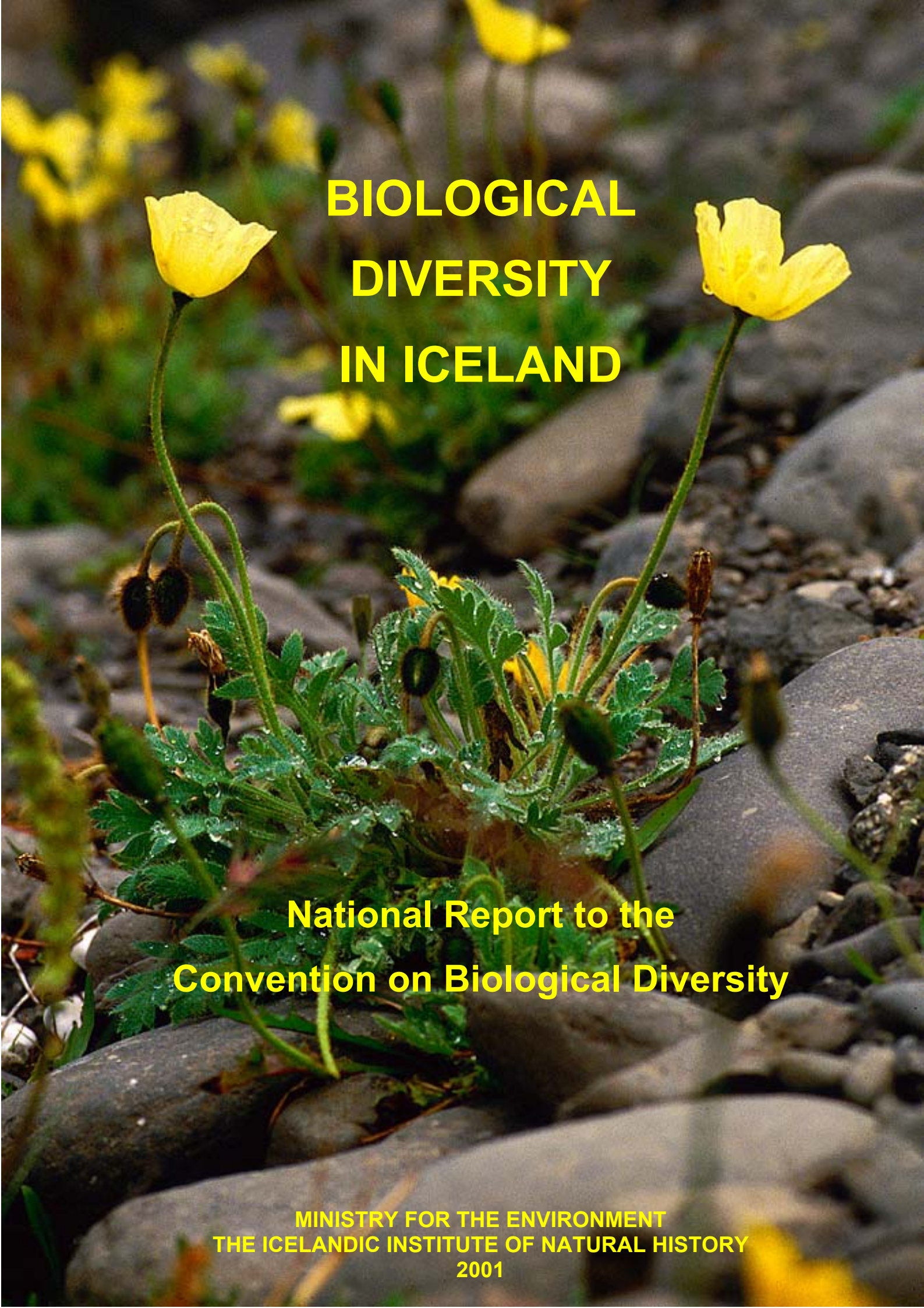

BIOLOGICAL DIVERSITY IN ICELAND

National Report to the Convention on Biological Diversity

MINISTRY FOR THE ENVIRONMENT
THE ICELANDIC INSTITUTE OF NATURAL HISTORY
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Cover: Papaver radicatum, arctic poppies or melasól in Icelandic.

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GENERAL OVERVIEW

Iceland is situated in the middle of the North Atlantic Ocean, approximately 290 km east of Greenland and 970 km west of Norway. The country is isolated from other landmasses, which makes it difficult for plants and animals to disperse to Iceland. Biological diversity is thus not very high, and there are few endemic species of fauna and flora. The country's northerly latitude and harsh climate prevent traditional crop cultivation, limiting agriculture mainly to animal husbandry. The country is, however, endowed with an abundance of renewable energy resources (geothermal and hydro power), living marine resources, and last but not least, a distinctive natural environment. Economic and technological advances during this century have facilitated utilisation of these resources, encouraging rapid economic growth and a standard of living comparable to that of other Western industrialised nations.

Physical Geography

Iceland covers an area of 103,000 km^2. Consisting mainly of a plateau. Iceland's average height above sea-level is 500 m, the highest point being 2,119 m. Only one quarter of the country lies below the 200 m contour line.

Iceland may be roughly characterised as a huge block built up by eruptive masses, and moulded by wind action, abrasion, frost action and other forces of erosion. The island is mountainous, surrounded by coastal lowlands, fjords and valleys shaped by marine abrasion and glacier erosion. Geologically speaking, the country is young and shows numerous signs that it is still in the making. On the whole, it appears rough-hewn, abrupt and jagged, without the softness of outline that characterises a more mature landscape.

Almost two-thirds of the country's surface, some 60,000 km^2, has sparse or even very sparse vegetation. Glaciers cover about 11,000 km^2 (11 per cent), and rivers and lakes cover 6,000 km^2 (about 6 per cent of the land mass). Most lakes are small, and rivers are not long but are fast-flowing and transport an enormous volume of water to the sea. Continuous vegetation covers some 26,000 km^2 (25 per cent), of

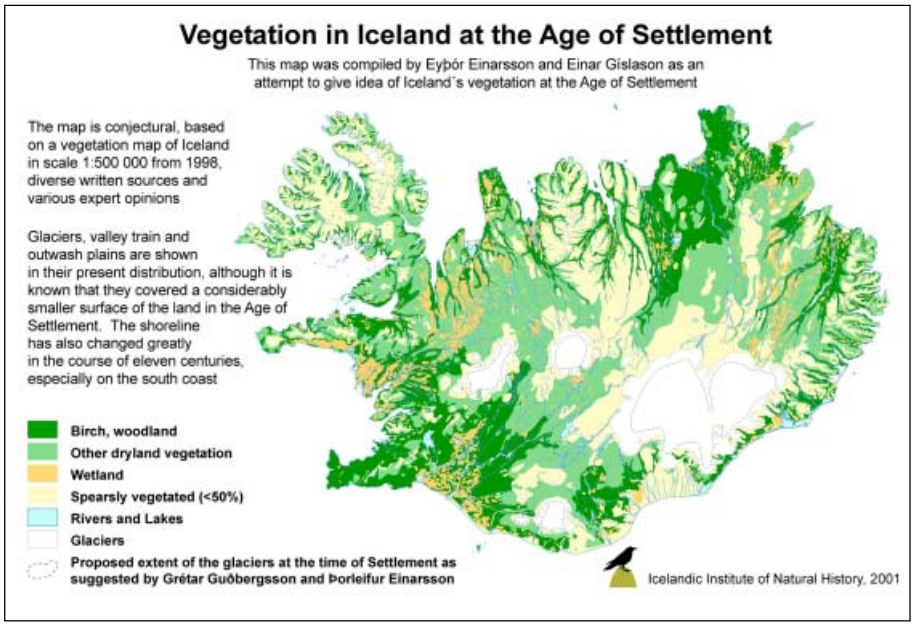

Figure 1. Estimated vegetation cover at the time of settlement.

which 16,000 km^2 is dry-land vegetation and 10,000 km^2 wetlands. Remnants of the old birch woodlands today cover less than 1 per cent, or 1,000 km^2. Arable land, partly vegetated and partly barren, amounts to approximately 25,000 km^2 (24 per cent).

Degradation of soil and vegetation

Soil erosion is one of the most serious environmental problem facing the country. It is estimated that over half the vegetation cover of the country has been lost since it was first settled 1,100 years ago, meaning that significant vegetation cover has decreased from 50-60% to only 25%. This has had a severe effect on vegetation and biological diversity in extensive areas in certain parts of the country. Furthermore, Iceland has lost over 95% of its original birch woodlands, which today cover only about 1% of the total area. The underlying reason for this extensive loss of soil and vegetation is mainly the early clearing of woodlands and subsequent overgrazing (mainly by sheep) throughout the centuries. The Icelandic Soil Conservation Service has been battling soil erosion since its establishment in 1907, and has succeeded in halting and reversing erosion in many of the most severely affected areas. However, large areas remain overgrazed and vulnerable to further erosion.

Soil erosion in Iceland.

Erosion grade	km^2	%
No erosion	4,148	4
Little erosion	7,466	7,3
Slight erosion	26,698	26
Considerable erosion	23,106	22,5
Severe erosion	11,322	11
Extremely severe erosion	6,375	6,2
Mountains	9,794	9,5
Glaciers	11,361	11,1
Rivers and lakes	1,436	1,4
No data	1,015	1
Total	102,721	100

According to a soil erosion survey published in 1997, vast areas of the country are under severe threat of erosion.

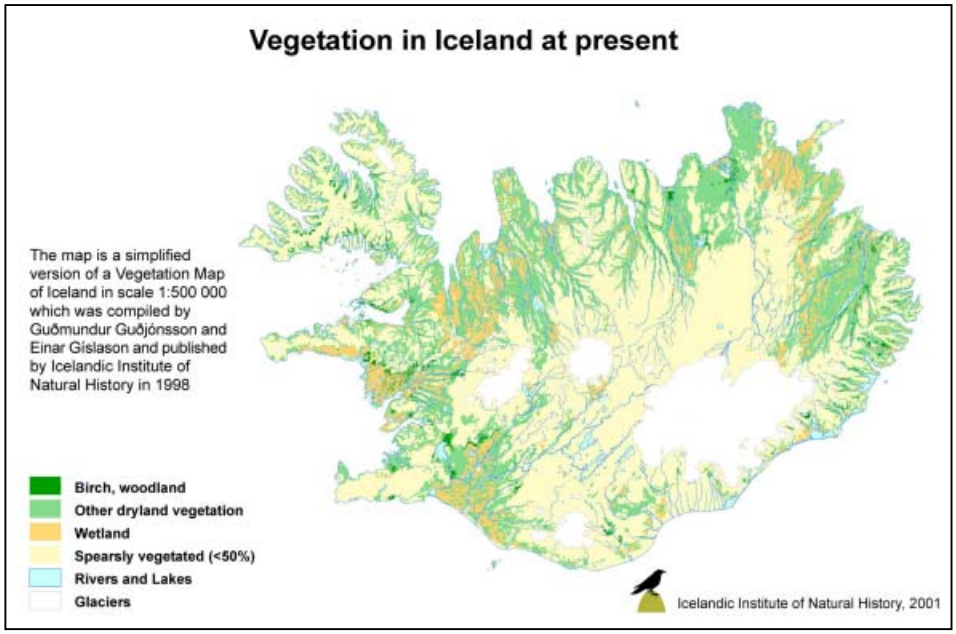

Figure 2. Vegetation map of Iceland showing major vegetation classes, birch woodland, grassland and dry-land vegetation, wetland, sparsely vegetated land and glaciers.

Approximately 30-40% of the country is threatened by soil erosion, and approximately 3,200 km^2 of vegetated land is under severe threat by erosion. Desertification is caused mainly by the interaction of grazing effects, both past and present, with sensitive vegetation and volcanic soils, along with erosion by wind and water. In some cases, grazing has been identified as having serious effect.

Land Use

Iceland is the most sparsely populated country in Europe, with an average density of 2.6 inhabitants per km^2. However, since more than half of the nation lives in the capital area of only some 50 km^2, the rest of the country is left with an average of less than one inhabitant per km^2. It should be remembered, however, that about four-fifths of Iceland is uninhabitable. In most parts of the country, habitation is restricted to areas below 200 m elevation, along the coast and in a few lowland areas.

Aside from tourism, farming constitutes the largest single category of land use, utilising in a broad sense approximately 80,000 km^2, or 79 per cent of the total land area. Most of the land is open range-land used for grazing purposes during the summer months while only some 1,360 km^2, or 1 per cent of the land, are cultivated. Urban settlement covers about 70 km^2, or 0.07 per cent of the total land area. Infrastructure (roads and airfields) outside urban areas occupy about 420 km^2, or 0.4 per cent of the total land surface, while energy harnessing and distribution exclude from alternative use some 540 km^2, or 0.5 per cent of the total land area in Iceland. The most

significant change in land-use during the past twenty years is due to the creation of national parks and nature reserves. In 2000, national parks and reserves and other protected areas amounted to roughly 11,900 km^2, or approximately 12 per cent of the total land area in Iceland, compared to 533 km^2 in 1970. Another major change in land-use, especially during the last 10 years, is afforestation and soil conservation.

Geothermal Activity

Iceland is very rich in geothermal heat. The regional heat-flow within the country averages two to four times the global average. Two main types of thermal areas can be distinguished on the basis of the maximum subsurface temperature of the thermal water. In low temperature areas, the maximum temperature at 1 km depth is less than 150°C, while hotter areas are classified as high-temperature areas. The low-temperature areas are characterised by hot springs with temperatures at or near the surface ranging from a little above ambient temperature to 100°C and with relatively low amounts of dissolved chemicals. Hot springs are common all over the country except in the east and south-east and are usually associated with dykes and fractures. About 1000 hot-spring localities have been located and 19 high-temperature areas with steam f ields fostering enormous diversity of thermophilic bacteria and micro-organisms.

Figure 3. One of a few protected geothermal areas, Námaskard at the Lake Mývatn and Laxá protected area.

The Marine Environment

Iceland has a coastline 6,000 km long and is surrounded by a shelf with an area of 115,000 km^2 above a depth of 200 m. The Icelandic continental shelf is connected to neighbouring countries by submarine ridges extending towards Greenland, the Faeroe Islands, and Jan Mayen. In addition there is the Reykjanes Ridge extending out into the North Atlantic towards the south-west and forming part of the Mid-Atlantic Ridge and the transoceanic rift system.

Iceland's exclusive economic zone extends to a maximum of 200 nautical miles, and elsewhere to the medium-line between Iceland and

its neighbours, covering an area of 758,000 km^2. The pollution control zone extends in some places beyond the 200-mile limit, following the continental shelf as defined in the United Nations Convention on the Law of the Sea.

The seas around Iceland are in the boundary area between the warm waters of the Atlantic and the cold Arctic waters, i.e. on the oceanic polar-subpolar front. This fact is brought home in particular by the distribution of sea-ice from the Arctic Ocean, which can occasionally block access to the coast in the north and east of Iceland. The warm Atlantic waters are a branch of the North Atlantic Current (the Gulf Stream) called the Irminger Current. This current divides into two branches west of Iceland.

The westerly one meets the cold East Greenland Current, which propels ice southwards along the east Greenland coast and westwards to western Greenland where the Irminger Current flows below and around the Polar Current. The easterly branch flows north and east into the north Icelandic waters or the Iceland Sea. In addition to the cold East Greenland Current, there is also the equally cold East Icelandic Current, which flows to the north and east of Iceland, and south and east towards the Faeroes.

To the east and west of Iceland there are also cold, deep bottom currents from the north, which flow over the submarine ridges into the North Atlantic, forming a so-called "overflow". In addition to these, there is a coastal current around the Icelandic coast which receives its input from the rivers and the land and mixes with the water masses in the ocean. The complexity and variety of ocean currents in Icelandic waters, along with the mixing of water masses, creates nutrient-rich and highly productive fishing grounds capable of supporting high diversity of living resources in great quantities. The diversity of marine fish species is well documented, as is the diversity of plankton, both zooplankton and phytoplankton, but the diversity of marine benthic organisms is less well known. An extensive study is being carried out to collect and identify benthic invertebrates and gather information on their distribution and abundance within the exclusive economic zone.

CASE STUDY

VEGETATION SUCCESSION IN AREAS COLONIZED BY THE INTRODUCED NOOTKA LUPIN (*LUPINUS NOOTKATENSIS*) IN ICELAND

The effect of Nootka lupin on vegetation and soil (0-10 cm) was investigated at 15 sites in southern and northern Iceland. Plant biomass was determined at 10 of the sites. The lupin had been at the sites for 10-40 yrs and colonized barren eroded areas, glacial river beds, partly vegetated moss heaths and denser dwarf-shrub heaths. Transects were laid out and a comparison made of lupin of different age within patches and the adjacent areas outside them. A total of 27 patches was investigated and measurements carried out in 93 plots. In the analysis CANOCO-ordination was used to analyze sucessional trends.

In southern Iceland, where annual precipitation is 900-3400 mm, the lupin was of high stature (80-120 cm) and formed a closed canopy. In northern Iceland, where annual precipitation is 500-800 mm, the lupin was lower in height (40-110 cm) and did not form a closed canopy on the driest gravel flats. There it, however, formed dense patches on dwarf shrub heaths and in coastal areas. Lupin biomass was 300-990 g/m^2 in the southern area and 80-650 g/m^2 in the northern area.

At sites where the lupin formed dense, long-lasting patches it had great effect on the vegetation development. The ordination results revealed that successional changes caused by the lupin tended to go into the same direction irrespective of the type of land it colonized. Within the patches the vegetation developed towards a forb-rich grassland, abundant in horsetails (Equisetum) at some of the sites. In the south *Poa pratensis* was the dominant grass species at most of the sites, but *Poa glauca* and *Festuca richardsonii* in the north. A dense moss layer developed underneath the lupin at most of the southern sites. The effects of the lupin were generally greater in the southern area and the vegetation of old patches was rather uniform. It was more diverse in the northern area, where the lupin had less pronounced effects on vegetation composition at the drier sites.

Species richness was greatly reduced at most of the sites where the lupin formed dense patches. At the southern sites 20-60 plant species were found in plots outside the patches but 5-25 species within the oldest parts of lupin patches. At the northern sites 10-55 species were found on the outside but 3-62 species within the oldest parts of the patches. The greatest reduction occurred where the lupin had colonized dwarf-shrub heath-lands in northern Iceland resulting in disappearance of most of the native species. At the drier northern sites species richness was little affected by the lupin or even increased. There, most existing species survived within the open lupin patches and at some of the sites birch (*Betula pubescens*) colonization occurred which was rare at other sites. The lupin was generally densest close to the edges of patches where the plants had just reached maturity. The lupin density tended to decrease towards the oldest center of the patches. The longevity of the lupin varied, however, greatly between sites. At some of the southern and the drier northern sites the lupin had degenerated in the oldest parts of patches, where it had colonized 15-25 years earlier. At other southern and northern sites the lupin maintained a high cover and was still dominant in the oldest parts of patches where it had been growing for 25-35 years. Most of these sites were from areas of high annual precipitation, late snowmelt in spring or high groundwater table.

The Nootka lupin is a very effective plant for land reclamation in Iceland. Dense plant cover and soil fertility can be gained within a relatively short time span, where the growth of the lupin is not limited by droughts. The lupin is well suited for reclamation of large, barren areas. The nitrogen fixation of the lupin, rapid growth, size and patch formation, on the other hand, enables it to invade moss-heaths and dwarf-shrub heath-lands which it will take over and displace. This calls for strict management guidelines on the future use of the plant in the country.

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Agricultural Research Institute.

BIOLOGICAL DIVERSITY

During the past 10-20 years, increased emphasis has been placed on conserving biological diversity and threatened habitats in Iceland, especially through protected areas but also for example by influencing practices used in agriculture, afforestation, road construction, power plants and reservoirs. Legislation on nature conservation has been amended and strengthened in order to further the protection of species their habitats.

Flora

One of the main characteristics of the flora of Iceland is the small number of species of vascular plants. According to Flora of Iceland, the official species list which dates back to 1948, there are a total of 483 native and naturalised species in Iceland. In addition, there are a number of species that have been deliberately introduced and cultivated for agricultural and soil conservation purposes. Of these 483 species, 37 are *Pteridophytes*, while only one gymnosperm is native to Iceland. There are 300 species of dicotyledons. The 145 monocotyledons make up 31 per cent of all the vascular plants, a proportion very similar to that found in most northern countries. By far the largest families, both belonging to the monocotyledons, include sedges (*Cyperaceae*) with 53 species, and grasses (*Poaceae, Gramineae*) with 47 species. The largest families of dicotyledons are daisies (*Asteraceae*, *Compositae*) with 47 species and pinks (Caryophyllaceae) with 28 species.

Figure 4. Vegetation in the Central Highlands can flourish where grazing is limited, *Rodiola rosea* patch in Thjórsárver Nature Reserve.

The Bryophyte flora of Iceland invcludes about 560 species. They are not all arctic; on the contrary, they are sometimes even more temperate than the vascular plants. The most common

moss species are Racomitrium languinosum and Racomitrium canescens. At least 550 species of lichens have been found in Iceland; about 200 of them are macrolichens, the exact number of which is unknown. With very few exceptions, Icelandic lichen flora is of a Scandinavian character. The number of fungi species reported from Iceland is around 1200; the fungi flora also has a Scandinavian character.

On the rocky coasts of Iceland, a very luxuriant littoral vegetation of algae occurs in many places, often displaying a considerable difference between the inner part of the fjords and the outer coast. About 220 species of marine benthic algae have been found in Icelandic waters. There is considerable difference between north-east and east Iceland, where a number of arctic species grow, and south and south-east Iceland, where arctic species are replaced by warm boreal water species.

The only native tree in Iceland that forms woodlands is birch (*Betula pubescens*). At present, birch forests and shrub-land cover approximately 1 percent of Iceland (1,250 km^2). Eighty percent of the birch is shrub-like, less than 2 m in height. Only 2 per cent of the woodlands have trees 8-12 m tall, and these are mainly found in the valleys of north and east Iceland and in the vicinity of the glaciers in the south. At the time of settlement (1,100 years ago) birch may have covered at least 25 per cent of Iceland. Other native trees include rowan (*Sorbus aucuparia*) and willow (*Salix phylicifolia*).

Wild Terrestrial Mammals

Besides commensal rodents, the terrestrial mammalian fauna of Iceland is composed of just four species, only one of which, the arctic fox (*Alopex lagopus*), is indigenous to the country. The others were brought to Iceland, either inadvertently or on purpose. Polar bears, protected since 1994 except when threatening human life, occasionally visit Iceland, usually coming only on drift-ice in years when it reaches the country.

The arctic fox (*Alopex lagopus*) has presumably inhabited Iceland since the end of the Ice Age. In the past, since at least 1295 A.D., there have been laws in Iceland promoting the extermination of this species, but since 1994, extermination is no longer the goal but rather minimising the threat and damage by control measures. In spite of heavy and steady hunting pressure, the arctic fox population is currently quite viable, with a population size in autumn estimated at approximately 3,000-6,000 individuals.

The estimated population size has undergone a number of long-term fluctuations in the past 140 years. The population was thus large

in the 1950s and severely depressed in the early 1970s, but it has now recovered to almost the same size as in the 1950s. The cause of these long-term fluctuations is not known. Superimposed on these long-term fluctuations is a weak 10-year cycle in north-eastern Iceland in response to cycles in the ptarmigan (*Lagopus mutus*) population, the most important prey for the arctic fox in winter.

The most serious threat to the arctic fox population in recent years has been the farming of imported blue foxes and silver foxes, some of which have escaped from captivity and interbred with the native fox population with a concomitant threat of gene swamping.

The American mink (*Mustela vison*) was imported to Iceland in the early 1930s for the purpose of fur-farming. Some minks escaped and bred in the wild. In spite of considerable efforts to stop its spread in the wild, mink had spread throughout the country by 1975. The arrival of the mink is believed to have affected the breeding distribution of some native wetland birds and ducks and has been considered to be one of the reasons, along with drainage of wetlands, for the disappearance of the water rail (*Rallus aquaticus*). It is not known to what extent bird population sizes have been affected, but mink hunting takes place all over Iceland. The mink population fluctuates somewhat, probably mainly in response to climatic fluctuations and hunting pressure, but around 3,500 to approximately 6,000 bounties are paid annually for minks. The population size is unknown but is probably somewhere around 10,000 animals in autumn.

The reindeer (*Rangifer tarandus*) in Iceland is of Norwegian domestic stock. Four groups of reindeer were imported into Iceland during the period 1771 to 1787. One group became extinct within a few years, but three feral herds were soon established, one in south-western Iceland, and two in north-eastern and eastern Iceland, respectively.

These three herds rapidly increased in size, and within a few decades were regarded as vermin due to the depletion of lichens and purported grazing competition with sheep. To begin with, hunting permits were limited, but from 1849 the reindeer herds could be hunted everywhere in all seasons. As a result of heavy hunting pressure and high natural mortality, the herds decreased steadily for the next 35 years, when hunting was again restricted, followed by total protection in 1901.

In spite of total protection, the herd in south-western Iceland continued to decrease and finally became extinct in the late 1920s. The herds in the north-east and east probably merged into one herd with a much reduced range. This herd remained very small, probably in the range of 100-200 animals, from the late 19th century until around

1940, when it began to increase again. In the 1970s and 1980s the population was approximately 3,500-4,000 animals, but in the early 1990s, it was decided to reduce the population to 2,000-2,500 animals and keep it stable at that level by annual hunting quotas.

It is believed that the wood mouse (*Apodemus sylvaticus*) was among the first wild mammals to be brought to Iceland. It thrives in most regions of the country, particularly in birch forests and along the coast. It is protected by law in the wild. It lives almost totally independently of humans but can cause some damage when entering or "invading" dwellings, as often happens in winter. The wood mouse population is known to fluctuate locally in size but probably exhibits no regular inter-annual population cycles.

Three species of rodents, the house mouse (*Mus musculus*), brown rat (*Rattus norvegicus*) and roof rat (*R. rattus*), live commensally with humans and appear to owe their survival totally to their presence. It is possible that competition with the wood mouse limits the distribution of the house mouse, and that predation by mink limits the distribution of brown rats. Roof rats occur in Iceland now and then, but there is no sustainable self-supporting population.

Bird Life

About 72 bird species nest regularly in Iceland. Nearly 20 additional species are known to have nested on one or more occasions. Some of these are in the process of establishing themselves in the country but are still rare. One breeding species, the great auk (*Pinguinus impennis*), was last seen in Iceland in 1844, when it became globally extinct. Two other species are extinct as breeders in Iceland, the water rail (*Rallus aquaticus*) and the little auk (Alle alle).

Figure 5. Látrabjarg the westernmost part of Iceland and home of the largest colony of *Alca torda* in the world and the largest colonies of *Fratercula arctica* in Iceland.

The most celebrated of all Icelandic birds is the gyrfalcon (*Falco rusticolus*), which in former times was much coveted by falconers. It is now fully protected and

found quite widely in the rocky and mountainous parts of the country. The huge white-tailed eagle (*Haliaeetus albicilla*) was formerly fairly common. The population has been reduced to such an extent, through persecution and indirect poisoning for foxes, that grave concern has been expressed for its future. Although eagles have increased slightly in number due to conservation efforts, now numbering 40-45 pairs, the population is far smaller than the estimated 150 pairs of a century ago. The third indigenous raptor species, the merlin (*Falco columbarius*), has a good-sized breeding population.

Figure 6. Approximately 20-40% of the North Atlantic population of the great skua *Stercorarius skua* breeds in Iceland.

Owls are represented by two species. The snowy owl (*Nyctea scandiaca*) is an irregular breeder that has nested only a few times during the last 45 years, although seen annually as a straggler. The short-eared owl (*Asio flammeus*) occupies low-lying moors, and is one of nine species of birds that started to breed in the country during the climatic amelioration in the first half of this century. The other eight species include the shoveler (*Anas clypeata*), the tufted duck (*Aythya fuligula*), the pochard (*Aythya ferina*), the lesser black-backed gull (*Larus fuscus*), the herring gull (*Larus argentatus*), the common gull (*Larus canus*), the black-headed gull (*Larus ridibundus*) and the starling (*Sturnus vulgaris*). The Iceland gull (*Larus glaucoides*) is a regular and common winter visitor. Most of the gull populations have increased in size, while those of the arctic skua (*Stercorarius parasiticus*) and the great skua (*Stercorarius skua*) have remained stable. The Icelandic population of the last-mentioned species represents nearly half of the world breeding population.

The gyrfalcon's main prey is the rock ptarmigan (*Lagopus mutus*), the country's only gallinaceous bird and also its most important game bird. The ptarmigan is one of the so-called cyclic species, which means that its population is subject to regular fluctuations. The length of the cycle in Iceland is about 10 years. In peak years, the ptarmigan appears in large numbers over the whole country, but during periods of scarcity, the population is reduced three- to fourfold.

The striking paucity of nesting passerines, which are represented by only ten species, is no doubt primarily due to lack of suitable habitats, especially the absence of forests, and to fluctuations in insect

life. The raven (*Corvus corax*), the snow bunting (*Plectrophenax nivalis*), the redpoll (*Carduelis flammea*), and the wren *(Troglodytes troglodytes*) are resident species, while the meadow pipit (Anthus pratensis), the white wagtail (*Motacilla alba*), the redwing (*Turdus iliacus*) and the wheatear (*Oenanthe oenanthe*) are common summer visitors. The starling (*Sturnus vulgaris*) has established itself in Iceland since 1940. Its breeding range is still restricted but expanding. The lapwing (*Vanellus vanellus*), the swallow (*Hirundo rustica*), the fieldfare (*Turdus pilaris*), the blackbird (*Turdus merula*), the brambling (*Fringilla montifringilla*) and the chaffinch (*Fringilla coelebs*) have attempted to breed in Iceland, but this has not yet resulted in permanent colonization.

The most characteristic wader species in Iceland are the golden plover (*Pluvialis apricaria*) and the whimbrel (*Numenius phaeopus*). Other common waders are the snipe (*Gallinago gallinago*), the redshank (*Tringa totanus*), the dunlin (*Calidris alpina*), the purple sandpiper (*Calidris maritima*), the ringed plover (*Charadrius hiaticula*), the oystercatcher (*Haematopus ostralegus*) and the red-necked phalarope (*Phalaropus lobatus*). The black-tailed godwit (*Limosa limosa*) has a less general distribution, while the grey phalarope (*Phalaropus fulicarius*) population is seriously threatened. The turnstone (*Arenaria interpres*), the knot (*Calidris canutus*) and the sanderling (*Calidris alba*) are regular passage migrants on their way to and from high arctic regions, such as Greenland and Canada.

Iceland has long been known as one of the major waterfowl haunts in Europe, and Lake Mývatn in the north-eastern part of the country is particularly noted for the abundance of its waterfowl. This remarkable shallow lake and its outlet, the River Laxá, are inhabited by all the freshwater duck species known to nest in Iceland, a total of 15 species, while the 16th Icelandic duck species, the eider *(Somateria mollissima*), is almost exclusively marine. The ducks include the Barrow's goldeneye (*Bucephala islandica*) and the harlequin duck (*Histrionicus histrionicus*), which are of North American origin and nest nowhere else in Europe. The same is true of the great northern diver (*Gavia immer*), which is sparsely distributed throughout the country, while its congener, the red-throated diver (*Gavia stellata*) is more common. Lake Mývatn is also a stronghold for the slavonian grebe (*Podiceps auritus*), which has seriously declined in the past few decades.

Geese are represented in Iceland by three nesting species. The greylag (*Anser anser*) inhabits the low-lying districts, while it is replaced by the pink-footed goose (*Anser brachyrhynchus*) in the highland regions. The barnacle goose (*Branta leucopsis*) is one of the rarest breeders in the country, having started to nest nearly 40 years ago. On the other hand it is a regular passage migrant, together with the white-fronted goose (*Anser albifrons*) and the brent goose (*Branta bernicla*). Iceland is one of

the few places where the whooper swan (*Cygnus cygnus*) can be called a common breeding bird. It most frequently inhabits lake-dotted high grounds on the borders of the Central Highlands.

Seabirds represent one of the most important elements of Iceland's bird fauna. Most of the seabird populations are of international importance because of the number of individuals, which represent large and in some cases substantial parts of world populations. On the towering bird-cliffs, which are occupied by a mixed assemblage of colonial seabirds, the most important species are the common guillemot (*Uria aalge*), Brünnich's guillemot (*Uria lomvia*), the razorbill (*Alca torda*), the kittiwake (*Rissa tridactyla*), and the fulmar (*Fulmarus glacialis*). The three largest bird-cliffs, Látrabjarg, Hælavíkurbjarg, and Hornbjarg, are all in the north-west, and are among the largest seabird-cliffs in the North Atlantic. Although also found on bird-cliffs, the puffin (*Fratercula arctica*), primarily inhabits grassy islands, and is probably the most common Icelandic bird. The black guillemot (*Cepphus grylle*) is less gregarious than the other auk species and nests sparsely in screes. The gannet (*Sula bassana*), the queen of the North Atlantic, nests mainly on rocky offshore islands and stacks. All these seabird species inhabit the Westmann Islands, off Iceland's south coast, together with three procellariform species, which are hardly found elsewhere in Iceland, Leach's petrel (*Oceanodroma leucorrhoa*), the storm petrel (*Hydrobates pelagicus*), and the manx shearwater (*Puffinus puffinus*). The arctic tern (*Sterna paradisaea*) is one of Iceland's most common seabird species, with colonies in all parts of the country, especially in coastal regions.

Figure 7. One of the most numerous bird in Iceland is the puffin, *Fratercula arctica* with approximately 1,000,000 breeding pairs.

Freshwater Fish

The productivity of rivers varies greatly according to their location, water source, volume of flow, length, gradient and water temperature, especially in the summer months. Rivers that have lakes as their source or that flow through lakes prove generally more productive than others. Lake productivity also varies greatly and is influenced by many factors: the geology of the surroundings, water temperature, depth, altitude above sea-level, quantity of nutrients, precipitation and renewal of lake water. Icelandic watersheds have been classified into ecological classes based on these factors, each class having its distinct

fauna. The fish species have different environmental needs, and the distribution of each fish species is therefore different. Owing to the cool climate and brief summers, the growing season for fish in lakes remains short. Shallow lowland lakes are generally most productive.

Five species of fish living partly or wholly in fresh water are native to Iceland. The Atlantic salmon (*Salmo salar*) ascends about 80 rivers and streams. The rivers consist of both spring-fed rivers and those draining low vegetated heaths. Brown trout (*Salmo trutta*) is common in lakes all over the country, and sea trout is common in rivers in western, southern and south-eastern Iceland. The arctic char (*Salvelinus alpinus*) is found in most lakes and rivers, and sea char is the dominant species in many colder and harsher rivers in the north-west peninsula and in northern and eastern rivers. European eel (*Anguilla anguilla*) is most common in the south and south-west part of the country. The three-spined stickleback (*Gasterosteus aculeatus*) is common all over the country, and some populations go to the sea. Rainbow trout (*Oncorhynchus myskiss*) has been introduced into hatcheries and has escaped into the wild.

Apart from extensive sport fishing of salmon, charr and trout, commercial fishing of trout and charr takes place in lakes. Salmon fishing by nets is forbidden in the sea off Iceland and in spring-fed rivers. To secure the sustainability of the salmon, charr and trout stocks, the number of fishing licences per river and lake are limited, both for sport and commercial fishing, and every year smolt hatched from the fish caught are released in many of the rivers.

Urban settlement causes increased contamination of some lakes and rivers. Farming and related activities, such as drainage of wetlands, has changed some watersheds. Rapid development of tourism, road building and hydro-harnessing developments pose a threat to fish habitats in rivers and streams and hence a threat to fish populations. Fish farming has in several cases caused pollution of lakes and streams. Furthermore, escapees of imported rainbow trout and Norwegian salmon from fish farms represent a danger of genetic pollution and erosion of natural fish populations and increase the chances of outbreaks of fish diseases.

Invertebrates

The insect fauna in Iceland is better known than most other groups of invertebrates, with 1,266 species recorded (including approximately 150 immigrant and accidentally imported species). As in other subarctic countries, the Diptera (flies, midges, etc.) form the most diverse and important group. Coleoptera (beetles) and

Hymenoptera (bees and allies) are also fairly well represented, whereas free-living ants are lacking entirely. Moths are the only fully indigenous representatives of the Lepidoptera. A few species of migratory butterflies, such as the red admiral and the painted lady, occasionally reach the country, although they never survive the winter. Acari (mites and ticks) are relatively well represented (several hundred species), but the Araneae (spiders) number a little less than 100 species. Terrestrial and fresh-water Mollusca (snails, bivalves, etc.), Oligochaeta (earthworms), Chilopoda (centipedes), and Diplopoda (millipedes) are poorly represented. There is much less species diversity for terrestrial and fresh-water invertebrates than for salt-water invertebrates.

Groups and numbers of invertebrate species.

Group	Number
Archaeognatha	1
Thysanura	1
Protura	3
Collembola	77
Ephemeroptera	1
Odonata	1
Plecoptera	1
Orthoptera	2
Dermaptera	1
Blattodea	5
Psocoptera	10
Mallophaga	67
Siphunculata	3
Hemiptera	78
Thysanoptera	7
Neuroptera	3
Trichoptera	11
Lepidoptera	118
Coleoptera	239
Hymenoptera	256
Diptera	373
Siphonaptera	8
Total	**1266**

Reptiles and Amphibians

A distinctive feature of the fauna of Iceland is the complete absence of reptiles and amphibians.

Marine Life

The ocean surrounding Iceland is characterised by current fronts and the mixing of warm and cold water masses, which carry a diversity and abundance of plants and animals. Throughout the year, marine life in Icelandic waters shows great seasonal changes. In winter, propagation is limited but in spring, after the upper water layers have warmed and stabilised, a great rise in the production of phytoplankton becomes evident. Primary production is followed by propagation of the zooplankton that grazes on the phytoplankton and in turn constitutes the main food of all pelagic fish, the baleen whales and an enormous amount of fish larvae.

The marine invertebrate fauna is relatively rich and productive, considering the northerly latitude of the country. Prominent marine invertebrate groups include, for example, Coelenterata (jellyfishes, sea anemones, etc.), Mollusca, Crustacea (sandhoppers, shrimps, crabs, etc.), Polychaeta (sandworms, tube worms, etc.), and Echinodermata (starfishes, brittle stars, sea urchins, etc.). Many other groups are also

represented, such as Protozoa (one-celled animals) and Porifera (sponges). The benthic invertebrate fauna offer a rich source of food for bottom-feeding fish, e.g. cod, haddock, plaice, and halibut.

In 1992 the first comprehensive study of the distribution and abundance of benthic invertebrates within the Icelandic jurisdiction was launched. It has been predicted that as many as 3,000-4,000 invertebrate species will be identified, many of them certainly new to Icelandic fauna, and some also new to science.

Approximately 270 fish species have been found within Icelandic jurisdiction, about 150 of which are known to spawn in the area. Most of the fish are warm-water species and inshore or bank spawners. Only a few are of subarctic or arctic origin. The majority include demersal fish such as cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), redfish (*Sebastes marinus* and *Sebastes mentella*) and plaice (*Pleuronectes platessa*). Relatively few are pelagic, e.g. herring (*Clupea harengus*), capelin (*Mallotus villosus*) and blue whiting *(Micromesistius poutassu*).

In spite of the great number of fish species, only about 25 are fished for utilisation, and of these species, only three, viz. cod, redfish and capelin, constitute on average more than three-fourths of the catch.

There is an abundance of invertebrates in Icelandic waters. However, only a few are commercially exploited, including the Norway lobster (*Nephrops norvegicus*), the Northern shrimp (*Pandalus borealis*) and the Iceland scallop (*Chlamys islandica*).

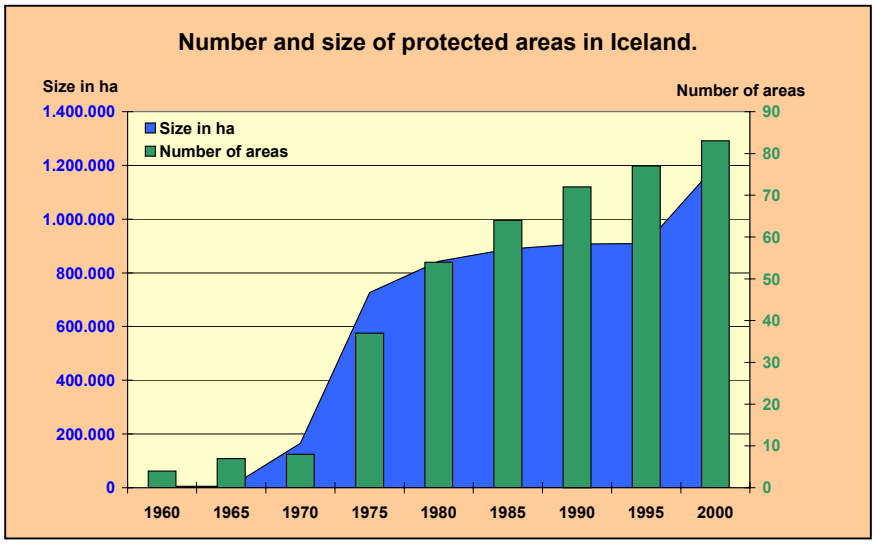
Several species of whales and two seal species inhabit Icelandic waters. The common seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) represent the only seal species that regularly breed on the coasts around Iceland. As the populations of both species are large, sustainable hunting is allowed in Iceland subject to certain rules. It is a tradition in some parts of the country to hunt them for their meat and fur.

At least seven odontocete species of whales (toothed whales) can be regarded as common in Icelandic waters. The large and medium-sized species include the sperm (*Physeter catodon*), northern bottlenose (*Hyperoodon ampullatus*), killer (*Orcinus orca*) and long-finned pilot whales (*Globicephala melas*). Of the smaller odontocetes, white-beaked (*Lagenorhynchus albirostris*) and Atlantic white-sided dolphins (*L. acutus*) and harbour porpoises (*Phocoena phocoena*) are most common. A few species of smaller warm deepwater species may occasionally appear in these waters, such as *Delphinus delphis* and *Mesoplodon sp.*, although the frequency of their occurrence is not known.

Of baleen whales, five species of rorquals are common, blue (*Balaenoptera musculus*), fin (*B. physalus*), sei (*B. borealis*), minke (*B. acutorostrata*) and humpback whales (*Megaptera novaeangliae*). In addition, a remnant population of right whales (*Eubalaena glacialis*) still appears to exist in these waters, although at extremely low levels. At present, whale hunting is not practised in Icelandic waters.

Nature Conservation

In the past, nature conservation has focused on the protection of areas but is now being diverted towards the protection of species and their habitats, habitat-types and ecosystem conservation. There are currently a total of 85 protected and reserved terrestrial areas in the country, totalling some 12,100 km^2, compared to eight areas totalling 533 km^2 in 1970. In accordance with the Nature Conservation Act,



these areas are classified as national parks, nature reserves, natural monuments, and country park recreation areas. All the designations entail restrictions on exploitation and development to a varying degree. In most cases, the areas are also declared open to the public within the limits set by their sensitivity to human traffic. It is estimated that 6% of protected areas classify as wetlands, and that approximately 4.5% of the wetlands in Iceland have been protected. Three protected wetland areas have been assigned to the Ramsar-list of wetlands of international importance, Lake Mývatn, Thjórsárver and Grunnafjördur. Major drainage and cultivation of wetlands was practised in the 1950's and 1960's, with adverse consequences for both the flora and fauna. It has been estimated that wetlands covered approximately 9,000-10,000 km^2, of which only 25-40% is still undisturbed or undrained.

The primary threat to terrestrial flora is overgrazing and loss of vegetation cover by erosion. Soil and vegetation conservation has been one of the conservation priorities in Iceland for several decades, with extensive recovery programmes in eroded areas. In some areas, grazing pressure has been regulated in co-operation with farmers in order to reduse soil erosion. Efforts to restore vegetation cover, sometimes using introduced plants, may pose a danger to biological diversity in specific areas, but measures are being taken to increase the use of native plants in re-vegetation programs. Out of 483 native species of vascular plants, the Icelandic Institute of Natural History has red-listed 52 as rare, vulnerable or endangered, while 31 are protected by law. Among lower plants, 580 species of lichens are known, 270 have been evaluated and 67 are red-listed; 585 moss species are known, 450 have been evaluated and 74 red-listed; 238 species of marine benthic algae are known, and 42 have been red-listed. An important conservation issue that has received greater attention in recent years is the need to protect Icelandic flora and fauna from genetic mixing with imported and cultivated species and the effect of alien species. The overview of ecosystems, biotopes and habitat types is still fragmentary, but new efforts for systematic surveying and classification of habitats are being carried out.

The state of knowledge of Icelandic fauna is generally rather poor - on a descriptive stage for most species except birds and mammals. Systematic surveying of marine, aquatic and terrestrial invertebrates is being carried out in order to collect information on species and distribution. There are few terrestrial vertebrate species in Iceland, but diversity of marine vertebrates, especially fish, is high. Some populations of birds and mammals that are of commercial use are monitored, as well as many fish stocks. All birds are in principle protected, with the exception of allowed seasonal hunting of 24 species. However, certain species and/or their products (i.e., eggs and down) are utilised for human consumption with restrictions to secure the conservation and sustainability of the populations. Four species that are considered to pose health hazards or economic conflicts with man are subject to unrestricted hunting throughout the year. The well-being of coastal ecosystems is of great concern in Iceland, and a large bay, Breidafjördur, in the western part of the country has been protected by a special nature conservation law. Fishing is prohibited in designated areas or with the use of certain types of fishing gear, in order to protect spawning fish and juveniles; and ocean areas are kept under surveillance in order to enable prompt action. Fisheries are regulated by a quota system based on scientific knowledge in order to secure sustainability.

Hunting of birds is a popular sport which is currently regulated only by assigned hunting seasons for every species. Hunters are required to register and buy an annual hunting license. Hunting is monitored using bag-statistics reported by hunters at the time of re-registration. Reindeer hunting is regulated by annual quotas based on population size and monitoring of sub-populations and distribution. The popularity of hunting has increased in the last few years, with 500-600 new licensed hunters annually, and an increasing number of hunters visiting Iceland every year for this sport.

Today, natural wilderness areas and high biological diversity are important ingredients in recreation and enhanced tourism. The

Hunting statistics based on annual reports on hunting of wild birds and mammals collected from hunters.

English name	Scientific name	1995	1996	1997	1998	1999
Great Black-backed Gull	*Larus marinus*	35,762	32,785	29,738	32,328	24,725
Lesser Black-backed Gull	*Larus fuscus*	22,340	22,390	27,257	34,030	19,714
Herring Gull	*Larus argentatus*	5,998	4,798	4,881	7,868	6,278
Raven	*Corvus corax*	7,119	6,653	5,987	5,535	4,519
Greylag Goose	*Anser anser*	35,348	37,657	41,028	37,623	33,901
Pink-footed Goose	*Anser brachyrhynchus*	10,695	12,182	14,639	15,330	13,614
White-fronted Goose	*Anser albifrons*	3,237	2,947	3,185	3,245	3,285
Barnacle Goose	*Branta leucopsis*	1,876	1,619	2,619	2,282	1,362
Mallard	*Anas platyrhynchos*	9,881	11,467	10,575	10,957	9,155
Teal	*Anas crecca*	1,033	1,377	1,207	1,095	1,160
Wigeon	*Anas penelope*	684	704	626	666	805
Scaup	*Aythya marila*	101	173	232	86	183
Tufted Duck	*Aythya fuligula*	126	70	158	196	463
Long Tailed Duck	*Clangula hyemalis*	2,022	1,860	1,510	1,496	1,806
Red-Breasted Merganser	*Mergus serrator*	488	757	672	665	543
Glaucous Gull	*Larus hyperboreus*	3,942	4,546	3,771	3,187	5,496
Black Headed Gull	*Larus ridibundus*	2,958	2,696	2,853	2,306	1,908
Kittiwake	*Rissa tridactyla*	1,371	1,461	2,324	1,413	1,596
Cormorant	*Phalacrocorax carbo*	2,550	2,975	2,678	1,890	1,627
Shag	*Phalacrocorax aristotelis*	5,128	6,499	4,410	2,253	2,237
Fulmar	*Fulmarus glacialis*	8,059	8,920	10,093	8,937	7,560
Razorbill	*Alca torda*	18,461	27,573	20,708	25,113	27,565
Common Guillemot	*Uria aalge*	52,747	65,099	59,031	65,378	58,990
Brünnich's Guillemot	*Uria lomvia*	15,114	20,479	15,339	18,294	21,635
Black Guillemot	*Cepphus grylle*	3,424	4,077	3,932	3,817	4,821
Puffin	*Fratercula arctica*	215,517	232,936	184,664	159,700	126,197
Rock Ptarmigan	*Lagopus mutus*	123,349	157,900	165,337	158,223	149,301
Arctic Skua	*Stercorarius parasiticus*	2,617	2,292	1993	1,752	1,287
Arctic Fox	*Alopex lagopus*	3,677	3,535	3,927	4,509	4,811
Mink	*Mustela vison*	6,341	6,693	7,995	7,769	7,673
Reindeer	*Rangifer tarandus*	329	359	260	300	401
Gannet (young only)	*Sula bassana*	707	994	636	686	433

Icelandic Central Highlands contains one of the few remaining large wilderness areas in Europe. The area is unique in many ways, characterised by glaciers, volcanoes, hot springs, lava fields and barren sands, with a few scattered oases of vegetation, wetlands and bird-breeding and moulting grounds. The popularity of hiking and eco-tourism is increasing in the area, as are revenues from tourism in Iceland.

Biotechnology is a growing field founded on biological diversity and genetic resources. Thermophilic bacteria and fish are examples of groups currently being studied for the purpose of industrial production of natural products such as enzymes and pharmaceuticals.

Physical planning has been strengthened by new legislation and environmental consideration is now a much more prominent factor in the planning process. Another important tool for implementation of environmental protection has been the Environmental Impact Assessment Act of 1993, which increased environmental awareness in the decision-making processes. A new act on Environmental Impact Assessment entered into force in June 2000.

POLICY FRAMEWORK AND INSTITUTIONAL RESPONSIBILITIES

The Ministry for the Environment is responsible for nature conservation in general and for integrating environment concerns and decision-making; for biodiversity conservation and sustainable use, both concerning ecosystems, habitat types, species and genetic resources; for wildlife management; for environmentally sound management of biotechnology; for the control of the introduction of alien species of flora and fauna, together with the Ministry of Agriculture; and lastly for land-use planning and management of land resources, including physical planning of the Central Highlands. The Ministry is also responsible for the protection of the marine environment and measures to prevent pollution. Protection of marine areas is the responsibility of the Ministry in co-operation with the Ministry of Fisheries.

Institutions under the auspices of the Ministry for the Environment and active in this field are the Nature Conservation Agency, which is responsible for nature conservation in general and the management of protected areas; the Icelandic Institute of Natural History, which is responsible for research into the natural history of Iceland in the areas of botany, zoology and geology, for monitoring and assessing the conservation value of species, habitats and ecosystems and providing advice on sustainable use and exploitation of natural resources; the Physical Planning Agency, which is responsible for physical planning and environmental impact assessments; the Food and Environment Agency, which is responsible for pollution measures and prevention; the Nature Research Station at Lake Myvatn, which does research and provides advice on the management of this protected Ramsar area; and the Wildlife Management Unit, which is responsible for wildlife management, hunting and hunting statistics.

The Ministry of Agriculture is responsible for land management for agricultural purposes, measures to combat erosion and reclaim eroded land, livestock grazing control, measures to combat deforestation and reforestation efforts, and for the management of salmon, trout and char fishing.

The agencies under the Ministry that are responsible for carrying out these tasks are the State Soil Conservation Service, which is responsible for land reclamation and actions against erosion; the State Forest Service, which is responsible for forestry and the management of forests; the Institute of Freshwater Fisheries, which is responsible for research, management and advice on freshwater fish; and the Agricultural Research Institute, which is responsible for research.

The Ministry of Fisheries is responsible for fisheries and the utilisation and conservation of commercial marine stocks, and for the conservation and utilisation of living marine resources other than marine birds.

The Ministry institutions that have an important role in this context include the Marine Research Institute, which is responsible for oceanic and fisheries research and providing advice on responsible and sustainable fisheries; and the Directorate of Fisheries, which is responsible for implementing government policy on fisheries management and the handling of seafood products as well as enforcing laws and regulations regarding fisheries management, the monitoring of fishing activities and the imposition of penalties for illegal catches.

The Ministry of Industry is responsible for industrial issues: industrial development and innovation, the harnessing, transmission and distribution of energy, energy sources, energy research and energy utilisation, district heating plants and electric plants, mines and mining, industrial rights, legalisation of professional titles in the fields of technology and design, industrial enterprises with governmental participation, and negotiations with foreign parties wishing to invest in power-intensive industry in Iceland.

Agencies under the Ministry are the National Energy Authority which is responsible for energy administration, i.e. information, advice, management and research activities, and which also carries out research, makes contracts, supervises energy research projects and monitors energy consumption in Iceland along with the Patent Office, which covers patents, trademarks and protection of designs; and the Institute of Regional Development.

Main laws concerning biodiversity conservation and utilisation

- Act on the Protection of Thingvellir of 1928

- Act on Afforestation of 1955 and 1966
- Act on Soil Conservation of 1965 and 1975
- Act on Salmon, Trout and Char Fishing of 1970
- Act on the Conservation of the Lake Mývatn and the River Laxá in Sudur-Thingeyjarsýsla of 1974
- Act on Marine Pollution Control of 1986
- Fisheries Management Act of 1990
- Act on the Héradsskógar Afforestation Project of 1991
- Act on the Icelandic Institute of Natural History and Nature Centres of 1992
- Act on Toxic and Hazardous Chemical Substances of 1988 and 1993
- Act on the Conservation, Protection and Hunting of Wild Birds and Mammals of 1994, pertaining to all wild birds and wild terrestrial mammals
- Act on the Conservation of the Bay Breidafjördur of 1995
- Act on Responsible Treatment of Commercial Marine Stocks of 1996
- Act on Physical Planning and Building of 1997
- Act on South Iceland Afforestation Project of 1997
- Act on Research and Exploitation of Subterranean Resources of 1998
- Act on Agricultural development of 1998
- Act on Regional Afforestation Projects of 1999
- Act on Nature Conservation of 1999
- Act on Environmental Impact Assessment of 2000

Some of those acts have recently been revised, either in part or as a whole.

In recent years, the concept of biological diversity has gradually been integrated into national legislation as laws and regulations have been revised and updated. The most extensive changes have been made in the field of nature conservation through amendment of the Nature Conservation Act, the Act on the Icelandic Institute of Natural History and the Act on the Conservation, Protection and Hunting of Wild Birds and Mammals, which contain provisions regarding the conservation and protection of Icelandic nature, its ecosystems, species and habitats. Biological diversity has also been integrated with legislation on fisheries, principally in the Act on the Responsible Treatment of Commercial Marine Stocks and into industrial legislation through the Act on Research and Exploitation of Subterranean Resources.

Recent legislation has taken account of the provisions of the Convention on Biological Diversity, concentrating on strengthening

the basis for implementing the Convention. It is appropriate, in this context, to mention the new Nature Conservation Act that entered force on 1 July 1999, which contains provisions regarding the import, cultivation and distribution of living organisms that aims at protecting biological diversity against the undesirable effects of alien plant and animal species in accordance with item h of Article 8 of the Convention. Regulations have been set regarding the import and cultivation of alien plant species, and a committee of experts appointed to advise the government on these matters in accordance with the provisions of the Act. The legislation also contains provisions applying to landscape features and ecological systems, such as ponds, lakes, moorlands, salt water marshlands and mud flats that enjoy special protection by law, and among other things, correspond to item d of Article 8 of the Convention, which applies to the protection of ecosystems, natural habitats and the preservation of viable populations in natural surroundings. The protection provisions of the nature conservation laws where also changed in order to strengthen the conservation and protection of organisms, habitats and ecological systems. A comprehensive Nature Conservation Strategy is to be presented to the Parliament at five-year intervals, for the first time in 2002. These plans represent full compliance with item b, Article 6 of the Convention, which discusses the plans and objectives of various sectors of society and their implementation of conservation measures and sustainable utilisation of biological diversity. In this context, it is important to consider ideas for co-ordinating these plans in connection with work on the framework plan for the exploitation of hydro and geothermal power that was initiated in 1999 by the Ministry of Industry and the Ministry of the Environment. In addition to the aspects of the nature conservation laws mentioned above, it is worthwhile citing the provisions for the commercial utilisation of plants and the authorisation to make regulations applying to this area, including information on species and the quantity utilised.

At the same time, temporary provisions have been added to the Act on Utilisation of Resources in the Earth, under the Ministry of Industry, according to Articles 15-19 of the Convention, dealing with access to the thermophilic micro-organisms found in hot springs and their exploitation. These provisions are currently under review by the Ministry for the Environment and the Ministry of Industry, which are preparing legislation that will apply to genetic resources, access to them, information exchange, technology transfer and the division of profits from their exploitation in accordance with the Convention. By law, authorisation is required from the Institute of Natural History in order to export samples of these micro-organisms and to monitor

Figure 8. Birch woodland mixed with willows in Skaftafell National Park, with the highest peak in Iceland Hvannadalshnjúkur in the background.

research into micro-organisms from geothermal areas and their genetic material.

Other recent Acts cover nature conservation as an integral part of other activities, stressing that attention must be given to nature in other contexts as well, such as the new Act on Physical Planning and Building where it is clearly stated that the Act shall contribute to wise and economic use of the land and its resources, ensure the conservation of nature and the cultural heritage and prevent environmental damage and overexploitation, with sustainable development as one of its goals.

The objective of the Fisheries Management Act is to promote the conservation and efficient utilisation of marine stocks and thus ensure stable employment and settlement in the country. It covers marine animals and plants, harvested or likely to be harvested, within Icelandic waters.

The objective of the Act on Afforestation is to combat deforestation by conserving and managing forest remnants in the country, and by encouraging afforestation where practicable. The goal of the Act on Soil Conservation is to combat soil erosion, destruction of the vegetation cover, and to reclaim eroded land. Both of these acts were adopted before the Convention and understandably do not mention conservation of biological diversity or emphasise re-establishing earlier or lost habitats or ecosystems. They are on the other hand both under revision and these issues will be considered in that process.

In 1997, the Icelandic Government adopted an Action Plan on Sustainable Development in force until the end of 2000, following a

strategic plan on Sustainable Development of 1993, "Towards Sustainable Development." The Action Plan is an important tool for ensuring sustainable development. Biological diversity was not addressed as a separate issue but rather as an integral part of sectoral activities. The Action Plan is currently being revised, with special attention being given to biological diversity and nature conservation.

NATURE CONSERVATION

Conservation of biological diversity on land depends primarily on the Nature Conservation Act, the establishment of protected areas and the possibilities the Act provides for habitat, species and ecosystem protection. In addition it rests on other legislative measures such as, the Physical Planning Act, the Environmental Impact Assessment Act and the Act on Protection, Conservation and Hunting of Wild Birds and Wild Mammals. The 85 protected areas in the country include some of the most important areas for conservation of biodiversity, but according to the distribution of species on the Icelandic red data lists, a number of other areas need to be protected in order to better secure conservation of threatened species and biological diversity. Some of these areas are listed on the Nature Conservation Registry as sites of considerable conservation value, but still remain to be protected. Currently, one new National Parks is being prepared covering the whole of the glacier Vatnajökull along with certain adjacent areas extending over some 8,000 km^2. Protection of marine areas has been based on responsible management of the utilisation of marine resources through establishment of annual Total Allowable Catches (TAC), area closures, various technical measures and rules regarding fishing gear. The first marine area that has been protected in accordance with the Nature Conservation Act was established in order to conserve and protect geothermal formations at a depth of 40 meters in the fjord Eyjafjördur in the northern part of the country.

Number and size of areas protected.

Protected areas	Number	Area, ha
National parks	3	188,705
Nature reserves	35	224,629
Natural monuments	32	28,926
Country parks	11	39,388
Special protection	4	732,015
Total	**85**	**1,213,663**

The amendment of the Nature Conservation Act in 1999 marked a fundamental change in nature conservation work in Iceland in a number of ways. First of all, the Minister for the Environment is required to prepare and submit to Parliament a Nature Conservation Strategy that shall be updated regularly. The first strategy is now being prepared and will be introduced in Parliament in the year 2002. This strategy will emphasis the preservation of biological diversity,

particularly through a better system of protected areas, the protection of endangered species, habitat types and ecosystems, and subsequently, the necessary management plans for threatened species and protected areas. Criteria and indicators for this work are being investigated and developed by the Icelandic Institute of Natural History and the Nature Conservation Agency.

In recent years, genetic resources in Iceland have attracted considerable interest from researchers and bioprospectors, especially the thermophilic bacteria that inhabit numerous hot springs in geothermal areas.

With regard to flora, over-harvesting has caused serious losses, while the impact of soil erosion and habitat destruction due to various causes threaten biodiversity. Currently 11-25% of native plants have been red-listed. Introduction and uncontrolled use of alien species

Classification of red-listed birds and plants according to the Icelandic Institute of Natural History.

	Birds	Plants	Lichens	Mosses	Algae
Extinct	1				
Extinct in the wild	2	1			1
Critically endangered	6	10	11	5	13
Endangered	5	9	17	12	
Vulnerable	15	18	10	27	28
Lower risk	3	10		14	
Data deficient			20	16	
Number of species total	76	485	580	585	238
Number of species evaluated	76	485	270	450	238
Number of species red-listed	32	52	67	74	42
% red-listed	42	11	25	16	18

poses a moderate but increasing threat to both flora and fauna. This applies, in particular, to freshwater fishing and, to a less extent, to some imported tree species and the seeding of land with lupins to combat erosion. All imports of alien species are now prohibited by law, but exemptions for import and cultivation can be granted by the Ministry for the Environment and the Ministry of Agriculture. Imports and use of alien species require the approval of a committee of specialists recently established by the Ministry for the Environment. This committee is responsible for setting up a list of alien plant species whose importation to Iceland is prohibited, and a second list of alien plant species that may be cultivated and distributed. All imports must be registered by the Icelandic Institute of Natural History.

Implementation

The Ministry for the Environment is responsible for the conservation and protection of nature. Agencies of the Ministry working in this field are the Nature Conservation Agency, the Icelandic Institute of Natural History, the Wildlife Management Unit,

and the Lake Mývatn Research Station. The Soil Conservation Service and the State Forest Service under the Ministry of Agriculture also have responsibilities in this field. Ministry of Fisheries and the Marine Research Institute, under the ministry, are also responsible for nature conservation in the marine environment.

CASE STUDY

INITIATION OF WETLAND RESTORATION IN ICELAND

Extensive drainage of wetlands occurred in Iceland in the period 1945 - 1985. In the lowlands only a few areas remain intact. With recent changes in agriculture some of the drained areas have fallen out of use. In 1996 an effort was started by the Ministry of Agriculture to restore some of the drained wetlands. In this paper operations at two of the sites are described and first results presented. At Hestur in SW Iceland a 35 ha sloping mire, drained in 1977, was selected as an experimental site for the project. In the summer of 1996 water table was monitored and vegetation cover and composition studied in the mire. The area was rewetted in October of 1996 by filling in the drainage ditches with the former excavated peat. Monitoring of water table was continued at the site in 1997. The blocking of the ditches led to a considerable elevation of the water table. In the summer of 1996 the water table was generally in the range of 20 - 100 cm below surface and fell down to 160 cm in the driest parts of the mire. In 1997 the water table was, on the other hand, within 40 cm of the surface over most of the mire area and did not fall below 90 cm in the driest parts. *Carex nigra* was the dominant species in the vegetation of the mire in 1996. It had not been greatly affected by the drainage. Several other wetland species remain in low abundance in the vegetation. They will probably respond to the elevated water table and increase their abundance again. Grass species that gained abundance following the drainage of the mire are likely to decline.

At Kolavatn in southern Iceland a 7 ha, shallow, drained lake in a mire area was restored. A 40 m long outlet from the lake to a drainage ditch was filled with soil material in early July 1997. The water level rose consistently over the summer and in early October the lake basin was full. By that time waterfowl had started to visit the lake. The site was not frequented by waterfowl before the restoration and overall birdlife was poor. Conditions for wetland restoration in Iceland are considered favorable as most of the drained mires have not been intensively cultivated or excavated. They still have semi-natural vegetation that is relatively rich in wetland species. In most cases establishment of suitable hydrological conditions should be sufficient in restoration of mires and other wetland areas.

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CENTRAL HIGHLANDS

The Icelandic Central Highlands are one of the few remaining large wilderness areas in Europe. The area is unique in many ways: characterised by glaciers, volcanoes, hot springs, lava fields and barren sands, with a few scattered oases of vegetation and bird-breeding grounds. There is growing pressure for development of the highlands,

Figure 9. Numerous waterfalls in and at the borders of the Highlands are popular tourist attractions and easily assessible while it may take some hiking to see others, such as Háifoss.

especially from the energy sector (construction of dams and hydro and geothermal plants) and tourism (construction of roads and tourist facilities). Efforts are being made to integrate these demands with nature conservation, under the leadership of a planning committee appointed by the Ministry for the Environment. The task has been complicated by legal uncertainties about the ownership of the highlands and utility rights. In order to clarify this uncertainties the Prime Minister has, in accordance with new act on the interior, established a special Committee for the Interior which has three main objectives to examine and rule on which land constitutes public lands, and where their boundaries with private lands lie, to rule on the boundaries of any part of public land which is utilised as an upland range and to rule on proprietary rights within public lands. Some of

the most unique geological and biological regions of the highlands have been designated protected areas, but a number of areas are still on the list of sites of special conservation interest.

In 1999, the Minister for the Environment approved a Regional Plan for the Central Highlands of Iceland, drawn up by the planning committee. The Plan covers approximately 40% of the total area of Iceland, or more than 40,000 km^2.

The chief aim of the Regional Plan is to co-ordinate natural resources and land use in a sustainable way. One of the main reasons for implementing the Plan is the increasing amount of building and construction being done in the Highlands.

The Regional Plan deals with the following issues:

- Protected areas, areas of natural beauty and significance, and historic sites
- Traditional utilisation, such as grazing, fishing and hunting
- Energy resources
- Tourism and recreation
- Transportation, in particular development of the road system
- Pollution

A biophysical inventory and analysis of the Highlands was carried out, and the area was classified into homogenous landscape units. These units were chompared according to value and the suitability of land for various uses. The Regional Plan is based chiefly on existing data and was prepared in close collaboration with a large group of scientists, institutions and individuals.

The main concept of the Plan is to limit building and construction to specified zones, in order to combine such activities as power generation, development of tourist services and road building and leave as much untouched nature as possible. The Plan allows for some hydroelectric plants, but no geothermal power plants, at least for the time being. Roads across the Highlands are to be kept to the minimum sufficient for summer traffic. Service centres for tourists are to be located primarily at the periphery of the Highlands, although there will also be smaller centres within the Highlands.

The Regional Plan sets the framework which municipal and local plans for the Central Highlands must adhere to. According to the Planning and Building Act, the Minister for the Environment shall appoint, after each general municipal election, a joint committee for the Central Highlands. The committee's role is to ensure that municipal plans in the region conform to each other and are coordinated with the regional plan. It also assesses whether certain aspects of the Regional Plan need to be amended, or whether the Plan as a whole should be reviewed.

Implementation

The Ministry for the Environment is the main governmental body responsible for implementation of the Regional Plan for the Central Highlands, along with the Central Highlands Planning Committee, the State Planning Agency and the regional governments in the area.

CASE STUDY

BENTHIC INVERTEBRATES OF ICELANDIC WATERS – BIOICE

The BIOICE program, commencing in 1992, is a collaborative research on marine benthic fauna around Iceland. Icelandic and Nordic institutes and universities are the main contributors to BIOICE together with many taxonomists around the world. With the BIOICE program research on Icelandic invertebrates has increased considerably resulting in substantial addition to our knowledge on the marine benthic fauna around Iceland.

More than 1000 samples have been collected around Iceland in thirteen BIOICE cruises (1992-1997) from 20 meters depth down to 2400 meters depth. Around fifty scientists and students from ten different countries have taken part in the sampling process. In the Village of Sandgerði (50 km west of Reykjavík) the BIOICE project has a special laboratory, Sandgerði Marine Center (SMC), where qualified technicians sort animals from the samples into sixty major taxa.

The BIOICE program is a base line study on the inventory of benthic fauna within the Icelandic territorial waters. The main objective of BIOICE is to revise the systematic of the marine invertebrates in these waters and to update their taxonomy. A cooperation between experts of various taxa within the international community is the best way to achieve this tremendous task. Accordingly the rich BIOICE material is now being identified by over seventy specialists from fifteen countries around the world.

Information on species identified within a sample together with data on environmental parameters on each sampling location is recorded in a database. This data will be the foundation to analysis on:

- species distribution patterns
- biodiversity
- benthic community structure
- possible effects of fishing activities on benthic communities
- tropic relations of benthos and fish stocks

Moreover, this data can aid future evaluation of possible faunal alteration due to climatic changes.

During the period 1992-1997, sampling has been carried out on three research vessels in thirteen expeditions. A total of 1049 samples from 347 locations have been sampled so far and around fifty scientists and students from ten different countries have taken part in the sampling process.

The Sandgerði Marine Centre (SMC) was established in October 1992. The main function of the station is to serve as a sorting centre for the BIOICE programme and to provide facilities for visiting specialists working on BIOICE material. At SMC benthic invertebrates are sorted into about sixty major taxa and their abundance estimated. At present three specialists and eleven technicians are working at the station.

In order to identify the BIOICE material to species level requests have been made to about seventy specialists. Most of them have already started the work. About 1800 samples are now being analysed of which 600 samples are being identified by Icelandic scientists. So far around 1250 species have been identified from the BIOICE material. A considerable part of the species is new to the Icelandic fauna and some are new to science.

The BIOICE programme is administrated by the Icelandic Ministry for the Environment in co-operation with Icelandic and Scandinavian research institutes.

MARINE RESOURCES

Marine resources are the most important natural resources in Iceland and the driving force behind economic development. Sustainable use of marine resources is therefore essential. The marine ecosystem is complex and interactive, and Icelanders are well aware that it is crucial not to disrupt the overall balance in the system and to conserve marine biological diversity. In order to pursue this priority objective, fisheries management is directed at sustainable harvesting of marine resources. Measures are taken to ensure that individual stocks are not over exploited.

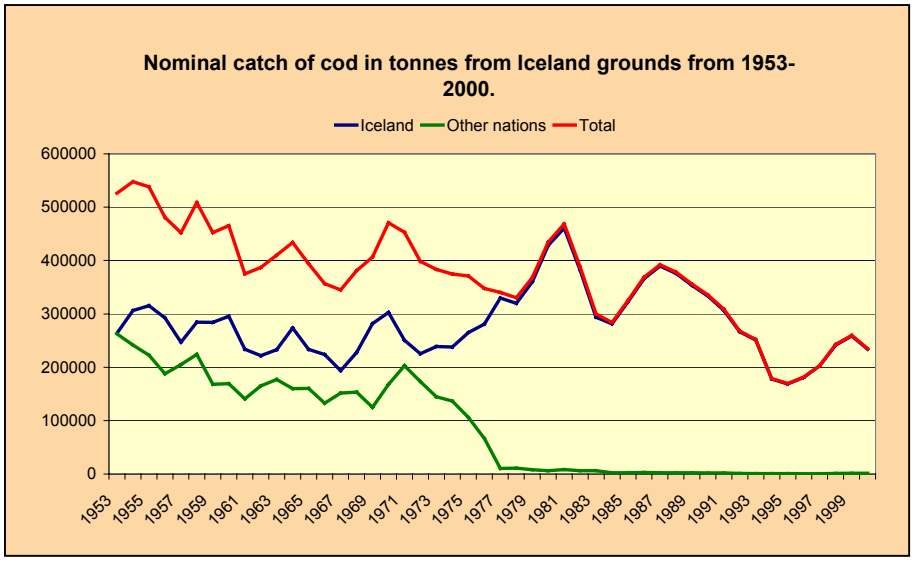
An important step towards sustainable harvesting and conservation of biological diversity is multi-species management of stocks. This has already been practised in several areas where dynamic relations between the stocks concerned have been investigated. However, for a general application of this approach, wide-ranging knowledge of the interrelationships between different parts of the ecosystem is required. In order to meet this requirement, an extensive long-term, multi-disciplinary research project has been launched, which will form an important basis for future management. Methods of applying the principles of the Ecosystem Approach are also being investigated. In the meantime, Icelandic authorities have and will continue to exercise a cautious approach towards harvesting of all stocks of fish, marine mammals and invertebrates. A vital consideration is to avoid overexploitation of the principal elements of the ecosystem.

Sustainable use

Implementation of effective fisheries management is based on scientific monitoring of stocks and environmental conditions. A system of individual transferable quotas and catch control rules has been developed in Iceland, which aims at harvesting stocks in the most responsible manner in order to ensure and maintain maximum long-term productivity.

In 1983, it became apparent that effort limitations, which had been in force since 1973, had not proved successful, and the cod stock was

in decline. The catch that year dropped to 294,000 tons from 462,000 tons in 1981. After marine biologists recommended a drastic cut in the cod catch for 1984 and subsequent years in order to allow the stock to recover, it was decided to adopt a system of transferable quotas for



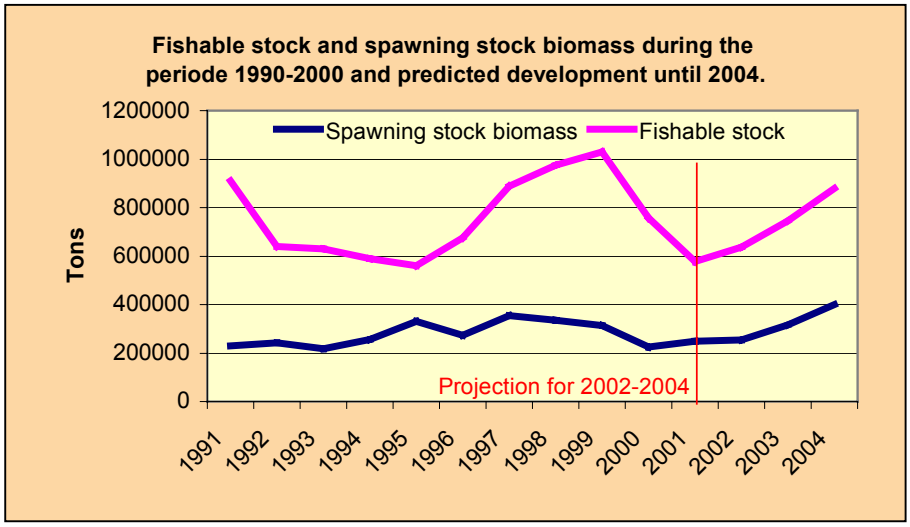
individual vessels (ITQ), based on each ship's catch performance over the period 1981-1983. The vessel quota management system had the twin objectives of limiting total catch and encouraging more efficient fisheries operations through the transfer of fishing rights among vessels, leading to a more rapid reduction in the fishing fleet. This management system has undergone a number of reforms since its introduction, in order to rectify or eliminate various shortcomings which have delayed the achievement of its objectives.

Every vessel with a commercial fisheries permit has been allocated a permanent "quota share," a percentage of the Total Allowable Catch (TAC) of all regulated species, which include all the main species that are utilised commercially. Currently the TAC of the main species in each fisheries year is set by the Minister of Fisheries. The TAC decision is based on recommendations from the Marine Research Institute. These recommendations are also submitted to the Advisory Committee on Fisheries Management of the International Council for the Exploration of the Sea (ICES) for comment.

The species subject to quota regulation are cod, haddock, saithe (pollock), redfish (ocean perch), Greenland halibut, plaice, nephrops (Norway lobster), shrimp, scallop, herring, capelin, wolffish and witch. In addition to the ITQ system which, along with the TAC decision is the cornerstone of Iceland's fisheries management, there are a number of other measures aimed at supporting the management system. Among them is the rule that for every new vessel added to the fisheries fleet, vessels adding up to the same number of metric tons have to be retired. There are rules concerning the type of fishing gear

permitted, e.g. the minimum mesh size. For example, in the cod fishery, the cod end minimum mesh size is 155 mm, the largest anywhere. Fishing with trawls is prohibited in large areas near the coast that serve as spawning and nursery areas. For shrimp fishing, sorting grids are required to prevent catches of juvenile fish. In addition, extensive provision is made for temporary closures of fishing areas to protect spawning fish from all fisheries. Other provisions give the Marine Research Institute the authority to close fishing areas temporarily without prior notice if the proportion of small fish in the catch exceeds certain limits.

The quota system has served adequately in keeping the total catch within previously determined limits. The actual total catch is closely monitored. With a few minor exceptions, all catches are landed in Iceland, and some 97% of the total catch is exported. The most important achievement in recent years has undoubtedly been the protection of the cod stock, the most important of the Icelandic commercial stocks. After 1990, the annual cod catch had to be reduced year after year, from 300-400 thousand tons, to less than 170 thousand tons. As a result of these reductions, however, it has been possible to increase the TAC for cod for the last five years. Although resent measurements indicate decrease in stock size for the TAC for 2001 is around 200 thousand tons without upsetting the recovery of the stock in the future.



At present the size of the fishable cod stock is around 577 thousand tons, and the objective is to let it increase to 880 thousand tons by 2004. As far as the Icelandic herring and capelin stocks are concerned, an informal rule has been followed for a number of years to manage these stocks, but the goal is to develop comparable formal catch rules for these and other species.

With regard to marine mammals, the policy of the Government of Iceland is that marine mammals should be conserved and managed in

a sustainable way subject to the same principle of rational utilisation that applies to other species of living marine resources.

Ensuring the sustainable use of marine living resources

In order to better ensure sustainable use of marine resources a committee has been entrusted with the task of making recommendations to the Ministry of Fisheries for improved handling of marine resources. Its main tasks are to promote improved utilisation of resources, and to minimise by-catch and discarding of catches. The committee consists of representatives from the fishery sector, the Ministry and its institutions. In the spring of 1996, new legislation was adopted by the Icelandic Parliament concerning responsible treatment of commercial marine stocks. It clearly specifies which actions are permissible and which are not. Abusive practices such as discarding fish, avoiding weighing of catch or fishing in excess of quotas will not be tolerated. There are clear provisions in the law concerning the responsibility of all parties involved.

Given the Icelandic economy's high dependence on fisheries and exports of seafood the sustainable harvesting of fish and other living marine resources is an economic as well as environmental priority in Iceland. The danger of overexploitation has been illustrated by recent examples of the decline or collapse of important fish stocks in some places. Dwindling stocks of cod and some other important species in Icelandic waters have resulted in the imposition of a strict quota system, limiting and enforcing the total allowable catch. It is hoped that recent international agreements on limiting the total allowable catch of such straddling fish stocks as the Atlantic herring and ocean redfish will keep them from being over-harvested. Iceland considers that it has the right to harvest all living marine resources, including marine mammals, provided that such harvesting is done in a sustainable manner.

In recent years, the main task of the authorities and scientists has changed from that of assisting fishermen in seeking new fishing grounds or new species to exploit, to that of setting up a series of restrictions designed to ensure long-term sustainable utilisation of stocks. Special emphasis is placed on augmenting scientific knowledge of the marine ecosystem and the biota of living marine resources.

Implementation

The Ministry of Fisheries is responsible for the management of Icelandic fisheries and the implementation of legislation applying to

this sector. The agencies responsible for implementation include the Marine Research Institute, the Centre for Scientific Research on Marine Resources, which is responsible for recommending annual TAC for the stocks subject to catch restrictions; the Directorate of Fisheries; and the Coast Guard, which is responsible for ensuring compliance with the Fisheries Management Act. Non-governmental partners include fishermen's associations and the fisheries industry.

CASE STUDY

NATIVE BIRCH WOODS IN ICELAND

Sub-Arctic birch woodlands and shrub dominated by (*Betula pubescens* Ehrh. var. *pumila* (L.) Govaerts) are the only indigenous woodland types in Iceland. Similar birch woods form the tree line in South Greenland, Scandinavia and the Kola Peninsula of North Russia.

Natural birch woods exist in Iceland from sea level to 300-550 meters altitude and about 28 thousand km^2 (28% of the land area) are within the climatic species limit of the birch. However, not all of this land may have sustained birch woods or scrub at the time of human settlement in 9^{th} century AD due to unsuitable soil conditions, such as wetlands and young lava fields or owing to frequent disturbance such as on glaciofluvial outwash plains. Taking this into account the birch woods and scrub may have covered about 20 thousand km^2 at the time of settlement.

The present area of natural birch woods is only 1,2 thousand km^2. Most of the original woodland cover was lost due to clearing of the woods for pasture and hay fields, overgrazing, and overexploitation for firewood and charcoal. Locally, and to a lesser extent, volcanic eruptions, catastrophic floods in glacial rivers and glacial advance during the Little Ice Age has contributed to the deforestation.

Birch trees may reach 8-13 metres in height at sheltered edaphically favourable sites, but only 1,7% of the birch woods are with taller trees than 8 m. Most (80%) of the present woodland area is covered by birch scrub less than 2 metres tall.

Birch is almost the only tree species in most native woodlands and scrub, but rowan (*Sorbus aquiparia*) and aspen (*Populus tremula*) are occasionally found among the birches. Tea-leaved willow (*Salix phylicifolia*), *S. lanata* and prostrate juniper (*Juniperus communis*) are common shrubs in birch woodlands.

The birch woods still retain most of their original biodiversity, while the deforested land has suffered degradation and has in some cases been reduced to deserts. The birch woods are home to a number of red listed species and the ancient native birch woodlands and scrub are key areas of terrestrial biodiversity in Iceland.

Harvesting of wood has been on a small scale and regulated for almost a century. Grazing of livestock, sheep in particular, has been the main threat to the birch woods and the principal obstacle to their expansion. Grazing pressure is declining and the main threat to the birch woodlands is now invasion of exotic tree species, conversion to conifer plantations, and development for recreation.

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AGRICULTURE

Agriculture in Iceland is mainly based on animal husbandry, chiefly old local breeds of sheep, dairy cattle and horses. Large scale poultry and pig farming are increasing. There is a long tradition of growing vegetables in greenhouses heated by geothermal energy. Approximately 1.3% of the country has been cultivated, mainly for hay production. During the summer, sheep and to some extent horses, use most of the country for grazing. Grazing pressure on uncultivated land has affected the vegetative cover and changed the species composition in many areas, and it has in that way influenced the biological diversity of grazing lands.

Changes in land use over 25 years shown in km^2.

	1970	1980	1995
Arable land and land under permanent crops	1,205	1,330	1,365
Land under permanent meadows and pastures	18,795	17,670	17,635
Land under mixed forests	1,250	1,325	1,445
Built-up and related land	800	1,100	1,353

The isolation of the country, as well as strict regulations and enforcement concerning the importation of animals to Iceland, which are intended to prevent the accidental introduction of animal diseases, has largely prevented genetic mixing of Icelandic farm races. In recent years, it was realised that these races possess certain qualities that need to be preserved and protected as a constituent of biological diversity. Under the auspices of the Ministry of Agriculture conservation measures have been initiated to monitor and ensure preservation of the indigenous breeds found in the country. Beside the three main domestic species these measures also include the preservation of the last remnants of the Icelandic poultry, the dog and goat, along with valuable phenotypes in indigenous sheep, cattle and horse breeds. Conservation of domestic animal genetic resources is directed through a committee under the Ministry of Agriculture. The work is closely linked to the Nordic Genebank on domestic animals (NGH), a regional institute under the auspicies of the Nordic Council of Ministers. Work on the conservation and sustainable use of plant genetic resources is likewise carried out in Nordic cooperation. The Nordic Genebank for plants in agriculture and horticulture was

established in 1979. Icelandic cooperationin international work such as within FAO in these fields are slosely linked to these institutions.

Fur-farming has been practised since the early 1930's first using imported American mink and later also a cultivated variety of the arctic fox originating from Greenland, Canada, the USA and Norway, as well as a variety of the red fox called silver fox. These species pose a moderate threat to the Icelandic population of arctic fox, while the mink affects the distribution and breeding of birds.

The current Government Agricultural Policy goal is that all Icelandic agriculture meet the requirements of sustainable development, in particular with respect to soil erosion and other measures to prevent the deterioration of land conditions, water and ground water pollution.

Measures are being planned to restrict livestock grazing to areas where it does not cause deterioration in the quality of the land, and the government has encouraged more conservative land-use by providing financial assistance and guidance. Other governmental activities include afforestation and the use of indigenous know-how and technology transfer. The legal and policy instruments used by the Government to combat desertification are the Soil Conservation Law (1965) and periodic National Soil Conservation Strategies, which are both currently under review. The Government intends to bring soil erosion under control and achieve sustainable land use as soon as possible. Landowners, institutions, enterprises, and society as a whole share responsibility for implementation. The soil conservation authorities, mainly the Icelandic Soil Conservation Service, will be given stronger authority to manage and monitor grazing practices, protect areas threatened by erosion and restore denuded land.

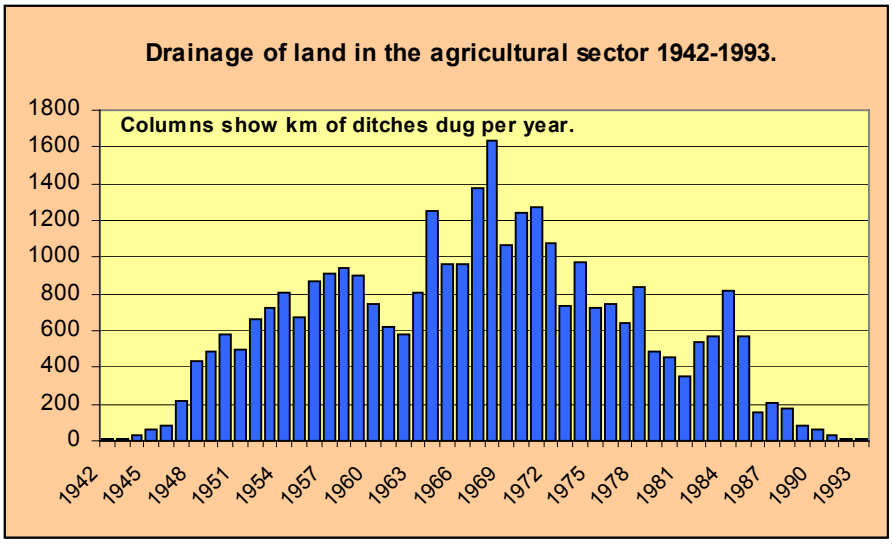
The future goal is to make all grazing and other agricultural land-use sustainable. To achieve this goal, surveillance of grazing lands will be improved, and grazing periods and grazing pressure reconsidered and better controlled. Plant diversity and abundance is greatly affected by grazing, and in some areas, species with low tolerance to grazing have become rare or are disappearing from certain types of ecosystems. In order to speed up the re-vegetation of eroded grazing-land, the Soil Conservation Service has co-operated with farmers since 1990 on better land-use and recuperation of vegetation. These measures, along with reductions in grazing have had a major influence on the biological diversity of selected areas.

In its restoration work the State Soil Conservation Service has used several plant species both indigenous and introduced. The main indigenous species used is the lyme grass (Elymus arenarius), but methodology in the use of willow and birch are being developed. Seed

production of grasses has been developed and indigenous and introduced species are grown for seed production. The Nootka lupin (Lupinus nootkatensins), imported from Alaska in 1940's, has been increasingly used for restoration work. The lupin is aggressive in most Icelandic ecosystems, forms dense patches and can dominate other vegetation for as long as 15-35 years, greatly reducing species richness. When the lupin retreats, species of grasses and mosses colonise the areas. The lupin is an effective plant for land reclamation, especially on large areas of barren land, but strict management guidelines are needed for future use of this species.

Drainage of wetlands

As a result of major drainage and cultivation of wetlands, there are only a few undisturbed wetlands left in the lowlands, which affects the flora and fauna in these areas. After the Second World War, extensive



programmes, subsidised by the authorities, were initiated to drain and cultivate wetlands, and over a period of 50 years, more than 31,663 km of ditches were dug, draining approximately 10,000 km^2 of wetlands, at least 60-75% of all lowland wetland areas and even more in certain areas of the country.

Today, the draining of wetlands has been virtually halted, but if draining of pristine wetlands is permitted, usually through the process of Environmental Impact Assessment, it has to be mitigated by restoration of drained wetlands.

Implementation

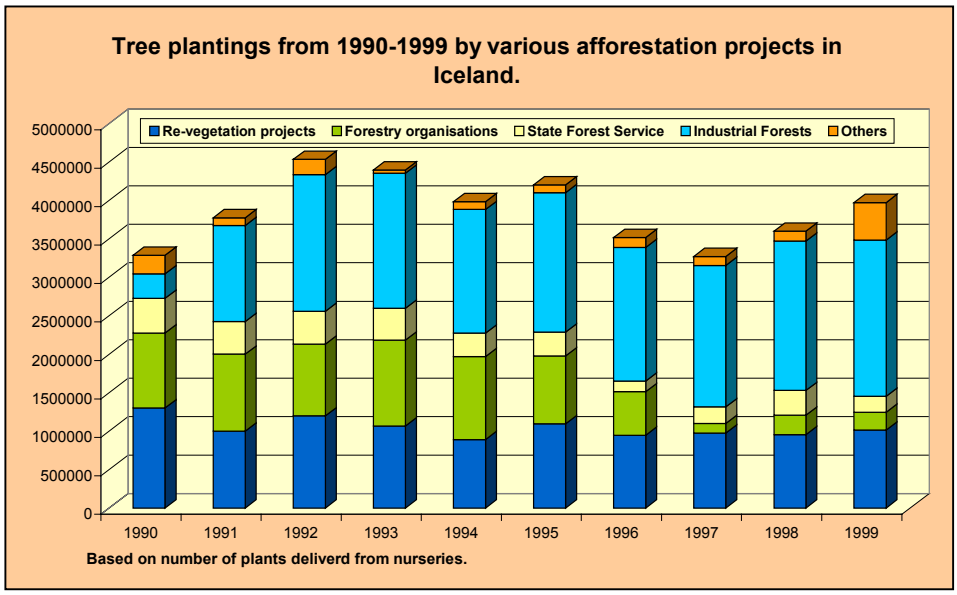
The Ministry of Agriculture is responsible for implementing agricultural policy and measures to manage agricultural land-use as well as soil and vegetation conservation in order to protect biological

diversity. Agencies of the Ministry working in this field are the Icelandic Soil Conservation Service and the Agricultural Research Institute. Farmers' organisations also have responsibilities in this field, along with the Nature Conservation Agency, the Icelandic Institute of Natural History and the State Planning Agency under the Ministry for the Environment.

FORESTRY

Forests in Iceland consist mainly of small areas of birch woodlands or plantations of native or exotic species, covering 1.4% of the total land area. At the time of settlement (AD 874), woodlands covered about 25-30% of Iceland, which means that 95% of the original forest cover has been lost for various reasons, such as clearing for agricultural purposes, charcoal-making, grazing and erosion. Native woodlands have been utilised for sheep grazing throughout the centuries. The number of sheep has been declining since 1980, due to social and market forces, and the grazing of woodlands has therefore been declining as well.

The current general Forestry Act of 1955 does not contain direct reference to biodiversity but the main objectives of the act are to conserve, protect and cultivate forests and forest remnants in the country, to cultivate new forests where appropriate and to advise on forestry services. More recent forestry acts, such as the Act on Regional Afforestation Projects of 1999 and the South Iceland Afforestation Project Act of 1997 do not address biological diversity. They set a goal of afforesting at least 5% of the land area below 400 m elevation, which would translate to about 2.5% of the total land area, over the next 40 years. Approximately 1,100 ha are afforested annually



by governmental institutions and non-governmental organisations through various planting programmes. Legal environmental constraints on forestry that can be used to protect biological diversity are presently provided in the Nature Conservation Act, the Physical Planning and Building Act and the Act on Environmental Impact Assessment. Afforestation plans for areas larger than 200 ha must be reported to the State Planning Agency, which may require that an EIA be done, especially if the land in question is considered sensitive for a variety of reasons, including considerations of biodiversity.

At present, some of the most important native forest remnants have been protected. Two native forest areas were bought by the Icelandic Forest Service in the 1990s, for conservation purposes. A comprehensive study of the current status of native forests is near completion, and in coming years, more areas will be set aside for protection purposes.

State supported afforestation plans stipulate that physical area planning according to the Physical Planning and Building Act should include an assessment of conservation value and biodiversity value, and that any areas considered valuable or sensitive shall not be afforested. It is therefore a general rule that wetlands shall not be drained and used for afforestation. There is also a general objective of planning for species mixtures rather than mono-cultures in afforestation. Over 70% of afforestation has been based on alien species, such as Russian larch (*Larix sukaczewii*), lodgepole pine (*Pinus contorta*), Alaskan black cottonwood (*Populus trichocarpa*), engelman blue spruce (*Picea engelmannii*), white spruce (*Picea glauca*), norway spruce (*Picea abies*), sitka spruce (*Picea sitchensis*), lutz spruce (*Picea x lutzii*), and silver birch (*Betula pendula*).

Figure 10. Mixed woodland with native birch and imported spruce.

The number of the most common species of trees planted in Iceland from 1993 to 1999, based on number of plants delivered from plant nurseries.

Species	1993	1994	1995	1996	1997	1998	1999	Total
Downy birch (*Betula pubescens*)	887.800	846.700	923.283	782.363	873.772	935.973	1.172.670	6.422.561
Tea-leafed willow (*Salix phylicofolia*)	200	1.000			4.195	4.899	20.840	31.134
Silver birch (*Betula pendula*)	70.300	10.400	1.805	86.361	19.473	32.160	87.255	307.754
Alaskan black cottonwood (*Populus trichocarpa*)	150.300	137.700	141.984	133.299	132.464	229.795	163.424	1.088.966
Felt leaf willow (*Salix alaxensis*)	36.600	29.400	136.276	42.740	39.455	100.936	36.252	421.659
Willow species (*Salix spp.*)	59.700	69.700	67.317	79.055	56.328	35.389	80.368	447.857
Engelman blue spruce (*Picea engelmannii*)	110.200	146.000	167.783	170.211	71.724	43.590	72.645	782.153
Sitka spruce (*Picea sitchensis*)	141.400	402.300	140.479	238.834	521.801	399.381	532.101	2.376.296
Lodgepole pine (*Pinus contorta*)	503.300	763.300	1.108.028	545.386	356.312	462.250	466.008	4.204.584
Mountain pine (*Pinus mugo*)	48.200	86.200	39.948	62.860	26.244	5.481	2.310	271.243
Russian larch (*Larix sukaczewii*)	1.849.800	1.202.900	1.174.142	1.011.916	1.003.973	1.185.124	1.082.794	8.510.649
Siberian larch (*Larix sibirica*)	148.900	12.100				24.665	65.325	250.990
Larix species (*Larix sp.*)	227.900	26.900	3.175	8.100	6.794	3.723	10.367	286.959
Sitka alder (*Alnus sinuata*)	11.000	54.900	144.711	85.895	5.925	3.840	58.360	364.631
Lutz spruce (*Picea x lutzii*)	12.200	76.200	57.815	131.247	68.499	630		346.591
Other species	138.600	118.400	96.113	140.190	83.252	131.938	121.497	829.990
Total	**4.396.400**	**3.984.100**	**4.202.859**	**3.518.457**	**3.270.211**	**3.599.774**	**3.972.216**	**26.944.017**

The first regional afforestation programme was initiated in 1991 in the Eastern part of the Country with the objectives to encourage afforestation and commercial forestry in the district in an effort to ensure that the district remains populated and to stimulate local economic activity. Today the 95 farms participating in the project have planted over 11 million trees in 10,700 hectares. The act on regional afforestation projects allows the Ministry of Agriculture to initiate up to six regional afforestation projects with the objectives to cultivate forests for wood production, shelter, recreation and diverse use such as soil conservation, grazing, berry-picking and recovery of birch woodlands. Each project shall be planned for up to 40 years and be subdivided in four 10 year periods. According to surveys in the eastern part of the country 80-90% of land for forestry is classified as heather and the rest mostly as grasslands, both are usually uncultivated grazing-land close to farms. The main species that will be planted are alien species, such as sitka spruce, Russian larch, Alaskan black cottonwood, white spruce and Norwegian spruce. Planting alien tree species on 5% of land under 400 m above sea level, a total of 210,000 hectares, will affect biological diversity of the area and influence species composition and abundance.

Implementation

Under the auspices of the Ministry of Agriculture, the National Forest Service and up to six Regional Forestry Action Plans are responsible for forestry in addition to a number of NGO's working in this field. The Ministry for the Environment along with the Nature

Conservation Agency, the Icelandic Institute of Natural History and the Physical Planning Agency has also responsibilities in this area.

CASE STUDY

WHITE-TAILED SEA EAGLES IN ICELAND

Sea Eagles were formerly rather abundant in Iceland, breeding in all parts of the country. Over 160 historical nest sites are known and in the early 1800s there were probably over 150 pairs nesting. Systematic persecution of eagles was initiated in the mid-1800s and bounties were paid (mostly by eider farmers) until 1905. Accidental strychnine poisoning from fox baits became an important mortality factor from the late 1880s on. Sea Eagle numbers declined rapidly and the birds were practically wiped out, except in their main stronghold in northwestern Iceland. When the eagles were granted full legal protection in Iceland in 1913, there were probably less than 25 pairs breeding. The population remained relatively stable at 20-25 pairs from 1920-1970. In the 1970s and 1980s eagle numbers increased at an annual rate of 3.3%, from 23 pairs in 1969 to ca. 40 pairs in 1986. The ban to use poisoned fox-baits initiated in 1964 was pivotal in the partial recovery of the eagle population. In the spring 2001, 43 pairs were found of which 37 pairs are known to have bred. Unfortunately, eagles are still persecuted in Iceland; birds are shot and nests are destroyed on purpose.

Icelandic Sea Eagles reproduce at low rates; on average less than 40% of the territorial pairs raise young (data from 1964-2001). The mean production is 0.5 young/territorial pair and 1.3 young/successful pair. Most losses of egg and young appear to be associated with inclement weather during hatching of eaglets in late May and early June. Eagle young production is positively correlated with mean temperature in April and June ($r = 0.597$, $p = 0.02$, $n = 14$). Human disturbance, intentional and accidental, is also to blame for the eagles' low rate of reproduction, stemming in part from increased recreational activity. To counteract this, breeding sites are protected (a 500 m-radius from nests) and should not be entered during the breeding season without a special permit from the Ministry for the Environment.

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ENERGY RESOURCES

The river systems of Iceland are important natural resources for generating electricity, as are geothermal areas, which are also important for space heating. Hydropower potential has been estimated at 40TWh per year, and geothermal potential at about 20 TWh per year. It has been predicted that the hydropower potential might be 20-30 TWh per year when feasibility and environmental consideration have been taken into account. Only some 10-15% of this potential hydropower is utilised today, and only 7-8% of potential geothermal power is used to provide electricity. The use of hydropower can have affects on the environment and biological diversity especially in the Highlands were vegetation usually is scarce except in valleys and areas where water is present. Such areas in the Highlands can be valuable as grazing land for sheep and are in some cases also important habitats for reindeer and wild birds. These areas are therefore often the most important centres for conserving biological diversity in the Highlands. The effect of large reservoirs are a source of concern due to the fact that most of them are situated in the Central Highlands. Currently there are around 10 hydro reservoirs in the Highlands covering 200-250 km^2. Among the detected environmental impacts of such reservoirs on biological diversity are disappearance of freshwater ecosystems, disappearance of freshwater fishes in some instances and flooding of geothermal area containing thermophilic bacteria.

Other forms of impact include the disappearance or alteration of waterfalls, reduced sediment transportation in glacial rivers downstream from the reservoirs and changed conditions for fresh-water fishing. Geothermal power plants are likely to have less environmental impact than hydropower plants.

Apart from dams and reservoirs, other aspects of hydropower development can affect biodiversity, such as road and power line construction and greater accessibility for tourists to areas of the Highlands that are normally inaccessible today.

Figure 11. Hafrahvammagljúfur, one of numerous potential sites for hydro power reservoir in the Central Highlands.

Master plan for the utilisation of energy resources

Today, only a small percentage of hydro and geothermal resources have been harnessed. Further development of energy production in Iceland will have to take environmental considerations into account. The Government of Iceland has initiated the development of a Master Plan for the Utilisation of Hydro and Geothermal Energy Resources. This process will be scientifically based and open to public involvement.

A large number of proposed power projects will be evaluated and categorised on the basis of efficiency and economic profitability, as well as their affect on the economy, employment and regional development, the environment, nature and wildlife, the landscape, cultural heritage and ancient monuments, grazing and other traditional land use, outdoor life, fishing and hunting.

The Master Plan will be based on the best available scientific information. Furthermore, in order to establish public confidence in the process, public and non-governmental organisations will be informed about the findings of the experts at all stages of the evaluation process.

Implementation

The Ministry of Industry, in co-operation with the Ministry of the Environment, has established a special Steering Committee for the

development of the Master Plan. The Committee, comprised of 16 members, has been mandated to develop a proposal for a Master Plan for the use of hydro and geothermal energy resources. In its function the Steering Committee will be supported by about 50 experts from governmental agencies, non-governmental organisations, local governments and the private sector, working in four different working groups to evaluate:

- what impact proposed power projects will have on nature, landscape, geological formations, vegetative cover, flora and fauna, as well as cultural heritage,
- he impact on outdoor life, agriculture, re-vegetation, fishing in rivers and lakes, and hunting,
- the impact proposed power projects can have on economic activity, employment and regional development,

and

- identify potential power projects, both hydro and geothermal, and carry out technical as well as economic evaluation of the projects.

Two agencies, the Icelandic Institute of Natural History and the National Energy Authority, are providing the Steering Committee with scientific knowledge and research on the project, and extensive research have been carried out. An environmental non-governmental organisation has been contracted to assist in the public consultation process.