Restoration challenges and strategies in Iceland

Ása L. Aradóttir

Soil Conservation Service, Iceland. asa@land.is

1 Challenges and strategies

The main challenge to restoration in Iceland is vast areas of severely degraded land that has limited resource retention and limited ecosystem functioning. These are often hostile environments for plant establishment and survival, due to unstable surfaces that are prone to intensive cryoturbation and erosion by wind and have limited water-holding capacity. Most of the degraded rangelands are open to traditional sheep grazing, which may limit restoration options and affect their success. The size of the degraded areas calls for low-input, but effective restoration strategies.

Iceland has long history of fight against soil erosion and reclamation for improved productivity of rangelands. However, these efforts have for the most part been based on agronomic approaches. Emerging restoration objectives, resulting in part from more diverse land uses and in part from new environmental standards on national and international level, call for new methodology.

Restoration of damaged ecosystems is one of the three main themes of soil conservation work in Iceland today. The others are halting of severe erosion and land degradation and promoting sustainable land use. Historically, most restoration work has been done by a public agency, the Soil Conservation Service (SCS), but increasingly more is being carried out by different stakeholders, including farmers and other landowners, NGO's, and interested individuals. Financial incentives and education about the importance of conserving and restoring fertile soils and healthy ecosystems are means to engage different stakeholders and promote sustainable use.

Methods of restoration in Iceland are shifting from being primarily agronomic in character to being increasingly based on ecological principles, where the aim is to promote ecosystem development and direct succession. The use of native species, including trees and shrubs is increasing, and there is growing emphasis on low input approaches instead of intense methods involving wholesale planting or sowing.

Research efforts are being directed at the underlying processes of succession and how it is affected by different reclamation treatment, the ecology and behavior of key species, the use of native species in restoration, and various technical aspects of revegetation.

2 Soil erosion

Land degradation and soil erosion have drastically changed the ecosystems of Iceland since the country was settled in the late 9th century. Birch woodlands, once extensive, have been reduced to cover only 1% of the country and much of the remaining vegetation is severely degraded. This degradation is the result of interacting environmental and anthropogenic factors, including fragile soils, climate, volcanism and glaciers that provide material for wind erosion, in addition to cutting and burning of the woodlands and grazing by livestock after the settlement.

Soil erosion in Iceland has in many cases caused the formation of barren or sparsely vegetated land with shallow and poor soils. These barren lands have been termed deserts despite a relatively humid climate (Arnalds and Kimble 2001). Some of the desert areas that cover 35-45% of the country were previously fully vegetated and covered with fertile Andosols. Soil erosion is still active in many areas and a recent assessment showed that considerable or severe erosion affects about 40% of Iceland (Arnalds et al. 2001). The most severe forms of erosion are sand encroachment, where sand buries vegetated areas resulting in bare sandy deserts, and erosion at *rofabards* (escarpments) where thick profiles of fertile soils can be removed (Figure 1). Other, less destructive erosion forms are, however, more widespread, including erosion spots, solifluction and surfaces of already desertified areas.

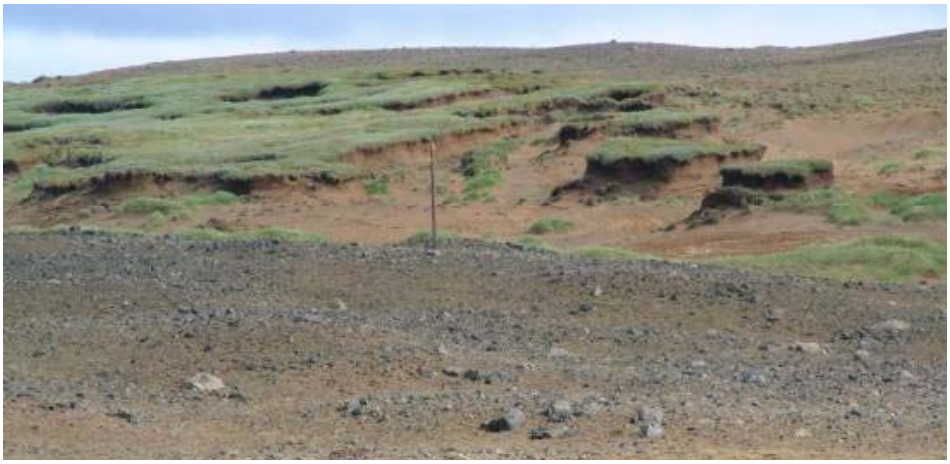

Figure 1. At rofabards (erosion escarpments), thick Andosoils are removed by the forces of wind and water leaving shallow and poor soils with limited vegetation cover (note a telephone pole at the center of the image). The picture was taken in northeast Iceland in 2002.

Some of the degraded land has high resilience and will recover without cultural inputs, if protected from grazing. However, there are extensive areas of Iceland where the degradation has passed a threshold where both the physical and biotic environment have changed too drastically for spontaneous recovery, and mitigation and reclamation efforts are necessary to encourage succession and recovery of ecosystem function.

3 Soil conservation

The Soil Conservation Service of Iceland was formed in 1907 and is therefore one of the oldest operating agencies of its kind in the world. Runolfsson (1987) and Magnusson (1997) have reviewed the history of soil conservation and reclamation in Iceland. In the beginning, the emphasis was on stabilizing drifting sand and halting catastrophic sand encroachment, but large-scale revegetation and range improvement by seeding grass species and fertilization became common in the 1940s and 50s. This was the main reclamation method until the mid 1980s when cultivation of an introduced lupin for reclamation started. Other activities have been

tried on a small scale in the last 10-20 years such as planting and seeding of native trees, shrubs and legumes. There is also an increasing interest in using tactics that encourage natural regeneration and promote ecosystem restoration with minimum cultural inputs (Aradottir and Arnalds 2001).

Most Icelandic rangelands are open to sheep grazing and horses are common in lowland areas. Protection from grazing was a part of many of the early soil conservation and reclamation efforts. Where this was not the case, grazing frequently hampered success. In the past few decades, the SCS has emphasized the promotion of sustainable land use and tried to encourage responsibility of the individual land users. An important development in this respect is a recent agreement between sheep farmers and the government, where a part of the production subsidies are tied to "quality management" that includes sustainable land use (Arnalds and Barkarson 2003).

Figure 2. Top: An experimental plot in a long-term study of the effects of reclamation treatments on succession and ecosystem services. The experiment consists of 40 experimental plots of 1 ha each, and 10 different reclamation treatments. Bottom: A complementary study of succession was performed in a chronosequence of older reclamation treatments nearby.

4 Changing paradigms

The objective of early soil conservation efforts in Iceland was to halt catastrophic soil erosion and preserve productive land. This objective is still important in areas with active degradation. Earlier reclamation efforts had for the most part the aim to

improve productivity of rangelands or to restore vegetation cover on denuded land, but often without a clear vision of the resulting ecosystem. The approach was mostly agronomic, based on large scale seeding of exotic grasses and fertilization, and later using an introduced lupin, *Lupinus nootkatensis*. This species can be very productive on poor soils, but it is invasive and can outcompete some of the native vegetation. Therefore the use of lupin has become controversial.

Current objectives for restoration are more diverse, including recreation and nature conservation, which might entail the restoration of ecosystems such as birch woodlands or wetlands, or restoration of ecosystem functions and services other than productivity. After Rio 1992, the preservation and restoration of biodiversity is an emergent objective, as well as mitigation of climate change, but reclamation of degraded areas has the potential to sequester considerable amounts of carbon in soils and vegetation of degraded areas with low organic content (Aradottir et al. 2000).

The traditional reclamation methods need to be reexamined with regard to how well they fulfill the current objectives. New ecologically based approaches are being developed, which will entail ways to encourage and direct succession and ecosystem development. Working with landscapes and natural processes in order to make better use of limited resources will also become an important component. There is recent emphasis on developing the use of native species for reclamation. Other methods, such as the use of preparatory crops that encourage the colonization of desired species assemblages are also explores. This calls for research efforts that not only deal with the various technical aspects of revegetation or restoration activities but also seek to understand the underlying processes of succession and ecosystem development and how they are affected by inputs to the system (Figure 2). Finally, there is need to harmonize different objectives. For example, a fast-growing exotic might be able to sequester a lot of carbon but if it has invasive characteristics the effects on biodiversity could be negative. Thus it might be better to use slower-growing species that are more compatible with the long-term ecological objectives for the area in question.

5 Conclusions

The barren desert areas of Iceland are affected by many of the same physical limitations as desert areas elsewhere in the world. The underlying ecological principles of ecosystem restoration are also basically the same in different parts of the world, although the methods and species that are used may differ. Cooperation between scientists, managers and policy makers from contrasting environments should therefore be productive in terms of understanding and developing innovative approaches to restoration work. Such cooperation is especially timely in light of changing paradigms, where restoration objectives are more and more influenced by international environmental standards.

References

Aradóttir, Á.L., and Arnalds, Ó., 2001. Ecosystem degradation and restoration of birch woodlands in Iceland. Pages 295-308 *in* F. E. Wielgolaski, editor. Nordic Mountain Birch Ecosystems. UNESCO, Paris, and Parthenon Publishing, Carnforth.

Aradóttir, Á.L., Svavarsdóttir, K., Jónsson, Þ.H. and Guðbergsson, G., 2000. Carbon accumulation in vegetation and soils by reclamation of degraded areas. Icel. Agricult. Science 13, 99-113.

Arnalds, Ó., and Barkarson, B.H., 2003. Soil erosion and land use policy in Iceland in relation to sheep grazing and government subsidies. Environmental Science and Policy 6, 105-113.

Arnalds, Ó., and Kimble, J., 2001. Andisols of Deserts in Iceland. Soil Science Society of America Journal 65, 1778-1786.

Arnalds, Ó., Þorarinsdóttir, E.F., Metusalemsson, S., Jonsson, A., Gretarsson, E. and Arnason, A., 2001. Soil Erosion in Iceland. The Soil Conservation Service and the Agricultural Research Institute, Reykjavík.

Magnússon, S.H., 1997. Restoration of eroded areas in Iceland. In: K.M. Urbanska, N.R. Webb, and P.J. Edwards (Eds.). Restoration Ecology and Sustainable Development. Cambridge Univeristy Press, Cambridge, pp. 188-211.

Runólfsson, S., 1987. Land reclamation in Iceland. Arctic and Alpine Research 19, 514-517.