# Vascular plants on Surtsey, Iceland, 1991-1998

STURLA FRIDRIKSSON
Skildingatangi 2, 101 Reykjavik, Iceland

ABSTRACT

The vascular plant life on Surtsey has been studied since the first plant was discovered in 1965. The dispersal, colonization and formation of communities have been monitored during the last study period of 1991-1998.

In 1998 there had been 54 vascular plant species recorded growing on Surtsey, about 85% of which are permanent residents, Of these species 75% may have been carried to Surtsey by birds, 11% by sea and 14% by air. About 80% may have derived from the other Westman Islands.

The colonization of the dry sandy lava is slow. The plant cover had increased during the study period from 5.2% to 21.4% in a quadrat, where a sand dune had been formed. In contrast, vegetation in a sea gull colony is rapidly developing, covering 6.3 hectares, about 4% of the dryland of Surtsey. The sea gulls are bringing plant seeds and increasing the soil fertility of that area by their droppings and food wastes.

## INTRODUCTION

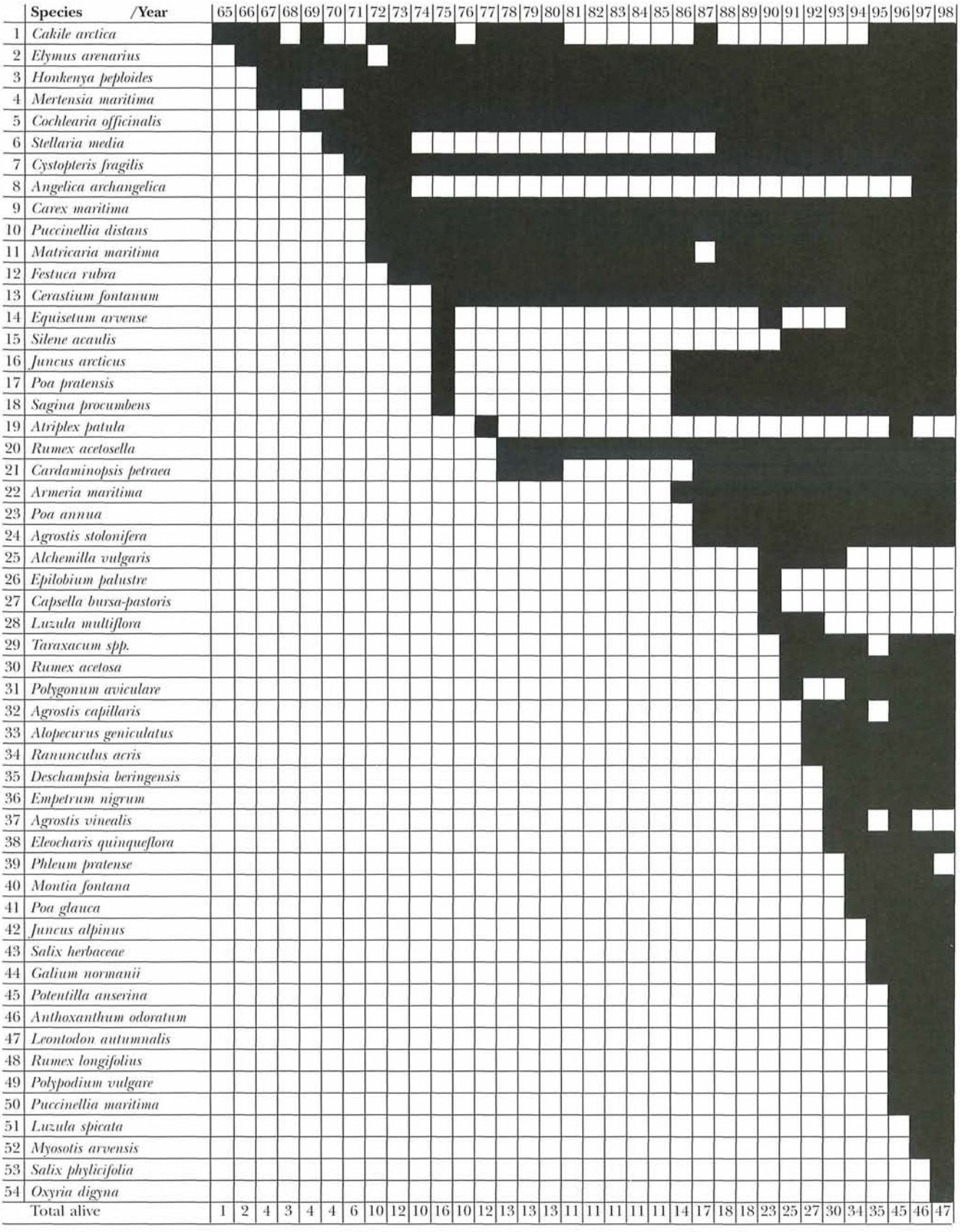
Since the first plant was discovered on Surtsey in 1965 an annual study has been made of the vascular plant life on the island. Previously reports have regularly been given of this investigation in the Surtsey Research Progress Reports. The last one covered the period 1981-1990 (Fridriksson 1992). In addition an overview in Icelandic of the Surtsey story including the plant research has been presented in a recent book (Fridriksson 1994) and also in a special publication celebrating Surtsey´s first 30 years (Jakobsson *et al.* 1993). A report on the development of the vegetation on Surtsey as studied on permanent transects and in a number of plots has been written in Icelandic with an English summary (Magnússon *et al.* 1996). Furthermore the ecological studies have been described in an international journal (Fridriksson & Magnússon 1992). Finally it may be pointed out that news about the biological expeditions to Surtsey has annually appeared in the local paper Morgunbladid.

In this article an account will be given of some facts relating to the investigation of vascular plants and their colonization on Surtsey during the years from 1991 to the summer of 1998. A separate paper covers a study of plant succession in permanent plots on the island during the same period (Magnússon & Magnússon 2000).

## RESEARCH METHODS

From the first years of the Surtsey studies attempts have been made to monitor the colonization of vascular plants using similar methods as described by Fridriksson (1992). Individual plant species new to the island were marked on

Table 1. Vascular plant species found on Surtsey during the years 1965–1998



a map and staked, but in 1978 the plants had become too numerous so that surveys were carried out to estimate the frequency and cover of the vegetation on transects or in quadrats. To document the appearance of plants and colonies a number of photographs have been taken every summer, and aerial photographs have been used to locate and map individual plants and vegetative areas. The annual expeditions have taken place after mid July and lasted for a few days, except in 1991 when the island was visited in September.

## RESULTS AND DISCUSSION

*Establishment*

It is one thing to reach a barren island, but quite another to become established and survive the unique conditions met at a sterile site, and then to go on to reproduce and become part of a new community. Considerable diversity may be found in conditions of plant growth on Surtsey. Seeds often arrive on the island, where they fall into an unfavorable habitat and do not manage to germinate or become mature plants. As conditions are relatively harsh, only the hardiest of plants have succeeded in becoming established on the frequently infertile substrate of the island.

Of all the vascular plant species that have been discovered on Surtsey, about 85% of them are permanent residents. The remaining plants have failed due to unsatisfactory conditions on the island, despite their successful arrival and first establishment. For many of them it proved impossible to occupy for any length of time the loose, dry sand, the hard lava surface or the gradually solidifying tuff. Or, as more recently, they have not withstood the rich, fertile soil and been subdued by secondary, more aggressive colonists in the newly established gull breeding area.

*Succession*

First of the vascular plants found on Surtsey in 1965 was a sea rocket (*Cakile arctica*). A year later, lymegrass (*Elymus arenarius*, also named *Leymus arenarius*) began to grow on the island. By 1967 sea sandwort (*Honkenya peploides*) joined the flora. It has since attained a widespread distribution.

A milestone was reached when the sea sandwort began to produce seed locally. At that point, the population increase of that species was no longer totally reliant upon the accidentally transported seeds. It took six years for the sea sandwort to bear seeds. But when that occurred, thousands of new plants grew annually. Now, sea sandwort has managed to distribute itself widely throughout the island's sand filled lava. It is currently the most common of all vascular plants on Surtsey.

In the thirty-five years since its formation, 54 vascular plant species have started growth on the island (Table 1). To begin with there was on the average an introduction of at least one species of vascular plants per year during the first fourteen years period. These were mostly coastal or fell-field species. During the following seven years period there was a lag in the increase as hardly any new species arrived. It looked like the first 11-14 species would for a while be dominating in the Surtsey flora. However, during the last decade a new invasion of colonists occurred, as on the average there was an annual addition of over three new vascular plant species in the flora of Surtsey. This rapid increase is brought about by the invasion of sea gulls as will be later discussed.

Pioneer species of the vascular plants, which have become established on Surtsey, also grow on the other islands, with a few exceptions. Even though the sample on Surtsey at present is only a fraction of that within the Westman Islands region, it can be said that the new island's biota is comparable to that found elsewhere in the area.

*Communities*

Indication of the first formation of plant association emerged when lymegrass and sea sandwort began in 1978 to spread over a sandy area in the east part of the island having their territories overlapping. The lymegrass had settled there as early as in 1974. The sandwort joined it later. These two species plus a lungwort (*Mertensia maritima*) have developed into a primitive, coastal community, which has been studied closely ever since it was formed. Here the sandwort serves as a pioneer plant holding the ground stratum, and lymegass grows above it, taking advantage of the moist sand media held in place by the former species. A plot (5x10 m) at this area has been measured, and a chart showing

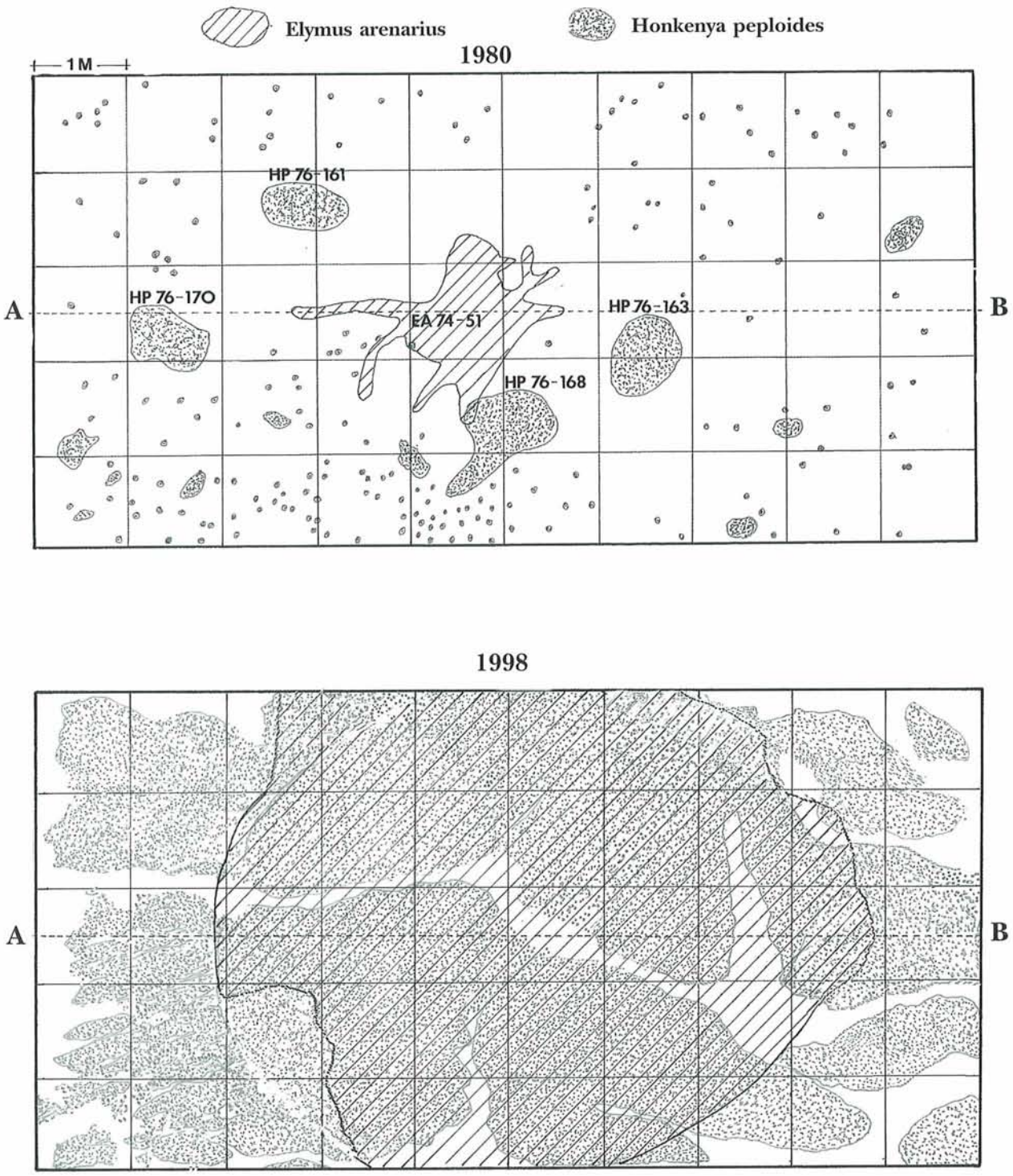



Figure 1. Distribution of two coastal plants forming a dune on Surtsey. The same study area is shown twice, first as it was in 1980 (above) and in 1998 (below). The two species, of *Elymus arenarius* and *Honkenya peploides* are now almost completely covering the plot.

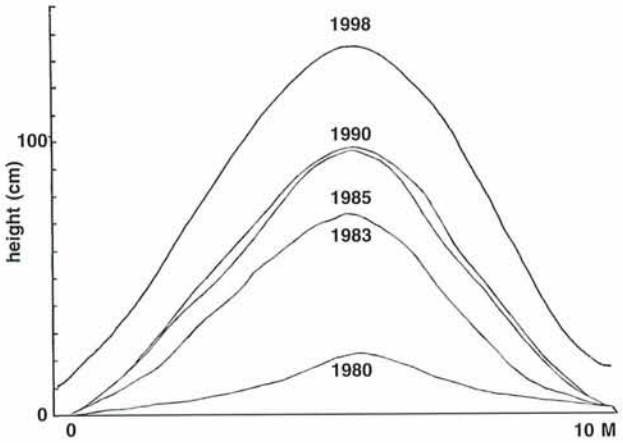



Figure 2. Transect A-B through the coastal community, shown in Fig. 1. The sand has drifted into the vegetated spot and gradually formed a dune 135 cm high.

the location of the individuals of the community has been drawn annually. Examples of the changes in development are presented here (Fig. 1).

Sand from the open beach, at this eastern side of the island, drifts to the vegetative spot, and has gradually built up a dune. This has previously been reported, but a close investigation of the formation of this sand dune has continued in the present study period. In Fig. 2 is shown how the dune has grown both in height and width. In 1998 the dune had reached the height of 135 cm, and had added 17 cm to its height in that last year. The base is over 10 m wide, and the measuring plot (5x10 m) was in 1998 over 90% covered by the two dominant species. However, on the NE side the dune has started to erode.

The lymegrass plant of the dune has flowered since 1979, making that site one of the centers of increase of this species on Surtsey. The production of successful offspring and the part this plant plays in the population increase of the species on the island has previously been discussed (Fridriksson 1992). The number of flowering spikes of the plant (No 74-51) in this dune and on one other lymegrass plant close by (No 74-78) have been counted for a number of years to monitor their fertility from time to time. The increase in flowering spikes of the former plant seems to have continued over a ten year period. After having reached a peak in 1990 the formation of spikes diminished, probably as most of the available nutrients had been used up for the advanced vegetative growth (Fig. 3).

Adjacent to the sand dune, on the eastern side of it, is a quadrat of 10x50 m on sand-filled lava. This plot has been investigated every summer for the last twelve years. The quadrat is occupied by three vascular plant species, that of *Elymus arenarius*, *Honkenya peploides* and *Mertensia maritima*.

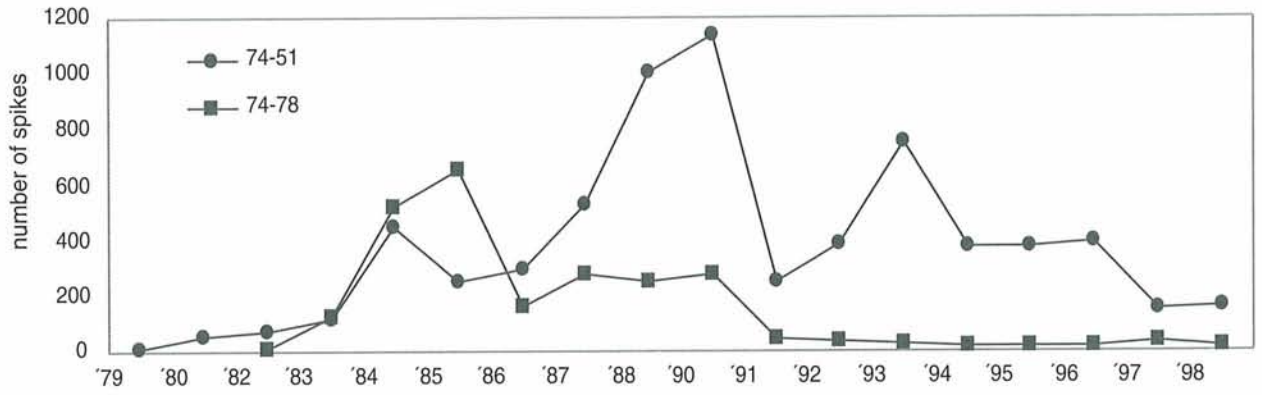



Figure 3. Number of spikes on two *Elymus* plants on Surtsey.

Table 2. Pellets from regurgitating sea gulls in Surtsey

| Contents | 1 DWg | 1 % | 2 DWg | 2 % | 3 DWg | 3 % | Average% |
|---|---|---|---|---|---|---|---|
| *Fish* | 1.4 | 70.6 | 0.97 | 76.9 | 1.83 | 93.0 | 80 |
| *Feathers* | 0.23 | 11.6 | 0.19 | 14.8 | 0.00 | 0.0 | 9 |
| *Plant material* | 0.21 | 10.8 | 0.09 | 7.4 | 0.12 | 6.0 | 8 |
| *Sand* | 0.14 | 7.0 | 0.01 | 0.9 | 0.02 | 1.0 | 3 |
| Total | 1.98 | | 1.26 | | 1.97 | | |

In 1987 the average plant cover at this site was 5.2%, and in 1998 it had increased to 21.4%. The dominant species was *Honkenya* covering 12% of the area, *Elymus* covered 9%, whereas the *Mertensia* only occupied 0.4% of the quadrat. This site is sheltered from the strong southwestern wind and was colonized early. Black-backed gulls visit the site, but do not influence it much. It was to start with only occupied by these few coastal plant species, and there has been no further introduction of species for the last thirty years. The *Honkenya* plant patches grow to a certain size (up to 1 $m^2$) and gradually the *Elymus* plants are also advancing in size. However, this vegetation is very slowly increasing in cover, due

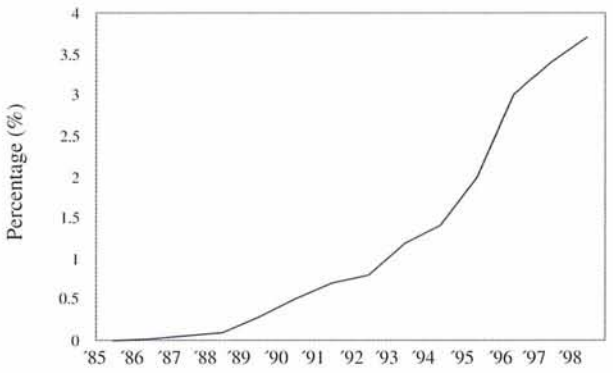



Fig. 5. Development of the vegetative area of the gull colony as percentage of the total dry land area of Surtsey.

Figure 4. The sand dune community in 1997.

to the limits of the quality of the habitat, and with the same progress the species there will only be forming a simple association in the future. As this vegetation may be considered rather typical of the sand-filled lava elsewhere on the island, a similar development may be expected there in comparable habitats (Fig. 4).

In contrast to this slowly advancing coastal community is the rapidly developing vegetation spot on the southern side of the lava apron. Initially a few procumbent pearlworts (*Sagina procumbens*) managed to become established there, on a flat lava surface. Grasses subsequently joined, and now there exists a dense section of nitrophilous species, much like any assortment in a barnyard flora. This rapid development of communities is due to the presence of gulls that carry seeds with them to the nest sites and increase soil fertility with guano and food waste. These gulls are the lesser black-backed gull (*Larus fuscus*) and the herring gull (*Larus*


Figure 6. An aerial photograph of Surtsey, taken 23 August, 1998. The major plant communities appear as a green spot in the central south part of the island. The dune vegetation may be seen as a small, light dot on the central eastern coast of Surtsey. Courtesy of the National Land Survey of Iceland.

*argentatus*) that started nesting at this site in 1985. During the last fourteen years this oasis has rapidly grown in density and total area. From being a small dot on the lava in 1985, that vegetative spot now covers about 6.3 hectares, which amount to about 4 % of the total dry land area of Surtsey (Fig. 5). This may be seen as a green spot in the central southern part on the aerial photograph of

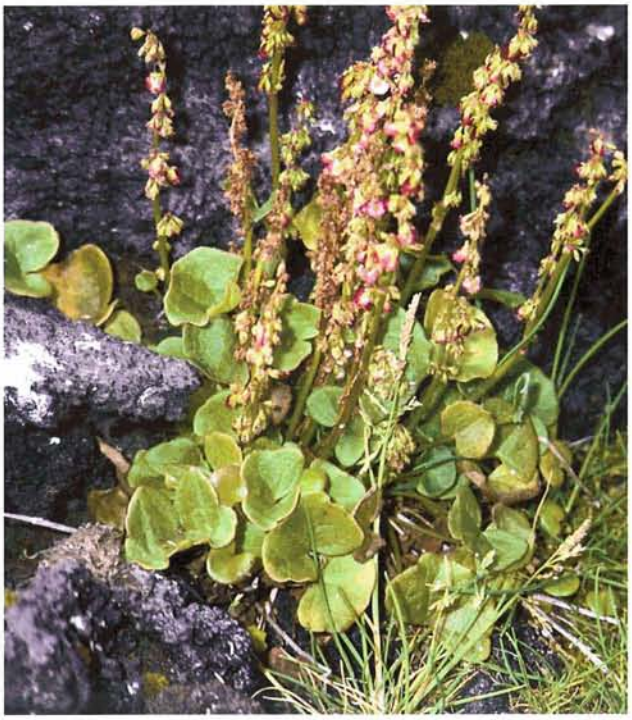


Figure 7. *Oxyria digyna*, the latest newcomer of vascular plant species to Surtsey in 1998.

the island (Fig. 6). Most of the new vascular plant species that have colonized the island since 1990 have been discovered in this area. These are 30 species found during the last nine years, which is a much higher rate of introduction of plant species to the island than in the previous years, being totally due to the various effects of the two kinds of sea gulls that occupy the territory. The latest newcomer of these species was mountain sorrel, *Oxyria digyna*, a common plant in ravines in Iceland and found growing on Heimaey, the largest of the Westman Islands (Fig. 7).

*The source and dispersal*

To demonstrate that sea gulls do carry vegetative material to the area pellets regurgitated by sea gulls at the breeding site were investigated in 1998. The material in those pellets was classed into four categories as shown in Table 2. This observation indicates that about 8 % of the food brought by sea gulls to their youngs may be of vegetative origin. The vegetative material in those pellets was mostly leaves and hulls of *Elymus*- plants. In addition three more pellets were collected. These turned out to be of pure vegetative material, mostly from common scurvygras, *Cochlearia officinalis*, but including also one seed of *Poa sp.* Such a high proportion of vegetative material in the diet might suggest that these birds had been feeding locally on the vegetation on Surtsey.

By investigating the likely dispersal routes of the plant material carried to Surtsey it was proposed (Fridriksson 1992) that 64% of the vascular plant species found on the island might have been carried by birds as to 27% by sea and 9% by air currents. However, with the formation of the sea gull colony, this proportion has changed considerably, as the corresponding figures of the plant material carried to the island in 1998 is 75% of the species by birds, 11% by sea and 14% by air.

At that time, in 1992, it was also estimated from what source the diaspores carried to Surtsey might have derived. It was suggested that some 72% of them had come from the close by source of the Westman Islands, whereas 21% might have derived from the mainland of Iceland and some 7% from a more distant source. This estimate may now also be revised, as a greater proportion of the presently found Surtsey plant species seem to come from the local area or 80%, whereas only 17% come from the mainland and 3% of the diaspores have been brought from a more distant source. These figures once more express the great effects of the lesser black-back and the herring gulls on the development of vegetation on Surtsey.

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