The vegetation of the Farne Islands

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THE VEGETATION OF THE FARNE ISLANDS

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THE VEGETATION OF THE FARNE ISLANDS

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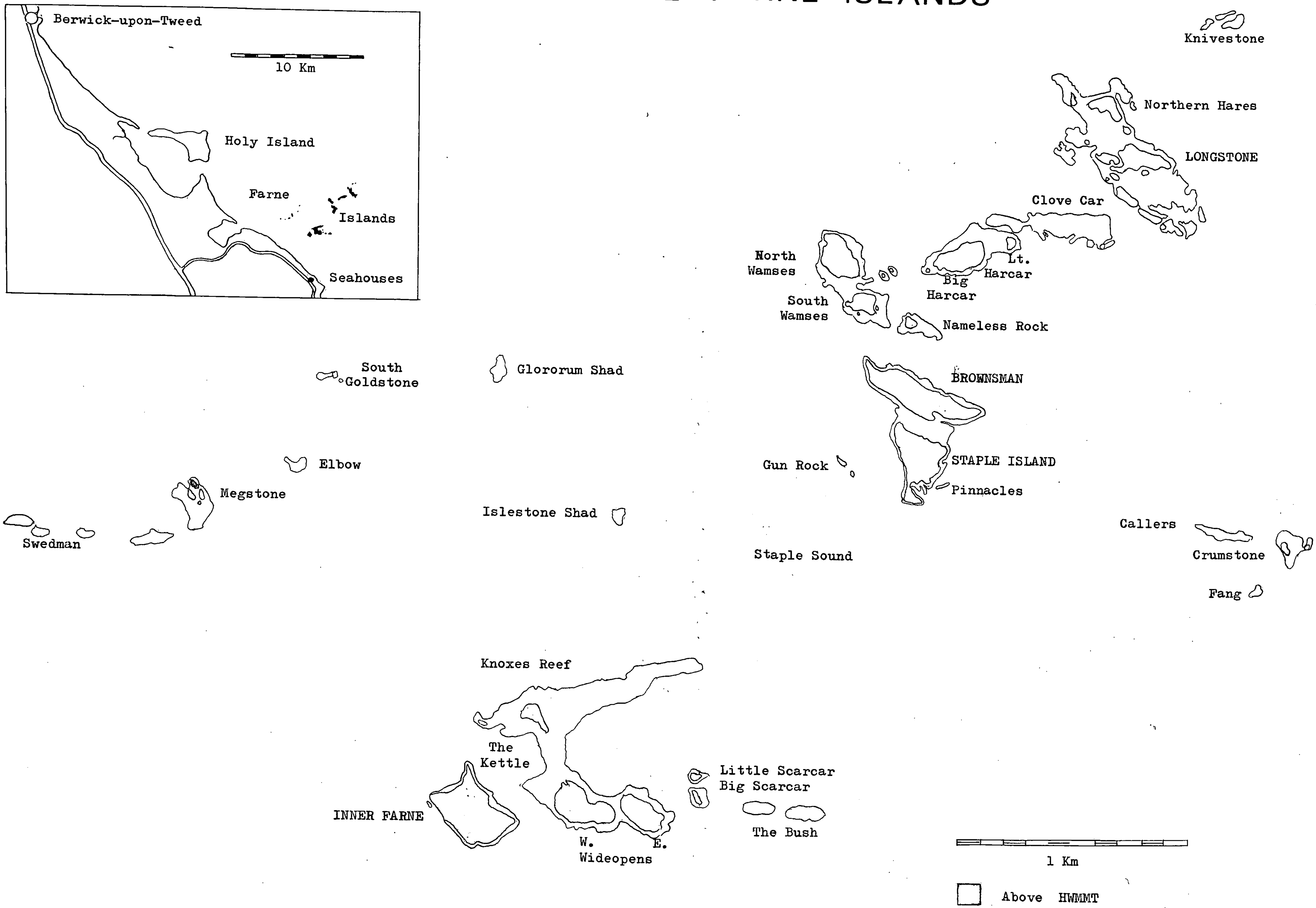
THE FARNE ISLANDS



THE FARNE ISLANDS

MAP 1

1. Introduction

The Farne Islands are internationally renowned for their large populations of breeding sea birds and as a breeding station for a rapidly expanding population of the Atlantic Seal (*Halichoerus grypus*) which represents at the present time more than 10% of the world population of this species.

Increased protection this century has resulted in an increase in the levels of breeding species, both birds and seals, but this appears to have resulted in a shift in the heterotrophic/autotrophic balance leading to a loss of vegetation and subsequent erosion. This is becoming a serious threat to the continued breeding of species requiring soil and plant cover.

Moreover the continued loss of soil will also result in the loss of an example of soil development on offshore islands and the vegetation it supports which is of much scientific interest.

The seal population is of concern to the coastal salmon fishery and a significant cull has been asked for in Parliament.

Day visitors to the islands have increased to such an extent that in future years numbers landing may have to be restricted.

In a general account of the Islands, Watt G. (1951) the vegetation is not described but a list of Farne Island plants collected by T.R.Goddard appears in an appendix together with a list of plants which have disappeared since 1857. In the bibliography of over 100 references only 3 refer specifically to plants.

This dissertation attempts to provide

(1) a map for each island giving the present plant cover and where possible an indication of the former areas of soil cover, the measurements taken from a base line which can easily be relaid so that comparative measurements can be made in the future.

(2) an account of the present vegetation of each island with quantitative measurements where possible, and applicable photographic cover which may be of use to future workers. (Phytosociological methods could not be employed on the Inner Farne due to the nesting terns, or on Wideopens due to the vulnerability of nesting puffins).

(3) To collate the information relating to the recent loss of plant cover.

(4) to examine the pollen spectrum in order to correlate the history of the vegetation during the formation of peat with the extant vegetation.

(5) to outline the conservation problem and to attempt to assess the climatic and biotic factors responsible for erosion.

(6) to initiate some long term studies relating to plant succession and soil cover on two of the islands. These are studies which I hope to pursue in the future in order to provide a measure of guidance for the Farne Islands Management Committee.

2 Position: geology, topography and soils.

The Farne Islands lie off the Northumberland coast in a line which extends for a distance of 6k from east to west. The number of islands varies from 15 to 28 according to the state of the tide.

The nearest point on the mainland is Monk's House and from here the nearest island is the Inner Farne 2.5k, while Knivestone the outermost island is almost 7k from this point.

The islands may be divided into 3 groups, the inner group, consisting of the Inner Farne, Wideopens and Knocks Reep, the middle group consisting of Staple Island, Brownsman and the Wamses separated from the inner group by Staple Sound, and the outer group, Longstone and the Northern Hares. These are to some extent connected to the middle group by Big and Little Harcars. The Megstone and Crumbstone are two outliers to the West and East respectively.

Geology and Topography

The Farne Islands represent the most easterly exposure of the Great Whin Sill which stretches across Northumberland and Durham and are composed almost entirely of this hard quartz dolerite. The islands apparently represent several sills situated on different horizons and although the dip of the whin surface varies from island to island the general pattern is a slope from SW to NE so that the cliffs on the larger islands are on the southern side. The highest of these, 20m above the mean sea level, occur near the lighthouse on the Inner Farne (Plate 1) and along the SE of Staple Island. The Pinnacles, a group of 17m stacks, (Plate 2) are situated just off the east cliffs of Staple.

The Inner Farne has a stack on the south side and a blowhole, the Churn, reputed to be capable of a spout 30m high. The Whin Sill of this island is particularly well fissured and includes St.Cuthbert's Gut, Churn Gut and Churn fissure all running roughly 30° west of north.

Stratified rocks occur in 4 places, two on Brownsman, one on Nameless Rock and the other The Bridges to the east of the Kettle which connects the Wideopens to Knocks Reef and is only uncovered at low tide. Glacial striae may be observed on a number of the islands and these run approximately ESE.

Deposits of glacial drift material occur on the Inner Farne, Staple Island Brownsman and West and East Wideopens. On Staple Island this deposit is some 4m thick consisting of a reddish clay containing boulders of Silurian greywackes, porphyrites and Carboniferous sandstones. (Gunn W. 1927) This deposit forms a wide plateau running down the entire length of the island Plate.

Soils

A peaty soil has developed especially where the glacial deposits overlie the quartz dolerite. This soil is rarely more than 30cm thick though this may be thicker in various areas of the Inner Farne. Much of this island has been ploughed and the aerial photograph (Plate 1) shows ridge and furrow across much of the island. Soils profiles in this area (Brown N. pers. comm.) lack the clear transition between organic peat and the underlying glacial drift which is seen on other parts of this island.

Peat has developed directly on the Whin Sill on the N. and S. Wamses, Big Harcar and Longstone though much of this has now been lost. These peats tend to be darker than those developed over the drift material and also to be more susceptable to water logging. All soils have been considerably enriched with guano.

Soil studies are treated more fully in Section 10.

3. History and Land Use

This can be conveniently divided into two sections (a) until 1925 and (b) after 1925.

(a) The salient points have been taken from Watt G. 1951.

Flint harpoons and arrowheads found on the Inner Farne indicate that this island was inhabited before the 7th century. It was visited by Bishop Aidan in 651 and St. Cuthbert lived as a hermit on this island between 676 and 685. He is believed to have protected some of the nesting birds including the eider duck - St. Cuthbert's duck, perhaps the first recorded attempt to conserve wild life.

Apparently a succession of hermits followed St. Cuthbert and sheep were kept on the island in the 12th century. About 1160 King Eistan from Norway who had raided the islands was living on the Inner Farne. He was followed by a small community of monks who grew barley (as much as 3 acres) and kept a variety of stock. This was the position until the dissolution of the monasteries in 1536. Prior Castell's Tower (Plate 1) was completed in 1500. The chapels of St. Mary and St. Cuthbert are much older buildings.

After 1536 the islands were granted to the Dean and Chapter of Durham and the tower was used as a fort. In the reign of Charles 11 the first official lighthouse was built on the Inner Farne and later beacons were established on Staple and Brownsman, the remains of which still exist.

During the 18th century the islands were rented by a number of people who used them for grazing stock and at the same time exploited the seabirds and seals. In 1809 two oil fired lighthouses were built, one on the Inner Farne and one on Brownsman together with adjacent cottages for the keepers but in 1826 a lighthouse was built on Longstone and the one on Brownsman demolished. According to Tate G. (1857) the island was grazed at various times by sheep, goats, cows and ponies but they left about 1855.

Most of the published material relating to the Farnes during the Victorian era deals with the details of egg collection and shooting parties which set out by hired boats from Newcastle and shot the cliff nesting birds from the sea. By 1880 the first Bird Protection Act was passed and a then recently formed Farne Islands Association stationed watches on the islands. The watchers were paid from the landing fees of the visitors and egg collecting was certainly much reduced.

In 1922 the Rev. Thorp proposed to sell the inner group of islands which he owned, and at the same time Lord Armstrong who owned the outer group offered to sell his as well if enough capital could be raised to buy all the islands and give them to the National Trust. The necessary £2,000 was raised as a result of a public appeal and they were duly purchased and handed to the National Trust in 1925.

(b) Current Use.

Since 1925 the islands have been maintained solely as a nature reserve. A study centre was set up on the Inner Farne and a considerable amount of research carried out mainly on the seabird populations of the Inner Farne, Staple Island and Brownsman.

National Trust Watchers have been employed during the breeding season (May to August) on the Inner Farne and Brownsman. Visitors are allowed to land on the Inner Farne, Staple Island and apparently the Longstone Lighthouse area. The main duties of the watchers are to supervise day visitors, collect the landing fees and ensure the minimum of disturbance to the wildlife. In spite of an increase in the number of watchers their task becomes increasingly difficult due to the continuing rise in the number of day visitors see Fig. 14. This factor is discussed later.

The grey seal <u>Halichoerus grypus</u> has been extensively studied by workers of Durham University and more recently by the Seal Unit of The Nature Conservancy.

The general administration is carried out by a number of Farne Island Committees and in 1970 a Warden Naturalist was appointed to take charge of the day to day administration and general supervision of the islands. New craft have been provided for the watchers as well as the warden so that the policy of conservation may be more efficiently carried out.

Plate 1. Inner Farne.

Note ridge and furrow system.

Photo. Philpson & Son Ltd. Jan 1956.

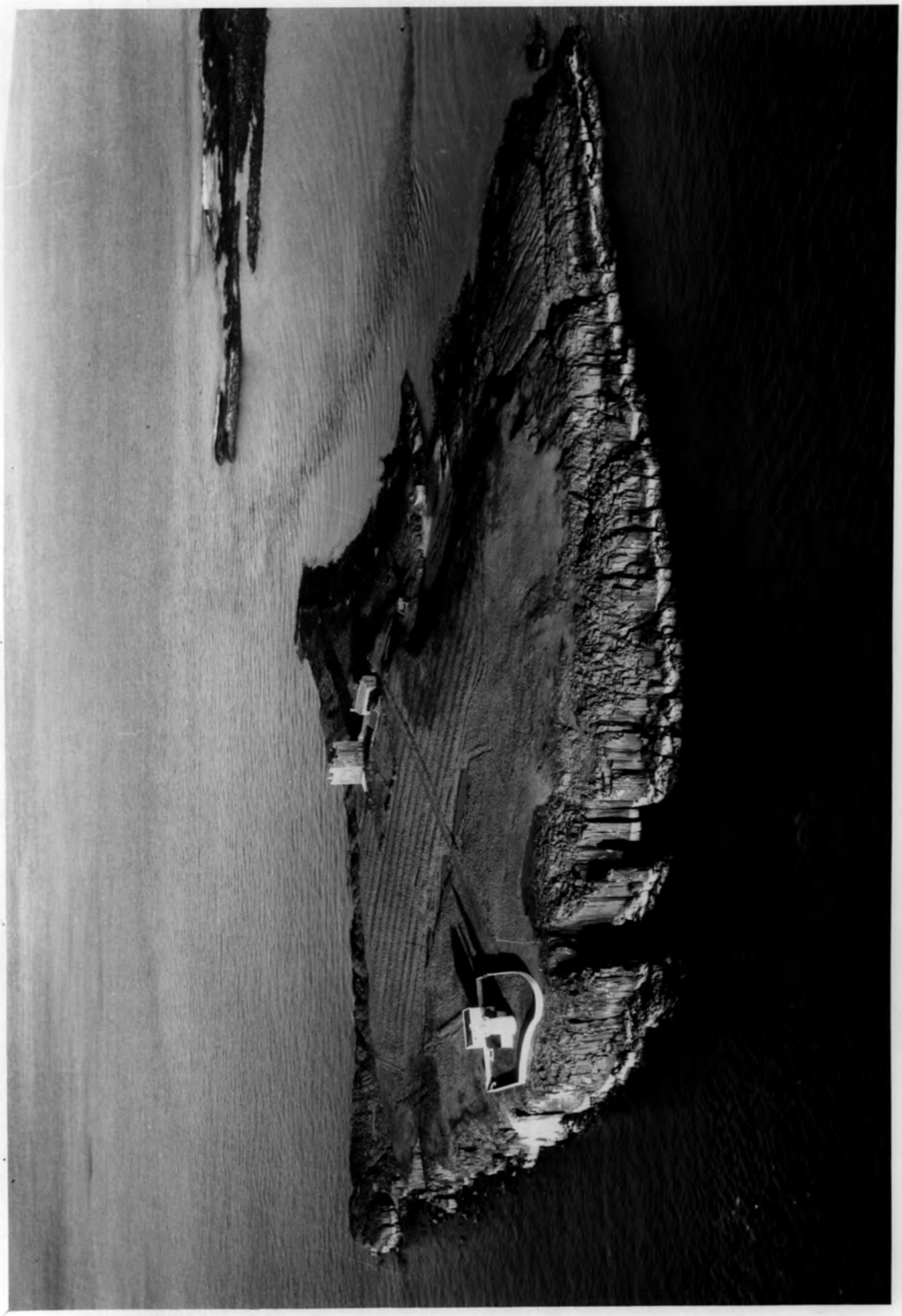
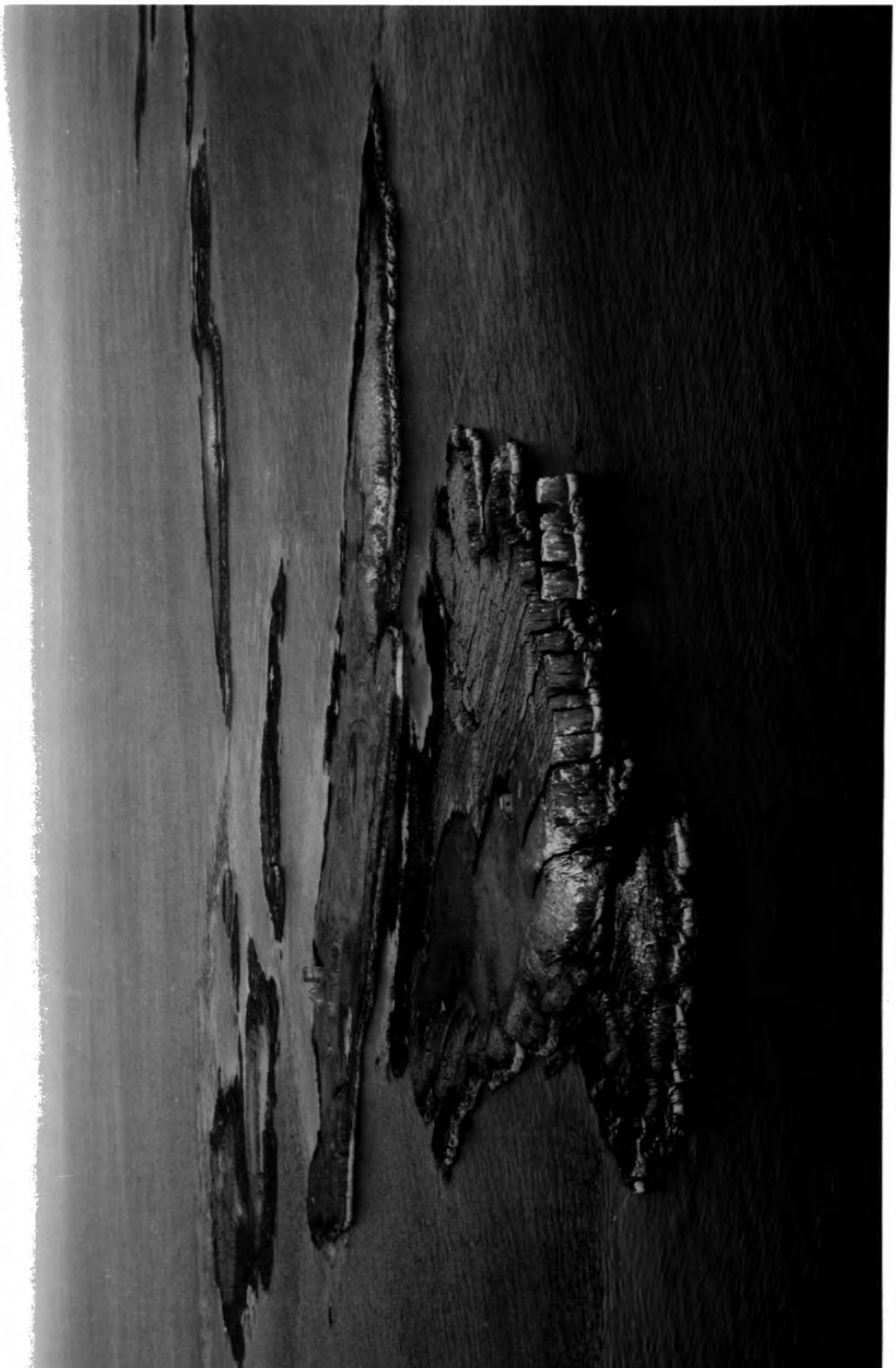


Plate 2. Middle and Outer Farne Islands.
foreground Staple Island, middle distance
Brownsman, far distance Wamses, Nameless Rock,
and Harcars. Photo. Philipson & Son Ltd. Jan. 1956.



4. Climate

1. Temperature

Like most offshore islands the climate tends to be less extreme than that of the adjoining mainland - the average temperature at the Farnes in summer being slightly lower and in winter slightly higher. The average minimum temperature recorded at Longstone Lighthouse is greater throughout the year than on the mainland and frosts are rare.

2. Rainfall

No rainfall is recorded at Longstone and rainfall records for Seahouses are only available since 1964 so I have used those of Berwick-on-Tweed Meteorological Station. Detailed recordingd for years 161 - 1970 will be found in Appendix I.

Total rainfall for years 1961 - 70

Year	Inches
1961	22.88
1962	24.95
1963	29.22
1964	18.64
1965	28.50
1966	26.34
1967	24.72
1968	23.58
1969	22.02
1970	22.9

The mean annual rainfall is therefore less than 25 inches and it is probable that the Farnes received even less rainfall.

The mean monthly rainfall over this same period is given in Fig. 1.

Coastal fog and mists are a common feature. During 12 years 1942 - 54 between 549 and 1,354 hours of fog per year were recorded. Trans. N.H.S. (1960)

This moist atmosphere will have an important bearing on the vegetation. Though the rainfall is low, moist conditions are likely to prevail except during prolonged dry spells in the summer months.

3. Wind

This may be the most important climatic factor affecting the vegetation and soil cover.

Wind-roses from data collected at Longstone Lighthouse are given in Fig. 2.

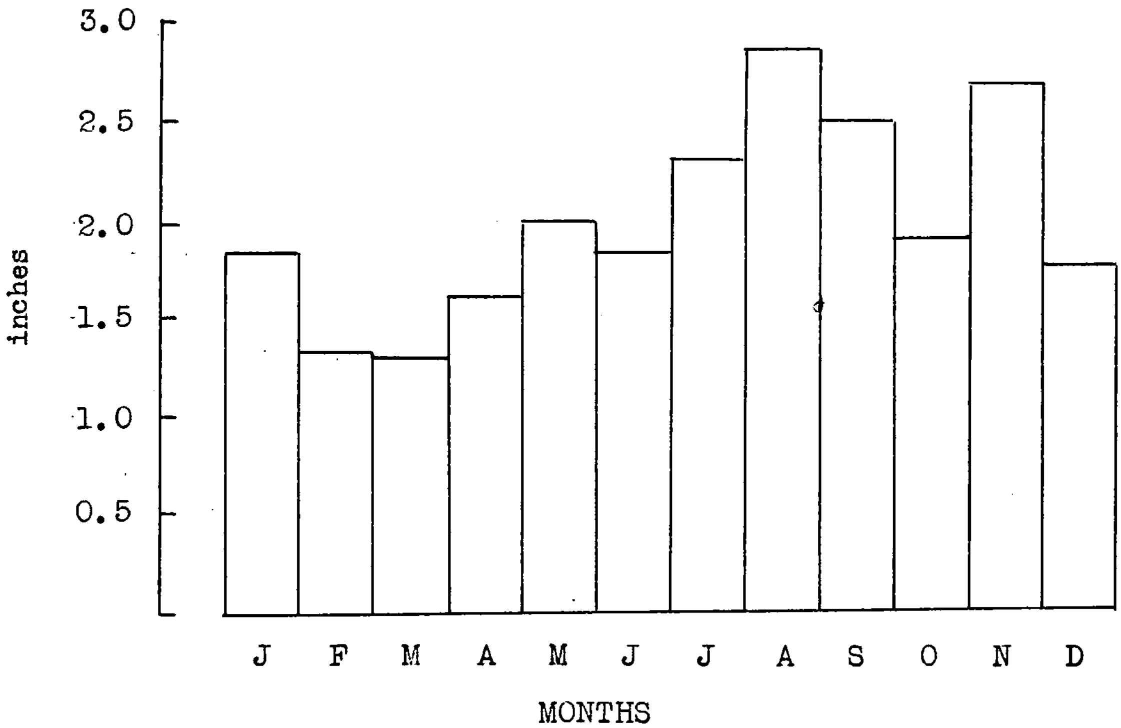


Fig. 1. Mean monthly rainfall from 1961-70
Berwick-on-Tweed

The prevailing winds are from the west, only a small percentage blowing from NE to SE.

The number of gale days, Beaufort scale 8 and 8+, 1966 - 70 were recorded from Longstone as follows:-

Months	1966	1967	1968	1969	1970
Jan.	2	0	2	0	2
Feb.	1	5	1	2	3
March.	4	0	3	2	3
April.	0	1	0	0	1
May.	1	1	0	0	0
June.	0	0	0	0	0
July.	0	0	0	0	0
Aug.	2	*	0	0	1
Sept.	2	1	0	1	2
Oct.	0	7	0	0	3
Nov.	5	3	6	6	5
Dec.	8	4	3	1	1
Total	25	22	15	12	21

* No records available

Mean number of gale days per year during this period - 19

Few gales occur from April to August but it is the gales which do occur during this period which adversely affect the vegetation. After a gale in June 1960 much of the vegetation was blackened and shrivelled. Trans. N.H.S. (1960)

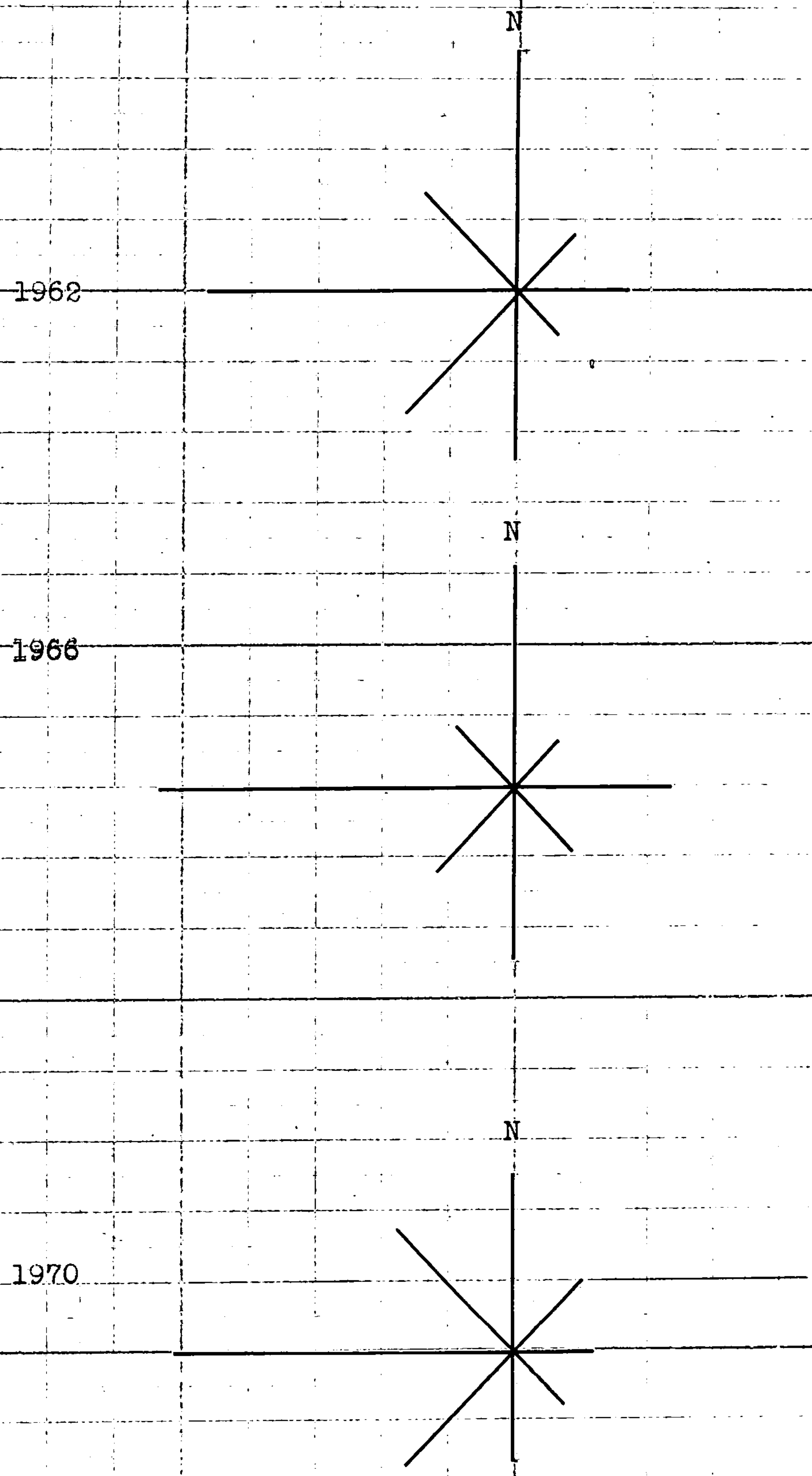


Fig. 2. Wind - roses for Longstone Lighthouse for 1962, 1964 and 1970.
Observations were taken 4 times daily.
1 square represents 4 observations

5. The Vegetation of the Farne Islands.

The islands are completely exposed and the largest, the Inner Farne, is only 6.5 hectares in extent and the tallest cliffs, also on this island, are not more than 30m high therefore any vegetation out of reach of the tides will be affected by the spray. No trees grow on the islands except a few stunted Sambucus nigra planted on the Inner Farne.

Apart from excessive exposure there is a second major factor affecting the plant communities - the deposition of large amounts of guano from the breeding colonies of sea birds.

Soil cover has already been referred to. Two of the island groups, Inner Farne together with Wideopens, and Staple Island with Brownsman have a peat cover overlying a drift deposit of clayey soil but on the other islands peat has been able to accumulate on the bare Whin Sill.

The list of species for each island 1971 is given in Table 1. The Farne Island list of plants published Watt G. (1951) is given in Appendix II. and plants which had disappeared between 1857 and 1951 are listed in Appendix III

The flora of these islands may be summarized as follows:-

(1) The Inner Farne.

Gramineae sp. predominate together with a number of halophytes, the most important being Silene maritima, and several ruderal species. The vegetation has probably been modified by agriculture and until recently was grazed by rabbits. There was probably a Festuca grassland community when agriculture ceased last century but maritime grassland can exist in the absence of grazing Tansley (1939).

(2) Wideopens.

Little cover by Gramineae sp. otherwise the plants are mostly those which are typical of the Inner Farne.

(3) Staple Island and Brownsman.

A closed vegetation consisting of Silene maritima, Stellaria media and Atriplex glabruiscula (some Gramineae cover on Staple).

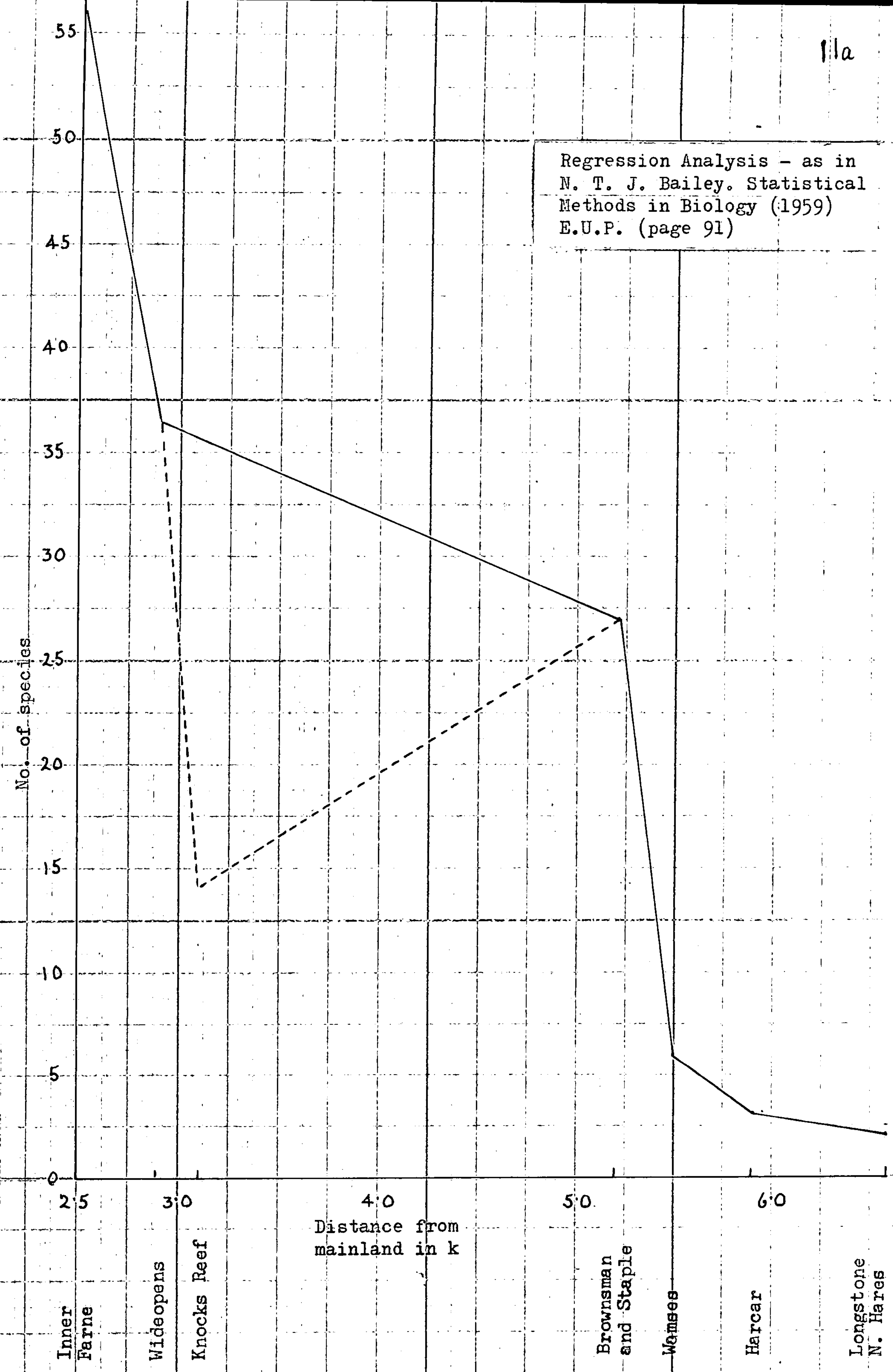
(4) The smaller islands -

Wamses, Harcar and Longstone have supported a maritime grassland type of vegetation but this has largely disappeared.

The list of species for each island Table 1. is arranged according to the distance of the island from the mainland. This table suggests that the number of species on each island declines with increased distance from the mainland.

These have been plotted Fig.1. Regression analysis shows evidence of a relationship between the number of species and distance from the mainland ($P < 0.001$).

Knocks Reef was not included because 90% of its vegetation disappeared when the storm beach was destroyed in 1953. A. Rutter (pers. comm.). At the present time, June 1971, it has been colonised by 14 species of plants which is only one less than the number recorded on Staple Island which has 22x greater vegetation cover.



Plants

Relationship between No. of species and distance from mainland ($P < 0.001$)

Fig.3

	Inner Farne	Wideopens	Knocks Reef	Brownsman	Staple	South Wamses	North Wamses	Harcars	N. Hares	Longstone
Ranunculus repens	x									
R. ficaria	x			x						
R. sceleratus		x		x						
Capsella bursa pastoris	x	x		x						
Sinapis alba				x						
Cakile maritima	x									
Cochlearia officinalis	x	x		x	x			x	x	
C. danica				x						
Silene maritima	x	x	x	x	x	x	x			
Cerastium holosteoides	x									
Stellaria media	x	x		x	x					
Sagina procumbens	x									
S. maritima	x			x						
Spergularia marina	x	x	x	x	x					
Chenopodium album		x								
C. rubrum	x	x		x	x					
Atriplex patula	x	x								
A. glabruiscula	x	x	x	x	x			x		
Trifolium repens	x									
Lotus tenuis	x									
Potentilla anserina	x	x	x							
Epilobium hirsutum	x									
Callitriche stagnalis					x					
Conium maculatum	x	x								
Polygonium aviculare	x		x			x	x			
Rumex acetosa	x	x		x						
R. crispus	x	x	x		x					
R. obtusifolius	x	x	x	x						
Urtica urens	x	x		x						
U. dioica	x	x		x						
Armeria maritima	x									
Primula vulgaris	x									
Glaux maritima	x	x		x	x					
Anchusa arvensis	x									
Myosotis arvensis	x	x								
Amsinkio intermedia	x									
Plantago coronopus	x	x								
Galium aparine	x	x	x			x				
Sambus nigra	x									
Senecio jacobaea	x	x								
S. vulgaris	x	x		x						
Bellis perennis	x	x								
Matricaria matricarioides	x	x		x						
Arctium nemorosum		x								
Cirsium vulgare	x	x								
C. arvense	x	x		x	x					
Sonchus asper	x	x		x						
S. oleraceus	x	x	x							
Taraxacum officinale	x		x							
Juncus gerardii	x									
J. bufonius	x	x		x						
Iris pseudocorus	x									
Eleocharis sp.	x									
Festuca rubra	x	x		x	x	x	x			
F. ovina	x	x								
Lolium perenne	x	x	x		x					
Puccinellia rupestris	x		x		x	x	x	x	x	x
Poa annua	x	x		x	x					
P. pratensis	x	x								
P. trivialis	x			x						
Holcus lanatus	x	x				x	x			
Agrostis stolonifera	x									
Agropyron junceiforme			x							
Elymus arenarius			x							
Hordeum vulgare			x		x					
Triticum aestivum					x					

Table 1. Plants of the Farne Islands

Table 1.

Plants of The Farne Islands.

Lichens

Black Zone (lower)	*	Verrucaria maura
	*	V. mucosa
Yellow Zone (middle)	*	Caloplaia granulosa
		C. marina
		Xanthoria lychnea
	*	X. parietina var. aureola
	2	Lecanora spp. (to be determined)
Grey Zone (upper)	*	Ramalina siliquosa
		R. subfarinacea
		Acarospora fuscata
		Anoptychia fusca
		Buellia canescens
		Lecanora atra
		L. dispersa
		L. gangaleoides
	*	L. heliopsis
		L. rupicola
		Lecidea sulphurea
		L. albocoerulesiens
		Ochrolechia parella
		Opegrapha saxicola
		Parmelia sulcata
		Xanthoria parietina
	*	Xanthoria aureola

* also recorded on Brownsman

The grey zone is well developed on the Inner Farne and walls and buildings on Staple and Brownsman.

The outer islands are swept with spray therefore there is no potentially grey zone.

6. The Inner Farne

Maps 2 and 3. This is the largest of the Farnes, approximately 6.5 hectares above H.W.M.N.T. of which nearly 3 hectares has some form of terrestrial vegetation and 2.3 hectares has a continuous soil cover overlying a drift deposit.

The vegetation is the most diverse in species of all the islands (Fig. 1 and Table 2). It appears that only minor variations occurred between 1953 and 1965 except that (a) Rumex obtusifolius spread southwards replacing Silene maritima which in turn invaded the Festuca Agrostis community in the lighthouse area, W.B.H. Sowerby (pers. comm.).

In 1964 Mrs.G. Hickling reported an increase in Senecio jacobaea, Urtica dioica and Rumex sp.

Since this time 2 measures have taken place which must have had, and will continue to have, a profound effect upon the plant communities.

(1) The extermination of the rabbit population.

In September 1968 48 rabbits were snared by the lighthouse keepers and in early October 100 were killed by the Divisional Pest Officer and his staff. They returned 3 weeks later and the remaining 40 were killed.

(2) It appears that weed killers were used from 1964 onwards, and in 1970 and again in 1971 Farmon Condox was used to 'control' Rumex species, especially Rumex crispus and Rumex obtusifolius. I am unaware of any quantitative data relating to the effects of these herbicides.

Results of a survey June 1971.

It was impossible to carry out detailed phytosociological studies in June and July (1971) due to the nesting terns principally Sterna paradisaea but also smaller colonies of S. hirundo, S. sandvicensis and S. dougallii see overlay on Map 3.

The enlarged paths were mapped and as far as possible the vegetation listed for each area (Table 2 and Map 3), with a tentative cover value on a 5 point scale.

List of species for each area is given in Table 2.

Area A (Maps 2 and 3 and Plates 3a and 3b).

This area in 1968 consisted of a Silenetum and Rumicetum. The latter area A1 is now dominated by Gramineae species as the Rumex crispus together with Rumex obtusifolius have largely been destroyed. Urtica dioica is spreading southwards especially from the area adjacent to the path leading to the jetty. The Silenetum A2 which is also the site of the East puffin colony is perhaps the simplest community now extant on the Inner Farne. A3 to the south of North Pond is dominated by Potentilla anserina with an adjacent strand A4 of Rumex crispus.

Area B. The Meadow (Maps 2 and 3)

Still exhibits ridge and furrow formation. Rumex acetosa appeared to be more abundant on the ridges.

An area apparently not treated by herbicides and dominated by Holcus lanatus, Rumex crispus and Rumex acetosa.

Area C. The Garden (Maps 2 and 3)

This area formerly an open area in 1958 (own notes) is now dominated by Holcus lanatus and Urtica dioica. Species such as Myosotis arvensis, Potentilla anserina and Cochlearia officinalis are reduced to a few etiolated specimens between the dominant species and the walls. A group of Anchusa arvensis occupying less than $1m^2$ is 'conserved' by removing all the nearby Holcus lanatus and Urtica dioica.

Area D. (Map 3)

An area dominated by Urtica dioica.

Area E. North Enclosure (Maps 2 and 3)

Dominated by Gramineae species together with Urtica dioica and Rumex acetosa with ruderal species close to the walls and buildings including Amsinckia intermedia.

This plant which now grows on all sides of 'Prior Castell's Tower is a Californian weed believed to have been introduced in chicken corn by the lighthouse keepers. It has become established and is spreading. First reported in 1923 Druce G.C.

Area F. (Map 3)

An open area with Silene maritima and Rumex acetosa in 1958 (own notes), now > 80 cover chiefly Urtica dioica and Conium maculatum with Rumex acetosa. Area formerly burrowed by rabbits.

Area G. (Map 3)

This includes St. Cuthbert's Gut and Whin Sill with incomplete soil cover.

Area H. (Map 3) Stellaria Zone

This includes a new public path (1971) and also reaches to the HWMMT on the NW.

The dominant species in the new path were Holcus lanatus, Agrostis stolinifera and Festuca rubra. By 9.7.71 all cover had almost disappeared due to 'wear' by the visitors.

Area I. Area adjacent to W. Puffin Colony. (Map 3)

(Low Light Sight)

This area was studied by W.B.H. Sowerby in 1955 and 1962. A copy of the results he obtained is given in Appendix IV.

Area J. West Puffin Colony (Maps 2 and 3)

This is the former site of some cottages and the soil is mixed with quantities of anthropogenic debris. Characterised by typical maritime cliff species together with ruderals.

Area K. Graminetum open to the public. (Map 3)

A significant change since the disappearance of the rabbits has been the replacement of Armeria maritima (own notes and photograph 1956) with Festuca rubra. This will be discussed later.

Area L. Cliffs on the South side of the Island (Map 3)

This area appears to have changed little since 1958 (own notes). The species list only contains one addition Capsella bursa-pastoris.

Area M. (Map 3)

This area is of special significance as it has been treated with Farmon Condox - to destroy the Rumex community.

In the run off at the junction of K and L a small community occurs consisting of Juncus gerardii with Festuca rubra and Holcus lanatus.

Mature plants of Rumex crispus and Rumex obtusifolius have been destroyed but 'drifts' of seedlings of Rumex sp. were evident.

The only other replacement seedlings were Urtica dioica.

Species which did not appear to have been adversely affected by the herbicide were Sonchus oleraceus, Sonchus asper, Poa trivialis and Holcus lanatus.

Silene maritima had suffered to such an extent that any plants which remained would not produce seed during 1971.

At a point just SE of Fishe House is a run off with a community dominated by Iris pseudacorus which flowered freely, June 1971. In this community is a group of Epilobium hirsutum a plant not before found on the Inner Farne. Cakile maritima has colonised the upper area of the sandy beach adjacent to this area.

Close to the doorway of the Fishe House is a typical scrambling growth of Galium aparine .75m high. This plant also occurs in a prostrate form on the pebble beach of W. Wideopens and S. Wamses. It was recorded by Watt G. (1951) as one of the plants which had disappeared since 1857.

Ponds (Maps 2 and 3)

High Pond, Middle Pond and Low Pond. These had completely dried out 1.7.71., they were also without water in June 1958 (own notes) and I understand from watchers that this is an annual occurrence during the summer months.

The bed of each pond had a partial cover of Juncus bufonius with germinating Atriplex glabruiscula. High Pond also had a zone of Juncus gerardii around the northern perimeter together with an Eleocharis species (not flowering).

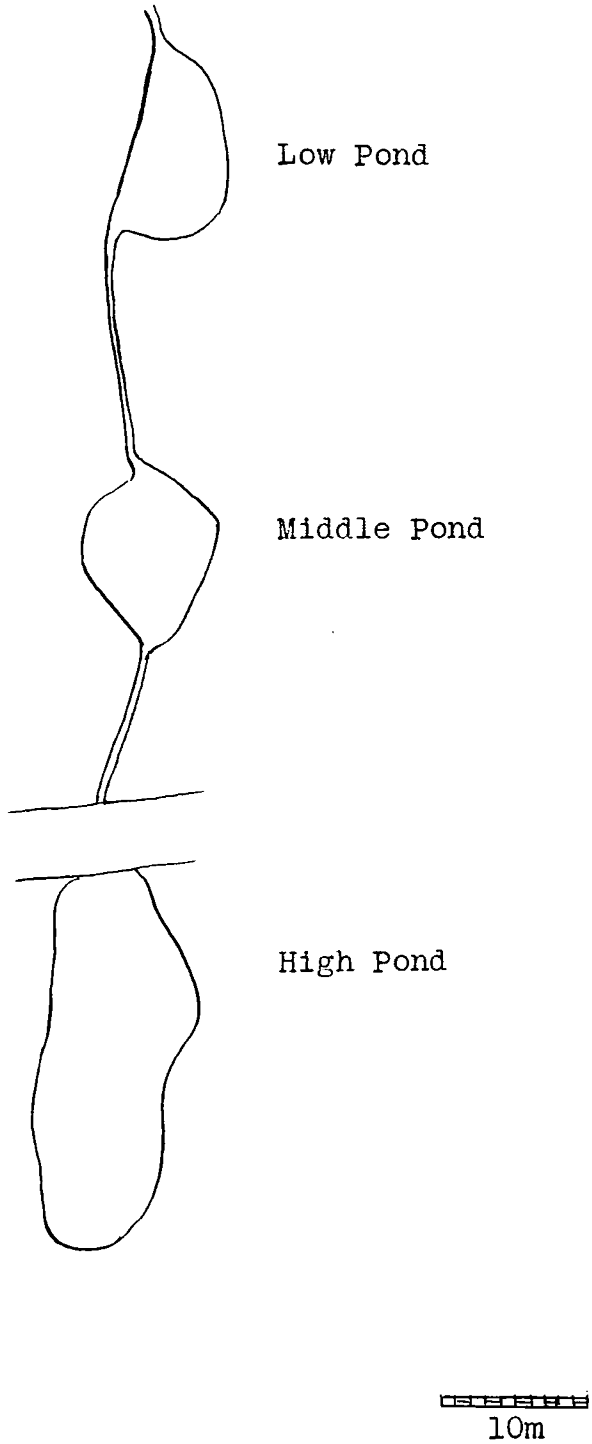
These were mapped Fig. 4 to ascertain any change in size which might occur in future years.

Gulls, apart from Rissa tridactyla on the steeper cliffs, do not breed on the Inner Farne, neither do seals frequent the island. The 2 puffin colonies (Map 3) are reported not to have commenced until the end of last century (Brown N., pers.comm.).

The Vegetational Changes on the Inner Farne.

In the 19th century at the time of the discontinuance of grazing by domestic animals the island may well have been Festuca grassland. Presumably rabbits also existed at this time, their numbers being controlled in a density-dependent manner by their food supply in winter.

Inner Farne



12.7.71 These pond were dry.
No trace of Ranunculus trichophyllum,
R. Baudotii or Spiraea ulmaria

Fig. 4

Sowerby W.B.H. (per. comm.) states that the vegetation of the Inner Farne remained fairly static between 1953 - 65 except for the spread of Rumex obtusifolia into the Silenetum and the spread of Silene maritima into the Graminetum near the lighthouse. This coincides with the area occupied by expanding colonies of terns especially Sterna paradisaea. Such a colony would increase the guano content of the soil but the treading and sitting of these species during the breeding season would have far less effect than a gull species in a similar situation. Any effect of mechanical injury to the plants, however, would be more detrimental to Silene than Rumex.

In 1964 Mrs. G. Hickling reported an increase in "Ragwort, dock and nettles" and it was assumed that this was due to the rabbit population estimated at ca. 130. The effect of rabbits is referred to later but Urtica, Senecio and Rumex species where they have sufficient shelter to enable tall growth to take place, are characteristic of bird communities in temperate latitudes in both the Northern and Southern Hemispheres.

The destruction of Rumex sp. has already been referred to. It appears that this has not resulted in a replacement by Silene maritima but by Gramineae species. This change may have been aided by the destruction of the rabbit population.

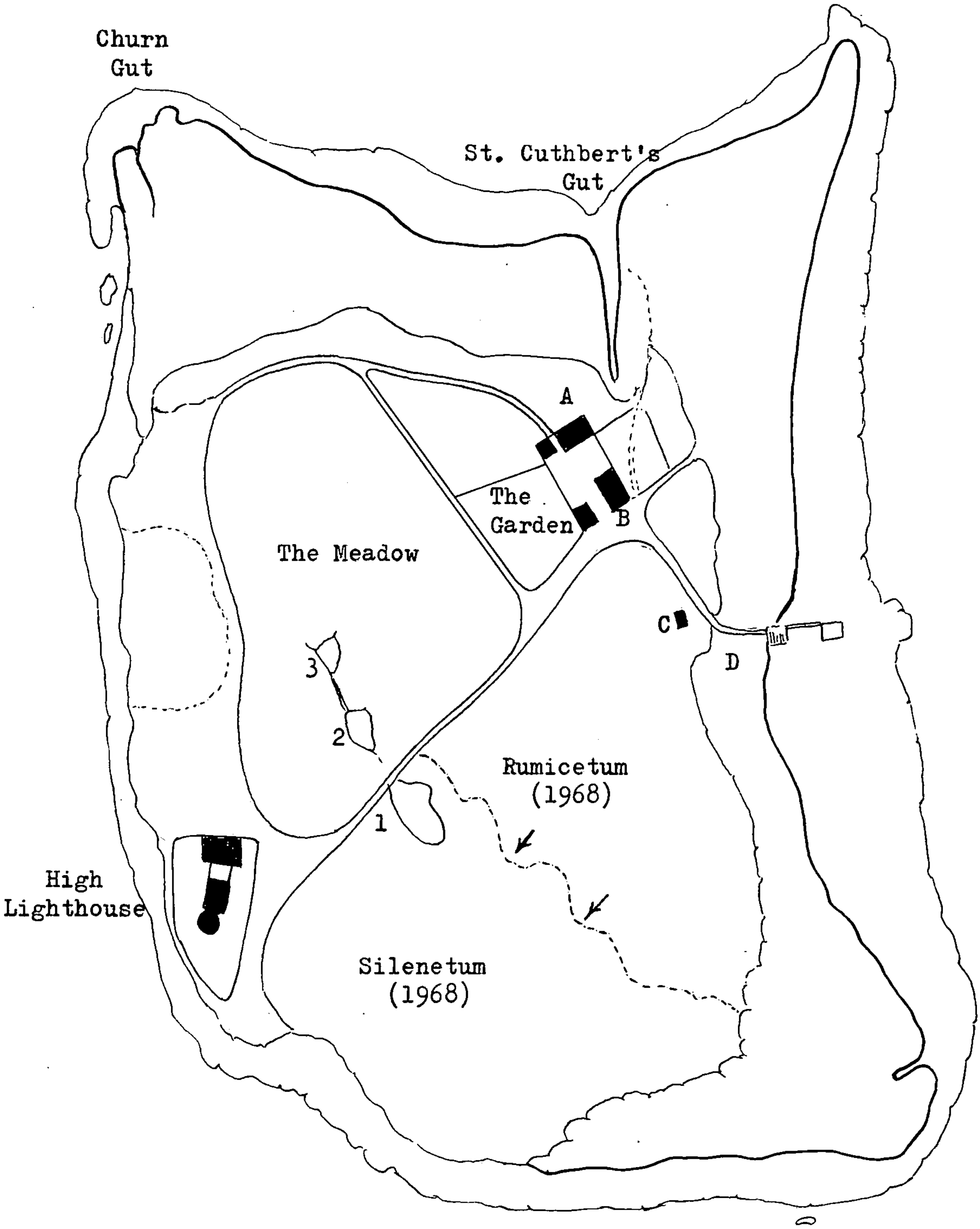
In the area adjacent to the shore line, L, already described, the cover 30.6.71 was very small apart from small Rumex seedlings and as these denuded areas are on a slope of some 45° this may well lead to a loss of soil during the run off from winter storms.

The paths are kept mown with a lawn mower. The 'new' Graminetum following the destruction of Rumex species was also cut during May but the subsequent growth resulted in a grass cover inimical to the Sterna species. Even if they continue to nest in this same area, the chick mortality during a wet fledging season could be increased.

This lack of grazing by rabbits is also evident in other areas. J (Map 3) in 1958 contained a community 7 - 8m long dominated by Armeria maritima (own notes). This community has now been overgrown by Gramineae species especially Festuca rubra. Exclosures on Skokholm Pembs. Gillham M. (1955), have demonstrated that without grazing (by rabbits in this instance) inevitably leads to the exclusion of Armeria by Gramineae species. Some plants on the Inner Farne were cropped by rabbits to such an extent that flowering was almost prevented. Many of these are now in 1971, much more robust and flowering freely e.g. Trifolium repens (Plate 4). The advance of this species into the Graminetum with a pronounced 'edge effect' is illustrated in Plate 5.

Before their extermination, the rabbits maintained an open community and a number of small plants including annuals were able to thrive. As many of these were pioneer species they may well have increased consequent upon the destruction of the rabbits but as the aggressive dominants are unchecked many of these minor species will not be able to compete in a closed turf. It is to be expected therefore that in the continued absence of grazing there may be considerable reduction in the number of species.

INNER FARNE



Public areas and paths - June 1971

1. High Pond, 2. Middle Pond, 3. Low Pond

A Prior Castell's Tower

B St. Cuthbert's Chapel

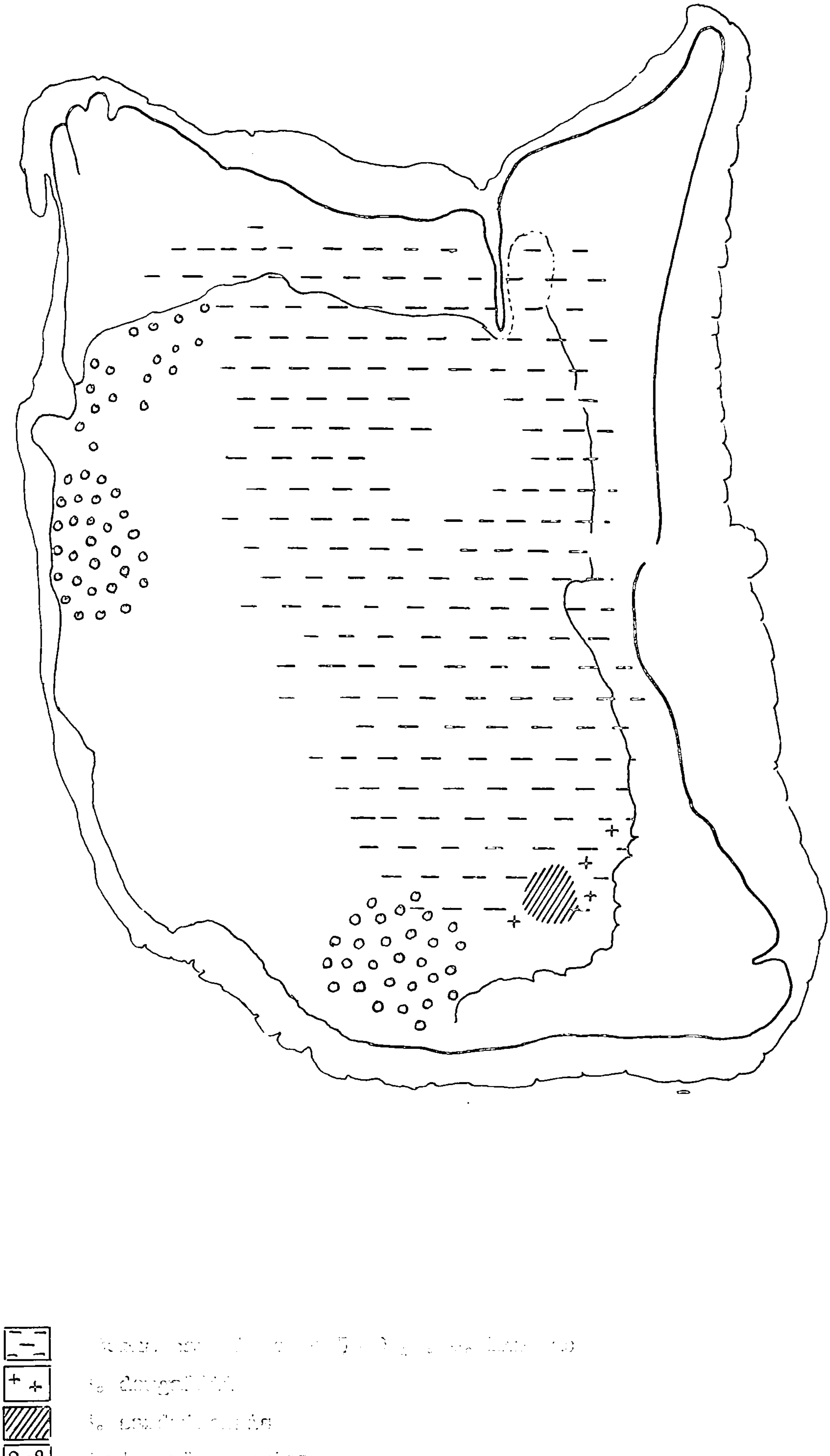
C Fishe House D St. Cuthbert's Cove

HWMMT

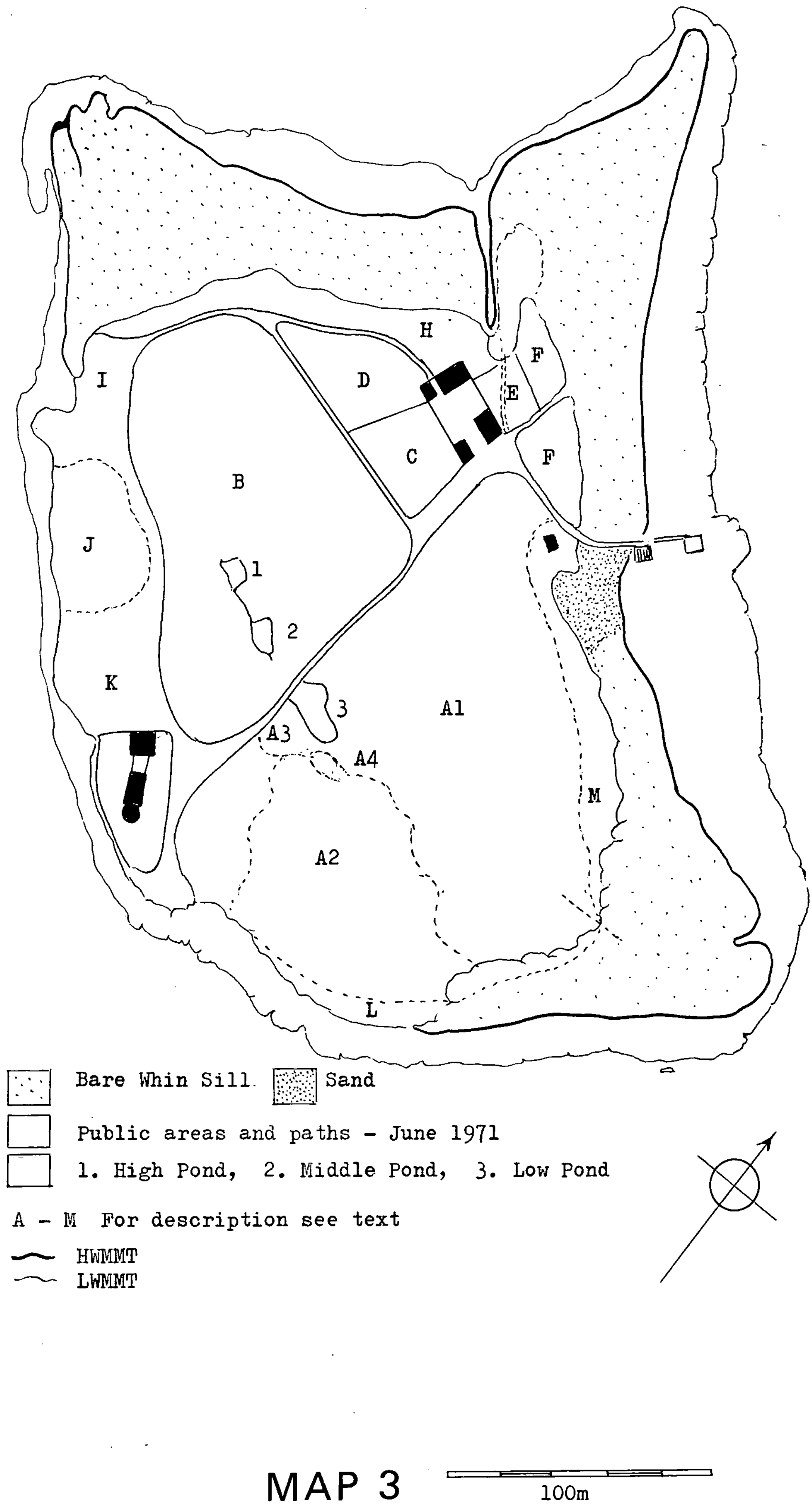
LWMMT

MAP 2

100m



INNER FARNE



MAP 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	Pond
Ranunculus repens	+	+			+		+							
Ranunculus ficaria	+													
Capsella bursa pastoris												+		
Cakile maritima													+	
Cochlearia officinalis			+		+		+							
Silene maritima	2	+		+	+		+			3	+	+		
Cerastium holosteoides	+													
Stellaria media	+				+		+	2		+		+		
Sagina procumbens							+					+		
Sagina maritima												+		
Spergularia marina							+							
Chenopodium rubrum							+							
Atriplex patula				+	+		+			+				
Atriplex glabriuscula								+		+				
Trifolium repens	+				+		+				+			
Lotus tenuis		+												
Potentilla anserina	1	+	+		+		+	+			+	+		+
Epilobium hirsutum													+	
Conium maculatum	+		1	2	+	3								
Polygonium aviculare										+	+			
Rumex acetosa	1	3			2	1								
Rumex crispus	1	2				+		+			+	+		
Rumex obtusifolius		+		+	+		+							
Urtica urens										+				
Urtica dioica	1	+	2	4	3	3								
Armeria maritima							+	+		+	+	+		
Primula vulgaris	+													
Glaux maritima								+				+		
Anchusa arvensis			+											
Myosotis arvensis	+		+		+		+							
Amsinkia intermedia			+		+									
Plantago coronopus							+	+				+		
Galium aparine													+	
Sambus nigra	+		+											
Senecio jacobaea	+	+		+	+		+				+			
Senecio vulgaris													+	
Bellis perennis					+									
Matricaria matricarioides							+							
Arctium nemerosum						+								
Cirsium vulgare				+						+	+			
Cirsium arvense	+	+			+		+				+			
Sonchus asper					+									
Sonchus oleraceus					+									
Taraxacum officinale					+						+			
Juncus gerardii														+
Juncus bufonius														+
Iris pseudocorus													+	
Eleocharis sp														+
Festuca rubra	+	+			+		+	+		+	3	+		
Festuca ovina											+			
Lolium perenne	+	+							+		+			
Puccinellia rupestris								+				+		
Poa annua												+		
Poa pratensis	+	+	+											
Poa trivialis					+							+		
Holcus lanatus	3	3	4		3		+	+		+	1	+		
Agrostis stolonifera	2	+	+					+		+		+		

Table 2. Plants of the Inner Farne 1971 see Map 3.

Cover values on a 5 point scale.

Plate 3. Inner Farne.

'A1' Area from S.W. 1969.

'advancing' Rumicetum _

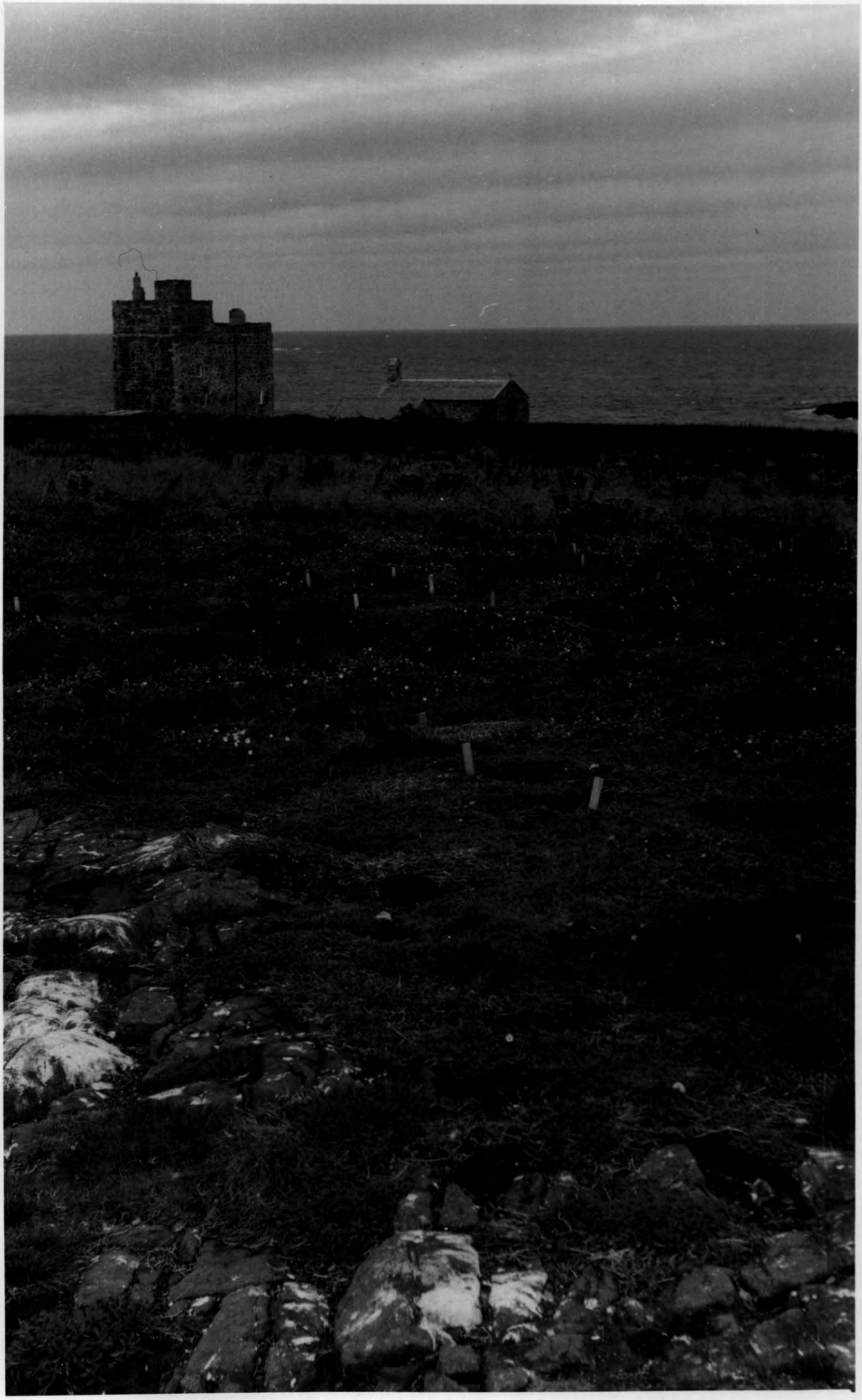


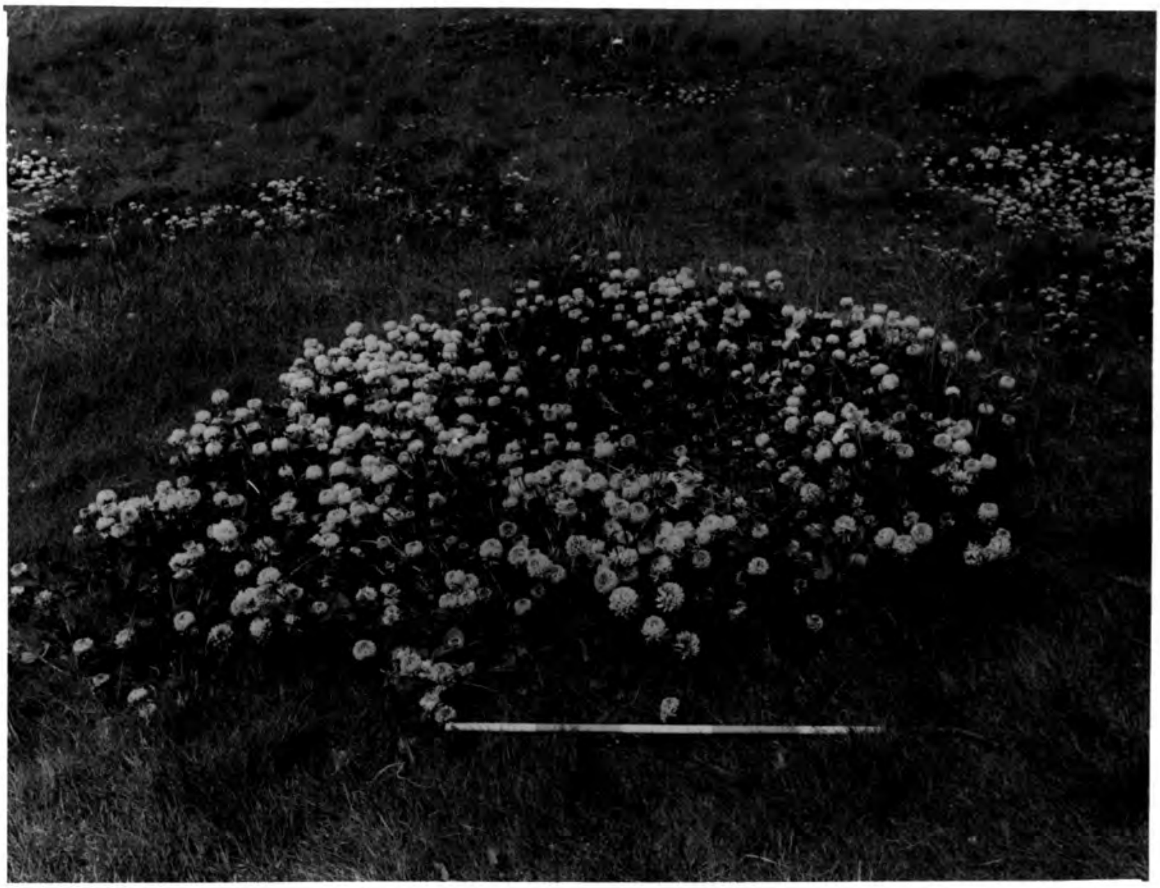
Plate 4. Inner Farne.

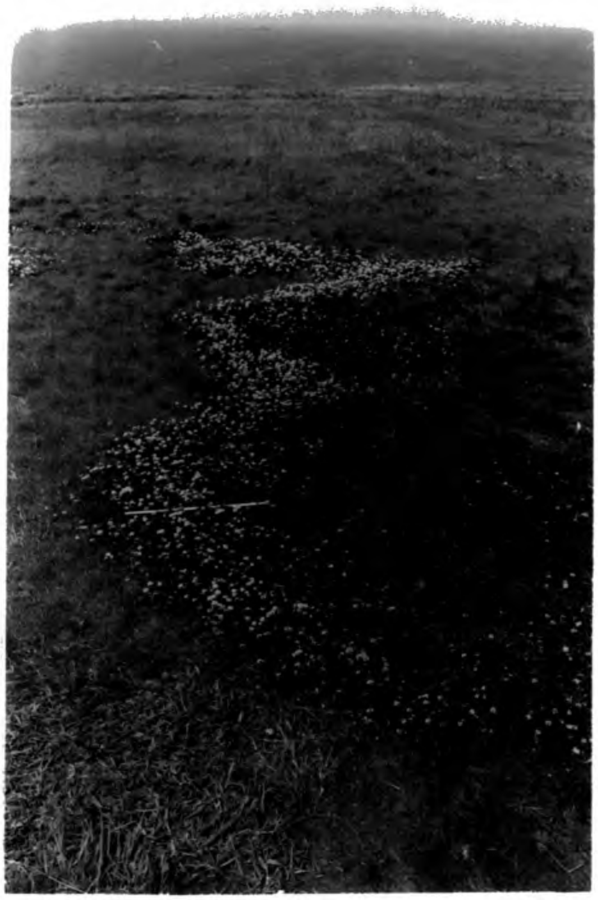
Trifolium repens Effect of lack of grazing by rabbits

rod =0.5m

Plate 5. Inner Farne.

Trifolium repens invading Graminetum. rod = 0.5m





7. East and West Wideopens

Maps 4 and 5. A list of plant species is given in Table 1.

West Wideopen

3 hectares above HWMMT, 47.5% of which has a soil cover composed of peat overlying a drift deposit.

Nearly all the island has been colonised by Larus spp. and Fratercula arctica and there are extensive areas of sheet erosion (plate 6. position marked on Map 5). Areas which appear to be relatively unaffected by these birds supports a luxuriant growth of Conium maculatum, Rumex obtusifolius and Urtica dioica in Places 1.75m high (Plate 7a) These areas are shown on Maps 4 and 5.

The east end of the island has a cover of sand, windblown from the beach, the thickness in some places being 1m. This area supports a different vegetation (Plate 7b) consisting of Urtica dioica, Arctium nemorosum, Senecio jacobaea together with Rumex crispus and Rumex obtusifolius. At the extreme eastern end is a Plantago coronopus sward.

Part of this island was mapped in 1968 by N.Brown during his studies of Fratercula arctica (unpublished). He also carried out a transect and inserted a number of permanent transect markers. (Map 5)

The same area was remapped in July 1971 and the transect redrawn. Some of the resulting changes are shown on Map 5. The recession of the dense vegetation cover over a period of 3 years is indicated and the remaining areas may be compared by reference to the data in Table 3. The new transect - 1971 is superimposed on the 1968 transect in Appendix IV and the data summarized in Table 4.

The original was made using feet and I have used the same measurements for the redrawing of this transect.

In 1968 it could be divided into 5 sections:-

(1) 40 feet, chiefly Silene maritima among the protruding Whin Sill, mean depth of soil 6ins (15cm)

(2) 95 feet, almost devoid of vegetation and with numerous derelict and a few occupied burrows, mean depth of soil 10ins (25cm)

(3) 108 feet, rank vegetation thinning out at each end and dominated by Urtica dioica with Rumex obtusifolius, Rumex acetosa and Silene maritima. Mean soil depth 8.3ins (21cm).

(4) 90 feet across the N. slope, 57% of the transect line bare soil, 20% Gramineae spp. chiefly Poa with some Silene maritima. Mean soil depth 11.8ins (30cm)

(5) 35 feet of dense vegetation described above, mean soil depth 8.5ins (21cm)

Sheet erosion will be discussed later but when the results of the 1971 work are compared with the 1968 results obtained by N. Brown it is clear that the reseeding efforts have had a very limited success. Some improvement has taken place in F (Maps 4 and 5) a a more substantial cover has been established in N/V but apart from these areas sheet erosion has not been arrested. The transect area (Table 4 and Appendix V) shows a significant decline in *Silene maritima* in each section where it occurred in 1968.

Section 2. no recolonisation

Section 3. 2 additional species but an increase in bare soil from 7 - 43%

Section 4. a loss of 2 species *Silene maritima* and *Stellaria media*. The loss of *S. maritima* may have been due to the preparation of the soil for grass sowing. This sowing appears to have resulted in a 10% gain in cover by *Grammineae spp*. but the total of bare soil recorded is practically the same as in 1968.

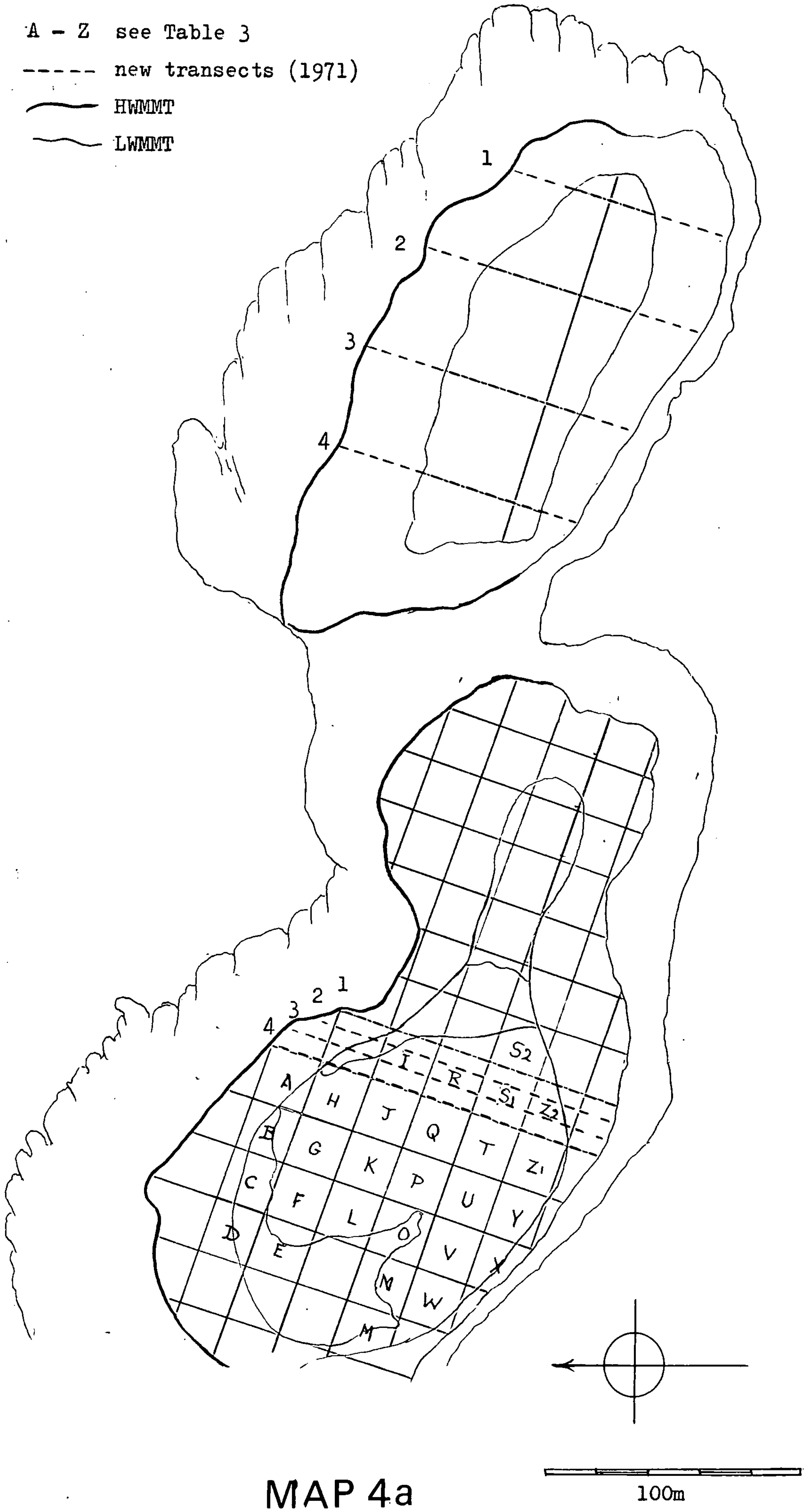
Section 5. The zone dominated by *Conium maculatum*, *Urtica dioica* and *Rumex obtusifolius*.

In this zone the height of the plants may vary from year to year but it is always very dense and difficult to penetrate J. Cranham (pers. comm.) This rank growth may be the result of supplies of nitrogen obtained from the guano in the run off from the eroded areas. It might therefore be expected that such a community would not be receeding (Map 5). There are 2 factors however, which may be helping to bring this about. (1) *Larus fuscus* breeds in the edge of this dense plant community and this would tend to injure new growth especially of *Urtica dioica* and *Conium maculatum* thus preventing these plants from colonising the adjoining bare areas. (2) Fratercula arctica shows some preference for burrowing under stones or vegetation and new burrows excavated under the perimeter of this vegetation are common, especially where the vegetation is adjacent to an already eroded area.This must have a detrimental effect on the rooting systems especially of *Conium maculatum* and *Rumex obtusifolius*.

There is a small colony of Oryctolagus cuniculus <10 on this island (July 1971) but their overall effect on the vegetation appears to be negligible. The reseeded areas are not closely grazed.

4 additional transects have been made Map 4. in order to give additional data to judge the performance of the vegetation in future years. Details appear in Appendix 6.

W. and E. WIDEOPENS



MAP 4a

Table 3. West Wideopen Plant cover - Map 4a (June 1971)
Nos. refer to cover within the 20m sq. (5 point scale)
* probably as a result of sowing

20m sq. See Map 5	% bare soil	% outcrop	Conium maculatum	Rumex obtusifolius	Rumex crispus	Urtica dioica	Stellaria media	Atriplex glabruiscula	Gramineae	Poa trivialis	Poa annua	Agrostis stolonifera	Lolium perenne	Silene maritima
A	60						1		2					1
B	60		2	2		1								
C	70		2	2		1								
D	40		2	2		1								
E	40		2	2		1								
F	60					+	+		2			+*	+*	
G	60					+	+		+					
H	90								2					
I	70								2					
J	98								2					
K	80		+		+	+	2		1					
L	70		2		2	1								
M	30	30	1	1		1								
N	50		2		1	1						3 *	2*	
O	40		2		2	2			1					
P	70		+		+	+								
Q	60						1		1					2
R	80								1		+			
S1	60													4
S2	70								1					
T	10				3		3		1					2
U	50				1		2			1	1			
V	30								1					2
W	30				2		1	1				+	+	
X	10	20												4
Y	20	30												3
Z	40				3		3	1						2
Z2	40													2

section	year	bare	out-crop	Silene maritima	Urtica dioica	Stellaria media	Rumex obtusifolius	Rumex acetosa	Gramineae	Conium maculatum	Atriplex glabruiscula
1 0'-40'	1968	53	7	40							
	1971	70	7	22							
2 40'-135'	1968	100									
	1971	100									
3 135'-245'	1968	7		6	60	44	33	11			
	1971	43		3	53	7	43			13	3
4 245'-333'	1968	59			12	3			28		
	1971	62							38		
5 333'-368'	1968										
	1971				30		30			40	

Table 4   <u>West Wideopen</u>   Summary of transect data 1968 and 1971 - from Appendix V

all figurers in percentages
figures for 1971 estimates

East Wideopen

Nearly 2 hectares above HWMMT.

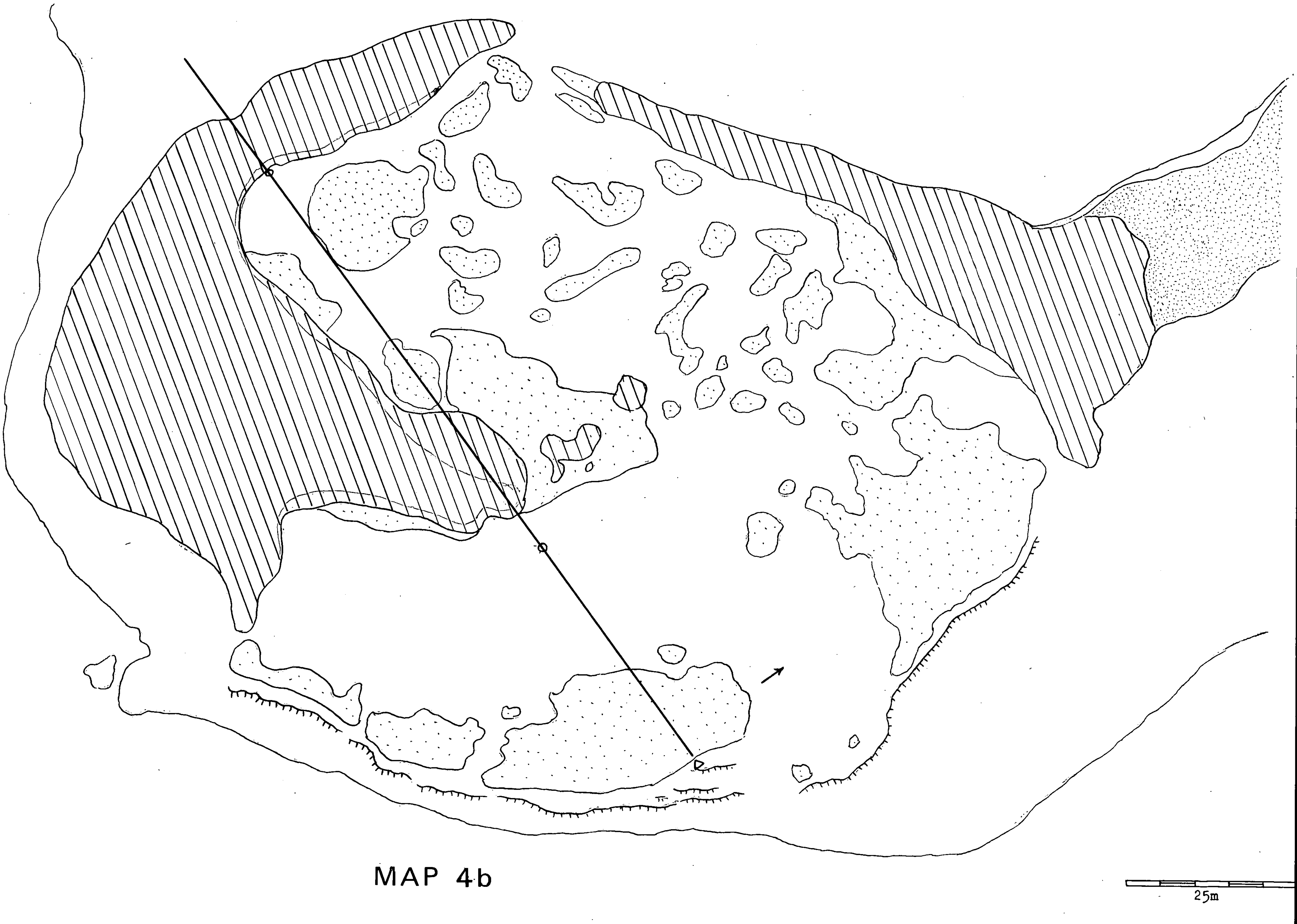
This island has a large area of sheet erosion (Plate 8) also large populations of Larus gulls and Fratercula arctica. (see Appendix X.)

In order to study this area, 4 transects were laid down (Map 10) and details are given in Appendix VII.

The most striking feature is the extent of the cover and frequency of occurrence of Cochlearia officinalis.

WEST WIDEOPEN (part)

June 1968



MAP 4b

WEST WIDEOPEN (part)

not burrowed, supporting a rank cover of Conium maculatum, Rumex obtusifolius and ~~and~~ Urtica dioica.

Area devoid of vegetation - June 1971

burrowed areas, retaining some plant cover mainly Silene maritima and Gramineae spp

sand zone, dominated by Urtica dioica Arctium nemorosum and Rumex obtusifolius

o permanent transect markers

line of N/S transect. For data see Appendix V

highest point on the island, 11m above mean sea level

position from which Plate 6 was photographed

Plate 6. West Wideopen.

Sheet erosion (see Map 5)

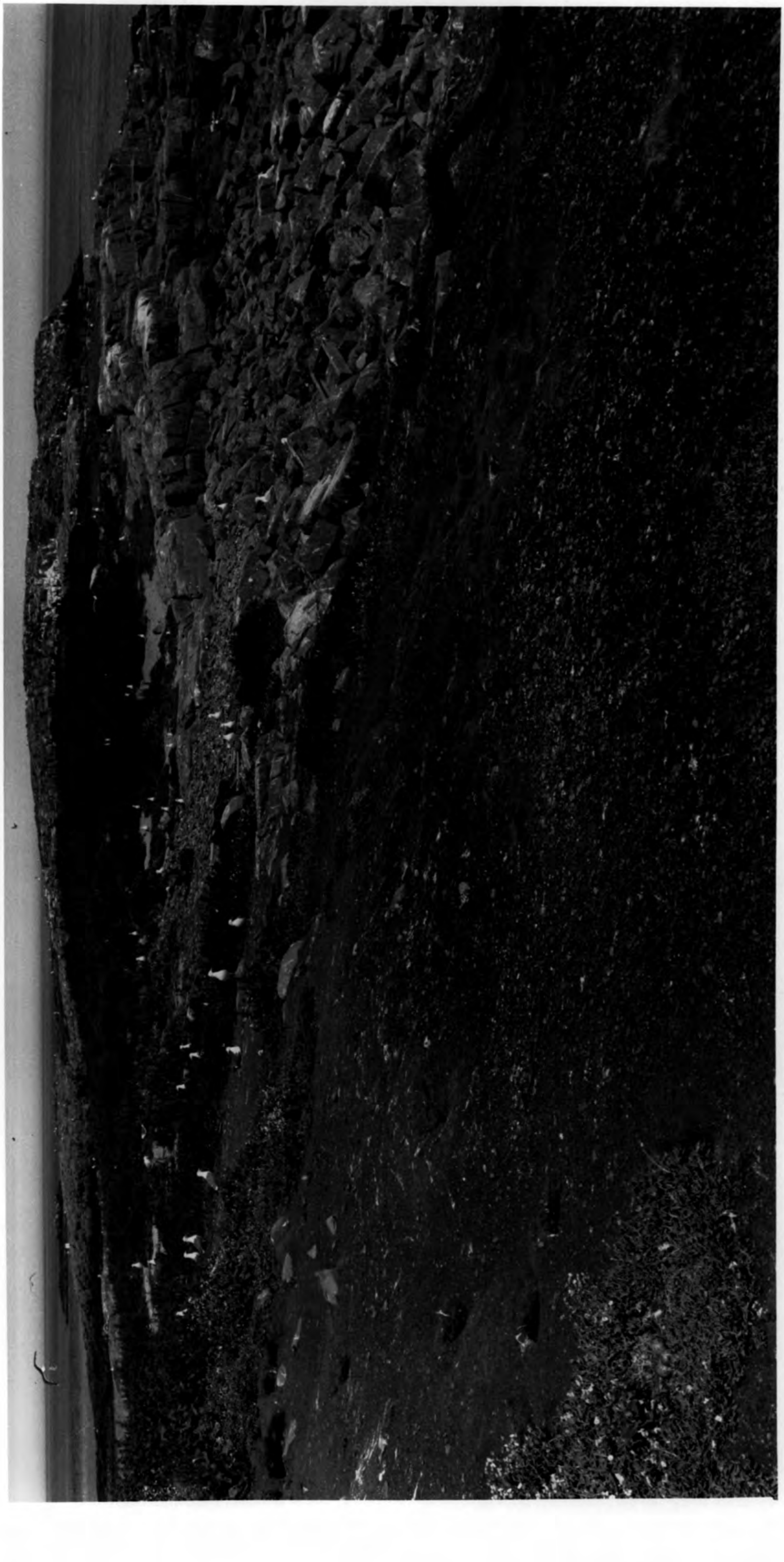


Plate 7a. West Wideopen.

Conium, Rumex, Urtica community.

Plate 7b. West Wideopen.

Urtica, Arctium community in sand.

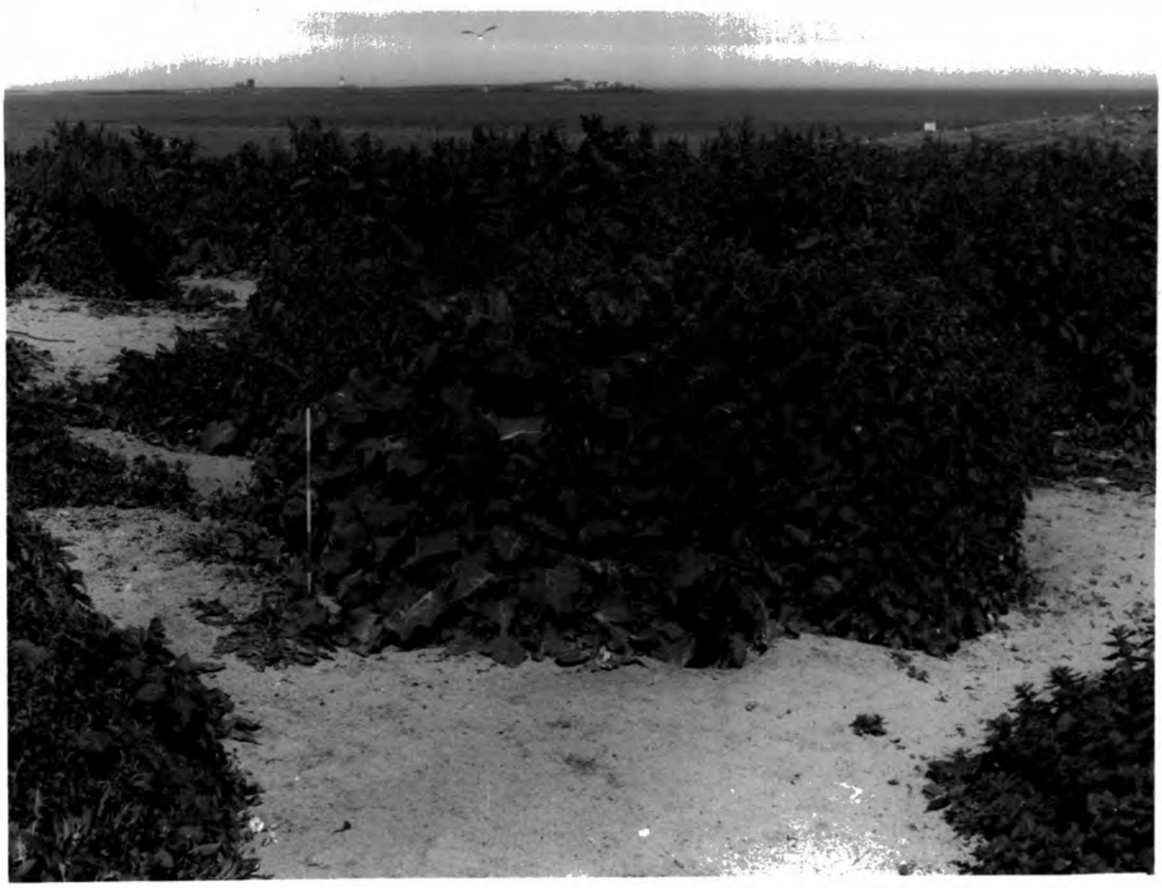
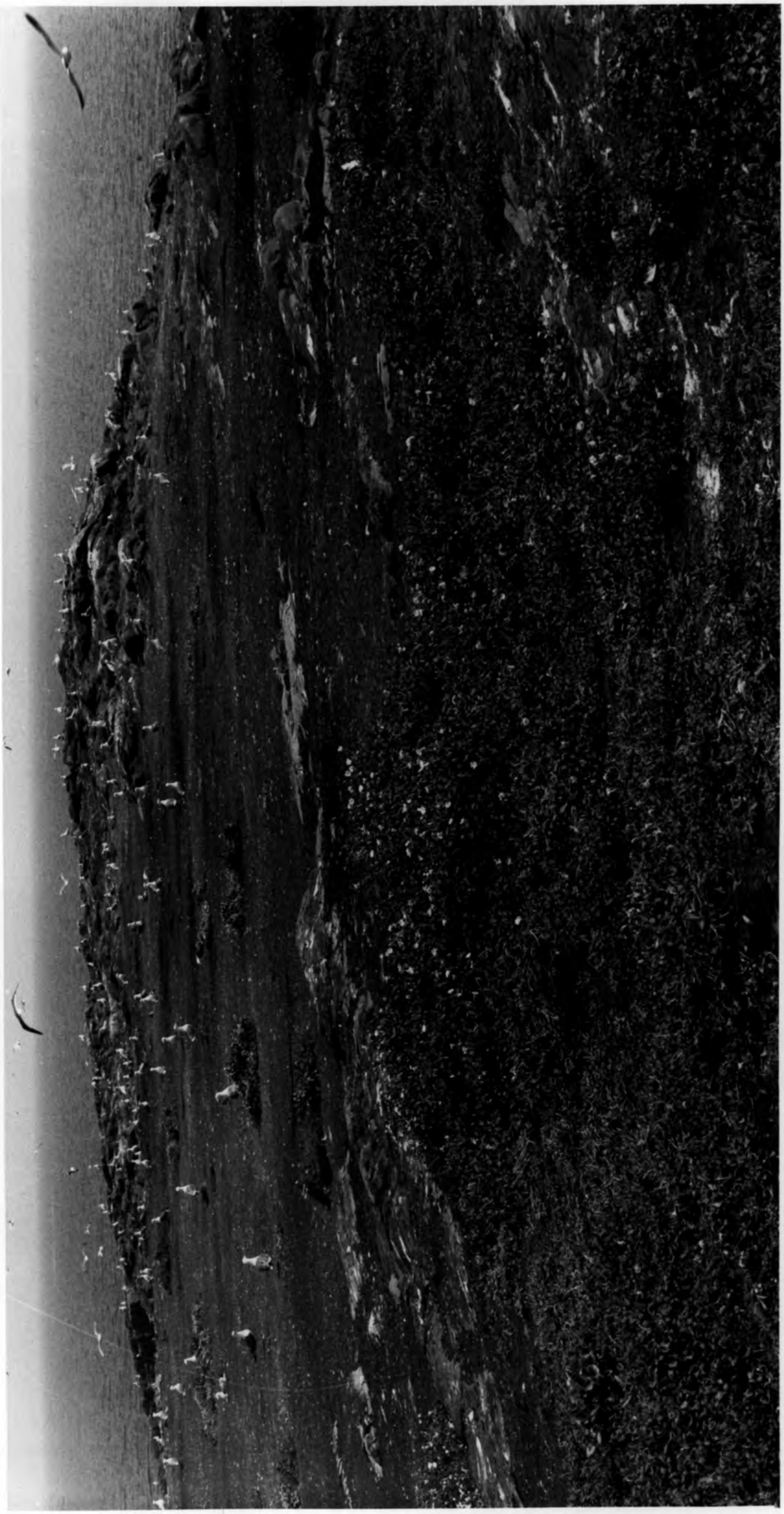


Plate 8. East Wideopen.

Sheet erosion.



8. Knocks Reef (or Knoxes Reef)

Map 5. This island is only 2.2m above mean sea level at its highest point and although .5 hectares are above HWMMT only a small area 45m by 9.5m (approx. 430m^2) supports vegetation (Plate 9a).

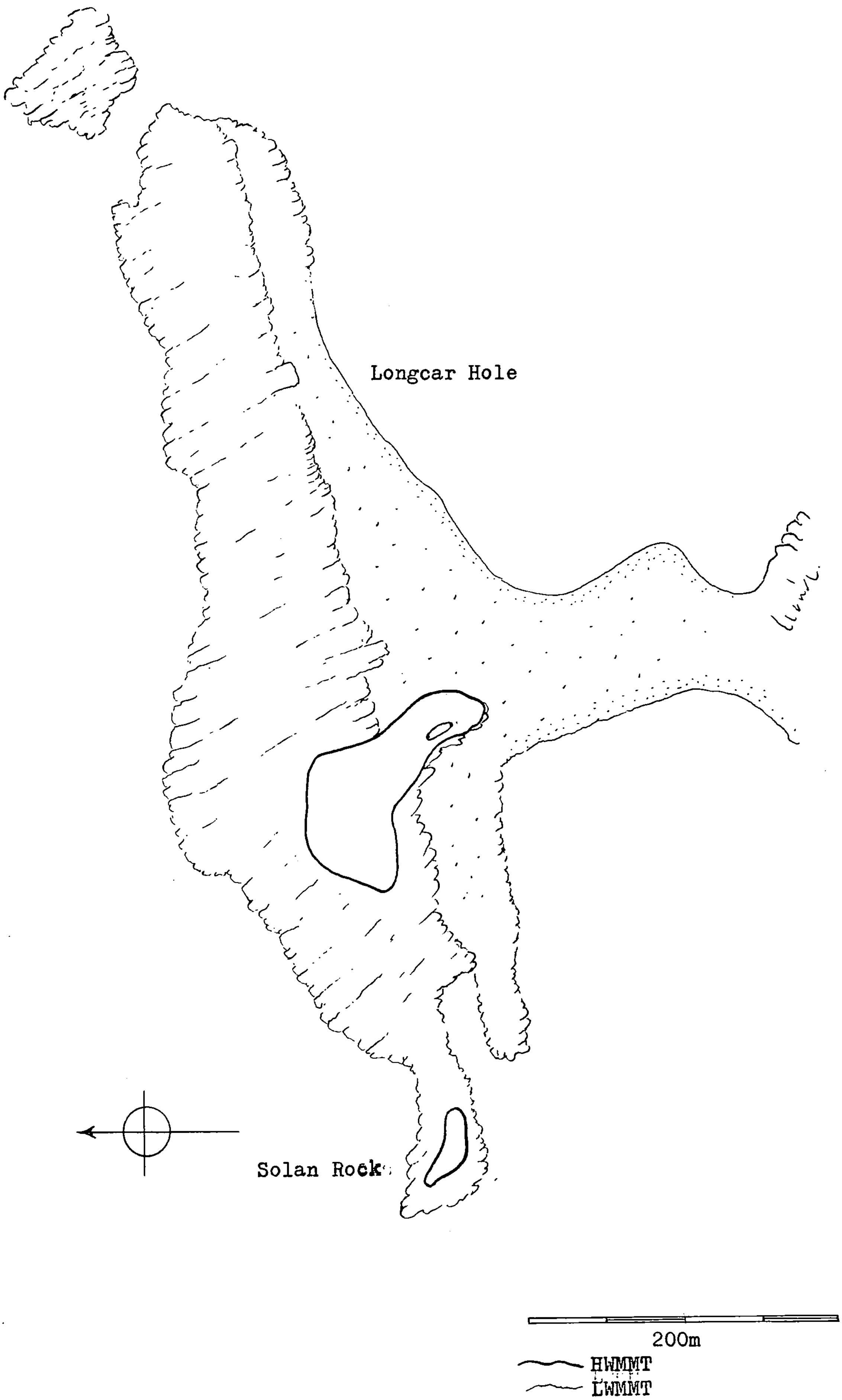
The only published account of the vegetation appears to be that given by Watt. G.(1951) "in the centre of the island there is a little sparse vegetation consisting mainly of coarse grass, docks and nettles"

The area which supported vegetation consisted of a pebble ridge with sand but almost all of this ridge disappeared together with its vegetation during the great gale of 1953.

At the present time (1971) 14 plant species occur including Elymus arenarius (Plate 9b) and Agropyron junciforme. These do not occur elsewhere on the Farnes and are additions to the 1951 list of species. Both of these plants form foredunes and are present on the Northumberland coast.

A list of species is given in Table 1.

KNOCKS REEF



MAP 5

Plate 9a. Knocks Reef (East Wideopens in the background) Area of 'new' vegetation. July 1971.

Plate 9b. Knocks Reef.
Elymus arenarius July 1971.

9. Brownsman

Brownsman and Staple Island which constitute the middle group are only separated at high tide by a channel which runs from Brownsman's Gut to Pinnacle Haven.

Brownsman (Maps 6 and 7 and Plate 41.)

This island is 4.83 hectares above HWMMT with a soil cover of 1.68 hectares.

The general features are given in Map 6; cliffs stretch from the NW to the SE where they reach a height of 13m. To the north there is a ~~grad~~ gradual slope towards the sea.

The old lighthouse built in the 17th century still stands, also the lighthouse keeper's cottage built ca. 1809 and now used by the watchers. Much of the walls of the sites of 3 former gardens still stand. A large pond has developed near the centre of the island (Plate 10). This usually dries out in the summer months but during the winter forms a wallow for Halichoerus grypus and later supplies much of the mud for the nests of Rissa tridactyla, not only for Brownsman but also for the neighbouring islands.

A list of plants is given in Table 1.

Previous work carried out on Brownsman.

In 1966 Dr. O. Gilbert studied 6 3yd x 3yd plots on Brownsman to ascertain the possibility of reseeding denuded areas.

Mrs.G.Hickling has kept a journal which has reference to the plant cover. I have extracted a number of these and they are acknowledged in the text.

Dr.O.Gilbert has supplied the following details.

10.3.66 Sowing of Poa pratensis and Festuca rubra carried out in unenclosed plots on (1) bare, badly eroded areas (2) areas with 20% vegetation cover (all Silene maritima) (3) areas with an 80% vegetation cover but starting to decline.

4.5.66 Roofed enclosures each three yards square were erected in the same areas as above and lightly sown with a seed mixture containing Festuca rubra, Poa pratensis, Lolium perenne (2 vars), Plantago lanceolata and Trifolium repens. It had been hoped to include also Poa annua and Agrostis stolonifera but seed was unavailable. Unenclosed plots were sown with the same mixture.

Visits were paid to observe and record the plots on 27.7.66 and 11.11.66.

Results

Unenclosed Plots   Initially there was a good take in all areas and for a short period there was a 40 - 70% cover of grass about 2cm high. This, however, failed to persist becoming disrupted by excessive bird trampling and possible grazing. By November only sparsely scattered plants were left, these though well established as small compact cushions were not slowing down the erosion nor is it conceivable that they will ever coalesce to form a continuous cover.

Enclosed Plots   Eleven weeks after sowing all enclosues were full of vegetation and where the grass projected through the netting it had been heavily grazed. In November the vegetation was as follows:-

(1) Completely Bare Badly Eroded Area: 100% cover L.perenne (abundant) Poa pratensis (frequent) Festuca rubra (occasional) Plantago (o-f) (see Plate 11 photographed by O.L.Gilbert) and in addition Stellaria media, Atriplex glabriuscula and Silene maritima had sown themselves in small amounts.

(2) 20% Vegetation Areas: Same as above but more Silene as there were several old plants in the enclosure.

(3) 80% Vegetation Cover Areas: 100% Cover Silene growing with great vigour and forming a dense canopy on top of the netting. Poor take of grass due to dense shade.

Synopsis of studies carried out during 1971.

(1) Mapping the soil cover and the extent of soil cover 'recently' lost (not connected with sheet erosion).

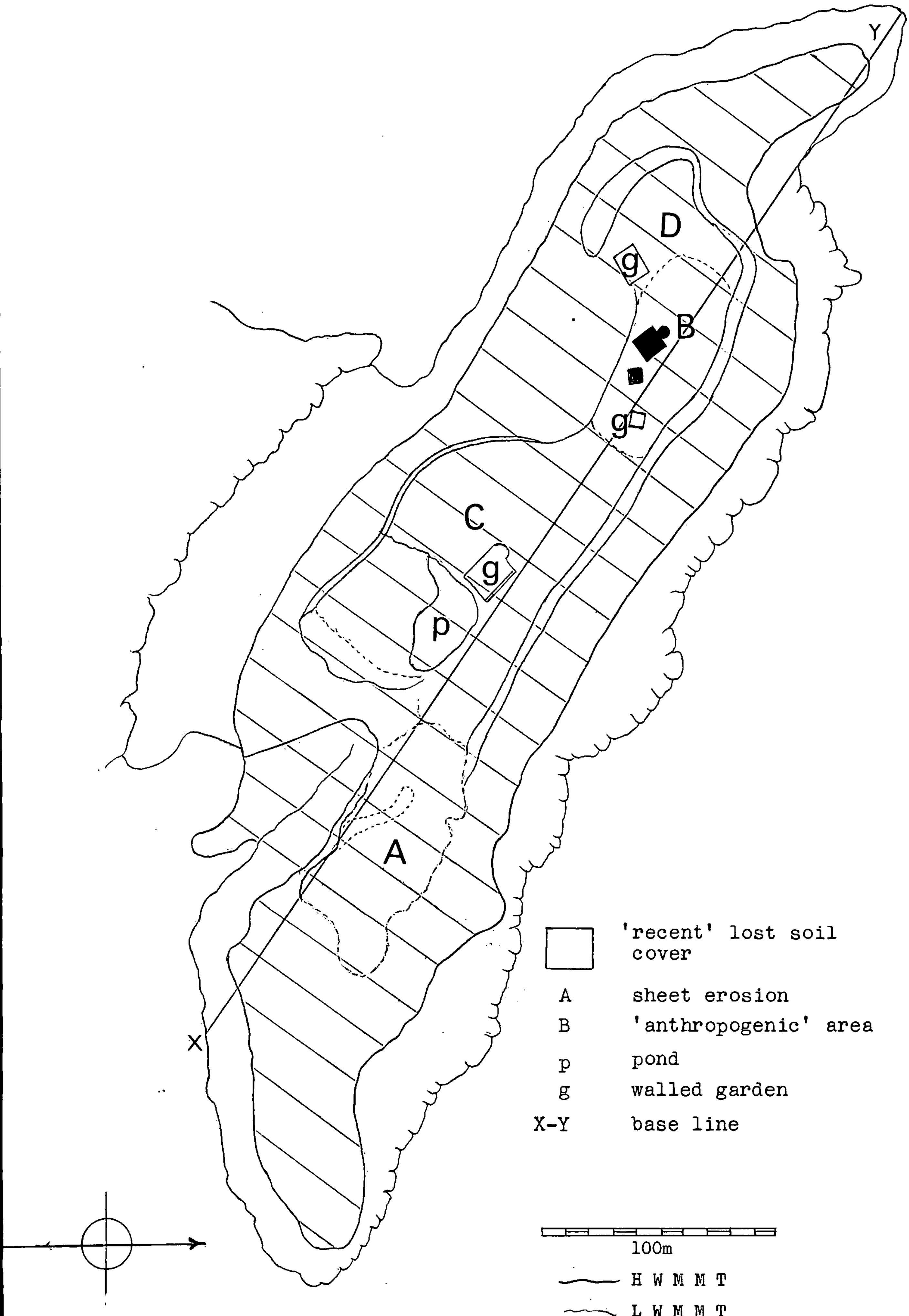
(2) Mapping area of sheet erosion together with measurements of cover.

(3) Mapping 'anthropogenic' area with measure of cover and sociability of species

(4) Mapping the remainder of the vegetation by means of random quadrats

(5) transect to measure differences in vegetation from eroded area to 'anthropogenic' area

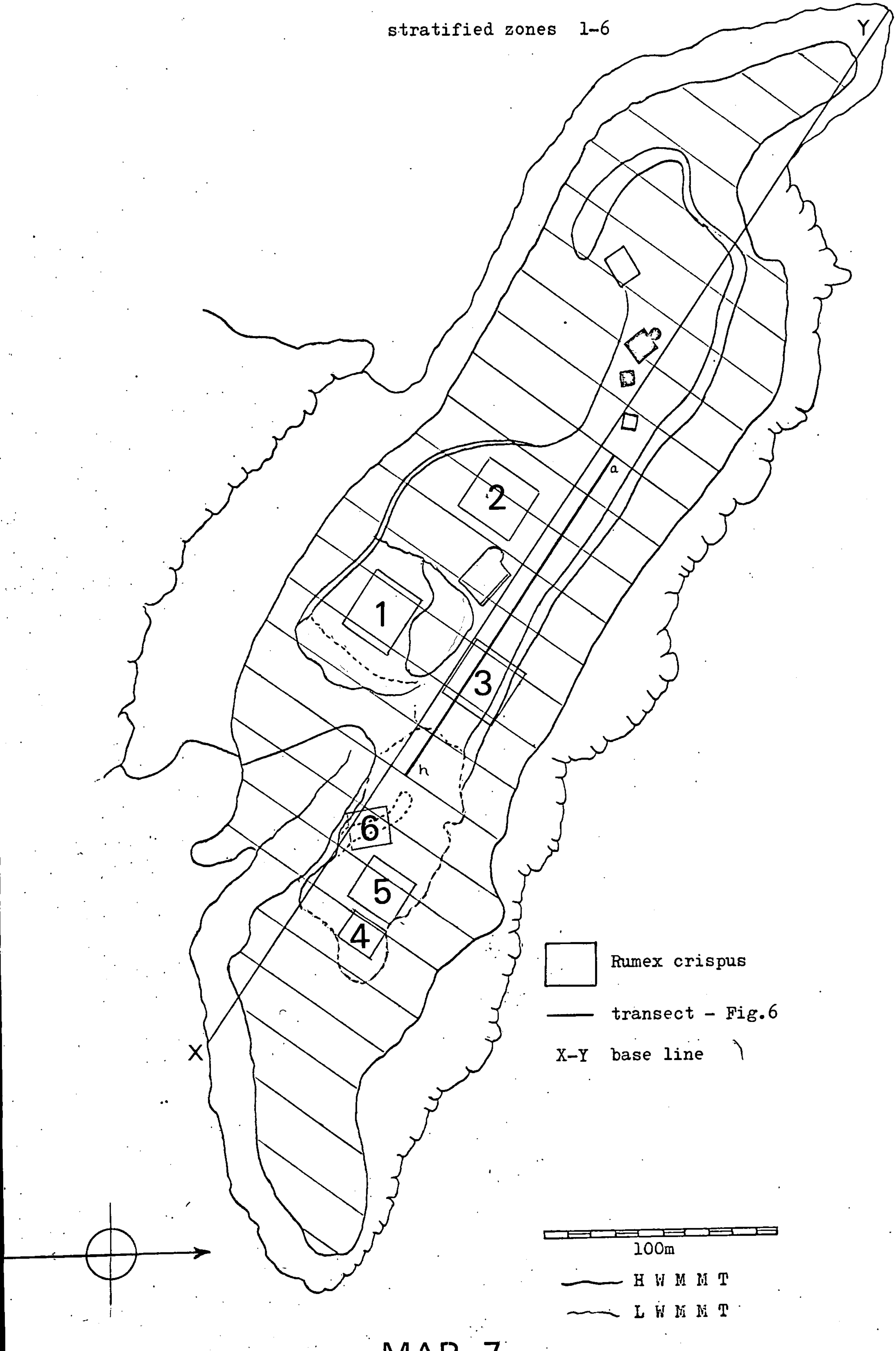
BROWNSMAN



MAP 6

BROWNSMAN

stratified zones 1-6



MAP 7

(6) stratification of vegetation and the collection of data by means of random quadrats

(7) studies relating to diseased Atriplex

(8) a study of the Larus population with special reference to the composition of the nesting material

(9) soil studies.

1. Mapping soil cover (Map 6)

A base line was established X - Y and lines at right angles marked at 20m intervals. From these (a) the area of soil cover was calculated, and (b) there is much evidence of the remains of a more extensive soil cover in the 'recent' past. This area which is plotted on Map 6 is .22 hectares, 11.6% of the formed soil cover.

The vegetation can be divided into 4 areas (Map 6)

A. an area of sheet erosion.

B. an area of vegetation surrounding the buildings 'anthropogenic' area.

C. an area with > 70% plant cover - the central part of the island.

D. an area to the W of B which has a plant cover similar to C.

2. 'A' Area of sheet erosion

The junction of 'A' with 'C' is shown in Plate 10 photographed 27.5.71. This area was marked out from the baseline in 10m squares and the cover of each species recorded. The data for the 2 most important species Silene maritima and Antriplex glabruiscula was then extracted for each square, and coloured as a percentage cover of each square Fig. 5. This illustrates for the total area the cover of the 2 most important species and also the extent of the soil without plant cover 25.5.71. Details of the other species recorded, but which had little cover value, are given in Appendix V. Square J. 6 (Plate 13) photographed 21 days later indicates a small percentage of cover resulting from the germination of Atriplex glabruiscula.

Calculation of soil lost by erosion

In the westerly section of the eroded area 'A' (Plate 10) the former soil depth could be gauged from the height of the Silene maritima plants above the surrounding soil level. All these were measured, and assuming the former soil was level the calculated loss of soil was 15.5cm. This is almost certainly too low a figure as the previous soil profile had almost certainly been convex as it is in the remaining soil cover of the island.

The remainder of the denuded area could not be calculated by this method due to the almost complete absence of S. maritima. This area, however, still contained one of the exclosures formerly set up in 1966 by O.L.Gilbert (Plates 15a and 15b) and the height above the surrounding soil level was measured at 20cm intervals around its perimeter . The mean of these measurements was 20.5cm so if the yearly loss of soil had been at a uniform rate it would amount to 4cm per year.

A 3rd method was also used. Numerous blocks of stone had been exposed and all those without any trace of lichen but still apparently in their original position (i.e. not moved due to reseeding, see below) were measured for height above soil level. Assuming that they had been exposed during the past year the mean of 47 measurements was 5.75cm cf. with the above calculated average of loss of 4cm per year. This measurement of 5.75cm may be the more correct as the height of the exclosure had been somewhat lowered by seal pressure.
There is, however, another factor which could have caused the soil loss to have been higher in 1970-71 than in previous years. In May 1970 an attempt was made to reseed the denuded area using a mixture of grass seed mixture. The soil was prepared by dragging a 'sleeper' with 4" spikes over the area to obtain a tilth. The grass seed was then raked in but a gale soon afterwards removed all the soil. These 'severe' preparations would tend to destroy any remaining S. maritima and generally alter the soil structure so that it would be more susceptible to wind erosion.

The importance of terrestrial algae

A number of small areas had a high cover of Atriplex glabruiscula 18.5.71 but these appeared to coincide with good drainage e.g. the fringes around old exposed burrows of Fratercula arctica (Plate 14). Of the remainder of the soil cover a large percentage probably > 70% was covered with an 'algal mat' consisting of a Prasiola Hormidium complex. Prasiola crispa is more tolerant of heavy manuring (and of salt spray) than are any angiosperms and grows equally well on rock or soil Gillham (1956).

This 'mat' which produces 100% cover, was extant over large areas of 'A' and prevented any of the underlying soil from being eroded. During a prolonged dry spell, however, this mat cracks into irregular shaped sections (Plate 16a - scale 0.5m rod). If drying continues each section turns up at the edges so its surface becomes concave and in the widening cracks soil particles are eroded by the wind. In the continuing absence of rain the sections become detached and are dispersed by the wind together with the adhering soil and eventually they are blown into the sea. Plate 16b. illustrates a 50% cover loss and plate 16c almost a total loss. The rod is 1m and the peg marks the remaining vestige of cover 5 x 7cm.

At the earlier stage shown in Plate 16a should a wet spell ensue, the convex edges turn down and the cracks will become far less wide. If the rainfall is accompanied by high winds, a common occurrence on the Farnes, the sections will be blown to a lower level (Plate 16d). Many of these are inverted and still with a considerable thickness of soil cover, mean of 20 measurements 1.8cm. The photograph was taken after a storm on 23.5.71. Subsequently they all disappeared and it is believed they would have blown over the cliff edge.

This algal-mat may also have a deleterious effect on the colonisation by higher plants. Few seedlings are able to penetrate this cover. Reference to Plate 16a illustrates Atriplex glabruiscula only growing in interstides. It may inhibit germination or prevent seedlings from developing. This is also illustrated in Plates 16b and 16c when the growth of seedlings which have been 'under' the cover is compared with those growing beyond the perimeter of the former algal-complex cover.

Further work carried out in this area with a discussion of the results appears in section (6) stratification of vegetation.

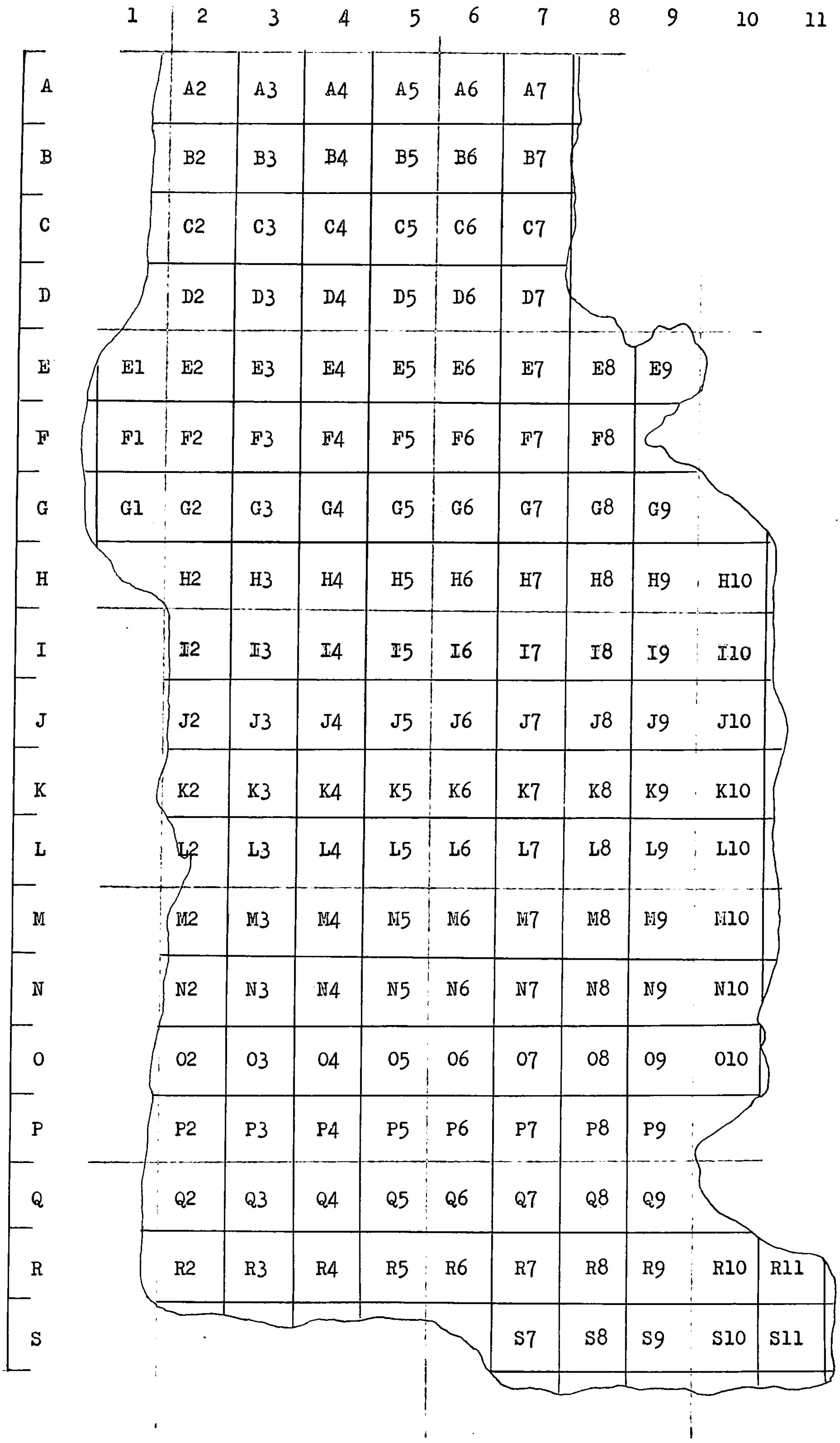
3. Mapping 'anthropogenic' area with measure of cover and sociability of species (measure of grouping).

The area 'B' Map 6 surrounds the buildings and supports a community which as a different floristic composition from the remainder of the island. It receives the kitchen waste water and it is also the area which is occupied during the summer months by a large colony of Sterna paradisaea.

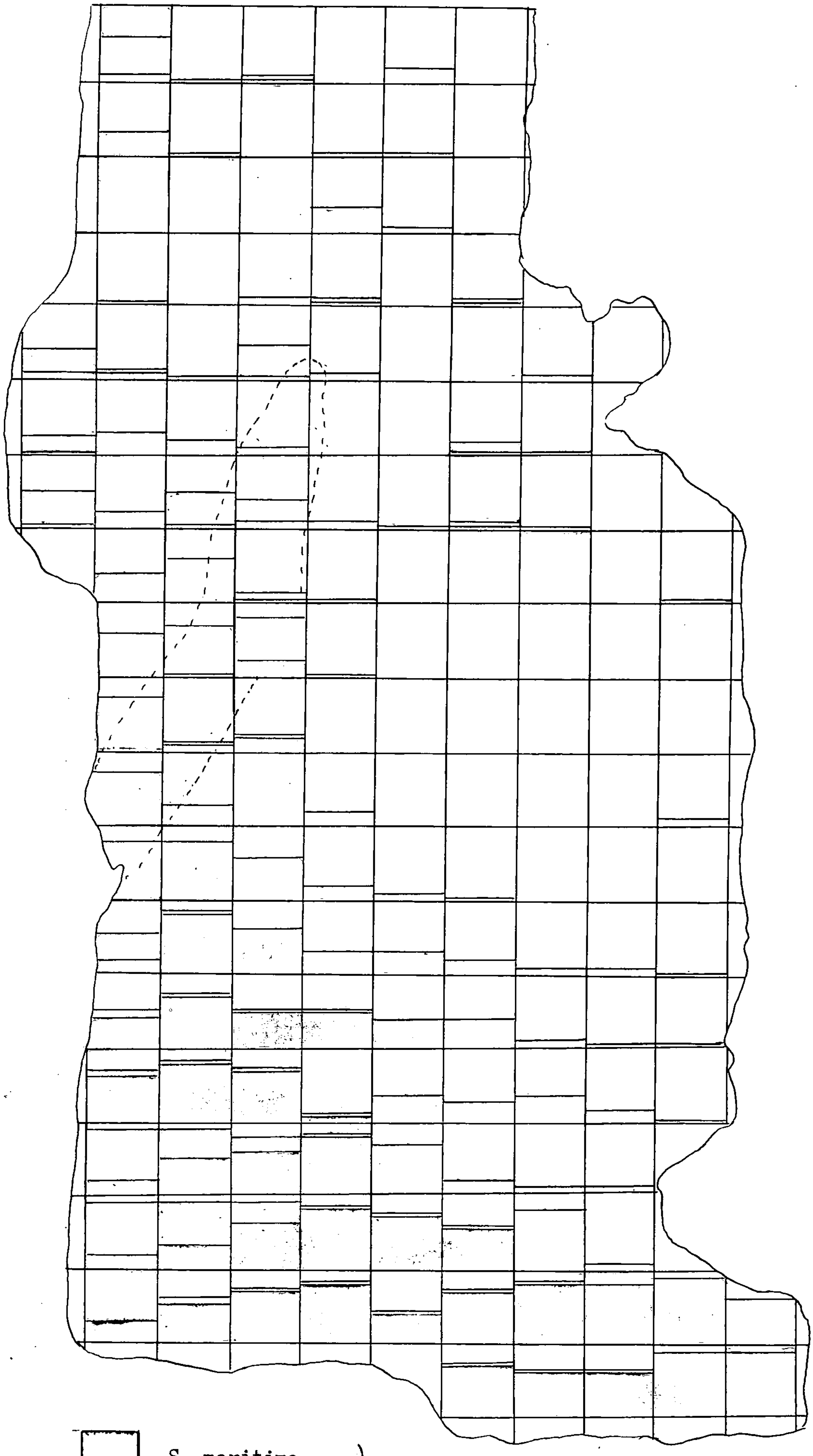
10m squares were marked out and for each square the cover and grouping of each species was recorded. A phytosociological analysis of the data is given in Appendix XII

Frequency:-

Atriplex glabruiscula	102/113
Silene maritima	99/113
Stellaria media	98/113
Rumex acetosa	81/113
Rumex obtusifolius	78/113
Prasiola Hormidium complex	57/113
Urtica dioica	47/113



Full cover data see Appendix XI.



S. maritima)
) % cover 10m squares
A. glabruiscula)

Fig. 5 Brownsman. Area of sheet erosion. See Map 6.

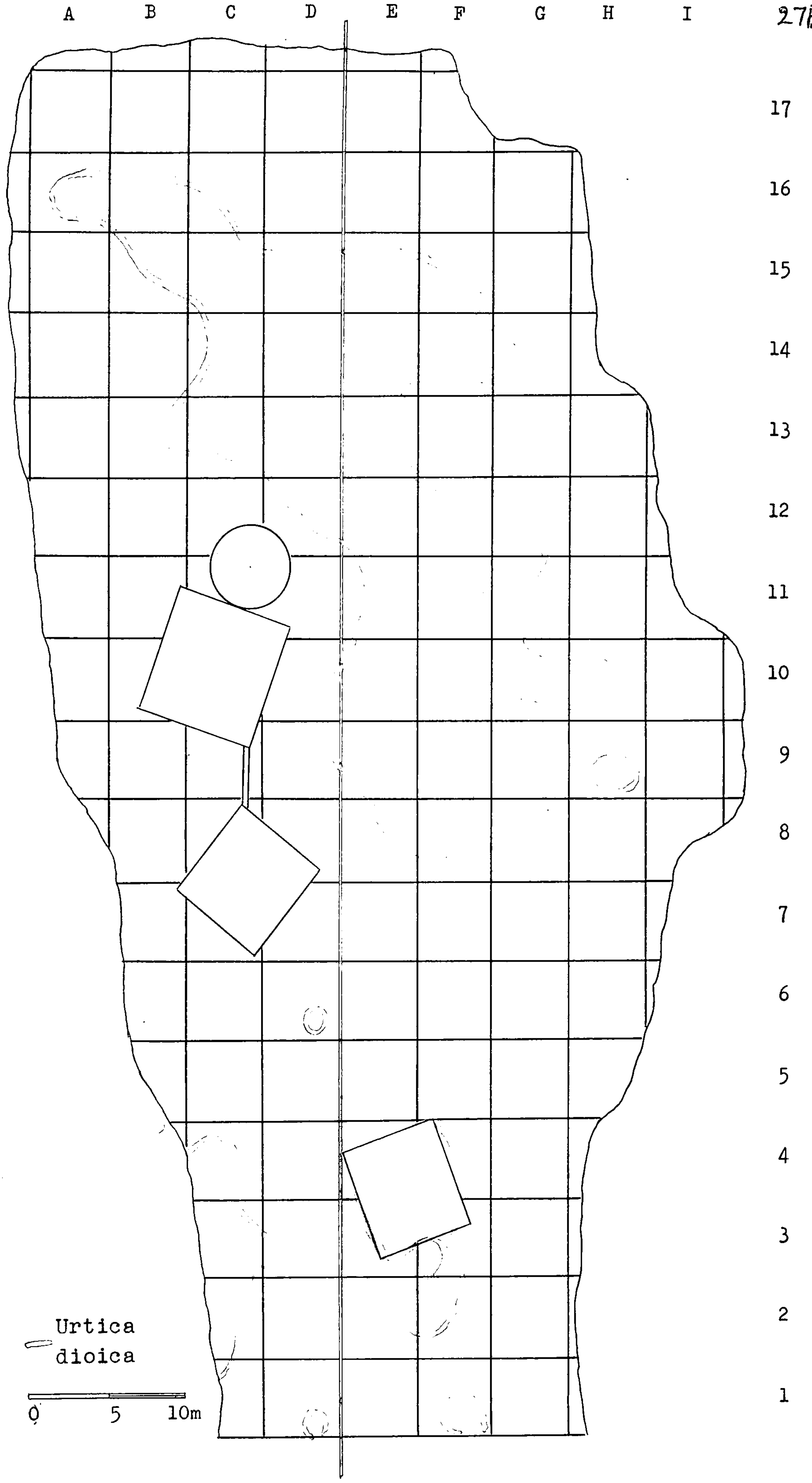


Fig. 6 'Anthropogenic' area Brownsman

Urtica urens	17/113
Spergularia marina	17/113
Cirsium arvense	9/113
Cochlearia danica	2/113

Fig. 6 gives the distribution of Urtica dioica and the overlay the distribution of Silene maritima, Stellaria media, Rumex acetosa and Rumex obtusifolius.

The distribution of the algae is an indication of the areas with higher plant cover at the end of May 1971. 21 days later all these areas had been covered by the growth of angiosperms. There are no signs of erosion in this area. All species appear to be rank probably due to the annual increment of guano from S. paradisaea.

Stellaria media is a characteristic nitrophile growing up to 40cm. S. maritima and R. acetosa are probably the species most generally distributed in heavily manured areas, both grazed and ungrazed Gillham (1956). Atriplex glabruiscula is less tolerant of trampling than is S. maritima and exhibits great plasticity occurring where-ever there is any bare soil from the damp pond side to the most shallow soils surrounding outcrops.

In this area 'B' however, trampling is not severe. Sterna paradisaea nesting in very young S.media in early June find their nest in a deep cup of this plant before the young are hatched.

Urtica dioica,another nitrophile, is especially rank and its 'spread' is a matter of some concern to the F. I. Management Committee and the area is likely to be treated with a herbicide. In view of this I was anxious to obtain an accurate measurement of its cover (Fig. 6) in order to be able to assess accurately the effects of this treatment.

4. The remaining vegetation 'C', 'D'

By means of random numbers 10 of the 20m square quadrats were selected (Map 6) and the cover, and measure of grouping of each species was recorded for each quadrat (Each 20m square was divided into 4 $10m^2$ quadrats and the average of the 4 squares used for the following table:-

	111	112	113	3	10	22	38	123	57	83
S. Maritima	X	X	X	X	X	X	X	X	X	X
A. glabruiscula		X	X	X	X	X	X	X		
S. media				X	X	X	X	X	X	X
R. acetosa						X	X	X	X	X
R. obtusifolia										X

←——— INCREASE IN DISTURBANCE

←——— LESS DIVERSITY

The decrease in the diversity of species is probably correlated with an increase in disturbance.

5. Transect to measure difference in the vegetation from 'anthropogenic' area to eroded area.

In order to gain more information a transect was made from N.W. to S.E. e.g. from'B' with the Sterna colony moving to ~~the~~ 'A' with an increasing disturbance from Fratercula arctica and Larus gulls.

This transect was laid down parallel to the base line (Map 7). For each metre the cover of each species and bare ground was recorded to the nearest decimeter. The total percentage per metre for each species and the bare ground was used to construct the transect (Fig. 7).

This indicates the transition from Silene Rumex area ——→ Silene area ←→ Silene and Atriplex and finally ——→ bare soil with a little Atriplex.

It would appear that increasing bird pressure tends to eliminate the perennials which are replaced by the annual Atriplex glabruiscula and when this species is unable to colonise the bare soil, erosion becomes a continuous process.

6. Stratification of vegetation and the collection of data by means of random quadrats.

From the above transect it appears that birds might be (a) responsible for the eroding areas or (b) their pressure might be so great as to inhibit recolonisation even by annual species.

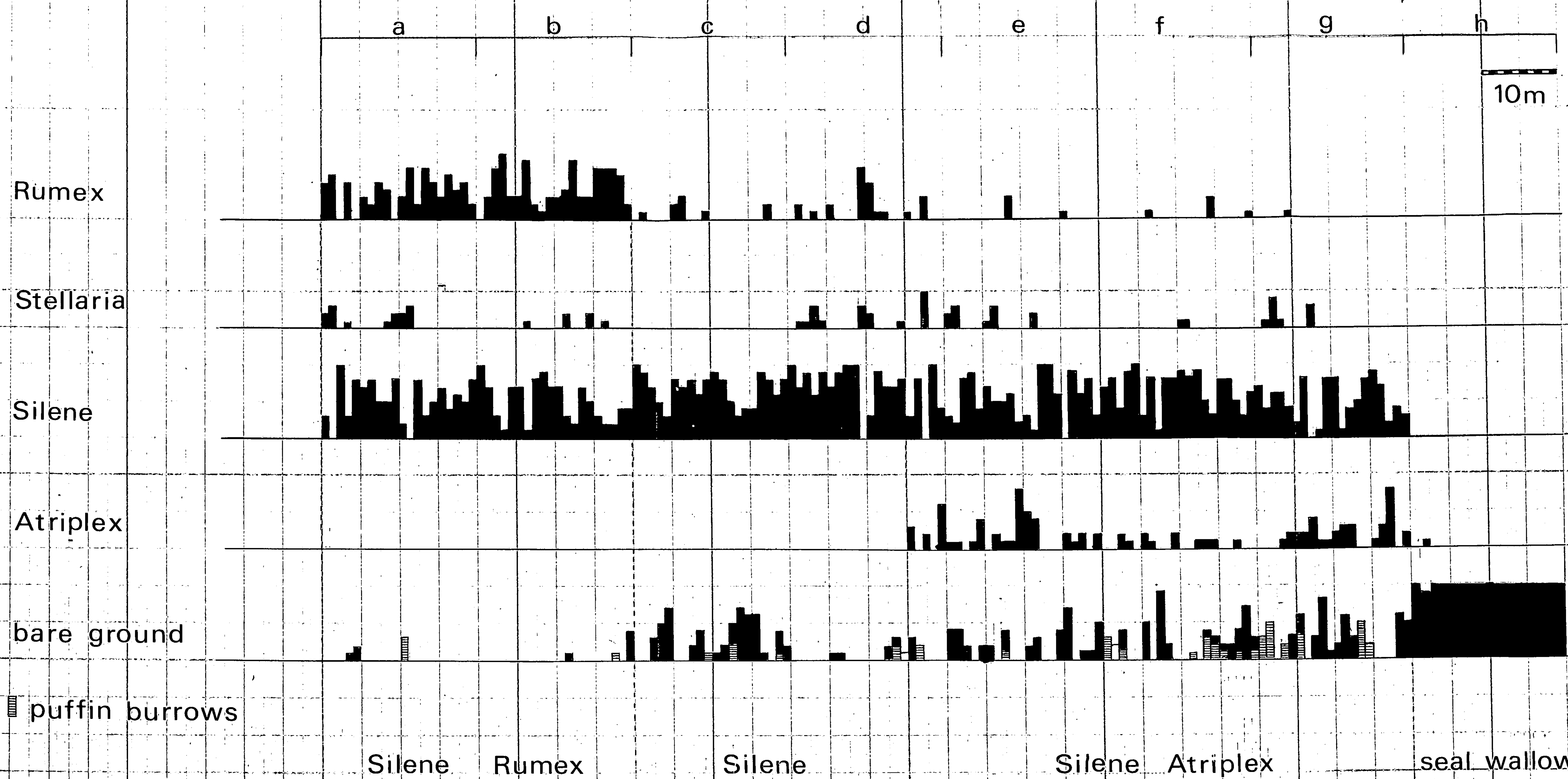


Fig. 7 160 m TRANSECT BROWNSMAN see Map 7
16.6.71

29a

In areas 'A' and 'C' the vegetation was stratified into 6 zones (marked 1 - 6 Map 7).

30 random quadrats were thrown in each zone using points from random number tables, Campbell (1967). The occurrence of all species was noted for each quadrat, and the percentage cover of the major species estimated.

In each zone the density of puffin burrows was estimated by the point-centred quarter method, Greig-Smith (1967) $\bar{I} = \sqrt{\frac{1}{D}}$ also the number of flowers of Silene maritima (any flowers showing white petals counted as a flower) were counted in each quadrat.

The data is summarized in Table 5.

Zones 1, 2 and 3 occur in 'C' (Map 6). Only a small number of Larus gulls nested in zones 1 and 2 and none in 3 and at such low densities their effect on the vegetation was probably negligible.

All 3 zones were burrowed by Fratercula arctica and visual impressions as to their density were confirmed by calculations (see Table 5).

Zone 1 1.7 burrows per m^2 - a colony of F. arctica of long standing

Zone 3 0.8 burrows per m^2 - much more recent colony - probably a shift from area 'A' due to sheet erosion.

Zone 2 0.14 burrows per m^2 - very recent colonisation.

The data from the 3 zones tends to confirm the results of the transect (Fig. 5) - increasing disturbance - less diversity of plant cover.

Zone 2 less Silene cover but a high Rumex cover with 100% frequency of occurrence, Stellaria - 100% frequency of occurrence and only a small area of bare soil - calculated as for plant cover, only 4.3%.

Zone 3 with a greater disturbance has the highest Silene cover and frequency of occurrence, a very small Rumex cover cf. with Zone 1 is significant ($P = < 0.001$), Stellaria, a lower frequency of occurrence but a slightly higher cover value which might be expected with the increased disturbance and greater area of bare soil 17% calculated as above. Atriplex has replaced the Rumex.

		Silene cover	Silene – frequency of occurrence	Silene – number of flowers	Atriplex – cover	Atriplex – frequency of occurrence	Rumex-cover	Rumex – frequency of occurrence	Stellaria – cover	Stellaria – frequency of occurrence	Other spp. – cover	Other spp. – frequency of occurrence	Puffin burrows per m^2	Bare soil – cover	Bare soil – frequency of occurrence	Mean depth of soil
Brownsman	1	54.6	86.6	7.4	0.1	10.0	0.03	3.3	0.1	10.0	0.66	6.6	1.7	43.3	66.6	
	2	43.0	90.0	6.8	-	-	45.3	100.0	6.1	100.0	-	-	0.14	4.3	17.0	
	3	72.0	100.0	6.1	1.2	26.6	0.1	10.0	7.6	70.0	-	-	0.8	17.0	43.3	
	4	0.03	3.3	-	50.3	96.6	-	-	0.03	3.3	1.1	26.6	0.15	48.6	87.0	
	5	3.6	6.6	-	33.1	80.0	-	-	-	-	0.4	26.6	0,14	61.3	90.0	17.4
	6	61.6	83.0	9.8	10,9	50.0	-	-	1.6	3.3	-	-	0.33	25.0	63.0	12.6
Staple Island	a	89.6	100.0	13.4	3.5	50.0	-	-	6.3	46.6	-	-	0.02	1.0	6.6	22.6
	b	20.0	43.0	5.9	57.7	96.6	-	-	2.1	23.3	-	-	0.33	20.0	73.0	26.7

Table 5. Summary of quadrat data on Brownsman and Staple Island.

Zone 1 Silene a lower frequency of occurrence, bare soil expressed as a cover value 43.3% cf. with Zone 2 ($P = < 0.001$) Atriplex is much reduced and the differences in Rumex and Stellaria cf. with Zone 2 are both significant ($P = < 0.001$).
Zone 1 was the only zone in which other species were recorded.

The degradation of Silene maritima by Fratercula arctica

S. maritima is intolerant of trampling and excessive wind action, but very tolerant of grazing and manuring. Its rooting system also enables it to survive among puffin burrows, it follows therefore that S. maritima is likely to be the most important plant species in preventing erosion in Fratercula arctica colonies on Brownsman. (Grazing will be discussed in 8. A study of the Larus gull population with special reference to nesting material).

In F. arctica colonies the deposition of guano occurs in 3 main areas, 1. on the communal cliff edge 'standing grounds' (unimportant on Brownsman as the cliffs support very little vegetation) 2. in special defaecation chambers within the burrows and 3. at the burrow entrances.

These entrances receive a high annual increment of nitrogen, Gillham (1956) showed that the nitrate content in equivalent of 1 lb. per acre at the entrance to a F. arctica burrow in Graminetum was over 100. The high nitrogen content of the soil results in a particularly lush growth of S. maritima. As the plant is tolerant to manuring the effects of trampling may be more important especially as the growth is lush which will make it more susceptible to this pressure.

The effects may be summarized:-

1. trampling (and plucking) will prevent plants from flowering so the Silenetum will first appear as a mosaic with (a) large lush flowering plants and others which although they provide a high percentage of ground cover are nevertheless prevented from flowering (Plate 17a). This also illustrates an early stage in a large Silene plant 'giving way' to increased trampling.

2. An increase in the percentage of Silene plants prevented from flowering.

3. Silene is unable to survive around the burrows (Plate 17b. and 17c). Plate 17c. also shows the additional pressure due to plucking for nest lining after a storm.

4. As more Silene plants succumb to increased pressure, the bare areas tend to coalesce and local erosion follows (Plate 17d).

These illustrations are from Zone 1 but due to the shift from the sheet erosion area 'A' already mentioned to Zone 3 the early stages of the degradation of the vegetation in this zone are already apparent. (Plate 18).

Zones 4, 5 and 6.

These zones all occur in 'A' (see also Fig. 5) the area of sheet erosion where many Fratercula arctica burrows are unoccupied but where there is still a considerable pressure from Larus gulls.

Zones 4 and 5 (refer to Table 5) both have large percentages of bare soil - 46.6% and 61.3%, both have little Silene cover but Atriplex cover is important, zone 4 50.3% cover and 96.0% frequency of occurrence and Zone 5 with 33.1% cover and 80.0% frequency of occurrence.

Zone 6 has significantly less bare soil cf. zone 5 ($P = < 0.01$) also less Atriplex but a Silene cover of 61.6% with a frequency of occurrence of 83.0%. This zone also has a mean depth of 12.6cm which is less than zone 5 with a mean depth of 17.4cm.

It is difficult to account for zone 6 without some knowledge of the previous history of 'A' though it appears that zone 6 represents the state of the former vegetation before the loss of perennial plant cover from the remainder of this area. Zone 6 contains a number of outcrops and it would probably not be included in the reseeding operations already referred to.

Plate 10. Brownsman 1.7.71.

The Pond. 90% cover - 70% *Juncus bufonius*, 20% *Spergularia marina*

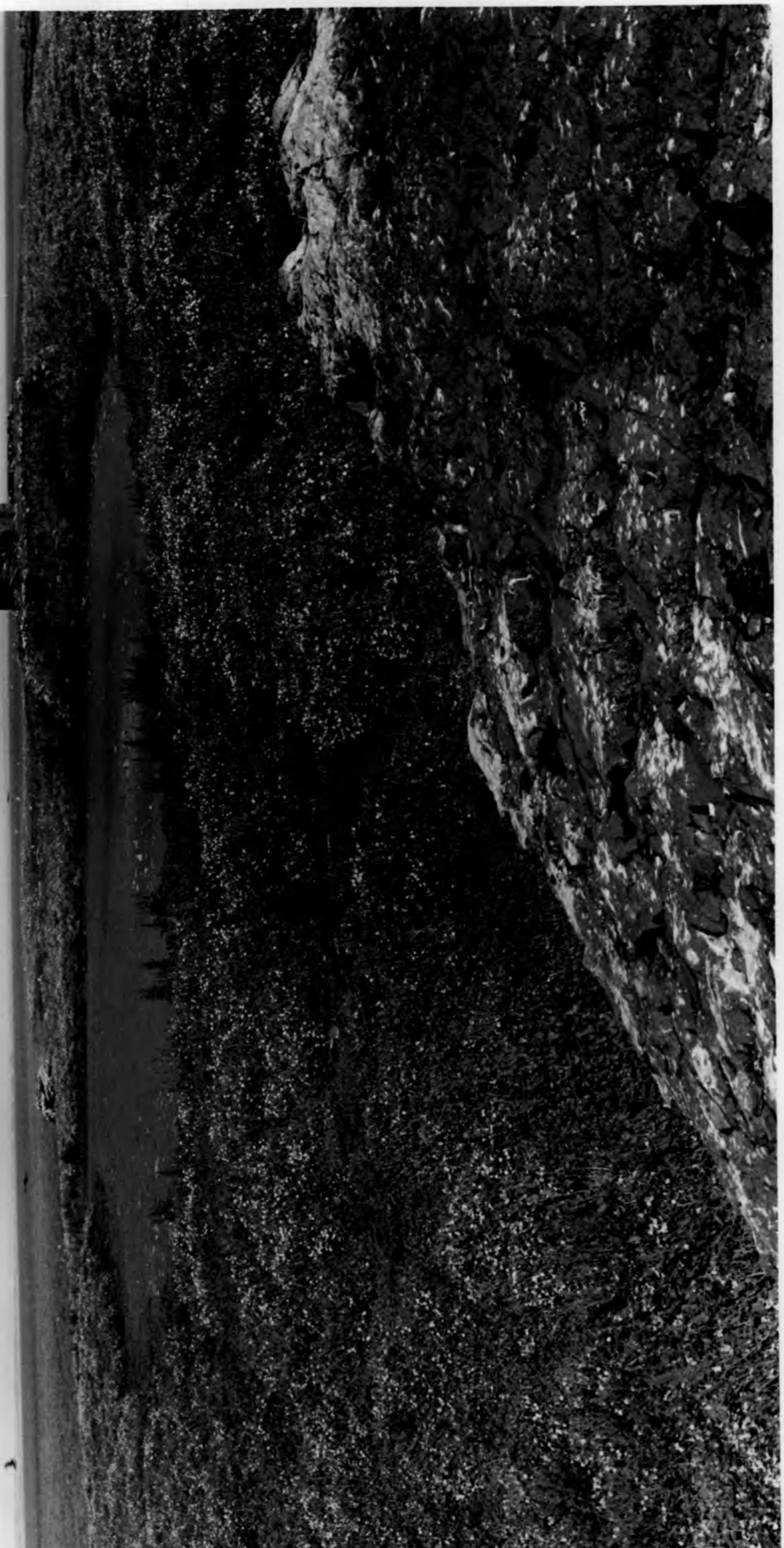


Plate 11. Brownsman.

Area 'A'. Exclosure set up 4.5.66. - cage just removed Nov. 1966,

photographed by O.L.Gilbert.

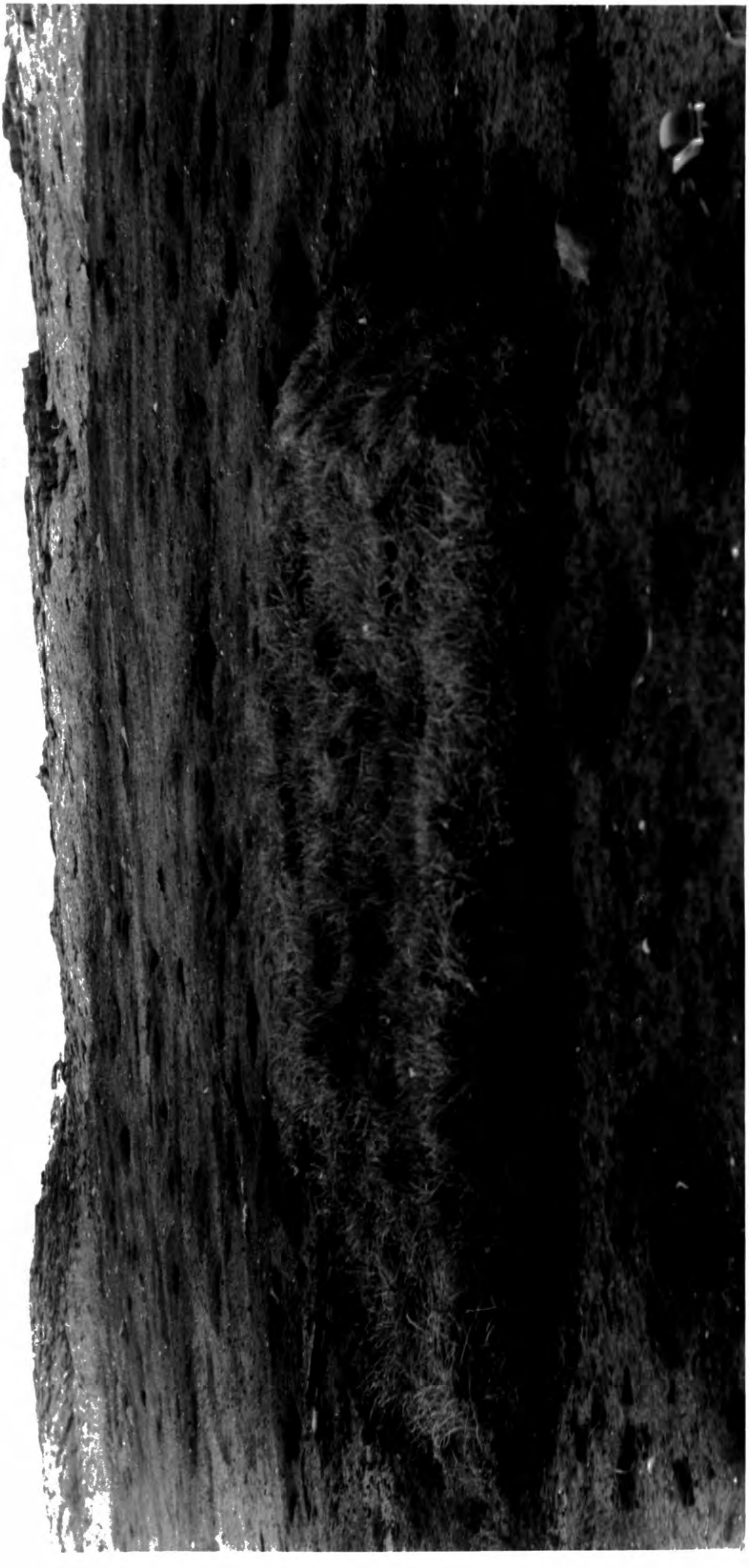


Plate 12. Brownsman 18.5.71.

Junction of 'A' eroded area with 'B'.Stakes 20m apart

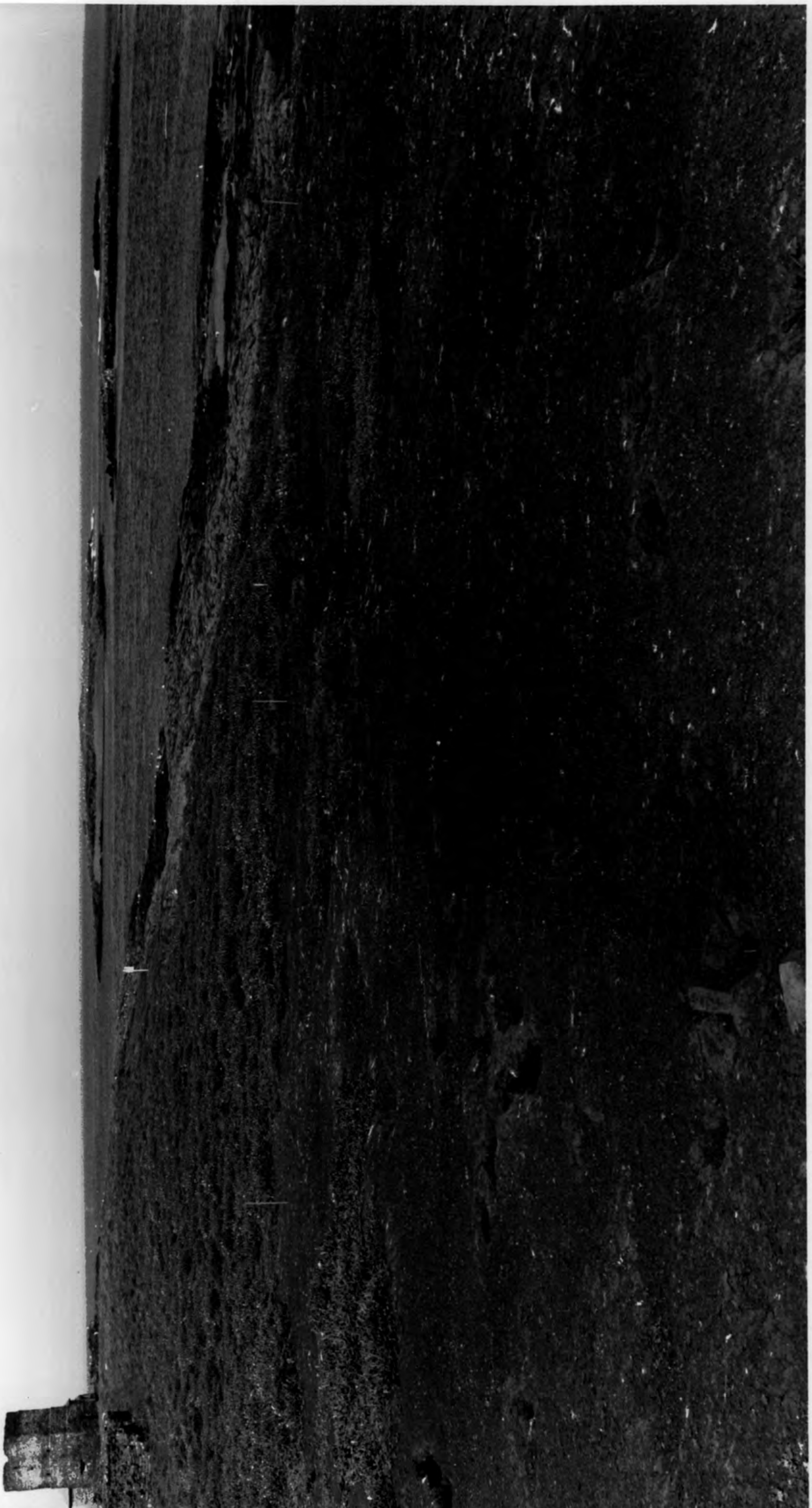


Plate 13. Brownsman.

J.9. Square of Fig.3 markers enclose 10m sq.

Small 'cover' from Atriplex glabruiscula

Plate 14. Brownsman.

Area 'A'. Atriplex glabruiscula on area drained by

denuded puffin burrows 18.5.71.

Plates 15a and 15b. Brownsman 6.6.71.

Remains of one of the exclosures erected by O.L. Gilbert in 1966. rods - 0.5m. Note (a) the depth of the soil which has eroded, and (b) the burrows of *Fratercula arctica*. (there is still some wire netting extant at the base of the *S.maritima*)

Plate 16a. Brownsman Area 'A' 18.5.71.

Prasiola - *Hormidium* complex. rod 0.5m

Plate 16b. Brownsman Area 'A' 22.5.71.

Prasiola - *Hormidium* complex 50% eroded. rod - 1m

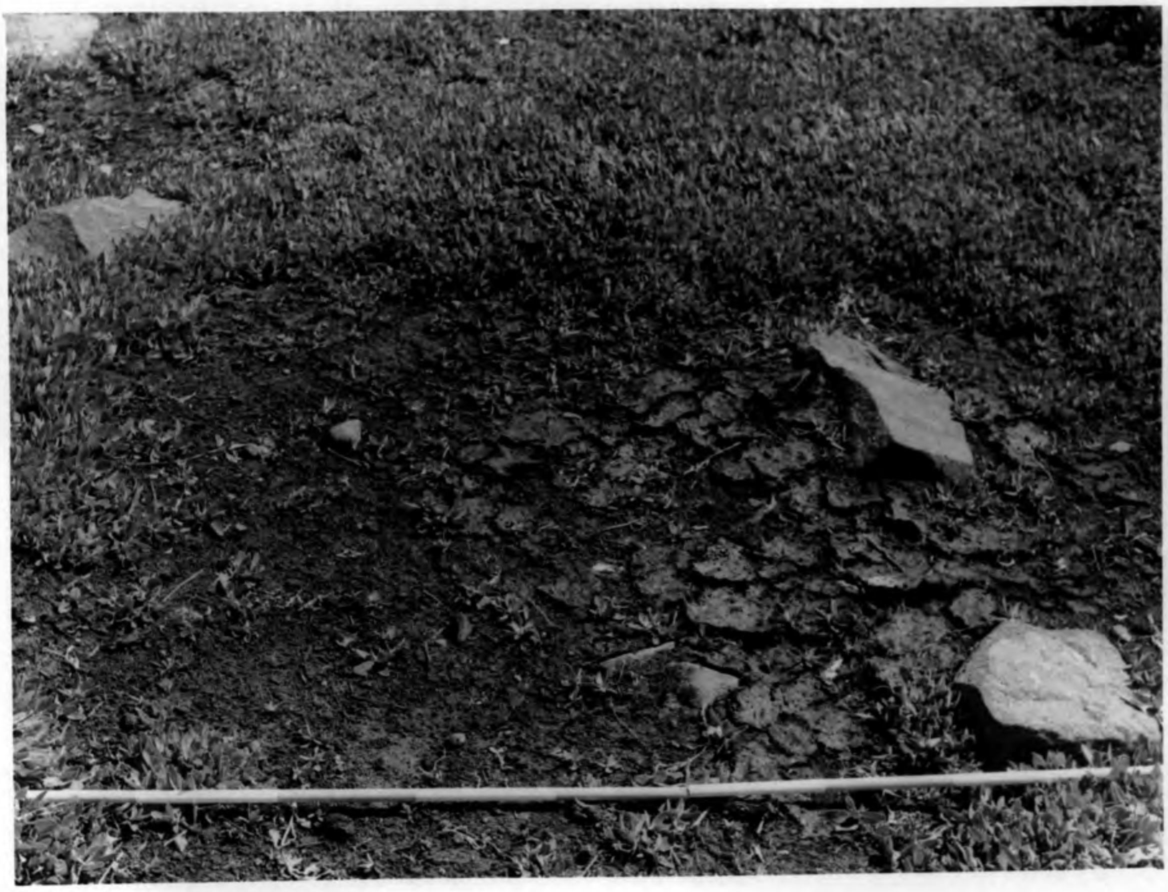


Plate 16c. Brownsman Area 'A' 22.5.71.

Former Prasiola - Hormidium complex. rod - 1m. Peg marks the remains of cover 5x7 cm.

Plate 16d. Brownsman Area 'A' 23.5.71.

Prasiola - Hormidium complex, detached sections blown and washed into a depression in the soil cover. rods - 0.5m

Plate 17a, Brownsman (zone 1)

Silene maritima 'giving way' to increased trampling by Fratercula arctica. rod - 0.5m.

Plate 17b. Brownsman (zone 1)

Silene maritima - prevention of flowering by the trampling of Fratercula arctica. rod - 0.5m

Plate 17c. Brownsman (zone 1)

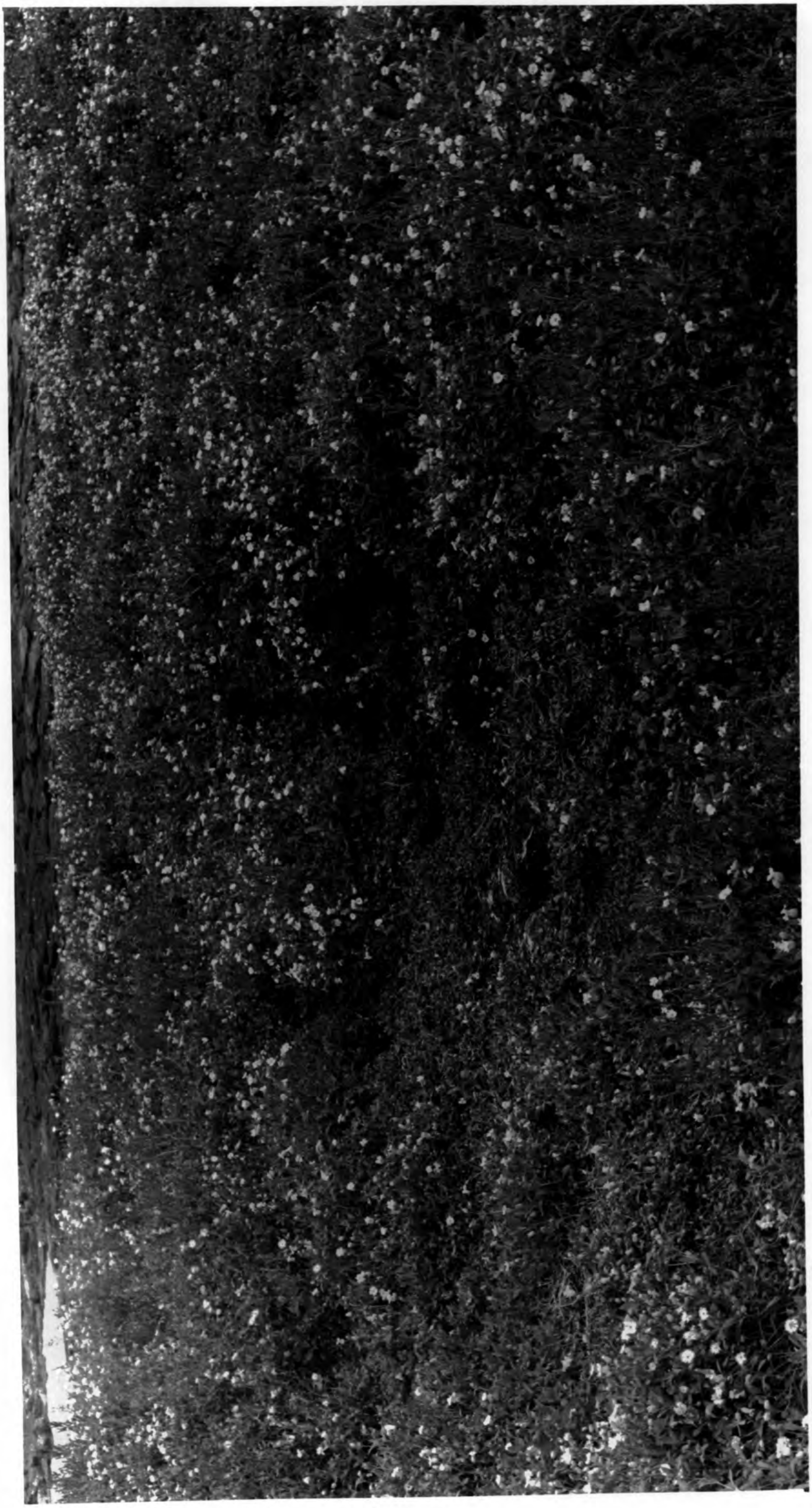
Note (a) absence of *Silene maritima* arround burrows and (b) remains of plucked *S.maritima* to line burrows. rod - 0.5m.

Plate 17d. Brownsman (zone 1)

The loss of *Silene maritima* cover resulting in areas of local erosion. rod - 0.5m.

Plate 18 Brownsman (zone 3)

recent colonisation by <u>Fratercula arctica</u>



7. Studies relating to diseased Atriplex glabruiscula.

Early in June (1970) many Atriplex glabruiscula plants showed signs of mildew (Plate 19).

The disease did not appear to be correlated with the density of the Atriplex plants.

Leaves were sectioned by hand and stained with lacto phenol aniline blue WS. The fungus was an Oomycete of the Genus Bremia (Plates 20a and 20b and Fig. 6a).

In the late June the number of diseased plants appeared to be increasing. 50 25cm. sq.quadrats were thrown in 'A' (the area of sheet erosion) and the diseased and non affected plants counted - 54.3% showed some trace of the disease.

Further examination of stained sections showed that a secondary infection had taken place by a Botrytis spp. Hyphae non -septate with aerial conidiophores. Young leaves were covered with mycelium but there appeared to be no infection in the roots. Leaves appeared to lack tugor and hand sections of fresh material showed a general breakdown of chloroplasts.

As this plant is the important species as a coloniser of area 'A' affected by sheet erosion this disease is of some significance. A. glabruiscula plants were also affected on Wideopens, Staple and Wamses.

On Staple many leaves of this species were also affected by roll galls caused by Homopteran Semiaphis (= Aphis) atriplicis.

Plate 19. Brownsman (6.6.71)

<u>Atriplex glabruiscula</u> affected by mildew (<u>Genus Bremia</u>)

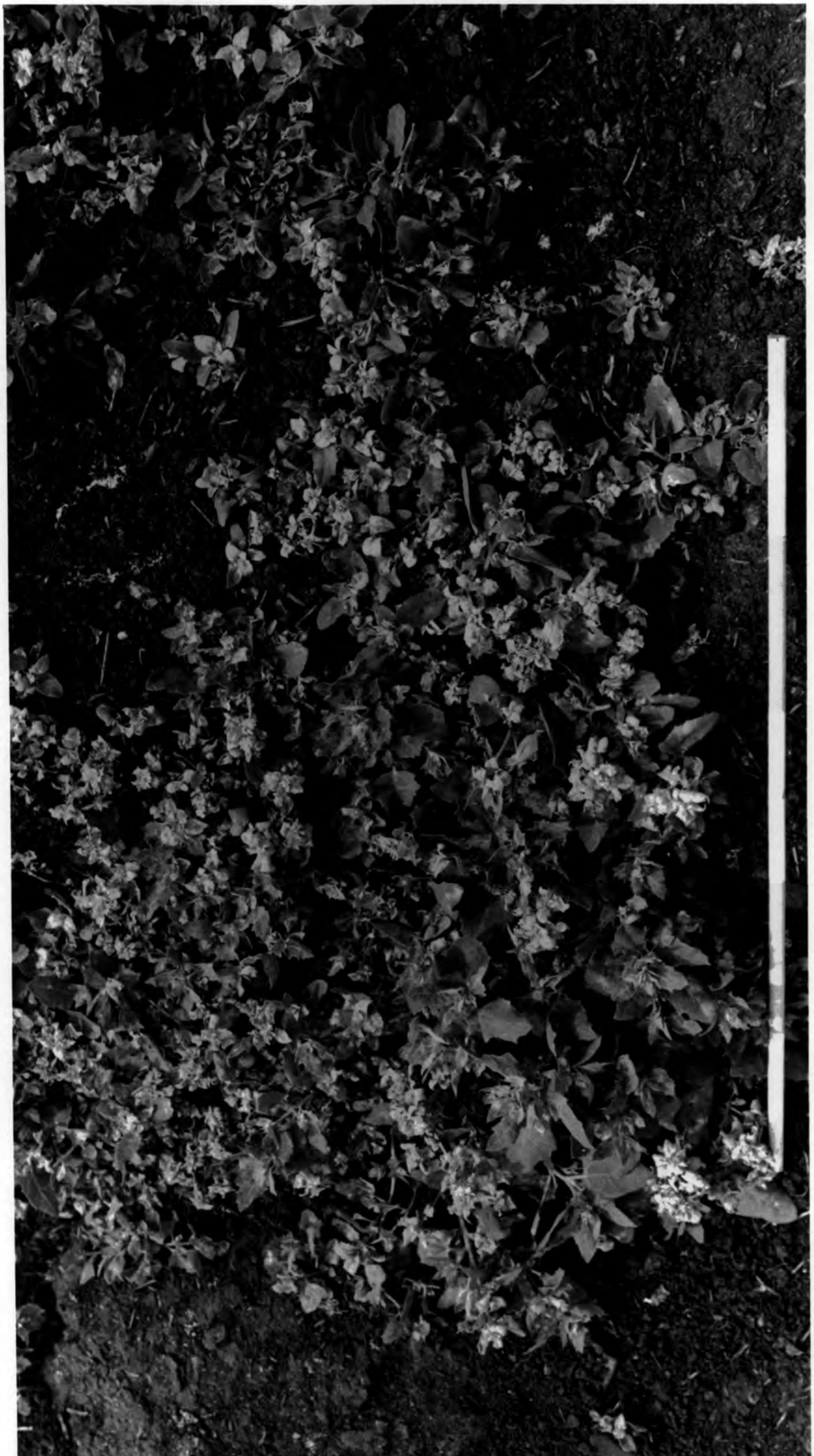
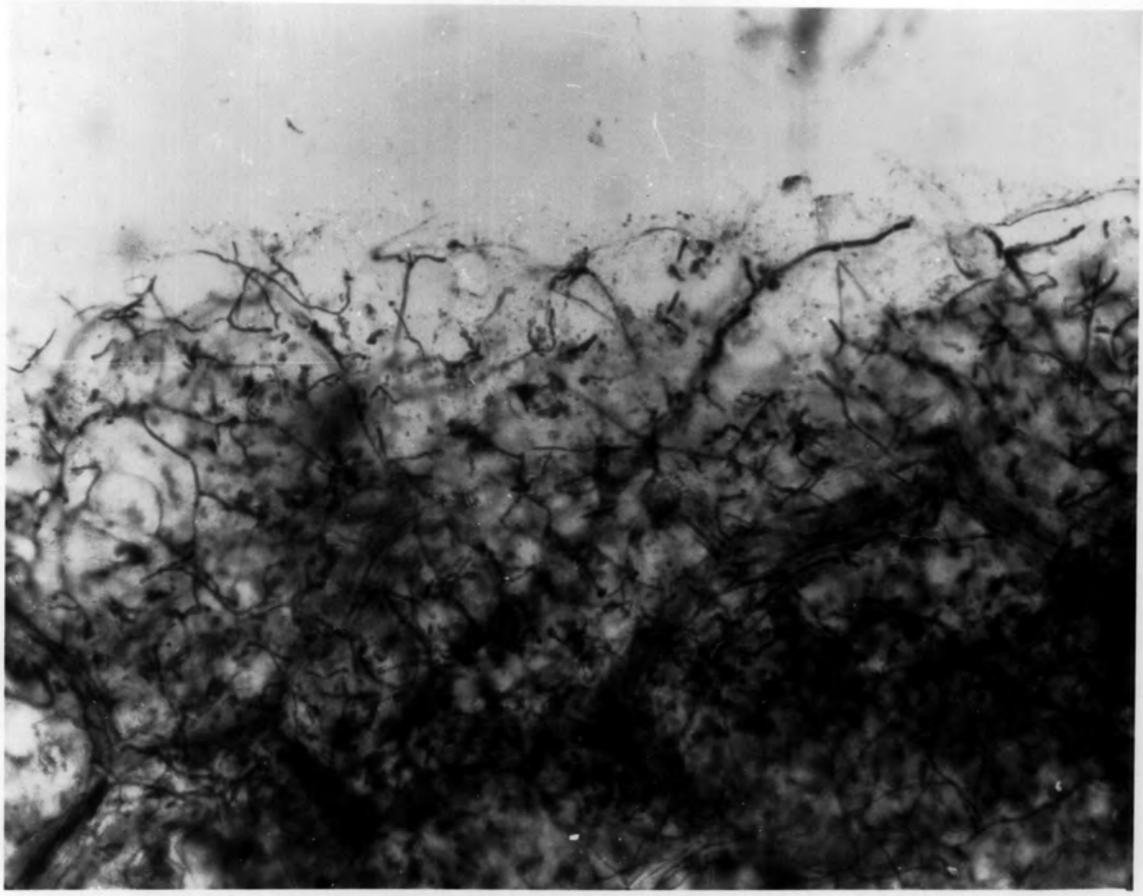
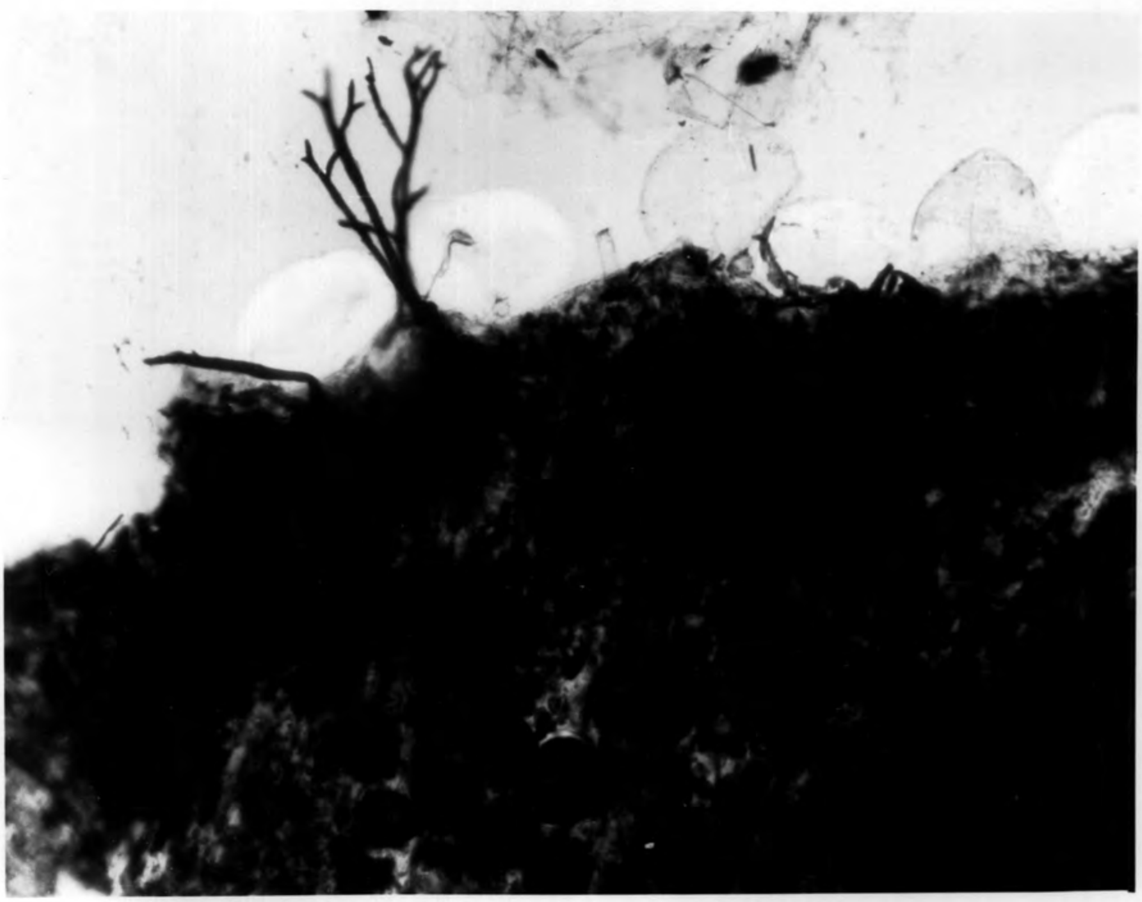


Plate 20a. T.S. Leaf of Atriplex glabruiscula
with heavy infestation of fungus (Genus Bremia)

Plate 20b. T.S. Leaf of Atriplex glabruiscula
with aerial conidiophores (note detached conidia)





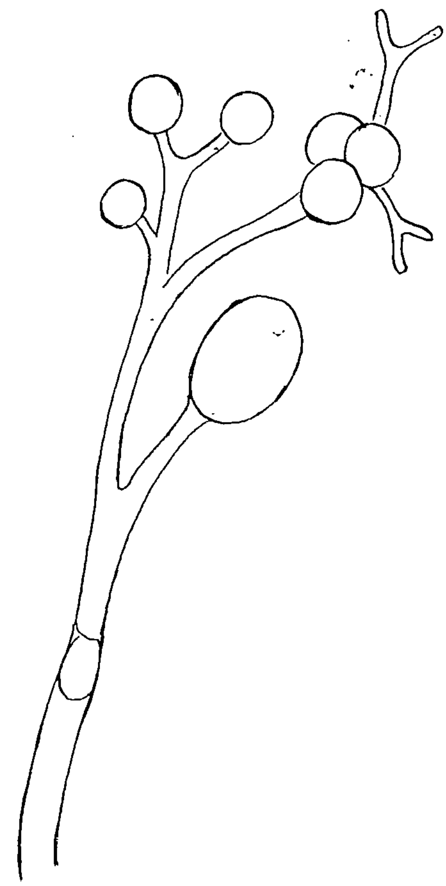


Fig. 6a. Oomycete - Genus Bremia conidiophore with developing conidia on T.S. leaf of *Atriplex glabruiscula*. 4mm objective.

8. A study of the Larus gull population on Brownsman with special reference to the composition of the nesting material.

Larus gulls destroy vegetation by plucking (a) during the display rituals (see Larus gulls on Staple (10).) (b) for use as nesting material.

To ascertain the rate at which Silene would produce new flowering stems a 'medium' size plant was selected and all the stems, 216, removed on 24.5.71. On July 12th very little shoot growth had taken place. (Plate 21)

Nests of Larus argentatus tend to be closer to the sea than Larus fuscus and also to construct more substantial nests, see (Plate 22a) On Brownsman it was difficult to differentiate between some of the nests unless the birds were present and for the following study no differentiation was made.

In order to obtain quantitative data for (b) above all the Larus gulls' nests on Brownsman were:-

(a) marked with a numbered pebble
(b) position recorded i.e. on bare Whin Sill or Vegetation
(c) dates recorded when new material was added
(d) the amount was estimated on a 3 point scale:-

i. 1 - 4 stems; ii. 5 - 19, and iii. 20 - 50 stems.

For the purpose of Table. 6. iii = a major amount of nest material

No. on bare Whin Sill - 66. and on Vegetation - 45.

From this table:-

(a) total nests 111
(b) total observations 650.i.e. ca. 6 per nest
(c) major quantity of material added

Silene 228 occasions = 35.1%
Atriplex 155 occasions = 23.8%
Algal soil complex 8 occasions = 1.2%
Other material chiefly marine algae 5 occasions = 0.8%

A major amount added was between 20 and 50 stems, if the mean is taken as 35, and 228 additions of S. maritima were made the total number of stems destroyed was 8,000.

Date	MAY 24	25	26	27	28	29	30	31
No. of observations	25	23	29	25		36		
Major amount of material added:-								
<u>Silene</u>	17	5	7	10		17		
<u>Atriplex</u>	7	4	3	9		6		
algal soil complex	1		1					
other material				1				

Date	JUNE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
No. of observations		55	35				60		41			52		49	28
Major amount of material added:-															
<u>Silene</u>		21	11				19		10			19		16	17
<u>Atriplex</u>		20	9				16		4			10		12	11
algal soil complex		2	2											1	
other material			1												

Date	JUNE 16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
No. of observations	29		41					51				34			
Major amount of material added:-															
<u>Silene</u>	9		14					19				16			
<u>Atriplex</u>	5		12					18				5			
algal soil complex								1							
other material															

Date. July	1	2	3	4	5				
No. of observations		1			36	=	650		
<u>Silene</u>					11	=	228	-	35.1%
<u>Atriplex</u>					4	=	155	-	23.8%
algal soil complex						=	8	-	1.2%
other material					3	=	5	-	0.8%

Nos. above = number of nests.

Table 6. Summary of Observations on <u>Larus</u> gull nests on Brownsman.

Soil Studies

Surface soil was collected from each of the 4 zones of the transect on Brownsman (Fig 7) and one farther to the east in area 'B' and pH readings taken.

'B' anthropogenic zone	pH 5.65
Silene - Rumex zone	4.8
Silene zone	4.8
Silene - Atriplex zone	4.2
Atriplex (seal wallow) zone	4.6

Soil from this latter area at 7.5cm and 12.0cm deep both gave the same reading, pH 3.8. From the same area fresh guano pH 7.0 and 'old' guano pH 7.2.

28 soil samples were analysed for moisture content and also for nitrate N, magnesium and calcium (Method - Appendix IX) The results are given in Table 9.

Samples A - C were taken on the same day, A and B had a moisture content less than 2X that of the exposed sand on Wideopens. The latter area, samPle C, is close to the sea and less than 3m above HWMMT which may account for the higher Mg and Ca content.

D, E and F from Staple suggests a greater water retention in the surface layers in the order:-

Atriplex (D above) → Graminetum → Silene

G. the seal wallow in the Atriplex zone above had a 2X the % of moisture but this could be expected due to drainage. Again the high N would be expected but the Mg in this seal wallow was ca. 10X higher than in most of the soil samples.

Samples H - L confirmed the importance of plant cover in preventing the surface layers from becoming excessively dry. This inevitably leads to a loss by soil erosion. M - O samples for the 'standing ground' of F. arctica show a similar pattern in the reduction of the moisture content. Where these birds have destroyed the Silene cover 7.5%, where 'dwarf' Silene plants exist due to treading 9.8% and where the Silene plants have not been trampled 15.5%.

It is suggested, page 37, that the distribution of Rumex crispus might be due to exposure. The moisture content of samples of soil 5cm deep from the 'R. crispus' areas showed considerable variation - 11.7%, 23.2% and 45.0%. The Mg and Ca readings at the pond side (inland) were much lower than the 2 coastal sites showing the influence of the sea.

The Graminetum on Staple Island (closely grazed by rabbits) had

30 almost dead patches of Puccinella rupestris measuring from 5 -50cm across. Samples Y1 and Z1 were adjacent, likewise Y2 and Z2. Soil from the living P. rupestris not only had a higher moisture content but also a much higher N content. The pH of Y1 and Z1 was 4.6 and that of Z2 and Y2 6.5.

As many of the areas from which the soil samples were obtained are close to the influence of the sea I would have expected the amounts of magnesium to have been greater.

	moisture % wet wt	nitrate N ppm	magnesium ppm	calcium ppm
A. South Wamses - sheet erosion	10.6	900	17.6	59.0
B. West Wideopen - sheet erosion	9.57	600	11.2	30.0
C. West Wideopen - sand area	6.51	1250	30.6	430.0
D. Staple - former area of sheet erosion.	15.98	500	12.6	30.0
E. Staple - *Graminetum*	25.38		10.6	20.0
F. Staple - *Silene* area	62.15		15.0	20.5
G. Staple - Seal wallow	30.54	1150	116.0	34.0
H. Brownsman - denuded area - surface . .	10.21	200	11.6	34.1
I. Brownsman - denuded area - 7.5cm deep.	62.04	400	6.4	27.0
J. Brownsman - denuded area -15.0cm deep.	63.97	300	7.6	17.5
K. Brownsman - under *Atriplex* - surface .	29.29	250	7.6	22.0
L. Brownsman - under *Silene* - surface . .	20.45	300	7.0	17.5
M. *F. arctica* 'standing ground' no cover	7.51	550	6.0	5.5
N. *F. arctica* as M small cover of *Silene*	9.83	250	7.2	5.0
O. *F. arctica* as M good cover of *Silene* .	15.49	450	2.6	23.5
P. Brownsman - new burrow, Zone 2. (Map 7)	30.92	250	5.8	30.5
Q. Brownsman - under *Silene* " " .	35.29	100	5.5	35.0
R. Brownsman - new burrow (2) " " .	42.85	300	7.8	67.0
S. Brownsman - under *Silene* (2)" " .	50.4	1900	11.0	34.1
T. Brownsman - under *Rumex* " " .	59.4	1100	7.8	50.0
U. Brownsman - under *Rumex* (2) " " .	58.17	1200	2.6	48.0
V. Brownsman - *R. crispus*. W. (Map 7) . .	11.70	600	9.4	100.0
W. Brownsman - *R. crispus*. E. (Map 7) . .	23.24	250	8.1	59.0
X. Brownsman - *R. crispus*. - pond side. .	45.1	750	3.4	27.1
Y1. Brownsman - *Graminetum* (living). . .	39.36	1050	5.5	26.5
Y2. Brownsman - *Graminetum* (living). . .	44.35	1200	12.0	42.0
Z1. Brownsman - *Graminetum* (dead). . . .	24.95	250	13.4	43.5
Z2. Brownsman - *Graminetum* (dead). . . .	14.31	700	15.0	45.0

Samples A - G collected on the same day
Samples H - Z2 collected on the same day

Table 9. Soil Analysis

Plate 21 Brownsman

Plant of *Silene maritima* 12.7.71 from which 216 stems were removed on 24.5.71. Little growth had taken place. *F. arctica* burrow unoccupied. Scale in cm.

Plate 22a. Brownsman

Nest of Larus argentatus constructed from eroded soil cover with Prasiola - Hormidium complex. Nests of L.argentatus tend to be more substantial than those of L. fuscus.

Plate 22b. Brownsman

Typical nest of Larus fuscus in vegetation - little nest material.

Distribution of Rumex crispus on Brownsman

Rumex crispus occurred in 3 areas (see Map 7). In each case the colonisation is in a sheltered area. (Plates 22a and 22b). Rumex crispus only occurs in one small area on Staple Island, and this is on soil washed down north of the 'garden' and this again is a sheltered site.

Plate 23a. Brownsman.

Rumex crispus sheltered site 1.

See Map 7.

Plate 23b. Brownsman.

Rumex crispus sheltered site 2.

See Map 7.

10. Staple Island.

Maps 8 and 9. Area above HWMMT 4.04 hectares.

A list of plants is given in Table 1.

The chief features are (a) the large expanse of Whin Sill, (b) the thickness of the drift deposit with a partially exposed steep bank running along its western edge, visible from the air in Plate 2, and (c) the cliffs, especially those to the south which provide nesting sites for Rissa tridactyla, Uria aalge and Phalacrocorax aristatelis. A base line was established in a line from the apex of Kittiwake Gully to the remains of the lighthouse tower on Brownsman. This line passed 6m from the old lighthouse tower on Staple.

Soil cover 1.68 hectares - 34.8% of the island above HWMMT.

The area of 'recent' soil cover lost 0.22 hectares - 11.6% of the former soil cover. The present soil cover overlies a drift deposit in places 4m deep and a large expanse of Whin Sill is exposed on the NE and E sides of the island which is above the normal high tides.

Plate 24 was photographed from the NE with the drift deposit in the background. Many of the fissures are filled with a deposition of peat and almost all have some plant cover, especially Atriplex glabruiscula, Silene maritima and Spergularia marina.

Plate 25, photographed from the top of the soil cover looking towards the Pinnacles depicts (a) a larger 'island' area of vegetation overlying drift deposit and (b) the extent of the former soil cover. A number of deeper fissures still retain this same cover but many are filled with water. (Plate 26) Many such pools support a growth of Callitriche stagnalis.

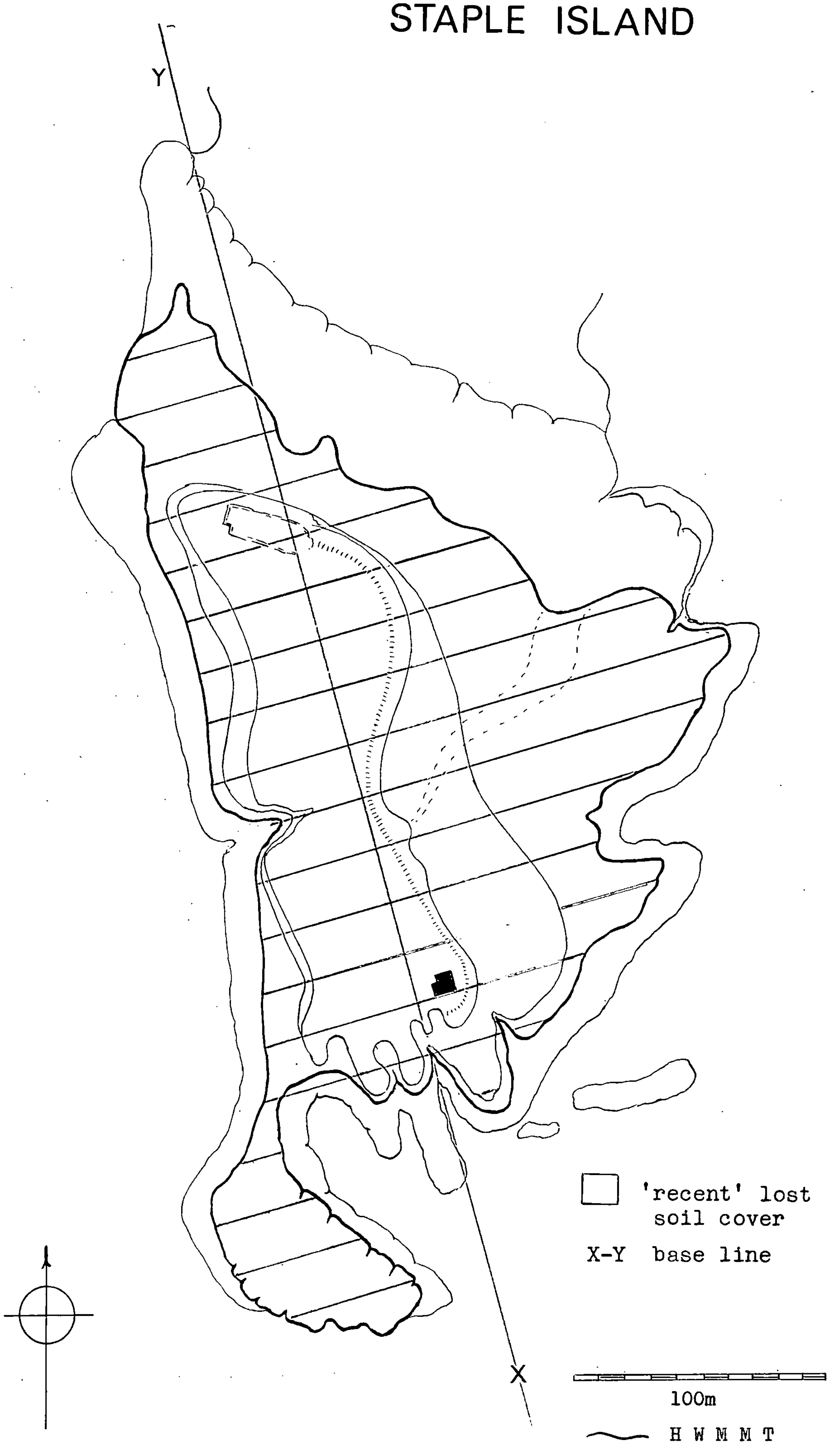
The above Plate (26) shows the remains of the drift deposit with peat cover roughly at the same level as the Whin Sill. If this area once had a cover as deep as that shown in Plate 24 then it must have disappeared, before the present soil cover was formed on the drift deposit in the fissure (Plate 26), and before the present peat was formed in the less deep fissures.

Transect along the baseline Map 9

This was made along the baseline to record the extent of the Graninetum and the varying character of the Silenetum (Fig. 7).

This does not show the same transition as Brownsman (Fig.5). Rumex acetosa is absent. (Rumex crispus only occurs in a deposit of soil washed down on to the Whin Sill just north of the garden) and

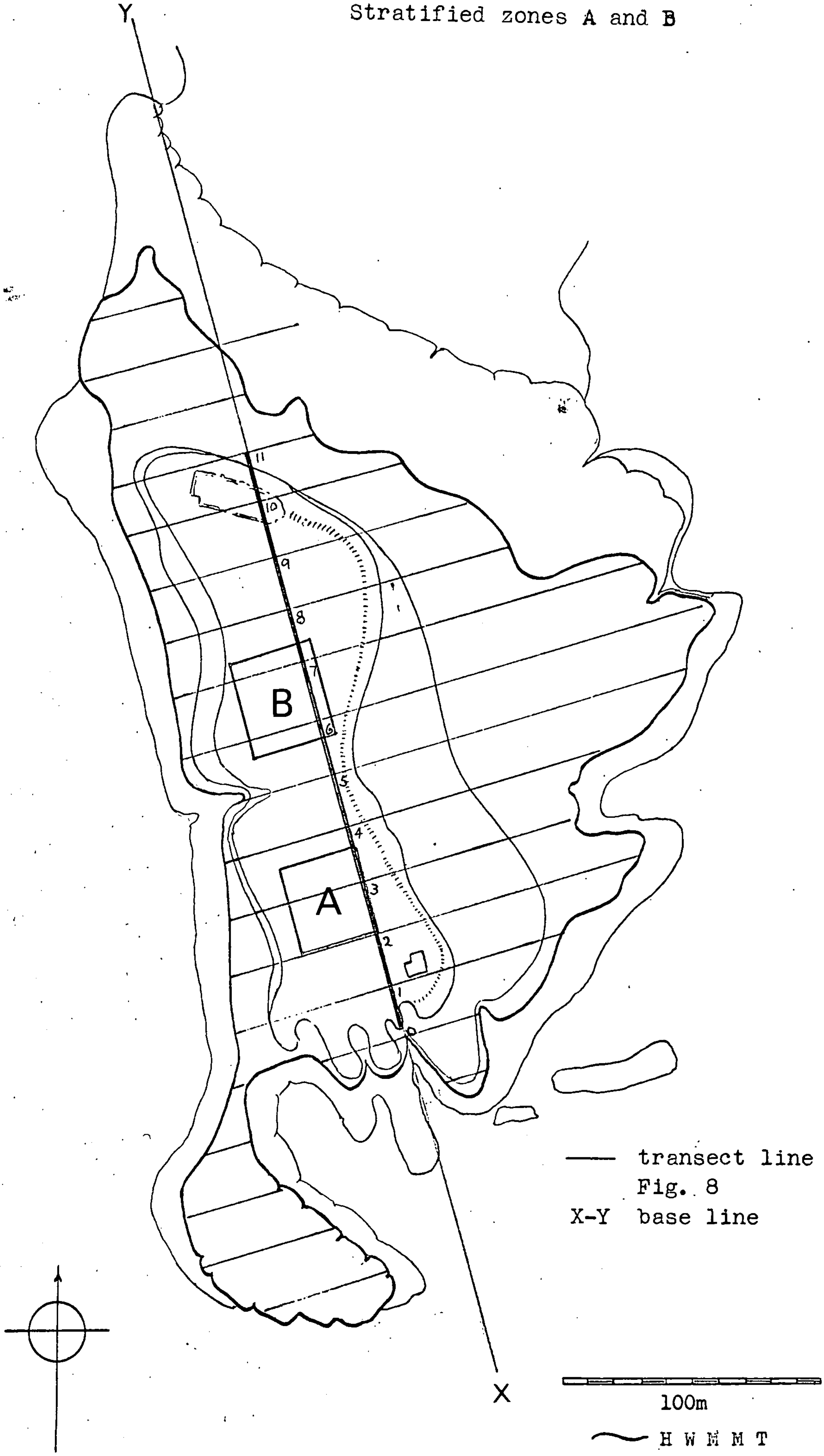
STAPLE ISLAND



MAP 8

STAPLE ISLAND

Stratified zones A and B



MAP 9

a Graminetum is present.

The vegetation of Staple began to change in 1962 (Mrs.Hickling's Journal) and by 1966 from the same source "fat hen' (Atriplex) was definitely spreading and the campion was disappearing. There are definite patches where erosion is begining". It appears that this developed into a large area of sheet erosion with insignificant cover from S. maritima or A. glabruiscula.

The transect shows 12.6.71

1. that a considerable recolonisation must have taken place
2. the soil cover still supports a large colony of F. arctica.
3. there is still a zone where annuals predominate with significant area of bare soil and numerous burrows
4. an almost pure Silenetum with nearly 100% cover and without F. arctica burrows
5. a Graminetum with a high density of burrows.

The recolonisation of the denuded area, 1 above, is depicted in Plate 27. Although much of the ground cover is A. glabruiscula there are considerable 'drifts' of S. maritima.

The zone occurring on Staple Island which is completely absent on Brownsman is the Graminetum consisting of Puccinellia rupestris with Festuca rubra around the tower. Chapman (1964) Coastal Cliff Vegetation, states that Festucetum rubrae appears to be the climatic climax in the absence of grazing. I have been unable to obtain any data regarding the recent history of the Graminetum but it appears however, from the moribund plants of Puccinellia rupestris under Silene maritima, that formerly the Graminetum was more extensive and that S. maritima has replaced a large part of it. Much of the Graminetum, especially near the cliffs, is densely burrowed by F. arctica (Plate 28) and they may already have been in part of the Silenetum before P. rupestris 'gave way' to S. maritima. As the burrows in this area have traces of decayed P. rupestris it is a more likely explanation than the alterative, i.e. F. arctica spread from the Graminetum into the Silenetum.

It would appear on Staple that the pattern of degradation is P. rupestris ⟶ S. maritima ⟶ S. maritima and A. glabruiscula ⟶ A. glabruiscula

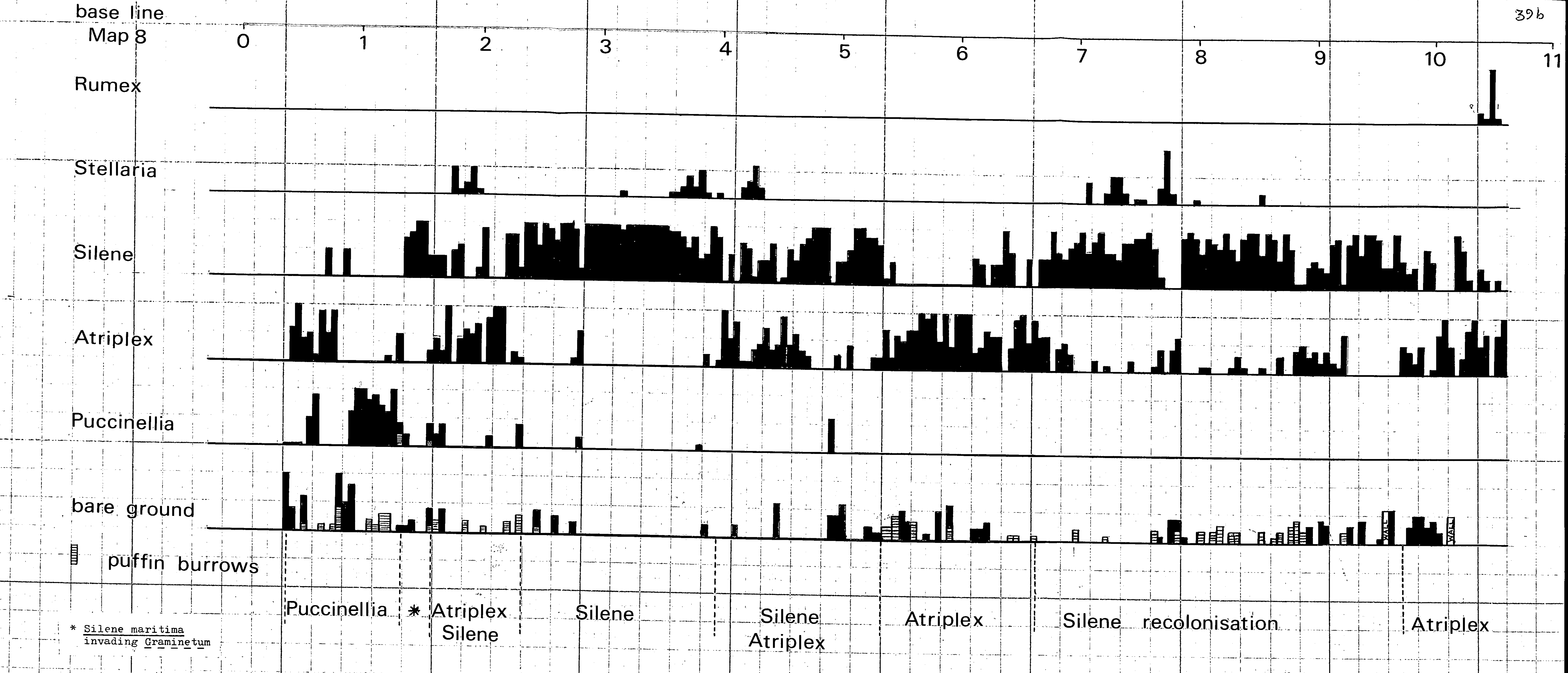


Fig 8 220m TRANSECT STAPLE ISLAND see Map 8
24.6.71

Stratification of vegetation and the collection of data by means of random quadrats

2 stratified zones were compared by the same techniques as those employed on Brownsman - Zones 'A' and 'B' (Map 9).

Zone 'A' in the Silenetum and zone 'B' in the previously eroded area. The results are summarized in Table 5.

There are significant differences in the cover of 1. S. maritima 2. A. glabruiscula and 3 bare ground, calculated as cover ($P < 0.001$ in each). There is also a significant difference in the number of Silene flowers calculated from all the quadrats in which Silene occurred ($P < 0.01$).

In zone 'A', the Silenetum, the puffin density was low 0.02 burrows per m^2. In zone 'B' it was much higher 0.33 burrows per m^2.

The 4 main biotic pressures on the vegetation were 1. F. arctica 2. Larus gulls, 3. Oryctolagus cuniculus and 4. Halichoerus grypus.

1. Fratercula arctica

This has already been discussed for Brownsman.

On Staple Island many burrows in zone 'B' were in ground cover of A. glabruiscula. The 'dwarfing' of these plants at the burrow entrances is illustrated in Plate 26b.

2. Larus gulls

The Larus gull population has remained fairly static at least since 1965 when control measures, similar to those used on Brownsman, were introduced.

The 1969 census - L. argentatus 65 $\pm$ 20, L. fuscus 95 $\pm$ 20 but over 60% of these hold territories on the bare Whin Sill.

For the first time a large area was fenced off to eliminate trampling by visitors, therefore nearly all the trampling which took place was due to Larus gulls and to a much lesser extent F. arctica.

The vegetation is adversely affected in 3 ways -

(a) plucking for nest material. Plate 29a illustrates the destruction in an Atriplex sward by a single pair of L. fuscus 2.6.71, 6 weeks later the bared soil showed signs of erosion.

(b) damage by display and posturing. Plate 29b illustrates damaged S. maritima plants in an area used by L. fuscus - many of the stems have been plucked as part of the display ritual 2 0.5m rods, 3m apart.

(c) trampling in the breeding territory. Plate 30a and 30b 8.6.71. This becomes progressively greater during the breeding season.

If control measures are taken to prevent breeding and replacement clutches are laid this will increase rather than decrease the overall damage by Larus sp.

3. Oryctolagus cuniculus

Staple Island supports a small population 6 - 8 O.cuniclus (31.5.71). These were mixed i.e. some typical of the mainland colouration and some sandy orange - probably a greater proportion of the latter. There appears to be no evidence of interchange between the populations of Staple Island and Brownsman.

4. Halichoerus grypus

The distribution of H. grypus in Nov. 1970 is also illustrated in the aerial survey Plate 65 b.

All the main wallows were mapped Fig. 9.

They were first examined on 14th May when the whole area was being rapidly colonised by A. glabruiscula. The density of plant cover in the wallows differed very little from that of the whole area. (subjective assessment). By June the soil cover in between, and surrounding the wallows was > 80% whereas the cover in the wallows had changed very little during the intervening period. In wallow 'C' 50% of the A. glabruiscula seedlings were dead. (see Table 7.) Wallow 'H' (Fig. 9.) was photographed 6.6.71 - Plate 31 and illustrates this lack of recolonisation.

Table 7. gives the percentage cover of each species in the 12 wallows. Spergularia marina had a higher frequency of occurrence in these wallows than any comparable 'bare soil' area on the island (subjective assessment). Chenopodium rubrum occurred in 4 of the 12 wallows but apart from these instances only 1 plant was recorded from the remainder of the island (on the Whin Sill E. of the drift deposit).

The overall effect of H. grypus is discussed in 15. Biotic Factors.

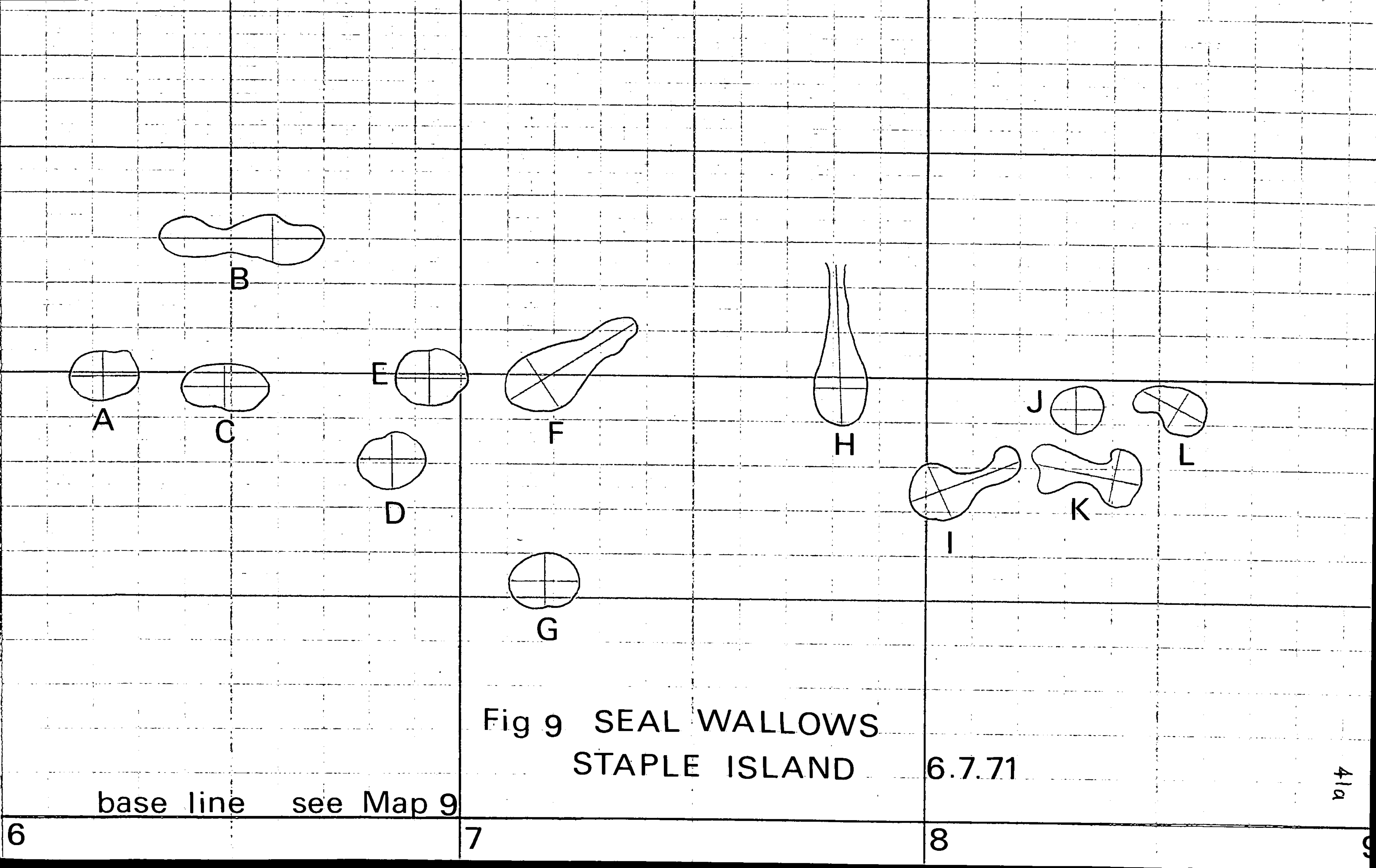


Fig 9 SEAL WALLOWS
STAPLE ISLAND 6.7.71

Seal Wallows	Atriplex glabruiscula	Spergularia marina	Chenopodium rubrum	Stellaria media	Poa annua
A	40	5			
B	30	5	+		
C	20 *	10	+		
D	30	5			+
E	10	5			
F	5	20			
G	50	5	+		
H	20	5	+	+	+
I	5	10			
J	5	10			
K	5	+			
L	5	5			

* 50% of this total consisted of dead seedlings

Table 7. Recolonisation of Seal Wallows

Staple Island 6.6.71 (see Fig. 9.)

Plate 24 Staple Island

Bare Whin Sill with drift

deposit in the background.

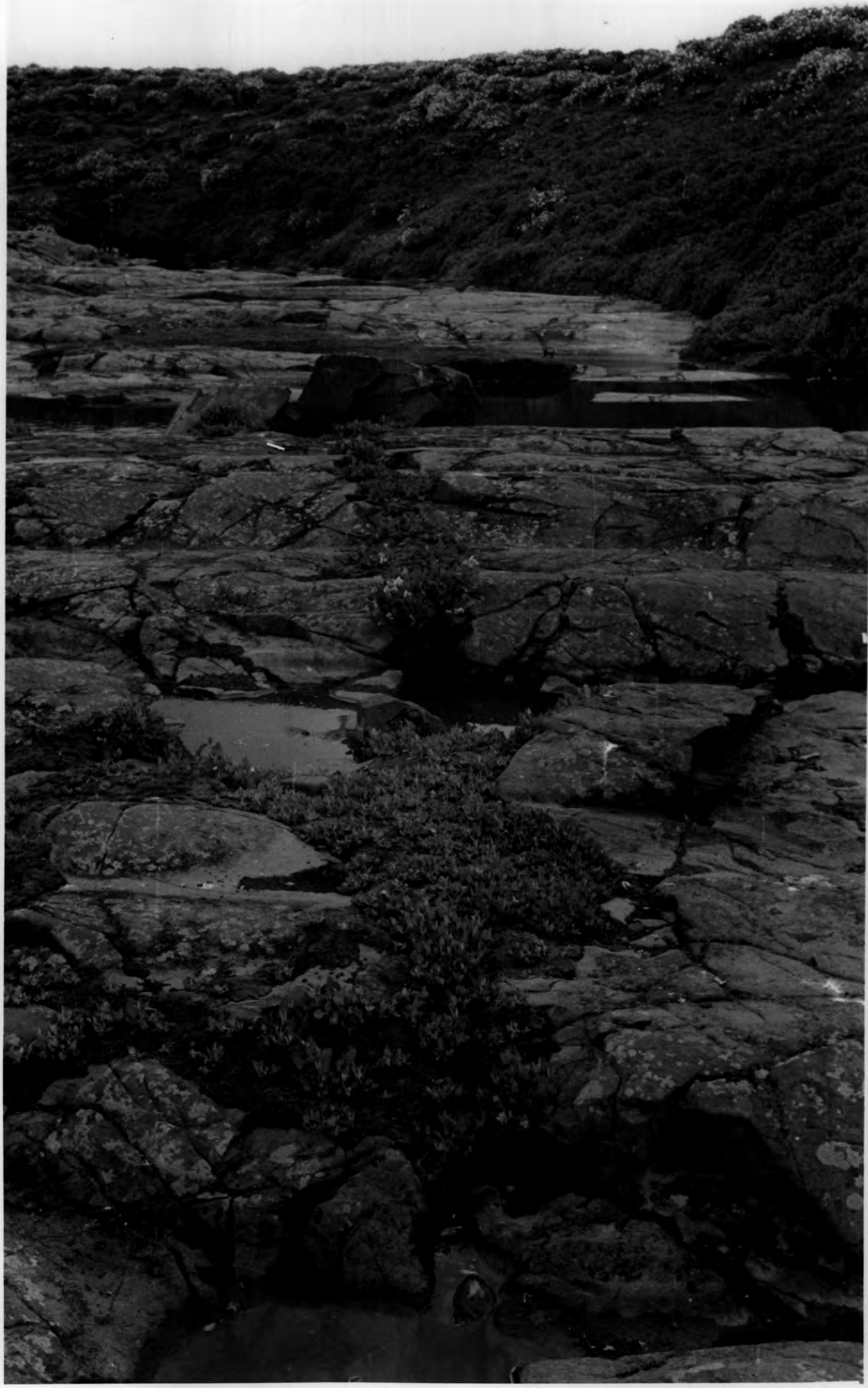


Plate 25 Staple Island

Almost bare Whin Sill. Note

evidence of formef soil cover.

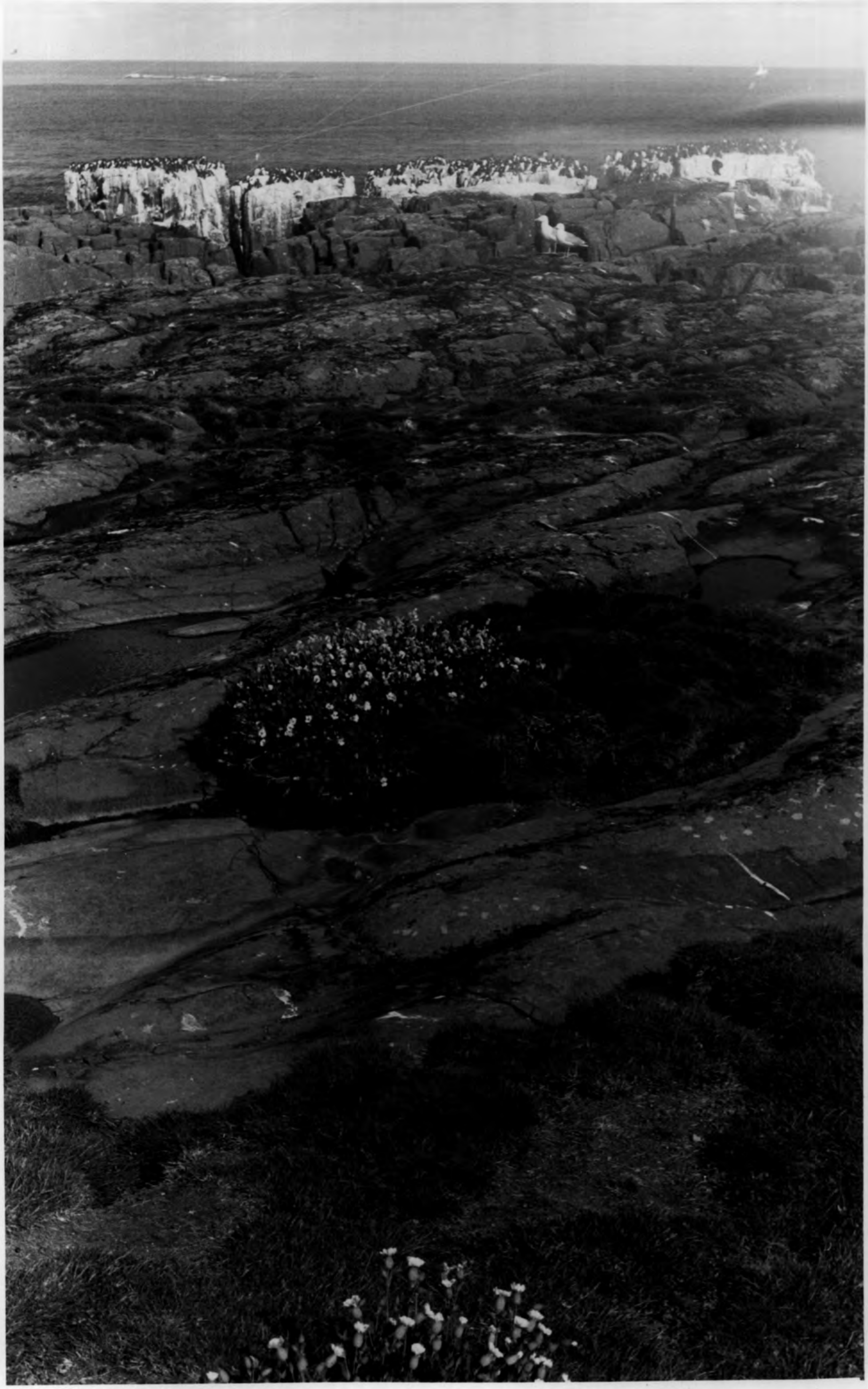


Plate 26. Staple Island.
Bare Whin Sill. Typical fissure.
Note the remains of drift deposit
with soil cover. rod - 0.5m.

Plate 26 B. Staple Island.
'Dwarfing' of Atriplex - entrance
to Fratercula arctia. rod - 0.5m.

Plate 27 Staple Island 28.6.71

Recolonisation of former area of sheet erosion

note 'drifts' of _Silene maritima_.

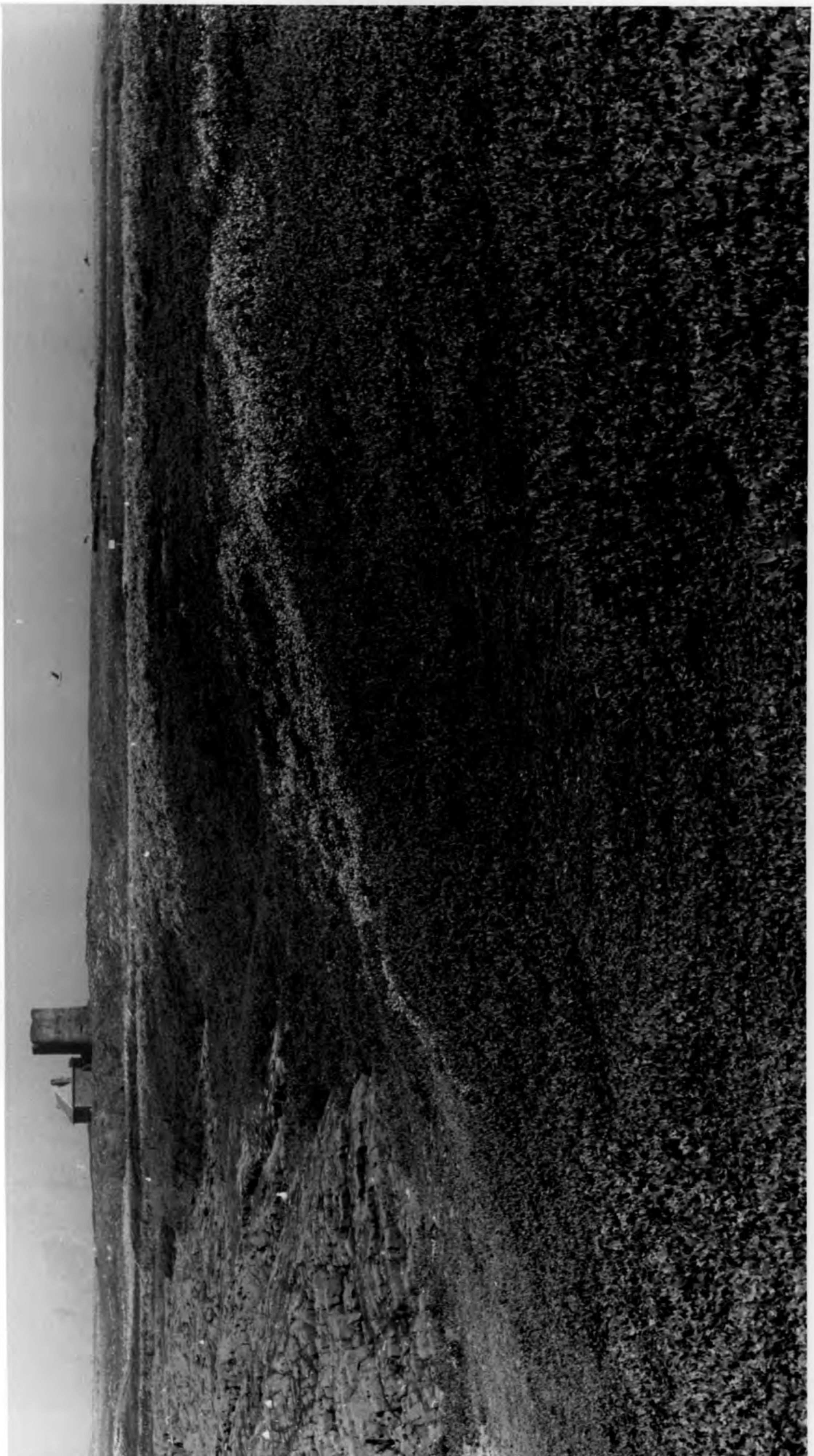


Plate 28 Staple Island

Graminetum dense colony of Fratercula arctica

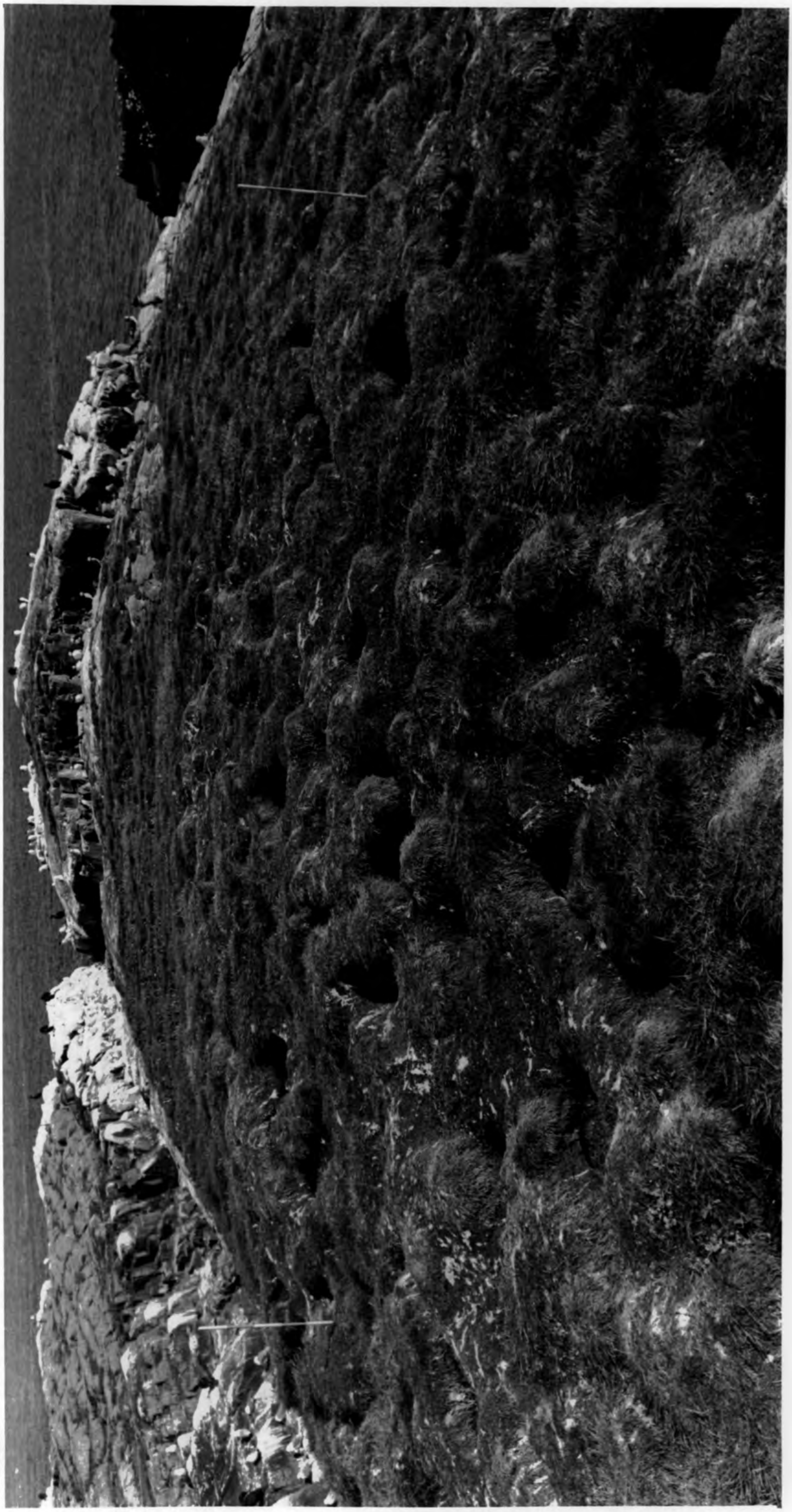


Plate 29a. Staple Island.
Atriplex plucked by a pair of
Larus fuscus for nesting material.
rod - 0.5m.

Plate 29b. Staple Island.
Display 'arena' of Larus fuscus -
damage to S.maritima by trampling
and plucking. 2 0.5m. rods 3m. apart.

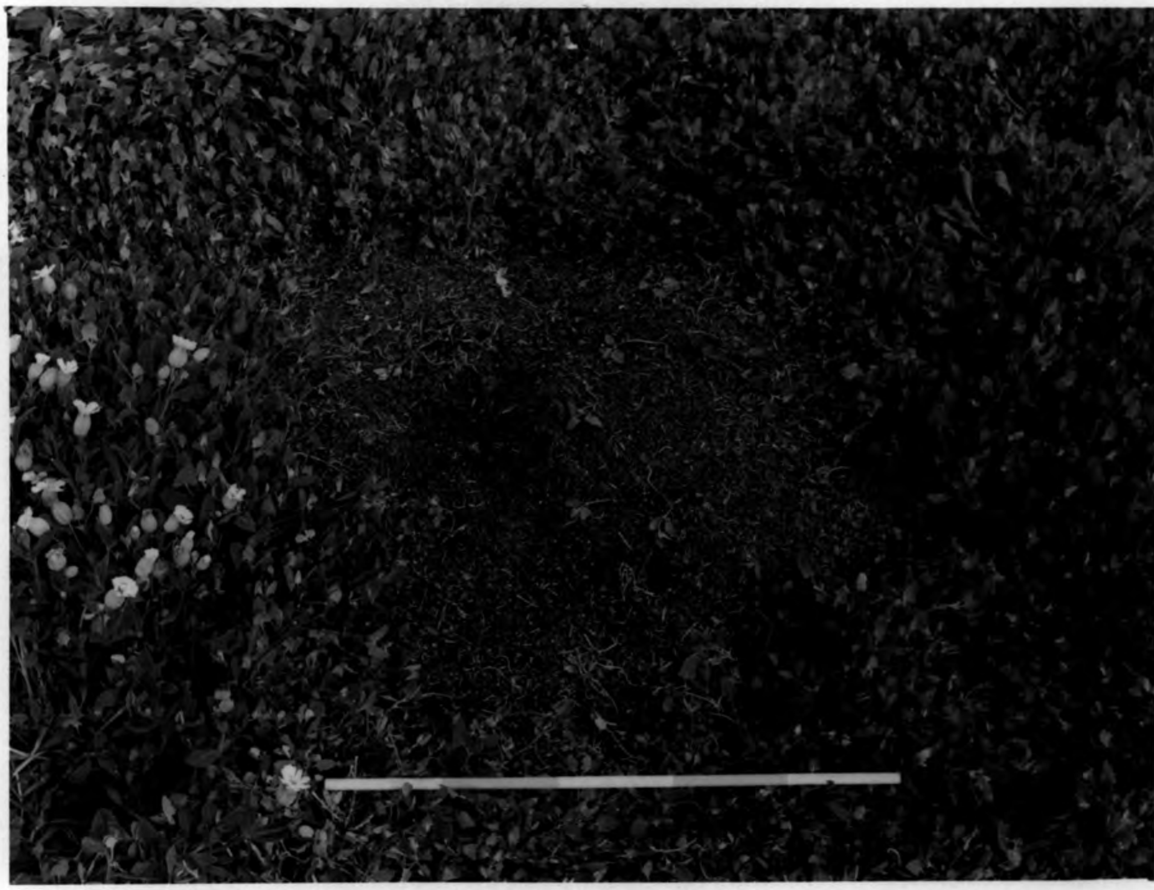
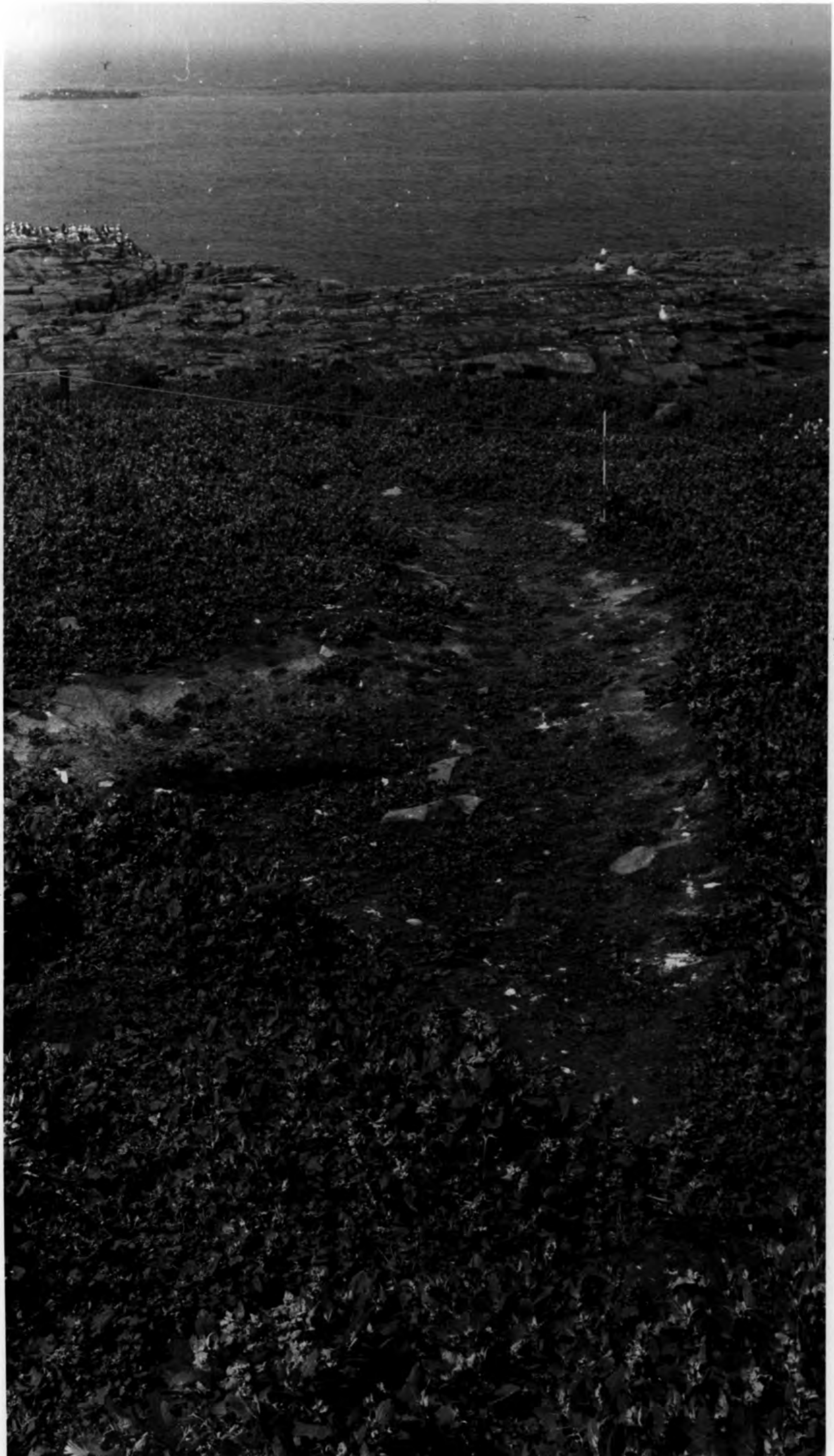


Plate 30a. and 30b. Staple Island.
Trampling of _S. maritima_ by _Larus fuscus_ in nesting territories.

Plate 31 Staple Island.
Halichoerus grypus wallow 'H' see Fig.
and Table 7. Note the lack of colonisation
by plants.



11.. N. and S. Wamses.

(a) South Wamses. Maps 10 and Fig. 10.

Area above HWMMT 0.81 hectares with 0.45 hectares of soil cover.

A list of plant species is given in Table 1.

The summit of S. Wamses is a plateau and due to sheet erosion the stony pavement is exposed.

A base line was laid down in a line from the 'Ware-cutters' hut to the radio mast on Longstone. From this baseline all land above high water mark was divided into 20m squares. The depth of soil was measured by probes along the ab and cd axes. (Fig 10) In each square the percentage cover of the vegetation was recorded, Table 8 , and the number of Larus gulls's nests counted - 560 on soil and 133 between the soil cover and HWMMT. (24.6.71) This is a density of 34.5 nests per 20m square for all land above HWMMT and 50.0 nests per 20m square on soil cover. (1 pair per 8 sq^2).

It would appear that S. Wamses has the maximum number of territories of Larus gulls. Due to this extreme pressure many nests were only 1m above the high tide line and would not survive even a moderate storm. At this density of 50 nests per 20m square of soil cover it is difficult to envisage any recolonisation by plants taking place.

Plate 33 illustrates the remaining plant cover, chiefly Festuca rubra and Holcus lanatus. This is the area also occupied by H. grypus (Plate 43). The seal wallows are visible from the air and they can also be seen in Plate 33.

Due to the annual increments of nitrogen this vegetation is very lush. Leaf length and width of Holcus lanatus was compared with this species on the mainland. In each the top leaves were discarded and 50 leaves from adjacent stems were then measured.

	mainland	S. Wamses
mean length	188.42	169.91
mean width	8.98	13.2

Although the leaves on S. Wamses were considerably shorter they were significantly broader ($P < 0.001$).

Some explanation would seem to be called for as to the existence of this vegetation at the high level of Larus gull pressure.

Larus sp. (these were almost all L. fuscus) defend a breeding territory and this precludes other gulls from collecting nest material. Larus gulls in the Graminetum use the material available in their territory (Plate 34), those in the small Silenetum, S. maritima(Plate 34b), those on the area of sheet erosion dead stems and leaves of Gramineae sp. (Plate 35a), while those which are forced to breed on the lower areas, between the soil cover and high tide line, use dead wrack. (Plate 35b)

It would appear, therefore, that this holding and defending of territories tends to conserve the larger grass hummocks.

(b) N. Wamses Map 10.

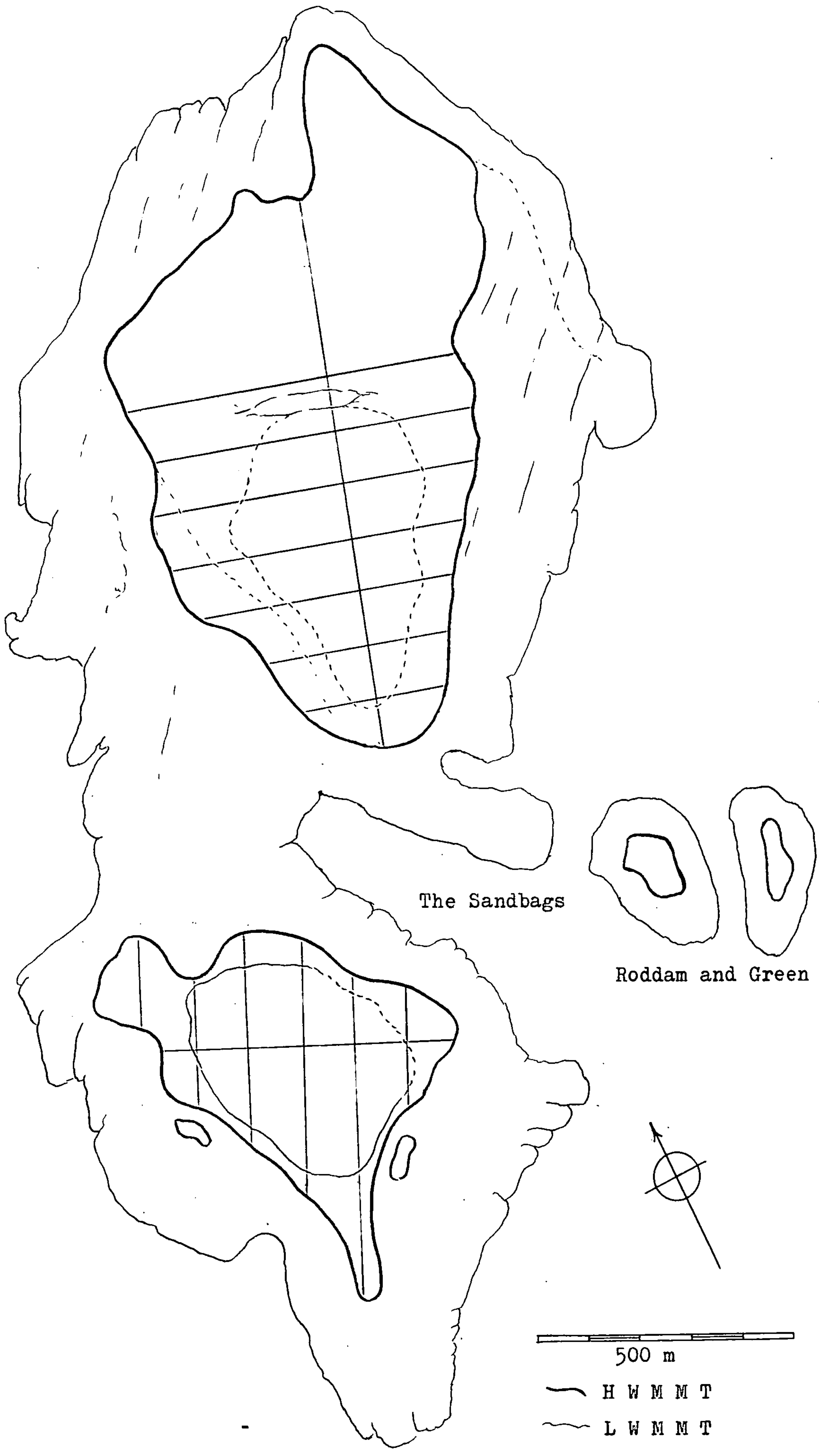
Area above hwmmt 2.09 hectares. A list of species is given in Table 1.

There is no continuous soil cover so much of the island may well be suitable for H. grypus and the distribution of the colony in Nov. 1970 is illustrated in Plate 43.

The vegetation has much in common with S. Wamses and the probability that it once had a continuous soil cover with a high density of Fratercula arctica burrows is discussed in 16. Erosion. Where any depth of soil remains sufficient for the burrowing of this species, occupied burrows are still to be found. The eroding tops of such burrows are still supported by the roots of Puccinellia rupestris (Plates 36a and 36b).

N. Wamses also supports a large Larus gull colony and two colonies of Phalacrorax carbo.

NORTH and SOUTH WAMSES



MAP 10

SOUTH WAMSES

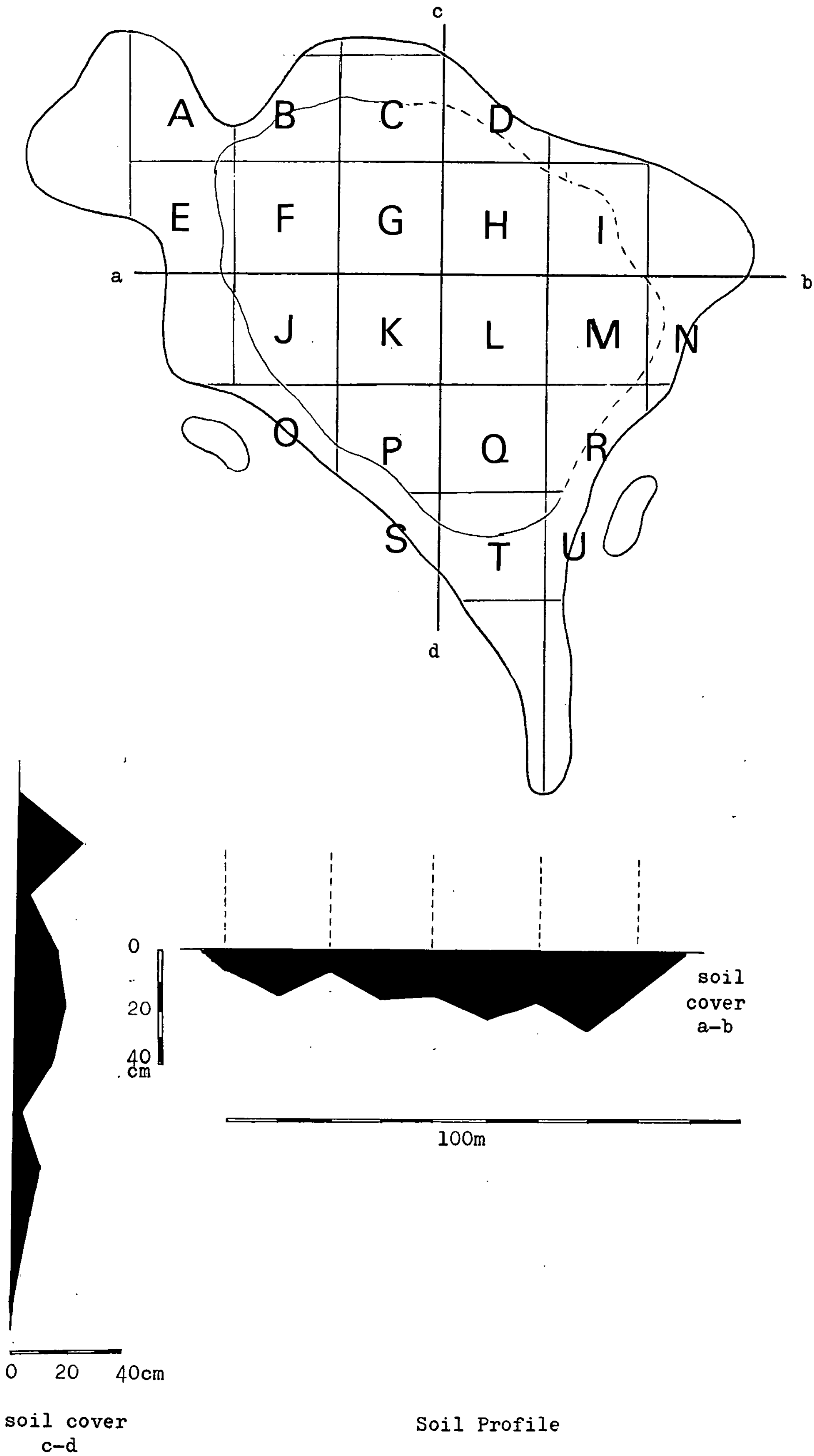


Fig 10

	Puccinellia rupestris	Holcus lanatus	Festuca rubra	Silene maritima	Cochlearia officinalis	Galium aperine	Atriplex glabruiscula	Polygonum ariculare	Larus gull's' nests on vegetation	Larus gulls' nests on beach	
A										7	
B		>1	1		>5				38	8	
C	30				>1	>1	5		39	18	evidence of former soil cover
D.	20								18	13	
E	5			5					11	3	
F		>1	1		1				42		
G	40	< 5					30	1	45		
H	10	10					15		38	15	
I	15						1		25	5	
J	1			5					42	4	
K		< 5					1		43	1	
L		20	+				10		37	10	3 seal wallows
M	10	10					15		42		
N	1								3	11	
O	+	+		+					2	16	
P	15	5	50				1		29	4	
Q	>1			>1					50		
R		5	10	> 5			5	2	24	5	
S	1								5	11	
T		25		+					21	28	
U									6		
									560	133	

Table 8. S. Wamses (see Fig 10)

Plant cover in percentages and No. of Larus Gulls' nests 24.6.71

Plate 32 S. Wamses 24.6.71.

Summit - sheet erosion - breeding ground of dense _Larus_ colony.

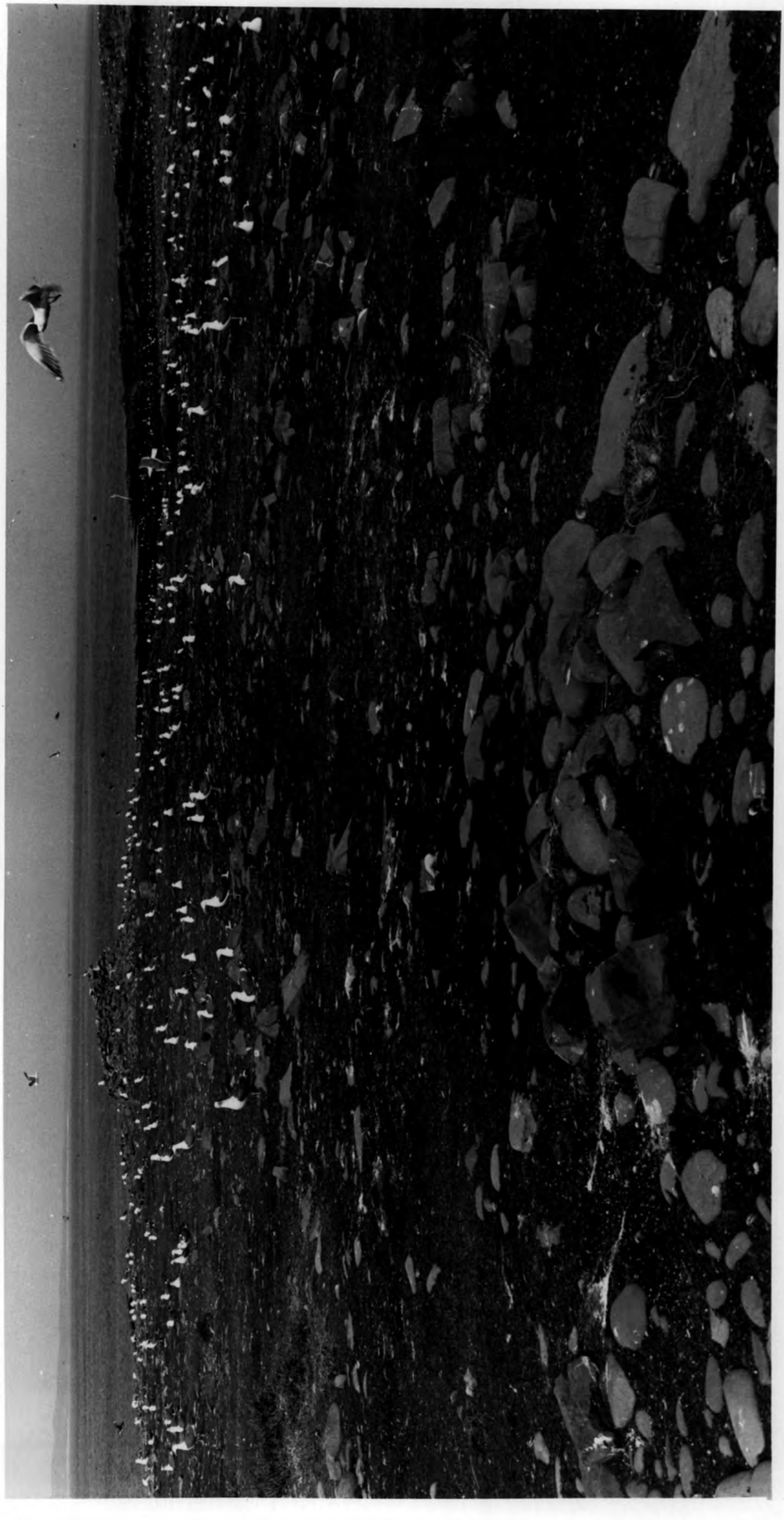


Plate 33 S. Wamses 24.6.71.

East side of plateau - *Graminetum* with *H. grypus* wallows in foreground.

Plate 34a. S. Wamses.

Nest of Larus fuscus in Graminetum.

Plate 34b. S. Wamses.

Nest of Larus fuscus close to Silenetum.

Plate 35a. S. Wamses.

Nest of <u>Larus fuscus</u> on area of sheet erosion.

Plate 35b. S. Wamses.

Nest of <u>Larus fuscus</u> on shore.

Plate 36a. and 36b. N. Wamses.
Occupied burrows of <u>Fratercula artica</u> in the remains of the <u>Graminetum.</u>

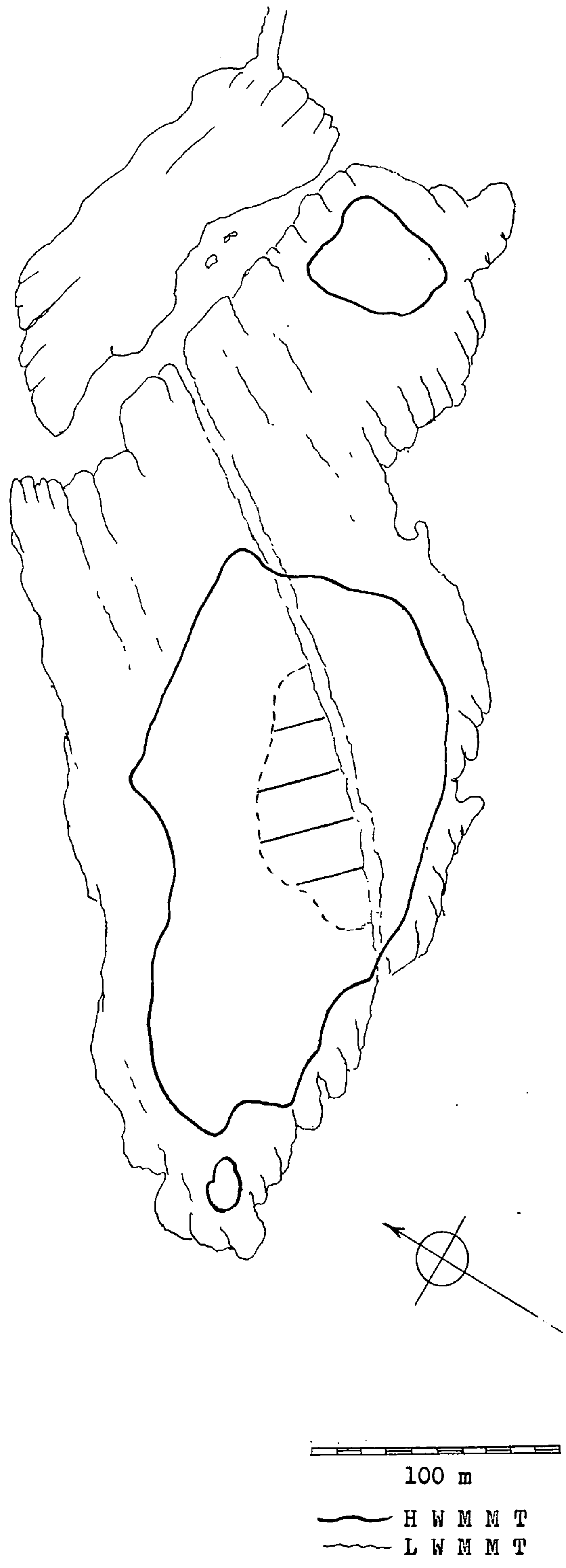
12. Big Harcar

2.02 hectares above HWMMT.

Area of former vegetation 0.33 hectares - 16.2% of the total area.

Plate 37 is a general view of the almost bare Whin Sill but many fissures in the above 0.33 hectares show the remains of a former Graminetum. The largest area of continuous soil cover is 14m - part of this area is illustrated in Plate 38a - and is still occupied by a small, but dense colony of F. arctica. Plate 38b is typical of much of the area. It appears that the whole soil cover and Graminetum supported a dense colony of F. arctica but eventually the balance was such that the vegetation, probably Puccinellia rupestris, was no longer able to prevent erosion on a large scale.
This is discussed in detail in 16. Erosion.

BIG and LITTLE HARCAR



MAP II

Plate 37 Big Harcar.

Area of former _Graminetum._ The nesting area of a dense _Larus_ gull population.

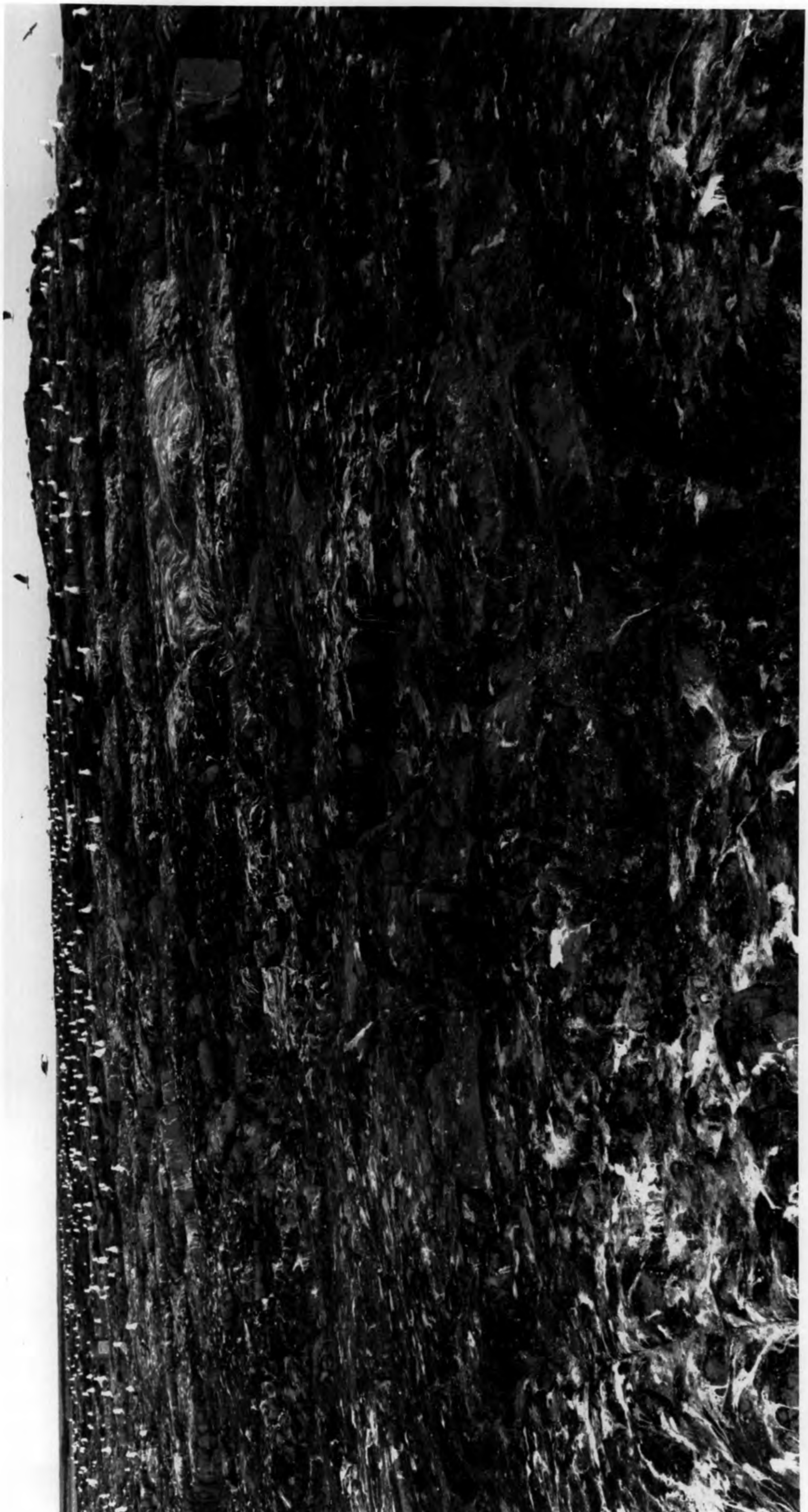
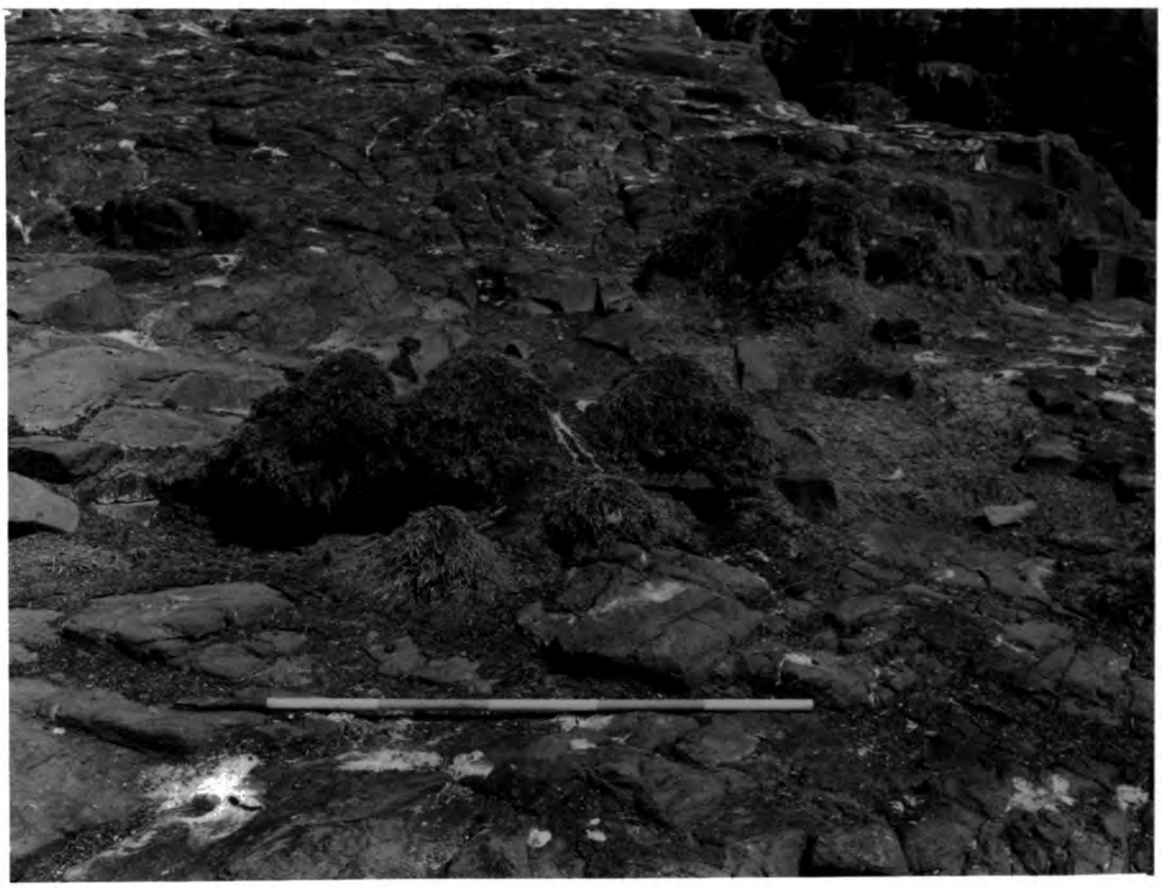


Plate 38a. Big Harcar.
Part of the remaining soil cover - occupied burrows of Fratercula artica.

Plate 38b. Big Harcar.
Typical remnant of former Graminetum with remains of F. artica burrows.



13. Longstone and the Northern Hares

Longstone

3.88 hectares above HWMMT.

The only continuous area of soil cover is $295m^2$ with Puccinellia rupestris (Plate 39) which provided (1971) cover for 17 pairs of Sonateria mollisima, 2 pairs of Sterna paradisaea, and a number of pairs of Larus gulls.

Most of the remains of the former cover of vegetation is reminiscent of Big Harcar and it is possible that it once supported a colony of Fratercula arctica. It is interesting to record 6 new burrows of this species in the remaining soil cover 25.7.71 but there was no sign of actual breeding.

The vegetation is discussed in 14. Some Aspects of the History of the Vegetation of the Farnes and also in 16. Erosion.

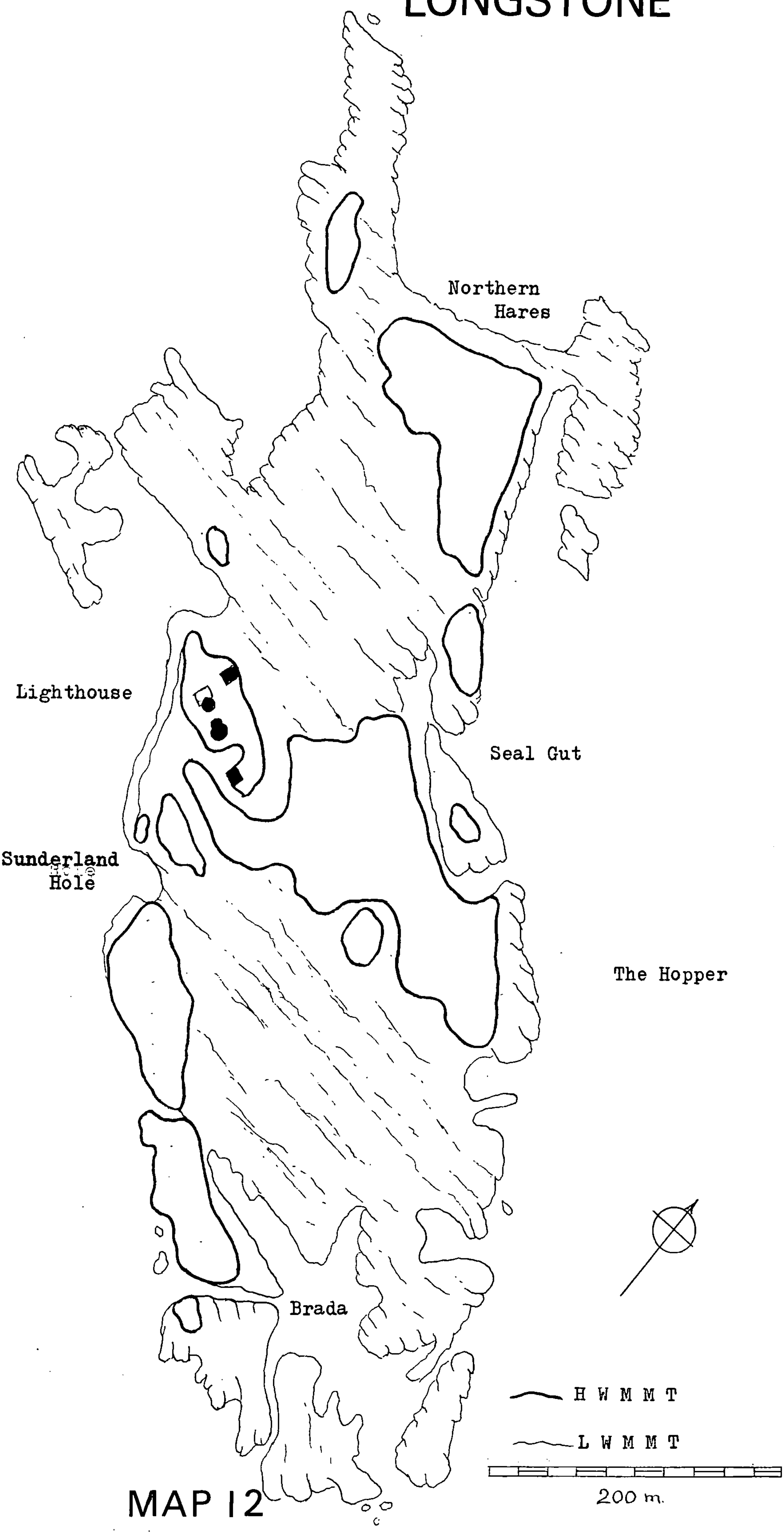
Northern Hares

There is no continuous soil cover.

Plate 40 records all the vegetation extant 14.6.71.

These tufts of Puccinellia rupestris may well be the remains of a former peat cover formed directly on the Whin Sill.

LONGSTONE



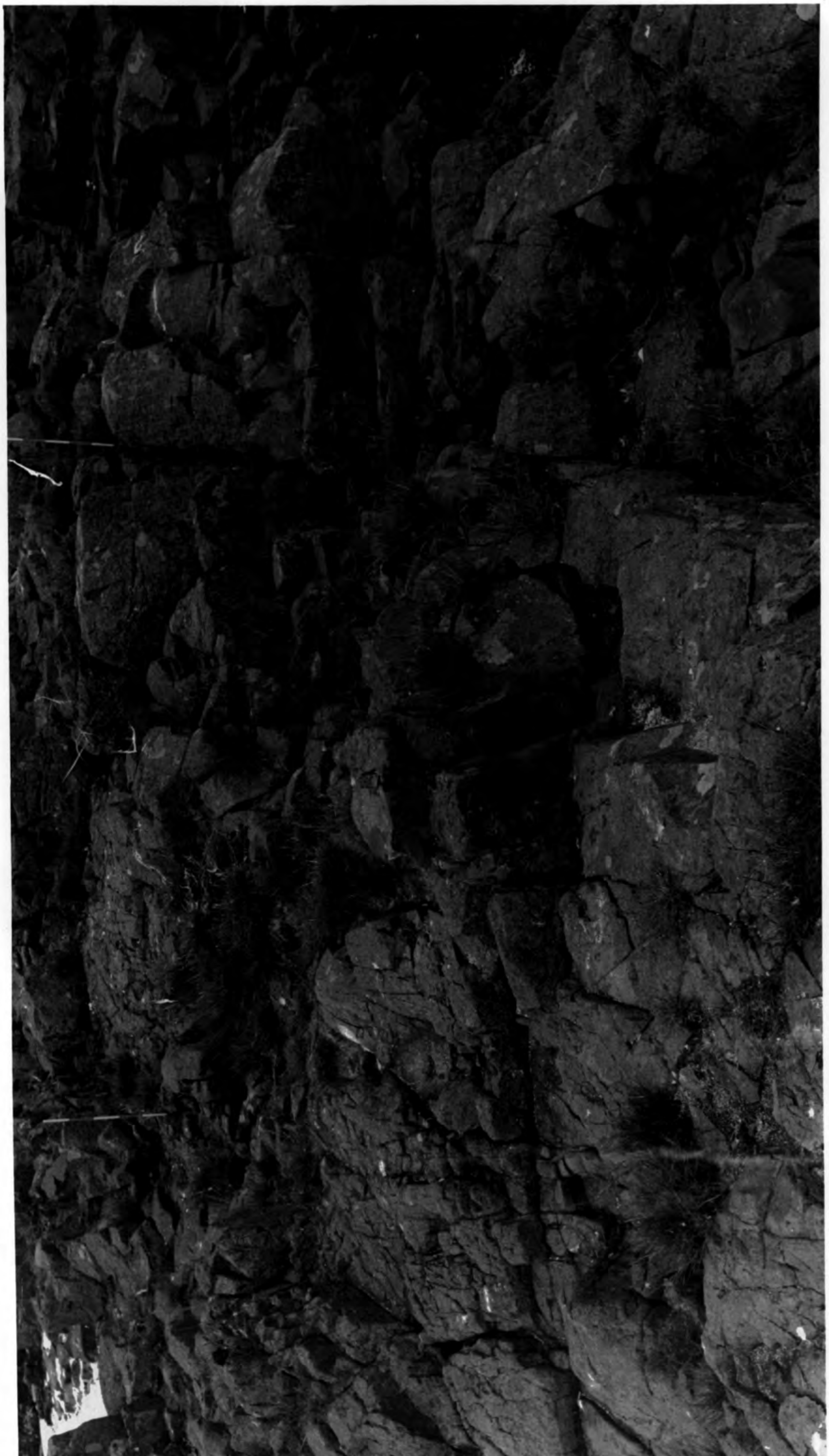
MAP 12

Plate 39 Longstone.

Remaining plant and soil cover. rods 0.5m.

Plate 40 Northern Hares.

All the extant vegetation 4.6.71. *P. rupestris*.



Some Aspects of the History of the Vegetation of The Farne Islands.

There is a considerable variation from island to island in the species which make up a high percentage of the vegetation cover. In order to ascertain if such variations existed during the formation of the peat cover samples were collected from 2 to 30cm from the Inner Farne at 2, 11, 20 and 29cm deep and from Brownsman, Middle Group, and Longstone, Outer Group, at 2, 9, 18 and 21cm. The Inner Farne samples were taken from the E.S.E. area at 20m from the edge of the soil cover (drift deposit) as this area probably suffered least from past disturbance due to agriculture i.e. outside the ridge and furrow system (Plate 1). The 21cm sample on Brownsman was taken from the drift deposit peat interface, and at the same level on Longstone from the rock peat interface.

All samples contained a high percentage of fine sand grains and slides for pollen analysis were made according to the method given in Appendix VIII.

A count of 100 pollen grains was made from each level see Figs. 11,12,13(except for Brownsman 21cm level which contained a large proportion of damaged grains. Species indentified are marked with + at this level). At each level a list of species present is given with the frequencies expressed as a percentage of the total pollen at that level.

The most significant thing about these results is that the major pollen types present are from species abundant in the vegetation of the islands and there is no question of mainland vegetation being recorded in significant amounts. The confidence limits used are those of Faegri and Iverson (1964).

There appears to be a considerable correlation between the results of the pollen analyses, particularly the general trends they indicate and the extant vegetation.

(a) The Inner Farne (Map 1) and (Fig. 11)

The present vegetation is dominated by Gramineae species with Potentilla anserina, Silene maritima and Rumex mainly acetosa. The extent of Urtica cover is probably recent and has already been discussed in Section 6. The 2cm pollen spectrum gives Gramineae 55%, Caryophyllaceae, presumably Silene maritima 3% Rumex acetosa type 3% and Potentilla type 4% presumably this is P.

anserina, thus there is a good correlation between the 2cm pollen spectrum and the present vegetation for 1. Gramineae, 2. Caryophyllaceae and 3. Rumex.

At this level there is a significant amount of Plantago-coronopus 19%. At present there are only small swards of this species 1 - 2.5m^2 in extent and these are adjacent to the cliff tops on the W. and S. of the island. It appears therefore that this species is now much less abundant than when the 2cm level was laid down.

There appears to be a steep rise in Plantago pollen from 29cm to the 20cm level which rises to 49% at the 11cm level when Plantago becomes significantly greater than Gramineae.

The percentage of Gramineae species at the 29, 20 and 11cm levels suggested a continuing rise with a significant increase from 11 to the 2cm level. This is in accordance with the present vegetation cover.

At the 29cm level one or more species of the Chenopodiaceae were dominant with a very significant decline at the 20cm level, the percentage of pollen remaining the same through the upper levels. Species of the Chenopodiaceae are important colonisers of bare ground especially in maritime situations, and this indicates at the time this level was formed, a large part of the Inner Farne had a limited amount of perennial plant cover. Parallel at the time of this decrease in Chenopodiaceae there appears to be a corresponding rise in Plantago pollen of the coronopus species. Both thrive in dry maritime soils but Chenopodiaceae is often more characteristic of disturbed soils so that a more stabilised soil brought about by Chenopodiaceae might be succeeded by the biennial (sometimes annual or perennial) Plantago coronopus.

(b) Brownsman (Map 1 and Fig. 12)

Species of Gramineae are only present on this island in small isolated clumps and most of these are the results of attempts at reseeding during May 1970. The total cover effected by Gramineae is probably less than 0.001%

The dominant species are Silene maritima, Stellaria media, Atriplex glabruiscula and Rumex acetosa type present in the lowest sample with significant amounts of these pollen types in the 3 upper levels. Gramineae appears to have been significantly less at the 2cm level than in the lower samples. Grasses appear therefore to be decreasing in importance so it is hardly surprising that there are few today cf. Inner Farne. Plantago appears to have decreased at the same time as Gramineae.

(c) Longstone. (Map 1) and (Fig. 13)

The pollen spectrum for this island indicates a continuing rise in Gramineae species and at the present time this is the only family represented in the vegetation. There are, however, indications that the former soil cover was greater than at present and thus could have supported a more diverse flora. The high percentage of Chenopodiaceae suggests that this annual was formerly an abundant species and that areas of soils were without perennial soil cover, or it may have occurred in a community with Silene maritima the pollen of which also occurs in the spectrum. These two species occur together on Brownsman (Figs. 7 12 The significant percentage of Cruciferae pollen at the 21, 18 and 9cm levels was probably derived from Cochlearia sp.

A single plant of Cochlearia officinalis was flowering on the Northern Hares 2.6.71

The present vegetation on Brownsman differs considerably from that on the Inner Farne,, Gramineae, dominant on the Inner Farne is absent from Brownsman and Plantago which has also disappeared from this island appears to have been less abundant at any level than on the Inner Farne. Not only do these 2 islands have different floras at the present time but they also appear to have had differing vegetation covers in the past.

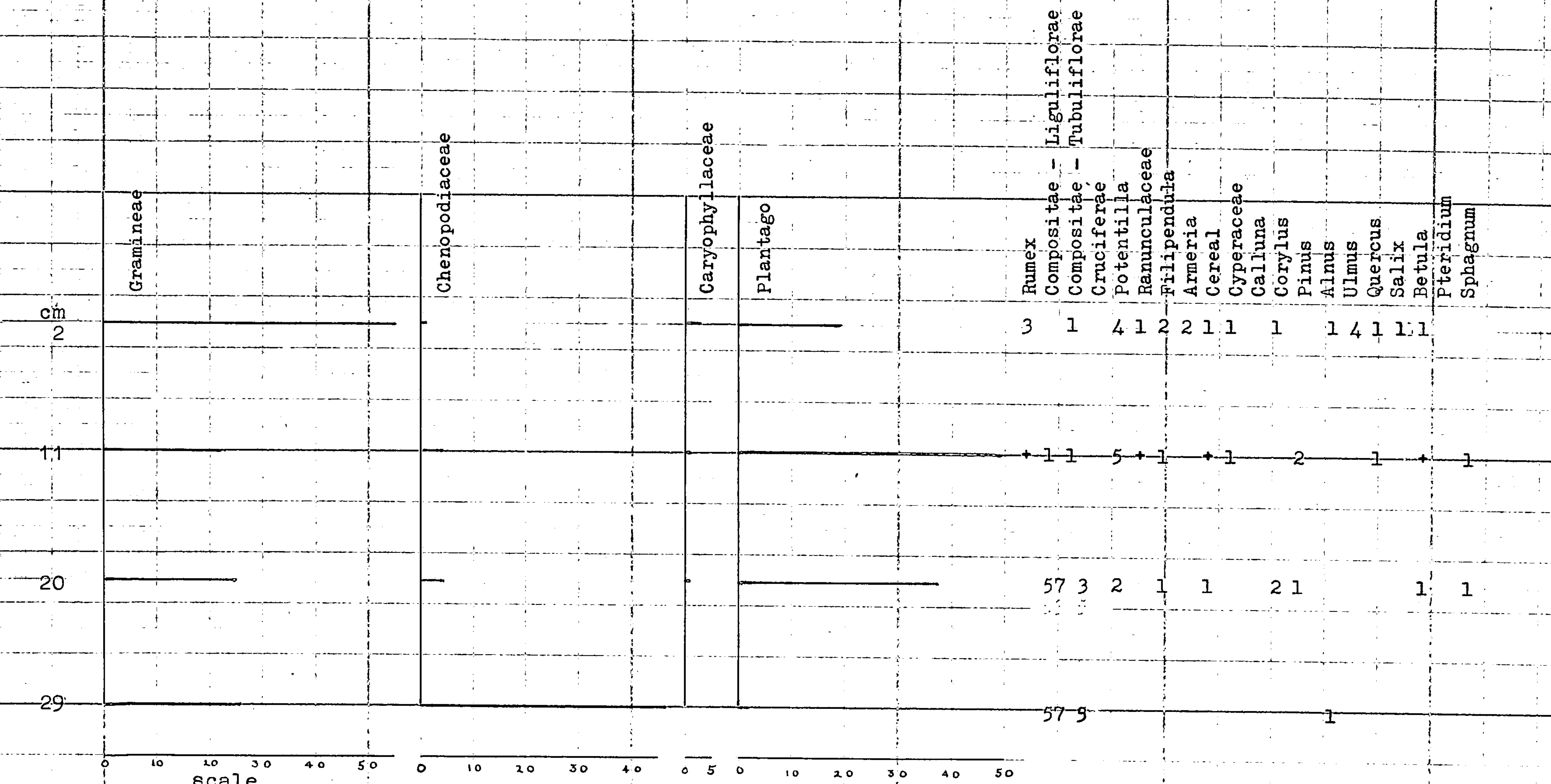
There is therefore 1.good correlation between the 2cm pollen and the present vegetation for (a) Gramineae (b) Caryophyllaceae and (c) Rumex.

2. The diagrams show the local vegetation succession e.g. Chenopodiaceae - unstable soils, Grasses and Plantago - stable soils, Plantago dying out.

It appears therefore, that the pollen spectra are local and indicate the history of the vegetation of each of the 3 islands during the period when the 20+cm of soil was formed.

The strongest argument in favour of this is concerned with the distribution of the Plantago pollen. Plantago is wind pollinated and its pollen travels a long way and is always well represented in pollen diagrams if it is present in the vegetation. No Plantago species is found on Longstone and no Plantago pollen was recorded in any of the Longstone soil samples. If the pollen spectrum for each island included a significant amount of wind borne pollen from the mainland then Plantago would have occurred in the Longstone samples even if only in small amounts.

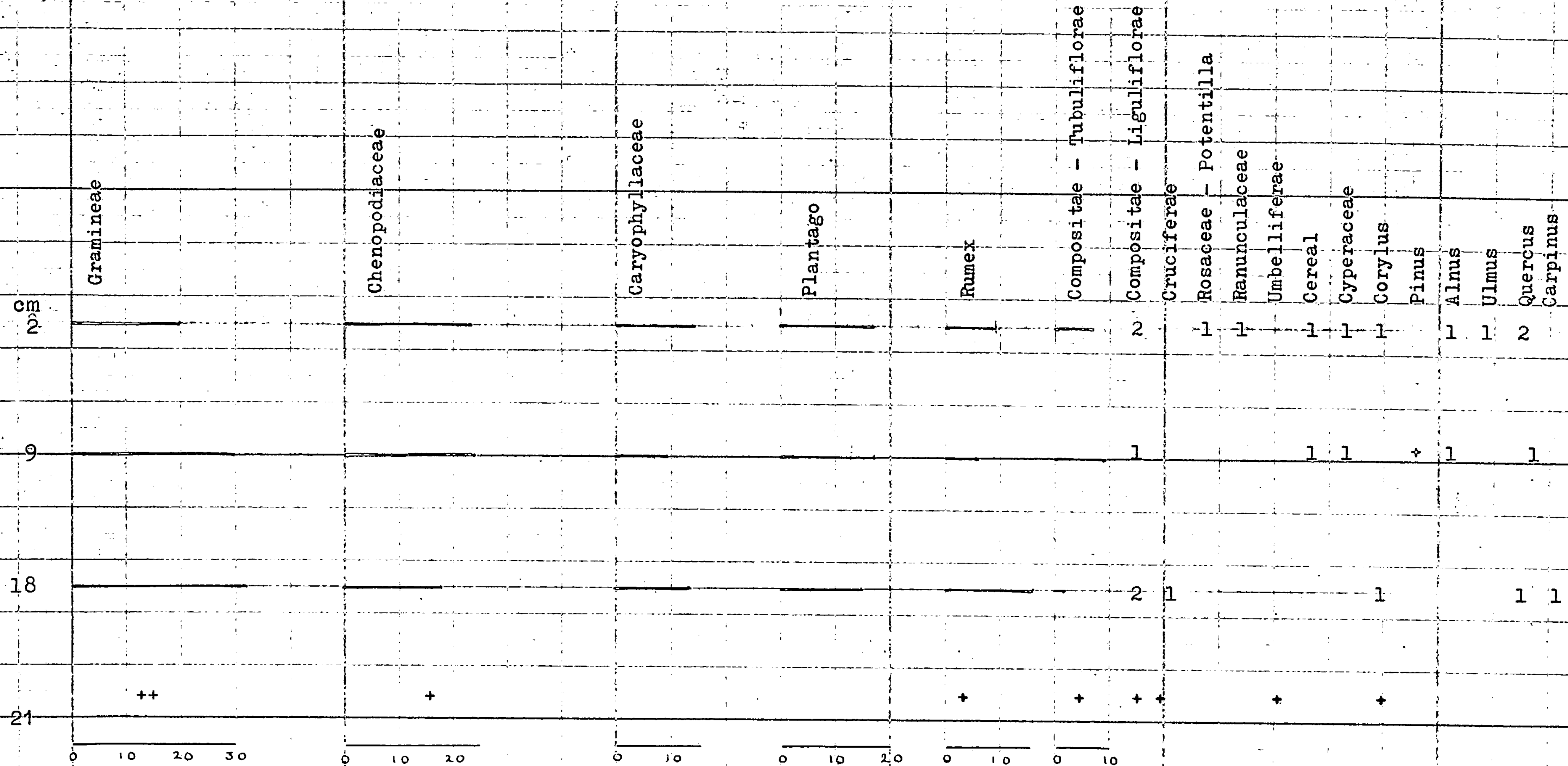
Apart from the general correlation between the pollen present and the modern vegetation on each island there are a few specific cases which support the idea of most of the pollen being locally derived e.g. Armeria maritima only found on the Inner Farne was recorded in one sample, the 2cm sample from this island. Species recorded from the Inner Farne from specimens collected by Goddard T.R., which form the present day Farne Islands plant list, Watt G. (1951) Appendix II and which are now probably extinct include Filipendula ulmaria and pollen of this species appears in the 2, 11 and 20cm samples. Tree pollen which must have been wind borne from the mainland is only recorded at very low levels.



Frequency expressed as percentage of total pollen

+ signifies present in the sample but not in the count of 100 grains

Fig.11 Pollen Frequency Inner Farne



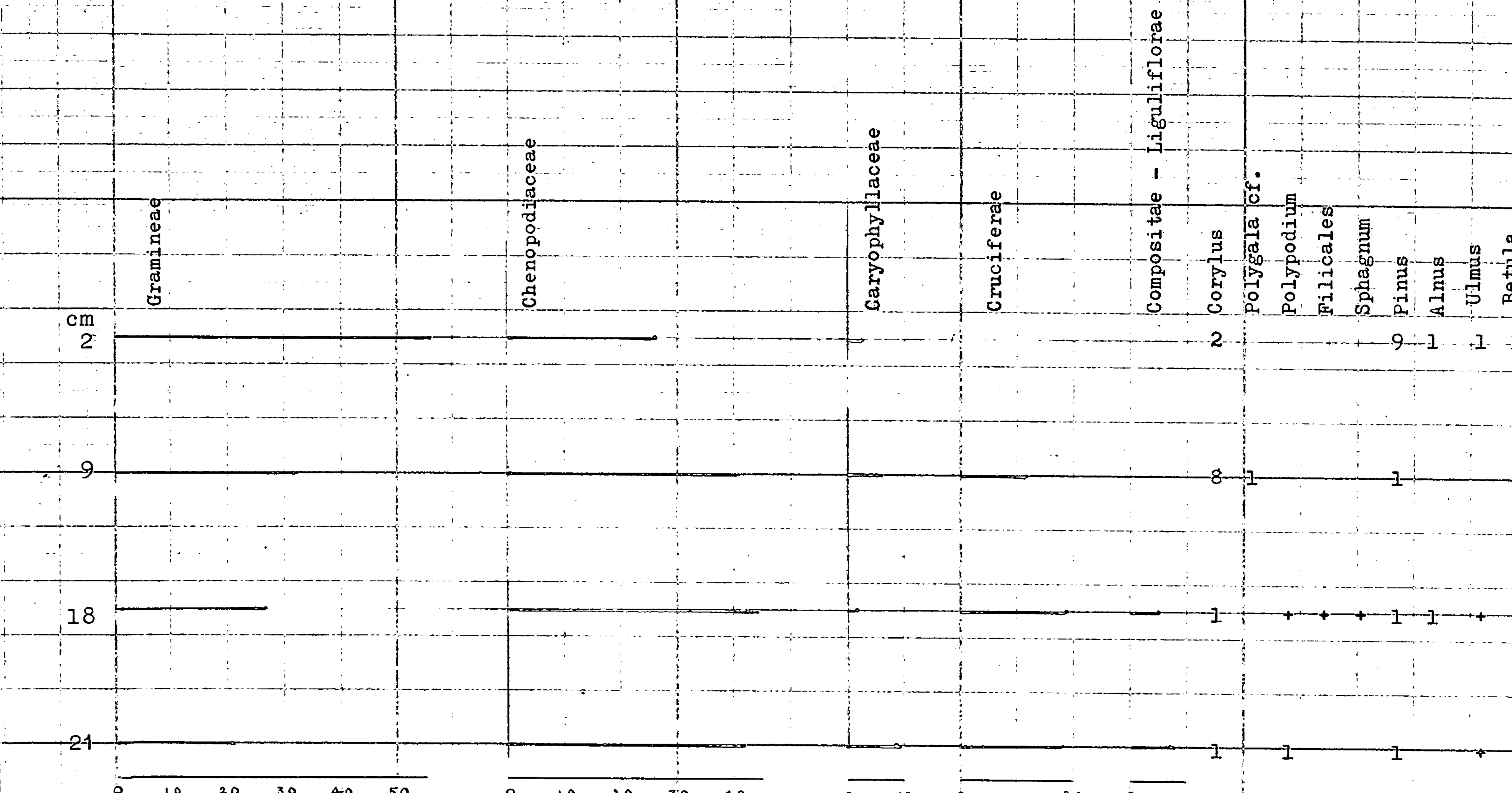
Scale

Frequency expressed as percentage of total pollen

+ signifies present at the 21cm level

✧ signifies present in the sample but not in the count of 100 grains

Fig. 12 Pollen Frequency Brownsman



Scale

Frequency expressed as percentage of total pollen

+ signifies present in the sample but not in the count of 100 grains

Fig.13 Pollen Frequency Longstone

15. Biotic Factors

The biotic factors affecting the vegetation of the Farne islands are 1. Man, 2. rabbits, 3. seals, 4. bird spp.

1. Man

A brief outline of land use has already been given (3. History and Land Use) which indicates that since ca. 1925 watchers have been in residence during the summer months on the Inner Farne and Brownsman (1941-44 Brownsman, 1941-45 Inner Farne excepted) and visitors have only been allowed to land on the Inner Farne, Staple Island and Longstone.

Man's influence resulting from this policy has been in 3 directions, (a) the trampling of vegetation on selected islands, (b) removing Man's influence from other selected islands and (c) by enforcing a rigid policy of protection for wild life which has enabled a number of populations to increase to such an extent that other natural balances have been adversely affected.

(a) Trampling

All the trampling of vegetation has taken place on 3 islands. Visitors to the Longstone usually land only at low tide and their stay is often confined to the lighthouse area. This precludes the small area of vegetation. The pressure from visitors on the vegetation of Staple Island and the Inner Tarne, however, is considerable. There are frequent occasions when visitors are landed on the Inner Farne but not on Staple Island therefore the greater pressure will be on the Inner Farne. On this island the visitors are restricted to marked grass paths so that all the effects from treading are concentrated over a relatively small area during the summer months.

Until 1968 the paths were grazed by rabbits but since their disappearance they have been kept mown by mechanical means.

These paths were formerly dominated by Poa pratensis and Lolium perenne but when they were enlarged 1968-69 by extending the fences, much of the 'new' paths consisted of Holcus lanatus with some Festuca rubra. This enlargement of the paths was considered necessary in order to spread the treading by visitors over a larger area and so reduce the wear on the original paths. The effects of this treading will vary from year to year as any increase will be due more to the prevailing weather conditions before the visitors arrive, rather than to an increased number of visitors.

Poa pratensis and Lolium perenne are characteristic of footpaths and both can tolerate puddling, Bates (1935) but inevitably they both suffer on the Inner Farne from the effects of treading by large numbers of visitors after an intense period of rain.

After a two month period, May and June 1971, during which time rainfall was slight the old paths did not show excessive wear but Lolium perenne was much greener and taller than Poa pratensis. This may have been due to L. perenne being a deep rooted species whereas P. pratensis is shallow rooted. The consolidated condition of soil due to treading exists only in about the first 3 - 5cm Bates(1953) therefore the rooting system of L.perenne would be less affected.

Holcus lanatus on either side of the old footpath areas showed less wear than I would have expected. This might have been due to many of the visitors still using the central parts of the paths where the attacks of Sterna spp appeared to be less intense. The new path on the Inner Farne (A/D Map 4.) differed little in appearance from the other established paths in May 1971 but this newly mowed path consisted largely of Agrostis stolonifera and Holcus lanatus together with some Festuca rubra. By July 7th (1971) the cover of this path had been reduced to 10%. If the loss of cover is followed by a prolonged spell of dry weather the top soil erodes away and the drift deposit underneath is exposed.

Staple Island On this island visitors are usually landed from a channel on the N.W coast and the majority only walk across the almost bare Whin Sill to view the Pinnacles, Kittiwake Gulley and Skeney Scar. To see this promontary involves walking across the Graminetum * chiefly composed of Puccinellia rupestris. This path showed considerable wear in July 1971.

For the first time the central area was fenced off (May 1971). Many visitors walked round the perimeter on the eastern side of the island and this resulted in a badly trampled area of Silene maritima adjacent to the fence. This plant may well recover later but it is probable that it would not be able to withstand constant treading during each growing season by a large number of visitors.

This problem of local erosion is likely to become more acute as the number of visitors tends to increase (Fig. 14.)

(b) Removing Man's influence from selected islands

This has completely eliminated the effects of trampling on the

* this underlining is used throughout as in continental phytosociology to differentiate from the scientific names

vegetation of the remaining islands apart from the small number of watchers resident on Brownsman.

Man can therefore be discounted as a factor directly affecting the vegetation of these remaining islands since ca. 1925. Its indirect effect has been to enable populations of some birds and seals to increase.

(c) The conservation of wild life

Reference to the exploitation of seals, the destruction of sea birds and the collecting of vast numbers of eggs during the 19th century has already been made (2. History and Land Use). Canon Tristram was able to report in 1860 that due to protection eiders had increased to scores from only 2 pairs a few years before and that Arctic and Sandwich terns which a short while before had been reduced to a few dozen pairs were again present in large numbers. Hickling (1951). Records documented in the same source indicate that the destruction of wild life continued for some time after the passing of the first Bird Protection Act in 1880, but after 1888 it appears that protective measures became more successful. Since this time, although fluctuations have occurred nearly all species of the avifauna have increased including those species which directly affect the vegetation.

Gull control

The eggs of Larus gulls had been collected by fishermen and others over a long period of time and sold on the mainland.

In 1965 the Farne Island Egg Sanctuary Order came into force and local fishermen were no longer allowed to collect eggs but the order was ignored.

The F. I. Management Committee believed that the large number of Larus fuscus and Larus argentatus were a serious threat to the other species and it was decided to consult the Nature Conservancy with a view to introducing control. (It appears that no data was available to provide evidence of a decrease in other species)

The watchers were told to destroy the eggs of all Larus gulls and this was carried out on Brownsman and Staple Island. Since 1965 very few chicks have hatched on these two islands.

In 1968 the watchers were ordered to prick and dye the eggs. This was not successful as the eggs tended to dry up, some were rolled away by the wind and generally the gulls tended to forsake

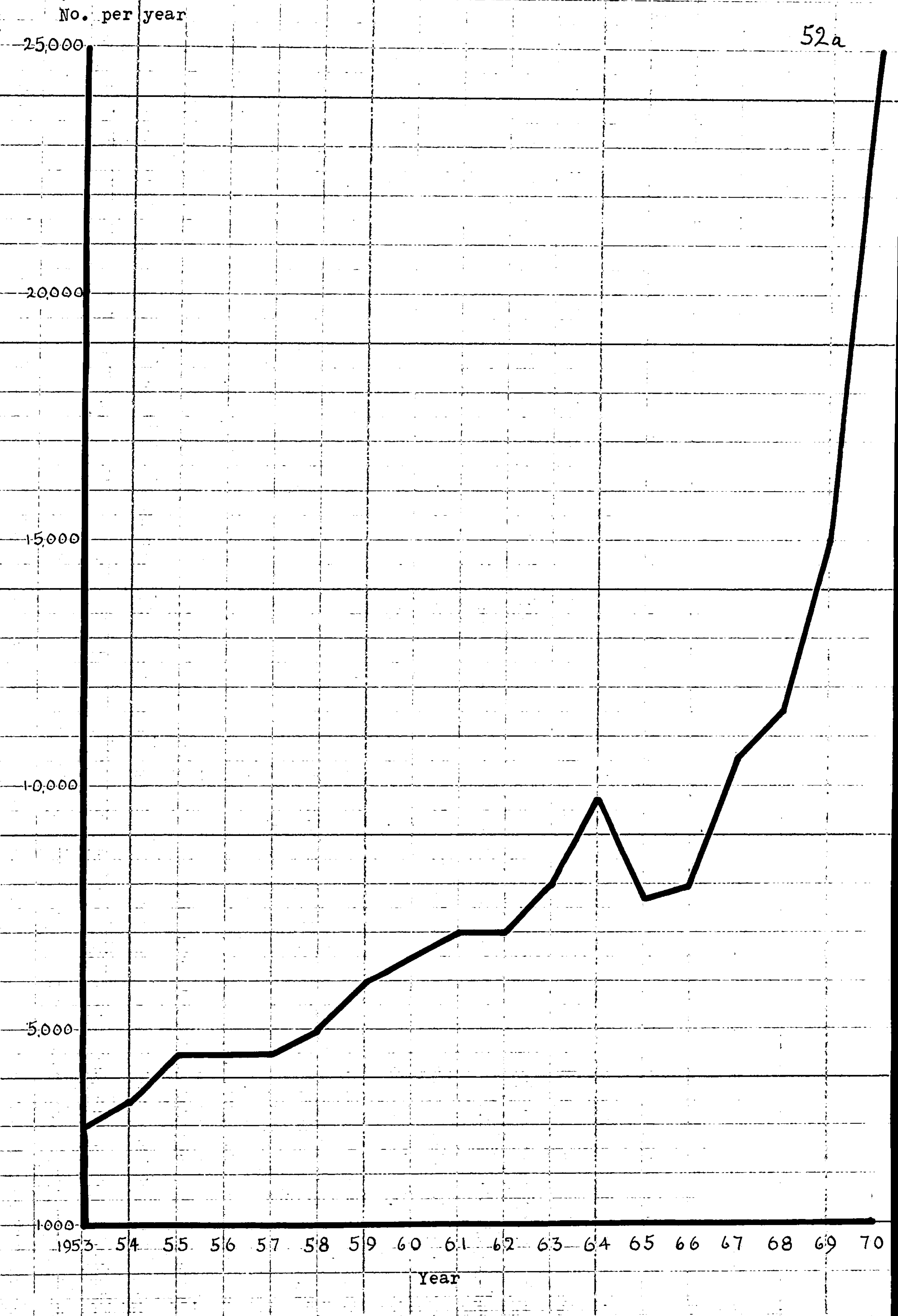


Fig 14 DAY VISITORS to the FARNES

1953 - 70

their nests and replacement clutches were laid. Licences were granted to 3 local fishermen on condition that all the eggs on Wideopens, Wamses and Harcar were collected and the final clutches destroyed. It appears that this directive was not carried out and a large number of young left these islands. The Wideopens permit was withdrawn and a small proportion of eggs and chicks were destroyed N. Brown (pers. comm.) In 1971 the Wamses permit was withdrawn and an attempt made on all the islands to prevent young being reared by injecting the eggs with formalin.

Rabbits - Oryctolagus cuniculus

Rabbits occur on Staple, Brownsman, W.Wideopens and until November 1968 a colony occurred on the Inner Farne.

The impact of the rabbit on the ecosystem of an island is to be seen in the modification of the vegetation, sometimes leading to soil erosion. The only island where this was apparent was the Inner Farne where the colony was exterminated in 1968. Some of these effects have already been discussed but it is intersting to note that of 6 rabbits caught early in March 1968 3 weighed 1727, 1642 and 1472 grams respectively (Report of S.D.Johnson Divisional Pests Officer). These weights would compare favourably with mainland rabbits at the same time of year. When 100 were destroyed early in October 1968 they were all in extremely poor condition but the remaining 40 rabbits killed in late November (1968) were in excellent condition. JohnsonS.D. (pers. comm.). This suggests that the population of 140 rabbits in Oct. was above the carrying capacity for the island.

Details of the small rabbit populations have been given in the accounts of the vegetation of Brownsman, Staple and the W.Wideopens. These islands each have a different vegetation (Table 1) but neither supports a large population. There is a small Graminetum on W.Wideopens and on Staple but these maynot be the limiting factors controlling population size as rabbits survive on Brownsman withpit any grass species being present.

Past and present watchers have informed me that on each island ant increase in spring and summer is only of a temporary nature.

It would appear that a large population cannot be supported in winter probably due to lack of aerial vegetation. This would apply especially to Brownsman where presumably the survivors feed partly by refection.

Although there seems to be little evidence at the present time that rabbits have a significant effect on the vegetation of the 3 islands Staple may be an exception as some grazing of the Graminetum takes place, at least during the summer months. It is hoped to gain some quantitative data on this aspect from one of the rabbit proof exclosures to be set up in this area. (17 Future studies on the vegetation of the Farnes.)

The Atlantic Grey Seal. *Halichoerus grypus*

The first known reference to the Farne Island Grey Seals is in a 12th century charter regulating the killing of seals in the vicinity of the islands.

After the dissolution of the monasteries a succession of island tenants followed and seals were slaughtered for their skins and oil.

In 1772 a Mr.Blackett killed 72 calves Selby (1841) so there must have been a population of ca. 300. The killing probably continued until 1861 when the Venerable Archdeacon Thorp employed watchers but since this time there is no evidence of large scale exploitation.

From 1841 to 1920 the few available records suggest that the colony consisted of about 100 individuals. In 1938 at a meeting held at Newcastle-upon-Tyne to discuss allegations of damage done to salmon fishing by seals the population was variously estimated at between 150 and 211, but the number may have been between 600 and 1000 Hickling (1962).

In 1950 it was estimated that 454 calves were born. If this figure is correct then the colony must have numbered ca. 1,600. The total population size is computed by multiplying the number of calves born by a factor of $3\frac{1}{2}$ Hewer (1964). More precise figures are available for the number of calves born in 1952 and subsequent years. By 1961 the number had increased to 1344, a colony size of 5,600. The population continued to expand and by 1970 2,361 calves were recorded so the colony must have been in excess of 8,300.

This continued increase is undoubtedly due to the measure of protection afforded to the seals by the Grey Seal Act of 1914 and 1932 together with special provisions for the Farne Islands.

An order amending the Grey Seal Act of 1932 became law from 17th Nov. 1958. A preliminary cull of 10 calves was made and this met with considerable public outdry. In 1963 351 calves and 1 adult were killed, 1964 343 and a further 318 in 1965.

A management plan has been drawn up by the Seal Unit of N.E.R.C. and the National Trust have announced, August 1971, that a cull of 3,500 seals will take place next year.

The chief breeding grounds are Brownsman, Staple Island and

N. and S. Wamses. The firstncalves are usually born in the last week in October and the breeding grounds are deserted in December.

Hickling (1962) stated that in 1959 few calves were born on the tops of Brownsman and S. Wamses and that given a free choice and suitable weather the majority of cows prefer to calve within easy access of the sea. Therefore it appears that up until this time few calves had been born on the soil and plant cover of Brownsman and S. Wamses. I have been unable to obtain records of the exact numbers born on the vegetation on Staple prior to 1961 but in this year the number had reached 130.

Since this time Dr.J.C.Coulson and his workers have shown that the beaches and rocky areas are the first to be colonised and later breeders are forced to occupy territories further inland, presumably these should be regarded as sub optimum territories for the following reasons,

(a) the further inland the longer and more difficult the journey becomes for the cows passing to and fro through the territories of the earlier breeders

(b) consequently the further inland the higher the calf mortality.

On Staple Island the territories can be divided into 3 zones (a) on the Whin Sill adjacent to the high tide line, (b) on the 'inland' Whin Sill and (c) on the vegetation. The first calves are born on zone (a) and their growth and fat deposit is very rapid with a mortality rate of 11% (b) the calves grow less well with a 17% mortality rate and (c) with the inland calves the mortality reaches 27%, Coulson and Hickling (1964).

Calves born on the vegetation would necessitate the cows making frequent journeys over this vegetation to suckle their young and to this must be added the effect of the overland journeys by the bulls.

When the colonies were small and all the calves born on the beaches or bare Whin Sill the effect on the vegetation must have been negligible but as the colonies on these islands have increased, more and more have had to resort to a sub optimum breeding territory, therefore as the pressure has increased so has the pressure on the vegetation increased.

Data kindly supplied by Mrs.G.Hickling has been used for the graphs, Figs.15 and 16 . These show the number of calves born on each island from 1961 - 1970 and also the proportion born on the vegetation. These graphs illustrate not only the dramatic increase in the number of calves born but a corresponding rise in the case of Brownsman and S. Wamses in the number born on the vegetation.

An increase in the damage to vegetation is more likely to be dependent upon weather rather than on an increase in the seal population. Heavy rainfall during the breeding season especially during November will result in an excess of puddling. References to 'a sea of mud' occur in extracts from Mrs Hickling's Journal - 2.12.65 Staple"..... the rain had turned top into a sea of mud". Any depression will fill with water and be used by seals as wallows. These are particularly numerous on Staple and have been mapped (Fig. 9.) so that any changes in the future may be measured. These wallows prove difficult to fill in and if they are used year after year they will inevitably increase in size. Colonisation of these wallows are referred to in the vegetation of Staple Island.

I have been unable to aquire any information concerning Silene maritima. From observations made on Brownsman on 9.12.70 I believe that many mature S. maritima plants can withstand considerable seal pressure provided that abnormally wet conditions do not occur. This pressure on the plant only occurs during the dormant period Nov-Dec but after excessive rainfall puddling occurs and it is likely that this will result not only in (a) a loss of soil structure but (b) damage to the meristem tissues.

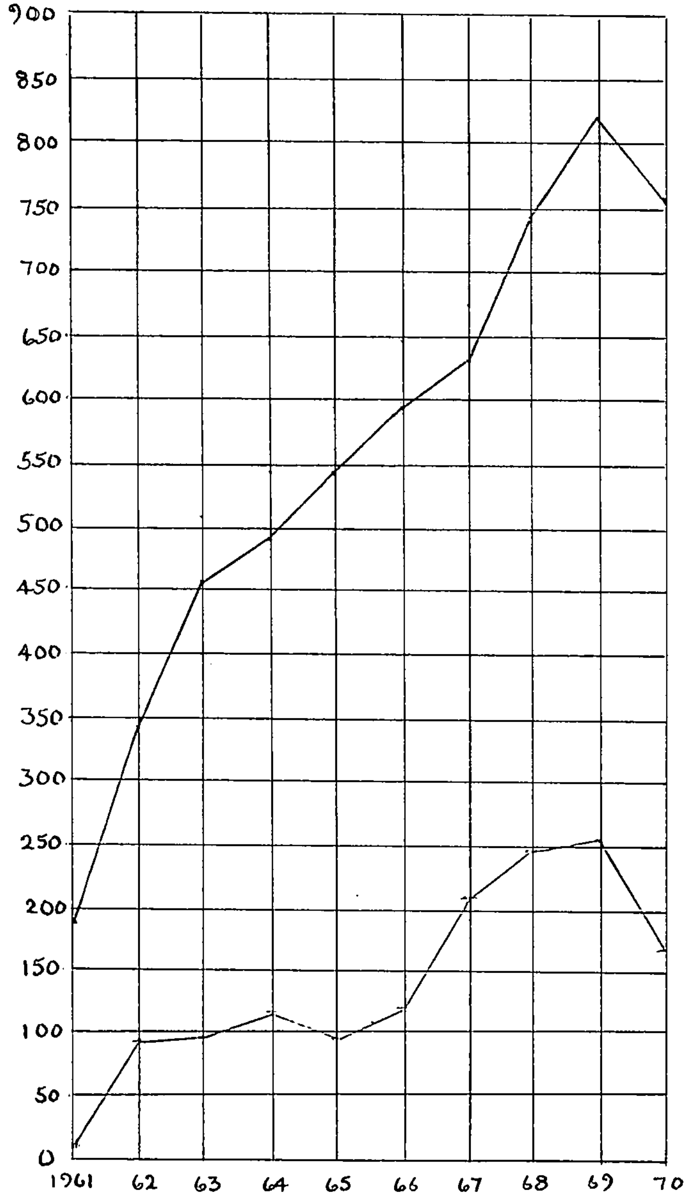
The scarcity of S. maritima plants has already been noted. A large number of seeds are produced although germination tests will be carried out in 1972 there are no reasons at present to suggest that a larger proportion of the seed is not viable. Germination takes place in May to July so that they overwinter as small seedlings. At this stage it is most unlikely that they could withstand seal pressure.

The effect of this pressure on Atriplex glabruiscula is probably much less since this is an annual plant which germinates in the spring. It produces an abundance of seed and even if a proportion is prevented from germinating there will be a surplus sufficient to produce a high percentage cover during the following year.

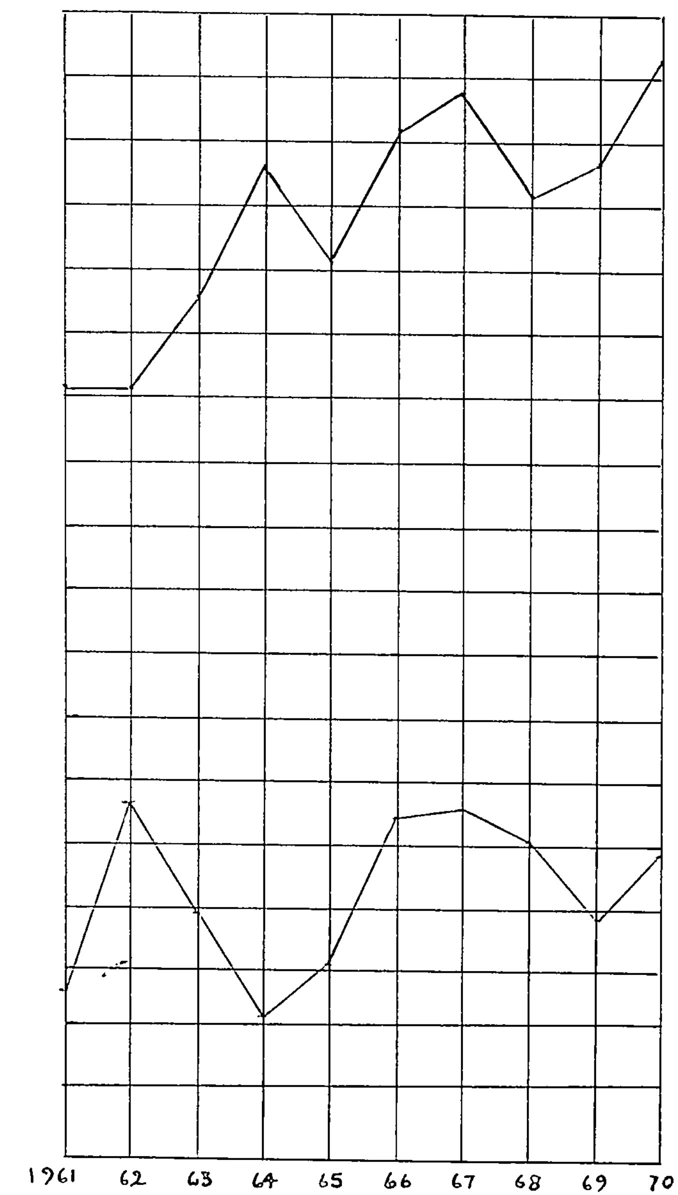
Staple Island

The area of Staple in which Atriplex glabruiscula is the dominant plant is exactly the area which is used by the breeding seals (Plate 42 photographed Nov.1970). The southern area, having predominantly a perennial cover , can be distinguished from the northern area which has largely an annual cover. It would appear therefore that the concentration of breeding seals in this area could be one of the factors responsible for the degradation of the vegetation.

—— Seal pups born on vegetation cover



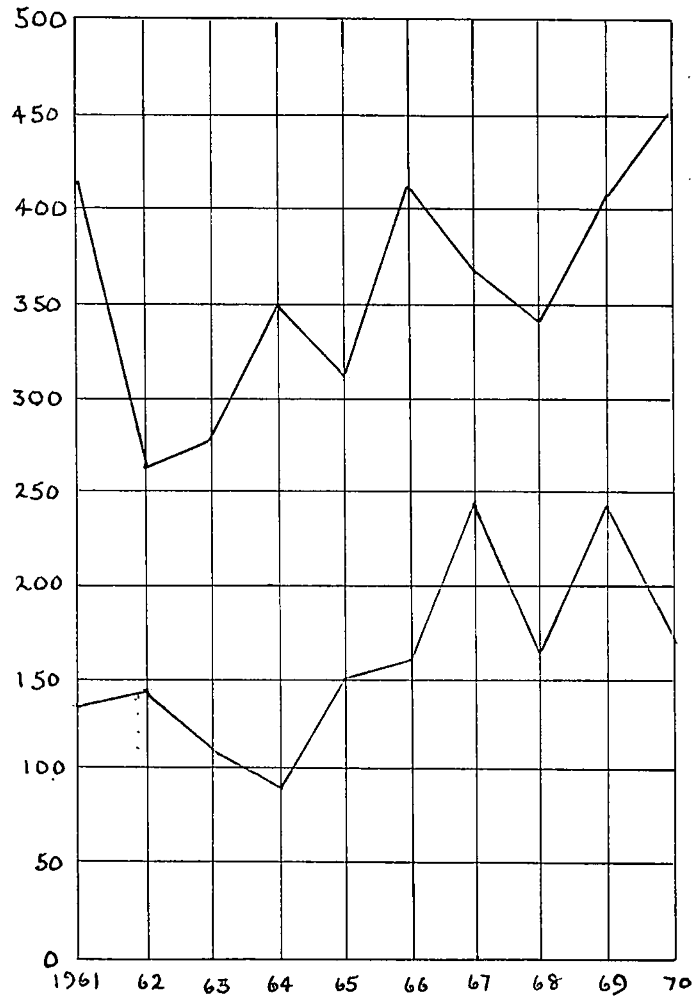
Seal pups born on Brownsman 1961-70



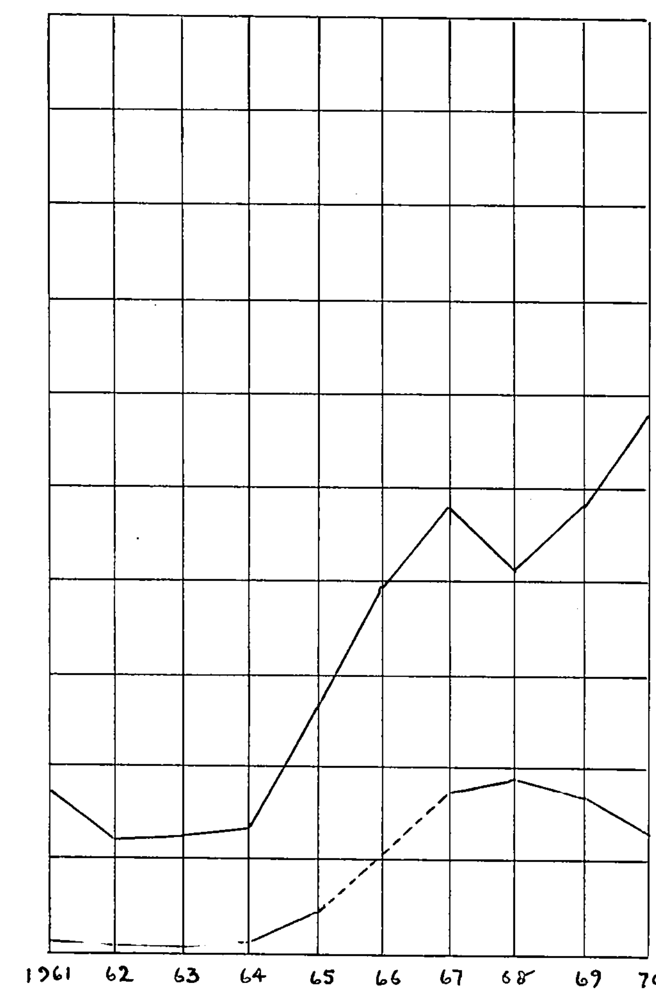
Seal pups born on Staple Island 1961-70

Fig.15

——— seal pups born on vegetation cover



Seal pups born on N. Wamses 1961-70



Seal pups born on S. Wamses 1961-70

Fig. 16.

Brownsman

On Brownsman there was a considerable drop in the number of calves born on the vegetation in 1970 when Plate 41 was photographed. Few are in the area of sheet erosion Area A Map 6 except in a large wallow in the western sector. A number appear in and around the pond. There was a much greater concentration on the vegetation 9.12.70 and during the breeding season a total of 168 (Fig. 15) were born on the soil cover.

South Wamses

There were few calves on the soil cover before 1965 (Fig. 16) Plate 43 photographed in Nov. 1970 shows nearly all the calves on the soil cover concentrated on the west side which is the remaining area of vegetation. This is the area containing the wallows also visible in this photograph.

North Wamses

A large proportion of the calves may have been born on the area of vegetation before 1961. During this and the succeeding years (Fig. 16) a high percentage of the cows have used this area for breeding purposes. The soil cover, however, is not continuous, few areas of soil are more than $2m^2$ resulting in small 'islands' of vegetation on the Whin Sill. Most of the terrain above HWMMT will therefore provide optimum conditions for the breeding seals.

The effect of seals as a causative agent of erosion is discussed in 16. Erosion.

Birds

Species which have a direct effect upon the vegetation - Rissa tridactyla and Phalacrocorax aristotelis vegetation for nest material, Sterna spp. and Larus spp. manuring and treading. Fratercula arctica burrowing, manuring and treading.

Rissa tridactyla and Phalacrocorax aristotelis both use vegetation for the construction of their nests and a proportion of both species appear to reline them at frequent intervals during the time the young are in the nest.

P. aristotelis

1931	1965	1970
1	362	204

R. tridactyla

1959	1970
1752	2247

In nearly all the nests of these species which I was able to examine Silene maritima was the chief plant used but I was unable to collect any quantitative data to calculate the total amount of vegetation used. Nearly all defecation takes place on the cliffs.

Sterna sp. There are apparently no records of any census work having been carried out on these species. The following figures are only estimates 1971:

S.paradisaea Inner Farne ca 1500, see overlay Map 4, Brownsman ca. 1,500, N. Hares ca 250.

S. hurindo ca. 250 nesting in or near the larger S. paradisaea colonies.

S. sandvicensis Inner Farne ca. 1000, Brownsman ca. 1000.

S. dougallii Inner Farne ca. 30.

The possible effects of these colonies on the vegetation have been discussed in 6. Inner Farne and 10. Brownsman. In general the effect of their treading is much less than the large Larus spp. They feed exclusively from the sea and their breeding grounds must be considerably enriched each year from the remains of food and guano.

Fratercula arctica and Larus sp. These are I believe the all important birds which have been, and still are, of vital importance to the economy of the islands. Some of their effects on the vegetation have already been referred to in connection with vegetation studies of Brownsman and Staple. They will be discussed in detail as causative agents of erosion in 16. Erosion.

16. Erosion

Erosion is almost certainly due to mutiple factors which are difficult to separate but 4 types of erosion may be distinguished.

(a) Loss of soil cover due to wave action
(b) local erosion i.e. on footpaths
(c) breakdown of soil cover due to burrowing
(d) loss of soil consequent upon sheet erosion

(a) Loss of soil cover due to wave action

This has been discussed for Staple and Brownsman where there is good evidence from the remains of peat, often still with plant cover, in the interstices of the Whin Sill. Such areas for these islands have been mapped (Maps 6 and 8). Such soil cover must have been in existence for a long time, therefore for a storm to wash away an area of drift deposit it must be a particularly violent one. That such storms have occurred is evinced as recently as the 4th Dec. 1788 which destroyed one of the 4 pinnacles leaving the present 3. It is conceivable that a soil honeycombed with burrows would be less likely to withstand wave action.

(b) Local erosion on footpaths

This has already been discussed - Man as one of the biotic factors in 15. Biotic factors.

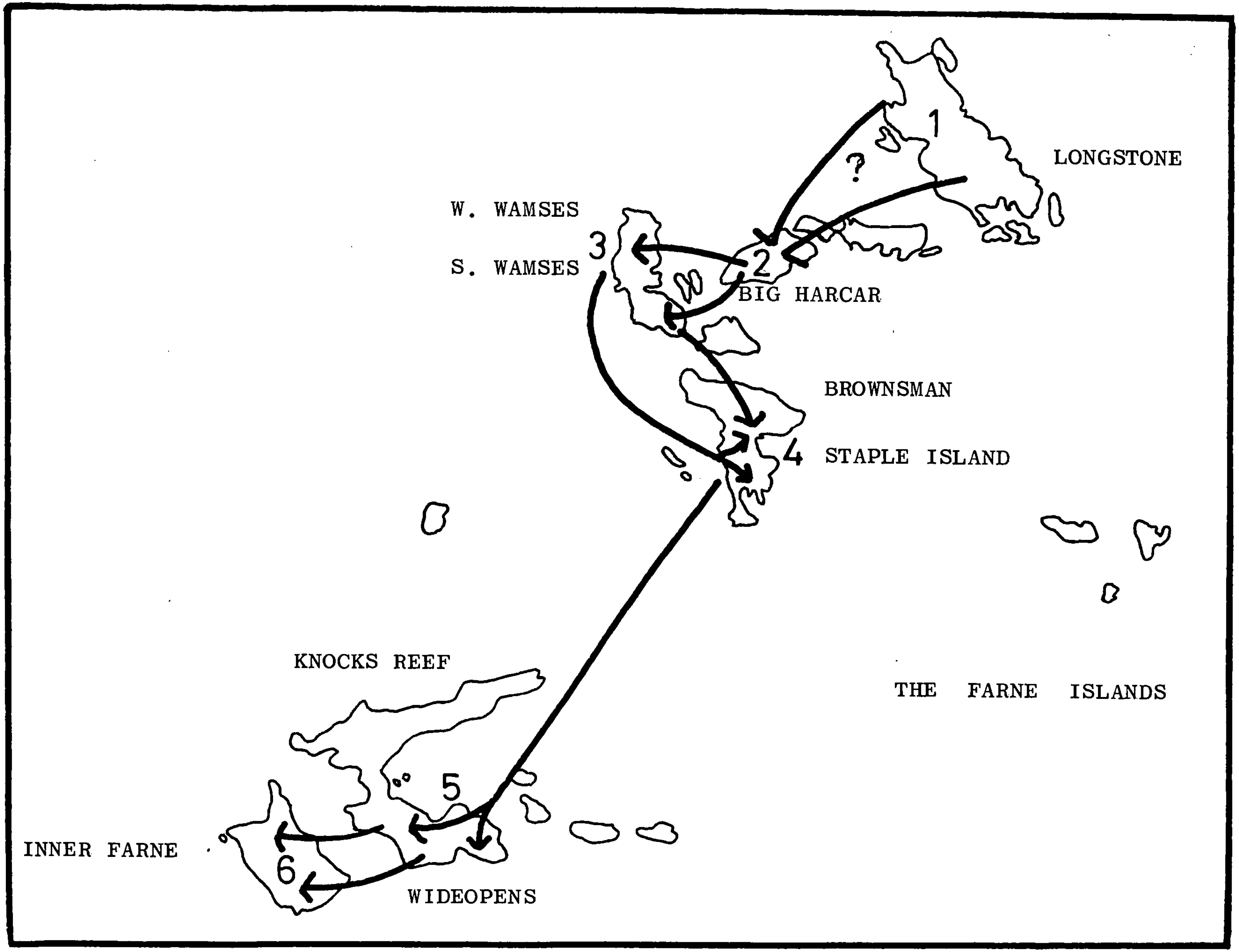
(c) Breakdown of soil due to burrowing

There is no evidence that rabbits have ever been responsible for anything more than local 'pockets' of erosion on the Inner Farne so that the burrowing referred to is exclusively that of *Fratercula arctica*.

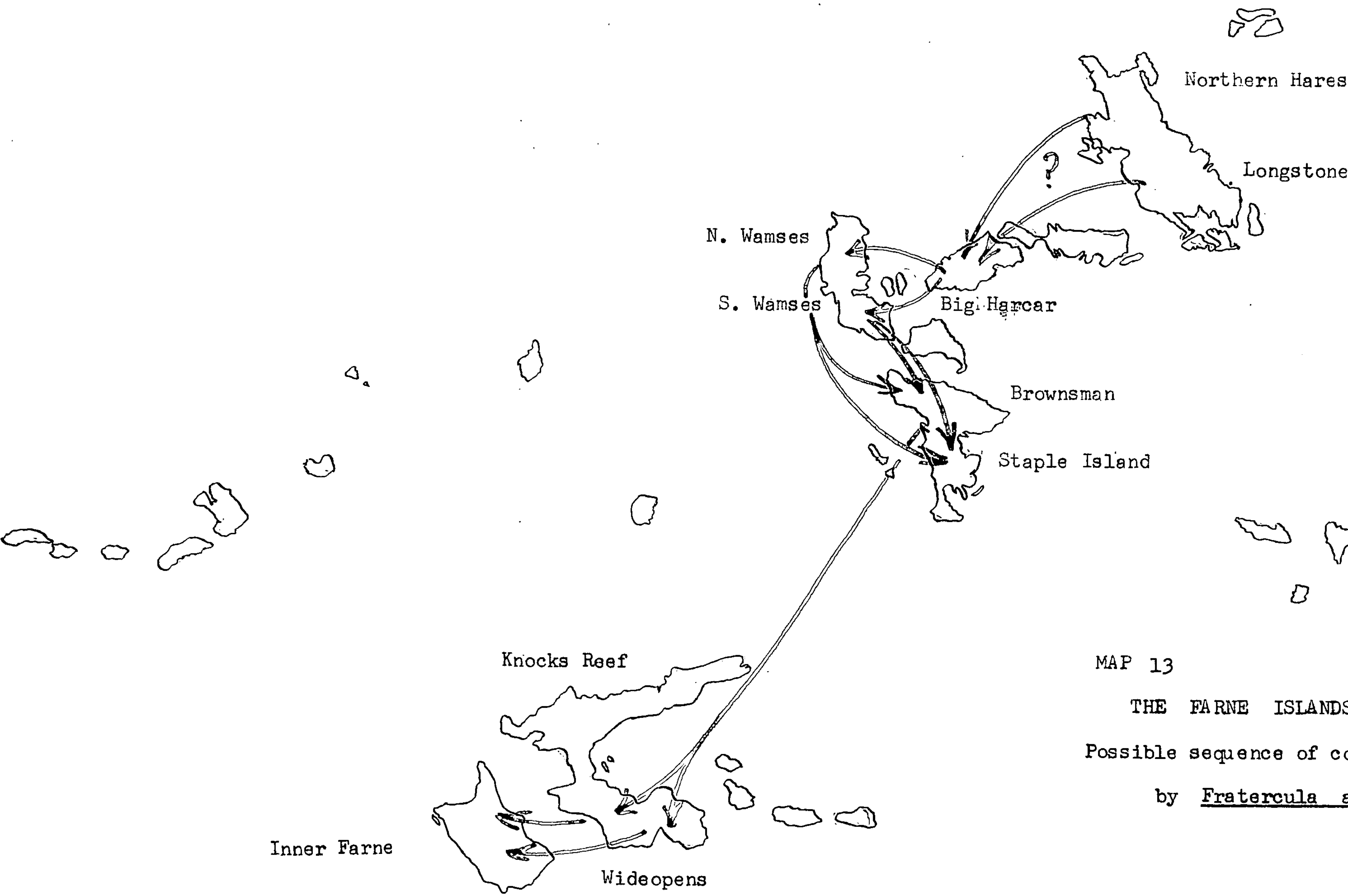
The islands with soil cover can be arranged in a series, each one at a less advanced stage of erosion due to burrowing than the previous one. This series begins with Harcars (possibly the Longstone) and ends with the Inner Farne and this may well represent the sequence of colonisation. (Map. 13.)

1. Longstone and N.Hares.

There appears to be no reference in the literature to any soil cover or *Fratercula arctica* breeding on these islands. The evidence from tussocks of *Puccinellia rupestris* still extant on these islands, and the results of the pollen analysis from the peat on Longstone (14. Some aspects of the History of the Vegetation of the Farnes) suggests that formerly there was a much larger area of peat cover formed directly on the Whin Sill. *Fratercula arctica* have started



LONGSTONE
1
?
W. WAMSES
S. WAMSES
3
2
BIG HARCAR
BROWNSMAN
4
STAPLE ISLAND
KNOCKS REEF
THE FARNE ISLANDS
5
INNER FARNE
6
WIDEOPENS



MAP 13

THE FARNE ISLANDS

Possible sequence of colonisation

by <u>Fratercula arctica</u>

excavating burrows on Longstone (June 1971) and many of the remaining tussocks are reminiscent of those remaining on Big Harcar and the Wamses, therefore F. arctica cannot be ruled out as one of the possible causes of the loss of soil cover on these islands.

2. Big Harcar

This island still has remnants of soil cover (Map 11) described in 12. Harcars. The evidence points to the fact that the whole of the soil cover was a Graminetum composed of Puccinellia rupestris and honeycombed with the burrows of F. arctica. Local fishermen believe that the soil was 'rolled up' in a great storm and blown into the sea. I have been unable to find any reference to this in the literature but if a soil cover was weakened by innumerable burrows it is conceivable that it could be removed by a storm of such violence as the one which demolished the Pinnacle. As all the remnants of soil cover have traces of burrows (Plates 38a, 38b) and the largest area of soil cover remaining (Plate 38a) still has a high number of burrows many of them still occupied. P. rupestris still survives but the balance between soil cover and density of burrows, plus treading, is such that this plant is unable to prevent further erosion taking place.

At the present time Larus gull may be hastening the disappearance of the remaining soil cover, but it will be suggested later that there is no evidence that Larus spp. were sufficiently numerous in the past to have played a significant roll in initiating the process which has resulted in the loss of the climax vegetation.

3. North Wamses

This island still retains a greater area of soil cover than Big Harcar, though it is nowhere continuous it is almost certain that it is the remains of a former extensive Graminetum. The peat which is 40cm thick in some areas still supports Gramineae spp. including Puccinellia rupestris. All the remnants show evidence of dense burrowing. The most degraded P. rupestris cover remaining is that still occupied by F. arctica (Plate 36a).

4. South Wamses

The northern area between high tide line and thenplateau is identical with that appertaining on N;Wamses. Where the remains of a former Graminetum is sufficiently deep it is still occupied by F. arctica.

Although the references in the literature do not differentiate between N. and S. Wamses they do indicate some of the past history of the two islands.

The first written reference to F. arctica on the Farnes is in the Bursar's Book of Durham. Wallis (1769) is the first to mention breeding but he does not indicate which island. Selby (1857) stated that the species for nesting 'resorts to the Wawmses'. T.H.Nelson visited the island in June 1885 and saw 'thousands of puffins' on the Wamses and that the spongy part was honeycombed with their burrows. Nelson (1887). The first mention of colonies other than the Wamses is given by Bolam (1912). He referred to the Wamses as being the principle breeding station but that the colony was extending and not confined to one island. Miller (1915) refers to 'tremendous numbers' nesting on Staple Island and other islands. It appears therefore by this time (a) the species had increased considerably and (b) that its principal breeding ground was no longer on the Wamses. Although the colonisation of Staple may have been due to an increase in the population it would have been accentuated if the soil cover was disappearing on the Wamses. Goddard in his journal, Hickling (1951), only mentioned puffins breeding on the Wamses on one occasion after 1915. There is certainly insufficient soil cover now to support more than a small population.

Plate 28 shows a section of the burrows in the Graminetum on Staple. The density of these burrows appears to have reached a stage when an additional factor such as drought conditions could result in a breakdown of plant cover. Brownsman may have been colonised soon after Staple Island, both still have large populations , but on Brownsman there is a shift away from the dunuded area into the areas of vegetation Perhaps this movement is a small scale example what has happened on a much larger scale in the past - a degration of vegetation due to too high a density, a less of soil cover and colonisation of a suitable terrain nearby.

There are now large populations on W. and E. Wideopens and 2 colonies on the Inner Farne Brown (pers. comm.) believes that the Inner Farne was the last island to be colonised.

Additional studies might result in a further clarification of the history of this species on the Farnes and the steps which could be taken to prevent further loss of soil cover by this species. Such information could be important for the future conservation practice on the islands.

(d) <u>Loss of soil consequent upon sheet erosion</u>

The vegetation of the Wideopens, Brwonsman, Staple Island and S. Wamses has already been described. All these islands have area where the vegetation has disappeared resulting in the beginning of sheet erosion as the exposed soil is blown and washed away. Eventually the stony pavement is exposed in the drift deposit. The most advanced stages are to be seen on S. Wamses (Plate 32).

The cause of this breakdown in what must have been a relatively stable system is not easily determined.

A number of suggestions have been put forward, the 3 most commonplace being an increase in the population of (a) seals, (b) puffins and (c) Larus.gulls. (One of the reasons advanced for the proposed 1971 seal cull was their damage to the thin soil cover - Sunday Telegraph 11.7.71).

I believe that the causes are multiple and although seals, puffins and Larus gulls are all concerned to a greater or lesser degree, neither has been responsible for initiating this type of erosion.

1. The breakdown of the vegetation occurred over a very short period.

1961 Relevant records from Mrs.G.Hickling's Journal:-
"S. Wamses 11.5.61. A good deal of the S. Wamses is covered in coarse grass"
"Brownsman 10.8.61. A luxuriant growth of campion on the Sandwich site". No mention of the S.E. area. This is adjacent to the landing site so if the vegetation had been disappearing it would have been noticed by Mrs.Hickling.
"Staple 13.10.61. Staple is covered with a luxuriant growth of vegetation and there is still a lot of campion in flower"

From these entries it appears that the vegetation showed no signs of disappearing in 1961.

1962 14.5.62. the following entry occurs "The vegetation is growing but its lateness is very apparent and there is much less cover than usual for the terns".

The reason for this may be due to lack of rainfall. During the first 5 months the average monthly rainfall was 1.22", the mean average for these 5 months from 1961 - 70 was 1.63", therefore dry conditions would prevail at the end of May. This was followed by June with only .63" rainfall (mean average for June 1961-70 1.86"). This is lower than any recorded June rainfall 1941-71. I have no records prior to 1941 from Berwick-on-Tweed (nearest meteorological station to The Farnes) but at Howick Hall where a continuous record has been kept from 1881 the mean average June rainfall 1881-1915 was 2.15" and from 1916-1950 1.92".

In this month also appears the following entry under the date 25.6.62. "Very strong gale on night of 23rd. Marked effect on islands' vegetation. Much of the campion on W. side of Brownsman flattened by spray". Silene maritima is less tolerant of sea spray than many maritime plants and on the island of Skokholm measurement of wind speed ahowed that this species was normally found in locally sheltered spots in an otherwise generally exposed situation. Goodman and Gillham (1954).

A further entry for Brownsman 7.7.62 in connection with a decrease in terns may be relevant "I think the very sparse growth of campion has affected all except the Sandwich" and again 2 days later "I feel this isn't a good year and the damage to the vegetation is bound to have an adverse effect" (on terns)

It would appear therefore that the vegetation in 1962 had been very adversely affected by climatic conditions.

1963 There are no entries for S. Wamses, Staple and Wideopens but 3 refer to Brownsman -

17.6.63 "I was struck by the stunted growth of the campion at the west side of the area above N. Cove. Large patches of soil were exposed whereas elsewhere the campion was high and luxuriant". 14.8.63 "The S. end of the island is very badly affected this year and there are large bare areas of peat" 22.7.63 "Lord Howick was very anxious about this" (large bare areas of peat.

It therefore appears that the loss of vegetation was very sudden and this is corroborated by the watchers who were on the islands and according to their information all 4 of the islands were affected in much the same way.

If this loss of vegetation occurred so quickly it is less likely that seals, puffins or gulls could have been the primary cause unless there had been a dramatic increase in their numbers over a very short period of time½ All showed some increase but it is doubtful if this was sufficient to account for the sudden disappearance of vegetation, moreover seals did not breed on the Wideopens and puffins were not using the Graminetum on S. Wamses, the 2 islands most affected. Larus gulls, however, breed on all 4 islands and there is some evidence that this species is chiefly responsible for preventing recolonisation of the eroding areas.

The continuing loss of plant cover

The effects of Larus gull density has already been described for

Staple Island and in more detail for Brownsman and may be summarized:-

1. a high annual increment of guano
2. this in turn produces large succulent plants especially gramineae spp. (cf. Holcus lanatus on the S. Wamses) Silene maritima and Cochlearia officinalis.
3. such plants are more easily damaged by trampling
4. the destruction of vegetation by plucking
5. Rumex acetosa, ,Silene maritima and Atriplex glabruiscula represent the probable order of increasing ability to survive trampling.
6. where all these plants are present this is the order in which the species are disappearing from the perimeter of the eroded areas, therefore the perennials are the first to disappear.

Erosion is increasing (1967) on Wideopens (Map 5) and probably on S. Wamses and there are no signs of recolonisation (except grass sown on W. Wideopens). On the other hand recolonisation is taking place on Staple and Brownsman. It may well be significant that the gull density is lower on Staple and Brownsman (Appendix 10). There may be two reasons for this (a) gulls are much less common where there is human disturbance - no Larus gulls breed on the Inner Farne (where there is no sheet erosion), the colony on Brownsman is at the opposite end of the island to the cottage and Staple has frequent parties of visitors throughout the breeding season. (b) gull control has been carried out on Brownsman and Staple not only for a longer time but also more effectively. Details of gull control have been given in 10. Biotic Factors. These measures although not effective in reducing the overall population on any of the 4 islands have nevertheless been more effective on Brownsman and Staple i.e. less young per pair have been reared. This in turn has resulted in less treading and less guano, not only from the young but also from the adults which leave earlier consequent upon having no young to feed. This reduced pressure on the vegetation may have enabled the present vegetation cover to re-establish itself on the previously completely denuded areas of Brownsman and Staple whereas on the Wideopens and S. Wamses, with the greater gull density, no recolonisation has taken place.

It should be pointed out that the areas of erosion also contain puffin burrows and in some cases these have moved into areas of deeper soil i.e. Brownsman. These burrows may have helped to accelerate the rate of sheet erosion but there is no evidence that puffins would suddenly bring about conditions which would eliminate the entire plant cover over a wide area. It has already been suggested that the breakdown of the puffin/vegetation balance is a long term process. There is no sign of sheet erosion on the Inner Farne where there are puffin colonies without Larus gulls.

Seals

There is evidence that on Staple where part of the vegetated area has been used for breeding purposes for a longer period than similar areas on Brownsman that the seals may have had an adverse effect on Silene maritima. They have certainly caused numerous wallows (Fig.31). The eroded area, however, is being recolonised without apparently any reduction in the number of seals on the vegetation (Fig. 27). On the Wideopens recolonisation is not taking place and the islands are not used by seals.

The available evidence suggests that the following erosion factors operate on the Farne Islands.

1. loss of soil cover due to storms. This must be a continuing process but large areas of soil are only lost in storms of exceptional severity.
2. local erosion on footpaths caused by visitors.
3. a breakdown in the puffin/vegetation balance, a long term process but this may have been responsible for, the partial or almost complete denudation of the outer islands.
4. sheet erosion, initiated by a sudden climate change. Increase is very rapid where dense breeding colonies of gulls occur and may be further accelerated if it encoaches on puffin colonies.
5. when this stage is reached the rate of soil loss is increased (a) by run off and (b) by wind.
6. in moist conditions an 'algal mat' is formed which prevents erosion but in a dry spell this breaks up and is blown away by the wind together with its adhering soil particles and seeds.

The 'algal mat' may also have a deleterious effect on the colonisation by angiosperms. It may inhibit germination or prevent the plumules of seedlings from developing. When this cover is removed the remaining soil may dry out so rapidly that the germination of any remaining seeds is inhibited.

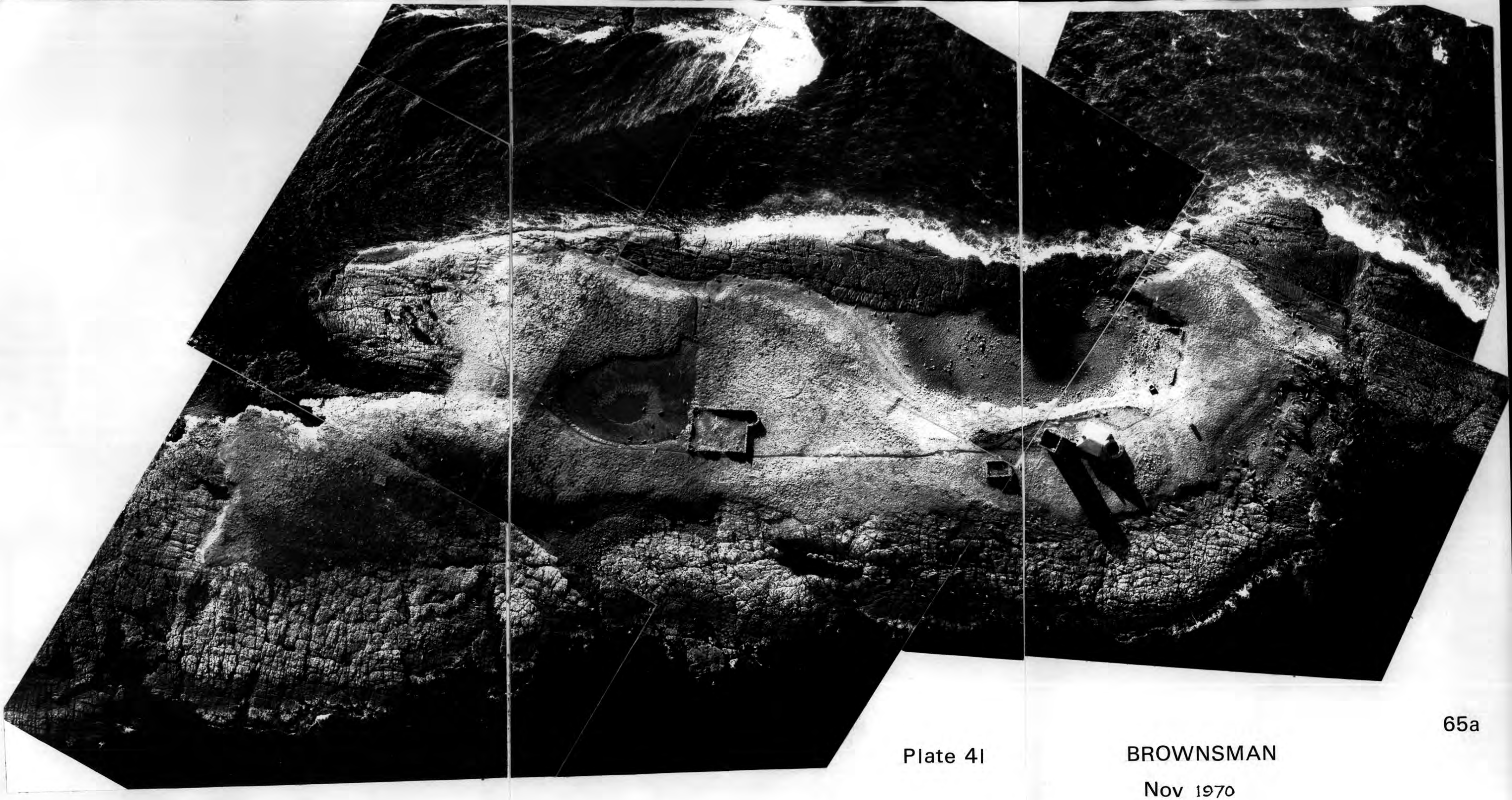


Plate 41

BROWNSMAN

Nov 1970

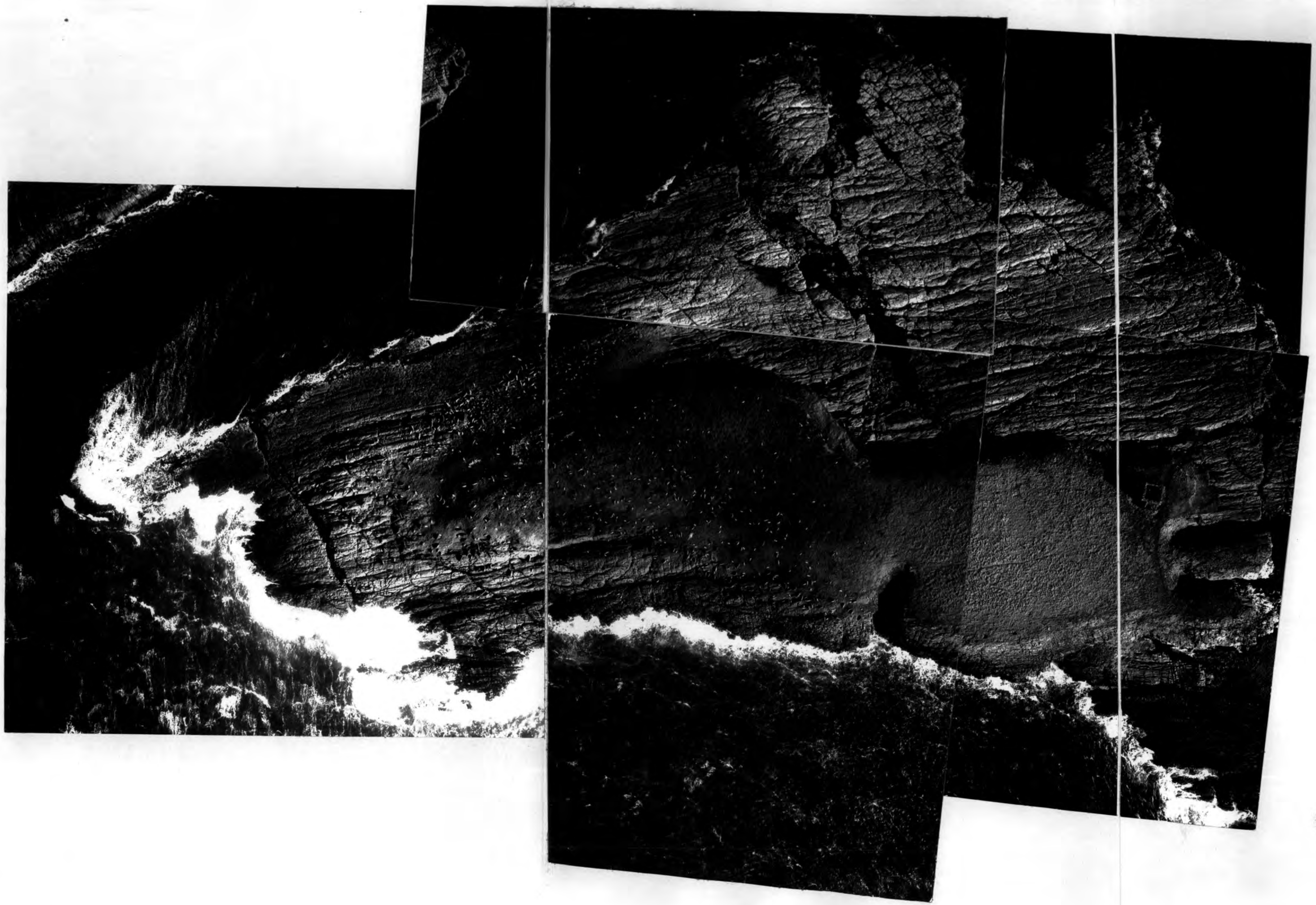
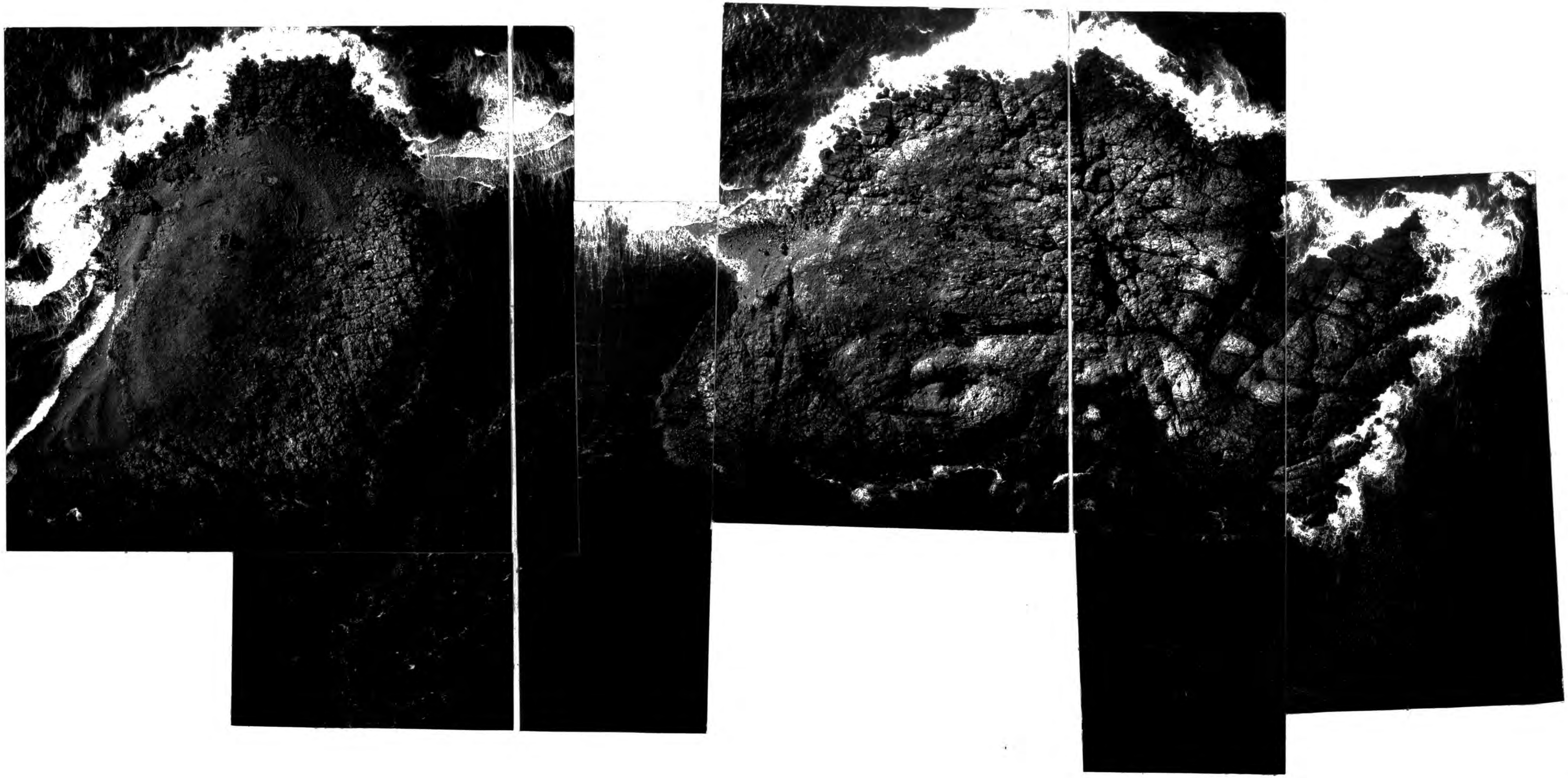


Plate 42

STAPLE ISLAND

Nov. 1970

Plate 43 WAMSES
Nov. 1970



17. Further studies on the vegetation of the Farne Islands

1. Staple Island

3 exclosures 2m x 1m are being erected on Staple Island to provide further information concerning the effects of rabbits, puffins and gulls on 3 distinct samples of the vegetation. (Fig. 17.).

(a) *Puccinellia rupestris*, *Silene maritima* and *Atriplex glabruiscula*.

(b) *S. maritima* and *A. glabruiscula*

(c) *A. glabruiscula* and a single *S. maritima* plant

The exclusures will be constructed of wooden frames 60cm above the soil level and plastic covered wire netting. Wires 4mm diam. will be pushed into the soil as far as possible at 5cm intervals to exclude rabbits and puffins. All exclusures will be surrounded by a seal fence.

2. The western edge of the drift deposit may be eroding. In order to measure any possible changes, measurements have been made (a) from the base line (this can easily be re-erected) to the top of the slope,(b) down the slope and on to the Whin Sill (also measured) Rectangular holes have been cut out and dovetailed  , and a cement tell-tale inserted and labelled 1971. These measurements are recorded in Fig. .

2. Brownsman

I believe that *Silene maritima* is the most important plant to recolonise the area of sheet erosion.

S. maritima seedlings growing in the drift soil close to the high tide line and some from the large seal wallow have been transferred to whale-hide pots in the walled garden (the wall will be repaired to exclude seals).

Two exclosures are being set up on the area of sheet erosion similar to those on Staple and the *S. maritima* seedlings planted (a) inside the exclosure, (b) between the exclosure and the seal fence (possible pressure from gulls, puffins and rabbits) and (c) outside the seal fence (the above pressures plus that of seals are possible).

I hope to gain information from these plantings as to the advisibilty of carrying out the raising of seedlings and replanting on a large scale.

Permanent exclosures erected on STAPLE ISLAND August 1971

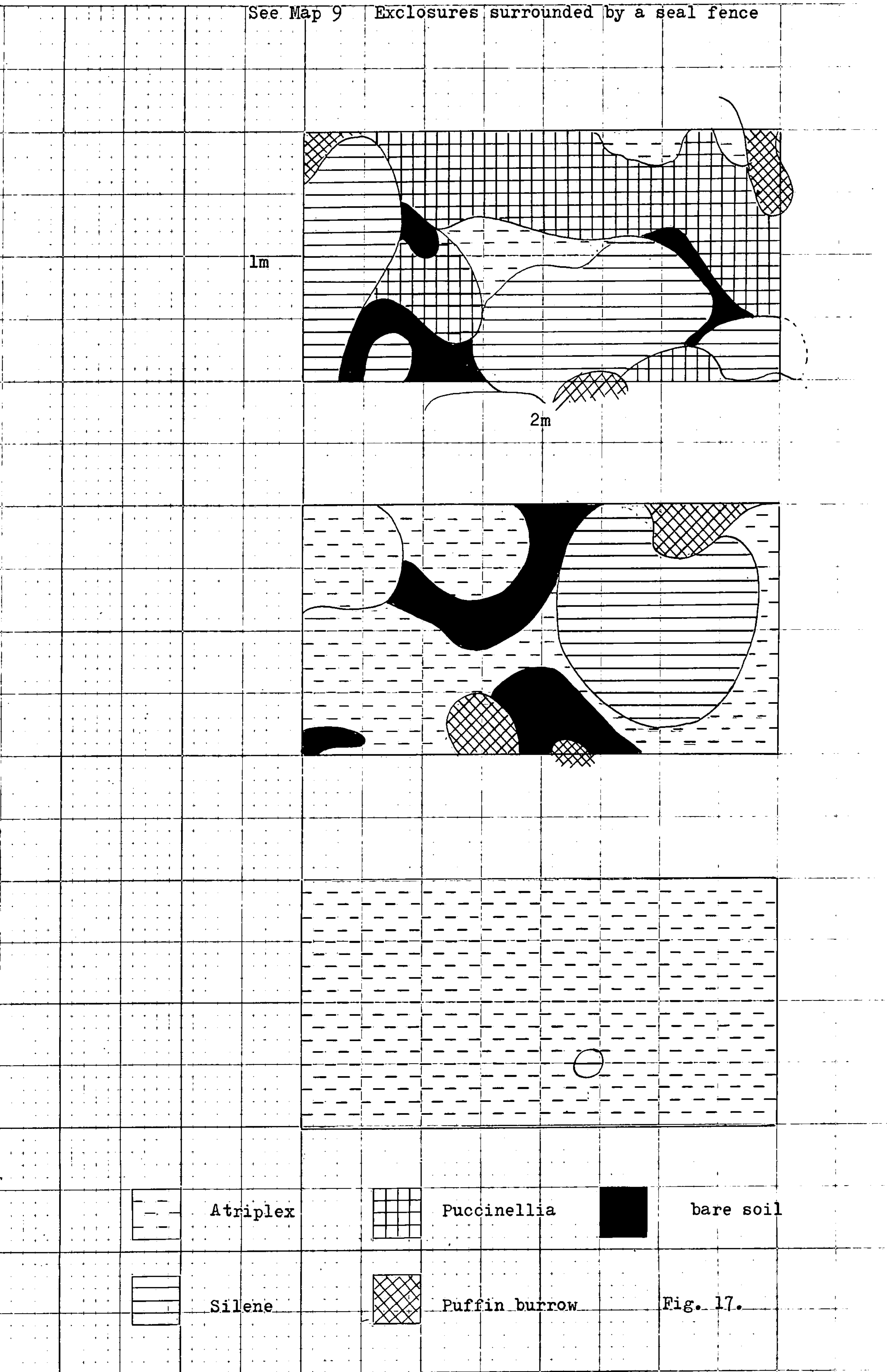


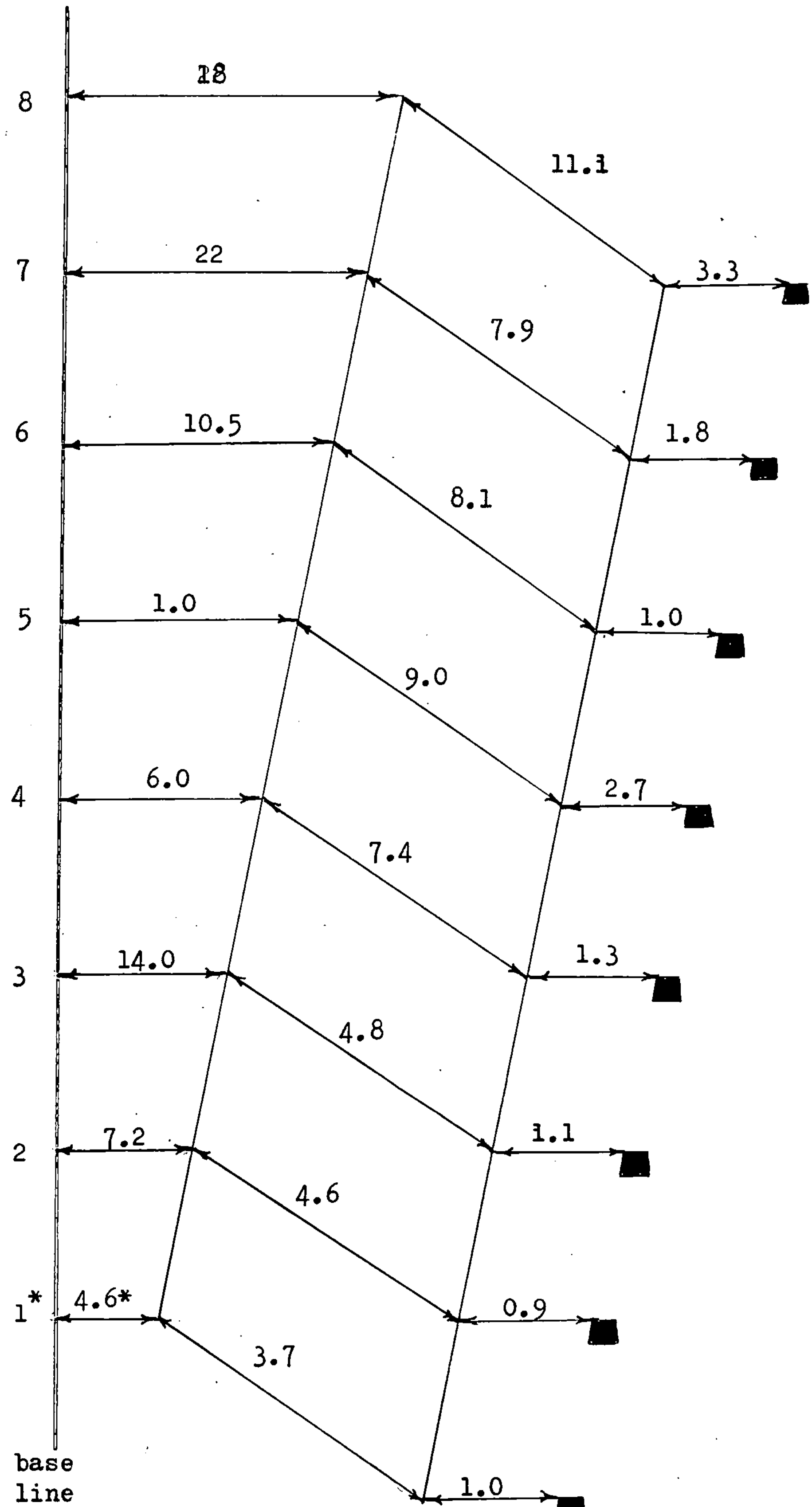
Fig. 17.

Position of tell-tales at the eastern edge of soil cover

BROWNSMAN

tell-tales of cement flush with rock surface - labelled <u>1971</u>

measurements in metres



see Map 9

* measured from N E corner of tower

Fig. 18,

18. Acknowledgements

I am most grateful for the help and co-operation of the Farne Islands Management Committee; Mrs. G. Hickling (Secretary) for details of seal counts and permission to quote from her journal; P. Hawkey (Warden), I. Deans, W. Shiel and the chief watchers for transport between the islands; Dr. J. C. Coulson for information on sea bird populations; Dr. J. Turner for checking the results of my pollen analysis; G. F. Banbury for help in connection with plant pathology and for Plates 20a and 20b; T. J. Bellamy for much help with soil analysis; Dr. J. P. Savidge for information on Silene maritima; Dr. O. L. Gilbert for help with lichens and for Plates 3 and 11; W. B. H. Sowerby for details which appear in Appendix IV; N. Bonner (Seal Research Officer N.E.R.K.) for Plates 42 and 43.

For much help with fieldwork my thanks are due to N. Brown especially for work on Wideopens and for supplying details of his 1968 transects, J. Cranham (Chief Watcher on Brownsman), my son G.J.M., and daughter A. E. M. Hirons.

Finally I must specially thank my wife and daughter for typing at short notice and my tutor Dr. D. J. Bellamy for all his advice and encouragement.

19 Summary

1. Each island has been mapped to give the area of soil cover and vegetation, and where possible the extent of 'recent' soil cover.

2. Plants extant on each island have been recorded.

3. An account of the vegetation is given together with quantitative measurements. This applies especially to areas of erosion.

4. Photographic cover is provided which it is hoped will be of use to future workers.

5. The pollen spectrum has been examined in order to correlate the history of the peat with the extant vegetation.

6. The problem of erosion is one of much concern - information relating to the recent loss of plant cover is collated, the conservation problem outlined and an attempt made to assess the climatic and biotic factors responsible for erosion.

7. Some long term studies relating to soil cover and erosion have been initiated on Brownsman and Staple Island. It is hoped to correlate these with studies connected with the population control of <u>Larus</u> gulls and Grey Seals.

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	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Means
Jan.	2.90	1.75	1.71	0.80	1.77	1.22	1.34	0.95	2.63	3.08	1.85
Feb.	1.20	0.51	1.32	0.60	0.41	2.15	2.08	1.21	2.10	2.15	1.37
March.	0.82	1.17	1.17	2.76	2.43	0.63	0.73	1.39	0.75	1.25	1.31
April.	2.41	1.68	1.55	1.46	1.76	2.17	0.78	1.81	1.20	1.39	1.62
May.	0.91	1.63	1.42	0.71	1.45	1.73	5.23	3.09	3.23	0.75	2.01
June.	1.99	0.63	2.83	2.08	2.00	2.63	1.71	2.05	1.82	0.90	1.86
July.	2.00	2.72	1.05	0.91	4.21	0.79	3.28	3.13	1.07	3.70	2.28
Aug.	2.66	3.25	6.30	3.00	2.35	5.87	1.28	0.99	1.16	1.96	2.88
Sept.	1.76	5.05	2.54	1.71	5.34	1.33	1.34	2.66	2.35	1.20	2.52
Oct.	3.02	0.57	1.34	2.15	1.19	3.23	2.44	2.63	0.66	1.85	1.90
Nov.	1.43	3.48	5.30	0.90	3.34	2.03	3.16	1.36	3.69	2.78	2.74
Dec.	1.78	2.51	0.69	1.56	2.25	2.56	1.35	2.31	1.36	1.18	1.75

Appendix I.

Rainfall 1961 - 1970 Berwick-on-Tweed Meteorological Station

Farne Island Plants Watt.G. 1951

Present - Day Farne Island Plants
(List compiled from specimens collected by T.R.Goddard)

Ranunculus trichophyllus Chaix. and R. Baudotii Godr.
R. repens L.
R. Ficaria L.
Papaver dubium L.
Cochlearia officinalis L.
C. danica L.
Sinapis arvensis L.
Cakile maritima Scop.
Silene maritima With.
Cerastium vulgatum L.
C. semidecandrum L. and C. tetrandrum Curt.
Stellaria media (L.) Vill.
Sagina maritima G.
Sagina procumbens L.
Spergularia salina Presl.
Trifolium repens L.
Spiraea Ulmaria L.
Potentilla anserina L.
Callitriche stagnalis Scop.
Conium maculatum L.
Sambucus nigra L. (introduced)
Bellis perennis L.
Matricaria maritima L.
Senecio jacobaea L.
Arctium nemorosum Lej.
Carduus nutans L.
C. acanthoides L.
Cirsium lanceolatum Scop.
Taraxacum vulgare Schrank.
Sonchus oleraceus L.
S. asper (L.) Hill
Armeria maritima Willd.
Glaux maritima L.
Primula vulgaris Huds.
Lycopsis arvensis L.
Myosotis arvensis Hill
Amsinckia intermedia F. and M. (introduced)

Prunella vulgaris L.

Plantago coronopus L.

Chenopodium rubrum L.

Atriplex patula L. and A. maritima E. Hallier

Rumex obtusifolius L.

R. crispus L.

R. acetosa L.

Urtica dioica L.

U. urens L.

Iris pseudacorus L.

Juncus gerardi Lois.

Carex distans L.

Agrostis tenuis Sibth.

Holcus lanatus L.

Dactylis glomerata L.

Poa pratensis L.

Glyceria maritima Huds.

Festuca ovina L.

F. rubra L.

Ophioglossum vulatum L.

Appendix III

Farne Island Plants   Watt.G.   1951

Plants which have disappeared since 1857
(Based on list compiled by Dr.G.R.Tate)

Ranunculus acris L.
Lotus corniculatus L.
Galium Aparine L.
Cirsium arvense Scop.
Plantago maritima L.
Orchis latifolia L.
Juncus bulbosus L.
Luzula campestris DC.
Carex diversicolor Cfantz
C. vulpina L.
Agrostis alba L.
Trisetum flavescens Beauv.
Poa annua L.
P. trivialis L.
Festuca ovina var. duriuscula Hackel
Agropyron caninum Beauv.

Appendix IV.

Inner Farne

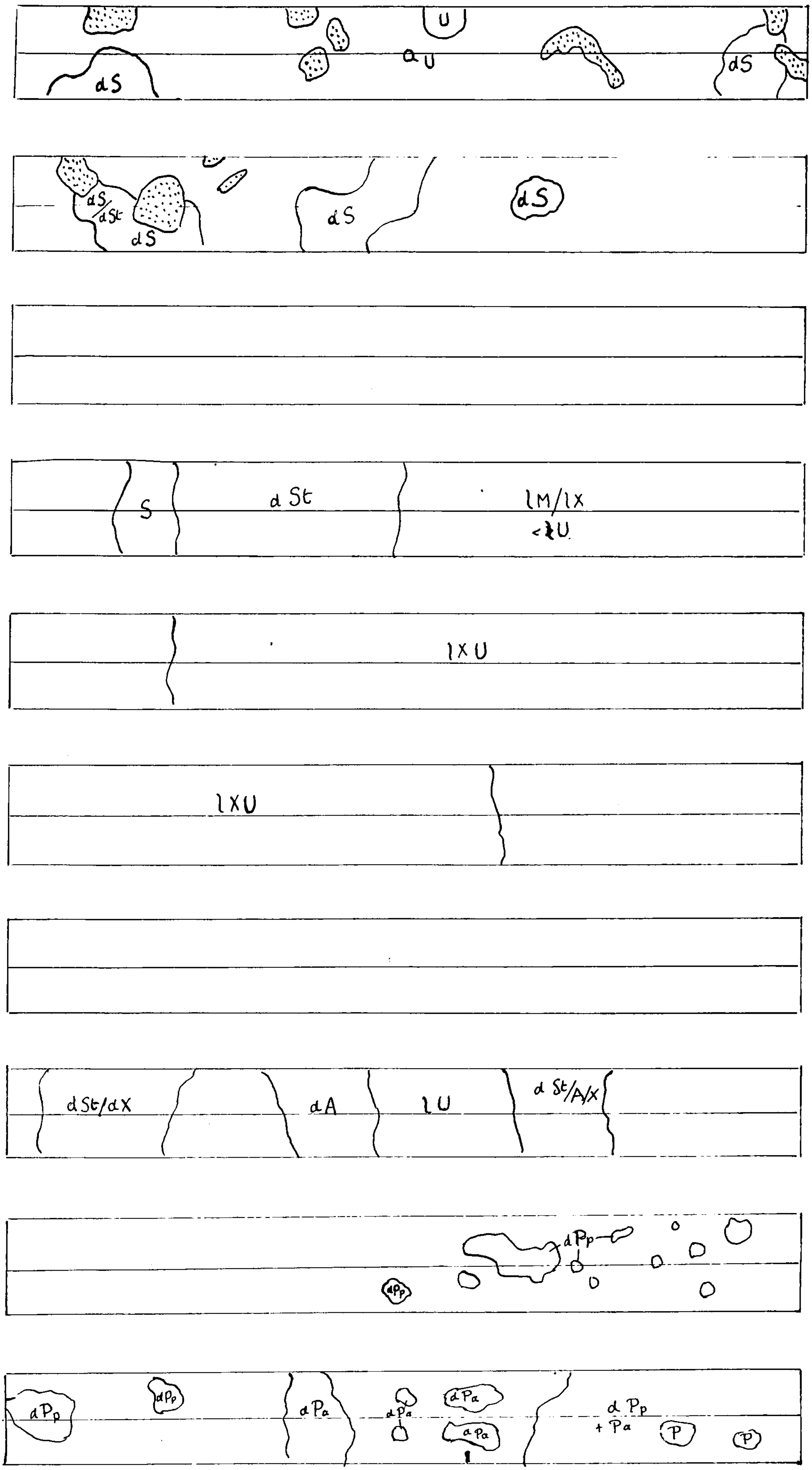
Comparative cover and frequency data of Low Light Site flora 1955 and 1962.

Quadrats 40 – $\frac{1}{2}$m x $\frac{1}{2}$m.

	COVER 1955	COVER 1962	FREQUENCY 1955	FREQUENCY 1962
Silene maritima	39%	38%	88%	85%
Potentilla anserina	30%	7%	82%	47%
Atriplex hastata *	5%	24%	22%	97%
Bare Ground	3%	25%	26%	60%
Festuca rubra	2%	1%	18%	12%
Poa pratensis	–	+	–	5%
Holcus lanatus	6%	1%	30%	10%
Agrostis stolonifera	3%	1%	31%	10%
Stellaria media	8%	+	18%	5%
Cirsium arvense	6%	1%	48%	12%
Cirsium lanceolatum	–	1%	–	10%
Rumex crispus	–	1%	–	10%
Glaux maritima	–	+	–	2%
Cochlearia officinalis	–	2%	–	2%

* I have not recorded A. hastata on any of the Farne Islands.

Data supplied by W.B.H. Sowerby.



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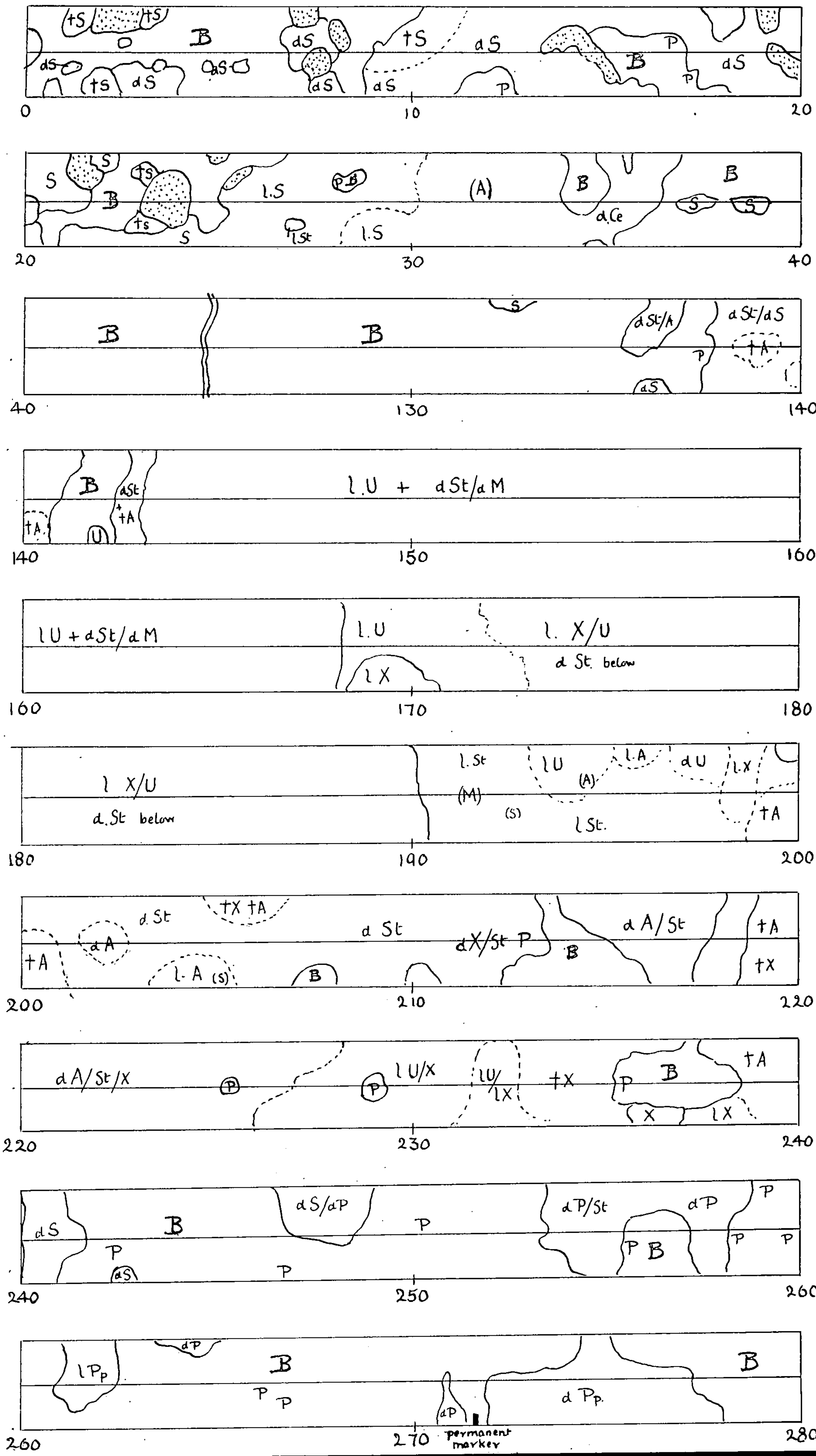
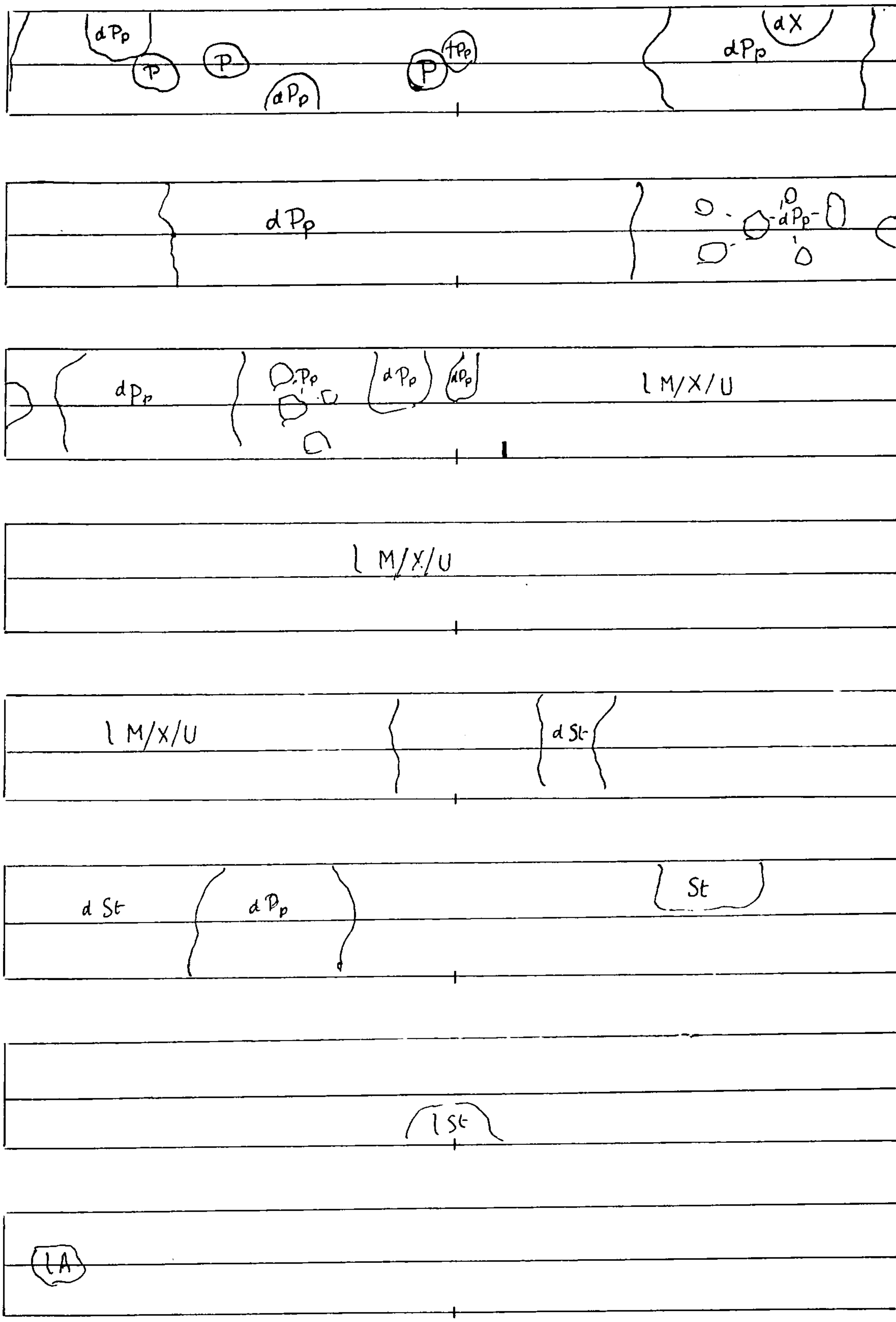
Appendix V.

West Wideopens N/S Transect data supplied by N. Brown June 1968. For position see Map 5

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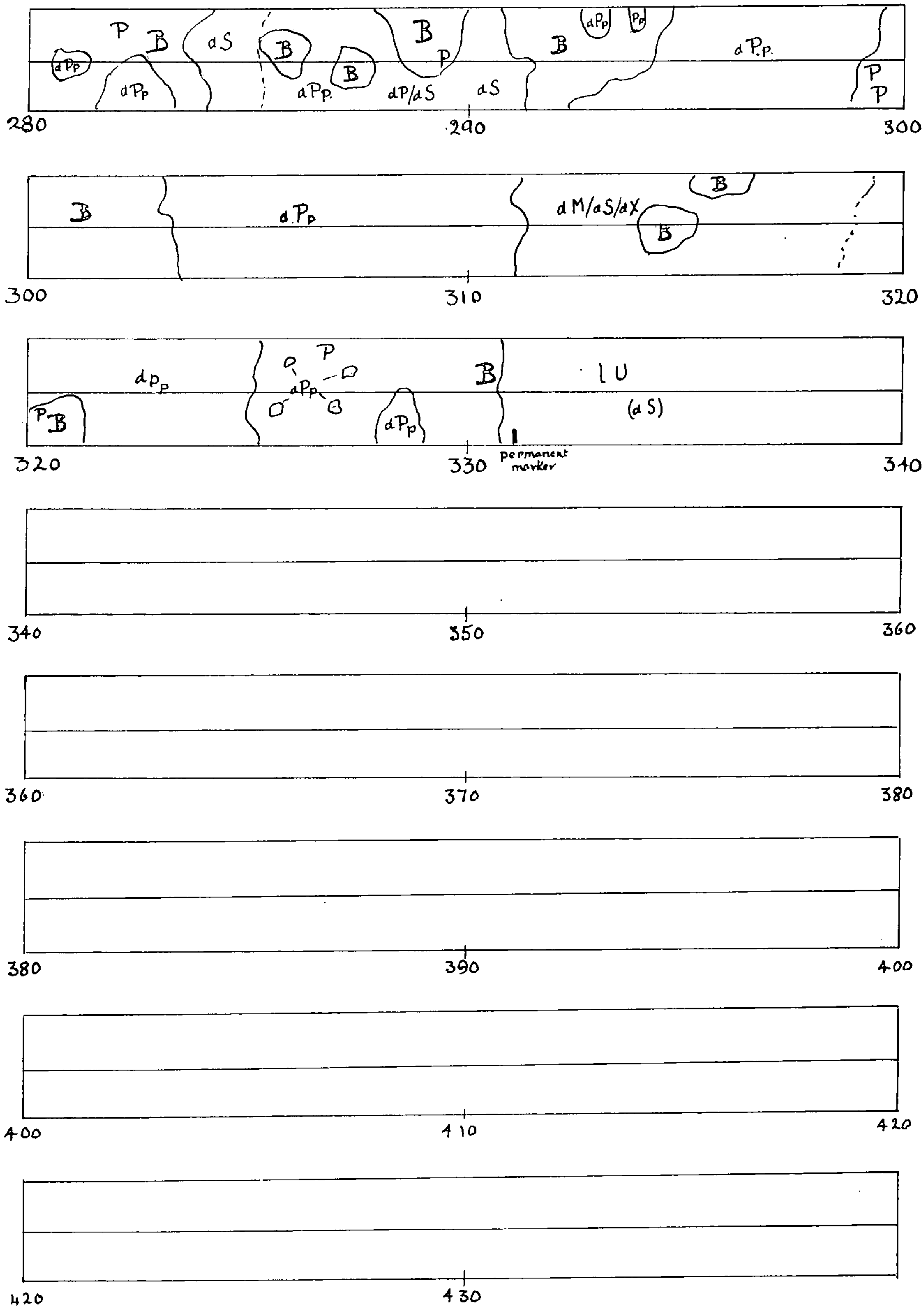
dPp
St
l St
lA

West Wideopens N/S Transect continuation sheet
(June 1968)



West Wideopen 'New' Transects July 1971 See Map 4.

Quadrat No	R. acetosa	S. maritima	A. glabruiscula	S. media	Poa spp.	R. obtusifolius	U. dioica	C. maculatum	Bare soil	Soil depth	P. burrows
1									100		
2	30	40	10	20						9.7	1
3		100								15.5	7
4		90							10	13,7	4
5		90							10	17.3	5
6		50							50	15.3	6
7		10							90	21.7	6
8									100	20.0	
9					30				70	21.8	6
10									100	26.8	3
11									100	34.0	8
12									100	40.0	12
13									100	49.6	11
14									100	35.7	12
15									100	31.1	3
16					30				70	33.5	2
17		30		20	10				40	30.7	8
18		10			20				70	21.9	3
19				20					80	33.6	7
20							90		10	22.5	2
21								100		13.0	
22							100			13.4	
23							100			11.4	
24							100			9.7	

Quadrats 3m x 3m. Soil depth = mean of 10 probes per m^2 along transect line.

Transect 1. 16.7.71

Appendix VI

West Wideopen 'New' Transects July 1971 See Map 4.

Quadrat No	R. acetosa	S. maritima	S. media	Poa spp.	R. obtusifolius	U. dioica	C. maculatum	Bare soil	Soil depth	P. burrows
1								100	0	
2		20		20				60	2.4	1
3	10	80						10	11.6	2
4	50	30						20	2.4	
5		40		60					17.7	3
6								100	32.0	6
7		5						95	21.9	8
8		10		30				60	23.8	3
9				40				60	28.8	
10				30				70	30.6	1
11								100	29.0	3
12								100	40.8	13
13		10						90	44.1	12
14		30	30					40	39.5	6
15		10	20	[illegible]	60			10	19.8	2
16						100			ca 20	
17						90		10		

Quadrats 3m x 3m. Soil depth = mean of 10 probes per m^2 along transect line

Transect 2. 16.7.71

Appendix VI

West Wideopen 'New' Transects July 1971 See Map 4.

Quadrat No.	R. acetosa	S. maritima	Poa spp.	R. obtusifolius	U. dioica	C. maculatum	Bare soil	Soil depth	Puffin Burrows
1							100		
2							100		
3	60	30					10	5.2	1
4		90					10	10.8	4
5		80					20	14.8	3
6							100	16.7	4
7		30					70	17.6	7
8							100	18.9	
9							100	20.5	
10							100	11.8	
11							100	21.9	3
12							100	33.8	9
13							100	44.2	9
14							100	42.3	9
15							100	31.8	6
16			20				80	23.9	1
17			60				40	23.0	1
18			90				10	25.0	
19			30				70	18.9	6
20							100	27.0	6
21				70			30	43.5	1
22					90		10	26.6	
23					100				
24					100				

Quadrats 3m x 3m. Soil depth = mean of 10 probes per m^2 along transect line

Transect 3. 16.7.71
Appendix VI.

West Wideopen 'New' Transects July 1971 See Map 4.

Quadrat No	R. acetosa	S. maritima	Poa spp.	R. obtusifolius	U. dioica	C. maculatum	Bare soil	Soil depth	P. burrows
1							100		
2							100		
3	50	30					20	9.5	
4		80					20	16.2	6
5		80					20	16.8	6
6		90					10	15.9	7
7		50					50	26.4	10
8		50					50	20.4	4
9							100	13.3	
10							100	10.0	
11							100	17.6	
12							100	26.3	8
13							100	30.6	10
14							100	27.8	9
15							100	39.2	6
16							100	25.9	2
17							100	29.1	
18			50				50	35.3	2
19		5					95	24.4	8
20			20				80	18.4	9
21				10			100	24.2	6
22				10			90	34.0	7
23					100			17.8	2
24					100			11.6	
25					70		30	9.2	

Quadrats 3m x 3m. Soil depth = mean of 10 probes per m^2 along Transect line

Appendix VI.

Transect 4. 16.7.71

East Wideopen 'New' Transect July 1971 See Map 4.

Quadrat No	S. maritima	Gramineae spp	C. officinalis	Bare soil	Soil depth
1	20			80	7.8
2	40		40	20	18.4
3	25		25	50	17.5
4	30	30	40		16.5
5	70	10		20	26.9
6	25	20	25	30	24.9
7	40		10	10	23.3
8	60	10		30	26.8
9	100				27.5
10	100				28.1
11	100				28.0
12	60	10		30	

29m to H.W.M.M.T.

Quadrates 3m x3m Soil depth = mean of 10 probes per m^2 along transect line.

Transect 1. 12.7.71.

Appendix VII.

East Wideopen 'New' Transect July 1971 See Map 4.

Quadrat No.	S. maritima	Gramineae spp.	C. officinalis	R. acetosa	Bare soil	Soil depth
1		10	30		60	10
2					100	10
3		5	10		85	20
4		40	30		30	14.7
5			10		90	23.0
6		10			90	10
7	70	20	10			30.4
8	60	10	30			31.4
9	60	10	10		20	32.0
10	30	10	50		10	32.5
11	20	20	50		10	31.3
12	10	10	80			26.1
13			100			25.7
14			90		10	20.3
15			80		20	21.9
16			100			16.4
17			60		40	16.0
18	10				90	9

29m Bare Rock.

Quadrats 3m x 3m. Soil depth = mean of 10 probes per m^2 along transect line.

Transect 2. 12.7.71.

Appendix VII.

East Wideopen 'New' Transect July 1971 See Map4

Quadrat No.	S. media	Gramineae spp.	C. officinalis	Bare soil	Soil depth
1				100	10
2		20	10	70	11.0
3		10	10	80	13.4
4			10	90	15.3
5				100	8.5
6		30	30	40	13.4
7		70	20	10	15.6
8	10	50	40		16.7
9		40	20	40	17.1
10		40	20	40	18.2
11		40	10	50	19.7
12		40	10	50	17.2
13		40	10	50	15.5
14		20	20	60	17.7
15				100	5.6
16			10	90	14.0
17			20	80	24.2
18					27.0
19					40.3
20					17.6

35m to H.W.M.M.T.

Quadrats 3m x 3m. Soil depth = mean of 10 probes per m^2 along transect line.

Transect 3. 12.7.71.

Appendix VII.

East Wideopen 'New' Transect July 1971 See Map 4

Quadrat No.	S. media	Gramineae spp.	C. officinalis	Bare soil	Soil depth
1					0.0
2					0.0
3					0.0
4	60	10		30	8.4
5	50	10		40	7.5
6	10			90	6.0
7	40	10	30	20	29.9
8		50	40	10	43.7
9		60	30	10	34.9
10	10		80	10	37.2
11	70			30	33.6
12			80	20	24.5
13		20	20	60	22.9
14	10		90		19.9
15	40		50	10	25.0
16	30		50	20	19.8
17	10		30	60	16.3
18	40		30	20	11.7
19			60	40	7.5

34m to H.W.M.M.T.

Quadrats 3m x 3m Soil depth = mean of 10 probes per m^2 along transect line.

Transect 4. 12.7.71.

Appendix VII.

Appendix VIII.

Preparation of Peat Samples for Pollen Analysis

(1) Breakdown of peat

(a) place material in a boiling tube and add 10% NaOH, boil using a water bath - 5-10 mins (breakdown may take up to 30 mins)

(2) Removal of large plant fragments

(a) filter using a clean sieve into a 40ml centrifuge tube
(b) wash out boiling tube with distilled water and pour washings through sieve into the centriguge tube.

(3) Removal of siliceous material with hydrofluoric acid

(a) centrifuge, discard the supernatant
(b) wash free of NaOH with distilled water, stir.
(c) repeat (a) and (b). (If necessary remove CO_3 with HCl)
(d) boil (c.a. 10 mins) with c.a. 30-40% HF in a nickel crucible.
(e) discard supernatant and stir sediment.
(f) boil with 10%HCl and HF ca. 10 mins.
(g) discard supernatant and stir.
(h) Heat with 10% HCl without boiling to remove colloidal SlO_2 silicofluotides. Centrifuge while still hot.

(4) Removal of cellulose by acetolysis

(a) wash with glacial acetic acid.
(b) centrifuge and discard supernatant
(c) (in fume cupboard) add 10ml Acetic anhydride, stir and add 1ml con. H_2SO_4, stir and place in boiling water bath for 1 min, stirring gently all the time.
(e) remove and quickly centrifuge.
(f) discard supernatant, add 2 drops of glacial acetic acid, stir and add 7ml distilled water.
(g) stir and boil for 1 min in water bath.
(h) centrifuge and pour away supernatant.
(i) add a few drops of NaOh plus 7ml distilled water, boil for 1 min and centrifuge.

(5) to mount

(a) discard supernatant, stand centrifuge tube upside down and remove excess H_2O with a rolled up slip of filter paper.
(b) add safranin in glycerine jelly (twice as much mountant as the volume of pollen. Stir until thoroughly mixed.
(c) mount 1 drop of mixture under a No.1 cover glass.

Appendix IX.

Method used for Soil Analysis

Total Organic Nitrogen

Adopted from Annual Report of E.M.R.S. for 1964
Allen and Whitfield.

Reagents' Standards. Aliquots of a standard containing 0.5mg N/ml as NH_4^+ are added to blank digests and are made up to 20ml with water (2.357gm/l)

Phenol-sodium nitroprusside soln.

12gm phenol is dissolved in 1 litre of water, 200ml of 1.7% sodium hydroxide soln. is added and 0.06gm sodium nitroprusside in a small amount of water. The whole is made up to 2 litres and stored in a dark bottle.

Alkaline sodium hypochlorite soln.

10ml of sodium hypochlorite soln. (Domestos) is added to 250ml of 1.7% sodium hydroxide soln.

Method

(a) Digestion.

Take 2ml con. sulphuric acid being a 0.1% soln. of selenium (dissolved whilst gently warmed) + 1ml hydrogen peroxide.

Mix rapidly with 100mg of soil sample, and when fuming ceased, heat for 1½hrs on electric Kjeldahl block to give a clear colourless soln.

(b) Dilution.

Take 2.5ml of digest which has been made up to 20ml with distilled water and dilute into 100ml distilled water.

1ml of this dilution then contains 0.025ml of original digest.

(c) Colour development.

Take 1ml of dilute digest and 5ml phenol Sodium nitroprusside and add immediately 1ml alkaline sodium hypochlorite.

Allow colour to develop in the sample tubes for 1hr. Evaluate colour using Eel Colorimeter with 680 filter (No.608).

Soil Nitrate.

Take 100mg of dried sample + 30ml distilled water, shake on shaker for 15mins. and filter. Take 10ml filtrate in an evaporating basin, add 2ml calcium carbonate suspension and 1ml of hydrogen peroxide, place on a steam bath for 2hrs. exactly (covered during this period).

Uncover and evaporate to dryness, continue heating for 15mins., cool and add 2ml con. phenol disuphonic acid + 20ml of 1/1 concentrated ammonia soln. (care required, in a fume cupboard).

Dilute to 50ml with distilled water, read on Eel Colormeter using dark blue filter (621).

If digest is to be retained it must be sealed. If digest appears dark brown after adding ammonia shows incomplete oxidation by hydrogen peroxide and the procedure repeated with 2ml of hydrogen peroxide.

Cations and phosphate

Place 500g of dry sample in a 250ml conical flask. Add 40ml con. nitric acid and 10ml con. hydrochloric acid plus 5ml concentrated perchloric acid.

Stand on sand bath and heat until the liquid just boils. Simmer for 1½hrs. and top up to original level with distilled water. Repeat topping up every hour for 4hrs. until the soln. is clear (and colourless in the case of plant material). Carefully filter (digest may need dilution) into a 250ml vol. flask and make up to 250ml with distilled water.
Phosphate - use Ultrviolet Spectrophotometer Sodium and Potassium - use Flame Photometer Remainder - use Atomic Absorption Spectrophotometer.

	1969 *Larus argentatus*	1969 *L. fuscus*	1971 L.a & L.f.		*Fratercula arctica*	
Inner Farne	0	0	0	Inner Farne	500 ± 80	W. colony 426)) 721
West Wideopen	35 ± 10	278	)			E; colony 295)
			)ca. 700			
East Wideopen	28 ± 10	200 ± 30	)	W. Wideopen	1500 ± 300	2400
Knocks Reef	10 ± 2	40 ± 5		E. Wideopen	700 ± 200	545
Staple Island	65 ± 20	95 ± 20	180	Staple Island	2000 ± 500	2000 + 500
Brownsman	20 ± 5	110 ± 20	111 census	Brownsman	2000 ± 500	3339 census
N. Wamses	35 ± 10	225 ± 40	300	N. Wamses	50 ± 20	ca. 50
S. Wamses	30 ± 10	120 ± 10	693 census	S. Wamses	50 ± 20	ca. 50
Big Harcar			700	Big Harcar		ca. 30
Little Harcar			100			
Nameless Rock			67 census			
Longstone			39 census			
N. Hares			15 census			

Appendix X Farne Islands *Larus argentatus*, *L. fuscus* and *Fratercula arctica* populations.

Appendix XI.

Zones		S. maritima	A. glabruiscula	S. marina	Gramineae	R. acetosa
A	2	40	10			
A	3	5				
A	4	5	5			
A	5		<1			
A	6	20	<1			
B	2	30	<1			
B	3	5	<1			
B	4	1	<1			
B	5		5			
B	6	5	<1			
C	2	1	<1			
C	3		1			
C	4	<1	<1	<1		<1
C	5	5	<1			
C	6	70	<5			<5
D	2	5	<1			
D	3	1				
D	4		10			
D	5	5	5			
D	6	<1	<1			
D	7	5	5			
E	1	30	10			
E	2	<5	10			
E	3		5		2	
E	4	40	5			
E	5	10	<1	<1	3	
E	6		<1			
E	7	<1	<1		8	
E	8	10	<1			
F	1	20	5			
F	2	70	30			
F	3	<1	20			
F	4	10	<1			
F	5	<1	<1			28
F	6		<1			
F	7	10	5			

Zones		S. maritima	A. glabruiscula	S. marina	Gramineae	R. acetosa
F	8	5	<1			
G	1	40	10			
G	2	20	1			
G	3	40	5			
G	4	30	10			
G	5		10			
G	6		5			
G	7	5	5			
G	8	5	<1			
G	9		<1			
G	10		<1			
H	2	40	<1			
H	3	60				
H	4	10	5			
H	5		5			
H	6	<1	<1			
H	7	<1	<1			
H	8		<1			
H	9	<1	<1			
H	10		5	<1		
I	2	60	<1			
I	3	70	5			
I	4		20	60		
I	5		5			
I	6		<1			
I	7		<1			
I	8		<1		4	
I	9		<1		7	<1
I	10			<1	5	
J	2	70				
J	3	5	10			
J	4	5	20			
J	5		<1			
J	6		<1	<1		
J	7		<1		8	
J	8		<1		2	

Appendix XI.

Zones	S. maritima	A. glabruiscula	S. marina	Gramineae	R. acetosa
J 9		<1		4	
J 10		<1			
K 2	70	5			
K 3		30			
K 4	<1				
K 5		20			
K 6		<1			
K 7		<1			
K 8		<1		2	
K 9		<1			
K 10		10			
L 2	80	<1			
L 3	<1	80			
L 4		60			
L 5		20			
L 6		10			
L 7		<5			
L 8		<1			
L 9		<1			
L 10		<1		9	
M 2	30	20			
M 3	<5	80	<1		
M 4		60			
M 5		<30		5	
M 6		30			
M 7		20			
M 8		10			
M 9		10			
M 10		5			
N 2	10	40			
N 3	5	60			
N 4	5	50			
N 5	5	50			
N 6		40	<1	3	
N 7		40			
N 8		10			
N 9		5			<1
N 10		5	8		<1
O 2	10	60			
O 3	5	80			
O 4	5	70			
O 5	5	10			
O 6		40			
O 7		30			
O 8		40		20	
O 9		20	<1		<1
O 10		5			
P 2	70	20			
P 3	40	50			
P 4	20	60			
P 5	5	80			
P 6	<1	70			
P 7		20			
P 8		10		4	
P 9		10			
Q 2	70	20			
Q 3	60	30			
Q 4	30	60			
Q 5	5	80			
Q 6	5	70			
Q 7	<5	50			
Q 8		80		40+	
Q 9		10			
R 2	70	30			
R 3	10	60			
R 4	5	70			
R 5	5	80			
R 6	5	40			
R 7	5	70			
R 8	5	80			
R 9		80			
R 10		90		+	
R 11	<1	70			

APPENDIX XI

Zones	S. maritima	A. glab ruiscula	S. marina	Gramineae	R.acetosa
S 7	5	70			
S 8	<5	60			
S 9	5	60			
S 10	<5	90			
S 11	10	90			

Gramineae Nos. refer to seedlings and not cover.

Brownsman Cover data for 'A' area of sheet erosion 24.5.71

see Fig. 5