

# Vascular plants on Surtsey 1981–1990

By

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## INTRODUCTION

A yearly study has been made of the vascular plants on Surtsey since the first plant was discovered growing on the island in 1965. Reports on this investigation have been given in the Surtsey Research Progress Reports. The last one covered the period 1977–1980. (Fridriksson, 1982a). An overview of the study of colonization of life on Surtsey, including the recordings of plants, has been presented in other journals for the period up to 1988 (Fridriksson 1982b, 1987, 1989). Reports of the studies have as well appeared in newspapers and magazines (Fridriksson 1984). These review papers gave an account of the species found on Surtsey in the various years since the birth of the island in a submarine volcanic eruption in 1963. However, in order to maintain continuity in the reports of the study of vascular plants on Surtsey in this journal, a description is given here covering the period 1981 to 1990.

## RESEARCH METHODS

The methods used in studying the vegetation of Surtsey have been described in previous papers of the Surtsey Research Progress Report. The individual plants were at first all recorded and marked on a map with the aid of an aerial photograph. These maps bore a grid of a coordinate system with quadrats of 100×100 m (1 ha), marked numerically and alphabetically. In 1979 the *Honkenya peploides* plants had become so numerous that detailed records of individual plants could no longer be kept. Instead their frequency had to be estimated in quadrats or on transects. However,

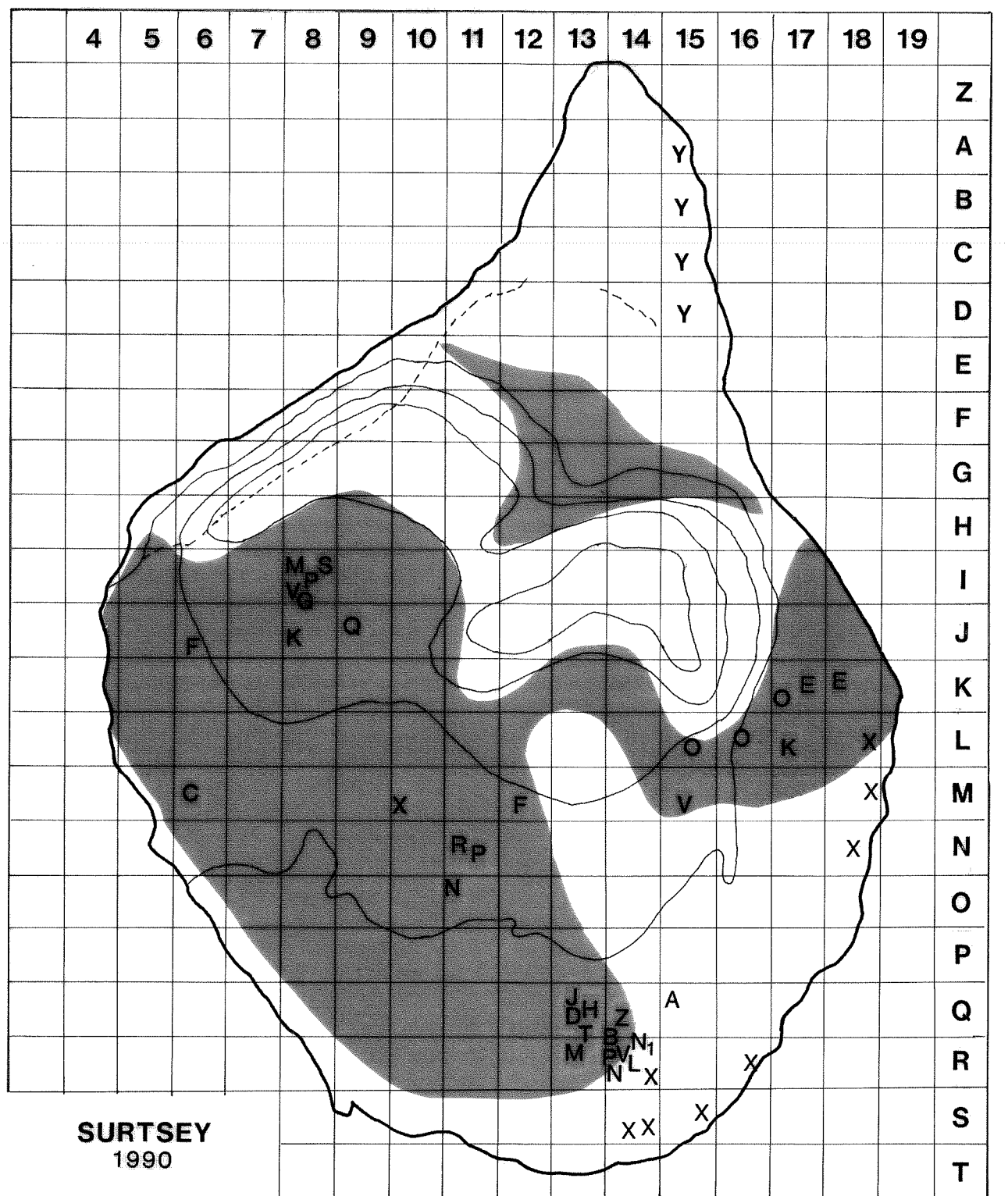
individuals of any new species discovered would still be marked on maps and staked.

The distribution patterns of the plants were investigated and a description made of their flowering and seed setting. Where associations were being formed a detailed study of their development was carried out. Photographs have been taken of individual plants and associations to document their appearance and characteristics. Aerial photographs were used to facilitate the marking and mapping of plants on a chart showing vegetation of the island (Figure 1).

## GENERAL DESCRIPTION

Of the 20 species of vascular plants that had been found on Surtsey from the time the island was born only 13 were growing there in 1980. This shows that the conditions on the island are not too favourable for plant growth. In the following year 1981, there was even a decrease in the number of species and during the period up to 1985 no additional species were discovered. Then in 1986 three new species were found growing on the island, two of which had apparently been there the previous year without being noticed. In 1987 two more species were observed and in 1988 some of the earlier colonizing species that had failed to grow there for a few years reappeared among the plants on the island. Thus there were 18 species growing there in 1988. In 1990 four new species were discovered and that year a total of 25 species of vascular plants was found.

During the 27-year period of the island's existence a total of 28 species of plants had been recorded growing on Surtsey at one time or another, but some of them were not repre-



#### VASCULAR PLANTS


 <b>Honkenya peploides</b>	<b>X</b> <i>Cochlearia officinalis</i>	<b>O</b> <i>Mertensia maritima</i>
<b>A</b> <i>Agrostis stolonifera</i>	<b>S</b> <i>Cystopteris fragilis</i>	<b>N</b> <i>Poa annua</i>
<b>T</b> <i>Alchemilla filicaulis</i>	<b>E</b> <i>Elymus arenarius</i>	<b>N,</b> <i>Poa pratensis</i>
<b>G</b> <i>Armeria maritima</i>	<b>D</b> <i>Epilobium palustre</i>	<b>P</b> <i>Puccinellia retroflexa</i>
<b>Y</b> <i>Cakile arctica</i>	<b>Q</b> <i>Equisetum arvense</i>	<b>R</b> <i>Rumex acetosella</i>
<b>B</b> <i>Capsella bursa pastoris</i>	<b>F</b> <i>Festuca rubra</i>	<b>L</b> <i>Sagina procumbens</i>
<b>C</b> <i>Cardaminopsis petraea</i>	<b>J</b> <i>Juncus arcticus</i>	<b>Z</b> <i>Stellaria media</i>
<b>K</b> <i>Carex maritima</i>	<b>H</b> <i>Luzula multiflora</i>	<b>M</b> <i>Triplorospermum maritima</i>
<b>V</b> <i>Cerastium fontanum</i>		

Fig. 1. Distribution map for plants on Surtsey.

sented at the end of the study period. There is apparently seasonal variation in the amount of dispersing seed to the island and seed of some of the colonizing species is not annually dispersed or manages to germinate.

## INDIVIDUAL SPECIES

### *Agrostis stolonifera* L.:

One plant of this common grass species of Iceland was discovered in Surtsey in 1987 and has been found growing there ever since. It was originally found at the edge of a patch of *Sagina* on a flat spot on the lava shield in the southern part of the island in quadrat Q-15. It flowered during that summer with eight panicles being produced. This plant has developed further but new individuals of the species have not been found. The patch covered an area of 5×10 cm in 1987 and had increased to 10×15 cm in 1990 with three distinct centres.

### *Alchemilla filicaulis* Buser:

One individual of this species was discovered in the spring of 1990 near the gull breeding colony on the southern part of the island (Einarsson 1990).

The plant has most likely grown from seed carried by a bird to the island.

### *Angelica archangelica* L.:

This species which is common on the cliffs of nearby islands has been represented on Surtsey by two seedlings in 1972 and 1973. It has never been found since on the island. It is a possible future occupant of the bird cliffs on the southern edge of the lava.

### *Armeria maritima* (Miller) Willd.:

In 1986 a single plant of this species was discovered growing high upon a narrow shelf in the southern rim of the Lava crater. The plant was then flowering with three heads. Its seed had apparently been brought to this remote location by ravens that frequently visited this spot and were obviously preparing to use the shelf as a site for their future nest. The birds had brought to this place pieces of strings, bones and wooden sticks intended for nest building and beside this debris the plant grew and increased in size during the following years. It had developed 31 heads in 1987 and was flourishing. In 1990 two plants were found growing side by side at this same location and both were in flower (Figure 2).



Fig. 2. An *Armeria* plant on a shelf of the rim of the Lava crater with moss on the crater floor.

### *Atriplex patula* L.:

A small plant was found growing in 1977 at the high-tide-line, by the north-eastern shore. This species, which is common on the nearby islands, has not been rediscovered on Surtsey.

### *Cakile arctica* Pobed. (syn.: *Cakile edentula* (Bigel) Hooker; *Cakile maritima* Scop.):

This species was the first to colonize the shore of Surtsey in 1965. The species, being an annual, has not managed to establish a firm foothold on the island and has only been found growing there in 13 years during this 27-year period. The plants have mostly been at the high-tide-line, as were the approximately 120 specimens found on the island in 1990, where they are favoured by the fertile environment of the sand mixed in with the decaying sea weed. Although some of the plants have been able to flower and develop seed their production has not been sufficient to ensure the preservation of the species on the island. The existence of the species on Surtsey is therefore almost exclusively dependent on seed dispersal from neighbouring sources.

This may be variable between years due to differences in the amount of seed produced on the neighbouring islands as well as the south coast and may depend on the prevailing winds following the fall of seeds.

*Capsella bursa pastoris* (L.) Medicus:

One individual of *Capsella* was discovered in 1990 growing on the sandy deposit covering the lava shield on the southern part of Surtsey at the edge of "Mávaból", the seagull breeding area. A seed of this plant has most likely been carried there by the birds. The plant had produced seven scalps and was blooming with five new flowers. This newcomer will probably have a chance to multiply in the area which is becoming fairly fertile due to bird droppings.

*Cardaminopsis petraea* (L.) Hiit.:

This species is common on gravel beds in Iceland and could be expected to find the environment favourable on Surtsey. Five plants of this species were first found on the island in 1978. They all grew together at the same spot in quadrat M-6 and were marked with a stake No. 78-136. This plant developed and bore seed that fell close by and in 1980 eight plants were growing there together. The plants were not observed during the five following years, but were rediscovered in 1987. At that time seventeen small and three larger plants were recorded at the same location on a 1 m<sup>2</sup> area. This small colony had grown to 25 plants in 1990 and is still isolated at the same spot in the south-western part of the lava flow.

*Carex maritima* Gunn.:

One plant of this species was first recorded on the island in 1972. Two individuals have both been successful in surviving and developing during this study period. Plant No 78-182 in quadrat L-17 has gradually increased in size by runners and had in 1986 managed to cover an area of 100×70 cm. It had 16 flowering culms, but there were no signs of new seedlings in the neighbourhood. In 1990 it had produced 50 stolons and 26 flowering culms. Plant No 78-148 was growing in quadrat J-8, but has not developed as well as the former. It covered an area of 20×30 cm in 1984 and was rather weak and did not bear flowers in 1990.

In 1986 two new individuals were found in quadrat S-14 on the southern part of the island. One of them was growing in a tuft of 8×40 cm in area and had 13 flowering culms.

The other, a smaller plant which was not flowering, was growing in a lava crack filled with sand. Both these individuals probably developed from seed carried by birds. These plants have continued to develop and in 1987 a well-developed plant was found under the north cliff of the Lava crater.

*Cerastium fontanum* Baumg. ssp *scandicum* H. Gartner:

This species which is common on dry, open land in Iceland has been found growing continuously on Surtsey since 1975 when it was first observed there. However, its population has not increased steadily as regards the number of plants. In some years several young seedlings have started growth but these have often not survived the following winter. There have mainly been two patches or colonies of these plants on the island; one is in a sand-filled depression of the lava in quadrat M-15 which is situated about 20 m south of the present hut. Occasionally there have been several dozens of plants in this colony, but in other years these were fewer and in 1987 and 1988 only one plant was growing there. The other colony of *Cerastium* is on the southern part of the lava shield in quadrat R-14. It grows there in a sandy layer covering a fairly flat surface of lava. The colony consisted of 25 plants in 1987 and 29 the following year. In the summer of 1990 over fifty plants were found growing at this site. Most of them were flowering and producing seeds.

*Cochlearia officinalis* L.:

Specimens of *Cochlearia* have been found growing on Surtsey ever since the species was first discovered in 1969. Apparently there is a steady dispersal of seed to the island probably carried by birds from nearby sources, but seed is now also produced locally and seedlings have been found in great numbers in some years growing beside the mother plants. However, there has been no major increase of the species on Surtsey during this study period. The older plants have developed and flourished, but the young seedlings seem to have difficulties in surviving. In 1990 there were over 100 individuals recorded on the island. Most of the plants were found in the south and south-eastern part of the lava-apron, especially on the edge of the ocean cliffs where the seagulls perch and feed their young. At the gull-breeding area "Mávaból" in quadrat

R-14 there were three large plants developing respectively with 35, 55 and 60 capsules. In the close vicinity there were 15 younger plants. The soil in this area is becoming quite fertile due to the droppings of the birds and the remnants of their food and other offal, such as feathers, broken eggs and bird carcasses. There is thus a good chance for future development of the species in this habitat. Further to the south along the edge near "Lýsuhóll" in quadrat S-14 around 85 plants were growing in the sand-filled cracks of the lava in 1987. These were again observed prospering in 1990. Thus the species is gradually colonizing the southern fringe of Surtsey. Although this is the site where the species is most common, a few plants may be found farther up in the lava. Thus one large plant, 25 cm high, was discovered in 1987 growing in quadrat M-10. It was flowering and had produced 26 branches with capsules. Another large plant marked No 77-88 growing by the edge had 8 flower stalks. The stalks having on average 25 capsules containing about 15 seeds each, it was thus bearing up to 3,000 seeds that summer. A marked increase in the number of seed of *Cochlearia* is therefore being produced annually on Surtsey.

#### *Cystopteris fragilis* (L.) Bernh.:

A few plants of this fern have survived and been recorded in most years since it was first found on Surtsey in 1971. Some individuals were growing in hollows out in the centre of the lava flow. Others were found in the Lava crater marked as quadrat I-8. Here the plants have grown in association with moss that forms tufts on sand deposits in cracks in the lava, so that the plants enjoy shelter and some moisture. Although some of the fronds have been found to be fertile, there has been no increase in the number of this species and in 1990 only five individuals were found growing in the Lava crater of Surtsey.

#### *Elymus arenarius* L.:

This perennial grass species is one of the major colonists on Surtsey. It was the second species of vascular plants to take root on the island as it was first found there in 1966 during the third summer of the island's existence. Since then plants have gradually developed, increased in size and multiplied.

During the first 13 years there was not much change in the number of individuals of

this species on Surtsey. Seeds were apparently being washed annually up on the shores of the island. Some of them germinated and developed into plants, but there was a high death rate. New individuals were recorded only later to be found wilted, buried by sand or torn up by birds. Thus during the first years the population had to rely on the import of seed to make up for the loss of individuals.

In 1979 there was a marked change in this development. Among the five plants of this species found on the island that year, was a five-year-old plant No 74-51, which was growing on the sand-filled lava surface on the eastern part of the island in quadrat K-18. During that summer the plant started to flower, bearing eight spikes. Again in 1980 it produced some fifty spikes. This flowering and seed setting has continued. The plant has gradually developed in size and the number of spikes has increased as the years have gone by. Thus there has been a great increase in seed production of this individual (Table 1).

In a similar way a slightly smaller plant was growing farther to the west and higher up on the lava in quadrat K-17. It also flowered but bore fewer spikes. Both these plants have considerably increased the availability of *Elymus* seed on Surtsey and thus given the species an additional chance to colonize and spread in this new habitat. Table 1 shows the gradual increase in number of spikes of these two plants. Obviously this seed formation has had a great effect on the *Elymus* population.

The transport of *Elymus* seed to Surtsey was fairly limited. During the first 18 years only ten *Elymus* individuals on the average were found growing annually on the island. Up to 1983 there had been little increase in the number of plants. The death rate of plants must have been almost equal to the rate of new introductions from dispersed seed. Although local seed production started in 1979 it was not until 1983 that new seedlings began developing near the parent plants. In the autumn of 1982 the old plants carried 76 spikes with approximately 4,000 seeds. The following summer there were 38 new seedlings found in the neighbourhood of these older plants which indicates that around 1% of the produced seeds succeeded in developing into mature plants. In the autumn of 1983 there were 240 spikes produced on the old plants which may have developed some 12,000 seeds. The following summer there were about 150 new seedlings

TABLE 1.

Number of flowering spikes on two *Elymus* plants on Surtsey.

Plant no	Years									
	1979	1980	1982	1983	1984	1985	1986	1987	1988	1990
74-51	8	50	70	115	450	250	300	529	1000	1138
74-78			6	125	520	650	160	280	255	274

found growing in the neighbourhood of these same two old plants, which again suggests that a little over 1% of the available seed had developed into a successful seedling. Now that the *Elymus* seeds are annually being produced on Surtsey in ever greater numbers there is bound to be a steady increase in the number of seedlings in years to come. At first this development will be slow, as the *Elymus* plants on Surtsey do not become fertile until they are five years old. Thus the second generation of *Elymus* plants on Surtsey has just started to become fertile. During the years to come one would expect a major increase in this species. The growing conditions seem to be perfect for *Elymus* and there is plenty of sand and lava which is an ideal habitat for the species. It is therefore likely that in the following years a cover of *Elymus* grass will be formed on the eastern part of Surtsey.

#### *Epilobium palustre* L.:

This species which prefers to grow in moist places was first discovered on Surtsey in 1990, when two plants were found near the fertile sea gull breeding area "Mávaból", in quadrat Q-13. These two new plants were both flowering. They both apparently grew from seeds that may have been brought by the birds or rather drifted by air to the island since the seeds are hairy-plumed and light and can easily be carried by wind to Surtsey.

#### *Equisetum arvense* L.:

This species which is very common on sand and pumice in Iceland was first found on Surtsey in 1975 but was not rediscovered there until 1990. The first location was in quadrat J-9 on the eastern side of the Lava crater, but the second time it was found growing on the

southern brim of the crater in quadrat K-9. This time three groups of plants were found in a colony growing on the ashy surface of the shoulder. The plants were all very small, about 2–4 cm long, with branches growing out of the prothallium. They may have started their growth that same spring from wind-borne spores. These two locations are peculiarly close together, which might indicate that the substrate there is particularly favourable for this species.

#### *Festuca rubra* L.:

This common grass species of Iceland has firmly established itself on Surtsey as it has been growing there since 1973. The plants have, however, not increased in number although they have annually flowered and set seed. Most of the time only one or two patches have been found growing there.

In 1987 two patches were found south of the Hole in quadrat J-6. Plants were flowering at both sites. One had 20 flowers while a smaller patch, further to the north, had 8 flowers. A patch 20×30 cm large and flowering was also found south of the new hut in 1984. The main patch is, however, in quadrat M-12 on a cinder surface. It has covered an area of 50×50 cm and has been flowering annually. In 1990 it covered only an area of 12×10 cm with eight stolons and had only one panicle. Although these fescue plants have borne seeds no seedlings have ever been found in the neighbourhood of the parent plants.

#### *Honkenya peploides* (L.) Ehrh.:

Of all the plant species found on Surtsey *Honkenya* is of special importance in forming a vegetation cover. It was the third species to be discovered and was found in 1967 the fourth

summer after the birth of the island. Ever since it has been growing on the island and spreading out in its new habitat.

During the first five years the population of this species on Surtsey was dependent on seed dispersal from outside the island. Annually some 20 to 30 new seedlings started growth and the death rate of individuals was 20 to 50%. Most of the losses were due to ocean flooding or the drifting sand that submerged the seedlings during the first winter. Already in the second summer the plants may form a patch 30×30 cm in area and they continue to spread out by runners forming flat mats up to 200×200 cm wide. It took the first plants up to six years to set seed on Surtsey. One out of five flowering plants had female flowers and produced seed in 1971. Of the seeds formed, approximately 1–2% may have germinated and produced successful seedlings. After seed setting started on the island there was a rapid increase in the plant population. The plants produce a large amount of seed. In 1976 a plant was estimated to have 1,000 pods, and in 1985 plant No 76-135 was measured 1.30×1.00 m in area and found to produce about 5,000 fruits, each containing ten seeds. So that this one plant could have given approximately 50,000 seeds. Thus with a 1% seed survival a single plant could produce 500 new seedlings the following spring and with a 50% death rate, the first winter the increase per year could be 250-fold for the largest fertile plants in the population. In reality the growth rate was, to start with, somewhat slower. When the second generation of plants started to produce seed in 1977 after another period of six years there was an even more rapid increase of new individuals. During the following years the population doubled annually in numbers for some time.

With the increase in population the *Honkenya* plants occupied ever new quadrats annually and spread especially out into the sand-filled lava in the south and south-western part of the island following the drifting of sand towards that area. With every year that passed there was an increase both in number of plants and in the size of individual patches. It takes a plant up to seven years to form a patch 1.3×1.0 m in area. Most of the patches do not become larger although one 12-year-old plant in 1983 measured 2.5×2 m or around 5 m<sup>2</sup> in area. The branches of the patches can become 25 cm tall and as the sand may drift in towards

their centre a small mound may be formed up to 40 cm high. Sometimes the centre of the plant may be suffocated and a green ring is formed with a sand depression in the middle. The particular size of the plants may be governed by the water and nutrient available for the roots of individual plants that are competing in the habitat.

In 1982 the number of plants and coverage was estimated in fixed transects and in quadrats. In the best developed areas on the eastern part of the island and in a depression in quadrats M-9 and N-10 which with optimism could be named "Grænalág" (the green depression), the coverage was on the average 1 to 1.5% with one plant per square metre. In 1984 the measurements gave around 3% cover in these areas and in 1987 this had increased to 8.5% cover. In 1990 the measurements in three transects from the eastern shore towards the hut showed the cover was 5.2%, 9.2% and 11.6% or around 8.7% in the best-developed areas. It was estimated on the whole that the vegetated area on Surtsey did not cover more than 1%. However, in one sheltered depression "Tröð" south of the hut in an area 10×10 m the cover could be estimated as 60%.

The *Honkenya* can definitely be called the leading colonist of the vascular plants on Surtsey. It now grows in 59 of the marked quadrats, which amounts to 43% of the quadrats on the lava and 29% of the total quadrats on Surtsey.

#### *Juncus arcticus* ssp. *intermedius* Willd:

In 1975 a young plant of this arctic rush was discovered on Surtsey and in the summer of 1990 one specimen was found there again. This time it was growing on a flat strip of sand in the lava flow near the bird-breeding area "Mávaból" in quadrat Q-13. That single plant was young and not flowering.

#### *Luzula multiflora* (Retz) Lej.:

A single plant of this common woodrush was first found in Surtsey during the summer of 1990. Like the former species it also grew near the gull breeding place "Mávaból". Only a few blades were sticking up through the cinder on the lava surface and no flowers had yet been formed.

#### *Mertensia maritima* (L.) S. Gray:

This coastal species was among the first four to take root on Surtsey and has also been one



of the most common plants, with a population of up to 1,000 individuals in 1990. The first plants were found growing on the eastern side of the lava, where they may have started from sea-borne seed washed up on the eastern shore in quadrat I-18. The colony has spread from there farther up the lava flow towards the west and the plants are now most common in quadrats K, L and M-15 to -17. The colony is particularly dense in quadrat K-17 where 30 plants were found growing in 1985 on an area 10×10 m in flat, sand-covered lava called "Liljuflöt". These have developed further. The large plants measured 30×30 cm in 1987 and have spread out so that three plants growing close together covered an area of 100×180 cm in 1990. Many of the plants are flowering but they are not good seed producers.

*Poa annua* L.:

This common, annual grass has been found on Surtsey since 1987 when a small mat of 34 plants was found covering a flat surface of aa lava in O-11. At the same spot there were 18 individuals the following year. By 1990 the mat of grass had extended slightly and consisted of some 60 individuals. Plants of this species were also found the same summer growing in the fertile patch of R-14. This place is frequented by sea gulls which have probably brought seed of this species to the island.

*Poa pratensis* L.:

A few plants of this common grass species have been found growing on the island mostly since 1986 when one plant was discovered in quadrat N-13, growing in the nest of a black backed gull. The following year two plants were found in the Lava crater with six and three panicles respectively and in 1990 five individuals were recorded, one of them being close to the *Rumex* spot in N-11. The seed of this grass has probably been brought to Surtsey by gulls and possibly a raven.

*Puccinellia retroflexa* (Curt.) Holmb.:

Since 1972 this grass species has been found growing on Surtsey and has been slowly increasing in numbers, mainly for the past four years. The species has established itself at four locations and has achieved the best development in the Lava crater, quadrat I-8 and especially on a flat shield of lava covered with sand in a fertile spot at quadrat R-14.

The plant grew from seeds that probably

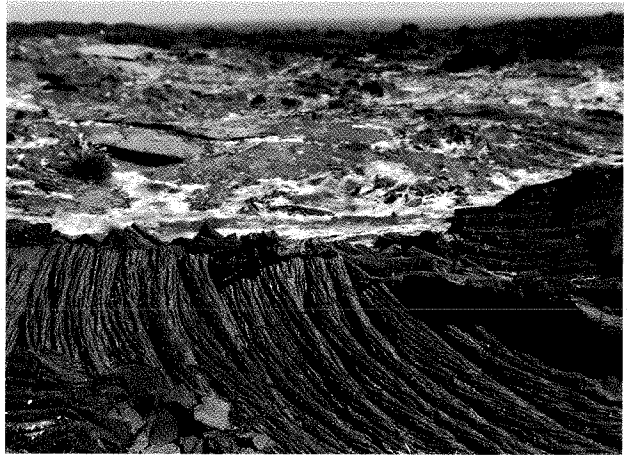


Fig. 3. The flat *Sagina* patch with a *Poa* plant left and ropy lava in fore-ground, 1990.

were brought by birds to these spots up on the island.

*Rumex acetosella* L.:

A few plants of this species had first been observed growing on Surtsey in 1978, when they were occupying a flat surface on the lava in quadrat N-11. In 1980 the colony was still developing with 40 plants on an area of 2 m<sup>2</sup>. During the following years there was a gradual increase in the number of plants and in the size of the colony. In 1990 the plants had spread out further so they were then growing in an area of 3×5 m with a few hundred individuals. The plants were occupying the sandy substrate between three patches of *Honkenya* and in some instances the patches of these two species were overlapping. These *Rumex* plants were spreading by stolons, but they were also annually producing a number of seeds. Three metres away from this colony towards the west were 25 seedlings starting a new cluster. However, during the twelve years that the *Rumex* has been growing on the island the species has only been found on this one spot. And although seeds have been formed locally they have not spread out to invade new habitats on the island.

*Sagina procumbens* L.:

This small, creeping perennial, which had earlier been identified as *S. saginoides* (L.) Karst., had formed a mat of 150 plants on a surface of aa lava in quadrat R-14. This flat lava surface can hold some water following rain and the vegetation there can remain moist for a length of time. The substrate of barren lava is becoming quite fertile by the



TABLE 2  
Species and total number of vascular plants recorded on Surtsey during the years 1965–1990.

Species	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'90
<i>Cakile arctica</i>	23	1	22	..	2	..	..	1	33	3	5	..	1	0	1	1	..	..	..	..	..	..	3	..	..
<i>Elymus armararius</i>	..	4	4	6	5	4	3	..	66	26	12	10	8	14	5	5	2	2	15	34	50	200	500	1000	2000
<i>Honkenya peploides</i>	..	24	24	103	52	63	52	71	548	857	428	500	632	3080	24000	50000	100000	∞	∞	∞	∞	∞	∞	∞	∞
<i>Mertensia maritima</i>	..	..	1	4	..	..	..	15	25	44	11	6	8	9	8	7	12	24	39	58	100	120	200	400	1000
<i>Cochlearia officinalis</i>	..	..	..	..	4	30	21	98	586	372	863	501	286	160	91	75	14	3	26	12	4	3	100	25	100
<i>Stellaria media</i>	..	..	..	..	..	4	2	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	20
<i>Cystopteris fragilis</i>	..	..	..	..	..	..	3	4	3	3	2	2	2	9	5	5	3	2	1	1	..	..	1	1	5
<i>Angelica archangelica</i>	..	..	..	..	..	..	..	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Carex maritima</i>	..	..	..	..	..	..	..	1	1	1	3	2	1	5	2	1	1	2	1	1	1	4	2	2	2
<i>Puccinellia retrofracta</i>	..	..	..	..	..	..	..	2	1	9	8	8	2	6	40	7	2	2	2	2	2	2	85	30	100
<i>Tripleurospermum maritimum</i>	..	..	..	..	..	..	..	1	5	2	2	2	1	4	1	1	1	1	1	1	1	1	..	3	6
<i>Festuca rubra</i>	..	..	..	..	..	..	..	..	1	1	2	1	1	5	3	3	1	1	1	1	1	1	2	2	2
<i>Cerastium fontanum</i>	..	..	..	..	..	..	..	..	..	..	106	99	19	6	97	150	120	100	75	20	20	34	25	29	53
<i>Equisetum arvense</i>	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	14
<i>Silene vulgaris</i>	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Juncus arcuatus</i>	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1
<i>Atriplex patula</i> (?)	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..
<i>Rumex acetosella</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	124	31	40	30	27	28	31	50	80	400	500	800
<i>Cardaminopsis petraea</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	5	6	8	..	..	..	..	..	..	20	25	25
<i>Poa pratensis</i>	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	2	3	5
<i>Sagina procumbens</i>	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	150	700	1000	5000
<i>Armeria maritima</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	1	2
<i>Poa annua</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	36	15	60	60
<i>Agrostis stolonifera</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	3
<i>Alchemilla filicaulis</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
<i>Epilobium palustre</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
<i>Capsella bursa-pastoris</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
<i>Luzula multiflora</i>	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Unidentified plants	..	..	..	1	..	..	4	2	1	1	2	1	..	1	..	..	..	..	..	..	..	..	..	..	..
Total	23	5	51	114	63	101	85	199	1273	1319	1449	1132	962	3428	24000	50000	∞	∞	∞	∞	∞	∞	∞	∞	∞

DISTRIBUTION OF TWO COASTAL PLANTS ON SURTSEY 1980 - 1985  
A SECTION OF QUDRAT K-18

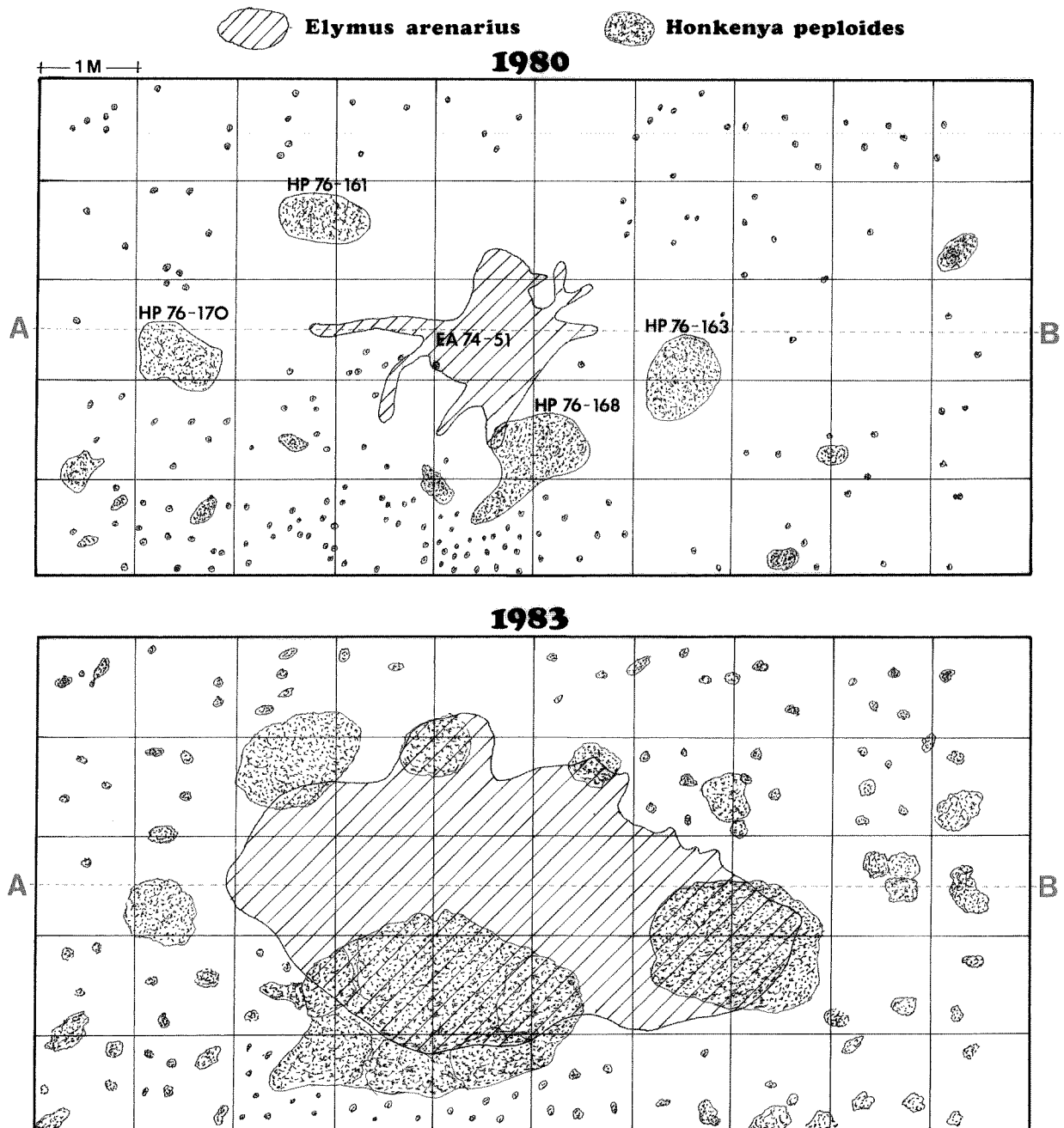
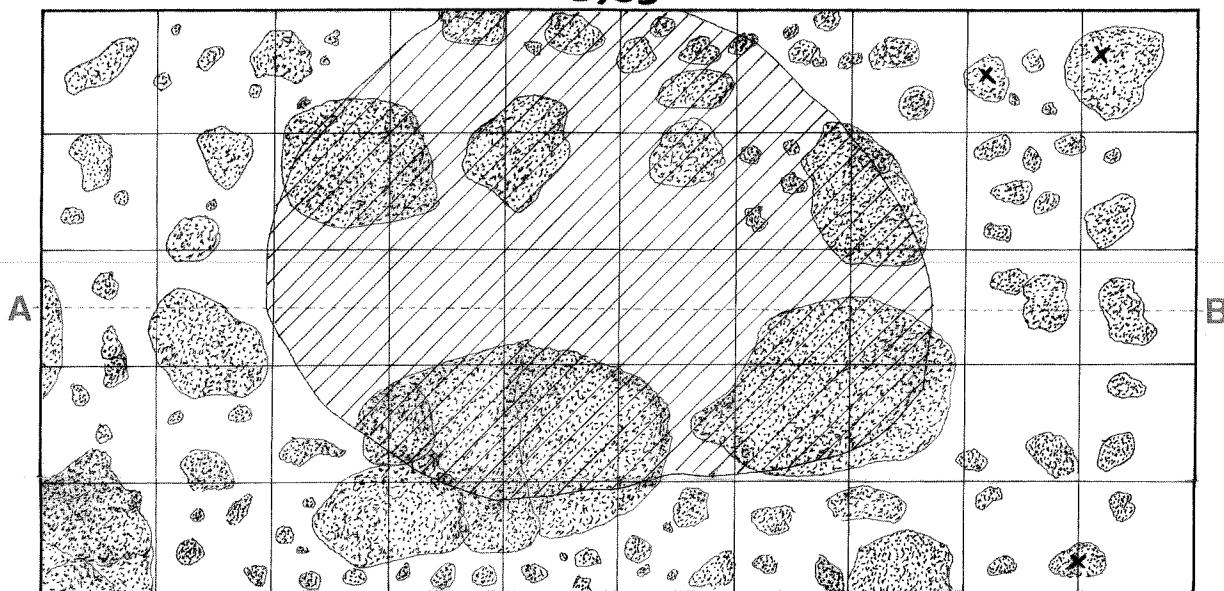
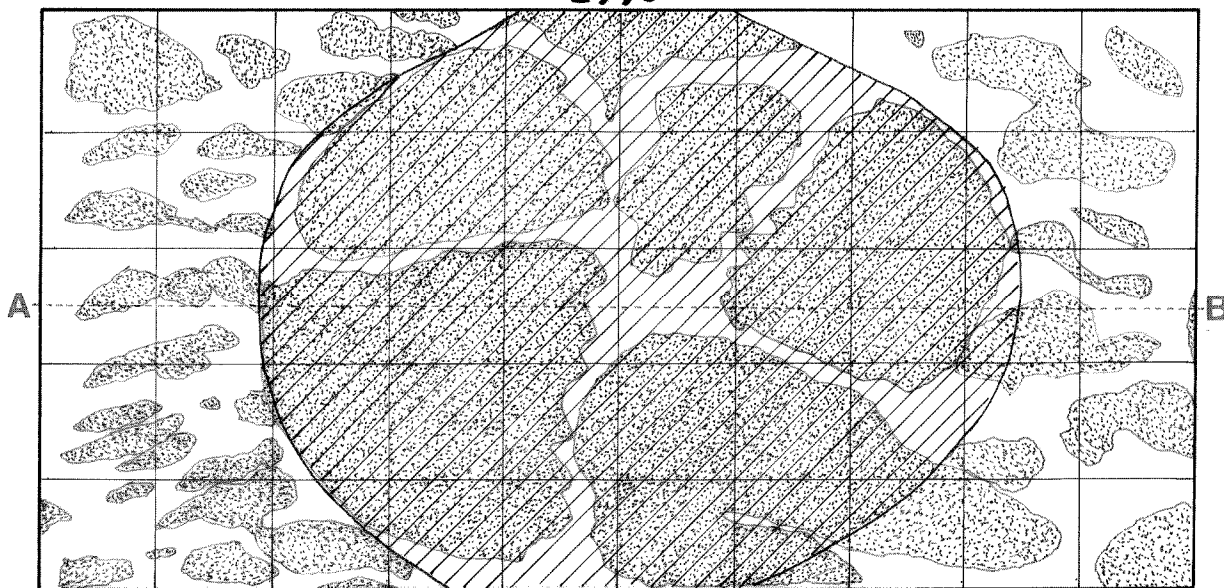


Fig. 4. Charts showing the development of a costal dune of *Elymus* – *Honkenya* association.

**1985**

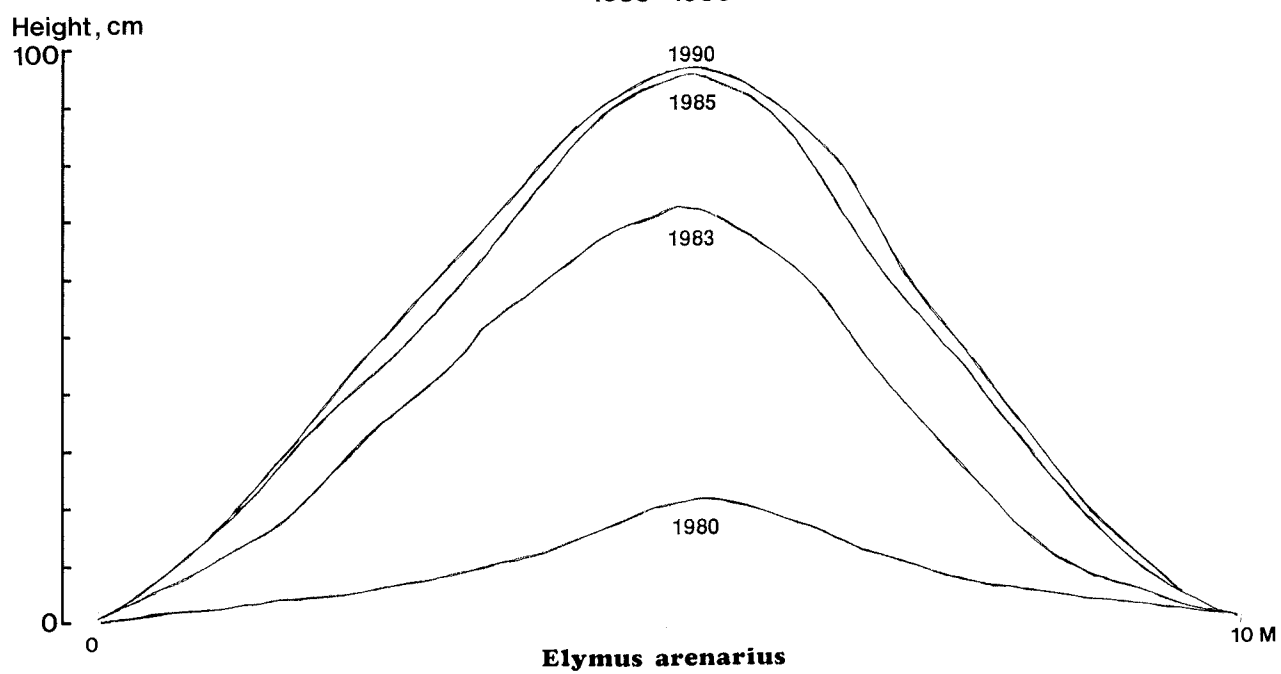


**1990**



**TRANSECT THROUGH DUNE A-B ON SURTSEY**

**1980 - 1990**



bird droppings as the spot is in the gulls' breeding area "Mávaból". There are even two nests of herring gulls just west of this colony and thus the plants are frequently fertilized. Both *Cerastium* and *Puccinellia* plants also grow in this habitat, to which their seed has probably been transported by birds. The vegetation there has achieved up to 100% cover in places and the area which extends over 200 m<sup>2</sup>, has on the average 70% cover (Fig. 3).

*Stellaria media* (L.) Vill.:

This Common Chickweed has been growing on Surtsey since 1988. In 1990 a large plant and up to 19 seedlings were found in the gull-breeding area. This older plant apparently grew from seed brought by the seagulls and enjoyed the fertile sand close to the herring gull's nests.

*Tripleurospermum maritimum* (L.) Koch:

One plant of this species was discovered in the Lava crater as early as 1972. Since then a few plants have occupied the sand deposited on the crater floor. In 1990 three new plants were found growing at the gull-breeding place on the southern part of the lava. These plants were flourishing in the highly fertile soil there and one of them bore 110 heads. Thus a number of seeds are now being formed locally.

## ASSOCIATIONS

In a previous report (Fridriksson, 1982a) a description was given of the first formation of a beach association and a sand dune. Two of the most common species of vascular plants on Surtsey were growing there together, having their territories overlapped. A close investigation was made of the formation of the sand dune and this has continued in the present study period. A section 5×10 m of the sandy area grown with this vegetation has been measured and mapped annually (Fig. 4). This was the first association of vascular plants being formed on Surtsey. The *Honkenya* holds the ground stratum where it enjoys the shelter and can make use of the sunlight in early spring and autumn. Leaves and stalks of the *Elymus* tower over the sward and receive most of the light in the middle of summer. The sward has been built up by the *Honkenya*, thus the soil's top-layer does not dry up as easily as on the black, open sand. The dune is a good example of how species twine together by vegetative growth when occupying the same hab-

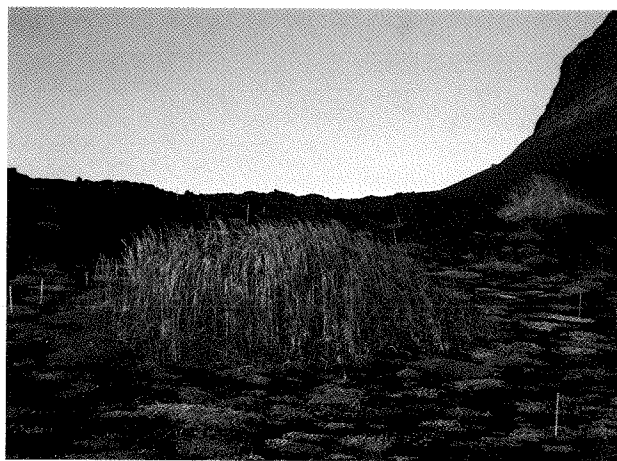


Fig. 5. The *Elymus* plants associated with *Honkenya* in 1990.

itat and thus consolidate into a consociation. These two species also form an association by a somewhat different mechanism.

In the neighbourhood of the large *Elymus* hill a number of *Honkenya* patches had been established. It was then noticed in 1983 that in the centre of some of these patches a young *Elymus* plant was developing.

The large *Elymus* plant had matured seed the year before and the seeds were distributed in the vicinity. Some were blown away by winter storms; they had fallen into the ocean or on the solid lava, others had been buried too deep in sand or withered on its dry surface and had not succeeded in developing into new seedlings. The Lyme grass seeds that landed in a *Honkenya* patch in contrast encountered more favourable conditions. Such seeds were not buried too deep in sand for successful germination, but they received an even supply of moisture and were better sheltered than on the open sand. This special microhabitat had obviously been favourable for the sprouting of *Elymus* seeds since in the spring of 1983 seedlings of twenty Lyme grass plants were found in the centre of the same number of *Honkenya* patches whereas no new seedlings had developed in the open sand around these patches. The following year in the summer of 1984 this tendency had increased and *Elymus* seedlings were found in patches of *Honkenya* growing at a distance of 350 m from the seed-bearing Lyme grass plant. A total of 100 association patches were thus found that year and twenty more even farther away. In 1986 there were 166 such patches. It is thus possible in this case to look at the *Elymus* as a secondary invader to the primary establishment of the *Honkenya*

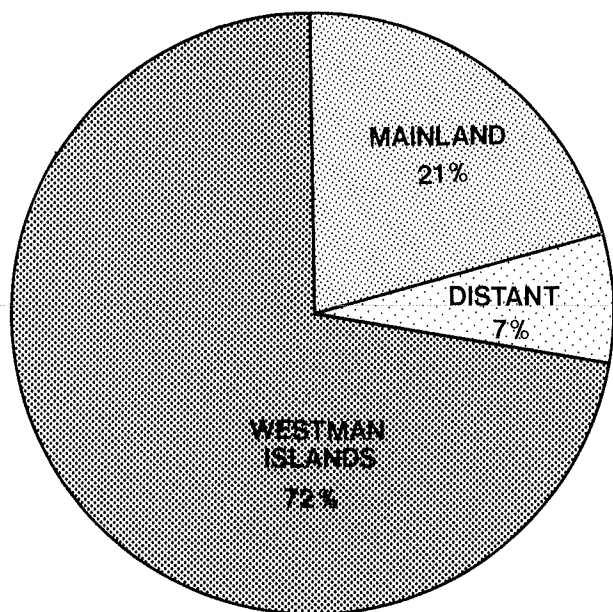


Fig. 6. Source of diaspores found on Surtsey.

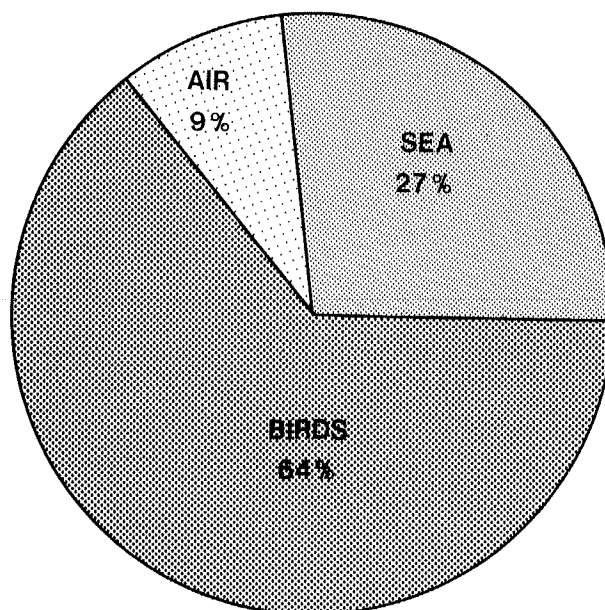


Fig. 7. Likely dispersal routes of vascular plants species found on Surtsey.

pioneer. In addition to the coexistence of these two species in this area *Mertensia* joins them in some places as it also enjoys the same habitat. These three species now form a coastal association on Surtsey (Fig. 5).

#### *Sagina* – *Poa* – *Puccinellia*

On the fairly smooth surface of the ropy aa lava on the southern part of the island in quadrat R-14 a colony of the low-growing *Sagina procumbens* plants had been developing since 1986. These plants have been fertilized heavily by the herring gull that breeds in the area. This same habitat is also occupied by the three grass species *Poa annua*, *Poa pratensis* and *Puccinellia*. This form of association is found on cliffs and bird-breeding grounds by the ocean or even around human dwellings in Iceland. This association will probably become still more common on the flat lava of Surtsey in the future.

The soil of this special habitat has become quite fertile with 60 mg N and 7 mg K per 100 ml of dry matter and 2.9 mg P in 100 ml of dry soil and a rather high acidity of pH 5.3.

#### DISPERSAL

As the flora of vascular plants on the various members of the Westman Islands is known, it is possible to show the shortest distance for a diaspore to be dispersed in order to reach Surtsey.

The number of potential species to be dis-

persed is 4 from the nearest rock of Geirfuglasker (5.1 km) and 7 from Súlasker (11 km). All these species are at present also found on Surtsey. In Fig. 6 it is demonstrated from what sources the plants on Surtsey may have derived. It is obvious that most of the diaspores have come from the nearby Westman Islands, although there have been instances of transportation from the mainland or over greater distances. From various circumstances and from the locations of the new colonists it has also been possible to guess in what way the diaspore may have been transported, whether by sea, air or birds. This is shown on the diagram in Fig. 7 where it is indicated that in most instances birds have been involved in the transport.

#### THE COLONIZATION

Only the most hardy pioneer species have been able to establish themselves in the immature ecosystem of Surtsey. The vascular species recorded on the island in 1980 were 13 and in 1990 they had increased to 25 (Table 2). Thus there had been an introduction of almost one new plant for every year that has passed since the island was formed.

It is obvious that birds have played a great part in this colonization. Under normal circumstances the establishment of plants on a newly formed inland-lava is a slow process. On Surtsey, however, conditions are different due to the proximity of the ocean and the pre-

sence of the numerous sea-birds which both transport plant material and fertilize the substrate.

The diaspores that happen to be dispersed annually to the island were few of any one species and as the casualty rate may be high, only rarely does an arriver establish a new colonist. The species that so far have dispersed to Surtsey do not necessarily represent the best pioneers, others may only have lacked the opportunity of being transported, thus there is often a certain amount of chance involved as to what species becomes established.

Although 25 species form the present members of the vascular flora of Surtsey, the total cumulative number of species that have been found growing there is 28. Thus three species have come and gone. Still other diaspores

have been found which have not developed into plants and others may have gone unobserved by our inspection. This is still a small sample or only 6% of the vascular species of Iceland.

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