix* spp) in the neighbourhood of Mt. Hekla. The primary objectives are to increase the resilience of the ecosystem to depositions of volcanic ash during the frequent eruptions in the volcano Mt. Hekla and prevent secondary distribution of the ash, by wind and water, to nearby areas. Other objectives are restoration of ecosystem function and biodiversity, carbon sequestration and improved options for future land use.

The Hekluskogar project started in 2007 and covers an area of ca 90 thousand hectares, most of which was grown with native birch and willows by the time of the settlement of Iceland. Historical records show that prior to that deposits of ash from eruptions in Mt. Hekla were mostly stabilised on the forest floor, preventing secondary distribution followed by large scale erosion. Following the settlement, forest clearage and intensive grazing started. This reduced the resilience of the ecosystem and the following volcanic eruptions initiated large scale soil erosion. Presently most of the area is eroded and the soil is poor in nutrients and water holding capacity and frost heaving is extensive. Therefore, establishment of seedlings is limited. Erosion is extensive, primarily wind erosion, but during spring thaw also water erosion.

Due to the size of the area, it was decided to use low cost methods. Therefore, the restoration of woodlands will mostly rely on self seeding of birch and willows, rather that large scale planting. To accomplish this, seedlings will be planted in small groups, from where the woodland will spread out by self seeding in the ensuing years. Experience, from excisting birch groves in the area, shows that this is a feasible method. However, stabilizing the soil in the nearby areas is needed to create favorable conditions for self-seeding. This is done by fertilizing the land in order to facilitate establishment of the local flora. If seeding of local flora is poor, sowing of a mixture of grass species is also needed.

Land owners in the area have been encouraged to participate in the project, mostly on the basis of receiving plants for free. Presently, three years after the start of the project, 150 land owners have joined the project and ca 1,350 thousand seedlings had been planted, spread on small groups throughout the area.

Vegetation recovery after transplantation in an alpine environment, Bitdal, Norway

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In Bitdalen, Southern Norway, a quarry made for dam rehabilitation has been restored. A modified topography was constructed from waste rock, subsoil and topsoil. 521 patches of existing vegetation adding up to 1300 m^2 was removed, stored for two years and transplanted. The restoration was finished autumn 2008.

In 2010, all vascular plants were recorded on 44 of the transplanted vegetation patches and the survival of trees of *Betula pubescens* ssp. *czerepanovii* were recorded on 120 patches. Species dominating the field layer on most of the patches were *Rubus chamaeomorus*, *Betula nana*, *Eriophorum vaginatum*, *Empetrum nigrum* and *Vaccinium uliginosum*. Dead plants of low growing woody species occurred in 41 of 44 patches and on average 25% of the woody plants were dead. *Calluna vulgaris* had highest death rate. In general most of the low growing woody plants survived the storage and transplantation. Grasses seemed to be more tolerant to transplantation stress as dead plants were found in only 6 of 42 patches with an average of 18% dead plants.

On about 60% of the patches with *Betula pubescens* ssp. *czerepanovii* one or more of the tree crowns survived storage. In the end of the second full growing seasons after transplantation the survival rate of the tree crowns was still about 60 % indicating that digging up the trees and storage was the most critical phase. Most trees suffered from serious decline and only 10% had fairly good vitality.

Due to spontaneous revegetation from the top soil, the vegetation cover increased from 20% in 2008 to about 65% in 2010. On sparsely vegetated areas (2% or less) the vegetation cover increased to about 55% within two years. *Agrostis capillaris, Rumex acetosella, Carex* spp. and *Avenella flexuosa* increased most. *Agrostis capillaris* and *Rumex acetosella* are rear in the adjacent vegetation. The large increase in these two species may therefore be partly due to introduction of seeds by sheep grazing on the area. In seed bank samples collected in spring 2009 few species germinated from the seed bank, but the dominating species from the seed bank also dominated the revegetation process, except for *Calluna vulgaris*, which was rather frequent in the seed bank, but hardly found in the vegetation survey.

Dam removal: enhancing or degrading ecological integrity?

Birgitta Malm Renöfält

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Removal of dams is increasingly being used to restore fragmented rivers and streams. The incentive is often to give migrating fish access to upstream spawning habitats, but dam removal may also bring other benefits, such as recovery of riparian vegetation and a more heterogeneous environment for aquatic invertebrates. Dam removal may also act as a disturbance on the system, releasing trapped sediments to downstream reaches. Depending on the amount of sediments in the former reservoir this disturbance may be transient or act over a longer time period. Whether dam removal is beneficial or not to the ecosystem may therefore depend on the type of organism. We have studied the effect of dam removal on riparian vegetation and benthic invertebrates in two Swedish streams over a period of three and five years respectively, and found that riparian vegetation generally benefitted from removal. Species richness increased, and community composition became more similar to a reference situation within a three year period. In contrast, benthic invertebrates seemed to be negatively affected by dam removal. While we saw no effects on community composition of benthic invertebrates, taxon richness decreased continuously over a five year period and total densities decreased initially but showed weak signs of recovery over the five year period. Our results also indicate that the response varies between invertebrate taxa.

The effects of birch forest degradation on beneficial soil fungi in Iceland and the Faroe Islands

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In a Nordic study, the effects of birch forest degration on the distribution of beneficial soil fungi was studied in Iceland and the Faroes Islands. The fungal groups studied were etomycorrhiza (ECM) and insect pathogenic fungi (IPF). This was done by mapping the distribution of ECM and IPF in soil originated from birch woodlands (Iceland and the Faroe Islands), heathland (Iceland and the Faroe Islands) and eroded, poorly vegetated areas (Iceland).

Both ECM and IPF were identified in vegetated ecosystems examined whereas no IPF were recorded in eroded ecosystems that supported significantly lower occurrence of ECM. This was reflected in poorer birch seedling performance in eroded soil.

Three IPF species were identified, *I. farinosa*, *B. bassiana* and *M. anisopliae*, latter two species have not been recorded earlier in Iceland. Preliminary phylogenetic analysis targeting internal transcribes spacer (ITS) sequences of the ribosomal RNA gene of mycorrhizal fungi from mycorrhizal birch root tips revealed three main groups, *Hebeloma* and *Cortinarius* spp., and Ascomycetes, whereof *Hebeloma* and Ascomycetes were more common.

The importance of these results regarding afforestation in the north-western part of the Nordic Countries is discussed.

Setting objectives and evaluating restoration

Joy B. Zedler

Aldo Leopold Professor of Restoration Ecology, University of Wisconsin-Madison

The temptation is great to claim that a restoration project is “successful” after time and money have been spent re-establishing native species. Yet restoration practice and science are best advanced by learning which objectives were and were not met—and why. Decades of experience and study of wetlands suggest that restorationists need to (a) set clear objectives; (b) use multiple indicators and specific standards to assess outcomes; (c) not depend on structural attributes to measure ecosystem functioning, despite Anthony Bradshaw’s prominent model of a positive linear relationship; (d) introduce assemblages of species that use resources differentially and test for complementarity; (e) seek and employ “superplants” that perform multiple ecosystem services at high levels; and (f) conduct restoration within an adaptive restoration framework. Learning is facilitated by undertaking large field experiments that test alternative restoration approaches (called “adaptive restoration”).

Driving forces behind EU (LIFE nature) co financed projects aimed at ecological restoration in Denmark

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Driving forces behind ecological restoration in Denmark were investigated by analyzing finalised projects co financed by the LIFE-nature fund of the EU. Fifteen projects all reported and partly or fully executed in Denmark were included. Marine projects and projects with monitoring purposes were left out beforehand.

The projects were analysed by use of the nine attributes for successful ecological restoration of the SER Primer and the five myths of restoration ecology by Hilderbrand *et al*. (2005). Project objectives can be divided into three categories: conservation of a single or a group of species, abandoning or traditional farming in former reclaimed sites, and management of natural areas to maintain certain desired nature types which often included remove of non-indigenous species. In spite of these groupings, improvement of living conditions for certain species associated with specific nature types were in focus in all projects. Manipulation of the physical conditions and elimination of exogenous threats to species were the most used tools. Few projects aimed at restoring natural landscapes, whereas all projects implied future management in order to keep the ecosystem structures. This is typically the myth of the Carbon Copy and the myth of Command and Control and clearly causes loss of ecosystem resilience. Often the target ecosystem is associated with a semi-cultural landscape, and the future management focus on keeping the vegetation low and prevent colonising trees. There is a general tendency to believe that the ecosystems will self-organize (the myth of the Field of Dream), combined with a lack of consideration of the presence of functional groups. This, combined with the Sisyphus Complex of the ongoing management, is seen as the weakness of the projects.

It is concluded that ecological restoration in Denmark does not initiate or facilitate the resumption of a development along a trajectory, but rather aims at maintaining semi-cultural habitats and highly prioritized associated species.

Short-term vegetation recovery in a large scale restoration project, Dovre Mountain, Norway

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In 1999 the Norwegian Parliament decided to close down a large military training area in Dovre Mountain, Central Norway. The area is situated within a unique high mountain ecosystem and surrounded by several protected areas. The stated goal is to restore the area for civilian application and nature conservation.

The large scale restoration and removal of technical infrastructure and roads started in 2008. In 2002 a pilot project was initiated, removing 1.2 km roads, to develop and test the technical, safety, economical and ecological conditions for further detailed planning.

Establishment of a monitoring program for vegetation development was initiated in the pilot sites to study the recovery of vegetation following different vegetation treatments. This study focuses on short-term (three to seven years) recovery following three treatment types; 1) soil (removal of pebble granules and stirring of the original soil layer down to 20 cm), 2) soil and fertilizer, and 3) soil, fertilizer and seeds of *Festuca rubra*. In addition, vegetation turfs (turft of 1 m^2, app. 5 m planting distance) were transplanted to the sites. The experimental set up was established in 2002. Nine blocks, each including 5 permanent plots (0.5 × 0.5 m) were established, and one treatment type was applied to all plots within a block. The vegetation in the plots was analysed in 2002, 2005 and 2009.

We studied the effect of treatments on vegetation recovery in terms of 1) species richness, and the cover of 2) living biomass, 3) dead organic matter, and 4) bare soil, three and seven years after treatment application. The initial vegetation recovery was characterised by good species colonisation, despite the harsh climatic conditions in this mountain area. Plant cover increased with time in all treatments, and was highest in the soil, fertilizer and seeds treatment after seven years. Similarly, species richness increased with time in all treatments, and there seemed to be a positive effect of closeness to transplanted vegetation turfs on species richness, although no similar effect was found on plant cover.

The results are discussed in relation to time scale (short vs. long term effects) and to the degree of intervention of the restoration treatments (introduction of non-native seeds, nutrient addition) to a ecosystem with slow nutrient turnover.

The results will be further discussed and evaluated related to the goal of ecosystem restoration in the large-scale project and to the degree of interventions that can be used to achieve this goal.

Restoration in the Faroes

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Abstract

In connection with the ReNo project, the Faroese Museum of Natural History has received information from local institutions and organizations, on activites relating to restoration. Activieties reported range from reducing CO_2 emissions, mapping the effects of hydropower and landslides to better use of soil. However, seemingly no activities can be regarded as a practical effort in restoring a degraded area back towards a natural state.

In my presentation I will present some of these activities. I will also describe how nature — and the protection of it — is administrated by the government and the municipalities.

Can restoration help conserving the biodiversity of ecosystems threatened by climate change?

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Riparian zones form the interfaces between land and freshwater environments and perform many different functions (Naiman and Décamps 1997). In boreal regions riparian zones harbor high numbers of species in comparison with surrounding habitats and are hot spots of plant species richness (Jansson et al. 2000, Nilsson and Svedmark 2002). The main driver of riparian vegetation dynamics is the flow regime of the streams. Flowing water regularly disturbs river banks, but also provides continuous water supply, disperses plant propagules and determines depth to groundwater tables (Naiman and Decamps 1997, Poff *et al.* 1997).

Expected changes in temperature and precipitation during the 21st century are believed to alter the hydrological regimes of rivers and streams. Climate change in northern Sweden is expected to lead to earlier and smaller spring flood peaks, higher flows during winters and potentially autumns with higher frequency of high flow events (Andréasson et al. 2004). All these hydrological changes will have consequences for riparian vegetation. Reduced spring floods will leave parts of the riparian forest zone unflooded potentially leading to species loss. Higher winter flows may also affect plants dependent on lower winter than summer water levels that leaves ice stranded in the riparian zone (Nilsson 1983).

In the past, most river channels in northern Sweden were transformed to facilitate timber floating (Törnlund & Östlund 2002). River channelization increased flow velocity, resulted in more flashy hydrographs and generally disconnected riparian areas from their rivers. River restoration entails removing stone walls blocking backwaters and side channels and replacing stones, boulders and logs back into the channel. This increases channel roughness, reduces flow velocity, and increases the duration of high flows. Such restoration measures have proved effective in increasing habitat availability as well as abundance and species richness of riparian plants (Helfield et al. 2007), but their function in a future climate is not known. Currently, state-of-the-art methods of restoration are being used as part of a new EU Life Project in northern Sweden. The methods consist of putting large boulders and uprooted trees logs in the stream channel, structures that have been lost or become rare but which are believed to be important for both the hydrology and habitat availability of aquatic organisms.

The goal of this project is to understand how climate change and different methods of ecological restoration will interact to affect the riparian vegetation along medium-sized boreal forest streams in northern Sweden. Using knowledge about riparian vegetation-flooding relationships, plant responses to ecological restoration and modeling of future hydrology, this project will test whether ecological restoration of streams can be an effective way to increase the resilience of riparian zones to climate change.

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Recovery of nursery areas for Atlantic salmon (*Salmo salar*) in River Ellidaár

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Since the beginning of the 20th century the River Ellidaár and its biota have experienced considerable human impact. The Ellidaár hydropower station, built in 1921, led to drying of some reaches of the river system and changes in the flow regime of others. It has been estimated that the construction and operation of the hydroelectric power plant influenced water flow in 43% of the total wetted area. The most obvious influence was drying of the Vesturkvísl and the Austurkvísl, two branches near the river´s estuary. Here, we evaluate recent efforts to restore the salmon populations in these two branches. In 1999 minimum flow standards were set at 0.4 m^3s^{-1} in Austurkvísl and 0.3 m^3s^{-1} in Vesturkvísl. To rehabilitate the Atlantic salmon juvenile population in these two branches, Institute of Freshwater Fisheries stocked 10.000 hatchery salmon juveniles in both 2000 and 2001. In the following years, density and growth of the salmon juveniles were estimated annually by electrofishing surveys at one location in Austurkvísl and two locations in Vesturkvísl. Stocked juveniles exhibited high survival and growth rates. Since management of the flow resumed in Austurkvísl and Vesturkvísl in 1999, wild salmon juveniles have been observed and salmon densities are now comparable to other areas of the river. These two branches represent 15% of the total salmon habitat and have likely increased salmon smolt production in the River Ellidaár.

Restoration of the Icelandic Sea Eagle Population

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Introduction

The White-tailed eagle or Sea Eagle, *Haliaeetus albicilla* was formerly abundant and widely distributed throughout Europe and northern Asia. During the 19^{th} and early 20^{th} century, eagle numbers decreased rapidly due to human persecution, habitat destruction, and environmental toxins. Being a top-predator, the Sea eagle is extremely vulnerable to bioaccumulation of harmful environmental pollutants which can affect reproduction (Helander et al. 2002). Sea Eagles disappeared from many areas and this led to classification of the Sea Eagle as a globally threatened species.

During the last four decades, restoration efforts, such as curbing the use DDT and PCB, translocation of captive bred birds and supplemental feeding have reversed this trend in a remarkable way (Helander et al 2003). Consequently, populations throughout Northern Europe have increased rapidly and the Sea Eagle has become a symbol of successful restoration of an endangered species on a large geographical scale. Following population recovery in many European countries, the Sea Eagle was down listed to Least Concern in 2006 (IUCN 2010). The European Sea Eagle population is estimated at 5,000-6,600 pairs, encompassing >50% of the global population, with most of the birds in Norway and Russia.

In 1963, when the isolated Sea Eagle population in Iceland was on the brink of extinction a few determined men founded the Icelandic Society for the Protection of Birds, primarily to save the endangered Sea Eagle. In this synopsis, the history of the pioneers and their quest to restore the eagle population in Iceland will be reviewed.

Life history

The Sea Eagle (Icelandic: haförn) is a large raptorial bird (5-7 kg) with a wingspan of up to 2.3 meters. Birds reach maturity at 4-6 years and may live for 20-30 years. The adults are easily recognized by their white tail and cream-colored head; the young birds are darker. In Iceland, the Sea Eagle's main habitats are archipelagos, shallow bays, and fjords as well as spring fed rivers in winter. The adult pairs use the same traditional nest sites (eyries) generation after generation, and stay on their territories year round. Young eagles however, may wander far and wide within the country before reaching maturity. Icelandic Sea Eagles are currently isolated from other Sea Eagles, thus no reinforcement of the Icelandic population can be expected from other areas. The low genetic diversity in Greenland and Iceland Sea Eagles, and the occurrence of a unique haplotype, strongly suggest that these populations have long been isolated from other White-tailed Eagle populations (Hailer et al. 2007).

Over 95% of known eagle territories in Iceland are within 10 km of the coast and their regional distribution is significantly correlated with the extent of the intertidal zone. Hence, most of the historical eagle sites are in the two big bays in western Iceland, Faxaflói and Breidafjörður (Skarphéðinsson 1994), which together hold over 70% of the entire intertidal area in Iceland.

Sea Eagle breeding success is considerably lower in Iceland and eagle numbers have grown much slower than in most other recovering populations (Evans et al. 2009). On average, less than half of the Icelandic eagle pairs breed successfully each year (Skarphédinsson 2003a). Most losses of eggs and young are associated with inclement weather and mean spring temperature explained almost half of the annual variation in the eagles' productivity. Human disturbance is also responsible for some eagles' poor breeding. Furthermore, a significant negative correlation was observed between eagles' breeding success and the concentration of environmental toxins such as DDE in eagles' eggs. Thus, pollutants may play a significant role in poor breeding performance of Icelandic Sea Eagles (Ólafsdóttir et al. 2004).

Persecution, protection and population trends

Sea Eagles were formerly abundant in Iceland and the population may have been 150–200 pairs in the early 19th century. Around 1900, eagles were nearly wiped out by systematic persecution that included high bounties paid by Eider farmers (Ingólfsson 1961, Skarphéðinsson 1994, 2003b). Accidental strychnine poisoning from fox baits also became an important cause of mortality from the 1880s on. Sea Eagles occasionally killed newborn lambs and frequently harassed Eider ducks which could affect the harvest of valuable eider down. Persecution of eagles became rampant; accessible nests were destroyed and the birds shot at whenever possible.

The demise of the Icelandic Sea Eagle had become painfully apparent in the early 1900s. Iceland became the first nation to grant Sea Eagles legal protection in 1914 when there were fewer than 40 eagle pairs remaining (Fig. 1). Their numbers continued to decline until the early 1920s but remained relatively stable at 22-25 pairs through the 1960s (Ingólfsson 1961, Skarphédinsson 2003a). Poisoned fox baits were banned in 1964. This proved to be the turning point for the Sea eagle population which has more than tripled since, to 66 territorial pairs in 2010, of which 28 pairs raised a total of 38 young (Skarphéðinsson 2010).

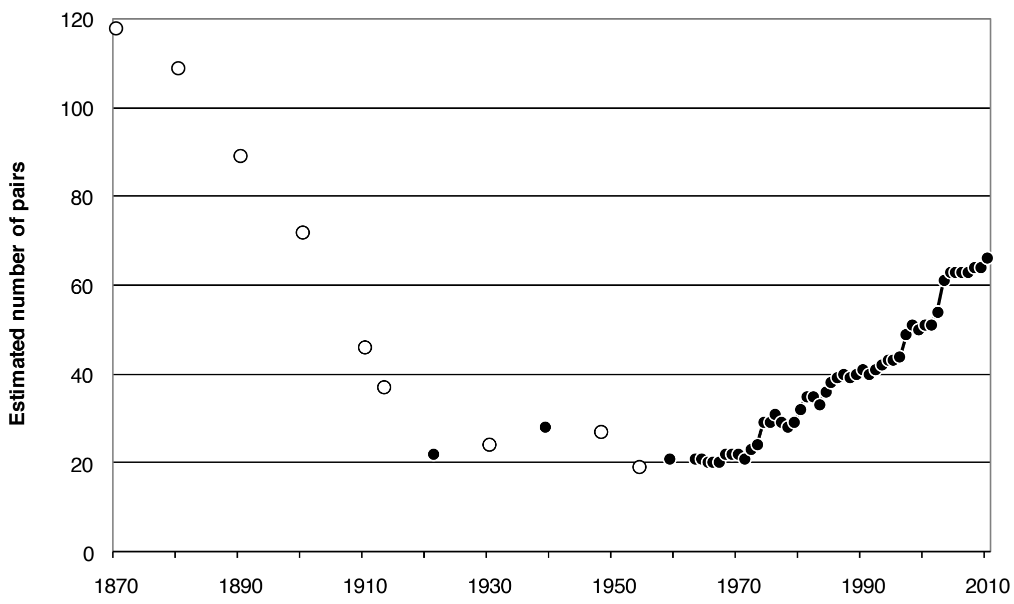

Fig.1. The Icelandic Sea Eagle population 1880 – 2010. Numbers are based on rough estimates (open circles) and partial or comprehensive surveys (closed circles).

Restoration

Björn Guðbrandsson (1917-2006) was a paediatrician devoting his live to saving children – and eagles. He founded the Icelandic Society for the Protection of Birds (BirdLife Iceland) in 1963 and was the undisputed leader for the protection of the Icelandic Sea Eagle for the next 30 years. Björn emphasized two important goals for the restoration of the Icelandic Sea Eagle: (1) to ban the use of poisoned fox baits and (2) to improve the conservation status of individual eagle nesting territories through personal contacts with landowners. It took only one year for Björn and his men to convince Parliament to ban the poisoned fox baits which had proven to be extremely deadly to eagles, especially the immature birds.

Björn and his associates visited "Eagle farmers" for many years. The purpose of these visits was to become acquainted with the landowners and simultaneously to monitor the eagle population. To further improve eagle conservation, BirdLife Iceland rented hunting rights to minimize disturbance in the vicinity of eagles nests. Landowners were rewarded a prize for each eaglet raised, be it monetary, perfumes, hard liquor and even fitted dentures and spectacles! Furthermore, Björn and his colleagues provided pro bono medical services for the farmers and their families. These highly unconventional methods soon proved to be successful; disturbances decreased and fewer nests were destroyed. In a few years, the eagle population began to increase, a trend that has continued to this day. For his relentless efforts to save the Sea Eagle, Björn Guðbrandsson received the Nordic Environmental Year Award in 1991.

Threats, conservation and monitoring

Regrettably, Sea Eagles are still persecuted; 25% of the eagles found dead have been shot at (Skarphéðinsson 2010) and nests are willingly destroyed. Eagles can cause considerable disturbance to nesting Eiders which occasionally leads to a reduced yield of down in some eider colonies. However, the overall financial damage is minimal (Skarphéðinsson 1994). Eagle habitat is also under threat; a single causeway in Breiðafjörður reduced the bay's intertidal zone by 5% and, 11% of eagle territories are either uninhabitable to eagles or under serious threat (Skarphéðinsson 2005).

Icelandic Sea Eagles and their nesting territories are strictly protected in line with their European counterparts. The same applies to traditional eagle nesting territories in Iceland. Eagle nest sites and their surroundings; within a 100 m radius from the sites are protected. Furthermore, a 500 m radius from active eagle nests is designated as a "safety zone" and may not be entered during the eagle's breeding season (15 March – 15 August) without a special permit. Landowners, however, are allowed to enter the zone but are required to minimize disturbance to nesting eagles.

In the past 25 years, the Icelandic Institute of Natural History has gradually taken over the monitoring of the Sea Eagle population from BirdLife Iceland. Lately, various research projects have also been expanded in collaboration with the Nature Centres in West- and Northwest Iceland. All eaglets are now ringed with individually numbered colour rings as a part of the international Sea Eagle ringing project and their blood sampled for genetic research. In addition, addled eggs are collected to monitor chemical pollutants in cooperation with the University of Iceland.

Conclusion

Attempts to restore the Icelandic Sea Eagle population were initiated long before the term "ecological restoration" was coined. Its restoration goes hand in hand with some other major conservation goals, i.e. reduction of environmental pollutants and the preservation of intertidal zone. The Sea Eagle may therefore be regarded as a sentinel species for the favourable conservation status of its main habitats

(BirdLife 2002, Helander et al. 2008). Despite the vastly improved standing of the Icelandic Sea Eagle, it is still classified as Endangered (EN) in the national Red List (IINH 2000). Future restoration goals include improving eagles' breeding success as well as the re-occupation of all parts of their former range in Iceland. Illegal activities must be minimized through education and stricter law enforcement. Destruction of eagle habitats and their traditional nest sites are continuing threats that must be stopped. Finally, it is crucial that up to date information on population parameters and well-being of the Sea Eagle population be maintained through research and monitoring.

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Legislation, Policy and Implementation of Restoration: A View from the Social Sciences

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Abstract

Our aim is to open up a new arena for mutual exchange between the natural and social sciences by identifying what social science can bring to the study of ecological restoration. The discussion is analytical, but also tentative, given the very limited engagement to date with this subject by the social science academic community. Acknowledging our debt to the well-developed philosophical study of ecological restoration, we begin with a conceptual discussion. We argue that the value of ecological restoration rests not just on ecological performance [structural replication, functional success & durability in restored ecosystem] but also needs to be adjudicated in historical, social, cultural, political, aesthetic and moral contexts. Beyond this, there is need to recognise that there is not one but many social science perspectives. We will lean towards a political science approach.

Examining disputes over ecological restoration, we identify the questions that a political scientist would ask:

- Why is ecological restoration undertaken and by whom?
- How is ecological restoration governed?
- To what political use can ecological restoration be put?
- Who gains and who looses in ecological restoration, including at the project level?

We explore some answers to these questions, looking at the problem of governance and the issue of [temporal and spatial] scale. Then, adopting a policy analysis perspective, we apply the ‘stages model’ of policy making to the study of ecological restoration. Some of the limitations of this approach are identified, but at least a start has been made on our task of bringing a social science, or more specifically policy analysis, perspective to the table. We stress the value of this perspective in identifying the prospects for, and barriers to, successful ecological restoration, particularly at the project level.

How sustainable is the sustainable mire and peatland strategy?

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Finland has a total of about 10 million hectares of mires and peatlands, which is about a third of the country's total land area. About half of the area of mires has been drained for the forestry use, and about 60,000 hectares are used annually for peat production. Thirteen percent of the mires are protected.

Due to the multiple needs and values relating to the use of peatlands, preparation of a Finnish National Strategy for Mires and Peatlands, coordinated by the Ministry of Agriculture and Forestry, was started at the beginning of 2009. The aim was to create common understanding of the sustainable and diverse use of mires and peatlands. Key aims were set by applying ecosystem approach: to secure the benefits and energy supply for agriculture and forestry, reduce harmful impacts on waters and climate, achieve favourable conservation status for mire nature and ensure the multiple use and cultural services. Specific aims were: securing employment and domestic supply of energy, the future use of drained low-productive peatlands, methods for estimating the degradation state of mires, mechanisms for protection, and life-cycle assessments considering greenhouse gas balance.

A working group started to prepare the strategy in February 2009. Besides four ministries, the group had members from research institutes, regional councils, environmental agencies, representatives from energy, peat and farming industries, and nature protection organizations. After two years and over 30 meetings in February 2011, the proposal of the working group was finally submitted to the Minister of Agriculture and Forestry. Simultaneously, discrepancy notices towards the proposal from inside the working group and from external experts came into publicity. EU parliament member from Finland's Green Party also made a parliament question claiming that the proposed strategy primarily supports continued burning of peat rather than environmental protection, nature conservation or restoration.

At the same time when the working group was finishing the proposal for the National Strategy for Mires and Peatlands, a local mire and peatland program was launched in Northern Ostrobothnia, the peatland-richest region in Finland. The local program has the same key aims as the National strategy, but local people and other stakeholders are better involved to the planning process using interviews and questionnaires concerning sustainable peatland use and values of peatlands. By this the social acceptability of the local mire and peatland program is aimed to be higher, although the final planning will be made by the regional council.

Sustainable strategies are compromises, which may eventually be dissatisfying to most interest groups. Scientific information can be overrun by local politics and employment needs. One of the key reasons for the discrepancy in the National Strategy for Mires and Peatlands is the plan concerning undrained natural mires, that in some cases would be used for peat production despite the fact that the strategy principally directs the peat production to previously drained or otherwise degraded mires. In the complaint to EU the implementation, the strategy is told to run counter to the EU's climate objectives, would be likely to increase damage to adjoining waters and infringe the Habitats and Wild Birds Directives. Use of peat for energy is not generally accepted in Finland despite Finnish government's tax support, as burning of peat is expected to produce more greenhouse gas emissions than burning coal, and since it destroys the excavated mire ecosystems completely.

National Strategy for Mires and Peatlands and newest results from the mire and program of northern Ostrobothnia will be further discussed at the RENO conference.

Using a social-ecological system framework to analyse the interactions between agri-environmental policies and rangeland restoration in Iceland

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Restoration of ecological integrity and function is defined as the essential basis for all restoration projects but the need for social acceptance and support is also widely acknowledged. The outcomes and the impacts of restoration are based on efficient governmental policies that in the long-term are meant to enhance restoration activities. The progress on the other hand, is directly related to the restoration's social-ecological system (SES) sustainability. In order to understand a SES it therefore has to be clear what natural resources and stakeholder groups are involved, their role within the social-ecological system and the interactions between all the related factors.

In the study introduced here, we are working on analyzing the SES of rangeland restoration in Iceland. It's a complex system, driven by agri-environmental policies, controlled by laws, regulations or other direct governmental decisions and supported and managed by related institutes with the aim to encourage farmers to use ecological approaches to restore degraded rangeland and practice more sustainable land management.

To get a deeper insight on how the system functions in practice, we interviewed stakeholders from different hierarchical levels within the SES and asked about their attitudes to restoration. Currently we are using a SESs framework to map the system's core social and ecological subsystems, second level variables, the interaction within the system, the social, economic and political settings that are influencing it and related ecosystems. The result will be used to design model/instruments for evaluating the impacts of Agri-environmental policies on rangeland restoration amongst sheep farmers and the sustainability of the related social-ecological system.

Drivers of restoration — lessons from a century of restoration in Iceland

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Since Iceland was settled in the ninth century, Icelandic ecosystems have been altered by severe ecosystem degradation and soil erosion. This was caused by unsustainable land use superimposed on harsh climatic conditions and fragile ecosystems. Natural woodlands have decreased by at least 95%; total vegetation cover has decreased by at least one-third with much of the remaining vegetation cover in a degraded state; and more than half of natural wetlands in lowland areas have been drained.

Different environmental, socio-economical, historical, and policy factors may act as drivers for ecological restoration of damaged ecosystems, with several interlinked factors acting at the same time. A recent review of restoration in Iceland — describing 85 projects extending over more than 1700 km^2 — provides a unique opportunity to investigate how drivers, goals, approaches and main actors of restoration projects have changed in the country during the last century.

Significant efforts for halting soil erosion and protecting remaining forests started in 1907, when a special law on forestry and protection against sand encroachment was passed by the Icelandic Parliament. For the first few decades, the immediate goal of most efforts was to halt severe soil erosion and protect the scant remnants of birch woodlands. Many of the actions taken, however, resulted in the restoration of birch woodlands and heathland vegetation. During the 1940's to 1960's, the main emphasis was on reclaiming barren land to use for grazing or hay production, which was needed because of a sharp increase in the number of livestock in the country.

In the 1970's growing environmental awareness lead to the formulation of green agendas and political activism in many industrialised countries. It is interesting to note that in Iceland, this trend manifested itself in a growing awareness about the state of the land, but there was less concern about pollution and water resources as emphasized more in other countries. Icelanders have always been conscious about the past ecological richness of the country as described in the Icelandic Sagas. The growing concern for the land in the 1970's among the public, administration, and in politics resulted in a special parliamentary act allowing for dramatic increase in funds for revegetation of eroded land, land resource focused research, vegetation mapping and a survey of the remaining birch woodlands. At that time, one of the reasons given for these increased revegation efforts was to 'repay the debt to the land,' Although restoration was not the immediate goal of the ensuing efforts, research has demonstrated that with time many of them led to successional trajectories toward native ecosystems.

Restoration as a mitigation of vegetated land submerged by dams, damaged by road construction or by gravel mines, started in the 1970's and has continued since then. In the late 1980's, there was a growing awareness of the ecological aspect of restoration and since the 1990's there has been increased emphasis on restoration of native habitats, such as birch woodlands, heathlands and wetlands. Attempts to restore the habitats of aquatic animals started in the 1980's; all related to some type of construction work. Efforts to protect the Icelandic sea eagle population started as early as 1914, but attempts to restore the population started by the end of the 1950's.

The increase in restoration of native habitats was among other factors aided by the availability of vegetation maps, better knowledge about the extent and state of the birch woodland remnants, surveys of the wetland destruction and a comprehensive mapping of soil erosion in the whole country. Towards the end of the twentieth century, number of research projects on restoration ecology increased sharply, which may have been a consequence of increased emphasis on ecological restoration, but also a driver for restoration projects. The number of M.Sc. and Ph.D. projects in the field of Restoration Ecology grew simultaneously.

Iceland became a signatory of the UN conventions on biodiversity (CBD), climate change (UN-FCCC) and desertification (UN-CCD) in the 1990's, which in part has called for an increased emphasis on the restoration of biodiversity and ecosystem services. Carbon sequestration has in part become an additional driver for restoration projects, of heathlands, forests, but also more recently the restoration of wetlands, now being proposed to be included within the UN-FCCC as a result of Icelandic emphasis within the convention.

For most of the 20th century, the majority of restoration work in Iceland was made possible by public funds and performed by governmental agencies — especially the Soil Conservation Service of Iceland and, to some extent, by the Forestry Service. Beginning in the 1970's energy companies and road authorities became responsible for an increasing number of projects. Farmers and other land owners, NGO's and interested public are more and more involved in restoration projects with the government increasingly sub-contracting their work

Most of the projects described in the review on restoration in Iceland, about 1500 km^2, involve revegetation or reclamation of eroded or severely degraded land, which primarily results in the restoration of grasslands, heathlands or woodlands. Areas that have been or are being restored to natural birch woodlands cover about 200 km^2 and restored wetlands are about 25 km^2. This is, however, only a small fraction of degraded or damaged ecosystems in the country.

The initial efforts of restoration in Iceland at the beginning of the twentieth century were driven by frequent dust storms in lowland areas, a clear risk of large farming areas becoming uninhabitable and a concern about the loss of woodlands. Many of those areas are now important agricultural areas and others support functioning ecosystems such as heathlands and woodlands. The experience from Iceland shows that the restoration of degraded ecosystem is a valid approach to regain ecosystem functions and natural capital.

Restoration of tributaries of the Vindel River combined with monitoring and evaluation of ecological responses

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The Vindel River system is one of the best protected Swedish rivers and one of the few free-flowing large rivers in Europe. The river is 450 km long and it originates in the Scandes mountains on the border between Sweden and Norway in the alpine region and joins the Ume River in the boreal region about 40 km upstream of the Gulf of Bothnia. The river and its entire catchment are part of the Natura 2000 network and it is also is one of four major rivers declared as national rivers in Sweden. The conservation status of the Vindel River is less favorable due to its exploitation for timber floating during the period 1850–1976. During this time the rapids of the Vindel River and its tributaries were channelized. Several side channels in multi-channeled rapids were cut off and the flow concentrated to one single channel. Also, many tributaries were dammed and the flow regulated. Almost all parts of the river system below the tree limit were altered in order to facilitate timber-floating. Timber floating activities significantly affected the river ecosystem, its catchment area, and populations of wild fish, otter (*Lutra lutra*), freshwater pearl mussel (*Margaritifera margaritifera*) and many other species in the aquatic and riparian habitats. The structures built to facilitate timber-floating provide considerable environmental constraints and need to be removed to improve the conservation status of the river's species and habitats. It is considered a priority to restore the river to a more natural state, both by the Swedish Environmental Protection Agency and the County Administrative Boards and the EU through the directives stated in the Habitat Directive and the Water Framework Directive. Vindel River LIFE started in January 2010 and is a 5-year river restoration project, co-financed by the LIFE-Nature programme. It focuses on removing the effects of fragmentation and channelization in Natura 2000 areas in the Vindel River catchment in order to increase conservation status for species and the water status. This will be achieved by restoring rapids along a total river stretch of 44 km in 22 tributaries.

The practical restoration work is preceded by a legal consultation procedure including municipalities, the County Administrative Board, Sami villages, NGOs, landowners and local inhabitants in the region. This work results in legal documents and Environmental Impact Assessments (EIA) that are reviewed by the County Administrative Board. The restoration work starts after approval of the respective EIA. Within the project, two major river restoration actions are applied: one in which restoration is more advanced, where methods of demonstrative character are used; and one which has a more traditional restoration approach, i.e., where a package of methods that previously have been tested and applied in other restoration projects in the Vindel River is used (best-practice methods). The advanced restoration action is applied in stretches within 10 tributaries where large boulders, large wood, and gravel from uplands are placed into the channel. This action is termed *Demonstration* since the methods used previously only have been tested in pilot studies. The demonstration sites will be compared with stretches upstream that previously have been restored by traditional, best-practice methods to evaluate the ecological response of the advanced restoration. The best-practice restoration action targets 13 tributaries where available rock material (often blasted) from the stream edges is placed in the channel, side channels are opened, man-made dams are removed or bypass channels are built to allow passage of migrating fish. Fish spawning areas will be restored in all 22 tributaries. The ecological success of the restoration actions will be evaluated by monitoring in the riparian and instream habitats. A pre-restoration study that was conducted in 2010 provides data that will facilitate the interpretation of the results of the monitoring actions.

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Forest restoration in Denmark — challenges and implementation — does close-to-nature forest management realize the principles of ecological restoration?

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Mixed deciduous forest dominated by beech is the principal potential natural vegetation type in Denmark. Due to almost complete deforestation in the late 18th century followed by extensive afforestation and intensive management within the last 250 years forests cover at present 13% of the land and mostly managed in uniform plantation like structures with more than half of the forests consisting of non native conifer species.

In 2002, the national forest programme layes down the so-called close to nature silviculture as guiding principles for managing the public forests in Denmark. These principles aim at mimicing natural disturbance regimes and include increased use of indigenous species, natural regeneration and selection supported by group or target diameter cuttings, and the refrain from clear cutting and chemical treatments.

The presentation describes the goals operationalised by use of socalled Forest Development Types and the implementation of close-to-nature forest management and analyses to which extend these goals and management lead to fulfilment of the nine attributes of the restored ecosystem according to the SER Primer on Ecological Restoration.

Finally, the principles are discussed in relation to a number of challenges including, restoration objectives (nature vs. man), climate change adaptablity (the reference system) and mitigation (CO2 sequestration), the balance between managed and untouched forests, and the landscape dimension (connectivity).

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International Training Programme on Land Restoration: Discussions between nations

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Land degradation is one of the major challenges faced by mankind and is expected to accelerate in coming decades. The effects are most dire in the developing countries where peoples' livelihood is directly dependent on the productivity of the land. This is however a challenge faced throughout the globe and must be fought on many fronts to sustain ecosystem services and secure human survival, development and welfare. UNU-LRT is an international training programme on land restoration devoted to assist developing countries, affected by severe land degradation, to fight land deterioration, restore degraded land and promote sustainable land use. The need for capacity building within this field of expertise is immense in the developing countries where crop failure as a result of degradation can lead to increased poverty and hunger. The programme builds on the knowledge and expertise gained in Iceland, through over 100 years of fighting land degradation, and is a venue for making that knowledge available. The experience gained in the four years since the programme started reveals that such a dialogue between individuals, countries, continents, biomes and climatic belts is a fruitful platform to disseminate and create new knowledge and is a win-win situation for all involved.

Role of theory in restoring peatland ecosystems

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Ecological restoration aims at returning the species composition and community structure and repairing the ecosystem processes that existed before human intervention. Restoration is based on many ecological theories that give the concepts for the patterns and processes in what the restoration aims at (Falk *et al.* 2006). Here we discuss peatland restoration, where theoretical knowledge on primary and secondary succession, soil hydrology impacts on soil processes and greenhouse gas exchange can be applied in practical restoration and in hypotheses of restoration research.

Peatlands are ecologically defined as ecosystems sustained by humid climate and characterized by water table close to the surface, due to which at least some of the organic matter accumulates as peat (Laine and Vasander 1996). As the definition states, hydrology plays an important role in ecological processes in peatlands, having especially great impact on soil processes. The high water table is the driver of the imperfect decomposition. As a result, peat accumulates and peatlands are therefore important stores of carbon (Laiho 2006). Peatland succession is impacted by both autogenic and allogenic factors, of which the formation of the peat layer has a crucial role. During succession, the autogenic control of water table increases and while the inlfuence of the water and nutrient input from surrounding areas decreases the nutrient status decreases. This process is called ombrotrophication.

When a peatland is drained for forestry, the lowered water table has detrimental impacts on soil processes and vegetation. The increased aerobic peat layer enhances decomposition and if litter input is not greatly increased the carbon accumulation to soil is decreased (Laiho 2006). In many cases, forestry drained peatlands release more carbon to atmosphere than is taken up by vegetation. Forestry drainage induces secondary succession of vegetation, during which forest species take over the space from peatland species (Laine *et al.* 1995). Peatland restoration is based on the theory of ecological processes in peatlands that are largely based on the high water table level. Generally, the peatland succession and accumulation of peat are expected to recover as a result of rising water table. In Finland, the suitable plant material is often nearby, and interventions, such as reintroduction of species, are seldon needed. Since the topographic heterogeneity is a typical feature of peatlands, as it increases environmental variability and diversity, it should be one goal of restoration planning.

We present two examples of forestry drained peatlands that have been restored in 2007 or 2008. The peatlands differ from each other in many perspectives, the most important difference being their developmental age. The first restoration example includes relatively mature pine fens in Kuhmo, eastern Finland. These oligotrophic fens are relatively nutrient poor and have well developed peatland vegetation and peat layer. Drainage of 30 years had had little impact on the understorey vegetation and the growth of the tree stand had started to decrease. Blocking of the ditches during restoration quickly raised the water table to similar level as in pristine reference pine fens, and the partial removal of the tree stand restored the landscape. Changes in vegetation were small, as expected. In pristine reference pine fens, the topographic heterogeneity was relatively low and wet hollows were not common. The typical hollow species that were infrequent in pristine pine fens were lacking from the restored sites. Filled ditches were not monitored, however, and may act a seed for depressions and therein for topographic heterogeneity in the future. The success of restoration of oligotrophic pine fens seems likely, given that changes in hydrological functioning occurred rapidly, and since little change has occurred in the vegetation composition after draining. Speeding up the regeneration process in these peatland types by restoration may, therefore, be recommended, especially if the drainage effect extends to nearby pristine mires and influences their biodiversity. More detail can be found from Laine *et al*. (2011).

The second restoration example includes young fens that have developed via primary paludification in depressions between sand dynes in the land uplift coast of Gulf of Bothnia, Siikajoki, western Finland. These fens are characterized by wet meadow vegetation, shallow peat layer and large variation in water table. The vegetation of the young fens is composed largely of pioneer species of forbs and sedges that are able to rapidly spread vegetatively (Ecke and Rydin 2000; Rehell and Heikkilä 2009). These young fens therefore have a capacity to quickly react to changing environment. Young fens have low autogenic control of water table and great water table oscillation (Laitinen *et al*. 2008) due to the lack of thick peat layer, which induces a high water holding capacity (Van Breemen 1995). For these reasons carbon gas dynamics of young fens are more sensitive to weather perturbations than in older bogs and fens (Leppälä *et al*. 2011a; 2011b). Long-term drought, caused by drainage, will decrease the water level oscillation and may cause regime shift from fen to forest vegetation and functioning. Restoration of such a rapidly responding system may in turn reverse the development and course a re-sift from forest to fen. In these sites we will measure ecosystem processes (gas fluxes) in addition to monitoring of vegetation. Impacts of global warming are also estimated with an open top chamber experiment.

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Starting from scratch: the effects of revegetation on successional trajectories, soil development and ecosystem function

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A large scale (1 ha plots) experiment was established in 1999 on a sandy sparsely vegetated surface in S-Iceland (63°49'N, 20°13'W) with the aim of studying long-term effects of different revegetation methods on an ecosystem development. It comprises nine treatments with input that varied from fertilizing only to combination of fertilizing, sowing of grasses or native legumes, and planting trees together with a control, all treatments replicated four times. Vegetation, soil and surface fauna, accumulation of carbon and soil development have been measured. The soils have already gradually started to build up carbon, ranging from 0,01 to 0,04 kg m^{-2} yr^{-1} depending on treatments, and total microbial C has also increased during the first seven years. Soil reaction has dropped by 0.2 on average in treated plots. The surface of treated plots has become much more stable than in control plots against frost action, and infiltration rate during winter had improved. Less water evaporation is experienced in treated plots, indicating improved soil function. Total vegetation cover (including vascular plants, mosses, lichens and biological soil crust) averaged around 5% in the control plots over the study period, while there was a steady increase in total cover for the first three years in all fertilized treatments (30-60%). In same treatments, biological soil crust had formed 6-17% cover in 2006, but none in control plots or plots with legumes. A similar pattern was observed in species richness, number of species were highest in fertilized treatments. Local species had colonized these plots and some of them are important in native heath and woodland communities, e.g., *Empetrum nigrum*, *Salix lanata* and *Trisetum spicatum*. Our results demonstrate clearly that simple revegetation treatments can trigger natural succession and development of ecosystem services. Within the time-frame of this study, treatments involving fertilization, with or without seeding of grasses, were the most effective in restoring vegetation cover, species diversity and OC. The experiment demonstrates also that the initial input determines successional trajectories. The large scale of the Geitasandur experiment provides a unique opportunity to study some of the fundamental processes involved in ecosystem development on severely degraded areas.

Restoration of alpine spoil heaps: successional rates predict vegetation recovery in 50 years

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Alpine and arctic ecosystems are in particular vulnerable to human disturbances because of their harsh environment and thereby slow biological processes. In many alpine areas the landscape is exploited for hydroelectric power. Such exploitation often gives surplus masses from tunnel excavations that are deposited in spoil heaps. The restoration goal for these spoil heaps should be that their species composition converges towards that of their undisturbed surroundings. However, at present we lack knowledge of the rate as well as the direction of these successions. In the present study (Rydgren *et al*. 2011) we examined the vegetation cover, species richness, species composition of five alpine spoil heaps in western Norway at two points in time, after 6–16, and 24–34 years of succession, and we compared the vegetation of spoil heaps with that of their undisturbed surroundings. After ca. 30 years, bryophyte and lichen cover and species richness were similar to those of their surroundings, while cover of vascular plants and species richness recovered more slowly. The species composition followed a successional trajectory in direction of the vegetation of the surroundings. Estimated linear successional rates indicate that 35–48 years are needed from construction of spoil heaps till a species composition more or less similar to their surroundings has been reached. But these estimates are likely to be over-optimistic because successional rates tend to decrease with time. We propose three changes to the current spoil-heap construction practice that will improve their restoration: (1) to increase surface unevenness, by which the number of safe sites will increase and germination and establishment success will be enhanced; (2) to increase substrate variability; and (3) to use seed from local sources or to let the spoil heaps regenerate naturally.

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Divides in Ecological Restoration

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Ecological restoration is increasingly popular but the views on how to perform ecological restoration are split. In many cases clear divides can be identified, caused by e.g. lack of ecological understanding and insufficient follow-up studies. Such shortcomings may result in poor guidance on how to choose between various restoration practices. In addition, there are differences of opinion about how policy instruments can be best used in restoration and what role the public plays in restoration efforts compared to institutions and experts. Climate change will likely increase the risk for restoration projects to fail because restoration has been traditionally based on knowledge about existing and past environments and weather situations rather than being designed to meet largely different future conditions. This makes it more important than ever to choose well thought out methods and to carry out long-term follow-up studies to increase the opportunities to make adjustments if a restored site develops in an unwanted or unexpected direction. In this paper we identify a number of ecological and political divides and discuss how restoration techniques could be chosen to lead to a system that functions under present-day conditions but also allows self or assisted adjustment to a future with a different climate. We conclude that there are several opportunities for wise choices, and likewise there are choices that should be avoided.

Ecosystem restoration in the Nordic countries

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Ecosystem degradation is a pronounced environmental problem in all the Nordic countries, but varies in nature, severity and scale between the countries and geo-regions. The native ecosystems have, in many cases, been overexploited, disturbed and even destroyed, disrupting the cycles of nutrients and water, damaging biodiversity and other ecosystem services.

There is a common need in the region for building and utilizing knowledge in restoration ecology to face current land-use challenges and threats to biodiversity. As an answer to this the Nordic Council funded the RENO network project (RENO - Restoration of damaged Ecosystems in the Nordic countries) in 2009 for a period of three years. The aim of the RENO project is to enhance restoration of degraded and damaged ecosystems through the establishment of a Nordic multidisciplinary network of scientists, practitioners, policy makers and contractors working with ecological restoration.

A review with a focus on ecological restoration in this region is believed to be essential for understanding its similarities and dissimilarities, with respect to natural conditions, cultural history, social and economic situation, and legislation. A first attempt on such a review will be presented.

Development of methods for preservation of threatened species and plant communities after road construction

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The Norwegian Public Road Adminstration (Statens vegvesen) is planning a new major road (E6) from Ringebu south to Otta in Gudbrandsdalen. A vegetation project for knowledge development concerning restoration and reestablishment of the vegetation were established in 2009, and accomplished by Bioforsk in cooperation with Vegetation adviser Tanaquil Enzensberger.

Gudbrandsdalen with the river "Lågen" is a valley in the middle of southern Norway. The area belongs to the slightly continental section of south-boreal vegetation zone (Sb-C1), a phyto-geographical region which is rare in Norway and contains unique biological diversity. As an example we have the fern *Diplazium sibiricum* that grows in fertile hardwood forest and is classified as vulnerable (VU) on the National red list, the ligneous plant *Salix triandra* (VU) that grows on the river banks and the vascular plant *Stellaria palustris* (EN), prefering swamps on the fluvial-areas. In addition there are many threatened vascular plants connected to the cultural landscape, huge rocks with rare lichens and ravines with unique species communities in the forests.

Climate, geology and vegetation of the area are described and different methods for conservation proposed. A method for decisions about which plant or plant communities to conserve by moving or propagation is suggested. Erosion, soil management, availability of phosphorus and nitrogen in the topsoil, alien and invasive species as well as restoration of wetlands are discussed.

Five different methods for establishing vegetation are proposed. 1: Conventional sowing on cultivated and other disturbed sites. The seed mixture should be of local origin, but for the time being not accessable. 2: Natural revegetation from topsoil in forest areas, with the exception of forest soils high in plant nutrition, which requires special adjustments as mixing the soil with nutrient-poor forest soil or sowing. 3: Spontaneous revegetation without topsoil on one location with calcareous and coarse mineral soil and drought-tolerant vegetation, where the risk for contamination of weeds is low. 4: Donor-receptor method ("hay method") for conservation of threatened seminatural meadows and creation of refuges for threatened plant species. 5: Vegetation-mat method ("turf roof method") on one location with natural pasture containing vegetation of special interest.

These five methods in combination with conservation of unique plants and plant communities will minimize the environmental impact of the road construction.

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Eradication of lupine by Roundup and effects on other vegetation and seed bank

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Reclamation with the Alaskan legume, Nootka lupine (*Lupinus nootkatensis*), is one of the most prolific reclamation tools used in Iceland. Large scale seed production started in 1988. It is a tall (1 – 1,2 m) vigorous plant producing multiple stems, each with multiple, large strongly blue, white and purple coloured flowers that produce about 8 - 10 seeds per pod. It has been used fore eclamation of barren areas, but also to foster young seedlings in afforestation projects. Due to its nature, the Nootka lupine spreads easily with wind or water and also because of human involvement, it is now found in all parts of Iceland and in the highlands. It is by no means restricted to reclamation sites, but is now found in most Icelandic ecosystems. Therefore it has raised concerns and awareness to the point that individual land owners and even communities have attempted to eradicate Lupine from selected sites. Icelandic law prohibits the use of it above 500 m or in protected nature reserves.

In order to study whether it is possible to eradicate Lupines from selected sites, an experiment was set up in 2007 in a 17 year old dense Lupine patch in South Iceland. The herbicide, glyphosate (Roundup) in three concentrations was spread over large experimental plots (10x20 m). Timing of the application was also tested: 1) young vegetative state, 2) early flowering, 3) peak flowering and 4) seed producing stage. In the following three years, density of Lupines was measured annually, the Lupine seed bank was monitored in 2008 and 2010 and the plant cover was measured in 2008.

The recommended dosage of Roundup (3 l/ha) turned out to be the most effective. Spraying when plants were vegetative gave poor results. However, spraying when plants were fully grown was most effective (Jóhannsson and Bau 2009). Other vegetation was not severely affected probably because of the sheltering effect of the dense lupine (Einarsson *et al*. 2009). The Lupine seed bank decreased drastically after eradication (Eyþórsdóttir *et al*. 2009).

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Evaluating processes in older stream restoration sites to measure restoration outcomes

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Ecological restoration is becoming an important tool for governments to try to meet environmental quality and species biodiversity goals (e.g. EU 2000). The majority of restoration projects are not monitored and the outcomes of these restoration projects are therefore not well known (Bernhardt *et al*. 2005). Thus, it is unclear if restoration projects are indeed delivering better environmental quality and increased biodiversity. Given that billions of dollars per year are spent on restoration (Bernhardt *et al*. 2005), there is a need to determine if restoration projects are successful and what ecosystem restoration policies and management tools can be developed to ensure that restoration projects are successful given climate and land-use changes.

There has recently been a strong call from ecologists to focus on restoration of process in rivers because it is more likely to succeed than restoring to a fixed endpoint (Palmer *et al*. 2005). We still do not know, however, how long it takes for many complex processes to develop after restoration (Palmer *et al*. 1997), which makes them difficult to use as success criteria. It will likely be years before many restoration projects will be able to report on their long-term results. In the mean time, systematically monitoring older restoration projects could provide insight into how long it takes for processes to develop and give us the ability to set sequential, multi-step goals for restoration (Palmer *et al*. 1997). Chronosequences, which substitute space-for-time, are often employed in terrestrial ecological research to gain information about the development of processes without the time and cost commitment of a long-term study (Fukami and Wardle 2005), but chronosequences have not yet been used to determine the development of processes in rivers after restoration.

Northern Swedish rivers may be a unique system in which to study restoration using a chronosequence because of the systematic damage that was done when rivers were channelized for timber floating (Törnlund and Östlund 2002). Although each stream will have unique traits, many streams are geologically similar and have experienced very similar land use history and disturbance (Nilsson *et al*. 2005). Furthermore, restoration is also occurring systematically in distinct waves over time that has targeted many reaches in each surge of restoration activity. This incremental, large-scale, watershed approach to restoration provides a unique platform on which to test how various ecosystem processes develop over time using a chronosequence of restored sites.

This project will use a chronosequence of stream restoration sites completed in about 1985, 1995, 2005, and 2011 to assess the development of ecosystem processes in northern Sweden. In particular, nutrient cycling, plant productivity in the riparian zone, retention capacity, and floodplain connectivity will be evaluated. This work is part of the RESTORE Project, a large interdisciplinary project examining the links between success of ecological restoration and societal actors' interests and institutional structures. The project will focus on evaluating existing forest and stream restoration projects in the context of different social and political frameworks.

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From puddle to pool: Restoration of Lake Kolviðarnesvatn syðra

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Restoration of freshwater ecosystems in Iceland is limited and monitoring of reclaimed freshwater habitats is scarce. Lake Kolviðarnesvatn syðra, on the Snæfellsnes peninsula in W-Iceland, is an example of restored freshwater habitat. In 1963 the lake was drained to utilize the land for grazing livestock. Naturally, the lake was shallow and once drained only a small spring fed puddle remained. The lake was restored in 2001 to it´s original size. The aim of the current project was to examine the status of the plankton after restoration in order to gather base line information to build on for future monitoring and to evaluate the success of the restoration project. The main focus was on the crustacea community composition and phytoplankton biomass (chlorophyll *a*). Plankton samples were collected during the summer 2003; from one sample location on 12th of June and from three different sites on 15th of July and 8th of August.

The cladocerans *Alona guttata*, *Acroperus harpae* and *Chydorus* sp. were most common in the plankton. The proportion of *A. guttata* increased from 12.5% in June to 89.7–98.0% in July and remained high in August (61.4–82.7%). *Acroperus harpae* was the dominant species in June (51.6%) but had decreased drastically by July (1.3–3.9%) and a slight increase again was observed in August, 5.2–16.1%. *Chydorus* sp. was the second most common crustacean taxa in June, its relative abundance was 22.7%, with a sharp decrease between June and July (0.3–3.6%). In August, the proportion of *Chydorus* sp. was between 8.1 and 16.0%.

In total nine taxa of Cladocera were found in Lake Kolviðarnesvatn syðra. The diversity of Cladocera was similar to what has been documented in number of ponds and small lakes in the highlands of eastern Iceland (Aðalsteinsson 1980) and in lowland ponds in South Iceland (Ingimundardóttir 2003). The species found in Lake Kolviðarnesvatn syðra were mostly benthic crustaceans, which might reflect the species composition in the puddle which remained or is indicative of the shallowness of the restored lake. It is vital to monitor the succession of the restoration of freshwater ecosystems in Iceland to be able to understand ecosystem function and enhance management with future restoration projects.

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Ice formation in rivers and streams: effects on vegetation and tools for proactive restoration

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One important component of the hydrology of streams in cold regions is the initiation, growth, and melting of different ice forms in and around the stream channel (Prowse and Beltaos 2002). The ecological effects of river ice have however rarely been studied (Scrimgeour *et al.* 1994, Prowse 2001, Rood *et al.* 2007). Climate models predict an increase in dynamic ice formation in northern streams due to increasingly fluctuating air temperature. More shifts between freezing and thawing as a consequence of climate change may stimulate the formation of frazil ice, anchor ice and ice dams (Beltaos *et al.* 2006). Events of sub-surface ice (frazil and anchor ice) and subsequent ice jams and flooding are also expected to become more frequent (Mote *et al.* 2003, Andreasson *et al.* 2004). Winter already represents a bottleneck in the life-history of aquatic plants and animals. If the disturbance is too extensive, i.e. if there is massive icing of the riparian zones due to flooding it might reduce the species diversity in the riparian zone. Today, there is greater interest in river ice research since climate change effects on ice may imply great economic and ecological consequences (Beltaos and Burrell 2003). The ecological implications of increased dynamics during this critical period are uncertain, as many of the ongoing aquatic processes are still poorly understood, e.g. the physical factors governing ice formation and the effects of ice on organisms are still relatively unknown.

This project studies the relationship between channel topography, hydraulics, ice abundance and distribution, and riparian and in-channel vegetation in rivers and streams. The study focuses on the effect of ice on plants and how temperature, stream morphology, discharge, and water current regulate ice abundance and distribution. The project also focuses on anthropogenic effects on ice dynamics – apart from climate change. There are observations suggesting that certain types of human impacts make rivers more sensitive to excessive ice formation. For example, the transformation of rivers and streams in northern Sweden to fit the needs of timber floating created many channelized reaches that produced abundant anchor ice. In addition, the ice break-up in channelized reaches could be intensive and have serious impact on vegetation due to ice jams. Recently, many of the floated rivers and streams have been restored by removal of piers and wing dams and replacement of boulders and large wood in the channel (Nilsson *et al.* 2005). Boulders and large wood reduce flow velocity and turbulence which should reduce the formation of anchor ice and might enhance the production of a stable surface ice cover. However, replacement of structural elements in streams has to be done with care because too many objects in the stream channel can result in jamming of ice and subsequent flooding of the riparian zone and beyond (Helfield *et al.* 2007). There are still many uncertainties in the current knowledge about the effects of ice formation on vegetation and the outcome of restoration. To meet the challenges of climate change, the study will identify the channel topography that is optimal for avoiding destructive ice formation. It will also prepare recommendations for proactive restoration methods to sustain the biodiversity that is typical for boreal streams.

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Invasive species in Iceland – Nootka lupine and Cow parsley

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Two plant species are considered invasive in Iceland, Nootka lupine (*Lupinus nootkatensis*) and Cow parsley (*Anthriscus sylvestris*). Nootka lupine (Fabaceae) is a perennial legume imported from Alasaka and has been used for revegetation in various parts of Iceland. It was first introduced in 1885 and again in 1945. Cow parsley (Apiaceae) is perennial and was imported around 1900 for ornamental purposes. It has since then spread into meadows and roadsides and often colonizes lupine patches resulting in the retreat of lupine. Both species spread with seed, Cow parsley spreads also with rhizomes, and both have naturalized in the country.

The species are likley to increase both spread and abundance in the future. In Iceland, there is increasing awareness about the negative effects that these species have on many ecosystems. However, it is important to note that the positive effect of lupine is considerable in reclamation of severly degraded areas.

In order to understand what possibilities are in this situation, the Ministry of Environment initiated a comittee in 2009 with representatives from the Icelandic Institute for Natural History and the Soil Conservation Service of Iceland. A smaller follow-up committe was established in 2010. The main focus is to keep the two species from the highlands (above 400 m), nature preserves and other protected sites. The general objectives of the committe are:

1) to collect information on the distribution of the two species,

2) to suggest ways to eradicate these species,

3) to prioritize sites for eradication,

3) to present information and recommendations for public.

The web page *agengar.land.is* (in Icelandic) was opened recently. The purpose of this site is to publish information about Nootka lupine and Cow parsley. As well introduzing ways to eradicate the species. Not only is it a site for acquiring information, it is also a site where people can report where they have found the plants growing. The data are compiled into a database where these findings are recorded, and also data on where the species have been eradicated.

Long term effects of revegetation efforts in Hjerkinn firing range, Norway, and the road ahead

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The long term effects of revegetation efforts (20 years) on plant succession are examined in the military Hjerkinn firing range in the Dovre Mountains, Norway. Revegetation by commercial grass seeds has been a much used management effort to increase vegetation cover in severely disturbed sites in Norwegian mountains during the last 30 years. In 1989 road-sides in the firing range were treated with commercial grass seed mixtures to increase vegetation recovery.

In 2010 the vegetation in treated sites were recorded and compared with ecologically and disturbed similar, but untreated sites. Six of the ten treated sites had significantly higher total plant cover (50-100 %) than the untreated sites (30-98 %). Deciduous dwarf-shrubs had significantly higher cover in two treated sites compared to the untreated, but did not differ in most of the sites. Herbs had no significant difference between the treated and the untreated sites. All treated sites had significantly higher cover of graminoids (13 - 80 %) than the untreated areas (3 – 45 %). The seeded species still persisted in the treated areas (10-75 %), and the seeded grasses constitute a major part of the graminoids and the total vegetation cover (11 – 80 % of the total vegetation). The number of species was significantly higher in two of the treated sites compared to the untreated sites, and varied from 6-26 species in treated sites and 11-29 species in untreated sites.

Still after 21 years the recovery has not led to a vegetation cover of native species, and the seeded species are still present. This study is a contribution to the long term studies of effects from these efforts. The results will give important input to the future management of disturbed sites and development of a site-specific treatment of these sites, including the upcoming large-scale restoration of the firing range and in general for restoration in alpine vegetation.

Manual for ecological restoration

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Norwegian Defense Estates Agency manages 1.5 million acres of land on behalf of the Defense sector, and is thereby one of the largest property managers in Norway. A large part of this area is made up of military training areas, and these are spread all over the country, from north to south, and from coastal to alpine areas. Military training areas therefore cover large areas of rich and varied biodiversity.

Military training areas are in many cases subjected to intensive use. Maintenance of functional training areas, while at the same time ensuring that important areas for biodiversity are preserved, represents an important challenge in the management of military training areas. Therefore a manual for ecological restoration is developed. The project was initialized by the Norwegian Defense Estates Agency (Forsvarsbygg) but was soon extended to include other public sectors; the Norwegian Public Roads Administration, the Directorate for Nature Management and Norwegian Water Resources and Energy Directorate. All sectors face similar challenges of practical management related to disturbed sites. Also new bodies of laws and policy instruments are of common interest.

The manual serves as a support in both practical and administrative work related to these issues, and helps to identify situations related to land-use activities that may cause negative effects. It provides guidelines for identification of preventive and remedial measures in order to minimize negative effects, and offers descriptions of procedures and costs related to implementing appropriate measures. The manual suggests a system for identification of situations that may involve a need for restoration, how to formulate realistic goals for restoration, outlines the best solutions in certain situations, and describes a range of restoration methods. The aim of the manual is to contribute to the establishment of standardized procedures for management of disturbed sites or areas, in order to prevent negative effects of land-use. The manual is publicly available on: www.forsvarsbygg.no.

Monitoring the ecological effects of peatland restoration in Finland

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Introduction

In large parts of Finland over 75% of the original peatland area has been drained for forestry. Drainage has profound effects on the hydrology: the water-table level is lowered, peatland is cut off from its original water sources and consequently the natural water flow patterns through the peatland are changed. Species composition changes when the original mire plant species decline and forest species take over. The accumulation of peat layer slows down and affects the carbon balance of peatlands.

Restoration of drained peatlands is required for conservation of biodiversity and peatland habitats and for re-establishing a carbon sink. The prerequisite for the recovery is the restoration of hydrology by filling in the ditches.

Monitoring the effects of restoration

Research and monitoring of the effects of restoration are needed to evaluate if the goals of restoration have been achieved and if there is a need to adapt the restoration methods.

Qualitative general monitoring is carried out on all restored sites to make sure that the restoration process is activated, to detect the need for corrective actions and to solve possible problems as early as possible.

A quantitative monitoring network including vegetation, hydrology and butterflies schemes has been established at restored peatlands. Plants are the key species group for the re-establishment of peat accumulation and the natural-like functioning of peatland ecosystems. Especially important are the *Sphagnum* mosses. The vegetation monitoring network includes seven different peatland habitat types with 7–10 replicates at both restored and pristine sites.

Hydrological monitoring includes monitoring of water-table level and water quality at restored and pristine control sites (46 monitoring sites). The impact of restoration on the amount and quality of runoff waters is monitored on 11 sites. Monitoring was started before restoration and is planned to last several decades.

Responses of animal populations to restoration are studied in 21 pine bog study sites where butterfly monitoring is repeated every 5–10 years. There are three different treatments (restored, drained and pristine) at each monitoring site.

Recovery of restored peatland is a long-term process. Therefore, also monitoring period should be on a scale of decades. National monitoring guidelines – defined by researchers and restoration experts – and field training of monitoring staff have been implemented to ensure uniform monitoring methods nationwide.

Monitoring the effects of forest restoration in Finland

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Introduction

A large proportion of Finnish conservation areas consist of forests used for silviculture prior to their protection. Human influence can be seen e.g. in monotonic tree stand structure, in the lack of gap dynamics and forest fires and, consequently, in the lack of dead wood. To improve the ecological quality of these former economic forests several restoration measures can be applied, such as controlled burning, damaging and felling of living trees to increase the volume of dead wood, and opening small gaps to increase structural complexity in the tree layer. The long-term goal of restoration is to promote the natural processes of forest habitats and thus to enable the persistence of viable populations of species characteristic for the forest ecosystem. In short term this usually means improving the habitat quality for the threatened and declined species, especially for dead wood dependent fauna and flora.

Monitoring the ecological effects of restoration

For the last six years a group of forest restoration experts has been working to enhance the link between science and practice for example by planning a monitoring network to assess the effects of restoration.

Metsähallitus Natural Heritage Services started the monitoring of focal forest characteristics and species groups according to the monitoring plan in the early 2000's. The monitoring network includes 24 nature conservation areas from the southernmost Finland to southern Lapland with a total of 150 permanent monitoring plots (experiments and controls). The effects of dead wood creation and small openings are monitored by measurements of living and dead trees as well as tree saplings and seedlings.

At sites where dead wood has been created, also beetle and polypore communities are monitored at five-year intervals. According to the first results, the number of dead wood dependent beetle species has increased significantly as a response to the restoration measures. The number of beetle species at the restored areas was positively correlated with the magnitude of dead wood increase, and negatively correlated with the proportion of young forests at landscape scale. The effects of restoration on the diversity of polypore communities will be revealed later when the decay process of killed trees proceeds. The diversity of polypores is known to be highest on trunks in intermediate or late decay stages.Within the first five years only a few pioneer species have established and started fruiting on the trunks created in restoration.

The monitoring measurements are intended to be continued for several decades.

Natural hazard and disaster risk reduction in Iceland regarding volcanic ash, vegetation and soil conservation

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Recent Icelandic eruptions (2010-2011), proved beyond a doubt the value of pre-event planning for natural hazards by the Civil Protection Department. Here I focus on possible pre-disaster mitigation responses for ash-fall and vegetation.

The United Nations International Strategy for Disaster Reduction defines "Disaster risk reduction" as "the concept and practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters. Reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness for adverse events are all examples of disaster risk reduction" [1].

Risk Identification

Active volcanism is prevalent in Iceland with active regions covering 30% of the land with historical eruption frequency of 20–25 events per 100 years [2]. There is considerable risk for ash deposition events to occur. Ash can destroy/damage vegetation by the initial direct burial or with post-eruptive transport either by water or wind, extending the area of influence far away from the initial deposition area. Ash deposition can also affect hydrology and air quality.

Ecosystem resilience against deposition of aeolian material and volcanic ash fallout depends on various factors e.g.: depth of burial, species capability of regeneration when buried, seasonal timing, water availability, toxicity etc. Vigorous ecosystems with tall vegetation generally have greater endurance capability; the sheltering effect minimizes the secondary wind transport of ash, and hastens the incorporation of ash into the soil. Whereas when ash falls onto areas with little or no vegetation, it is unstable and easily moved repeatedly by wind and water erosion possibly causing further abrasive damage.

Risk reduction

Build-up of healthy ecosystems increases resilience providing better capability of surviving ash fallout. The common range land in the highlands that are now degraded pose as Iceland´s most serious environmental problem. Existing vegetation in common range lands is generally sparse and low growing and is therefore vulnerable to disruption. Ash-fall onto land in such condition can be catastrophic as seen in recent events. Resilience to catastrophic events can be drastically improved by reclamation efforts.

Effective governance through alignment of policies, e.g.: land use planning/zoning, natural resources management, agricultural policies, mitigation action against climate change through revegetation and carbon sequestration, restoration of natural birch forests [3], along with coherent legislation, multi-sectoral coordination with effective knowledge sharing, are important in successful risk management.

Encouragement of sustainable use and appropriate management of fragile ecosystems through better land-use planning and development activities now has an additional aim to reduce risk and vulnerabilities to natural hazards. [4]

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Organic matter build-up in *Leymus arenarius* dunes in Leirdalur north of Mt. Hekla, S-Iceland

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Mt. Hekla is an active volcano that has erupted five times during the last century. There is very active erosion in the area around Mt. Hekla (Thorarinsdottir 2010), caused in part by ash fall from the recent eruptions. Lyme grass *Leymus arenarius* is widely used in areas of active erosion to halt the movement of sand. Areas seeded with *Leymus* accumulate sand, often causing build up of sand dunes. The Soil Conservation Service of Iceland has sown *Leymus* to stop wind erosion on areas affected by the Hekla eruptions in 1970, 1990 and 2000. The Andosols of the eroded areas are very low in soil organic matter (SOM), but studies have shown that it will build up after re-vegetation with *Leymus* (Arnalds 2000). Because of the deep penetration of *Leymus* roots and sand accumulation in the *Leymus* dunes/stands, standardized soil sampling methods down to 30 cm soil depth, probably only capture a faction of the annual SOM build-up in areas with *Leymus*.

The objective of this study was to quantify the build up of organic matter in profiles of *Leymus* areas of different ages. The study area was Leirdalur northwest of Mt. Hekla, where eroded areas seeded with *Leymus* after the 1970, 1990 and 2000 eruptions (40 years old, 20 years old and 10 years old) are found in a close vicinity of each other. Three sites were selected within areas of each age and three sites in untreated eroded land. A soil profile was taken at each site, trying to reach at least below the 1970 ash layer. The profiles were from 1.2 to 3.3 m deep, depending on the age of site and sand accumulation. Aboveground biomass was measured in a 0.5x0.5 m quadrate above each profile. A soil column was collected in 10 cm intervals for the topmost 30 cm, then at 30 cm intervals thereafter down the profile. All the samples were sieved through a 2 cm sieve to collect live roots from each sample. Thereafter, soil was dried at room temperature and vegetation samples dried at 40° C, until they reached a constant weight. Then the soil samples were sieved (2 mm sieve) and grinded and total C and N analysed in Macro elementary analyser (vario MAX CN, Elementar analysensysteme GmbH, Hanau Germany). Organic matter (OM) in the ecosystem consists both of living components, mainly consisting of aboveground vegetation and living roots, and dead components, mostly found as SOM, which was measured as soil organic carbon (SOC).

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Participatory approaches in land restoration in Iceland

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The Soil Conservation Service of Iceland (SCSI) has combated land degradation for over a century. Historically, the work of SCSI was characterised by top-down approaches and most soil protection and restoration activities in Iceland where carried out by SCAI staff. The SCSI has, however, increasingly involved landowners and other stakeholders in land restoration projects and currently participatory approaches are used in most of SCSI's large-scale projects.

This study looks at how participation is perceived and carried out by the SCSI. Its objectives are to detect what theories and aims lay behind the use of participatory approaches, how participation is carried out in reality and what the results are. Furthermore, it takes a closer look at communicative competences and skills in relation to participation, as well as the personal experience of staff members working closely with other stakeholders. The study looks at the SCSI both in general and in connection with two projects:

a) *Hekluskógar*, a multi-stakeholder project, initiated by the SCSI but involving landowners and representatives for other organisations in goal setting and planning processes as well as implementation.

b) *Farmers heal the land (FHL)*, a SCSI project inspired by the Australian Landcare movement where revegetation is carried out by local farmers, while the SCSI provides supervision, seeds and funding to cover fertilizer costs.

Semi-structured interviews were made with relevant SCSI staff (key officials, extension officers and others involved in participatory projects) as well as land-owners and collaboration partners from other organizations. The study is still in progress and will result in a master thesis at the Agricultural University of Iceland.

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Propagation of the moss, *Racomitrium lanuginosum*, for restoration

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Moss heaths dominated by *Racomitrium lanuginosum* are prominent in Icelandic vegetation, especially on lava fields and in highland areas. Moss heaths are vulnerable to disturbances due to construction, traffic and other human activities. Attempts to restore the moss cover of disturbed moss heaths have, however, been limited. Here we report on greenhouse and field experiments to test different propagation methods for *R. lanuginosum*

In a greenhouse we tested which parts of *R. lanuginosum* are capable of regrowth by cutting branches into 1 cm fragments, from the top down to 6 cm (F1-F6), and compared with whole branches. All treatments were tested on two types of substrate; coarse tephra and mineral soil. Survival and activity (ability to form new leaves and branches) of the moss fragments was recorded after 145 days. These studies were followed up by field experiments near the Hellisheiði geothermal power plant in the summer of 2010. Here the top 1 cm of *R. lanuginosum* fragments (F1) and whole branches were tested on two substrates; bare mineral soil near a geothermal steam pipe and an abandoned road through a lava field, where the gravel surfacing had been removed and replaced with coarse tephra. Frequency of green *R. lanuginosum* propagules was measured in December 2010. The *R. lanuginosum* moss for both experiments was collected at Hellisheiði.

In the greenhouse experiment survival of whole branches and 1 cm fragments from the top of branches (F1) was good but decreased as fragments originated lower on the branches and was nil at F6. Only whole branches and fragments from the top three cm of branches (F1-F3) were active after 175 days. Survival and activity of propagules was higher on coarse tephra grains than on mineral soil. After 145 days, a part of F1 and whole branches had formed rhizoids on both substrates. The frequency of live proportions of propagules after five months in the field experiment was higher in treatments with whole branches than F1 fragments, and higher on the abandoned road (coarse tephra substrate) than on the mineral soil. It is, however, possible that a part of the propagules, particularly the 1 cm fragments (F1), were blown away by wind or water before they could attach to the surface.

These first results indicate that the propagules tested in this study can be used to accelerate colonisation of *R. lanuginosum* on disturbed areas, especially if the substrate is coarse tephra or lava.

Representing reintroduction as nostalgic news

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Although restoration ecologists have debated the role of historical baselines in restoration efforts, restoration may be widely understood by the public as an activity for reclaiming the past. This paper analyzes newspaper media coverage of European beaver (*Castor fiber*) reintroduction to Scotland published in five UK newspapers between 1997 and 2010 to expose how journalists present restoration projects to the public. The most prominent feature identified in the newspapers is the portrayal of the beaver as “missing” from Scotland for centuries because of human hunting. The historical interaction of humans with beavers has been interpreted as creating a moral obligation to reintroduce the animals. The beaver’s 400 to 500 year absence from the British Isles is thus often invoked as the reason for its contemporary return. At the same time, the ecological grounds for the reintroduction, i.e. the beaver’s role as a keystone species in wetland restoration, is much less visible in the press. Nostalgia for a by-gone world thus becomes the most common framework in which beaver reintroduction news is presented. Understanding how the media covers reintroduction may give scientists insights into reasons for public support or opposition to proposed projects.

Restoration of native vegetation in Iceland by seed-containing hay transfer

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This study reports the results of introducing plant diaspores by transferring seed-containing hay from undisturbed natural vegetation to disturbed sites for restoration purposes. The experiment was conducted in 2007-2009, at two sites in the Hellisheiði highlands, 30 km from Reykjavík. In 2007, two disturbed sites were chosen where the vegetation cover had been lost due to construction of Hellisheiði Geothermal Plant. Close by an undisturbed natural vegetation, a grassland and a heath, were chosen as donor sites for the hay. The donor sites (2 x 1 m plots) were cut in mid- August and in the end of August. The seed and moss fragment-containing hay was transferred directly to the disturbed sites and spread over 2 x 1 m receptor plots. The establishment of plants in the receptor plots and control plots (no hay transfer) was recorded the two following years.

The receptor plots that received hay from the grassland showed two- to three-fold increased establishment of native vascular plants cover compared to the control plots, and up to ten-fold more moss cover compared to the control plots. The vegetation succession of the receptor plots, towards the flora of the donor areas, was more rapid than in the control plots. The number of seedlings of *Bistorta vivipara, Festuca* sp. (*F. richardsonii/rubra/vicipara*), and *Luzula multiflor*a, and the cover of the mosses *Hylocomium splendens, Rhytidiadelphus squarrosus* and *Racomitrium ericoides* was much greater in the receptor plots than in the control plots. These species were all abundant at the donor sites. Cutting the hay and transferring it in the end of August was more successful than the mid-August timing.

The experiment where heath vegetation characterized the donor site had fewer replications and statistical significance was not tested. At that site, *Alchemilla alpina, Festuca* sp. and *Racomitrium ericoides* showed increased establishment in the receptor plots compared to the control plots.

The re-growth of the vegetation in donor plots was also recorded. Two years after cutting, the cover of vascular plants was not significantly different from the original cover, but the abundance of bryophytes had reduced significantly. The results indicate that this method is promising for restoration of grasslands and possibly also for restoration of moss heath if the cutting is not to close to the surface.

Soil conservation in Iceland and the future implications of whether Iceland will join the EU

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Iceland is currently involved in accession negotiations with the European Union. Iceland already cooperates closely with the EU and has adopted significant amount of EU legislation into Icelandic law, through the Agreement on the European Economic Area (EEA). Issues not covered by the EEA such as nature protection, agriculture and rural development are however subject to negotiations.

Iceland can deliver a substantial added value to the European Community through its experience in participatory land conservation programs and services. Iceland has North Europe's only designated, and possibly the world's oldest, Soil Conservation Service (SCSI), established 1907. The organized soil conservation in Iceland began as a response to severe land degradation and desertification that was seriously threatening the existence of several communities. Harsh nature and unsustainable land use over 1100 years had degraded Icelandic ecosystems to the extent that severe soil erosion covered 40% of Iceland (http://www.lbhi.is/desert/). A century of soil conservation has provided a learning process on various aspects in environmental legislation, policy design and implementation approaches.

EU membership could be beneficial for soil conservation in Iceland, indirectly as an external driver for legislation improvements and directly through capacity building for environmental assessments needed for designing future policy for sustainable land use. However, Iceland´s uniqueness compared to other European countries, regarding it soil, geographical location, low population density, agriculture and vast land degradation may limit the benefits as EU solutions may not provide the answers Iceland needs.

Given the current difficulties that the proposed EU Thematic Strategy for Soil Protection is experiencing, particularly for its legally binding component, there is a need for a fresh start in European soil protection strategies. Redesigning the EU approach to soil protection on principles of stakeholder participation and bottom-up approaches involving the local farming community could prove to be the best way forward also for other EU countries, as it has been the case for Iceland. Introducing participatory soil conservation practices in a reformed CAP could be the way forward for future EU soil protection.

The effects of lupin on the growth of birch in Iceland

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Birch woodlands, abundant in Iceland when the country was settled about 11 centuries ago, now cover only about 1% of the country. One of the long term goals in revegetation of degraded areas in Iceland is restoration of birch ecosystems. That goal can be difficult to reach in areas where there has been massive degradation and soil erosion, resulting in sparsely vegetated land with poorly developed soil. Nootka lupin (*Lupinus nootkatensis)*, a legume introduced from Alaska, has been widely used for revegetation of eroded or degraded areas in Iceland. The lupin has spread rapidly in many areas and forms dense stands where it is a strong competitor with many native species. The objective of this study was to assess whether lupin facilitates or inhibits the colonization and growth of native birch.

Four sites, representing different climatic and/or edaphic conditions were selected in areas where lupin was expanding over eroded or sparsely vegetated land. At each site, experimental plots were established inside mature lupin stands, at their edges and on sparsely vegetated soil outside the lupin stands. Half of the plots inside and at the edge of lupin stands at each site were cut during the flowering period of lupin in 1995 (late June – early July) and birch was planted or seeded in the plots in late autumn the same year. Survival and growth of birch was monitored from 1996 to 1998. The results varied between sites but in general the best results were in the edge plots and in the plots where the lupin was cut before planting of birch (Aradottir 2004). Survival of birch in uncut lupin stands was limited because of intense competition from the lupine, but in the sparsely vegetated areas outside the lupin stands, frost heaving of birch seedling seemed to be the main cause of seedling mortality. Therefore, the lupin seemed to have both facilitative and inhibitive effects on birch establishment (Aradottir 2004).

In 2011, birch in the experimental plots was measured again in order to study the longer term effects (16 years) of lupin on its survival and growth. The poster will present the 2011 results and compare them with the shorter-term results from 1996 to 1998.

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The invasive *Anthriscus sylvestris* in Iceland

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Anthriscus sylvestris or cow parsley is native to mainland Europe and temperate Asia. The species was introduced to Iceland shortly after year 1900 for ornamental purposes. Today it is considered invasive. The species became widely established during World War II when transporting increased and around 1950 it had reached most parts of the country. Since then it has spread out, especially where soil is fertile and moist. Cow parsley is found in old pastures, hedgerows by roads, river banks and old Nootka lupin patches (*Lupinus nootkatensis*).

Cow parsley is a perennial species that can reach height of 150 cm. The flowers are white and many in rather large umbels. The species starts flowering in early June and spreads seeds in late July. Seed production of single plants is in the range of 800 – 10,000. It reproduces mainly by seeds but also by root buds from the top of the root. Where cow parsley grows it develops dense patches and outcompetes other plant species, resulting in open sward. The spread and abundance of this species is likely to increase as a result of reduced grazing and increased temperature.

In the last few years a few communities in Iceland have started controlling cow parsley. The drive for this is that the plant has established dense patches, changed native vegetation, influenced pastures as well as having visual impact. Methods that have been used are mainly cutting and herbicide application as well as pulling out individual plants. The impact of grazing is unclear. Success of those methods has not been measured yet but there are indications of less cover in several places. A group of scientists is preparing a research program were methods to control the plant will be assessed and ecological impact measured.

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UNU – Land Restoration Training Programme: what do we offer?

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The UNU – Land Restoration Training programme (UNU-LRT) is an international post-graduate training programme operated in Iceland. The mission of UNU-LRT is to train professionals from developing countries to combat land degradation and restore degraded land, and to assist strengthening institutional capacity and women empowerment in the field of land restoration and sustainable land management in developing countries. The programme is built on the knowledge and expertise gained within Iceland, which faced severe land degradation problems in the beginning of the 20th century. UNU-LRT currently offers a six-month training, divided into nine modules. The first three months are dedicated to course work and practical training, while the focus of the latter three months is on an individually based project work. The candidates for UNU-LRT are carefully selected in cooperation with partner institutions in developing countries and their training is considered a contribution to capacity building of their institutions.

Use of turf-transplants for restoration of alpine vegetation: does size matter?

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A potential method for restoration of native vegetation on disturbances associated with construction of roads, power plants, etc., is to save and transplant native turf from roadbeds and other areas that are being stripped of vegetation. There is, however, scant knowledge on optimal size of turfs and the tolerance of different plant communities and species to transplanting. A study to assess the effects of turf size for restoration of plant communities in disturbed highland areas was initiated in 2007. Experimental treatments tested in 2 m^2 plots were: (1) planting of sixteen 5x5 cm turfs, (2) four 10x10 cm turfs, (3) one 20x20 cm turf, (4) one 30x30 cm turf, (5) one 20x20 cm turf shredded and strewn over the plot and (6) controls without turfs. The turfs came from nearby heath and grassland vegetation and were planted in road verges and mudflats at 280 to 405 m elevation in SW-Iceland. Species composition of individual turfs, cover of vascular plant and moss species and colonization patterns were monitored for three growing seasons. The heath vegetation was more susceptible to division into small turfs than the grassland, but responses varied by functional groups. Grass cover was highest in plots with 5x5 turfs, but lowest in plots with shredded turfs and controls. Cover of dwarf shrubs, which were only found in the heath land turfs, decreased with decreasing turf size. Moss cover, on the other hand, tended to be highest in plots with shredded turfs. The results support the hypothesis that optimum turf size varies between functional groups.

Vegetation establishment after disturbances in Norwegian mountain areas: Effect of soil type, liming and no seeding versus seeding of native or imported seed mixtures

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In restoration projects, it is often debated if sowing is necessary or if the disturbed area will be able to regenerate a plant cover by spontaneous establishment of indigenous vegetation. Practical experience suggests that the need for seeding depends on soil type, soil amendment and several other factors. A factorial trial comparing three subsoils (mineral, organic, and 50/50 (v/v) mineral/organic mixture), no liming vs. liming (1.1 Mg CaO/ha), and no seeding vs. seeding of an imported seed mixture or a mixture composed of Norwegian mountain ecotypes, was established according to a split-split-plot design on 9 July 2008 in Bitdalen, Norway (59.8°N, 7.9°E, 930 m a.s.l.). The imported seed mixture consisted of 40% *Festuca rubra* L. ssp. *commutata*, 35% *Festuca trachyphylla* Hack., 10% *Festuca ovina* L. ssp. *capillata* and 15% *Lolium perenne* L. The native seed mixture consisted of 34% *Festuca rubra* L ssp. *rubra*, 41% *Festuca ovina* L. ssp. *ovina*, 22% *Poa alpina* L. and 3% *Avenella flexuosa* L; due to lack of seed this was further supplemented with transplants of *Agrostis mertensi i* Trin., *Phleum alpinum* L. and *Avenella flexuosa* (L.) Parl. at densities of 1.8, 2.4 and 1.8 plants/m^2, respectively.

Vegetation establishment was significantly faster on the organic and mixed soils than on the mineral soil, but differences decreased over time leading to an average of 93, 86 and 56 % plant cover (including mosses) twenty-six months after establishment, respectively. *Festuca* sp. contributed 55% of the plant cover on the mineral soil vs. 33% of the organic and mixed soils. Conversely, sedges, rushes, herbs and unsown *Agrostis* sp. contributed an average of 16% on the organic soil vs. 5% on the mixed soil and only 1% on the mineral soil. Although the initial pH was higher on the mineral soil (5.8) than on the organic and mixed soils (4.9-5.0), liming exhibited the greater effect on total plant cover on the former soil type. Plant cover developed faster from the imported seed mixture, mostly consisting of Danish and Dutch varieties, than from the mixture composed of Norwegian ecotypes, but this difference was no longer significant two years after seeding. Twenty –six months after establishment, fescues made up 80% of the plant cover on plots seeded with imported seed, whereas unseeded plots had developed a 76% cover mainly consisting of *Agrostis capillaris* L and mosses. Plots sown with Norwegian ecotypes had significantly lower biomass production and a higher diversity of species than either unseeded plots or plots seeded with imported seed.

Verification of GHG flux turnaround of restored peatlands: The usefulness of soil water table level as a proxy variable

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Icelandic peatlands have been extensively drained for agricultural purposes. Current estimates indicate that over two thirds of the original peatland area has been altered through draining and approximately half of the area fully drained. Recent studies have shown that peatland restoration can significantly reduce GHG emission or even stop it altogether. Majority of the drained peatlands within Iceland are no longer in agricultural use and hence represent a great potential for reducing GHG emission through peatland restoration. For this purpose emphasis is currently being placed on developing methodologies for verifying restoration success in reducing GHG emission. We here report on a project aimed at examining the feasibility of using soil water table level as a proxy variable for GHG flux turnaround following peatland restoration.

Wetland restoration at Stokkseyrarsel, South Iceland

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Introduction

Wetlands provide a multitude of ecosystems services, such as carbon sequestration, flood control, water purification, reservoirs of biodiversity, sediment and nutrient retention, and recreation. Wetlands of South Iceland are productive and have in general greater densities of birds as compared to wetlands in other parts of the country (Tómas G. Gunnarsson *et al.* 2006).

Already, by early 1990's about 97% of all wetlands in the lowlands of South Iceland had been drained to some degree (Þóra Ellen Þórhallsdóttir et.al. 1998). Since then more drainage projects have been conducted in the area due to more intensive agriculture, housing development, and a wider spread of holiday homes and forestry initiatives. The counties Árnessýsla and Rangárvallasýsla alone have a 9000 km drainage ditch system below 200 m above sea level (Fanney Ósk Gísladóttir, personal communication).

Wetland protection and reclamation has become one of the policy priorities of the Environmental Ministry in Iceland (Nefnd um endurskoðun náttúruverndarlaga, 2011). Revision on current nature conservation laws (nr. 44/1999) puts heavier restrictions on wetland drainage than before. Proposed by the new law, all wetlands 10,000 m^2 or larger will be considered to be under special protection, as compared to wetlands 30,000 m^2 or larger protected by the nature conservation laws from 1999.

From 1942 until 1993, about 30,000 km of drainage ditches were dug in Iceland in addition to about 60,000 km of smaller scale ditches (Óttar Geirsson 1998). From 1950 and until 1986, more than 500 km of ditches were dug per year on State support, giving rise to a certain phase of wetland drainage in the history of Iceland. At the onset of the drainage phase, the purpose was to prepare hayfields for agricultural purposes. Later, and close to the maximum intensity of the drainage phase in 1968, the major purpose of drainage was to improve rangelands for lifestock grazing and to provide rural jobs. Public grants for wetland drainage have been available from the government since the first fiscal year of the Icelandic parilament in 1876. The farm improvement law from 1923 provided a formal avenue of State funding for drainage projects. In the version of the farm improvement law from 1987 (nr. 56/1987), the State funding was cut to 60% of the cost of drainage. Farming law nr 368 from 1998 abolishes public fundig for new drainage projects, but public grants for mainenance of older drainage systems are still available.

Wetland restoration at Stokkseyrarsel

Stokkseyrarsel is a 365 ha farm situated in Flói, an extensive drained and partially drained wetland area between two of Iceland's largest glacier rivers, Ölfusá (Hvítá) and Þjórsá. The Flói irrigation system was dug into its wetlands in the years 1922-1927. At that time, the irrigation system was the largest developmental project in the history of Iceland. The purpose of the project was to use then turbid glacial water from river Hvítá to increase the yield of the wetlands for farming purposes. Altogether 300 km ditches were dug into the wetlands for the irrigation project and 800 km of smaller ditches to control the flood water were dug, mostly using hands and horses. Around 1940, with the onset of mechanical agriculture, most of the irrigation channels were dug deeper for drainage, and an extensive web of more ditches were dug in the area.

Stokkseyrarsel is geographically a part of the Ölfusá estuary system, but outside the area influenced by floods from the river Ölfusá. The Ölfusá estuary and the lava coast and wetlands east of the estuary is one of Iceland's most important wetland areas for bird. It is also a home of several rare plant species including both endangered and critically endangered species. The area is on the International Bird Life list of important bird sites, and is considered to hold on a regular basis more than 1% of a biogeographic population of congregatory waterbird species and more than 1% of a flyway or other distinct populations of several water bird species (Bird Life international, 2011). The area has long been on a list of sites that need to be protected by law as a nature reserve. In fall of 2011, a proportion of this area, the farm of Stokkseyrarsel will protect 313 ha of its lands as a nature reserve. The intention of the reserve is to protect its rich bird life and to restore its wetlands while still maintaining farming at a sustainable level. The Wetland Institute of the Agricultural University of Iceland will have an oversight of the reserve and the restoration efforts. Furthermore, an experiment will be set up to monitor air and soil temperatures, incoming solar radiation, soil moisture and site hydrology. The effect of the restoration efforts on gas fluxes and the water quality of surrounding lakes and ponds will, furthermore be monitored.

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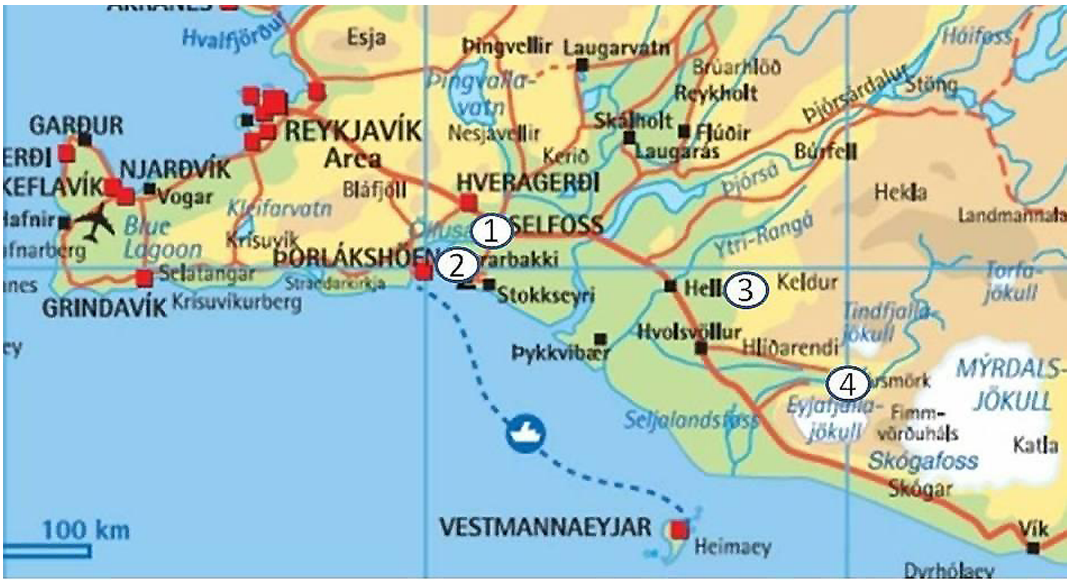
Field excursions

Short excursion will take place in the afternoon of the first conference day (Oct. 20). We will go from Selfoss (1) to Friðland í Flóa (2), which is a birdlife reserve in South Iceland. Much of the area was drained, but restoration started in 1997 and now the area is renowned for wetland birds.

The field trip on Oct. 22 will leave from Selfoss (1) at 8:30 a.m. to the headquarters of the Soil Conservation Service in Gunnarsholt (3) where the director Sveinn Runólfsson will tell us about the history of land degradation and land restoration in Iceland. We will also visit nearby restoration research area (LandAid project).



After lunch in Gunnarsholt we will drive to Þórsmörk = Thors Woods (4) (named after the the old Nordic god). Þórsmörk lies just beneath the volcano Eyjafjallajökull and the whole area was significantly affected by the 2010 eruption. The birch woodland was badly degraded in the beginning of the 20th Century but has been restored. In Þórsmörk we will inspect the effect of volcanic ash deposition on degraded vs restored ecosystems and discuss the importance of restoration on ecosystem resilience.

Birch in Þórsmörk covered with volcanic ash from Eyjafjallajökull (Hreinn Óskarsson)

Birch seedling in Þórsmörk growing out of the volcanic ash from Eyjafjallajökull (Hreinn Óskarsson)