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The Vegetation and Flora of Iceland

Dr. Hörður Kristinsson, *Akureyri, Iceland*

Introduction. The youngest of all European countries is Iceland. The highest age identified in its presently accessible surface layers is 16-20 millions of years, but since the older layers have sunk below the present sea level, the real age of the country must be higher, estimated around 40 millions of years. The flora of Iceland is of special interest, because of the long distance of about 800 km, that a new flora had to move over oceans from Europe, in order to get established in Iceland in postglacial time. It is true that Greenland is much closer (300 km), but the species composition of the Icelandic flora does not indicate Greenlandic origin to any great extent.

It is the purpose of this article to draw some general outlines of interest to the vegetational history of Iceland.

Geology. The oldest rock formations in Iceland are in the extreme east and west, and consist of tertiary flood basalt layers (Miocene). The age decreases both from east and from west towards the center of the country, where most surface layers are glacial (tuff) or postglacial (lava fields). This center area, which in reality constitutes the extensions of the Mid-Atlantic ridge through the country, is characterized by parallel fissures or rifts, and by its neovolcanic activity. New lava fields are added almost every decade, the most recent additions being the new island of Surtsey (1963-1965), a lava field by Hekla (1971) and the extension of Heimaey in Vestmannaeyjar Islands (1973-1974). Postglacial lava fields cover about 1/10 of the country. The plants constantly colonize the new lava fields in a characteristic sequence, but the colonization is different in different climatic regions of the country. There are many species too, that do not distribute in to the younger regions, but remain faithful in the geologically older parts of the country.

Nobody has yet been able to give an answer to the interesting question, whether Iceland originally was formed as an island through submarine, volcanic activity in the Atlantic, or whether it was originally connected to Europe and (or) to Greenland, before it was isolated as an island. It is a possibility that the tertiary basalts, which now form the basis of Iceland, rest on older, now submerged basalts, which may have been a part of the early tertiary ridge extending from Scotland through Faroes Islands to Greenland.

More than 10% of Iceland is now covered by glaciers which have accumulated during the last 2000-3000 years because of deterioration of climate. These glaciers have retreated considerably since the turn of the century.

History of Vegetation. Sufficient plant remains have been preserved between the tertiary basalt layers to prove that a luxurious vegetation flourished in Iceland during Miocene (10-20 million years ago), just as has been demonstrated for other North Atlantic countries. The occurrence of *Sassafras* and *Magnolia* reminds one of the present vegetation of North Carolina (the southeastern United States).

After subsequent deterioration of climate during the Pliocene and a corresponding change in vegetation from deciduous to coniferous forests, all but the

hardiest plants became extinct under the Pleistocene ice cover. The plants on an island like Iceland had no opportunity to move temporarily southward to a warmer climate as they did in Europe. In the long interglacials, however, the flora was enriched again through long distance dispersal over the oceans, but this transport was restricted to a low number of species with sufficient dispersal ability. The present flora of Jan Mayen may perhaps give some idea about the species composition able to disperse over oceans in this region. It consists of about 50 species, most of which are also frequent in Iceland.

All the conifers became extinct in Iceland during the Pleistocene glaciations except *Juniperus communis*. The heavy seeds of the conifers never did reach the country and successively colonize it again, even though the climate of the interglacials and the postglacial probably was favourable to coniferous forests in Iceland. Even today, with approximatly 2° C lower temperature than in the postglacial time, conifers can tolerate the Icelandic climate. The reforestation experiments made by the Icelandic State Forestry Department have shown that *Larix sibirica* develops well in the more continental northeastern part of the country, and *Picea sitchensis*, originating from the coasts of Alaska, is a suitable tree in the oceanic south and southwest Iceland.

Deciduous trees like *Fagus*, *Corylus* and *Acer*, which all are known from the tertiary basalts, became extinct in the Pleistocene, and the present climate is too harsh for their natural reestablishment, even though certain species can be kept in the garden. *Alnus* is known from layers up to the third last interglacial, then representing as much as 70% of the tree vegetation in southeastern Iceland, judging from pollen analyses. No trace of *Alnus* is known from later interglacials, nor does it exist in Iceland now. The climatic conditions should however be good for this tree in Iceland at the present time, and it is still a part of the natural vegetation in Greenland.

The Present Woodlands. *Betula pubescens*, *Sorbus aucuparia* and *Salix phylicifolia* are the only trees present in layers from the two last interglacials in Iceland, and they are also the only natural trees of Iceland today, with the exceptions of very isolated populations of *Populus tremula*.

The birch woods reach their best developments in the relatively continental north and northeastern Iceland, where the trees reach the hight of 6-10 m. In the more oceanic regions the birch forms only scrubs of 2-4 m, and in extreme oceanic sites it usually creeps along the ground and hardly exceeds 1-3 m. Exceptions are found in oceanic areas, where glaciers form a shelter against the oceanicity, as known for some of the southern glaciers (Mýrdalsjökull, Vatnajökull). This explains the relatively favourable conditions found in Thórsmörk, and in Skaptafell National Park. The mountain ash occurs in some areas intermixed with the birch, but *Salix phylicifolia* predominates in the wetter habitats. It forms beautiful, round cushions of svereal m diameter and 2-4 m height, where protected. The *Salix* must however withstand constant cutting by the sheep and horse grazing, so that its typical growth form is seen hardly anywhere in the country doday. Without the preservation it expresses the growth form of short or creeping dwarf shrubs.

Even though the birch scrubs and woodlands represent the climax vegetation in the Icelandic lowlands, they are not prominent in the landscape. In reality the visitor drives mile after mile without seeing as much as a single tree. This is a secondary effect due to deforestation which followed the settlement of the country. Iceland was settled in the period from 874-1000, mainly from Norway and Britain.

The change in the vegetation of Iceland in the centuries after the settlement can partly be traced from the history, and has also been demonstrated by means of pollen analysis by Thorleifur Einarsson. New plant species were imported, the proportion of grasses increased, and the quantity of birch pollen dropped down. The settlers depended on wood for different purposes, and during the climatically unfavourable middle ages, they consumed it faster than it could be restored. Sheep grazing helped to prevent the regrowth, and the sensitive, deforested soil was subsequently subject to heavy erosion, which is still in effect.

But why did Iceland suffer more than other northern countries through the harsh treatment by man? Simply because it was more sensitive. One of the main reasons is the recent, volcanic origin of its soil, which is unique for northern countries. The Icelandic soil has a very weak structure, and frequent accumulation of volcanic ash further helps to reduce its resistance agains wind erosion, and also provides drifting material. This fact was a new experience for the settlers from Norway, which was only learned in several hundreds of years. No preventive measures were taken until too late, when the deforestion was already completed with quite few exceptions, where the climax vegetation can still be seen.

Reforestation experiments first started in this century, partly by using the native birch, and partly with imported tree species, like those already mentioned.

The Icelandic Fora. After having learned something about the natural history of Iceland, one will not be surprised to hear that its flora is relatively poor in species number compared with its neighbour countries in similar latitudes. The Icelandic flora counts approximately 450 species of vascular plants, including some that have been brought in by man.

Most of the Icelandic native plants are found on both sides of the Atlantic Ocean, and about 150 of these can be considered circumpolar. There is also a considerable number, about 100 species of European origin, which are lacking in North America or have been introduced there in recent time. On the other hand, species of western origin, lacking in Europe are quite few, probably less than 10. These figures are subject to some variation depending on the species concepts used.

Among the western species in Iceland are *Chamaenerion latifolium* (River Beauty), one of the most attractive decorations of the gravelly river beds, and *Carex lyngbyei*, a very productive, robust sedge with drooping spikes.

None of the generally recognized species are endemic to Iceland alone, but one, *Alchemilla faroënsis*, is endemic to Iceland and the Faroes Islands. Only quite few taxa rcognized as varieties or subspecies are endemic in Iceland, with the exception of the genus *Hieracium*.

Many species have been unintentionally imported by the activity of man. Some were probably brought in by the first settlers like *Stellaria media*, *Capsella bursa-pastoris* and *Poa annua*. Among very late invaders are *Matricaria matricarioides* (1902), and still later *Stellaria graminea*. *Matricaria matricarioides* was rapidly distributed throughout the inhabited parts of the country, probably mainly by truck wheels from the harbours to the loading places in villages and farms. *Stellaria graminea* is frequently seen around farms. Practically all the invaders are limited to the vicinity of utilized land in their distribution, but some, like *Poa annua*, have been brought widely around by the feet of the sheep, but are unable to compete with the natural vegetation outside the manured sheep tracks. No plants, which with certainty are adventive in Iceland, have managed to establish themselves in the really wild and uninfluenced tracts of the country. They are not competitive with the natural

vegetation in the nitrogen deficient Icelandic soils. *Lupinus nootkatensis* may possibly turn out to be an exception.

Alopecurus pratensis, Trifolium pratense and *Lupinus nootkatensis* are examples of plants which have intentionally been brought in by man. The two first mentioned have in some places escaped from cultivation. *Lupinus nootkatensis* has recently been imported in order to increase the nitrogen supply of many aroded gravel flats. These efforts have been successful, and the plants distribute slowly on their own by seeds. The affected plots are prominent at a distance in the landscape by their deep blue color.

Survival or Long Distance Dispersal. With the exception of the adventive plants, all members of the Icelandic flora must either have survived the Pleistocene glaciations in Iceland, or otherwise have been carried by long distance dispersal through hundreds of miles across the Atlantic Ocean. This is a fact that to many botanists seems rather unacceptable.

Opinions differ as to what extent these two possibilities were realized. One Icelandic botanist, Steindór Steindórsson, has brought together a number of arguments which support the idea that a great part of the Icelandic flora, possibly half of it, did survive the last glaciation on nunataks and exposed coastal strips. His arguments were based mainly on a characteristic distribution pattern of many plant species (*Papaver radicatum, Campanula uniflora*) which correlated to geological indications of exposed areas. The most conspicuous of these areas were the northwestern Vestfirðir-Peninsula, the mountain area around Eyjafjörður in the middle north, and the eastern fjords. All these areas have in common relatively high coastal mountains. It is clear that no other places had a better chance to escape being covered by the central glacier of Iceland moving toward the shore, than such ranges of coastal mountains. But we should not disregard the possibility that this topographic quality may also affect the present local climate and result in the same distribution pattern. Large amounts of snow tend to accumulate in these coastal mountains and their valleys, and this may explain the peculiar distribution pattern of some of the centric species (*Blechnum spicant, Athyrium distentifolium, Cornus suecica, Lycopodium dubium*).

The ideas of Steindór Steindórsson have been opposed by some authors but the basic theory, that a substantial part of the flora survived the glaciations, and that the rest of it arrived by long distance dispersal in postglacial time, is generally accepted. Opinions differ merely about the extent of survival and the extent of long distance dispersal.

In fact, if mountain slopes or some coastal areas have remained ice free, it is hard to believe that no plants were there, and besides vascular plants, there must of course have occurred a great number of mosses and lichens. Many of the hardiest plants that are now widely distributed throughout the country, like *Saxifraga caespitosa, Poa alpina, Festuca vivipara, Saxifraga oppositifolia, Salix herbacea, Luzula arcuata* and *Cerastium alpinum* certainly had very good possibilities to survive the glaciations, and some of them may of course partly be survivors and partly postglacial dispersed, too.

There are some indications that oceanic and lowland plants had a greater chance for survival in the western and eastern area, and that arctic continental species had a better chance in the middle north. Possible explanation is that the oceanic southern winds probably had better access to the two first areas during the glaciations. Before reaching the middle north they had to move a long way through the extensive glaciers of the Central Highlands.

There are still relatively large gaps in our knowledge of the distribution patterns of the Icelandic plants, and we may develop better understanding of some of the mentioned problems after they have been bridged. In order to do this a project for mapping the flora of Iceland by aid of 10 x 10 km grid has been initiated, and it is hoped that this can be completed through cooperation of all interested in the matter.

Unfortunately, botanical interests are rare in Iceland. The Icelander is by nature more geologically oriented. Visitors often make the observation that natives know every fault and ridge in the landscape by name, but their questions about the plant world remain unanswered. In fact, the country offers much more variation in geological formations, with frequent creation of new land before the eyes of the inhabitants, than it offers in its living world.

[This article was in the American Rock Garden Society Bulletin accompanied by four figures with the following text:]

Fig. 1: A protected island in the Laxá River, North Iceland, against the unprotected riverside in the background.

Fig. 2: *Chamaenerion latifolium*, the River Beauty, one of the most attractive Icelandic plants. It decorates the gravelly river beds, even up to the Central Highlands.

Fig. 3: *Alchemilla faeroënsis*, a species endemic to Iceland and the Faroes Islands. In Iceland it is limited to the eastern part of the country.

Fig. 4: A map of Iceland showing in black those areas with the highest number of "centric" species.