Phytosociological studies in the southern Isles of Shetland

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Phytosociological Studies in the Southern Isles of Shetland

By

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The fieldwork for this project was carried out with Anne M. Lewis, who was studying the vegetation of the Northern Islands of Shetland, but the content of this thesis is entirely my own work, except for the text references to publications.

It has not previously been submitted for any degree or diploma.

Judith Hilliam

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ABSTRACT

Over 500 samples were collected from as wide a variety of vegetation types as possible. The principles of the Zurich-Montpellier School of phytosociology were followed to form the data into a species-relevé matrix for each vegetation type. The CLUSTAN package of computer programs was utilised, using Ward's Error Sum of Squares as a sorting routine, to produce differentiated data tables.

72 groups were identified, and described and compared with units recognised in Britain and North-West Europe.

38 groups were assigned to 21 Associations and the remainder were left as noda of doubtful status within alliances and orders. All communities were classified into higher syntaxa following, with only a few exceptions, the scheme of Westhoff and Den Held (1969).

The Classes and Alliances used to contain the communities are as follows:

Cakiletea maritimae	Atriplicion littoralis Open communities (of mainly annual species) of shingle beaches and strandlines
Agropyretea pungentis	Honkenyo-Crambion maritimae Open, unstable, halonitrophile communities of biennials and perennials, of shingle beaches and strandlines.
	Agropyrion pungentis Stable communities in maritime areas subject to disturbance.
Ammophiletea	Agropyrion boreoatlanticum Unstable, pioneer communties on sand.
	Ammophilion borealis Mobile dune communities.
Plantaginetea majoris	Agropyro-Rumicion crispi Disturbance communities of transitional and relatively unstable habitats.

Phragmitetea	Magnocaricion Large sedge communities.
Koelerio-Corynephoretea	Galio-Koelerion Dry grasslands on acidic soils in the atlantic sector
Festuco-Brometea	Mesobromion erecti Semi-dry calcareous grasslands.
Saginetea maritimae	Saginion maritimae Closed maritime grasslands on sandy soils in the upper saltmarsh regions.
Asteretea tripolii	Puccinellion maritimae Halophyte communities of lower saltmarshes.
	Armerion maritimae Halophyte communities of upper saltmarshes.
	Elecharion uniglumis Communal sedge communities of saltmarsh boundaries.
	Puccinellio-Spergularion salinae Distrubed maritime communities on sand and gravel.
Molinio-Arrhenatheretea	Calthion palustris Fen meadow vegetation.
	Cynosurion cristati Communities of grazed, lowland pastures and similar habitats.
Montio-Cardaminetea	Cratoneurion Chalk and limestone spring communities.
Parvocaricetea	Caricion curto-nigrae Small sedge communities in habitats near springs.
	Caricion davallianae Small sedge vegetation of base-rich habitats.
Scheuchzerietea	Rhyncosporion albae Species poor vegetation in pools in poor fens and mires.

	Caricion lasiocarpae Communities of pools in moderately rich fens and mires.
Oxycocco-Sphagnetea	Ericion tetralicis Wet heath communities on shallow peat.
	Erico-Sphagnion Bog communities.
Nardo-Callunetea	Violion caninae Rough grasslands.
	Ulicion nanae Oceanic heaths.
Caricetea curvulae	Arctostaphyleto-Cetrarion nivalis Chionophobous montane grass and dwarf-shrub heath communities.

The occurrence and inter-relationships of the plant communities of the Southern Isles are discussed, and the potential pressures on Shetland vegetation are examined.

ACKNOWLEDGEMENTS

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A number of people have helped with the identification of specimens, and in this respect thanks are especially due to Dr.M.Roberts, Rev.G.G.Graham and J.Skinner in Durham, and Dr.P.Yeo, Cambridge.

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CHAPTER 1

INTRODUCTION

1.1 THE SHETLAND ISLES

The Shetland Islands lie across latitude 60°N, about 241 km north of Duncansby Head, Scotland, and 322 km west of Bergen in Norway. There are over 100 islands, ranging in size from the Mainland which is 88 km long and, at its broadest, 32 km wide, to countless stacks and holms barely as large as an acre. Fig.1.1.1 shows the position of the Shetland Isles.

Until recently the Islands' economy rested on crofting, fishing, knitwear and tourism, but the discovery of oil beneath the North Sea has brought new wealth, new ideas and new people to this isolated archipelago.

This study is particularly concerned with the Southern Isles, that is, south of an imaginary line drawn through the Yell Sound (see Fig.2.1.1) but is intended to complement a similar survey of the Northern Isles by Lewis (1976).

1.2 BACKGROUND TO THE PROJECT

Since the "phytosociological revolution" brought about by Braun-Blanquet and his followers in Europe, British ecologists have described parts of the United Kingdom according to his methods. But most have worked on specific vegetation types, e.g. grasslands (Shimwell 1971a,b, Williams and Varley 1967), heath and bog (Moore 1968) and wetlands (Wheeler 1975), while few have studied discrete areas. Among those of the latter category are Adam, Birks, Huntley and Prentice (1975) working at Malham Tarn, Randall (1972) on the Monach Isles, Birks (1973) on Skye and Prentice and Prentice (1975) on North Hoy, Orkney.

Larger areas have been described to a more general level, e.g. McVean and Ratcliffe (1962) in the Scottish Highlands. To date no such varied island group close to Britain has been surveyed with reference to most of its natural vegetation types.

It seemed, then, that to study islands, with relatively definite boundaries between land and sea, and between island group and mainland

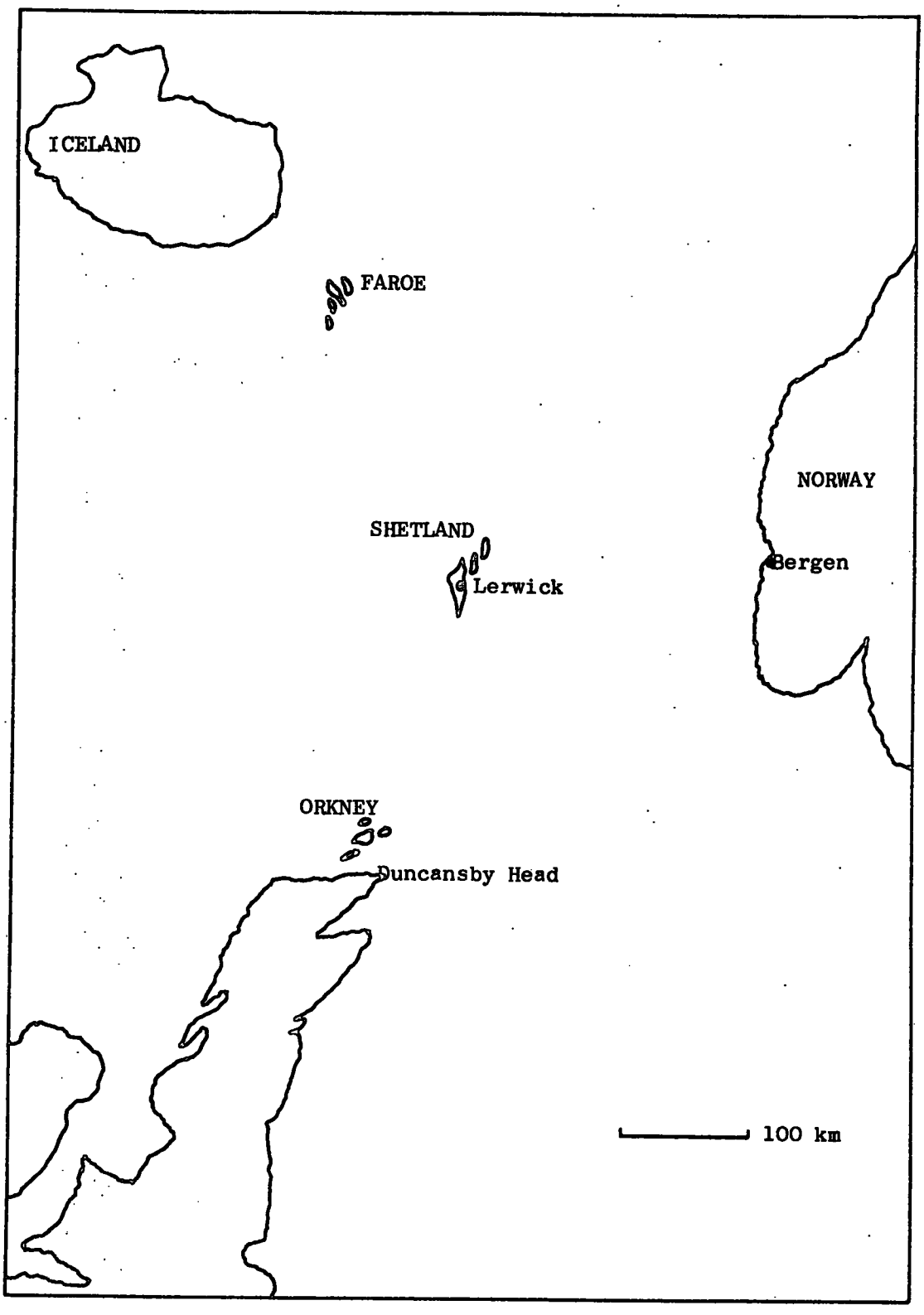


FIG.1.1.1. MAP TO SHOW THE POSITION OF THE SHETLAND ISLES

Britain, would make a valuable contribution to classification of British vegetation in a European context. This could be done particularly through the works of Oberdorfer (1957), Westhoff & Den Held (1969).

The choice of the Shetland Islands resulted from consideration of a number of factors.

At the onset of the project, in 1972, these Islands, as a whole, had been subject to no botanical work other than the production of species lists and short ecological observations (see 2.4). The way was thus open for a complete survey.

The Islands are the most northerly parts of Britain, and second only to St.Kilda in isolation from the mainland, they are approximately equidistant from Scandinavia, Britain and the Faroes (see fig.1.1.1).

Finally, within an extremely oceanic climate, a wide range of vegetation types can be found viz: blanket bog, heath, grassland and coastal communities.

The area lacks woodlands (the plantations at Kergord were not studied), deep rivers and associated riverbank communities.

In the time available it was not possible to cover all vegetation of the Southern Isles. The sea forms a natural boundary to all islands and in the study the mean low water mark was the borderline for vegetation samples. With the exception of saltmarsh species, algal communities were not included. Lochsides were sampled, but not the aquatic, open water vegetation, except where silting or erosion made the 'edge' difficult to define and where emergent communities were prominent.

Agricultural land and ruderal areas were not sampled since they did not fall within the 'natural/semi-natural' brief set for the survey.

This brief may be considered as: to define, describe and characterise the main natural and semi-natural vegetation types in the Southern Islands of Shetland, and to relate these types, where possible with established phytosociological units.

1.3 IDENTIFICATION

Identification of some species in such an area proves quite difficult. Many of the sedges and grasses never produce flowers, while the vegetative forms are often stunted by climatic effects. Plantago maritima is notable, being found in an extremely hairy and succulent form near coasts, on serpentine and at higher altitudes. This was described first by Thomas Edmonston and later named Plantago Edmonstoni by Druce (1920). However, the former, more widespread name has been used here.

There are 21 microspecies of Hieracium in Shetland which have been described and mapped by Walter Scott, who also identified some specimens from the present survey.

Similarly the Euphrasia species are diverse and stunted by climate. These were identified by Dr.P.Yeo.

Mosses and liverworts were brought back to Durham for checking. Once again lack of fruiting material made identification difficult, especially of Bryum spp which could only be named to generic level. Rev.G.Graham and Dr.M.Hill were most helpful with checking and identification and Miss E.Lobley checked a number of Sphagnum spp.

Most lichens were identified by J.Skinner, and Dr.M.Roberts named a number of the algae collected from saltmarsh communities.

1.4 CONVENTIONS AND TERMS

Species nomenclature, unless indicated otherwise, follows these authorities:

Phanerogams:	Flora of the British Isles, 2nd ed. Clapham, Tutin and Warburg (1962)
Mosses:	Census Catalogue of British Mosses, 3rd ed. Warburg (1963)
Liverworts:	Census Catalogue of British Hepatics, 4th ed. Paton (1965)
Lichens:	A New Check List of British Lichens. James (1965)

The following abbreviations were used in both the text and phytosociological tables:

Agrostis canina	=	A canina ssp.montana
Dactylorchis ericetorum	=	D.maculata ssp.ericetorum
Trichophorum cespitosum	=	T.cespitosum ssp.germanicum
Hypnum ericetorum	=	H. cupressiforme var.ericetorum
Sphagnum capillaceum	=	S.nemoreum Scop.

In the phytosociolgical tables the species names have been abbreviated, but a full list of the species in each vegetation type is included with each table, and ambiguities may be distinguished by the reference number.

In the text sub-Alliances, Alliances, Orders and Classes are underlined with a double dashed line; lower units (Associations and comparable syntaxa) are underlined with a single dashed line.

CHAPTER 2

THE SHETLAND ISLES

(General Background)

2.1 PHYSICAL

The area studied can be divided conveniently into a number of smaller regions based on topography and geology (Fig.2.1.1). These are:

1) Mainland
   a) North Mainland. From Brae northwards, and including Esha Ness and Muckle Roe.
   b) Walls. Land to the west of the Walls Boundary Fault.
   c) Delting, Lunnasting. Land to the east of Brae, and north of Voe.
   d) Central Mainland. Nesting and Tingwall, and all land lying between Voe and an imaginary line drawn between Lerwick and Scalloway.
   e) South Mainland, including Mousa.
2) Bressay and Noss.
3) Whalsay and neighbouring islands.
4) Out Skerries.
5) Burra and Trondra.
6) Papa Stour and Vaila.
7) Vementry.
8) Foula.
9) Fair Isle.

The geology of the Shetland Islands is very complex (Fig.2.1.2). Within a small area are found examples of rocks of widely ranging ages and origin. In the extreme north of Mainland are some of the oldest rocks in the world - Pre-Cambrian gneiss, while the granitic rocks of North Mavine formed about 350m.years ago. More recently, the Ice Age left its mark in the form of glacial deposits carried from Scandinavia (Chapelhow 1965), and at the end of this period Shetland had its own ice-cap, which was probably responsible for much of the appearance of the Shetland landscape today (Charlesworth 1956).

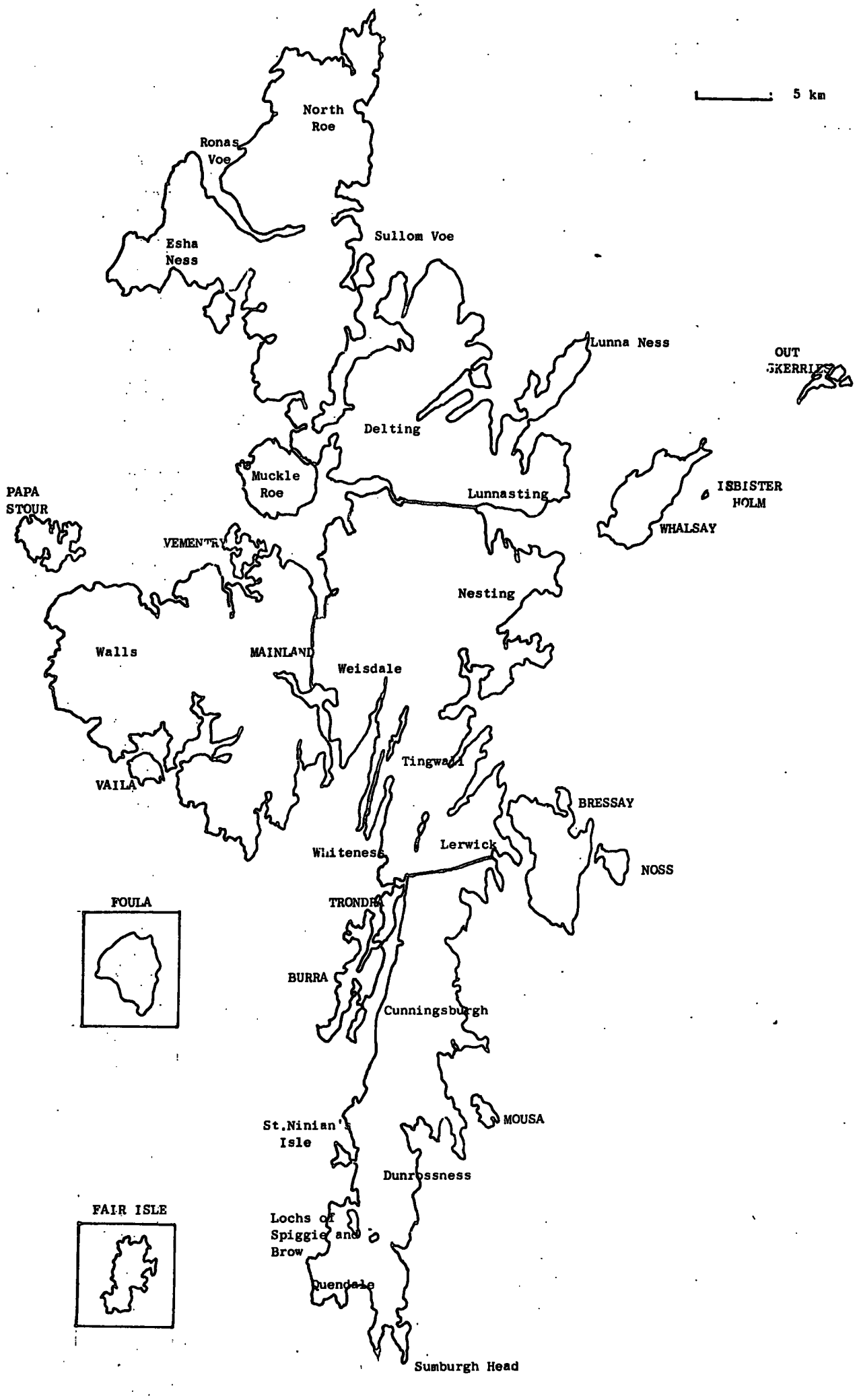


FIG. 2.1.1. Geographical areas of the Southern Isles

The islands are dissected by a series of faults; the two main ones running through mainland are the Walls Boundary Fault and the Nesting Fault. The former is believed to be an extension of the Scottish Great Glen Fault (Peach and Horne 1879).

The central north-south rock mass originated during the Caledonian orogeny. These rocks, lying in north-south bands give a characteristic appearance to Mainland, of hills of relatively hard rock around eroded valleys of softer rocks, for example, the limestone of Tingwall Valley.

The effect of the sea has been to create a coastline of great contrasts.

Since the last Ice Age, the whole of Shetland has been sinking. Hoppe (1965) dated submarine peat samples taken from Whalsay, and showed that 5,500 years ago sea level in Shetland was at least 9 metres lower than today. Deep inlets, or voes, have formed from drowned valleys, and have, characteristically, at their heads areas of salt marsh or shingle where the tidal effect is less dramatic.

Another effect of this submergence is the formation of 'ayres' - stretches of sand. These may extend out from the sides into voes, and occasionally, as at St.Ninian's Isle, actually link an island to the mainland by a tombola. These spits and bars receive material from the sea and may eventually completely cut off the head of a voe from the sea, e.g. Vidlin Bay, and form a brackish loch.

There are over a hundred sandy beaches in Shetland (Flinn,1974) found either as "benches" at the foot of cliffs, (one of the most spectacular examples of this being the Lang Ayre below Ronas Hill), or on gentle, wave-cut platforms around the lower coast. The chemical and physical structure of this sand depends on the nature of both the nearby bedrock and of the deepwater sand supplies from which the beaches may be replenished.

A smaller proportion of the coastline consists of much older sea-cliffs. As opposed to the lower cliffs bordering voes and inlets and

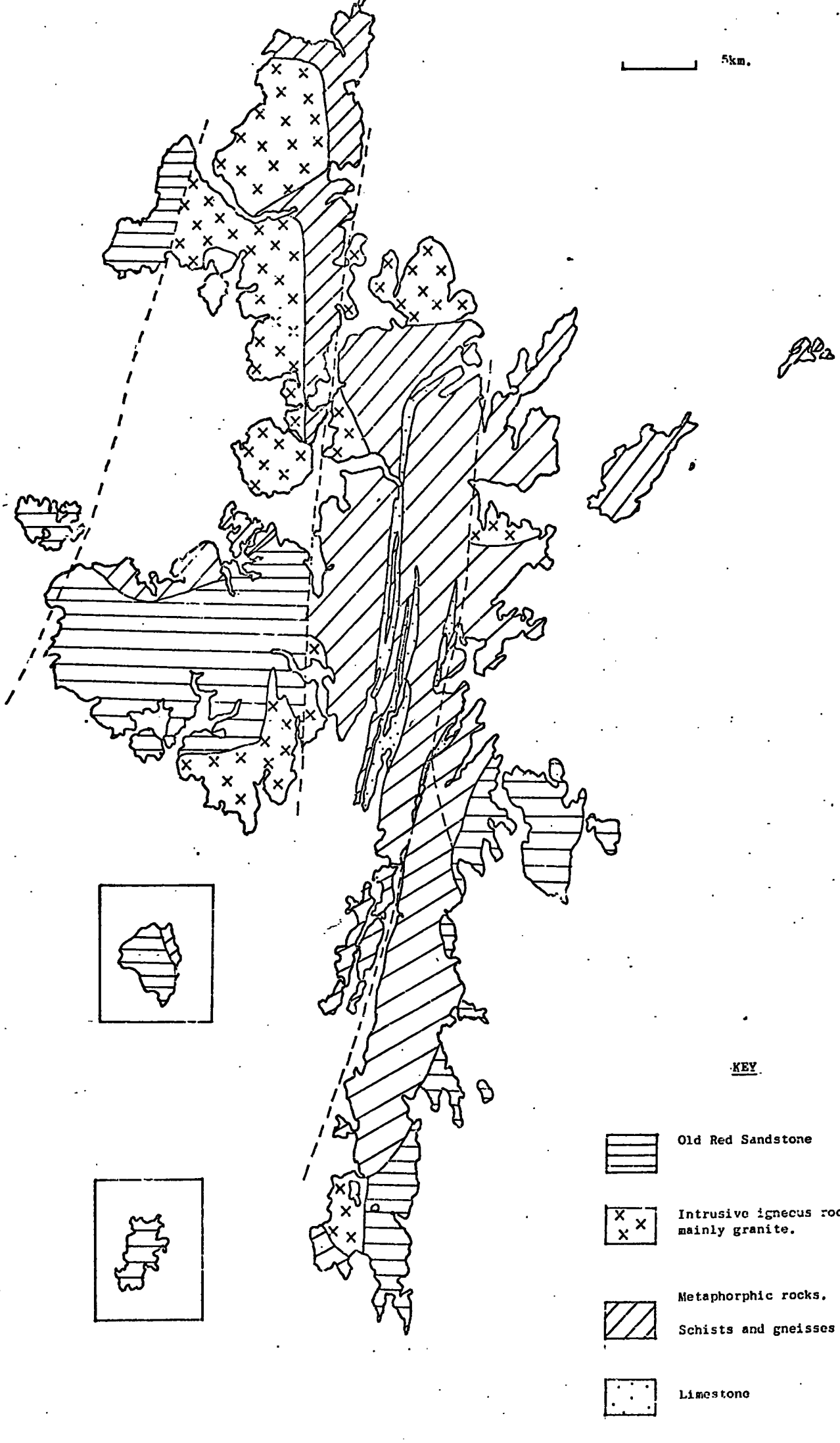


FIG.2.12 Simplified geological map of the Southern Isles

which once formed the sides of valleys, these are the result of marine erosion acting over millions of years on ancient mountain ranges.

Since they have taken a long time to form these cliffs ("Outer coast", Flinn 1974) are less fragile, as a habitat, than the comparatively recent "inner coast".

The Islands have no "mountains". The highest point is on Ronas Hill (HU305835) at 453m, while most ground lies below the 183m contour. There are no waterways that could be called rivers, although there are 1,577 bodies of standing water and thousands of streams, shown on the 1" O.S. map (Britton 1974).

An interesting feature resulting from the recent change in sea-level is the presence of peat on, or very close to, the surface of beaches. Climatic conditions have encouraged widespread, and often very deep, peat formation wherever the topography allows, and this cover extends right to the highwater mark on some parts of the coast.

2.1.1. MAINLAND

2.1.1.1. North Mainland

The overall appearance of this area could be described as "rugged". The base-rock throughout most of it, particularly in Muckle Roe and to the west of the main A970 road, is granite, which outcrops in several places to form small inland cliffs and provide isolated habitats for small shrubs and trees, e.g. Sorbus aucuparia, Salix spp.

The peat cover in such a region is thin.

Ronas Hill, the highest area in Shetland, dominates the area. On its upper slopes there is only sparse, arctic-alpine vegetation, and the whole resembles arctic fell-field, with red-brown granitic boulders and small scree and debris patches.

To the north of Ronas Hill the blanket of peat covers an area of approximately 1600km^2, with a network of pools and Sphagnum hummocks. In the extreme north, near Sand Voe, pre-Cambrian, and more recent, schists

and gneisses are the base-rocks, and produce a more gently-undulating grassy sward. These give lower, and more fertile land, and have, accordingly, cultivated and improved soils.

In the extreme west of this region, the Esha Ness peninsula, the rock is mainly old red sandstone, dating from Devonian times, and has been eroded to give sheer cliffs. These have a band, < 100m wide in places, of heavily grazed grass at their immediate edge, giving way to peat in the central part.

Thin blanket peat extends, with breaks only on some higher ground, right across to the east coast where, for example at Ollaberry, crofts have been established and the brighter green patches of more fertile grasslands are found.

The deep, Ronas Voe, is the only major sea inlet into this area although Sullom Voe borders it to the south-east.

Muckle Roe, an island, is connected to Mainland by a bridge across Roe Sound, while at Mavis Grind the Atlantic Ocean and North Sea are separated by a neck of land only 50m wide.

2.1.1.2 Walls

The rocks on which this area is based are all between 350 and 400m years old. They are mainly old red sandstones with intrusion of granite and diorite in the southern part of the peninsula. These rock types give an undulating and rugged landscape, with few of the north/south trends seen in the rest of Mainland. The lower part of the sandstones was formed partly from fens and partly from river deposits, while in the upper, mid-Devonian layer, fish remains have been found. (Mykura.1974)

The Walls peninsula is covered in blanket peat varying greatly in depth. Near SeliVoe peat-cutting has revealed banks over 2 metres deep, while on some of the higher ground, e.g.Sandness Hill (HU 192556) Simli Field (HU 186514) and Hestaford (HU 275514) the soil is shallow and a stoney heath is seen.

The northern half of the region has numerous lochs and lochans (about 100 areas of water marked on the OS 1" map). Of these lochs Kivkigaforth & Bardister (HU238497 and HU238502) contain the largest variety of mestrophic aquatic plant spp. in Shetland while Loch of Clousta (HU315582) contains holms supporting rare relict scrub vegetation. At Culswick (HU274448) a mesotrophic marsh has been formed when a shingle bar cut off drainage to the sea.

The Walls coastline is typically varied. In the north gneisses and schists give a series of rugged cliffs while the south has wider, lower inlets with ramifying voes, e.g.Olas Voe, Voe of Browland. These have shallow sandy heads, where the red sandstone shingles form short beaches. In the sandness region, around Melby, there is a low coastal plain of fertile land over softer, more calcareous, sandstones which has enabled farming to prosper, while there is a similar rich area centering on the village of Walls.

2.1.1.3 Delting and Lunnasting

The whole of this region is based on a gneiss/metamorphic bedrock, with the exception of an area of intrusive igneous rocks to the north of Firths Voe and Garths Voe. But all the central part has been covered by a very deep blanket peat, giving an undulating series of valley bogs and smooth hills.

This is broken in parts of Lunnasting, where the soil is shallow and rock outcrops occur, and along the Burn of Sandgarth (HU410675) where a limestone band gives less acidic soils.

Around Vidlinand Lunna, agricultural land improvement has taken place. It is in this region that the impact of oil in Shetland is having its greatest effect at present. One pipe is coming ashore at the head of Firths Voe, the oil being stored near Graven, beside Sullom Voe. Oil related buildings, are evident at Firths Voe Camp, (on the Hill of Lee) on Calback Ness, and alongsidetheformer R.A.F. base at Scatsta. A

second pipelines land-fall at Lunna has created less physical change in the area to date.

The coastline varies greatly. Along the Sullom Voe and Yell Sound borders the land is low, falling gently to sea-level with shingle beaches or flat, rocky stretches. On the north-east side, Dales Voe, Collafirth and Swining Voe are all long, sheer-sided inlets, the fjord-like remains of the drowned valleys left by glaciation, while Lunna and Lunning have some steep, relatively high cliff stretches alongside shingle beaches.

The only SSSI in this area is the Burn of Valayre (HU 369 693), a deep ravine, the sides of which support relict scrub vegetation such as Lonicera periclymenum, Salix spp and Rosa spp.

2.1.1.4 Central Mainland

Here can be seen the pronounced north-south lie of hills, valleys, voes and peninsulas, e.g. the Kames hill range. The pattern is caused by the folding of the metamorphic rocks making up this central region. The foliation is such that some of the bands of limestone have been weathered away to give long, fertile valleys, e.g.Tingwall, or simply local outcrops such as are seen in South Nesting.

Over other areas a deep blanket peat has formed, masking the presence of a granitic intrusion near Dury Voe, and a large area of old red sandstone around Lerwick.

The fertility of the limestone areas has produced a number of biologically interesting sites. Lochs Tingwall and Asta (HU 412414 and HU 416428) are richer in base elements than most Shetland lochs, and have a correspondingly richer flora and fauna; while Loch of Girlsta (HU433522) is notable for its depth (maximum recorded - 22.5m) and the presence of Char (Salvelinus alpinus) and large brown trout. A fourth loch, like the former three lying on the crystalline limestone belt, is Sand Water (HU415547), which has a large bed of Common Bulrush (Schoenoplectus lacustris)

At Catfirth, the limestone outcrops in a narrow ravine where the only wild Coryllus avellana bush grows, alongside other remnants of former wooded areas.

At Kergord (HU 395 545) a series of plantations was established in the relatively sheltered Weisdale valley in 1920. This now has the largest area of woodland in Shetland.

The White Ness peninsula is the largest limestone outcrop, and consequently, one of the most successful areas, agriculturally, in Shetland.

Scalloway, the former capital of the Islands, lies on the west side of this area, while Lerwick, the present major town is on the east protected from the North Sea by the island of Bressay. Of the total estimated county population of 18,623 of December 1974 (Z.C.C.1975), approximately 1000 live in Scalloway and 6000 in Lerwick (Nicholson,1972). These figures are now changing rapidly with influx of new (and possibly temporary) workers associated with oil related construction programmes.

2.1.1.5 South Mainland

The rocks of this area are in the main an extension of the metamorphic gneisses and schists of Central Mainland, with outcrops of old red sandstone along the east coast and on Mousa. There are also local intrusions of granite, the largest being at Spiggie.

The metamorphic rocks produce, along the west coast, a series of rugged, north-south running hills, which are covered in blanket peat or heath. These form the Clift Hills (highest point Royl Field 293m) and, further south, the Ward of Scoaburgh (262m) and Fitful Head (283m).

The east side is much lower altogether and, due to the nature of the bedrock, gentler in its topography. The O.R.S. gives richer soils, and with slightly better climate than has most of Shetland, made the east coast and southern Dunrossness some of the best agricultural land in the country.

The Lochs of Spiggie and Brow are highly base-rich waters, separated only by a fen, while the Lock of Hillwell is regarded as a machair loch,

lying as it does at the landward edge of Quendale dunes. These form the largest dune complex in Shetland, about 1 sq.kilometre containing some million of tons of sand (Flinn1974). Nearby St.Ninian's Isle (HU372 208) is connected to the mainland by a sand and shingle tombola - both sites being evidence of the large supplies of sand off the coast of South Shetland.

The population of Dunrossness is locally high, particularly around the agricultural areas; while the airport at Sumburgh and new oil storage facilities at Sandwick have led to recent increases in the numbers in both these areas.

2.1.2. Bressay and Noss

Geologically these islands, separated from Lerwick by the Bressay Sound,are part of the old red sandstone outcrops found all along the south-east coast of Mainland.

Bressay had a propulation of 258 in 1971 (Nicholson 1972) but has increased recently as it became more accessible and attractive as a "commuter community" for Lerwick businessmen.

Its low lying west coast has a narrow band of agricultural land, but this gives way to heath and blanket bog as it rises towards the west. The highest point is Ward of Bressay (226 m).

Across the narrow Noss Sound lies Noss, a small island, inhabited only in summer by a shepherd and the N.C.C. wardens. The cliffs below the Noup of Noss (181m) support a wide and interesting range of breeding seabirds, which have led to the island's designation as a National Nature Reserve.

2.1.3. Whalsay

Whalsay and the small islands around it are part of the central metamorphic mass of gnessies and schists mentioned previously. This gives them the characteristi c rugged and undulating topography, although essentially being low lying (highest point Ward of Clett (119m)), with a number of lochs.

The island has a thriving fishing fleet - most of the population of

970 in 1971 (Nicholson 1972) depend upon this. Except for a south-west marginal band there is little improved agricultural land.

2.1.4. Out Skerries

This, the most easterly part of Shetland, is a group of islands, the largest, inhabited three, Housay, Bruray and Gruney, being linked by bridges.

Although essentially composed of gneiss and schists, there are outcrops of limestone on the islands, which have only a very thin soil cover throughout. Areas of scree-like debris occur on Housay.

The population of about 90 has three fishing boats and its own processing factory.

2.1.5. Burra and Trondra

The north-south lie of these islands is a further manifestation of the north-south folding of the metamorphic rocks of which they are made up, and which is seen through Central and South Mainland.

Soil cover is quite thin (<30cm) over all higher ground, giving a stony heath vegetation over most of East and West Burra. On Trondra, and lower-lying parts of the other islands there has been improvement of the land by farmers to give pastures for sheep.

These islands have a population of over 600, centered on Hamnavoe, employed mainly in fishing and knitwear industries.

2.1.6 Papa Stour and Vaila

Lying 1.6 km off Melby on the north-west coast of Walls, Papa Stour forms a continuation of the sandstones west of the Melby Fault. Its coastline has been greatly eroded and inundated by the sea to produce a notable series of caves and rock formations.

About 30 people live on the island, in a crofting community.

Vaila consists of the more acidic sandstones and is a small island about 2km^2 in area situated across the Vaila Sound from the village of Walls. It is inhabited by a single family living in Vaila House.

2.1.7 Vementry

This is an unihabited island about 2½ km^2 in area, situated off the

northwest coast of Walls. Like the Mainland immediately across the Cribba Sound from it, Vementry consists of gneisses and schists, and has a rough, undulating topography, with numberous areas of standing water.

2.1.8. Foula

This is the most isolated part of Shetland lying 33km west of Scalloway. For the greater part it consists of soft sandstones, revealed dramatically in the famous cliffs along its Atlantic coast. The highest point of Foula, the Sneug, is 418m high and is thought to have had a local glacier towards the end of the Pleistocene age. Only on Foula are corries found which can be compared with those formed by glaciation in Scotland. (Mykura 1974).

Most of the island is covered by blanket bog, with the exception of an east coastal strip, along which most of the (decreasing) population of 30 live. The island has no natural harbour, so that a fishing industry has not survived there.

2.1.9. Fair Isle

This island, owned by the National Trust for Scotland lies 36km south-west of Sumburgh Head. As on Foula, its sandstone base rock is displayed in dramatic cliffs and stacks. Most of the population of 70 depend on sheep and knitwear for their livelihood, there being limited harbour facilities on Fair Isle.

2.2. CLIMATE

The climate of the Shetland Isles can be described as temperate, moist, windy and lacking in sunshine. Most of the statistics available certainly present this overall pattern which is brought about by their geographical position. The islands lie in the Gulf Stream which produces mild winters, but far enough north (lat.60°N) and in the path of weather systems moving in from the Atlantic to give high and constant wet winds.

Basic meteorological observations have been made regularly at Lerwick Observatory (93mvane; 82m base) and Baltasound (alt.9m) with occasional readings taken at Saxavord, Sullom and Kergord.

These data have been grouped & modified further by Birse and Dry (1970) and Birse and Robertson (1970) to form part of their climatic maps for the whole of Scotland. Birse (1971) went on then to correlate some of the effects of climate on vegetation in devising a system of bio-climatic zones. These are described more fully later in this section.

Rainfall

The average annual rainfall over the years' 1916-1950 ranges from 1000mm at Lerwick to 1125 mm at Baltasound (Met.Office 1958) while around Ronas Hill the figure reaches 1270mm (Nicholson 1972). Over the wettest months, November, December and January the monthly average is 117.1mm for Lerwick (127.8mm Baltasound). These values are both higher than for the comparative three months in Orkney (Hellyar Holm alt.10.6m - 98.3mm) or Dyce (Aberdeenshire , alt.90. m, rainfall 82.3mm). However, in summer, the three driest months May, June and July have an average monthly rainfall of 57.9mm in Lerwick (64.4mm Baltasound) while the corresponding values for Orkney and Dyce are 49.6mm and 68.2mm. The rainfall figures are similar to those experienced by the Faeroes. There the effect of mountains on the north-east islands gives an average annual rainfall of 3020mm falling along a NE-SW cline to 825 mm in the south west. Sandur

on Sandoy has an annual average of 1161 mm rain at 30m altitude. (Hansen 1966)

Lerwick has an average of 248 raindays per year (Nicholson 1972) and the relative humidity of the islands is the highest in the British Isles - monthly average of 80-85% (cf Scottish mainland value of 70-80%) (Met.Office 1952). Hansen (1966) gives a mean value of RH of 85% for the Faroes.

Birse and Dry (1970) calculated values of potential water deficit for May, June, July for Lerwick (44 mm) and Baltasound (33mm). They point out that these values are rather high for Scotland (Dyce 40mm).

Shetland falls into their categories of P.W.D. of moist, rather wet and wet. Table 2.2.1 shows Birse's P.W.D.categories.

The high ground around Ronas Hill has zero P.W.D; land between 200 - 800 m tends to fall into the 0-25 mm P.W.D.category while the lower-lying areas have between 25 and 50mm P.W.D.

All observations indicate that the climate of Shetland is wetter than places of similar altitude on the Mainland. This is responsible for the large areas of blanket peat which have formed and their associated rich bryophyte flora.

Table 2.2.1

RANGE	DESCRIPTION
> 75mm	Dry
50 - 75 mm	Rather dry
25- 50 mm	Moist
0 - 25 mm	Rather wet
0 mm	Wet

To show scale of Potential Water Deficit Divisions, Birse and Dry (1970).

Table 2.2.2

	Average Annual temp. °C	Jan - Feb mean temp. °C	July-Aug mean temp. °C
Lerwick[1]	7.1	3.4	11.9
Baltasound[1]	7.6	3.8	12.4
Dyce[1]	7.7	3.1	13.5
Faroes[2]	7.1	3.6	10.6

Comparison of temperatures at sites in Shetland, Scotland and Faroes

1. Figures from Meteorological Office (1953)

2. Figures for 4 sites, from Hansen (1966)

Temperature

The mean annual temperatures for Lerwick (7.1°C) and Baltasound (7.6°C) are slightly lower than for Dyce (7.7°C) taken over the years 1921-50 (Met. Office 1953).

As Birse (1974) points out, this falls in line with a general drop in mean annual temperature of 0.2°C per 100 km moving from south to north in Scotland.

But when winter and summer figures are examined it can be seen that Shetland has, on the whole, warmer winters and cooler summers than parts of Scottish mainland - see Table 2.2.2. In fact, from March to September the Islands have the lowest daily average temperature in Britain (Neustein 1964).

Table 2.2.2 also shows the mean annual temperature, mean January, February temperature and mean July, August temperature calculated from four lowland sites in Faeroe. (Hansen 1966). These agree with the Shetland observations of cool summers and warm winters.

Accumulated temperature is a function of the number of degrees by which each monthly mean temperature exceeds a baseline temperature, and the number of months this occurs. Birse and Dry (1970) used a baseline of 5.6°C, being the threshold above which plant growth occurs, to calculated accummulated temperature as a bioclimatic factor.

The summit of Ronas Hill falls into their category 'very cold' (see Table 2.2.3 for scale of categories), and some land above 61m into 'cold'. However, most of Shetland has 825-1100 day degrees C, and is classed as 'cool'.

At Lerwick the accumulated temperature value is 939 day°C, while at Dyce it is 1217 day°C. The figure is valuable for determining the potential for plant growth at a site. Comparing Lerwick and Dyce figures show the much longer time available annually for plant growth to occur in Scotland, and hence greater potential in crop and natural vegetative production.

Table 2.2.3

RANGE (Day degrees C)	DESCRIPTION
≥ 1375	Warm
1100 -1375	Fairly warm
825 -1100	Cool
550 - 825	Cold
275 - 550	Very cold
0 - 275	Extremely cold

To show Scale of Accumulated Temperature Division, Birse and Dry (1970)

An allied factor in determining the period of plant growth is amount of sunshine. Due to its northerly latitude Shetland has potential for more hours of sunshine than anywhere else in Britain. The day length in June averages 18.59 hours but of this only 20-25% is bright sunshine (as defined by Meteorologists (Met.Office 1952). Senior and Swan (1972) point out that in the period May to September there were only 670 hours bright sunshine, compared with over 770 hours on the Moray Firth, 300 miles further south.

The value of this factor in limiting vegetation is probably overridden by the thermal or moisture factors. In Shetland, at least, plants appear to have become morphologically adapted to the latter two, e.g. Plantago maritima hair formation, but do not seem to have adapted to low sunshine hours (see Chapter 6.2). This however needs further evaluation.

Wind and Exposure

Neustien(1964) regards wind as the climatic factor having greatest effect on vegetation in Shetland, with an average wind speed of 6.7 - 7.45 m/sec measured at Sullom and Kergord trial plantations. There are an average of 30 days per year with gales, and apart from the Butt of Lewis the islands are the windiest place in the British Isles (Johnston 1974). Lerwick (where the Observatory vane is at 93m) has about 236 hours of gale force winds, that is force 8 or above, per year (Nicholson 1972). Of 27 days with gales recorded in Lerwick in 1974, 22 occurred in January and December, indicating the importance of winter winds (Z.C.C.1975). This is confirmed by foresters' observations on spring growth of trees in plantations; the growth seems to be inversely related to the severity of winds the preceding winter (Neustein 1964).

Spence (1957) considers the effect of wind on the Shetland vegetation. He compares the mean annual windspeeds at points in Aberdeen, Eskdalemuir (Dumfrieshire) alt. 242m, Lerwick 93m, Sandness Hill 249m, Ben Nevis 1343m. Sandness Hill is twice as windy as Eskdalemuir, and three times as windy as Aberdeen. Also mean annual windspeed of 13.50 m/sec (30 m.p.h.) is

reached at an altitude of 244 m in Shetland, while at the summit of Ben Nevis this value is only 16.9m/sec. Spence (1957) describes the Shetland climate as "submonta ne-oceanic" from sealevel to 305m and "subarctic-oceanic" above that height. It is interesting to note a further similarity with Faroes climate here; Hansen (1966) shows that Sunnbur at 90m altitude, has an average of 88 days per year with winds force 6 and comments that wind can be assumed to have a great influence on the vegetation.

Connected closely with the effect of wind is the effect of the salt spray that it carries. The salt concentration in the air at Lerwick Observatory is the highest value recorded for Europe; since no part of Shetland lies more than 5.5 km from the sea the influence of salt spray must be felt to some extent by all vegetation.

Birse and Robertson (1970) classified areas of Scotland according to their degree of exposure; "exposure" was judged by assessing the effect of wind (and any characteristics which may modify its effects, such as salt content) on broad-leaved trees and Calluna. Although this may appear subjective it was found to correlate well with average wind velocities. Shetland falls in to the categories of exposed, average wind velocity (4.4. - 6.2m/s), very exposed (6.2 - 8.0 m/s) and extremely exposed (>8.0 m/s). Sheltered valleys or voes have poor tree growth (exposed); over about 122 m has zero or prostrate heather (extremely exposed), while most of the islands fall into the very exposed group characterised by "very short heather".

Snow and Frost

The mild winters of Shetland have already been mentioned. Snow rarely lies for long periods. Of an average of 35-40 days per year that snow falls on land below 61m, it is only found lying on 0-5 days in S.Mainland and 5-10 days in N.Mainland (Met.Office 1952). Similarly the average annual frequency of days when the minimum temperature is $0^{o}C$ or less is only between 10-25 whereas it numbers up to 100 in Central Scotland.

Birse and Robertson (1970) calculated the annual accumulated frost in day degrees centigrade at certain sites in Scotland (as complement to accumulated temperature). (See Table 2.2.4). They used the base-line of $0^{o}C$, being the level at which cells of certain plants suffer frost injury. Shetland lies in the range 0-110 day ^{o}C accumulated frost. The coldest category, "moderate winters" is found only on Ronas Hill, in The Kames, on Roylfield and Ward of Veester in Cunningsburgh, and The Sneiug (Foula). All coastal ground and that lying below about 122 m have "extremely, mild winters", while the rest of the land lies in the middle category - "fairly mild winters".

The general climatic pattern of the whole of the Shetland Isles has been presented.

Mainland differs only in two points:

a) The extreme height of Ronas Hill (453m) which alone has the bioclimatic classification of cold (and very cold) uphill and mountain (Birse & Dry 1970). The effect of such a climate at this altitude allows the growth of subarctic vegetation types, and produces topographic features characteristic of northerly latitudes of Europe and Scandinavia. (See Chapter 5)

b) South Mainland has a slightly warmer climate than the more northerly parts of the island. Parts are sheltered from the direct effects of westerly gales by the Clift Hills and the range running right down the west coast to Fitful Head. The ameliorating influence of the sea is felt slightly more because this neck of land is at no point more than five miles wide. These factors are discussed further in Chapter 6.2.

Table 2.2.4

RANGE Day degrees C	DESCRIPTION
<20	Extremely mild winters
20 -50	Fairly mild winters
50 -110	Moderate winters
110 -230	Rather severe winters
230 -470	Very severe winters
470	Extremely severe winters

To show scale of Accumulated Frost Divisions, Brise and Robertson (1970)

2.3 SOILS AND LAND USE

The soils of Shetland have not been surveyed in detail, and due to the complex geological base, it is difficult to generalise about them. Most, however, have derived from glacial deposits, though in many cases they derive from the underlying rock (Senior and Swan 1972)

A large percentage of the Mainland is covered by blanket peat, encouraged by the gentle slopes and high rainfall (see Chapter 6).

In the area around Sullom Voe, north Mainland Birse (1973) reports on wide variety of soils from flushed brown forest soils on slopes too steep to support blanket peat, through non-calcareous gleys, peaty podzols and peaty gleys, to basin and blanket peat. There are also alluvial soils. This pattern is typical of central Mainland.

In the north, the granite bedrock gives an acidic, shallow mineral rich soil, while the limestone valleys and White Ness have rich brown earths.

The arable land of southern Mainland and in coastal patches appears to be based on glacial deposits and the soils derived from them.

The landscape of the whole of Shetland in 1974 is summarised in Table 2.3.1 below (The statistics are for holdings having more than 40 standard man days agricultural activity (Z.C.C.1975)).

Table 2.3.1.

To show land-use in Shetland 1974 (From Z.C.C.publication 1975)

	acres
tillage	2,428.5
grassland & crops	15,988.75
rough grazing and common grazing	309,830.00
woodland	230.25
roads,buildings,etc.	361.75
total	328,839.25

Tillage crops are particularly important in the South Mainland where oats form the major proportion of the crops. Throughout all the inhabited islands, however, barley, potatoes, turnips, swedes, kale and cabbage are grown close to cottages, although not necessarily on any large scale.

Grassland, other than rough grazing, occupies 13,560.25 acres in Shetland (see Table 2.3.2). This includes the reclaimed grasslands regenerated on shallow peat, usually sown with a Lolium-Cynosurus seed mixture. This grassland is grazed or mown for hay or silage. In 1969, 82% grass cut was used for hay (Senior and Swan 1972).

Woodland occupies only a small proportion of land area, mostly on Mainland, where plantations at Kergord, and trial areas along Sullom Voe represent the very limited extent of trees in Shetland. A small garden-plantation on Unst, and some shelter belts in Scalloway make up most of the rest of the 230.25 acres.

By far the greatest proportion of agricultural land in Shetland is the rough grazing, including the common land or scattald. Sheep represent the main livestock of the islands and these wander freely over most of the scattald. This is the most efficient grazing use made of the blanket bog and heath vegetation without active management.

The heather scattald is not regularly burnt, as seen in the Pennine and Scottish moors, but the peat is regularly cut for fuel.

Table 2.3.2.

To show acreage of grassland and crops in Shetland in 1974 (2.c.c.1975)

	acres
Grassland	13,560.25
Tillage	
Oats	1,531.25
Potatoes	403.50
Turnips & Swedes	249.25
Kale & cabbage	118.50
Rape	69.50
Other crops	23.25

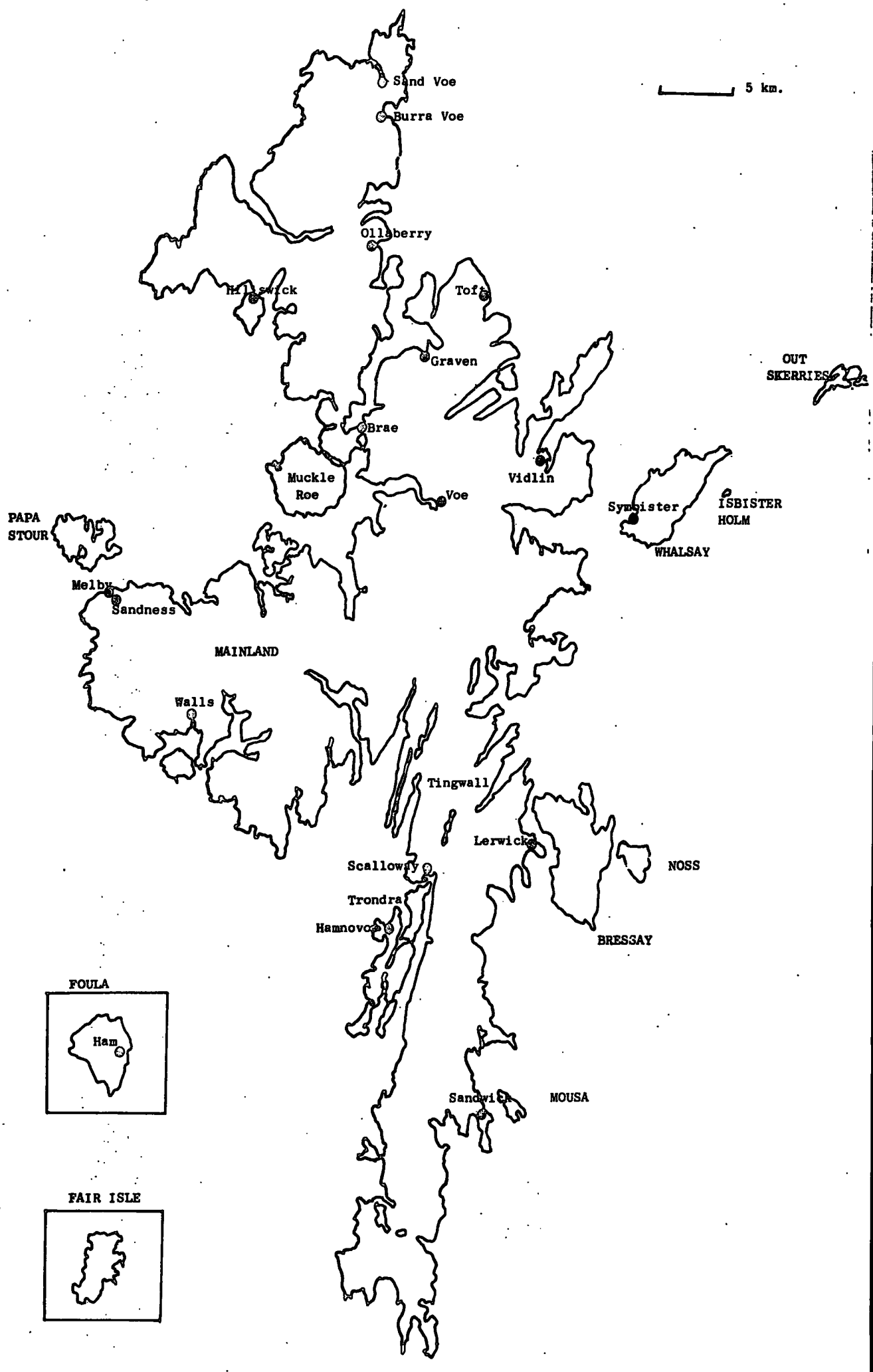


FIG.2.3.1. Main settlements of the Southern Isles

Cattle, pigs, poultry and ponies are all kept, but are relatively unimportant in the overall picture.

The population of Shetland at the 1971 Census was 17,327 and has been estimated at 18,623 in 1974 (ZCC. 1975). In 1972 over 13,000 people lived on Mainland about half of these in Lerwick (see Table 2.3.3). However, since that date there has been a considerable rise in the population due to industrial expansion related to oil development and research, and there may have been considerable changes in the distribution patterns of the population. Figure 2.3.1 shows the settlements in Southern Shetland.

Sandwick, Brae and Lerwick itself, have all expanded physically, particularly in housing developments. At Sandwick and Graven areas of scattald have been used for oil-storage vessels, and at Firth, near Graven, a large, temporary work camp covers most of the Hill of Lee.

Table 2.3.3

To show approximate populations of inhabited islands, 1971 (from Nicholson 1972)

Island	Population
Mainland	13,000
Bressay	258
Trondra	30
Vaila	5
Muckle Roe	100
Papa Stour	30
Whalsay	970
Burra	600
Fair Isle	70
Foula	40

2.4 PREVIOUS WORK ON SHETLAND VEGETATION

The first records of the vegetation of the Shetland Isles lie in the description of the area made for the purposes of census and statistical accounts. These give a picture of barren moorland with small fertile areas where crops could be grown.

"The only grains that grow in this place (Dunrossness) are oats and Bear, of which (if they sold none to other places of the country) they would seldom want as much as serve themselves, which is a peculiar advantage of this place." (Montieth 1711)

During the late eighteenth and early nineteenth century travellers (Low 1829, McAllum 1829) through the Isles recorded their impressions of the bleak areas in their journals: "the scenery in general is exceedingly barren, and I do not think we saw a single spot which could be classed as beautiful or picturesque " (Atkinson 1833)

There was not an academic description of the flora of Shetland until 1841 when the remarkable Thomas Edmonston jnr. published his "List". This was followed by "Remarks upon the Botany of Shetland" (1842) in which Edmonston commented upon the composition of the Shetland flora with respect to climate, geology and the vegetational history of the area. His 'Flora of Shetland' (first published 1845) was the first complete species list of plants for the islands. It was, however, criticised and amended by Tate (1866) who grouped the species according to being indigenous or introduc ed, and related the flora to those of Orkney and Faroe.

There then followed a series of publications by various authors (Beeby 1890, 1891, 1892, 1907, 1908, 1909; Craig-Christie 1870; Graves 1899; Johnston 1927, 1928, 1929; Turrill 1928, and West 1912, who first included lichens) which simply added to, or confirmed the initial list of higher plants growing in Shetland.

G.C.Druce (1921) in his "Flora Zetlandica" discussed the possible origins of the Shetland flora, dismissing the idea of a post-glacial land bridge in favour of wind, sea and animal transport of incoming species.

He compared the flora of Shetland with that of the more arctic Faroes.

The first attempt to classify the vegetation in any sort of ecological way was made by Price (1928). After only a fortnight's fieldwork in the islands, he proposed 5 major "communities", Arctic-alpine, Heath moor, Cultivated, Marshland and Halophyte, and within them a number of associations. From this he suggested the possible lines of development of the communities from sea coast association, lakes and streams and the Arctic alpine area, and recognised that in Shetland the heath was held at a sub-climax to scrub-forest climax, by sheep-grazing and by human agency.

The same year Turrill (1928) published an analysis of the flora of Foula including a simple classification on the basis of Rannkiaer's life-forms.

There was then a period of nearly 25 years in which only one paper on Shetland vegetation was published. This was a study of agricultural practices (Howie 1945).

The first detailed ecological study made on any part of Shetland was between 1957 and 1963.

Spence (1957, 1958, 1959) described the vegetation on the serpentine debris of Unst and related this to the unique combination of minerals found in serpentine and the exposed nature of the climate, giving an analysis of the habitat preferences of a number of species. Further (1959) he demonstrated that the pioneer species of the flora were restricted to the serpentine debris because they could not withstand the competition during establishment on other sites, while having the ability to grow on toxic soils.

The same author (1960) then examined the vegetation of a number of rock ledges and ravines, particularly on Mainland, and concluded that these sites represented the natural vegetation of the islands in the absence of sheep. Later he surveyed some of the Shetland lochs and described the macrophytic vegetation (Spence 1964). Finally, Spence and

Millar (1963) returned to the question of the serpentine soil effects with some experimental work on oats from which it was concluded that phosphorus deficiency in soils which are also low in potassium and nitrogen caused most infertility.

More recently Spence (1970) has related the vegetation of serpentine outcrops in Unst and Mainland, Shetland to that of similar areas in Scotland.

During the past 20 years there have been a number of works dealing with more specific aspects of the flora and certain areas. In 1954 Denis and Gray produced a list of fungi for the islands with some habitat notes, while Goldsmith (1975) described the sea-cliff vegetation.

Fair Isle was visited on numerous occasions resulting in the expansion and correction of Trail's (1906) original plant list, by Pritchard (1957), Fitter (1959), Currie (1960) and Palmer and Scott (1965).

Botanical interest in Foula was shown in papers by Messenger and Urquart (1958), Holbourn (1961), Hawkesworth (1969a) and the Brathay Exploration Group (1971, 1974) all of which added to the general list included in Turrill's work (1928).

More specialised studies at this time produced lists of lichens by Hawksworth(1966), and bryophytes (Hawksworth 1969b) for the island.

Some lichens from the rest of Shetland were listed by Duncan (1961) and Hawksworth (1961) and for Fair Isle by Currie (1961) and Duncan (1963). Paton (1972) produced the first list of hepatics for the Islands.

The culmination of the general recording of higher plants was the thorough check-list of Palmer and Scott (1969).

The history of vegetational change in the islands, using pollen analysis has not been widely studied.

During the early 20th century two studies were made of the peat deposits of Shetland mosses. The first by Lewis (1911) sets out a scheme of the successive increases and decreases in tree cover in Shetland, showing stages of tundra-like Salix-rich vegetation, and Betula

dominated tree periods. He believed that present day peat, in Mainland at least, was "wasting away".

Erdtman (1928) took a number of bores in the west and central Mainland from which he obtained a similar picture of post-glacial vegetation. However both authors remained doubtful as to its validity for certain genera e.g. Pinus, due to the ability of grains to travel long distances in air currents.

Recently this idea has been supported by findings at the Lerwick Observatory (Tyldesley 1973), where tree-pollen traceable only to Scandinavia has been detected in quantities similar to those found by the two palynologists. Pollen transport may explain the identification of spruce being used in the construction of a temple near Stanydale (Mainland). Edlin (1957) suggests that this spruce was probably growing nearby at the time (1500 B.C.), having been carried as seed from Scandinavia, and thus being native of that period. i.e. seeds and pollen could be transported by similar means.

Hoppe (1965) used pollen data from underwater peat on Whalsay to determine sea-level changes around the islands. In doing so he obtained figures for oak, elm, hazel, birch, willow and pine presences that agree with those of Lewis and Erdtman.

A peat deposit at Fugla Ness, Mainland, was correlated by Birks and Ramson (1969) with the Gortian Interglacial period of Ireland. This revealed pollen remains of a number of species no longer native to Shetland or Britain.

Johansen (1975) compared vegetational trends in Shetland and the Faroes and concluded that the slight differences shown were due to the warmer Shetland mean July temperature, and the greater distance of the Faroes from a major land mass.

The only plantations of size in Shetland have been described by Stewart (1962) and Neustein (1964). Stewart documented the history of tree-planting and management in Kergord, Mainland from 1913-1960, while Neustein covered that area and four other trial plots on the islands, established by the Forestry Commission in 1952. Both authors concluded

that the Sitka Spruce is the only tree species likely to be able to survive the rigours of the Shetland climate, particularly winter.

Two major studies have been prompted by the increasing pressure being put on the whole Shetland environment by the oil-related developments. A synposium held under the auspices of the Nature Conservancy Council (1974) brought together the recent work in Shetland with a view to making proposals for future studies in the islands. This came to a similar conclusion to the "discussion paper" produced by Warren and Harrison (1974) which stressed the delicate nature of many Shetland habitats from the point of view of both flora and fauna, and the need for careful monitoring of wildlife changes in the islands.

CHAPTER 3

M E T H O D S

3. METHODS

In this chapter the process of making a phytosociological survey has been broken down into a number of stages, each of which is discussed with reference to the end-product required of this survey of Southern Shetland.

The advantages and disadvantages of the various schools of thought are examined in terms of overall strategy (3.1.1.), field methods (3.1.2) and data analysis (3.1.3). Section 3.2.summarises the methods decided upon for this work and gives definitions of some of the terms to be used.

Finally, the methods followed in the course of the three years' study are described in detail (3.3).

Figure 3.3.1.shows all the sites sampled in the Southern Isles.

3.1 THE POTENTIAL METHODS OF PHYTOSOCIOLOGICAL SURVEY

The processes of making a phytosociological survey have been fully described by various authors (Shimwell 1971; Mueller-Dombois and Ellenburg 1973; Poore 1955a,b,c,1956). At each stage in the survey, however, there is potential for using any one of a number of methods, the choice of which must be made according to the end product required of the study.

In this survey the points to be considered were:

a) The large-scale nature of the study

The Mainland of Shetland is over 85 km long and an average of 16km wide, while the surrounding area contains up to 80 small islands. With a limited fieldwork season (June-August flowering for most 'summer' species), and difficult travel conditions, relevés could only be collected from widely-spread sites, and no detailed description of all vegetation types could be attempted within the scope of this work.

b) The 'primary' nature of this survey

With the exception of the work of Spence (1957,1958,1960,1970) no work at all had been done on the plant communities of the Shetland Isles prior to 1972. Thus, the methods used had to be as broadly based as possible in order to allow any "endemic" characteristics of the vegetation to reveal themselves, ie. there could be no preconceptions of the communities likely to occur there, in relation to other countries or islands.

c) End-product required

The aim of the study was to produce an overall conspectus of the vegetation of the Southern Islands of Shetland. Thus, vegetation units on a relatively large scale, e.g.Alliance, were required to tie in with other phytosociological works; while units at a smaller scale would be identified, and as far as possible related to Associations already named. Therefore, the method of grouping the samples must align closely with those already used in conventional phytosociology.

d) The use of the computer to sort and group vegetation samples has been developed by many authors (e.g. Moore et al (1970); Williams and

and Lambert (1959,1960); Sneath and Sokal (1973), and has been further modified in Durham by Wheeler (1975). With information and programmes available, the use of computer analysis and computer-aided hand-sorting seemed eminently suitable for a large data collection such as this.

These, then, were the main points considered when choosing the methods by which the study would be carried out.

The areas in which decisions had to be made were:

1) Overall phytosociological strategy.

2) Field methods.

3) Comparison of samples and detection.

4) Vegetation units, i.e. analysis of data.

3.1.1. Phytosociological Strategy

There are a number of approaches to phytosociological survey; these have been described by a number of workers (Shimwell 1971; Whittaker 1973; Mueller-Dombois and Ellenberg 1973).

The Continental European Vegetation has been covered by proponents of the Zurich-Montpellier School, founded by J.J.Braun-Blanquet. It is basically a system which delimits the vegetation units on floristic characteristics. Due mainly to the nature of the vegetation it has been greatly used on, it distinguishes units by their "character" and "differential" species (see 3.2). Thus, it relies on species abundance and diversity a great deal for its efficient characterisation of syntaxa.

The basic vegetation unit founded on "differential" and "character" species is the Association. A hierarchial grouping of associations is recognised, into Alliances, Orders and Classes. This latter group includes vegetation of generally similar habitat or ecology e.g. Oxycocco-Sphagnetea includes all wet heath and blanket bog vegetation; Ammophiletea pioneer sand dune communities. With larger amounts of data, it may be possible to subdivide an association into sub-associations, variants and facies, as well as geographical races.

Its use in Britain has been outlined by many workers covering a range of vegetation types (see 1.2). Poore (1955a,b,c) set out a number of criticisms of the methods.

Developing simultaneously in Scandinavia was a method of description and classification suited particularly to the vegetation of that region (Becking 1957). The Uppsala School, expounded in the 1920's and 1930's by Einar du Reitz, bases the delimitation of its units to a large extent upon the dominant species, forming "sociations", and places stress upon the strata of vegetation and, thus, its "vertical" classification. The Hult-Sernander cover scale is used (see Table 3.1)

Table 3.1

The Hult-Sernander Cover Scale

Cover Value	Area Covered
5	50-100%
4	25-50%
3	12½-25%
2	1/16-1/8%
1	1/16%

Nordhagen (1936) ties his work and classification of Scandinavian vegetation in the units of the Z-M school.

Closely related to the Uppsala school of thought is what Shimwell (1971) calls the "Norse-Scots" School. Essentially it was an 11-point (Domin) cover scale in field description, and associations are formed on the dominance, constancy and floristic similarity of samples. Dahl and Hadac (1941) and Nordhagen (1936) enable this classification to fall into the recognised Z-M units. McVean and Ratcliffe followed this method when they surveyed the vegetation of the Scottish Highlands (1962).

3.1.2. Field Methods

Having made the decision as to which phytosociological school is to be followed, the field methods to be used would seem to be predetermined. But, as has been noted previously, Shetland lies at the geographical boundary of the work carried out by the Z.M and Uppsala Schools, and the survey is not strictly within the range of the Norse-Scots approach, with its detailed consideration of vegetation layers. Therefore, more careful consideration of the sampling strategy is required.

3.1.2.1 Choice of Sites (i.e. their geographical location)

The decision to be made here is whether to make an objective or subjective selection. In a study of single vegetation types, or of a relatively small area, where the whole can be visited and assessed, stands are chosen to be representative of the type.

However, on a larger scale, and when covering many vegetation types, the choice must be made at two stages. Firstly the investigator, having decided how many sites he can visit in the time available, must select these geographical locations. Then, within the location (or sites) he must decide what stands (or samples) to describe. On choosing sites, the objective approach simply requires the selection of a number of map coordinates at random. It is probable that a number of the locations chosen will not be suitable, falling, for example, on man-made structures, water masses or vegetation types not being considered. A further disadvantage is that rare vegetation types, or those only represented by small areas may not be included at all. In a survey through which it is hoped to cover as many vegetation types as possible this is not satisfactory at all. Conversely, types covering large areas would be over-represented in the sites selected by a truly random sample.

Subjective site choice could be carried out by visiting as much of the area as possible, and using local knowledge, map features and previous data collected from the region, making a positive selection of sites covering

all the vegetation types required. This would probably give over-representation of the rarer types, and would make the results unsuitable for some statistical treatments, but would allow more efficient use of time in visiting sites and collecting data.

How large should a "site" be? This can only be decided according to the size of the whole area under consideration, the time available and considering the number of samples to be taken within the site. It must be borne in mind that excess data on a vegetation type can hinder the initial analysis in a preliminary survey. It is much easier to distinguish units using approximately 30 samples, and add in 20 more later than deal with all 50 in the first analysis.

In this Shetland work, a site of 1 hectare, in which an average of 6 stands were examined, took 1½ hours to sample. This was preceded by a ½ hour reconnaissance of the whole site. In this case the terrain was easy to cover, on the whole, having no large obstacles other than water masses. Also, species numbers are lower than on mainland Britain (Palmer and Scott 1969). Of course sampling times will vary according to the complexity of the habitat, and familiarity with the vegetation type.

3.1.2.2. Choice of Stand (sample)

Having selected a site before going to the field, the actual samples of vegetation to be described must be chosen. Again this can be an objective or subjective decision. Moore et al (1970) conclude that "no advantage can be seen in randomisation in the case of the careful and conscientious worker" while Becking (1957) recognises the importance of a subjective sample choice to the processes of both the Z-M and Uppsala Schools of phytosociology.

Objective methods can vary from simple random grid references to elaborate grid systems to ensure samples from all vegetation layers as well as all types, arranged through a statistically unbiased pattern. These are, of course, readily repeatable methods, but hold the same

disadvantages, on a smaller scale, that objective site choice had. Moore et al (1970) also point out the difficulty of finding random grid coordinates in the field.

The danger of subjective stand choice in the field is that the field worker may only sample the communities he is expecting to see or even, subconsciously, looking for. Also, the size of a stand and its borders must be defined carefully so as to describe only one community at a time. The homogeneity of a stand, and its recognition has been widely discussed (Dahl and Hadac 1949 ; Poore 1955a; Shimwell 1971), but ensuring that the sample is of uniform nature falls back on the field worker, who must select a plot that, while being representative of the vegetation, is neither too small to include all species, nor too large as to overlap distinct communities.

3.1.3. Analysis of data

The analysis of the samples involves the stages of:

1) Bringing together samples of greatest similarity with in a data matrix.

2) Detecting the hierarchical gaps in this matrix which may be recognised as units of vegetation in the field, whether at Class, Order, Alliance, Association or other taxonomic level.

3.1.3.1 The first process in analysing the collected data can be a hand-sorting one, a numerical and statistical method, or a combination of the two. The relative merits of a number of methods have been studied in detail by Moore et al (1970), Frenkel and Harrison (1974) and Wheeler (1975), and only those eventually used in this study are outlined here.

The traditional hand-sorting of data (Braun-Blanquet 1966; Poore 1955a) by which tables are re-arranged by rewriting, and, thus, regrouping visually similar samples can be speeded up by the application of the digital computer and programmes such as PHYTO (Moore 1971) and SHUFFLE (Wheeler 1975).

SHUFFLE simply allows the phytosociologist to rearrange his rows and columns of species and releves using the computer as a "typewriter", while PHYTO arranges the species in descending order of presence, and releves divided or grouped on the presence or absence in them of chosen pairs of species.

The most recent development in the overall phytosociological strategies is that of "numerical taxonomy" - the mathematical estimation of similarity between vegetation samples and groups of samples to detect classes (or groups of samples having similarity greater than a predetermined standard). Similarity coefficients have been used for a long time in both plant and animal sampling technqiues, but the improvement in computer facilities has made the application of these methods, particularly to large data collections, much more attractive (Frenkel and Harrison 1974). To all the methods, outlined below, there is one major drawback, not always recognised in the academic descriptions - the mathematician and the botanist (or zoologist) have not yet overcome one problem. Mathematics and computation follow rigid procedures with clearly-defined boundaries and limits. However the natural pattern of vegetation is one of great variation. Even the most simple habitat has a number of overlapping parts in both time and space, between which there may be considerable variable interaction. For example, a pond has a flora and a fauna, each of these includes a variety of species populations, each with a different age-structure. Additionally there are varying physical factors of temperature and water chemistry, and the biological changes caused by the succession of plant species and communities which may lead to the infilling of such a pond. It must always be recognised that the mathematical formulae cannot yet replace or simulate the natural unpredictability and variation of vegetation.

Numerical taxonomic methods require a choice between monothetic procedures - where a single character is used for group formation, or

polythetic (using several characters). Further, the process can be agglomerative, where a large number of individuals (e.g. releves) are compared by one of many possible procedures and fused into smaller groups; or divisive, when a large data set is progressively divided into smaller groups, on the basis of some coefficient, e.g. Information Statistic I. (Orloci 1968).

The computer program package CLUSTAN IB (Wishart 1969) includes a selection of programs which can carry out these processes. They involve a number of different sorting processes, to link with similarity coefficients; particularly centroid (where the two most similar samples are fused and a new series of similarity coefficients calculated between the new one and all others, and so on until one large group has been formed) and nearest-neighbour (where adjacent samples are arranged in order of their similarity coefficient, then grouped according to the similarity of these indices). This method lacks the advantage of increasing information content obtained during the calculations of the former.

Both Frenkel and Harrison (1974) and Wheeler (1975) conclude that the methods apparently best (when considered in respect of time, efficiency, clarity of results, consistency and ecological validity of results) were Wards Error Sum of Squares (Ward 1966) and Information Analysis (Lambert and Williams 1966). But all these authors, as well as Moore et al (1970) feel that the Braun-Blanquet method should be used with these methods.

Frenkel and Harrison (1.c) point out that Ward's method often produces a classificatory hierarchy that, while clear, may prove difficult to interpret spatially, "except at the higher levels of fusion", while Diaz (pers comm.) suggests that in a large and diverse data set, with a high number of species absences (such as is found when studying overlapping vegetation types) the high frequency of negative characters in the process may produce an unsatisfactory classification.

3.1.3.2. Having grouped the data, the groups must next be linked with those already described, if the survey is to have any relevance. Classes and

and orders should not prove very difficult to identify unless the vegetation type is distinct geographically from existing descriptions. However at alliance and finer levels the problems may be caused by:

(i) Under sampling of vegetation types. It is difficult especially for the inexperienced worker, to designate a group of less than 5 relevés as a new association or sociation.

(ii)Borders. Natural vegetation does not in most cases have clearly defined borders between communities (Becking 1957; Whittaker 1962); the sampling techniques should avoid samples from such border regions, but in difficult cases it is better to sample than to ignore. Such relevés, however, can confuse the delimitation of small groups.

(iii)Geographical variation. One effect of this is on species distribution. Shetland, for example, has a depauperate flora in comparison to Europe, Scandinavia or even the Faroes, and lacks many of the quoted differential and character species referred to in the literature. In some cases it is problematical as to whether a group of relevés having a reduced constancy of a character species is really a geographical sub-association or variant, or simply a poor example of the association.

All three of these problems were encountered during this work.

3.2.SUMMARY AND DEFINITION OF TERMS

These then, are the main potential methods considered for this survey of the Shetland Islands. Following predecessors in Durham, and the predominant works on British phytosociology, the Zurich-Montpellier traditionswere followed in the course of field-work (see 3.3)

However, the availability in Durham of suitable computer programs for numerical taxonony made the use of such processes attractive. This seemed a further advantage when the large number of relevés, from a wide-range of vegetation types, to be analysed was considered. The exact procedures followed are described in section 3.3.3. Ward's Error Sum of Squares was chosen because of its use of numerical, as opposed to binary,

data in its sorting processes, its high preference given by Frenkel and Harrison (1974) and Wheeler (1975), and its recommendation by Wishart (1969) for a large data matrix of this type.

Terms used in the phytosociological sections and in delimiting units follow the Zurich-Montpellier School (Wheeler 1975).

A nodum is a vegetation unit of rank below that of alliance which does not clearly fit any described associations nor is it sufficiently strongly characterised, or widespread in its distribution to be given association status. A nodum is placed within an association when it is considered to be very closely related to that association, or a geographical variation of it.

An association is an abstract floristic unit definited by a characteristic species combination. This differs slightly from the Zurich-Montpellier concept of requiring the presence of a character species, but follows the work of Westhoff and Den Held (1969).

A sociation is a vegetation unit definted by the dominance of one species in different vegetation layers (Du Rietz 1936).

Associations are fused into higher units or subdivided into lower categories, denoted by suffixes attached to the name. The rank is indicated by the following scheme:

Class	-	etea
Order	-	etalia
Alliance	-	ion
Association	-	etum
Sub-Association	-	etosum
Variant) Sub-variant) Facies) Nodum)	-	no ending

In the present survey the characteristic species combination was used to describe and define the vegetation units recognised. Following the Z-M school this consists of constant companions, differential species and character species.

A constant species is one occurring in 81-100% (i.e.constancy class V) of

the relevés in a given vegetational unit. Species occurring less frequently may be assigned to lower constancy classes:

Constancy Class	% relevés in which sp.occurs
V	81-100
IV	61-80
III	41-60
II	21-40
I	<20

A differential species ("Differentialart"; "Trennart") is one with pronounced affinity for a certain vegetation unit, and is used to differentiate between similar units of the same rank.

A character species ("Character ; "Kennart") is a special differential species of more restricted nature, being confined to specific vegetation units and hence having great diagnostic value.

In this survey, a site refers to the area of one hectare selected either at random or, later, by choice.

A sample refers to a stand, or unit of vegetation within the site, and which was described (≡ relevé ≡ aufnahme.)

3.3. METHODS USED

The fieldwork was carried out with A.Lewis, who was studying the Northern Isles.

3.3.1. Choice of sites

The field methods were modified during the three-year field period, when it was found that the first, random and objective techniques for choosing sites produced little information at the expense of much time and travelling.

It was changed to a more subjective method of choice which, it is felt, gave a much more representative view of Shetland vegetation in the time available.

In October 1972, a brief preliminary survey of the Islands was made, to determine the major vegetation types, and a suitable method to approach the following summer's fieldwork. At this time only Mainland

could be visited, but discussion with local inhabitants gave information about other areas. At this time it was felt that the method should be to sample at sites chosen at random.

300 sites were chosen at random, by selecting National grid references (by writing the numbers on papers drawn from a hat) and plotting these on the O.S.1" map, as 1-hectare sites. A number fell in positions that were either not accessible or not suitable, such as sea-stacks, inland waters, farmyards or buildings. Where they could be recongised, these were rejected and replaced by new choices.

In Summer 1973, 45 sites were visited and relevés recorded. The results from this, however, proved rather unsatisfactory. It is obvious, to even the most casual observer, that most of Shetland iscovered by heath and blanket bog; accordingly, most of the random sites fell in such areas, and to continue this method would have produced excess information on such vegetation, with none on the less extensive types, such as saltmarsh or sand-dunes.

It was decided that to overcome this problem a more subjective choice of sites must be made. Prentice and Prentice (1975) support such a method for an area encompassing a large number of variety of vegetation units.

For the purposes of this survey, then, 18 major vegetation types were designated from general knowledge of the area gained from the literature and the first year's field work. They were not intended in any way to be synonymous with recognised classes of vegetation described in phytosociological literature; only to be general terms to describe areas or habitats. It was felt that in this way the 'temptation' to look in the field for already described classes would be avoided.

It did lead, later, to complications in analysis of the results; these, caused by overlapping of an already recognised taxon across two of the

the vegetation types, are fully discussed in Section 3.3.3.

The 18 types were delimited thus:

1. Blanket bog

As defined by Moore (1968); areas of vegetation dominated by ericaceous species and Eriophorum on deeper peat (>220mm) and having a rooting layer with pH 3.0-5.0.

2. Blanket bog flushes

Smaller areas within blanket bog, where there is some evidence of water flow, either visible water movement, or channelling in the peat surface.

3. Bog pools

Either semi-permanent or permanent areas of standing water on the surface of bogs, often dominated by Sphagnum cuspidatum.

Heath

As defined by Bridgewater (1970) "that type of land covered wholly or partly by ericaceous shrubs, with a peat depth of not more than 220mm." Two types of heath were distinguished - wet and dry.

4. Wet Heath

Heath on peat or heavy soils with impeded drainage, often intermingling with blanket bog vegetation.

5. Dry Heath

Heath on lighter, well-drained soils.

6. Wet Heath Flushes

7. Dry Heath flushes

These (6 and 7) are flushed areas within (4) and (5) respectively. As with blanket flushes they are recongised by either surface flow or channel formation.

8. Grassland

Vegetation dominated by grasses and non-ericaceous flowering herbs, and on light soils of good drainage and not falling into categories 10, 11 or 16.

9. Wet Meadows

Herb dominated grassland vegetation on heavier, often waterlogged soils, with Caltha palustris present.

10. Ruderal/In-field

These two categories consist of types determined by their ecology and habitat rather than species. The terms cover all relevés described in the vicinity of farms and crofts. The number completed is low since it was felt that it could not be described as 'natural'.

11. Cliff top

A vegetation type common along the tops of sea-cliffs in Shetland was noted, and sampled separately from general grassland which it most closely resembled.

12. Dry Grassland flush

An area or channel, of surface-flowing water on otherwise dry grassland.

13. Sand-dunes

Vegetation growing on sand, and at various stages of dune formation as described by Ranwell (1959). This includes "machair-like" communities.

14. Saltmarsh

Shoreline vegetation of saltmarsh areas, i.e. where there is influence of both tidal salt and freshwater upon the soil.

15. Shingle

Shoreline vegetation growing on shingle, gravel, small pebbles or boulders.

16. Roadside

Vegetation of the immediate edges of tarred roads. The relevés from such sites were always taken from within 1m of the road surface itself. This "vegetation type" is not delimited by the species it contains but entirely on situation and ecology. Thus, relevés from such sites may fall into other types on specific grounds but are classed here on siting.

17. Disturbed

This vegetation type was originally intended to cover the semi-natural areas

which have resulted from man's destructive interference with the region, e.g. areas of regeneration after peat cutting. However, it became difficult to recognise this always in the field and very few relevés could be satisfactorily allotted to this type.

18. Stream-side

A similar definition to (16); communities found within 1m of the edge of a stream. Relevés were placed here in preference to the "type" delimited by species.

In the field it proved difficult at times to allot relevés falling on the borders between two (or more) of these vegetation types, particularly where the influence of blanket bog species was felt (-and this is an extremely widespread effect).

Further, 5 "rock-types" were delimited on a broad geological basis:

a) Old Red Sandstone, including the sandstones of Lerwick and Bressay.

b) Granite, including all igneous complexes.

c) Serpentine, including greenstone and related types. This is not very common in Southern Shetland.

d) Limestone.

e) Schist, gneiss and quartzite.

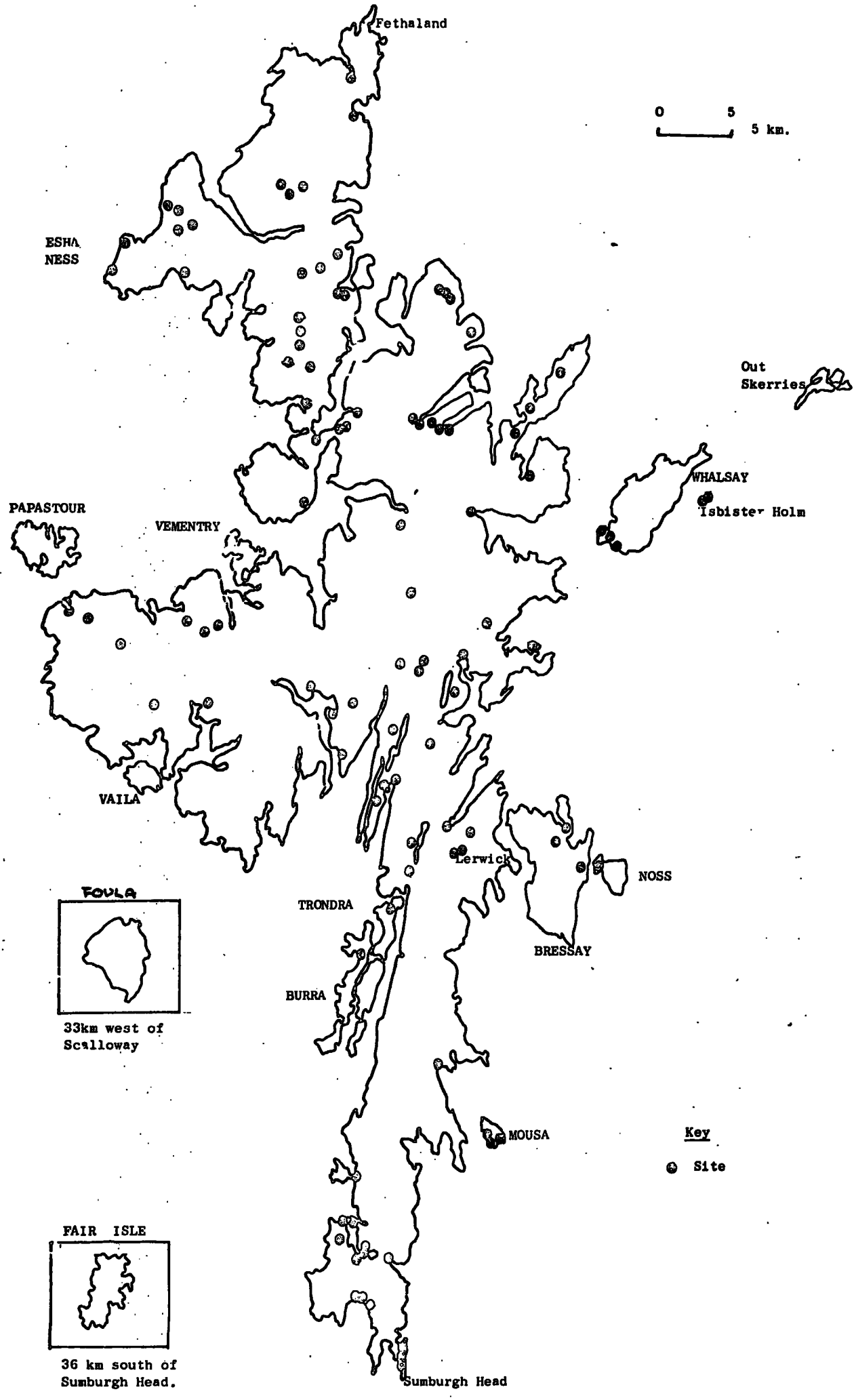
(See Fig.2.1.2.)

By references to the O.S.1" and 6" geological maps these were regarded as the base-rock for any given site. In some cases deep peat formation or the constant influence of sea-spray would have an effect on the vegetation over-riding that of base-rock type. This is discussed with appropriate results.For the purposes of collecting a representative relevé cover of as many vegetation types as possible, the use of these geological patterns was felt to be most suitable.

Figure 3.3.1. shows the position of all 104 sites visited.

The field method then was to obtain a minimum of 10 relevés from each vegetation type on every rock type wherever the possible combination

FIG.3.3.1 Distribution of Sites sampled in the Southern Isles



occurred. Local knowledge, map features and published information (Spence 1957 and 1959; Warren and Harrison 1974; Palmer and Scott 1969) were used to select sites which may include suitable vegetation types.

The detailed vegetation descriptions obtained by sampling from chosen sites were then complemented and expanded by general observations on larger areas, thus fitting the specifically sampled sites against the background pattern of the general vegetation.

3.3.2. Sampling Procedures

Throughout the study the same field method of data collection was used.

The hectare was first surveyed generally to distinguish the main stands of different and visually homo-geneous vegetation. Any two stands were designated "different" when one or more of the following criteria applied:

a) They had less than 50% common species.

b) Different species were clearly dominant.

c) There was an obvious physiogromic difference.

d) The individual stands were visually homogeneous over an area equal to, or larger than, the minimal area calculated for that vegetation type.

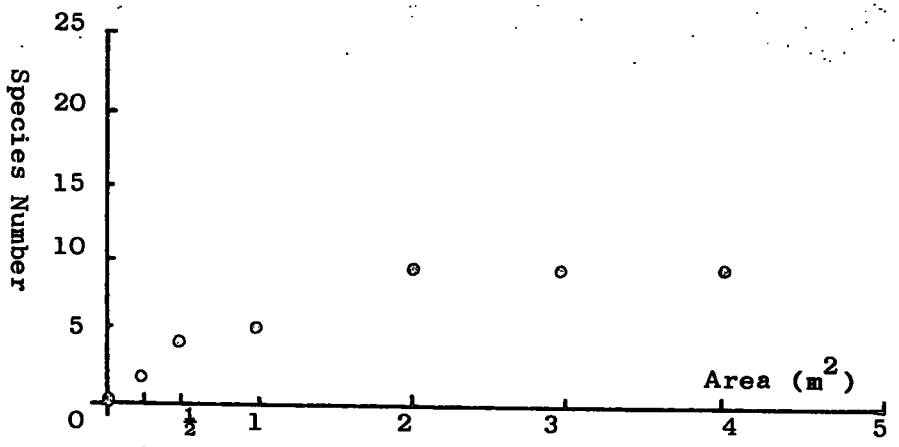
Samples from borders were identified in the association tables.

Minimal area curves were plotted for shingle, sand-dunes, saltmarsh, grassland, wet meadow, blanket bog and heath vegetation.

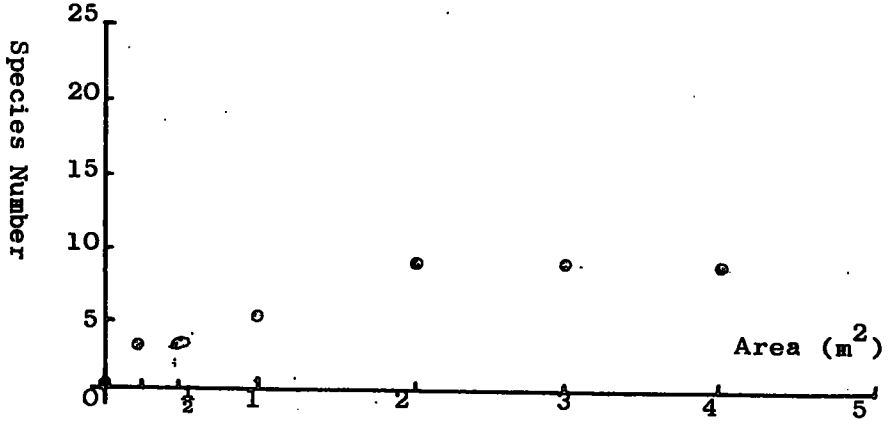
The resulting curves are shown in Figure 3.3.2. In all cases, the relevé size chosen was 2m x 2m.

The criteria for differentiating stands are more wide ranging than those conventially used (Poore 1955, a,b; Wheeler 1975) but this was necessary to allow for the variety of vegetation types being dealt with. Braun-Blanquet does not recommend the use of dominance in making decisions on stand homogeneity and distinction, mainly because of the species - rich nature of the vegetation dealt with by continental phytosociologists (Becking 1957).

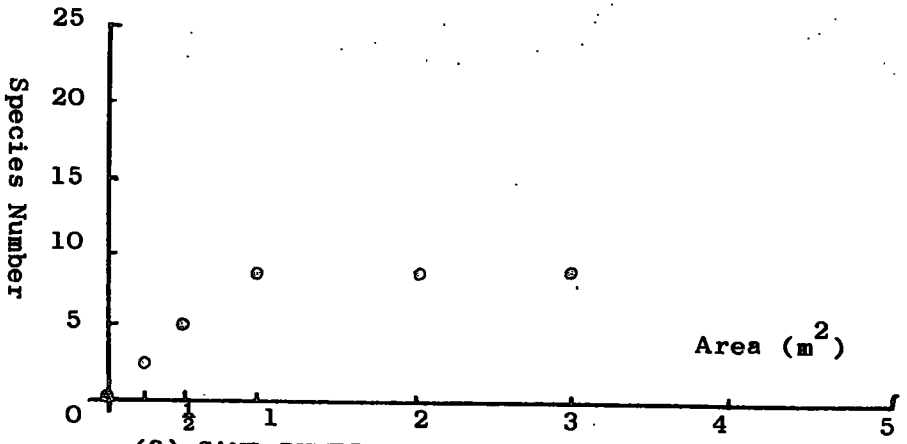
Figure 3.3.2. Minimal Area Curves



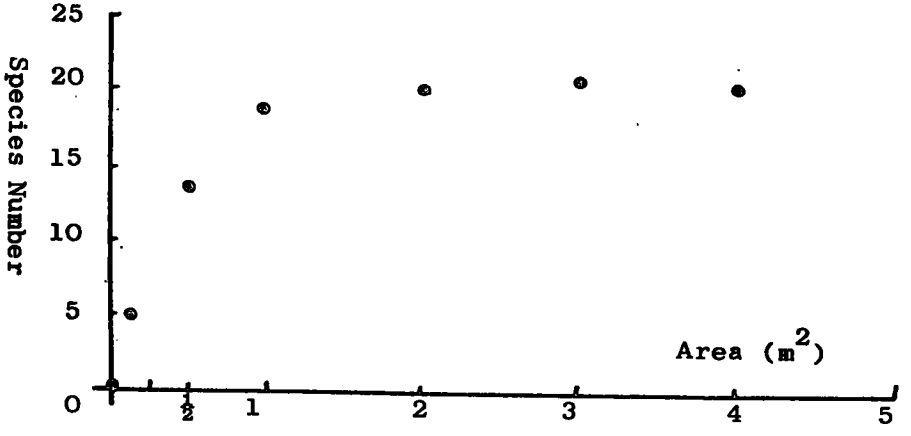
(1) SHINGLE, Ellwick, North Mainland



(2) SALT MARSH. Ellwick, North Mainland

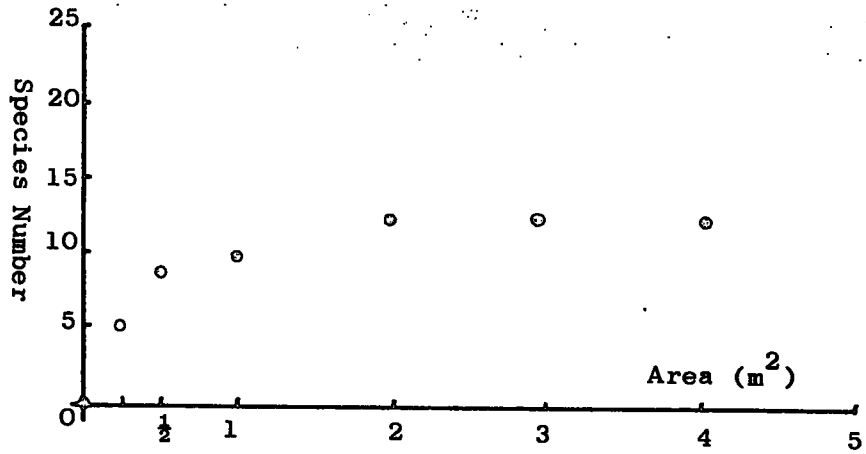


(3) SAND DUNES. St.Ninian, South Mainland

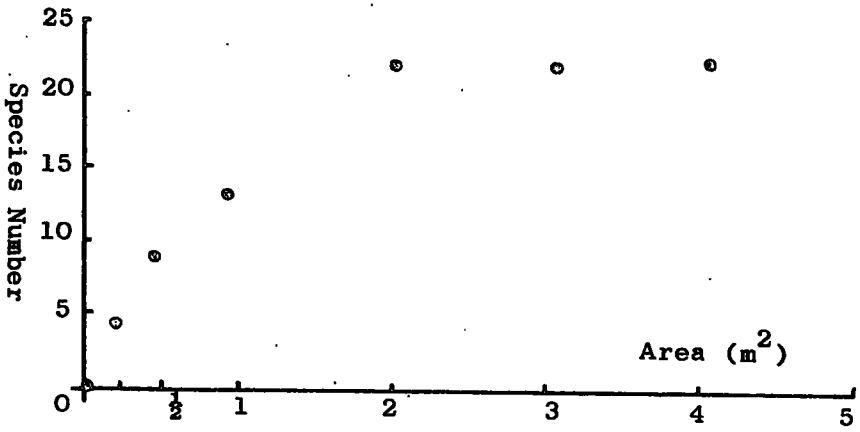


(4) GRASSLAND. Spiggie, South Mainland

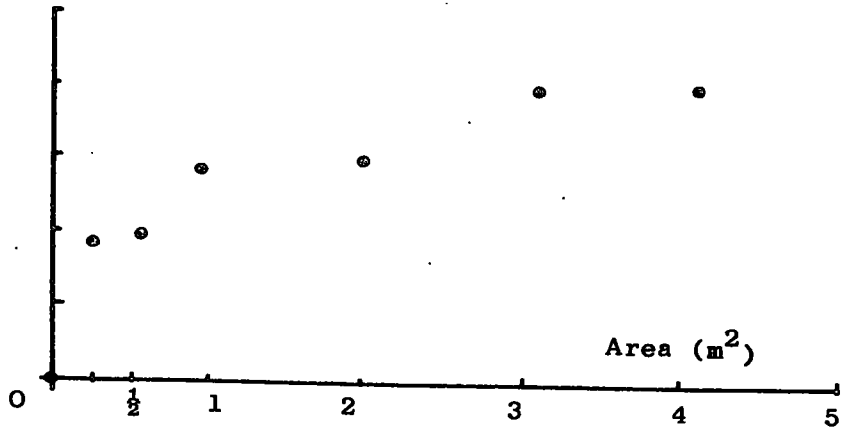
Figure 3.3.2. contd.



(5) WET MEADOWS. Spiggie/Brow, South Mainland



(6) BLANKET BOG. Tresta, Central Mainland



(7) HEATH. Hurda Field, North Mainland

The ScandinavianSchool however uses the concept of dominance in the different vegetation layers to distinguish its vegetation unit, due to the frequency of species-poor stands covering large areas. Similarly McVean and Ratcliffe (1962) use dominance to characterise their vegetation units in the Scottish Highlands.

Shetland lies geographically central amongst these areas of work, and it seemed likely at the onset of the project that the vegetation might fall into a similar position. The vegetation is generally species poor, compared to the rest of Britain (Palmer & Scott 1969).

Therefore a very broadly-based differentiation between vegetation stands was adopted. The process usually gave less than 10 relevés per hectare; commonly about 5 per hectare were described.

The description of each releve followed a modified version of that set out by Poore (1955a) on a recording card, shown completed in figure 3.3.3.

Cover and sociability indices used were:

Cover

% cover	Index
80-100	5
60-80	4
40-60	3
20-40	2
1-20	1
<1, scattered.	+
additional species	.

Sociability

Index		Description
1	-	growing singly
2	-	clumps, groups or tufts
3	-	patches, cushions, mosaics
4	-	dense mosaics, "carpet with holes"
5	-	$\overset{+}{-}$ pure stands

Any species found close to the relevé, but not included in that list was designated an 'additional species'. pH was recorded in the field using a portable pH meter. Other habitat notes were recorded as shown on the field card.

Fig. 3.3.3.

Completed Field record-card

University of Durham.

SHETLAND SURVEY.

Card No. 234

Date. 22.8.73

Locality. South Nesting, Mainland. Catfirth (SS.S.I)

Site No. AE 6328

Auf. No. 18

Grid Ref. HU 438538

Site Descr. Heathery hummock, directly above 'gorge'. Level on top then abruptly steeply to rocky outcrops by stream.

Area. 2 x 2 m²

Alt. 50' (15.2m)

Aspect. E.

Slope. <5°

Cover.	%	Ht
Shrubs	100	1
Herbs	90	15
Mosses	70	5
Lichens	5	lo

Comm. size. app. 30 x 20 m²

Veg. type.

Adj. comms. Stream; heath

Comm. Descr. Dense, low growing heather (in flower) with good moss understorey.

Land use: present. Grazing - sheep

Land use: past. Grazing.

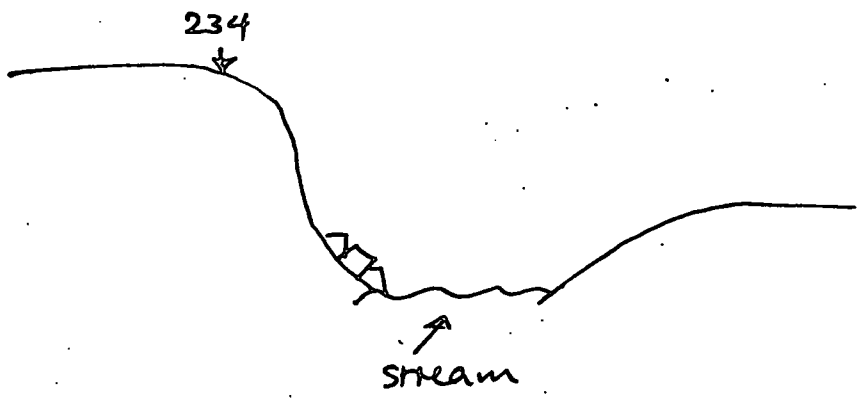
Soil (parent mat. & text.). Peat - thin, brown. limestone rock.

Sample.

H_2O level & flow. Dry - damp.

pH. 4.0

Sketch map.



Calluna vulgaris	4	4	Hylocomium splendens	2	1
Juncus squarrosus	1	2	Rhytidiadelphus loreus	1	1
Nardus stricta	1	1	Hypnum cup ericetorum	1	1
			Scapania gracilis	1	2
Luzula multiflora	+		Polytrichum formosum	+	
Potentilla erecta	+		Rhacomitrium lanuginosum	+	
Festuca vivipara	+		Thuidium tamariscinum	+	
			Fullania tamarisci	+	
Trichophorum cespitosum	+		Pleurozium schreberi	+	
Festuca rubra	+				
Empetrum nigrum	+				
			Cladonia tenuis	+	
			C. uncialis	+	

Higher plants were identified as far as possible in the field with the exceptions already noted in Section 1.3, but most mosses and liverworts were air-dried and brought back for laboratory identification.

3.3.3. Analysis

The data was transferred from field cards to computer punch cards in preparation for analysis using CLUSTAN IB series of programmes and SHUFFLE.

At first it was intended to handle the 18 vegetation types separately, but when the data limits for SHUFFLE were expanded (Wheeler pers.comm) some groups were fused. This also cut down the number of "borderline" vegetation samples.

This fusion gave 11 vegetation types for analysis. These were:

1) Blanket bog (includes the former blanket bog, blanket bog flush).
2) Bog pools.
3) Heath (includes wet heath, wet heath flush, dry heath, dry heath flush).
4) Grassland (includes dry grassland, dry grass flush, cliff tops, ruderal and infield).
5) Wet meadows.
6) Sand-dunes.
7) Salt-marsh.
8) Shingle.
9) Roadside.
10) Streamside.
11) Disturbed.

This obviously gave a higher number of relevés per type than the first arrangement; it was felt that this would make analysis more meaningful, being based on a greater sample number. The number was also increased by combining with the data collected from the Northern Isles by Lewis (1976). This improved the statisical value when the clustering techniques were applied.

Ward's Error Sum of Squares

This statistic, first developed for use on U.S.Army personnel data

(Ward 1966) uses an information statistic in conjunction with a centroid sorting routine. (Wheeler 1975)

Each vegetation type was subjected to normal and inverse analysis using Ward's E.S.S. as the clustering routine in the program HIERAR of the CLUSTAN package. Normal analysis bases the clustering on similarity of species content, while inverse analysis compares the occurrences of species within releves.

2 and 20 fusion groups were considered as useful limits on the hierarchical grouping i.e. having neither too high nor too low species or releve numbers.

Using DENDECK, then SHUFFLE, a partially differentiated table was produced for each (normal and inverse). Finally the two were combined to give a partially differentiated table for all the Shetland data.

These were then split again to separate northern and southern data for each vegetation type.

At this point further rearrangement of the tables was necessary to give a differentiated table for each vegetation type. After sorting by eye, and printing using SHUFFLE the tables described in Chapter 5 were produced. These display the vegetation units or groups and their characterising species.

Care had to be taken that all the computer-formed groups could be recognised in the field, and did not include "dustbin" groups: species or releves brought together through lack of information.

Description of units (see also 5.1)

The vegetation groups or units in the tables were given a group name based on a dominant or diagnostic species or habit feature. Each was then described and related to existing descriptions. The groups were defined by floristic composition and a characteristic species combination.

The arrangement of association into higher syntaxa follows the scheme of Westhoff and Den Held (1969) except where indicated (see Chapter 4).

CHAPTER 4

SYNTAXONOMIC CATEGORIES OF VEGETATION FOUND IN THE SOUTHERN ISLES

4.1 Class: CAKILETEA MARITIMAE R.Tx and Preising 1950

This class includes the communities found on shingle, gravel and sandy beaches, of the strand-line and higher zones. They are generally species poor, but those present are encouraged by the enrichment in nitrogen and phosphorous and overlap in many cases with weed communities, particularly of the Agropyro-Rumicion. In some cases the species have to be adapted to occasional storm and sea damage, and an unstable substrate eg through the runners of Galium aparine. To the landward side the effect of the terrestrial vegetation becomes more dominant when the ground becomes more stable (Gimingham 1964).

Westhoff and Den Held (1969) give no true character species for this class due to the species paucity of the communities. They regard Atriplex hastata as a weak character species in the Netherlands; it is rare in Shetland (Palmer and Scott 1969).

Only one order is found in Western Europe.

4.1.1 Order: CAKILETALIA MARITIMAE Tx.apud Oberd.1949

These are the open, pioneer communities of shingle beaches of Western Europe and Baltic regions, where the order character species are: Cakile maritima and Salsola kali (Westhoff and Den Held 1969). Of these, only Cakile is recorded for Shetland.

The only alliance found in Britain is the Atriplicion littoralis

4.1.1.1. Alliance: ATRIPLICION LITTORALIS (Nordhagen 40) R.Tx.50

This covers the pioneer communities of shingle beaches and sand or clay strandlines which are not, or only slightly, affected by blown sand. The character species given by Westhoff and Den Held (1969) are: Atriplex littoralis (transgressor) and Tripleurospermum maritimum, both of which are found in Shetland.

The alliance is extensive along north-west European and Baltic coastlines.

4.2 Class: AGROPYRETEA PUNGENTIS' Gehu et Gehu 69

Synon: Artemisietea vulgaris Tx + Prsg.50 pp
Plantaginetea majoris Tx.+ Prsg.50 pp
Cakiletea maritmae Tx.+ Prsg.50 pp

This class was created by Gehu et Gehu (1969) to embrace communities of predominantly perennial species on drift line and shingle beaches (Adam 1976). These are frequently found in exposed situations, along Atlantic and Mediterranean coasts.

It includes some of the communities previously placed in the Agropyro-Rumicion crispi Nordh 40 (of the Plantaginatea majoris) and in the Convolvulion which show affinity to the Cakiletea maritimae in the presence of halonitrophile species. These were however perennial species so that their association could not be accommodated by the Cakiletea.

Gehu and Gehu (1969) suggest the following character species:

Agropyron pungens	Crambe maritima
A.acutum	Suaeda vera

and as differentials from the plantaginetea and Artemisietea:

Atriplex hastata var salina	+
Atriplex littoralis	
Beta vulgaris ssp.perennis	
Cakile maritima	+
Lavatera arborea	

The species marked + have been recorded in Shetland, although varieties were not distinguished in the present survey.

The French authors described two orders within their new class: the Honkenyo-Crambetalia maritima and the Agropyretalia pungentis. Both have been recognised in Shetland.

4.2.1. Order: HONKENYO - CRAMBETALIA MARITIMAE Gehu & Gehu 69

Essentially this is an order of North-Atlantic and Baltic coast communities. Only one alliance is recognised.

4.2.1.1.Alliance: HONKENYO-CRAMBION MARITIMAE Gehu & Gehu 69

These communities of halonitrophilic bi-annuals and perennials are usually open and quite simple. They are found on semi-protected to moderately exposed coasts; the substrate may be coarse sand or pebbles, mixed with organic material and hence rather unstable.

Gehu and Gehu (1969) propose the following character species:

Beta vulgaris ssp.perennis	Raphanus maritimus
Crambe maritima	Rumex crispus var.triangulatus +
Honkenya peploidis +	R.rupestris
Lavatera arborea	Sonchus maritimus

Those marked + are recorded in Shetland.

4.2.2Order: AGROPYRETALIA PUNGENTIS Gehu & Gehu 69

Included in this order are stable communities of closed vegetation forming raised swards above the zone occupied by the Honkenyo-Crambetalia communities. The substrate is diverse but is generally enriched with organic matter. The order is found in Mediterranean and Atlantic regions.

Only one alliance is recognised by Gehu & Gehu (1969), the Agropyrion pungentis.

4.2.2.1.Alliance: AGROPYRION PUNGENTIS Gehu & Gehu 69

Synon: Agropyro-Rumicion crispi Nordh 40pp
Convolvulian sepii R.Tx.47 ap.Oberd.49pp

The French authors considered this alliance to include some of the more maritime communities of the Agropyro-Rumicion crispi (while the remainder lie in the Honkenyo-Crambion). However, Adam (1976) feels that it may be possible to enlarge the alliance to include all communities embraced by Nordhagen's original conception of the Agropyro-Rumicion. However, this latter alliance has been extended by Tuxen (1950) (see Adam 1976) and Westhoff and Den Held (1969), and it is not realistic to include the extensions in an enlarged Agropyrion pungentis.

In the present work maritime disturbed communities have been assigned

to the Agropyretea pungentis while those lacking maritime species have been placed in the Agropyro-Rumicion crispi Nordh.40 em Tx.50, in the Plantaginetea majoris following the scheme of Westhoff and Den Held (1969).

For their alliance Gehu and Gehu (1969) suggest the following character species, none of which is recorded in Shetland:

Agropyron pungens	Lepidium latifolium
xA. acutum	Suaeda vera

4.3 Class: 'AMMOPHILETEA' Br-Bl.et R.Tx 43

This class comprises the young and mobile sand dunes of Western European and Mediterranean coasts, characterised by the presence of Ammophila arenaria. Braun-Blanquet and Tuxen (1943) (see Lohmeyer et al 1962) described only one order within the class, the Elymetalia arenarii, containing an alliance of pioneer communities on unstable dunes (the Agropyro-Honckenyion peploidis) and one of the vegetation succeeding on more stable areas (the Ammophilion borealis).

However, Gehu and Gehu (1969) described two further orders along the French coasts - the Euphorbia-Ammophiletalia and the Ammophiletalia arundinaceae. They renamed the Elymetalia arenarii Br-Bl et Tx 43 as the Elyno-Ammophiletalia, and divided it into two alliances;theAgropyrion boreoatlanticum (synonymous with the Agropyro-Honckenyion peploidis Br-Bl et Tx.43) and the Ammophilion borealis (Tx55) Gehu et Gehu 1969.

4.3.1.Order: ELYMO-AMMOPHILETALIA ARENARIAE Gehu et Gehu 69

The communities of this order are found on white or mobile maritime dunes of the Western and Mediterranean coasts of Europe. They are characterised by the presence of Ammophila arenaria and Agropyron junceiforme.

Both of the alliances recognised for this order are found in S.Shetland.

4.3.1.1 Alliance: AGROPYRION BOREOATLANTICUM Gehu et Gehu 69

These communities consist of those plants which form the first stages of dune colonisation; they are, therefore, on the seaward side and subject to occasional wetting. The unstable and specialised nature of the habitat make the overall species number low.

Character species is Agropyron junceiforme (Gehu et Gehu 1969, Westhoff and Den Held 1969) while the alliance is differentiated from the Ammophilion borealis by the presence of Cakile maritima (Westhoff and and Den Held 1969).

Its distribution follows the order

4.2.1.3 Alliance : AMMOPHILION BOREALIS (R.Tx.) Gehu and Gehu 69

Above the zone occupied by the Agropyrion boreoatlanticum lie the young, mobile dunes occupied by communities of this alliance. They are more stable, and hence have a higher number of species. Herbs and bryophytes can grow here.

Character species given by Westhoff and Den Held (1969) are: Ammophila arenaria, Elymus arenarius(preferential) Festuca rubra and Sonchus arvensis, while Gehu and Gehu (1969) differentiate this alliance from the latter by the presence of Elymus and Lathyrus japonicus (=L.maritimus Bigel), and the absence of the thermophilic species of the Ammophiletea, Lathyrus maritimus is only known to grow at Norwick, Unst in Shetland.

The Ammophilion borealis extends along Northern European coasts.

4.4.Class : PLANTAGINETEA MAJORIS R.Tx.et Prsg.50

Synon: Rudero-Secalinetea Br.-Bl.36 pp.

This is a class of ruderal communities maintained by heavy biotic influences, such as severe trampling, overgrazing or the resulting ground instability. In all such situations a similar group of characteristic species can be found (O'Sullivan 1965). These normally include:

Lolium perenne + Poa annua +
Matricaria matricarioides + Polygonum aviculare +
Plantago major +

All are recorded from Shetland, although Polygonum aviculare is known only from Fair Isle.

Only one order is recognised, the Plantaginetalia majoris RTx (47)50

4.4.1 Order: PLANTAGINETALIA MAJORIS R.Tx (47)50

The class and order character species given by Westhoff and Den Held (1969) are:

Agrostis stolonifera var prorepens +
x Festulolium loliaceum
Juncus compressus
Lolium perenne +
Plantago major (transgr) +
Potentilla anserina (transgr) +
Ranunculus sarduous

Poa annua + and Leontodon autumnalis may have limited value as order and alliance character species (Oberdorfer 1957, Westhoff and Den Held 1969).

Two alliances have been recognised by the Dutch authors, the Lolio-Plantaginion Siss.69, of trampled areas, and the Agropyro-Rumicion crispi Nordh.40,em.RTx 50. Only the latter was described in Southern Shetland.

4.4.7.1 Alliance: AGROPYRO-RUMICION CRISPI Nordh40 em.R.Tx.50

This alliance is found throughout Europe outside the Mediterranean area. It embraces, 'contact' and disturbance communities in relatively unstable situations along transitional gradients of a variety of factors

e.g. wet/dry, nutrient rich/nutrient poor, salt water/fresh water. Both natural and anthropogenic influences may affect the communities in which rosette-forming species and rhizomatous species predominate. Certain authors (see Westhoff and Den Held 1969) have created sub-alliances within the Agropyro-Rumicion according to the dominant environmental factor, while Gehu and Gehu (1969) removed those communities of strand-lines with halophytic species (see 4.2.2.1).

Westhoff and Den Held (1969) suggest the following character species:

Agropyron repens +
Carex distans var distans
C.divisa
C.hirta
C.otrobae
Eleocharispalustris +
Gratiola officirnalis
Juncus effusus +
J.inflexus
Leontodon autumnalis +
Lotus corniculatus ssp. tenuis ifdius +
Mentha pulegium
Oenanthe peucedanefolia
Polentilla anserina +
Pulicaria dysenteria
Ranuncls repens +
Rumex crispus +
Scripus planifolius
Stellaria palustris var virens
Teucrium scordium
Trifolium fragiferum
T.hybridun +
Triglochin palustris +
Veronica scutellata +

and list a number of differential species "with special affinity to the Agropyro-Rumicion crispi:"

Ophioglossum vulgatum +
Agrostis canina var canina
Alopecurus bulbosus
Bromus racemosus
Carex disticha
C.punctata
Cirsium eriophorum
Hydrocotyle vulgaris +
Juncus articulatus +
J.maritimus
Mentha arvensis var arvensis
M.xverticillata
Myosotis caespitosa +
Odontites verna ssp. serotina
Ranunculus flammula +
Rumex conglomeratus
Trifolium micranthum

Those marked + are recorded in Shetland

4.5.Class: PHRAGMITETEA R.Tx et Preising 42

Synon: Phragmito-Magnocaricetea Klika 44

This is a class of the communities of tall-growing grasses and sedges of the early stages of hydroseral development (Wheeler 1975). A wide range

of vegetation is included; from those in the early stages of encroachment onto open water, to the communities where the water level may occassionally be at or below ground level.

It is a relatively widespread vegetation type, particularly being associated with nutrient-rich waters in lowland regions. Due to a lack of such habitats, rather than due to climatic factors, this class is rarely encountered in Shetland.

A wide variety of character species have been given for the class by various authors, but Wheeler (1975) gives the following:

Equisetum fluviatile +	Rumex hydrolapathum
Alisma plantago-aquatica	Berula erecta +
Iris pseudacorus +	Sparganium erectum ssp. microcarpum.

Those marked + occur in Shetland.

Three orders have usually been distinguished only one of which was found in the Southern Isles of Shetland.

4.5.1.Order: MAGNOCARICETALIA Pignatti 53

Following the scheme of Du Rietz (1949) the vegetation in this order is that of rich fen. It appears to be one of transient communities in the succession from reedswamps (placed in the order Phragmitetalia) and the and the fen woodland (Wheeler 1975).

The order is distributed throughout Europe and has representatives in both maritane and lowland region.

Only one alliance, the Magnocaricion has been clearly defined.

.5.1.1.Alliance: MAGNOCARICION (ELATAE) Koch 26

These "large-sedge" communities are charaterised by:

Carex acuta	Peucedanum palustre
Galium palustre ssp.elongatum +	Poa palustris
Lysimachia thryrisiflora	Scutellaria galericulata
Carex vesicaria	Carex elata
C.paniculata +	C.acutiformis
C.aquatilis +	

(Westhoff and Den Held 1969, Wheeler 1975)

Those marked + occur in Shetland, however Carex paniculata and C.aquatilis are

known only from single sites on Fetlar. Sub-species of Galium palustre were not distinguished in the present survey.

4.6 Class: KOELERIO-CORYNEPHORETEA Klika apud Klika & Novak 41

Synon: Festuco-Brometea Br.-Bl.Tx 43 sensu acict p.p.
Sedo-Scleranthetea Br.-Bl.55 em. Oberd.61 apud.Krausch 62.
Corynephoretalia R.Tx.33

This class of dry, sandy grassland is closely related to the Festuco-Brometea Br.-Bl. et Tx.43 em.R.Tx 1961.

Westhoff and Den Held (1969) give the following character species:

Agrostis canina var arida
Carex arenaria +
Corynephorus canescens
Potentilla argentea
Scleranthus perennis
S.polycarpus
Trifolium arvense
Ceratodon purpureus +
Polytrichum piliferum +
Rhacomitrium canescens +
Cladonia Chlorophaea
C.foliacea
C.furcata +
Peltigera polydactyla

and as differentiating this class and the Festuco-Brometea Br.-Bl.et R.Tx.43 em.R.Tx.61 from all other classes:

Allium oleraceum
Arenaria serpyllifolia
Artemisia campestris
Cerastium arvense
C.semidecandrum +
Erigeron acer
Euphorbia cyparissias
Festuco ovina s.s.
Galium verum +
Helictotrichon pubescens +
Hieracium pilosella
Koeleria gracilis
Orobanche vulgaris
Pimpinella saxifraga
Potentilla tabernaemontani
Ranunculus bulbosus +
Thymus pulegioides
Abietinella abietina

Only those species marked + occur in Shetland.

Ranunculus bulbosus is known only from St.Ninian's Isle.

A number of orders have been recognised by various authors ; the Corynephoretalia (Klika 31) Tx.33 em.Pass.60, Sedo-Scleranthetalia Br.-Bl. 55 and Sedo-Festucetalia Tx.51 em. are described by Passarge (1964). However, the scheme of Westhoff and Den Held (1969) which was followed by Ivimey-Cook and Proctor (1966) and Birse and Robertson (1976) is preferred whereby three orders are involved - the Corynephoretalia R.Tx.

33 em.62, Sedo-Scleranthetalia Br.-Bl.55 and the Festico-Sedetalia (acris) R.Tx.51. It is the latter order that has been recognised in Southern Shetland.

4.6.1.Order: FESTUCO-SEDETALIA (ACRIS) R.Tx.51

Synon: Coryneph retalia R.Tx.33 pp,Kilka 34 p.p.Br.-Bl.et R.Tx.43 pp

This order of species rich, more or less closed pioneer communities on dry, light sandy ground is found throughout Europe except in the Mediterranean regions or above the subalpine zone.

Westhoff and Den Held (1959) list the following as order character species:

Aira praecox +
Alyssum alyssoides
Arabidopsis thaliana +
Cerastium pumilum
Draba muralis
Erodium cicutarium + ssp.dunense
Erophila verna
Helichrysum arenarium
Holosteum umbellatun
Jasione montana +
Myosotis stricta
Satur e ja acinas
Sedum acre +
Silene armeria
Taraxacum tortilobum
Teesdalia nudicaulis
Thymus serpyllum
Trifolium campestre
T. striatum
Tuberaria guttata
Vicia sativa ssp.angustifolia +
V. lathyroides

Birse and Robertson (1976) give only three order character species for their Scottish data:

Carex arenaria +
Vicia angustifolia +
Cladonia rangiformis +

Those species marked + are recorded in Southern Shetland.

Westhoff and Den Held (1969) recognise three alliances; the Thero - Airion R.Tx.51 of Western European, ephermeral communities on neutral sandy ground; the Sedo-Cerastion Siss.et Tidman 60 embracing open Sedum rich vegetation and the Galio-Koelerion (R.Tx.37) Den Held and Westhoff 1969 nom.nov.of dry grasslands on acid soils in the Atlantic sector including Britain.

This latter alliance was described in Southern Shetland.

4.6.1.1.Alliance: GALIO-KOELERION (R.Tx 37) Den Held & Weshoff 1969 nom nov.

Synon: Koelerion albescentis Tx.37

The Dutch authors renamed the Koelerion albescentis because of taxonomic confusion around the species Koeleria albescens and K.gracilis; although the older name is still retained by many authors (e.g.Ivimey-Cook and Proctor 1966, Birse & Robertson 1976). Westhoff and Den Held (1969) give the following alliance character species:

Anthyllis vulneraria ssp.maritima +	Jasione montana +
Artemisia Lloydii	Milium scabrum
Asparagus officinalis var prostratus	Ononis repens
Cerastium diffusum +	Poa bulbosa
Festica rubra var arenaria + *	Silene otite
Galium verum var maritma + *	Taraxacum Vubicundua
Helianthemaum nummularium ssp.ovatum	T.lacistophyllum
Hieracium umbellatum var.armerii folium	Viola tricolor ssp. curtisii
Himantoglossum hircinum	Ceratodon conicus
	Hypnum cupressifsome var lacunosum +
	Cladonia pityrea +
	C. rangiformis +

Birse and Robertson (1976) add to those marked * in the above list

Festica rubra +	Tortula ruraliformis +
Koeleria cristata (K.gracilis; incl.Kalbescens auct.)	

Those species marked + have been recorded in Shetland. Varieties of Festuca rubra were not distinguished in the present study.

4.7 Class: FESTUCO-BROMETEA Br.-Bl.R.Tx.43 em.R.Tx.61

Dry anthropogenic calcareous grasslands are placed in this class which extends across central and western Europe. The class is widespread, on suitable soils throughout Southern Britain, but is virtually absent in the Southern Uplands and Highlands of Scotland due to the lack of the appropriate base-rich soils and the wetter climate. In these areas the class Elyno-Seslerietea is found (Shimwell 1971a)

Two orders have been recognised in central and western Europe; the Festucetalia vallesiaceae Br.-Bl.et R.Tx.43 embraces the eastern continental dry, steppe grasslands, while only the Brometalia erecti Br.-Bl.36 is found in the British Isles.

4.7.1.Order: BROMETALIA ERECTI Br.Bl.36

The communities of this order are of dry and semi-dry grasslands on base-rich soils with a little humic material and are very much the result of human interference (Jones 1973). The distribution of the Class is from the Mediterranean region to south Scandinavia and northern England, extending westwards in Britain to the Atlantic coasts of Wales and Ireland (Shimwell 1971a).

Since the Order is the only one of the class found in Britain, its British Class and Order character species are the same. Shimwell (1971a) gives:

Acinos arvensis	Helianthereum canum
Anthyllis vulneraria +	H.chamaecistus
Blackstonia pinnatum	Helictotrichon pratense
Bromus erectus	Hippocrepis comosa
Carlina vulgaris	Koeleria cristata
Centaurea scabiosa	Potentilla tabeonaernontani
Cerastium pumilum	Potentium sanguisorba
Filipendula vulgaris	Scabiosa columbaria
Gentianella amarella +	Viola hirta ssp.calcarea

Only the species marked + have been recorded in Shetland. The composition of this list indicates the close relationship between this order and the Galio-Koelerion

Two alliances are recognised in the Order. The Bromion erecti Br.-Bl (1925) 36 includes open, dry, thermophilous, chiefly primary communities of rocky ground, usually limestone, It has very restricted distribution in Southern England. However the second alliance, the Mesobromion erecti Br.-Bl & Moor 38 em.Oberd.49 is more widespread in Britain and was recognised in Shetland.

4.7.1.1.Alliance: MESOBROMION ERECTI Br.-Bl.& Moor 38 em. Oberd.49

Within this alliance lie most of the chalk and limestone communities in Britain, as well as some of those of stablised calcareous dune systems related to the Galio-Koelerion.

The communities are of semi-dry grassland, tolerating a damper

climate and greater grazing pressure than those of the Bromion erecti (Shimwell 1971b)

None of the 27 character species of the Mesobromion given by Shimwell (1971b) are present in Shetland. The Islands are north of the normal distribution of the alliance (sub-mediterranean to sub-Atlantic and Atlantic zones) and therefore beyond the range of most of these species.

However Shimwell (1971b) gives a number of species which differentiate the Mesobromion from the British sub-alliance of the Bromion erecti (the Xerobromion). Of these Briza media, Carex flacca, Plantago lanceolata, Ranunculus bulbosus and Succisa pratensi are found in Shetland. That author also indicates that many Molinio-Arrhenatheretea species can be present in a more secondary role because of grazing pressure on the communities, e.g. Holcus lanatus, Cynosurus cristatus.

It is thus possible that degraded forms of Mesobromion communities are present in limestone grasslands of Southern Shetland.

Two sub-alliances have been recognised within the Mesobromion. The Seslerio Mesobromion Oberd 57 is a montane sub-alliance, while the Eu-Mesbromion Oberd 57 includes almost all lowland Mesobromion communities.

The Eu-Mesobromion would appear to be found in Shetland, but because the alliance as a whole is at the edge of its range in the Islands, there is a lack of differential and character species on which to base a definite decision.

4.8 Class: SAGINETEA MARITIMAE Westhoff, Van Leeuwen & Adriani.62

This class embraces the communities of upper salt marshes, characteristic of the beach plain/marsh/dune transition. The substrate is usually sandy, and the vegetation is characterised by annuals or short-lived perennials. (Westhoff and Den Held 1969, Adam 1976).

The class is found in north western Europe, but while the characteristic species of the class are present in British saltmarshes, the communities on

cliffs and sand-dunes which they are said to delimit, are not clearly recognised (Adam 1976).

Westhoff and Den Held (1969) give one order with a single alliance.

4.8.1. Order: SAGINETALIA MARITIMAE Westhoff, Van Leeuwen & Adriani 62

4.8.1.1. Alliance: SAGINION MARITIMAE Westhoff, Van Leeuwen, & Adriani 62

Westhoff and Den Held (1969) list a number of species characteristic of the Class, Order, Alliance and single association. These are:

Bupleureum tenuissiunum
Catapodium marinum
Cochlearia dainca +
Hordeum marinum
Plantago coronopus +
Sagina maritima +
Amblystegium serpens var salinum +
Pottia heimii +
Rhyncostegiella compacta var salina

Those species marked + are recorded in Shetland.

4.9 Class: ASTERETEA TRIPOLII Westhoff & Beeftinck 62,

Synon: Juncetea maritimi Br.-Bl.1931 pp
Puccinellio-Salicornietea Topor 1939 pp
Astereto-Salicornietea Westhoff et al 1942 prov.pp.
Salicornietea Br.-Bl.et R.Tx.1943. pp.

This class includes many of the communities of saltmarshes and halophytic grasslands. It extends through western Europe from the Arctic to the coast of Western Spain. In the mediterranean region it is replaced by the Juncetalia maritima Br.-Bl.31 of the Juncetea maritimi Br.-Bl.31 (Westhoff and Den Held 1969).

It is characterised by:

Aster tripolium +
Plantago maritima +
Triglochin maritima +

In Shetland, Aster tripolium occurs on only one small holm, while Plantago maritima is found far from the sea.

The class has only one order in western Europe - the Glauco-Puccinellietalia Beeftinck and Westhoff 62.

4.9.1.Order: GLAUCO-PUCCINELLIETALIA Beeftinck & Westhoff 62

The halophytic communities of western European and western Baltic coasts are characterised by the following according to Westhoff and Den Held (1969):

Limonium vulgare
Spergularia mariginata
Parapholis strigosa

None of these species is found in Shetland, and saltmarshes there are generally low in species making characterisation with respect to order difficult.

Four alliances are generally recognised:

Puccinellion maritimae Christiansen 27 em Tx.37, the Armerion maritimae Br.-Bl.et De L.36, Puccinellio-spergularion salinae Beeftinck 65 and the Silenion maritimae Malloch 71. The latter, an alliance of cliff top vegetation, is not recognised in the Southern Isles of Shetland, although Lewis (1976) describes it in the Northern Isles.

Adam (1976) regards the Eleocharion uniglumis Siira 70 as a sub-alliance of the Armerion. This scheme is followed here.

4.9.1.1.Alliance: PUCCINELLION MARITIMAE Christiansen 27 em Tx.37

The vegetation lying between about mean high water mark and mean spring high water mark falls in this alliance. The soils are thus subject to inundation by water a number of times, but only for short periods. It thus includes the vegetation of the seaward edges of salt-marshes as well as the immediate coastal vegetation of gravelly shores.

Westhoff and Den Held (1969) propose the following character species:

Puccinellia maritima (transgressor)
Cochlearia anglica
Halimione portulacoides
Bostrychia scop ioides
Catenella opuntia

Only Puccinellia is found in Shetland. The alliance has a wide distribution along the coasts of western Europe, from Norway and Iceland to the Iberian Peninsula.

4.9.1.2.Alliance: ARMERION MARITIMAE Br.-Bl.et De L.36

The communities of this alliance occur higher up the shore than those of the previous alliance, from just below mean spring high water mark to the storm zone, and are thus subject to less frequent inundation. The substrate can be silt or mud as in the upper salt marsh vegetation, or gravelly. Birks (1973), includes in this alliance a community of rock crevices near the sea.

For the Netherlands, Westhoff and Den Held (1969) give the following character species:

Armeria maritima var maritima (transgr.) +	Alopecurus bulbosus
Festuca rubra +	Hordeum marinum
Glaux maritima +	Carex distans var vikingensis
Juncus gerardii +	Agrostisstolonifera var compacta

The species marked + occur in Shetland, although varities were not distinguished.

Birks (1973) differentiates the Alliance from the Puccinellion maritimae in Skye by the absence of Puccinellia maritima. However, Dahl and Hadac (1941) give Aster tripolium, Glaux maritima, Plantago maritima, and Puccinellia maritima as character species of the Festucion maritimae Willi Christionsen 27 which they feel is synonymous with the present alliance. Adam (1976) includes a Juncus gerardii - Puccinellia maritima nodum in this alliance for British saltmarshes.

The alliance is found along Western European coatas from Norway, probably to South-West France where it overlaps with the Puccinellion maritimae and other alliances.

.9.1.2.1.Sub-Alliance: ELEOCHARION UNIGLUMIS Siira 70

This contains those communities dominated by colonial members of the Cyperaceae: Blysm us rufus, Eleocharis spp (Adam 1976). Adam recognises three communities within the alliance in Britain. In his original concept Siira (1970) (see Adam 1976) described only the Elocharetum uniglumis

within the alliance, placing those dominated by Blysmus (Blysmetun rufi) in the Armerion.

4.9.1.3. Alliance: PUCCINELLIO-SPERGULARION SALINAE Beeftinck 65

This alliance is considered transitional between the Armerion and the Puccinellion (Adam 76). It is north-Atlantic in distribution and is characterised by Spergularia salina. Generally it includes disturbed or trampled maritime communities on sand, silt or fine gravel (Adam 1976, Westhoff and Den Held 1969).

4.10. Class: MOLINIO-ARRHENATHERETEA Tx.37

Synon: Molinio-Juncetea Br-Bl.47 +
Arrhenatheretea Br.-Bl.47

This class includes many of the lowland grassland communities of periodically wet or damp pastures and hay meadows. It covers both natural and semi-natural meadows, a wide range of nutrient status and grazing effects, and slightly acidic to basic soils. It occurs throughout western Europe under sufficiently moist ground conditions.

The class character species given by O'Sullivan (1965) for Irish and European communities are:

Alopecurus pratensis +	Plantago lanceolata +*
Cardamine pratensis +*	Poa pratensis
Cerastium holosteoides +*	P.trivialis +
Festuca pratensis +	Ranunculus acris +
F.rubra +	Rhinanthus minor +
Helictotrichon pubescens +	Rumex acetosa +*
Holcus lanatus +*	Trifolium pratense +*
Lathyrus pratensis +	Vicia cracca +*

Only those species marked + occur in Shetland.

Three Orders are commonly recognised. The Holoschoenetalia Br.-Bl.31 is confined to the northern Mediterranean region. The Arrhenatheretalia Pawlowski 28 includes communities of fertile, damp, basic or neutral soils which have been periodically grazed or mown, while the Molinietalia Koch 26 embraces the natural or semi-natural wetter meadows.

4.10.1.Order: MOLINIETALIA W.Koch 26

The grasslands of this Order are only slightly affected by management and grazing and are thus considered to be "semi-natural" (O'Sullivan 1965). They are found on nutrient-rich to nutrient-poor soils, but always subject to periodic wetting. In Holland, Westhoff and Den Held consider the Order as usually being species-rich. It is found in western Europe, but in the Mediterranean region is replaced by the Holoschoenetalia.

The character species recognised by the Dutch authors are:

Achillea ptarmica +*	Lathyrus palustris
Angelica sylvestris +*	Lysimachia vulgaris
Cirsium palustre +*	Orchis praeterissima
C.oleraceum	Rhinanthus glaber
Deschampsia cespitosa +*	Sanguisorba officinalis
Equisetum palustre +*	Thalictrum flavum
Galium uliginosum +*	Valeriana dioica
Hieracium caespitosum	Ophioglossum vulgatum +

O'Sullivan (1965) adds to those marked * a number of species, all of which are dependent on high-soil-moisture conditions, and which form a suitable group of character species for his Irish communities, viz:

Filipendula ulmaria +	Lotus uliginosus
Hypericum tetrapterum	Lychnis flos-cuculi +
Juncus acutiflorus +	Lythrum salicaria
J.conglomeratus +	Myosotis caespitosa +
J.effusus +	

He does point out, however, that only Juncus effusus, Cirsium palustre, Lotus uliginosus, Filipendula ulmaria and Juncus acutiflorus are at all common in Ireland.

In Shetland only those species marked + are recorded.

A number of alliances have been recognised within this Order in central and western Europe, including the Deschampsion caespitosae Hovatic 30 Alopecurion pratensis, Passarge 64, (Wheeler 1975), Cnidion venosi, Balatova-Tulackova 64, Juncion acutiflori Br.-Bl.47, Molinion caeruleae Koch 26, Calthion palustris Tuxen 37, and Filipendulo-Petasition Br.-Bl.47. The Junco (subuliflori)-Molinion Westhoff 69 includes unmanured wet meadows and mires in

which Molinia is an important component. However, the only alliance described from Southern Isles is the Calthion.

.10.1.1.Alliance: CALTHION PALUSTRIS Tx.37

This includes the damp or wet meadows that are enriched by manuring, including enrichment artifically or by deposition from nutrient-rich waters. It includes communities on peat and clays.

O'Sullivan (1965) suggests the following as European character species:

Bromus racemosus	Myosotis scorpidioides +
Caltha palustris +	Polygonum bistorta +
Cirsium oleraceum	Scirpus sylvaticus
Crepis paludosa	Senecio aquaticus +

while to Caltha and Crepis, Westhoff and Den Held (1969) add:

Carex disticha	Lychnis flos-cuculi +
Lotus uliginosus	Orchis majalais
Luzula multiflora ssp multiflora +	Taraxacum hollandicum

O'Sullivan points out how reduced this list is for Ireland. Similarly, only those marked + occur in Shetland, and of these both Myosotis scorpidioides and Polygonum bistorta are uncommon.

4.10.2.Order: ARRHENATHERETALIA ELATIORIS Pawlowski 28

This Order of permanent hay meadows and pastures is found throughout Europe wherever the climate is moist and temperate. O'Sullivan (1965) proposes the following character species for Irish and European communities:

Bellis perennis +	Knautia arvensis
Bromus mollis	Taraxacum sect.vulgaris +
Chrysanthemum leucanthemum +	Trifolium dubium +
Dactylis glomerata +	Trisetum flavescens
Daucus carota	Veronica chamaedrys +

Shimwell (1968) adds:

Achillea millefolium +
Arrhenatherum elatius +
Heracleum spondylium +
Veronica officinalis +

Thos marked + are recorded in Shetland; Trifolium dubium is rare.

Three alliances have been recongised in Britan. The Arrhenatherion elatioris Koch 26 includes permanent meadows. The Cynosurion cristati Tx.47

covers lowland grazed or managed grasslands while the northern sub-boreal damp meadows and pastures lie in the Ranunculo-Anthoxanthion Gjaerevoll 56 em Shimwell 68.

Only the Cynosurion has been recognised in the Southern Isles.

4.10.2.1.Alliance: CYNOSURION CRISTATI Tx.47

This alliance embraces all the Irish pastures (O'Sullivan 1965) and, generally, grazed lowland pastures and similar habitats, showing in some way the effects of human management. It was formed when Tuxen recognised the difference between managed pastures, for which he created the Cynosurion, and the richer, permanent meadows of the Arrheratherion elatioris Pawlowski 26. It is found on moist but well drained soils receiving regular monthly rainfall, and is confined to Western Europe.

In Ireland it is not strongly characterised but O'Sullivan gives four character species:

Cynosurus cristatus	+
Senecio jacobea	+
Trifolium repens	+
Phleum pratense	+

and three differentials (from the Arrhenatherion elatioris Koch 26):

Achillea millefolium	+
Cirsium arvense	+
Lolium perenne	+

He feels that considered together these seven species distinguish the alliance. All seven are recorded in Shetland, although Senecio jacobea is extremely localised.

4.11.Class: MONTIO-CARDAMINETEA Br.-Bl.et Tx.43

These are the communities of springs or shallow flowing water, and are moss-rich, growing either on rocks in the water or on associated soil or silt (Westhoff and Den Held 1969). They require a more or less even water temperature and good oxygenation. The class is distributed in the Euro-siberian region, centred around the boreal-montane zone.

It contains one order, the Montio-Cardaminetalia Pawlowski 28, divided into three groups covering calcicole, calcifuge and alpine vegetation. Oberdorfer et al (1967) consider these as alliances, but Westhoff and Den Held recognise only two. These are the Cratoneurion Koch 28 of calcium-rich waters, and the Cardamino-Montion of calcium-poor waters; they divide the latter into two suballiances to cover the wide range of calcifuge spring vegetation. Only the Cratoneurion was recorded in the present survey.

4.11.1.Order: MONTIO-CARDAMINETALIA Pawlowski 28

The character species of this order are the same as those for the class. Jones (1973) gives:

Caltha palustris +	Cratoneuron decipiens
Cardamine amara	Philonotis fontana +
Epilobium alsinefolium	Pohlia wahlenbergii +
Brachythecium rivulare +	

Those marked + are recorded in Shetland.

4.11.1.1.Alliance: CRATONEURION Koch 28

These are communities of chalk and limestone springs and the alliance is recognised through most of Europe.

Oberdorfer (1957) gives five character species:

Saxifraga aizoides	Eucladium verticillatum +
Cratoneuron commutatum +	Philonotis calcarea
C.filicinum +	

Those marked + are recorded in Shetland.

4.12.Class: PARVOCARICETEA Den Held & Westhoff 1969

Synon: Scheuchzerio-Caricetea fuscae (Nordh.36) Tx.37 pp.
Caricetea nigrae Tx.71

This class of small sedge mire communities arose from a series of divisions and agglomerations of mire and bog vegetation following Tuxen's creation of the Scheuchzerio-Caricetea fuscae. Jones (1973) and Westhoff and Den Held (1969) have described the changes fully, whereby the present scheme involving two classes, Parvocaricetea and Scheuchzerietea was evolved.

4.12.1.Order: CARICETALIA NIGRAE Koch 26 em.Nordh 36 denuo em Tx.37

This order contains the communities of poor fens (of oligo-to mesotrophic water). Only one alliance is usually recognised nowadays, although Koch's original concept of the order (as the Caricetalia fuscae) contained three alliances; the Caricion davallianae, the Caricion fuscae and the Rhyscosporion albae.

4.12.1.1.Alliance: CARICION CURTO-NIGRAE Koch 26 em.Nordh.36
(Sub-nom.Caricion canescentis-Goodenowii)

This is an alliance of small sedge communities of the ground around streams and springs. These are oxygen-rich, but nutrient-poor. They are usually species rich and found in a variety of habitats having such ecological properties, e.g. dune slacks, soligenous mires.

Westhoff and Den Held(1969) suggest the following order and alliance character species:

Carex curta	+	Juncus filiformis	
C.echinata	+	Ranunculus flammula	+
C.nigra	+	Viola palustris	+
Epilobium palustre	+	Sphagnum recurvum ssp.amblyphyllum	+

Those marked + are recorded in Shetland; in the present survey Sphagnum recurvum was identified only to the specific level.

These authors also add:

Drosera rotundifolia	+	Sphagnum cuspidatum	+
Veronica scutellata		S.palustre	+
Acrocladium stramineumx	+	S.plumulosum	+
Aulacomnium palustre	+	S.squarrosum	+
Calypogeia fissa	+	S.subsecundum	+
Polytrichum commune var.uliginosum		S.teres	+

as species differentiating these communities from those of the Tofieldietalia. Polytrichum commune is recorded in Shetland but was not identified to the sub-specific level here.

The distribution of the alliance is the same as the class except that it is not found in alpine regions. Some workers believe that there the Eriophorion scheuchzeri Hadac 39 replaces the Caricion curto-nigrae (Westhoff and Den Held 1969).

The class contains mire vegetation with a herb layer of grasses, sedges and rushes, and a well-developed bryophyte layer.

The water-table, which is always high, may be mesotrophic to eutrophic, base-poor or base-rich. However it is always poor in nitrogen and phosphorus, but is minerotrophic.

Wheeler (1975) points out the wide range of situations in which these communities can occur; on peat or mineral soil; associated with areas of flushing or water seepage; in flat, peaty fens; or in dune slacks.

The class is found throughout the Euro-Siberian region but is most widespread in the north.

Westhoff and Den Held (1969) give the following class character species:

Calamagrostis neglecta	Pedicularis palustris +
Carex demissa +	Stellaria palustris
C.diandra	Acrocladium cordifolium +
C.lasiocarpa (weak)	Drepanocladus exannulatus +
Epilobium palustre +	D.sendtneri
Hydrocotyle vulgaris +	Riccardia pinguis +

and add a further five species which they believe differentiate the Parvocaricetea & Scheuchzerietea from all other classes of vegetation:

Agrostis canina var fascicularis
Carex rostrata +
Hammarbya paludosa +
Menyanthes trifoliata +
Sphagnum teres

The class is differentiated from the Scheuchzerietea by:

Cardamine pratensis +	Peucedanum palustre
Caltha palustris +	Potentilla erecta +
Dactylorchis spp.	Salix repens +
Equisetum fluviatile +	Succisa pratensis +
E.palustre	Triglochin palustris +
Galium uliginosum +	Valeriana dioica
Myrica gale	

Those marked + are recorded in Shetland. Hammarbya is known only from one site on Yell.

Two orders have been recognised, the Caricetalia nigrae Koch 26, em.Nordh 36 denuo em.Tx.37 and the Tofieldietalia Prsg.apud Oberd.49

4.12.2.Order: TOFIELDIETALIA Prsg.apnd.Oberd.49

The communities of this order are those of rich fens, of relatively high base and nutrient status, having less Sphagnum spp.in the moss layer.

Their distribution follows that of the class (Jones 1973).

Shimwell (1968) gives the following character species:

Bartsia alpina	Juncus alpino articulatus
Carex flava	J.triglumis
C.dioica +	Campylium stellatum +
Eleocharisquinqueflora +	Scorpiduim scopidioides +
Equisetum variegatum	

to which Jones (1973) adds Drepanocladus revolvens + and Campylium chrysophyllum +, from the work of Westhoff and Oberdorfer.

Those species marked + are recorded in Shetland.

Two alliances are usually distinguished, the Caricion bicoloris-atrofuscae Nordh.36 of sub-arctic and sub-alpine to alpine regions of central and northern Europe, and the Caricion davallianae Klika 34 of lower areas.

Only the latter is found in Shetland.

4.12.2.1.Alliance : CARICION DAVALLIANAE Klika 34

Synon: Eriophorion latifolii Br.-Bl et Tx.43

These are the communities of lowland and sub-alpine rich fens, developing under the influence of neutral to alkaline water. Small Carex spp. play an important role in the herb layer, while pleurocarpous mosses develop extensively in the bryophyte layer. A high base level is required in the substrate.

Wheeler (1975) gives the following character species for the alliance:

Carex lepidocarpa +	Dactylorhiza incarnata +
Epipactis palustris	Eriophorum latifolium
Liparis loeselii	Parnassia palustris +
Taraxacum limnathes	Acrocladium giganteum +
Bryum pseudotriquetrum +	Catascopium nigritum +
Camptothecium nitens	Campylium elodes +
C.polygamum +	Drepanocladus lycopodioides
D.vernicosus	Fissidens osmundoides +
Mnium rugicum +	M.seligeri
M.pseudopunctatum	M.cinlidioides
Pellia endiviifolia +	P.neesiana +
Riccardia multifida +	Sphagnum contortum
S.platyphyllum	

These are compiled from the work of Westhoff and Den Held (1969) and Oberdorfer (1957). The Dutch authors also give Carex pulicaris+, but Jones (1973) points out that this has been found in communities of the Caricion curto-nigrae in Britain and does not therefore seem to be a valid character species.

Those species marked + are found in Shetland.

4.13.Class: SCHEUCHZERIETEA Den Held, Barkman and Westhoff 69

As mentioned earlier this class arose from the separation of the communities of the Scheuchzerietalia palustris Nordh.36 from those forming the new Parvocaricetea Den Held and Westhoff 69. It thus contains only one order, the Scheuchzerietalia palustris comprising the vegetation of bog or fen hollows and pools. All require a constantly high water table, through stagnant or slowly moving water.

4.12.1.Order: SCHEUCHZERIETALIA PALUSTRIS Nordh.36

The distribution of both order and class is centred on the boreo-sub-Atlantic region.

Two alliances have been recognised within the order, the Rhyncosporion albae Koch 26 and the Caricion lasiocarpae Vanden Bergen 49. Both have been recorded in southern Shetland.

4.13.1.1.Alliance: RHYNCOSPORION ALBAE Koch 26

This is the only alliance recognised in the order by Westhoff and Den Held (1969) and for it they give the following character species:

Rhyncospora alba	S.pulchrum +
Cladopodiella fluitans (transgr.)	S.recurvum +
Sphagnum cuspidatum +	ssp.recurvum
S.lindbergii +	
S.majus	

plus fungi species

These authors also give:

Oxycoccus palustris	S.papillosum +
Sphagnum tenellum +	

as differentials between the class and the Parvocaricetea. Those species marked + have been recorded in Shetland.

Communities of the Rhyncosporion are generally species poor; the herb layer is poorly developed, often having only seedlings of grasses and sedges, but the moss layer is usually luxuriant, dominated by Sphagnum spp. They are usually found in wet depressions in poor fens and mesotrophic mires.

4.13.1.2. Alliance: CARICION LASIOCARPAE Vanden Bergen 49

Only some authors place this alliance in the Scheuchzerietalia; Westhoff and Den Held (1969) consider it to lie between the Rhyncosporion and the Parvocaricetea.

It embraces vegetation of hollows where the water has a slightly higher base status than in the latter alliance and is considered to be more or less synonymous with the Eriophorion gracile Prsg.apud Oberd.57. Wheeler (1975) describes these 'pioneer' communities as often forming floating mats of vegetation on open water. Birks (1973) suggests that characteristic species are:

Carex chordorhiza
C.diandra
C.lasiocarpa
Eriophorum gracile

while Wheeler (1975) proposes:

Carex lasiocarpa	Menyanthes trifoliata +
C.rostrata +	Potentilla palustris +
Eriophorum gracile	
Equisetum fluviatile +	

Only those species marked + have been recorded in Shetland.

The alliance has a northern distribution within the Euro-Siberian region.

4.14. Class: OXYCOCCO-SPHAGNETEA Br.-Bl.et Tx.43

The syntaxonomy and evolution of this class is fully discussed by Jones (1973). It is a class of heath and bog communities, (Moore 1968) where the soil is a shallow to deep, waterlogged peat, and with a well-developed moss layer, especially of Sphagnum spp. There have been numerous classification schemes (e.g.Duvigneaud 1949) but that of Moore (1968) has been followed in the present work except where indicated

otherwise. . . . . The position of the Pleurozia-purpurea - Erica tetralix Association is discussed in 5.6. Moore's grouping on an ecological and floristic basis, as opposed to a geographical one, divides the communities into two Orders, the Ericetalia tetralicis for vegetation on shallow peat in the Atlantic region, and the Sphagnetalia magellanici for that on deeper peat, dominated by Sphagnum, in both Atlantic and continental parts of Europe.

The class character species given by Moore (1968) are:

Drosera rotundifolia	Lepidozia setacea
Aulacomnium palustre	Sphagnum capillaceum
Calypogeia trichomanis	S.tenellum

All are present in Shetland. Jones (1973) adds Dactylorchiis maculata ssp. ericetorum from Westhoff and Den Held (1969).

Westhoff and Den Held (1969) add further species to this group, but Moore considers them characteristic of certain Orders and Alliances, and they are not listed here.

Vegetation of this Class is found throughout northern Europe and northern Russia. It extends southwards as far as the Mediterranean, but in that region is found only in alpine zones.

4.14.1.Order: ERICETALIA TETRALICIS Moore (64) 68

This Order of damp heaths on shallow peat in the Atlantic region has only one alliance, the Ericion tetralicis.

The general descriptions of each are therefore the same.

4.14.1.1.Alliance: ERICION TETRALICIS Schwick 33

These are wet heaths (Heidemoore) on shallow peat (25-100cm) with a fluctuating, but generally high, water table. They are relatively species riding compared with the communities of the Sphagnetalia, but with a reduced moss layer.

Westhoff and Den Held (1969) suggest the following as Order and Alliance character species:

Erica tetralix	+	Sphagnum compactum	+
Juncus squarrosus	+	S.tenellum	+
Gymnocolea inflata	+	Zygogonium ericetorum	

The species marked + are found in Shetland. The absence of any record of Zygogonium may indicate under-surveying of the Islands rather than its absence.

The Dutch authors further give the following differential species between the alliance and the Sphagnetalia:

Gentiana pneumonanthe		Potentilla erecta	+
Juncus acutiflorus	+	Hypnum cupressiforme var ericetorum	+
Nardus stricta	+		
Pedicularis sylvatica	+	Pleurozium schreberi	+
Polygala serpyllifolia	+	Cetraria islandica	+
		Cladonia uncialis	+

Those species marked + are found in Shetland. The alliance extends mainly along the Atlantic sector of Europe, from Denmark and North Germany to Spain, although it has occasional sub-Atlantic occurrences.

4.12.2. Order: SPHAGNETALIA MAGELLANICI (Pawlowski 28pp) Moore (64) 1968

These are the communities of ombrotrophic bogs growing on deep peat (1.5 m and deeper). It includes both hummock and hollow forming blanket bogs as well as raised bogs.

The order is characterised by the abundance of Sphagnum spp.eg S.magellanicum and S.rubellum.

Moore (1968) gives the following character species:

Andromeda polyfolia		Carex pauciflora	
Eriophorum vaginatum	+	Vaccinum oxycoccus	
Calypogeia sphagnicola	+	Cephalozia connivens	+
C.macrostachys		Mylia anomala	+
Pohlia nutans	+	Polytrichum alpestre	+
Sphagnum majellanicum	+	S.recurvum	+
S.rubellum	+		

Only the species marked + are recorded in Shetland. Westhoff and den Held (1969) add Sphagnum balticum to this list. They also propose that Eriophorum vaginatum and Sphagnum rubellum are only valid for the Netherlands, while Vaccinium uliginosum may differentiate this Order from the Ericetalia.

The Sphagnetalia is Euro-Siberian in distribution.

It is divided into two alliances, the Sphagnion fusci Br.-Bl.(1915) 1920 e.m.Moore (64)68, of regions with late snow lie where Sphagnum fuscum is prominent in the vegetation and the Erico-Sphagnion Moore (64) 1968 of Atlantic areas. Only the Erico-Sphagnion is found in Shetland.

4.14.2.1.Alliance: ERICO-SPHAGNION Moore (64) 68

The communities of this alliance are distinguished by the abundance of Erica tetralix, and the absence of Sphagnum fuscum. They form bog vegetation extending from the west of Ireland to W.Germany and S.Sweden.

As character species Moore (1968) gives:

Drosera intermedia		Odontoschisma sphagni	+
Myrica gale		Sphagnum imbricatum	
Narthecium ossifragum	+	S.papillosum	+
		S.plumulosum	+

and proposes the following as differentials between this alliance and the Sphagnion fusci:

Erica tetralix	+	Campylopus flexuosus	+
Eriophorum angustifolium	+	Hypnum cupressiforme	+
Molina caerulea	+	Leucobryum glaucum	+
Rhyncospora alba		Cladonia impexa	+

Those species marked + are found in Shetland.

4.15.Class: NARDO-CALLUNETEA Preising 49

The class is composed of the dwarf shrub, dry heaths and rough grasslands on rather acid soils in western and northern Europe. The vegetation usually forms as a result of grazing, trampling, mowing or burning of land, and the soil is mineral and nutrient poor. It may be dry to moderately damp. The class arose from the uniting of the Calluno-ulicetea Westhoff and Den Held 1969, a class of Calluna and Genista heaths of Europe, with the Nardetalia.

Jones (1973) concludes that of the character species given for the class by Westhoff and Den Held (1969) and Oberdorfer (1957) only the following are reliable for British vegetation:

Calluna vulgaris +	Hieracium pilosella
Carex pilulifera +	Veronica officinalis +
Cuscuta Epithymum	

She excludes Potentilla erecta and Sieglingia decumbens on the grounds that they can also be found on base-rich soils which do not support Nardo-Callunetea communties.

The class extends in Europe, in the Atlantic, sub-atlantic and sub-continental regions, and in an impoverished state into the continental sector. It is also found in mountainous parts of the Mediterranean region.

Various schemes of sub-division of the class have been proposed, e.g. Bocher (1943), Bridgewater (1970), Jones (1973). The scheme followed here has representatives of two orders in southern Shetland; the Nardetalia (Oberd.49) Prsg 49 and the Calluno-Ulicetalia (Quantin 35) Tx.37. Following the system of Rivas Martinez (1968), Bridgewater (1970) and Jones (1973) assign all British heaths to this order.

4.15.1.Order: NARDETALIA (Oberd.49) Prsg 49

These are the rough grasslands on acidic soils, found throughout western Europe, but not in the Mediterranean region. Jones (1973) has extracted four order character species for British vegetation from the works of Westhoff and Den Held (1969) and Oberdorfer (1957). They are:-

Antennaria dioica +
Gentianella campestris +
Nardus stricta +
Botrychium lunularia +

All are found in Shetland.

Of the four alliances recognised within the Order by Westhoff and Den Held (1969) only one is present in Britain (Jones 1973) - the Violion caninae.

4.15.1.1.Alliance: VIOLION CANINAE Schwick (41) 44.emPrsg.49

Synon: Nardo-Galion saxatilis Prsg.49

This embraces the communities of anthropogenic, heathy grasslands, which are slightly richer in nutrients, and in species, than the heaths of

this class (Jones 1973).

Its distribution is sub-Atlantic through the north-west and west of Europe, to an improverished form in east Germany and north-west Czechoslovakia.

Jones (1973) suggests the following as useful character species in Britain:

Carex ovalis +	Juncus squarrosus +
Centaurea nigra	Luzula multiflora +
Dactylorchis maculata ssp.ericetorum +	Meum athamanticum
Euphrasia borealis +	Pediculeris sylvatica +
E.nemorosa +	Polygala serphyllifolia +
Galium saxatile +	P.vulgaris +
Gentiana pneumonanthe	Viola canina ssp.canina +

Those species marked + are found in Shetland.

4.15.2.Order: CALLUNO-ULICETALIA (Quantin 35) Tx.37

This order comprises the dry, dwarf shrub heaths, on acidic and nutrient-poor soils. Its communities are maintained by trampling, grazing mowing and burning, and occur throughout sub-Atlantic and Atlantic Europe.

Jones (1973) fully discusses the complicated syntaxonomy of this order. Westhoff and Den Held (1969) recognise only the Vaccinio-Genistetalia Schubert 60, which remains when the Ulicion nanae Duvign.44 em.Vanden Bergen 58. is removed from the present order.

Oberdorfer (1957) gives the following character species:

Calluna vulgaris +
Sarothamnus scoparius
Hypnum cupressiforme var.ericetorum +

to which Jones (173) adds Arctostaphylos uva-ursi+

Oberdorfer (1957) gives a number of differentials (from the Nardetalia):

Dicranum spurium
D.undulatum
Ptilidium ciliare +

to which Jones (1973) added Juniperus communis +.

Only those species marked + are recorded in Shetland.

Bridgewater (1970) recognised four alliances within the order:

Empetrion boreale Bocher 43
Calluno-Genistion pilosae Duvign.44
Sarothamnion Tx.45 apud.Prsg.49
Ulicion nanae Duvign.44.em.Vanden Bergen 58

Only the latter alliance has been recognised in Shetland.

4.15.2.1.Alliance : ULICION NANAE Duvign.44 em.Vanden Bergen 58

This is Bridgewater's (1970) "Erica cinerea Heath", defined, rather than characterised by Erica cinerea, Calluna vulgaris and Potentilla erecta. These three species are found in Shetland, but Ulex gallii and Agrostis setacea, which Bridgewater (1970) believes are confined to this heath are not present there.

Braun-Blanquet and Tuxen (1952) describe the Alliance in Ireland. There they give Erica cinerea and Festuca vivipara as character species.

This is an oceanic heath type; Bridgewater (1970) believes its distribution is centred on the south and west of England and Wales although represented in north western and central Scotland.

4.16.Class: CARICETEA CURVULLAE Br.-Bl.48

This is a class of chionophobous heath communities, on poor soils, in mountains. Dahl (1956) follows the scheme whereby the dwarf shrub heaths of the Rhodoretalia ferruginei Br.-Bl.26, Nordh.36 are united with grass heaths within a single order, the Caricetalia curvulae Br.-Bl.26.

In view of the limited amount of vegetation of this class present in Shetland it seems appropriate to adapt this simplified approach.

4.16.1.Order: CARICETALIA CURVULAE Br.-Bl.26

Dahl (1956) also united two alliances, the Juncion trifidi scandinavicum Nordh 43 and the Loiseleurio-Vaccinion uliginosi Nordh 36, to form a single alliance comprising the heath communities over a wide altitudinal range. This alliance, the Arctostaphyleto-cetrarion nivalis Dahl 56 is found in southern Shetland.

4.16.1.1.Alliance: ARCTOSTAPHYLETO-CETRARION NIVALIS Dahl 56

This alliance embraces all chionophobous, oligotrophic to eutrophic, weakly and strongly acidophilous heath communities and has been described fully in the Rondane region of southern Norway, Dahl (1956). There is no waterlogging, or ice-cover in winter. Podsolisation is slight and humus,

if produced at all, is sandy.

Dahl (1956) gives a number of characteristic species, many of which are locally characteristic or differentiate the alliance from others not occurring in Britain. The more widespread are:

Arctuous alpinus +	Parmelia physodes +
Cesia coralloides	Sphaerophorus fragilis +
Rhacomitrium languinosium +	Haematomma ventosum
Cornicularia aculeata	Ochrelechia tartarea
C.divergens	

Those species marked + have been recorded in Shetland.

CHAPTER 5

THE PLANT COMMUNITIES OF THE SOUTHERN ISLES

5. RESULTS

As described in Chapter 3, the data for each vegetation type was displayed in the form of a computer print-out table. These are found in Volume 2.

The groups of vegetation distinguished in each of seven vegetation types are described here. Each group has been given a name which is suited to its appearance in the field. It has been attempted to fit the groups to already established associations or equivalent syntaxa, but where this was not possible the group has been assigned as a "nodum" or "variant" of an established syntaxon. This is usually at alliance level, sometimes at association level, and rarely, at the level of order or class. On some occasions the name has then been changed to avoid confusion with other syntaxa.

A synopsis of the syntaxa found in each vegetation type is the Southern Isles is given at the beginning of each of the seven sections.

For each vegetation type a similar pattern of description is followed. The vegetation type as a whole as found in Shetland, with particular reference to the Southern Isles is described. Then the appearance of each group in the field is outlined and the position of each with reference to established syntaxa is covered. Finally a comparison with the data for the Northern Isles from the contemporary study (Lewis 1976) is made.

Three vegetation types mentioned in Chapter 3, do not appear as individual types here. These are "Road-sides", Stream-sides" and 'Disturbed". It was found that such communities closely resembled groups in the larger types, particularly heath and grassland. Therefore, they have simply been described in the appropriate sections of these vegetation types.

5.1 SHINGLE COMMUNITIES

Table 5.1

5.1.1. Introduction

Shingle beaches are common in Shetland. Those sampled were all on Mainland and consisted of areas where the substrate raanged from fine gravel to beaches of large boulders, up to 0.3m diameter. All were close to sea water; the fine gravel beaches at the edges of some freshwater and brackish lochs were not included.

A common feature of the Shetland coastline is a shingle spit running across the head of voes and bays. In some places this cuts off an area of water from the sea, elsewhere it forms only a partial barrier to tidal flow, and is often associated with a salt-marsh complex. Not surprisingly then, some of the features and species of the latter type of vegetation are found along the shingle spits, e.g. Juncus gerardii at Ell Wick, releve 479.

Partly because of the paucity of species on most of the shingle areas it is difficult to define clearly the communities found. No species is characteristic or constant to all types of beach, but Festuca rubra and Poa annua occur on most sandy and gravelly beaches, while Atriplex patula and Galium aparine are found on the larger stone shingles.

Commonly associated with the communities of larger stones is a mosaic, or at times a complete mat of decaying seaweed and tidal litter. As at Melby, this may be at the base of a sea wall, or may be along the winter high water mark.

The samples from Sand Voe at the extreme north of Mainland appear to form a local variant of the shingle community while the vegetation at Boddam, South Mainland seems to be extremely localised, but closed related to the Atriplex patula communities (5.1.5)

Mertensia maritima occurs rarely on beaches throughout the islands. Samples containing it were recorded from Gluss Voe on Mainland.

The temporal aspect of colonisation of shingle beaches is not

immediately clear from these data. The species are not stable and over a period of years may change shape and position according to tidal conditions. The vegetation of group 5.1.2.1. appears to represent the extreme colonised stage in the pattern, while it may be assumed that the less species-rich releves of that group e.g.Bixter, relevé 880, have not been at such a stage for as long as, for example, the vegetation at Fitch, relevé 882.

The classification of these shingle communities proved difficult because of the paucity of clear descriptions of similar vegetation types, particularly in Britain. Adam (1976) has attempted to fill this gap, but his main work was on the saltmarshes in the areas he studied. Other authors, working on specific areas (e.g.Birks 1973; Braun-Blanquet and Tuxen 1952) have sampled only limited sites and have encountered similar problems of community identification. Gimingham (1964) provides an ecological account of maritime communities in Scotland, many of which appear in Shetland, but does not deal to any extent with their phytosociology.

Thus only one shingle community has been assigned to an existing association, the Atriplicetum littoralis (Warming 06) Westhoff and Beeftinck 50, while the rest must remain as noda until further sampling in Shetland, and a revision of the classification of the vegetation makes their affinities clearer.

Figure 5.1 gives a synopsis of the classification of shingle communities of the Southern Isles.

5.1.2. Vegetation Groups

5.1.2.1. Shingle spit community Relevés 479-881

As implied by the name given to this vegetation it is a community characteristic of the fine gravels and coarse sands which build up to form the barriers across Voes in Shetland. It also occurs on such spits at the extreme heads of voes.

The vegetation is only subject to irregular cover by the sea during winter storms or Spring tides; its rooting layer is thus more generally affected by precipitation than salt water (soil mean pH 6.9).

A shallow, sandy soil usually covers the shingle so that a good herb and moss cover develops (Herbs recorded up to 95%, mosses 5% cover). Grasses, particularly stoloniferous forms a notable component of the vegetation which is grazed by sheep, where accessible. These and the more open sites are also favoured nesting places for terns; they thus receive considerable natural encrichment in nitrogen and phosphates, viz. the occurrence of Urtica dioica at Fitch, releve 881.

Festuca rubra is constant and often dominant; also in constancy class V for the community are Sagina procumbens, Plantago maritima, Cerastium holosteioides and Cochlearia officinalis. Trifolium repens, Plantago coronopus, Agrostis tenuis, Poa annua and Eurynchium praelongum are common. The vegetation is the most species rich (13 per relevé) of all that recorded on shingle, because of its stable position away from the regular influence of tides, waves and salt-water.

Sagina procumbens occupies the bryophyte layer to the exclusion of all others except Eurynchium praelongum, Lophocolea cuspidata and Amblystegium serpens.

Relevé 693, from Burra Voe, North Mainland was taken from the vegetation on a spit between a loch and the sea. A number of species were representative of lochside communities are therefore present, e.g. Hydrocotyle vulgaris, Carex nigra, Alopecurus geniculatus.

This vegetation was recorded from five sites on Mainland, north of Lerwick. Similar vegetation was seen on the freshwater shingle beach at the eastern end of Loch of Brow, South Mainland, but where adventives from adjacent arable land and pastures were found.

This community is closely releated to the species-rich upper saltmarsh communities (5.3.2.1.1.) but lacks Glaux maritima found in that vegetation

However, in creating his new noda within the Molinio-Arrhenatheretea, Adam 1976 expects these maritime grasslands to lose the characteristic salt marsh indicators. It has been decided to assign these shingle spit communities to the Agrostis tenuis nodum recognised more definitively in 5.3.2.1.1.

That nodum is one of borderline vegetation between Molinietalia pastures and the Juncetum gerardii and parallels to the noda created by Adam (1976) for mainland Britain. Maritime influence is shown by the presence of Juncus gerardii, Amblystegium serpens, Plantago maritima, P.coronopus, Cochlearia officinalis and Armeria maritima, but the constancy of Festuca rubra, Trifolium repens, Agrostis stolonifera, A. tenuis and Anthoxanthum odoratum indicate closer affinities with the Molinietalia coeruleae. Sagina procumbens is characteristic of this order in S.Shetland.

It resembles the Carex distans - Plantago maritima Association described by Ivimey-Cook and Proctor (1966) and the Plantago coronopus - Cerastium tetrandrum Ass.Br.-Bl.& R.Tx.1952 but both these are much denser swards with constant Carex distans and Cerastium tetrandrum respectively. It is felt that these mainly cliff top communities in Ireland represent a more advanced stage in soil stabilisation and succession than the vegetation under discussion. The absence of Sagina procumbens from the Irish communities may also be indicative of this.

Relevé 693 from Burra Voe includes species of the Agropyro- Rumicion crispi Nordh. 40 em.R.Tx.50, viz: Alopecurus geniculatus and Potentilla anserina. As was mentioned earlier this was from a 'disturbed' site, however it also contains the majority of species constant to the present community and has therefore been placed within the Agrostis tenuis nodum.

5.1.2.2. Honkenya peploides community Relevés 685-687

This community is considered to be a local variant of shingle vegetation peculiar to Sand Voe.

At Sand Voe, North Mainland, a series of releves recorded on a gneiss, pebble beach appear to form a distinct community having closest floristic similarities with groups 5.1.2.

The beach here slopes considerably with a level landward portion of stones up to 0.3m diameter. These grade downwards in size towards the sea, to small pebbles, about 100mm diameter with a coarse gravel and sand between them.

It is possible that a combination of the steep slope and the extremely protective nature of the Voe allow vegetation atypical of shingle beaches to grow here.

Honkenya peploides is constant and dominant and with Festuca rubra and Potentilla anserina also in constancy class V. Cerastium holosteioides, Silene dioica, Holcus lanatus and Plantago lanceolata are also common. Cochlearia officinalis, Plantago coronopus, Agrostis tenuis and Eurynchium praelongum, are absent but the presence of Trifolium repens, Cerastium holosteioides, Festuca rubra and Plantago maritima gives it tenuous links with the shingle spit vegetation.

However the presence of Atriplex patula, Stellaria media and Galium aparine in relevé 685 indicates its relationship with the vegetation of the open boulder beaches of 5.1.2.5.

Herb cover is high, 90% on average, but no mosses were recorded at all.

This vegetation has been assigned to the Honkenyo-Crambetalia maritimae Gehu & Gehu 1969, Agropyretea pungentis Gehu & Gehu 1969. The order has only one alliance - the Honkenyo-Crambion maritimae Gehu and Gehu 1969 into which open vegetation dominated by perennials of pebbles and coarse sands on North Atlantic and Baltic coasts are assigned. Gehu and Gehu (1969) describe an association dominated by Honckenya peploides (the Honckenietum peploidis) but this does not correspond to the present vegetation since it lacks Potentilla anserina, but contains a large number of species not found here, and for the most part not recorded in Shetland.

Adam (1976) describes a Potentilla anserina nodum within this class which has constant Potentilla and Agrostis stolonifera, and where Trifolium repens and Festuca rubra are common. However the habitat of this nodum is not the same as this Shetland site and Honckenya peploides is absent.

Gimingham (1964) describes a beach in East Lothian where Honkenya increases with proportion of sand in the shingle. It would seem therefore that the sandy nature of the pebble beach at Sand Voe gives rise to a variant of the usual perennial vegetation. This has been designated a Honkenya peploides nodum.

5.1.2.3. Mertensia maritima community Relevés 482-483

Mertensia maritima was recorded at Gluss Voe, but similar vegetation without this species was recorded from Ell Wick and appears to be the same community.

Found on a medium size gravel, up to 500mm pebbles and coarse stones, the community is quite open. Herb cover is usually about 50% and mosses are absent. The plants grow within a zone which receives frequent inundation by the sea, usually above the spring high water line but below the more stable band on which the shingle spit vegetation (5.1.2.1.) can give greater cover.

An average of only 6 species per relevé were recorded; since only four releves are included it is difficult to characterise the vegetation. Festuca rubra, Poa annua, Rumex crispus and Plantago maritima are common, while Armeria maritima and Sagina procumbens occur occasionally.

This community has affinities with the shingle spit vegetation (5.1.2.1.) but the occurrence and local dominance of Mertensia distinguish it as an entity.

Vegetation containing Mertensia has been placed in the Mertensio-Atriplicetum laciniatae (Nordhagen 40) Tx.67, and in Scotland this association was recognised by Birse and Robertson (1976). These authors comment upon the disappearance of Mertensia from this community. The

Shetland data have very little in common with the three relevés described by Birse and Robertson (1976) in lowland Scotland - their data, from East Lothian, Fife and Caithness reflect the distribution of the plants found - Salsola kali and Atriplex laciniata are not found in Shetland, while Elymus arenarius and Ammophila arenaria are confined to sandier substrate than that on which Mertensia grows.

Gimingham (1964) describes the contracting distribtuion of this species and points out that it is usually found on the "pebble-wrack-sand" beaches of the north and west coasts of Scotland - this description would seem to be more typical of its Shetland occurrence. Birks (1973) found Mertensia only in the Atriplex glabruiscula-Rumex crispus Association on Skye. This is within the Atriplicion-littoralis (Nordhagen 40) R.Tx.50, a general strandline alliance. It is to this alliance that the present vegetation has been assigned. In the absence of data from other Mertensia sites in S.Shetland the community has been named Mertensia maritima nodum.

5.1.2.4. Atriplex patula community Relevés 809-096

This appears to be the typical Shetland vegetation of boulder beaches found at the landward edge of sandy bays or shingle beaches.

Pebbles and stones up to 0.3m diameter occasionally having a gritty soil filling the cracks, support a species poor and often open vegetation. Tidal drift and rotting seaweed are commonly found here. It is possible that, with further sampling, a distinction could be made between stands with only 10% cover of straggling stoloniferous herbs and those with 90% cover of one or two dominant species. At present however they have all been united by the presence of Atriplex patula, Stelleria media, Galium aparine, and the absence of Festuca rubra. Cakile maritima occurs twice in the releves, Tripleurospermum maritimum, three times and Agropyron repens, Agrostis stolonifera and Poa annua are common.

The relevé from Mail, South Mainland is distinct in that it contains the only shingle record of a number of species, e.g. Matricaria matricarioides,

Juncus bufonius and Raphanus raphanistrum. A small stream runs through the shingle at this point and it is possible that these annuals were introduced by animals visiting the stream or carried from the farmland through which it flowed.

This vegetation was recorded from 5 sites throughout Mainland and was seen on Bressay, Whalsay and Out Skerries. It was found on gneiss, schist and old red sandstone beaches; presumably the breakdown of granite does not give suitable habitats, forming gravels and sand rather than pebbles.

A further three relevés included on this table are transitional between the vegetation and that found on medium size stones c.60mm. They lack the dense cover of herbs seen on the shingle spit vegetation but are dominated by a combination of grasses, e.g.Festuca rubra, Poa annua Agrostis stolonifera, A.tenuis Agropyron repens and Anthoxanthum odoratum. The occasional presence of Stellaria media and Atriplex patula indicate the relationship between the transitional group and the open boulder Atriplex patula community. With further relevés it may be possible to distinguish a distinct community of medium gravels characterised by grasses or Potentilla anserina.

The Atriplex patula vegetation has been assigned to the Atriplicetum littoralis (Warming 06) Westhoff and Beeftinck 50. The naming species is absent from Shetland altogether, apparently being replaced on shingle by A.patula. The association is heterogenous and species poor with dominant Atriplex spp., Tripleurospermum maritimum, Sonchus arvensis, Stellaria media, Urtica dioica, Cirsium arvense, Polygonum lapathifolium or Beta maritima (Adam 1976). The latter two are not recorded in Shetland.

Westhoff and Den Held (1969) give Tripleurospermum maritimum as a character species of the alliance Atriplicion littoralis - this is common on Shetland shingle beaches. Cakile maritima has its only S.Shetland shingle records in this vegetation.

The association is not clearly defined in Britain; similar vegetation on Skye has been assigned to the Atriplex glabruiscula-Rumex crispus

Association by Birks (1973) but the habitat of that community appears to be of smaller pebbles and coarse gravels, rather than the 'boulders' encountered here.

The vegetation has affinities with the Agropyro-Rumicion crispi Nordh. 40 which has now been included in the Agropyretea pungentis Gehu et Gehu 69, as an alliance of disturbed communities, viz. the presence of Agropyron repens, Potentilla anserina and Rumex crispus, but the co-dominance of Atriplex patula, Stellaria media and Galium aparine place it in the Atriplicion littoralis. However releves 816-694 are intermediate and may be considered as a transitional group between the two classes.

5.1.2.5. Geranium robertianum community Relevés 094-099

At Boddam, on sandstone boulders at the edge of the bay, a distinct community was recorded. It is dominated by Geranium robertianum and Arrhenatherum elatius, with Rumex longifolius and Poa subcaerulea. Herb Robert occurs only at this site in Shetland, and the combination of the other three species was otherwise seen only at Haraldswick, Unst.

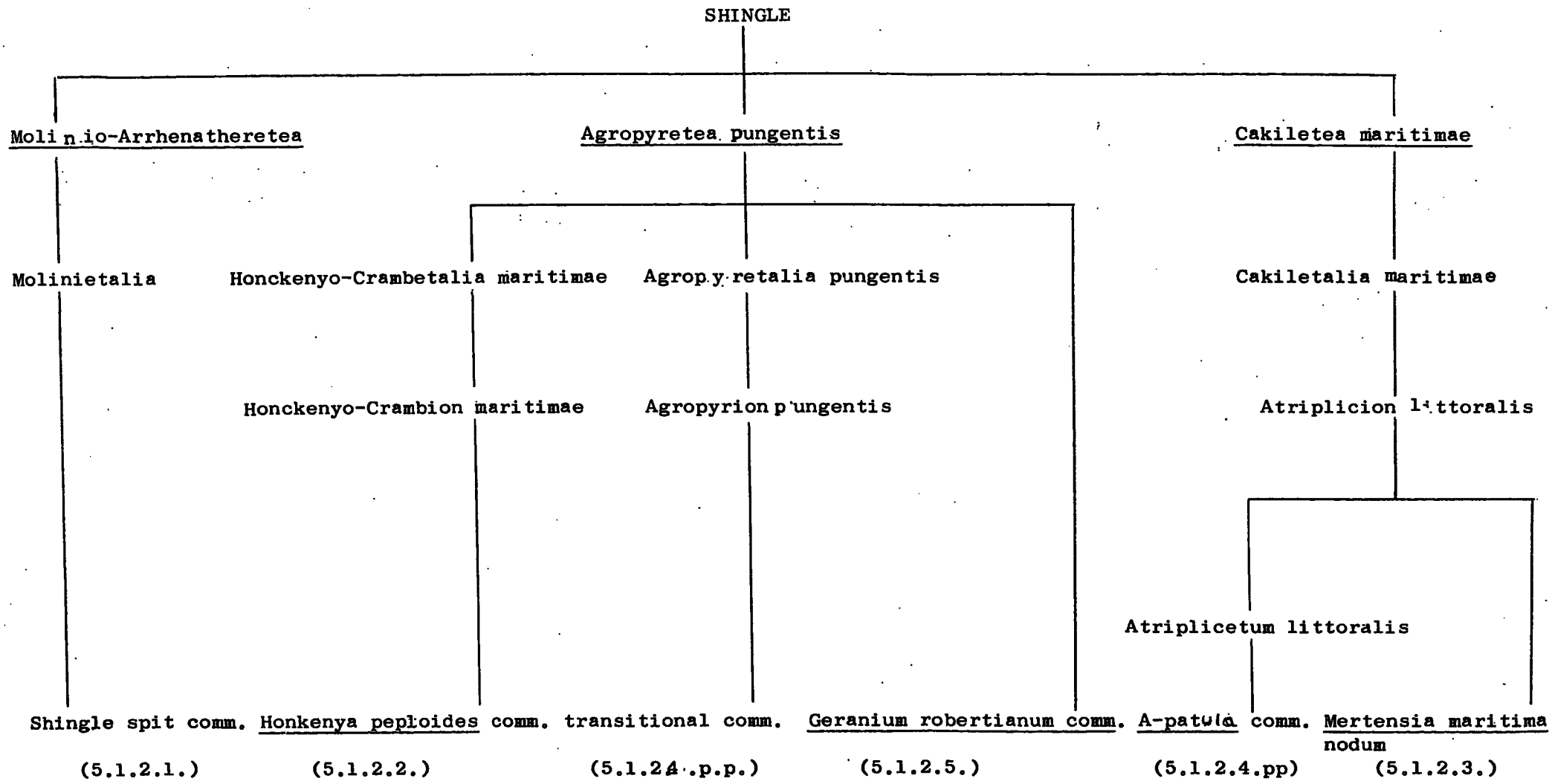
The site is well above the spring high water mark, 7m above sea level, and consists of a plateau of large rounded stone, up to 500mm in diameter, with some gritty soil in the crevices.

The vegetation is open and is probably most closely related to the Atriplex patula community although that species is only present in one relevé. Its distance from the sea separates it from other shingle groups described here.

Gimingham (1964) describes the vegetation of apposition banks, banks of shingle or stones thrown clear of the highest tides. These are often dominated, in Scotland, by stands of Arrhenatherum elatus, while Geranium robertianum "is prominent in several examples." It would thus appear that the Boddam shingle vegetation falls into this category.

The vegetation is dominated by perennials - and on this ground has been assigned to the Agropyretea pungentis. As was noted above,

FIG. 5.1 Synoptic classification of shingle communities of the Southern Isles



Agropyron pungens is not present in Shetland, but A.repens is found in this community.

In the absence of data from any similar community this vegetation can only be described as an Arrhenatherum elatius nodum within the Class. The name Geranium robertianum is not used, because of its unique Shetland occurrence here.

5.1.3. Comparison with Northern Isles

Lewis (1976) recognised only three syntaxa for shingle and boulder beach vegetation in the Northern Isles. Of these, her Festuca rubra - Trifolium repens group is essentially the same as the shingle spit community. In the Southern Isles this has been placed in an Agrostis tenuis nodum of the Molinietalia following the work of Adam (1976) on British saltmarshes and related coastal vegetation.

However Potentilla anserina, Stellaria media and Agropyron repens appear to be more widespread on the beaches of the Northern Isles leading to differences between that and the Southern vegetation.

The Atriplex patula community of the south (5.1.2.4.) is much more typical of the Atriplicetum littoralis than is Lewis' nodum related to the Atriplicetum littoralis' while her Potentilla anserina-Atriplex patula nodum in the Honkenyo-Crambion has no real parallel in the Southern Isles.

5.2.SAND DUNES

Table 5.2

5.2.1.Introduction

This term was used to embrace all vegetation samples taken on sandy substrates, ranging from the pioneer communities on open beaches exposed to the tide to dune grasslands, further inland, from which the truly maritime species are virtually absent. Although the sand content in the soil was not analysed, it was judged by eye, and wherever the substrate had above 50% sand/sand minerals content it was sampled as "sand-dune".

There are over 100 sandy beaches in Shetland (Flinn 1974) although the dividing line between fine gravel, shingle and sand may be rather arbitrary. Sandy beaches occur at the foot of cliffs, where cliffs are retreating to leave a 'bench' or at the head of shallow inlets; in both cases indicating large supplies of sand offshore. The large dunes area at Quendale fills about 1 sq.km with blown sand and has completely covered farmhouses and church on the former estate of Brow (Monteith 1633, Low 1774). This is the only fully developed dune system in Shetland, although there is an important area of blown sand at Breckin on Yell. However it is species poor when compared to British mainland dunes, lacking the attractive annuals, orchids and small shrubs, e.g. Salix spp. found usually. The other sites from which sand-dune vegetation was recorded are at Spiggie (where dune pasture forms), Ling Ness, Meil (West Burra), Mail, Bigton, Sandwick (Whalsay) and Noss. In many cases it seems that vegetation groups are localised, e.g.releves 744, 750 from Quendale, because of the limited distribtuion of dune vegetation.

The development of dunes and dune slacks is fully described in a series of papers by Ranwell (1959,1960). The progression is seen, in a modified form at Quendale. Climate restricts the presence of annuals, e.g.Ononis repens, Artemisia vulgaris, but the overall increase in Festuca rubra and Agrostis tenuiscover at the expense of Ammophila is found here.

In slacks, a continuum along a wet-dry gradient is suggested - this would be endorsed by the Quendale slacks data.

Machair is a type of dune pasture (often calcareous) subject to local cultivation developed in wet and windy conditions in the north and north-west of Scotland (Ranwell 1974). It requires rainfall of 1016mm or more per annum with temperate climate, and is managed, often intensively, by crofters. It requires a highly calcareous sand and produces a lime-rich soil. Machair does not appear to form in Southern Shetland, probably because the shell content is not high enough (Flinn 1974) while there is no management of dune pasture by the Shetlands.

Vose, Powell and Spence (1956) describe 'machair' grazings from the Inner Hebridges. Their definition does not concur with that given by Ranwell (1974) and their vegetation more closely resembles general dune pasture and dry grassland.

A synopsis of the classification of the sand-dune vegetation of the Southern Isles is given in figure 5.2.

5.2.2. Vegetation groups

5.2.2.1. Sand Pioneer vegetation — Relevés 761-807

Within this description lie the three communities found on sandy beaches and at the seaward, or mobile, side of sand dunes, and characterised by the presence of *Elymus arenarius*.

They are poor in species (mean 6 per relevé) being composed of those specially-adapted grasses or higher plants that can tolerate the extreme conditions of their habitat. The species must be able to survive strong winds carrying sand, storms, and the occasional winter submergence of high tides. Thus, stoloniferous and creeping species, such as *Potentilla anserina*, *Agrostis stolonifera*, *Elymus arenarius* and *Agropyron repens* are found with xeromorphic species such as *Cakile maritima* and *Atriplex patula*.

All such pioneer communities on sand with *Ammophila* and *Elymus* are placed in the class *Ammophiletea* Br.-Bl.et Tx.43. This includes pioneer

dune and beach vegetation.

5.2.2.1.1. Open, beach community Relevés 761-808

Only three relevés were recorded from this vegetation group although it was seen on a number of sandy beaches, throughout the Southern Isles.

It is the community of the beach at Quendale and at Mail, South Mainland, and is characterised by the constancy of Cakile maritima and Atriplex patula. Elymus arenarius was recorded once, and Ammophila twice, but the species content is so low (4 per relevé) that it is difficult to define the community.

It is open, with scattered, straggling plants, and grows directly upon sand. It would seem that it can develop into either of the following pioneer communities. (5.2.2.1.2. or 5.2.2.1.3). If wind and tidal conditions favour dune formation, as at Quendale and Spiggie, the Elymus-Festuca dunes form, whereas on open sandy shores with sheep or human interference, the disturbed Elymus community is found.

This community has been assigned to the order Elymo-Ammophiletalia arenariae Gehu et Gehu 1969, and within this the Agropyrion boreoatlanticum Gehu et Gehu 1969, an alliance consisting the vegetation of the first stages of succession on sand. The characteristic species, Agropyron junceiforme ssp. boreoatlanticum was not recorded. Palmer and Scott (1969) describe the species as "rather local" in Shetland, possibly reflecting only the localised nature of the sandy beaches. Cakile maritima is constant to this southern Shetland community indicating some affinity with the Cakiletalia maritimae.

It is however a companion species to the Elymo-Agropyretum junceiformis R.Tx.55 (Gehu et Gehu 1969) the association with which this community has closest affinity. The link with pioneer communities of shingle was noted by Birks (1973) on Skye, where Cakile was present in fore-dune communities which he placed in this alliance.

Birse and Robertson (1976) assign their pioneer sand communities to the older order, Ammophiletalia arenariae Br.-Bl.(1931)1933. It is not possible, with the limited data presented, to fully compare their Scottish community with this Shetland one. It appears, however, that the importance of Agropyron junceiforme and Ammophila in the Scottish open sand communities represents a significant difference to this. The Shetland community has been named a Cakile maritima -nodum within the Elymo-Agropyretum junceiformis R.Tx.55. Gehu et Gehu indicate that this association of beach strips can have many phases due to the dynamic state of the succession, including an initial form with representatives of the Cakiletalia. It would seem that this is the phase found in the present group.

5.2.2.1.2. Elymus-Festuca dunes Relevés 798-795

Only four relevés of this type of pioneer dune were recorded, from Spiggie.

Elymus and Festuca rubra are co-dominant while Plantago lanceolata Sonchus asper and Ammophila arenaria are frequently found.

This is an intermediate stage between open, beach communities (5.2.2.1.1) and the Ammophila-Cirsium arvense dunes (5.2.2.2.1.). It occasionally contains Plants such as Trifolium repens and Galium verum found on better developed grasslands as well as the pioneers such as Cakile maritima and Agropyron repens.

The mosses Camptothecium lutescens and Bryum capillare were recorded here.

Herb cover is quite high, up to 70%, with bryophytes covering about 30% ground area. All the releves collected were on gently sloping dune sides, but with the limited data it is not clear how relevant this is to the development of the community.

The overwhelming frequency and dominance of Elymus arenarius in a relatively closed turf indicates that this community (and the following one)

should be included in the Elymo-Ammophiletum arenariae Br.Bl.et DeL.36, in the alliance Ammophilion borealis. Gehu & Gehu (1969) describe this association from the seaward slopes of dunes and once again indicate that many phases may be found. It appears that these lists represents a later stage in the succession, when mosses and higher plants, e.g. Galium verum, Plantago lanceolata, more typical of dune or sandy grasslands, appear.

Birse and Robertson (1976) describe similar vegetation in Scotland. This however seems to represent a slightly later stage in succession where Ammophila arenaria replaces Elymus to a greater extent. They assign their data to the same association, in particular to the subassociation with Festuca rubra.

.2.2.1.3. Disturbed sand community Relevés 2796-807

It is possible that this group covers more than one community, but the five relevés linked by the constancy of Potentilla anserina and dominant Elymus or Honkenya peploidis have been left as one type. This is a vegetation of the early stages of succession, between the open beaches and disturbed sandy grassland. The disturbing agency may be man or animal. At Sandwick, Whalsay this vegetation was found on a sloping, sandy bank which was eroded and slipping away due to wind and human trampling.

The sand is often gritty and mixed with soil, giving it a lower mean pH than the other sand communities (pH 7.2). Only Potentilla anserina occurs in all releves, but Agrostis stolonifera, Elymus arenarius, Festuca rubra and Honkenya peploidis are in three or more releves. Although the mean species number per relevés is only 7, a diverse list of species is recorded from all sites, indicating the heterogeneous nature of the community. Species having only single occurrences include Atriplex patula, Silene dioica, Poa subcaerulea, Rumex acetosa, Stellaria media, Agropyron repens Arrhenatherum elatius, Angelica sylvestris and Urtica dioica.

The heterogeneous nature of this community makes it difficult to place

with certainty in any established nodum. With further data, particularly from sites disturbed by human influence such as the one at Whalsay, it may be possible to create a new association. At present however the community has been named a Potentilla anserina nodum of the Elymo-Agropyretum junceiforme. The nodum has affinities with the Agropyro-Rumicion in the prominance of Potentilla anserina and Agrostis stolonifera, with Agropyron repens and Stellaria media. However the constancy of Honkenya peploidis, Atriplex patula and Elymus arenarius seem to indicate slightly closer links with maritime pioneer communities. It is possible too, that in Shetland, where Agropyron junceiforme seems to be under some distribution pressure and not occurring as widely as its Atlantic distribtuion might predict (Goode 1974), Festuca rubra or Agropyron repens may replace the species.

5.2.2.2. Ammophila dunes Releves:-53-757

These communities are those of dunes in the later processes of stabilisation. They are characterised by the dominance of Ammophila arenaria with Festuca rubra and Trifolium repens in a moderately dense, tall sward.

They are all found behind the main sand ridge next to the sea and develop, landwards into the dune grasslands described later (5.2.2.3).

Two types or stages have been distinguished, although in such a seral development it would probably be possible to recognise more stages if more data had been collected.

Common to both types are F.rubra, Cirsium vulgare, Trifolium repens, Ammophila arenaria, Plantago lanceolata and Poa subcaerulea. The first, Ammophila - Cirsium arvense community, is found nearer the sea in less stable areas. It is differentiated from the second, Ammophile -Bryophyte community, by the presence of Cirsium arvense and the virtual absence of bryophytes. Ammophila appears to remain an important factor in dune grassland vegetation to a much later stage and further inland in dunes, than in described sites. Gimingham (1964) attributes this to the constant deposition of blown sand in exposed dune systems.

5.2.2.2.1. Ammophila-Cirsium arvense community Releves 153-800

This stage of development of grassland on dunes was recognised at many sites and appears to be a widespread and characteristic community.

Spikes of Marram, Festuca rubra and thistles (Cirsium arvense and C.vulgare) form a tall vegetation type, up to 1m in most places, with an "understorey" of Trifolium repens, Agrostis stolonifera, Plantago lanceolata, Bellis perennis, Achillea millefolium and Poa subcaerulea. Cover is about 70% in the herb layer. Bryophytes are uncommon; the only record for the survey of Tortula ruraliformis was made in this community (Releve 998, Noss). The rooting substrate is and rather than sandy soil, mean pH 8.5.

In places the vegetation is subject to disturbance by man (Ninian, releves 153,152), sheep and rabbits. This could account for the occurrence of Potentilla anserina, Agropyron repens and Agrostis stolonifera.

The two releves from Spiggie (800,801) are clearly related to this group but transitional to the next, i.e. intermediate in development to a closed herb and bryophyte layer. They contain Brachythecium rutabulum Rhytidiadelphus triquetris, Euphrasia agg and Lotus corniculatus, all more typical of the later stage.

This community lies between the dune communities of the Ammophiletea and the closed grasslands of the Molino-Arrhenatheretea. (The Festuca-Brometea appears to be absent from most of Scotland (Shimwell 1971a) because of the lack of suitably base-rich soils and high rainfall.)

Its affinities to the Ammophilion borealis are suggested by the constancy of Ammophila and Cirsium arvense but the stablised nature of the sands suggest that the community lies beyond the scope of that class. Birks (1973) tentatively assigns very similar "grey dune turfs" on Skye to the Ammophilion. These share with the Shetland community the presence of Achillea millefolium, Lotus corniculatus, Bellis perennis and Festuca rubra while Ammophila is absent and it would appear that they represent a stage of succession even further from the Ammophilion than the present data.

The community in Southern Shetland has been assigned to the Galio-Koelerion (R.Tx.37) Den Held & Westhoff 1969 nom nov.

The position of this alliance is discussed in Chapter 4.6 and is here considered within the class Koelerio-Corynephoretea and order Festuca sedetalia . Of the characteristic species for the Galio-Koelerion given by Westhoff and Den Held (1969), only Festuca rubra (possibly var.arenaria) and Galium verum are recorded in the present community. Although the distribution of the alliance is atlantic, many of the character species have more southerly distributions in Britain and hence do not extend to Shetland, e.g.Asparagus officinalis var prostratus, Helianthemum nummularium ssp.ovatum.

Ivimey-Cook and Proctor (1966) place the grey dune communities of the Burren region into the Koelerion albescentis Tx.37(synonymous with the Galio-Koelerion) distinguishing them by the dense Festuca rubra cover with Lotus corniculatus, Thymus drucei and Koeleria cristata. (The latter species is not recorded in Shetland.) However, it is felt that the present Shetland vegetation is not as well developed as these Burren stands.

Birse and Robertson (1976) describe an association of fixed dunes on hyperoceanic coasts, the Euphrasio-Festucetum arenariae Gehu et Tx.MS., differentiated from a more easterly association by Euphrasia spp, Viola tricolor ssp.curtisii, Gentianella campestris, Bellis perennis and Ranunculus acris. These species, with the exception of the unrecorded Viola, are found in the present vegetation, while Ammophila was noted in 2 of their 3 releves. However, it is felt that with such little comparative data, with the overwhelming dominance of Ammophila, and the presence of Poa subcaerulea, Cirsium arvense and C.vulgare it is not possible to place the Shetland vegetation in the association.

Randall (1972) describes a "stable dune" in which the following species have greater than 80% frequency:

Ammophila	100%	Carex arenaria	100%
Festuca rubra	98%	Galium verum	94%

Ranunculus acris 88% Trifolium repens 82%

This is similar to this Ammophila community except for the important part played by Carex areneria and Galium verum - these two species appear to indicate the more stablised nature of this vegetation on the Monach Isles. It may also be that the Shetland dunes are sufficiently heavily grazed by sheep and rabbits to impede growth of herbs such as those, while favouring grasses such as Poa subcaerulea, Agrostis stolonifera and A.tenuis.

Until a full phytosociological study of machair and sandy grasslands in Britian is made it will be difficult to define stages in their development.

The present vegetation has been named an Ammophila-sociation of the Galio-Koelerion.

5.2.2.2.2. Ammophila-bryophyte community Relevés 758-750

This community occupies the more central parts of the dune system at Quendale, being a vegetation of stablised sandy soils. It merges with the dune grasslands (5.2.2.3.) to the landward, and with the Ammophila-Cirsium arvense community on the less stable sandy slopes.

It has dense bryophyte cover, mean 70% particularly Rhytidiadephus squarrosus, R.triquetris, Hylocomium splendens and Brachythecium rutabulum. These four species differentiate it from the previous community. It differs also in the virtual absence of Agrostis stolonifera, Cerastium holostioides, Achillea millefolium and Cirsium arvense and the presence of Euphrasia agg. and Lotus corniculatus. Ammophila arenaria becomes the sole dominant grass at the expense of Festuca rubra and Agrostis stolonifera.

The mean soil pH is 8.1 and the ground is usually damper than for that of the latter group - hence the development of a bryophyte layer, also encouraged by the reduction in blown sand brought by increasing plant cover.

The two relevés 744 and 750 have been included here since they appear to be transitional between this vegetation and the dune grasslands (5.2.2.3.). Ammophila and the bryophytes are very much reduced in cover,

while the flowering herbs such as Euphrasia agg., Lotus corniculatus and Trifolium repens are present. In addition, however, these examples contain a wide variety of species not recorded elsewhere on the dunes, viz: Solenostoma triste, Gentianella campestris, Peltigera canina, and Aira praecox. Thymus drucei, Linum carthaeticum and Viola riviniana have only single other records elsewhere.

Many of the remarks made on the previous community and the difficulties of classifying such a dynamic community, apply to this vegetation. However with increased stability of the substrate it seems that more-regularly occurring groups can be distinguished, and this community can be placed in an association erected for Irish dune grasslands, the Viola curtisii-Syntrichia ruralis Association Br.-Bl et Tx.52. This is a moss rich vegetation, characteristically having Syntrichia (= Tortula) ruralis, Viola curtisii and Cerastium tetrandrum. Although none of these species found in present community, some of the character species of the subassociation with Peltigera canina viz: Peltigera canina, Euphrasia spp., Rhytidiadelphus squarrosus, R.triquetris, Thymus drucei and Prunella vulgaris are.

Ammophila, Plantago lanceolata and Trifolium repens are common companion species.

Braun-Blanquet and Tuxen (1952) give the following as order and alliance character species:

Galium verum var litorale
Lotus corniculatus subvar crassifolius
Festuca rubra ssp.eu-rubra subvar.pruinosa
Aira praecox
Sedum acre
Vulpia bromoides

The last is not recorded in Shetland, while Sedum acre is found only in South Nesting limestone grasslands. Aira praecox is present in the two transitional relevés. None of the first three mentioned were identified to such detail in the present survey, but Galium verum, Lotus corniculatus and Festuca rubra are all common in this Ammophila-bryophyte community.

Ivimey-Cook and Proctor (1966) also recognise this association near the Burren. They suggest that the more recently developed grasslands lie in the variant with Camptothecium lutescens of the Peltigera canina subassociation, since these are species poor and on skeletal, and probably, therefore, leached substrate.

Gimingham (1964) recognises a Rhytidiadelphus triquetris facies of the fixed dune vegetation at Quendale, but gives no further data.

It would appear then that of the present group, the first six relevés (758-757) are in the aforementioned variant, while the transitional relevés, 744 and 750, represent the better developed variant with Ditrichum flexicaule.

5.2.2.3. Sandy grasslands — Relevés 994-135

These grasslands develop on sand or sandy soil, but do not contain the more characteristic maritime species found in the former groups, e.g. Ammophila, Elymus arenarius or Carex arenaria. They are found on more or less level ground, at the landward edge of beaches and dune systems and are closely related to the dry grassland communities which they separate from the dune communities.

Only five relevés were recorded in this group, from two sites, Noss and Meil, West Burra. At both places the grassland was subject to sheep grazing and trampling by people. The latter was more noticeable at Meil where the picturesque beach attracts a large number of people. These releves were recorded close to the beach and to the path down to it.

The vegetation is formed of a dense low, grazed sward in which Plantago lanceolata, Festuca rubra and Bellis perennis are constant and co-dominant. Achillea millefolium, is also constant, while Cerastium holosteoides and Holcus lanatus are common, but of only low cover.

Bryophytes have little prominence, the well-drained sandy substrate would appear to be too dry for their success.

These grasslands have been placed in the Cynosurion cristati Tx.47. Although they are clearly not good examples of pasture in Shetland,

intensive grazing has led to the development of an array of low grasses, e.g. Festuca rubra, Poa subcaerulea, P.annua, Agrostis tenuis and Holcus lanatus with Trifolium repens, Plantago lanceolata, Bellis perennis and Ranunculus acris. All are species adapted to constant grazing pressure. The Irish character species for the alliance given by O'Sullivan (1965) are:

Trifolium repens
Cynosurus cristatus
Senecio jacobea
Phleum pratense

The last two are rare in Shetland; Cynosurus occurs in one relevé here, and Trifolium repens is common on all the sandy grasslands described. He also gives Lolium perenne, Achillea millefolium and Cirsium arvense as differentials from the Arrhenatherion. Of those, only Achillea millifolium is recorded here. It is found in most of the sand communities, recorded, reflecting the well drained nature of the substrate, but does have its optimum in the present type of vegetation.

Galium verum is occasionally present, and this would seem to link the vegetation with the communities of the Galio-Koelerion, adjacent to which they often lie.

The optimal development of Achillea millefolium here leads to the description of this vegetation as an Achillea nodum.

5.2.2.4. Disturbed sandy grassland Relevés 112-811

The four relevés of this community are linked by the disturbed or borderline nature of the vegetation. It is not a clearly defined group. Festuca rubra, Potentilla anserina and Agrostis stolonifera are constant but a large number of species are found in different pairs of relevés, e.g. Agrostis tenuis, Rumex acetosa, Stellaria media, Cerastium holosteoides and Poa subcaerulea. This broad spectrum indicates that more than one community may be present. However all are linked by the dominance of Potentilla anserrina and the presence of stoloniferous grasses, e.g. Agropyron repens.

The rooting substrate is usually a sand/stone mixture; all these sites are on old red sandstone bedrock, but with such limited data it is not possible to tell how important this is to the development of the community.

The resulting vegetation is quite open - about 70% herb cover with no bryophytes recorded, and subject to heavy sheep and rabbit grazing.

It is related to the communities of shingle beaches (see relevé 811) but appears to be a more stablised form. However, the occasional presence of Rumex crispus, R.longifolius and Stellaria media indicate the disturbed nature of the habitat. At Noss and Ling Ness this is probably due to trampling by sheep, but the site at Melby is close to the seawall and, presumably, liable to the effects of storm tides.

By its habitat and ecology this disturbed community must be at a borderline, and this appears to be between the pioneer dune communities with Ammophila and Agrostis stolonifera, ... the grasslands of the Galio - Koelerion, and the Cynosurion pastures described above.

Within the Agropyro-Rumicion crispi Nordh.1940 em.R.Tx.1950 this gradient from unstable, maritime influence to stable, non-maritime features can be encompassed. The alliance character species (Westhoff and Den Held 1969), Potentilla anserina, Ranunculus repens and Agropyron repens are common. Agrostis stolonifera, a species with affinity to this alliance is constant to the present community.

The association Poo-Lolietum D.M.de Vries et Westhoff n.n.apud A. Bakker 1965, is characterised by a combination of Lolium perenne, Poa trivialis (in Shetland replaced by P.subcaerulea). P.pratensis, Trifolium repens, Ranunculus repens, Taraxacum sect Vulgaria pro max.P and Plantago major. Plantago major and Poa pratensis are not common in Shetland but all the other species in the list are frequent in the present community. Westhoff and Den Held (1969) describe the species-poor nature of this association and its affinity with the Arrhenatheretalia.

On the data of only four releves it is difficult to place this community more than tentatively within the association.

5.2.2.5. Dune slacks — Releves 743-746

As noted earlier, the only full development of dunes in Shetland is found at Quendale, and hence the releves represenative of slack vegetation all come from that site.

These communities, on damper, less well-drained part of dune vegetation, have constant, and occasionally dominant, Agrostis stolonifera.

Two distinct groups have been recognised here, although it would seem that with further sampling a number of variants of the first, Galium palustre, community could be defined according to the different dominant species combinations.

5.2.2.5.1. Galium palustre community — Releves 743-754

This is the community of the wettest part of the dune slacks, although the high proportion of sand in the soil should enable it to be relatively well-drained for most of the year. At the time of sampling, July 1974, the ground was damp to dry.

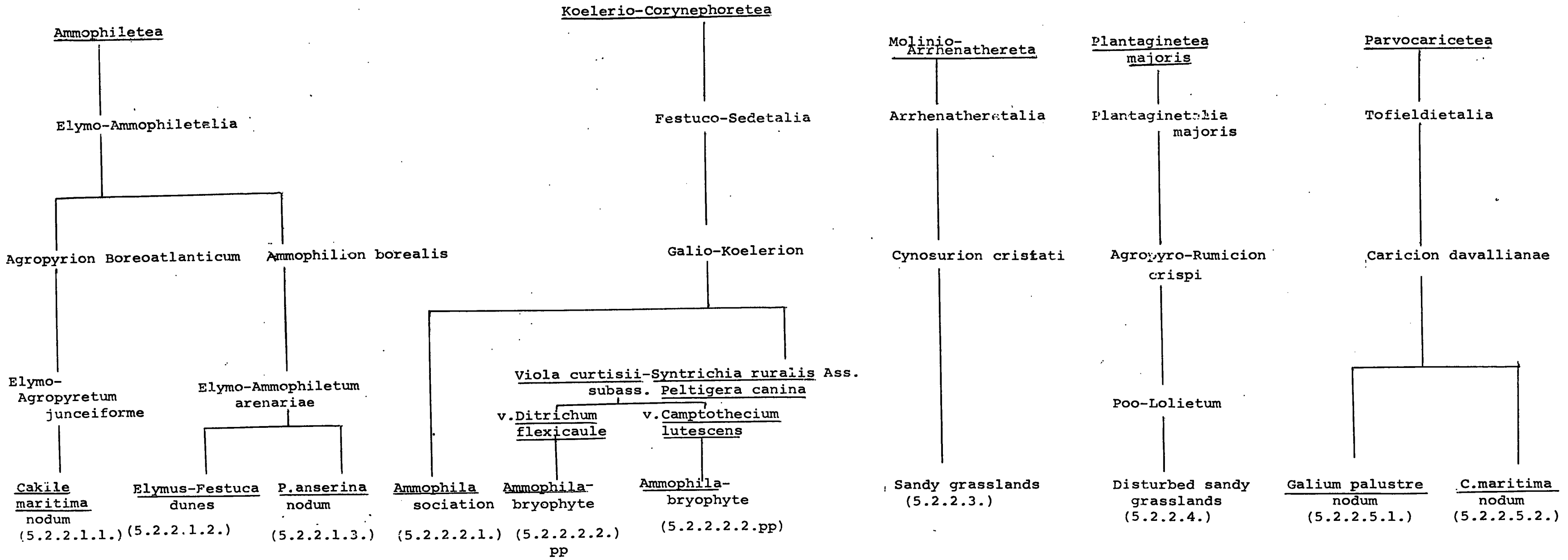
The vegetation consists of a mosaic of a low number of herbs and bryophytes (mean 9 species per relevé) which form an almost closed carpet (herbs $< 90\%$, bryophytes $< 80\%$).

Agrostis stolonifera is constant to the community - this is a species tolerant of anaerobic soil conditions in pastures, and here may be indicative of soil waterlogging in winter. Similarly, Galium palustre, Carex nigra, Cardamine pratensis, Acrocladium cuspidatum and Drepanocladus aduncus are typical marsh or fen species having regular appearances in this community. Conversely Achinllea millefolium is absent; this species favours well-drained soils.

This community can be distinguished from the following slack vegetation by the presence of Galium palustre and the absence of Cerastium holosteoides, Bellis perennis and Plantago maritima.

It is characterised by the dominance of varied species combinations,

Fig. 5.2 Synoptic classification of sand-dune communities of the Southern Isles.



the Caricion davallianae. Galium palustre is normally a species of the Magnocaricion - its presence here is presumably indicative of the mesotrophic nature of the water supply.

Randall (1972) describes a "peaty sedgeland" with Carex nigra and Holcus lanatus, but this grows on accummulated organic matter derived from Carex arenaria pastures - a stage not recorded at Quendale.

The two communities have been named thus:

5.2.2.5.1. Galium palustre nodum

5.2.2.5.2. Carex maritima nodum

within the Caricion davallianae.

5.2.3. Comparision with Northern Isles

It is perhaps notsurprising that there are several differences between the two sets of data, when the limited types of sandy substrates sampled is considered. Most of the Southern Isles releves were collected from the dune system at Quendale, for which there is no Northern Isles equivalent. Conversely, the largest area of true machair in Shetland is at Breckin on Yell; no similar data were collected in the south.

The pioneer communities of open sand appear similar throughouth Shetland. The Elymo-Agropyretum junceiforme is well represented, although a Potentilla anserina and Agrostis stolonifera dominated ~~the~~ community assigned there by Lewis (1976) has been placed in the present work in the Agropyro-Rumicion crispi (see 5.2.2.4.).

The links community at Spiggie and similar areas were assigned to the Galio-Koelerion because of their intermediate nature and possession of a number of sand-dune species e.g. Ammophila arenaria (5.2.2.2.1.). Corresponding vegetation in the Northern Isles appears to represent a more developed machair stage, much closer to the closed grassland and has accordingly been placed in the Festuca-Brometea. It is possible that some of the releves assigned to the Camptothecium-Ass peruletum cynichae-Carex areneria sub-association by Lewis (1976) could equally well lie in the Galio-

Koelerion on present information. This applies particularly to those lacking Plantago maritima, Prunella vulgaris, Holcus lanatus, Leontodon autumnalis, Carex arenaria and Viola riviniana which closely resemble those described in an Ammophila sociation in the Southern Isles.

The Rumex acetosa variant of the Lolio-Cynosuretum is not found in the south, while the dune slack communities are not recorded in the Northern Isles.

5.3 SALTMARSH

Table 5.3

5.3.1. Introduction

Areas of salt-marsh are of only a limited extent in Shetland, confined to small patches at the heads of voes. Many of the species characteristic of saltmarsh in mainland Britain, e.g. Halimione portulacoides, Spartina townsendii and Limonium spp. are absent from the islands altogether, while others, such as Spergularia marina and Salicornia sp. are found only infrequently. The latter species is not recorded in the Southern Isles at all (Palmer and Scott 1969)

Saltmarsh data was collected from 10 sites: Burra Voe, Tresta Voe, Ness of Bixter, White Ness, Colla Firth, Dales Voe (North), Bridge of Fitch, Ell Wick, Vidlin Voe and Gluss Voe. All these sites are on Mainland. Small areas of saltmarsh occur on Bressay and Whalsay.

Festuca rubra, Plantago maritima and Armeria maritima are highly constant to saltmarsh vegetation at all levels.

This is different to the situation in mainland Britain, where Festuca rubra does not usually extend in such abundance into the lowest saltmarsh regions. In those areas Puccinellia maritima usually becomes constant or dominant, but in Shetland this species is local.

The classification of the saltmarshes follows, predominantly, the system proposed by Adam (1976) following an extensive survey of this vegetation in Britain. However only a small number of the taxa he recognised appear to be present in Shetland; this seems a further illustration of the unique nature of these northernly saltmarshes.

5.3.2. Vegetation Groups

5.3.2.1. Upper Salt-marsh Communities Releves 473-537

Two types of community have been distinguished under this general name, to embrace all that vegetation which is not as directly affected by salt water inundation, but lies within the area recognisable as marsh by its floristic characteristics.

The first, species-rich, community is found at the inland boundaries of the saltmarshes with shingle, grassland and heath communities, and is thus rich in species more typical of them. The second, species-poor, vegetation is that of the vertically higher, parts of the marshes in the centres of the hummocks between lagoons and channels, which are rarely submerged.

Of Constancy V to all this vegetation are Fesuca rubra, Plantago coronopus, and P.maritima, while Armeria maritima, Glaux maritima, Agrostis stolonifora, Juncus gerardii Sagina procumbens, Cochlearia officinalis and the moss Eurynchium praelongum are all very common.. These four latter species are found only here and occasionally in the flushes with Eleocharis quinqueflora (5.3.2.2) and may be used to distinguish this type of vegetation from other saltmarsh groups in S.Shetland. The absence of Triglochin maritima, found in other higher saltmarsh vegetation, is a further diagnostic feature.

The two communities may be usefully separated floristically on the presence of Agrostis tenuis A.stolonifera Anthoxanthum odoratum or Nardus stricta in the species-rich groups, and their absence from the species-poor regions. However, the two vegetation types are spatially well separated and were not confused in the field. The presence of the grasses of pastures (Agrostis tenuis A.stolonifera, Nardus stricta, Anthoxanthum odoratum and Holcus lanatus) appear to be indicative of the lack of salt-water impact on the vegetation.

Festuca rubra and Puccinellia maritima were the only other grasses recorded in saltmarsh vegetation in Southern Shetland.

.3.2.1.1.Species-rich community of upper saltmarsh Releves 473-567

The mean number of 14.7 species per releve was the highest recorded for saltmarsh vegetation in the present study, and is, it seems, indicative of the borderline nature of the vegetation. It is, however, regarded as a distinct community found typically at the edges of the marsh. A second habitat is along raised spits of fine silt that cut across the voes

between the saltmarsh area and the sea. This was seen at Bixter and Colla Firth (see also 5.3).

The vegetation is not submerged by the summer tidal pattern, but may be during winter and spring tides. It may be grazed quite intensively by sheep, according to its accessibility; this was noted at Bridge of Fitch, White Ness, Bixter and Colla Firth.

Characteristically, a dense mat of Festuca rubra and Plantago maritima is interrupted by clumps of Armeria maritima with low spikes of Agrostis tenuis, A. stolonifera and Juncus gerardii, Sagina procumbens is prominent in the "moss" layer, where Eurynchium praelongum, and Rhytidiadelphus squarrosus are also common. Glaux maritima, found throughout the saltmarshes is only occasionally found here.

The moss Leptodictyon riparium has its only record in this survey in this vegetation (relevé 567), while relevé 473, from Ell Wick includes the lichen Leptogium tremelloides.

Herb cover is generally high - 80-100% (including Sagina procumbens) while bryophytes cover approximately 30%. The soil is a dark, soft silt with mineral particles and roots. In sites near the shore fine gravel may be mixed. Mean pH is 6.2

This vegetation was recorded from all sites except Dales Voe (North) and Gluss Voe.

Upper saltmarsh vegetation generally is referred to the Armerion maritimae Br.-Bl.De Leeuw 36. Armeria maritima, Festuca rubra, Glaux maritima, Juncus gerardii and Agrostis stolonifera are character species (Westhoff & Den Held 1968) which are all present in this community.

A number of different noda can be identified within this group.

Adam (1976) assigns saltmarsh vegetation with Juncus gerardii, Agrostis stolonifera, Festuca rubra, Glaux maritima and Trifolium repens to a sub-association with Leontodon autumnalis Raabe 50 of the Juncetum gerardii. He uses Trifolium to differentiate the sub-association from the

Festuca-Glaux nodum. Leontodon autumnalis is common. It appears, then, that relevés 862 and 473 should be placed in this taxon.

However vegetation of the borderline between saltmarsh and meadow has not been previously studied and Adam created a number of new noda within the Molinietalia caeruleae Koch 26 to embrace those communities found close to the shoreline and under some effects of sea-spray but lacking the full complement of saltmarsh character species. At the same time however, they do contain a number of the character species of this damp grassland order.

The two relevés 889, 874 containing Juncus effusus fall within this Holcus lanatus - Juncus effusus nodum. Juncus gerardii, Triglochin maritima, Armeria maritima and Glaux maritima are absent from both.

The remaining relevés in the community do not identify directly with any suggested by Adam (1976) and have accordingly been placed in a new nodum - the Agrostis tenuis nodum, of the Molinietalia. They are clearly intermediate between this order and the Juncetum gerardii.

The high constancy of Festuca rubra, Plantago maritima, Agrostis spp., Rhytidiadelphus squarrosus, Eurynchium praelongum and Sagina procumbens are all characteristic of the order in S.Shetland. Saltmarsh species, although present, do not have the prominence they achieve in lower communities, e.g. Juncus gerardii, Triglochin maritima, Armeria maritima.

No comparable description can be found for this community.

It resembles the Plantago coronopus - Cerastium teteandrum Ass.Br.-Bl. et Tx.1952, but contains more Molinio-Arrhenatheretea species than that vegetation, at the same time lacking Cerastium tetrandrum, Carex distans and Silene maritima, which are constant to the Irish community. It is also related to the "Plantago sward" described by many authors, (incl. Praeger 1911, Barkley 1953) on cliff tops, but these lack Glaux maritima and Juncus gerardii.

It appears that this type of vegetation has been considered fragmentary or borderline in many investigations. However, it is felt that the indication by Adam (1976) that similar "borderline" noda can be clearly defined, justifies the inclusion of this community in the Molinio-Arrhenatheretea.

5.3.2.1.2. Species-poor Community of Upper Saltmarsh Relevés 475-537

This vegetation has a mean of 8.3 spp./relevés and, as was mentioned earlier, if found on the raised parts of saltmarsh which are only submerged during winter flooding, even though they may lie close to the sea.

Plantago coronopus, P.maritima and Festuca rubra form dense sward in which Glaux maritima and Juncus gerardii ar constant. Plantago maritima is usually dominant, but co-dominants can be Festuca, Plantago coronopus or Glaux. Other species at all common are Armeria maritima, Agrostis stolonifera and Cochlearia officinalis. Bryophytes are rare-usually Campylium polygamum, Amblystegium serpens or Eurynchium praelongum - with only fractional cover value. Herb cover is high - 95% - 100%.

Occasionally (e.g.relevé 499) the fucoid stage of an alga is found, linking this vegetation with those zones closer to the effects of the sea (5.3.2.4. - Spergularia marina community or 5.3.2.5. - algal communities). The soil is one again a dark, soft silt with roots and fine gravels. At Ell Wick, this was only 50mm deep formed over a coarse gravel.

Mean pH of the rooting layer is 7.3, the higher pH indicating the greater effect of salt-water on this vegetation than in the last.

This community was recorded from all sites except White Ness (where the centre of the saltmarsh was covered in vegetation unique to that site), Burra Voe and Colla Firth. It is possible that the lower or more exposed nature of these saltmarshes leads to greater sea water inundation and hence the absence of this community.

It has been difficult to assign this community to any established taxon, but it has been tentatively placed in the Saginion maritimae Westhoff, Van Leeuwen et Adriani 1961.

The class, order and alliance character species (Westhoff and Den Held 1969) include Cochlearia danica, Plantago coronopus, Amblystegium serpens and Sagina maritima. It is probable that S.procumbens replaces Sagina maritima in Shetland saltmarshes, although the latter species is "common" (Palmer and Scott 1969), and Cochlearia officiualis included C.danica and C.scotica in this survey.

All these character species are found in this vegetation.

Westhoff and Den Held (1969) describe within the Sagino maritimae - Cochlearietum danicae a sub-association juncetosum geradii, differentiated by the presence of Juncus gerardii, Glaux maritima and Plantago maritima. Although this would seem to be the community here, further data would be required to make a firm identification.

Birse & Robertson (1973) recorded one releve from Hamar, Unst in which Plantago coronopus Festuca nutra and Poa pratensis, Plantago maritima, Sagina maritima and blue-green algae are important constitutents. It is not clear from what habitat this list was collected, other than from close to the sea, but it is floristically very similar to the present community. Juncus gerardii is, however, absent.

5.3.2.2. Eleocharis quinqueflora flushes Releves 502-501

This is an extremely characteristic community, found at the edges of saltmarshes, where there is an influx of freshwater draining from the surrounding, inland vegetation. Triglochin maritima, Eleocharis quinqueflora and Plantago maritima have constancy V to the community while Juncus articulatus, Carex nigra, Festuca rubra, Glaux maritima and Agrostis stolonifera are in the constancy IV class.

The community is differentiated from all other saltmarsh ones by the presence of Triglochin maritima, Carex nigra, Juncus articulatus and Eleocharis quinqueflora.

Species number is generally low, 10 per releve, but Carex panicea, Eriophorum angustifolium, Ranunculus flammula and Lychnis flos-cuculi were all recorded. Although releve 501, from Gluss, contains none of the

differential species, it has been placed on the table according to the dominance of Eriophorum angustifolium which links it with more typical examples. Eurynchium praelogum is the only moss occurring regularly.

The vegetation is open, with low herb cover, about 50% and the layer is a black gravelly, and pH 6.5.

The community was recorded from all sites, except Colla Firth and Vidlin, and on gneiss, granite, limestone, quartzite and schist bed-rock types; a particularly species-rich relevé was found on schist at White Ness where grassland species such as Trifolium repens and Bellis perennis were prominent.

Blysmus rufus was recorded on two occasions (Ell Wick and Dales Voe, North) and appears to be exclusive to this community.

These flushes have not been widely described. Birse & Robertson (1973) described one similar releve from Baltasound, Unst which they very tentatively placed in the Juncetum gerardii in the absence of further data.

From Skye Birks (1973) gives a series of relevés, some of which occur "on stony ground at the landward edge of saltmarshes". These contain occasional Eleocharis uniglumis, Blysmus rufus and Juncus gerardii but do not include Carex nigra or Juncus articulatus, which are so constant to the present community. He places the Skye data in an Juncus gerardi - Carex extensa Association which includes the Junco-caricetum extensae Br.-Bl. & De Leeuw 36 pro parte. Adam (pers.comm.) does not believe that this latter association is present in Britain.

Instead he puts similar vegetation dominated by Eleocharis uniglumis into the Eleocharetum uniglumis of the alliance Elechorion uniglumis Siira 70. The association is characterised by stands dominated by the nominal species with Agrostis stolonifera also a constant, found in areas of freshwater seepage.

It would seem that the present community is a Shetland variant having Eleocharis quinqueflora in the dominant role.

The two relevés containing Blysmus rufus must indicate a transition

to the related Blysmetum rufi (G.E.& G.Du Rietz) Gillner 60 since the other character species of that associate (Glaux, Triglochin maritima and Juncus gerardii) are not common.

5.3.2.3. Triglochin maritima zone Releves 476-001

This vegetation covers large areas of most of the saltmarshes surveyed. A very dense sward of co-dominants Plantago maritima and Festuca rubra has constant Triglochin maritima while Armeria martima and Glaux maritima are the only species in constancy class IV. The community is low in species diversity (only 6 per releve); Juncus gerardii or Agrostis stolonifera may be present.

The habitat is the central part of the 'flats' between the lagoons and channels dissecting the marsh; hence the 'soil' is a wet, rooty, soft and often smelly silt, mean pH 7.1.

At White Ness, the corresponding part of the saltmarsh was occupied by a related, but obviously distinct vegetation characterised by Puccinellia maritima and Atriplex patula. The area is isolated and a protected nesting site for terns. While sheep grazing was common at other sites this was not the case at White Ness and a lush vegetation cover has resulted. The releves (003, 002 and 001) have been included here because of their otherwise floristic similarity to the Triglochin maritima zone.

Releves 476-868 identify closely with the Festuca-Armeria nodum, Adam (1976) of the Juncetum gerardii. He differentiates this nodum from the similar mid-marsh community, Festuca-Glaux nodum, by the complete absence of Agrostis stolonifera. This is the only type of Shetland mid-saltmarsh vegetation in which that species plays virtually no part. Adam (1976) gives the following constants for the Festuca-Armeria nodum: Festuca rubra, Plantago maritima, Armeria maritima and Glaux maritima.

Triglochin maritima is constant to this zone in Shetland, and plays an important part in the data for the Festuca-Armeria-nodum Adam 1976.

Some of the vegetation placed by Birks (1973) in the Juncus gerardii - Carex extensa Association could be placed in this nodum, although Triglochin

martima is not recorded as frequently on Skye. Similar vegetation has been described near the Burren (Ivimey-Cook and Proctor 1966) and by Braun-Blanquet and Tuxen (1952) from other parts of Ireland.

The relevés containing Puccinellia maritima appear transitional between the Armerion and the Puccinellion. The site at White Ness is unique among Shetland saltmarshes in its ungrazed nature and the resulting lush growth of Puccinellia maritima and Atriplex patula. Further, detailed sampling of the whole area is necessary to determine its exact relationships to the British saltmarshes. At present these three relevés (003-001) are referred to the Festuca-Puccinellia nodum Adam 1976. In this Festuca rubra, Puccinellia maritima, Plantago maritima, and Armeria maritima are constant. Agrostis stolonifera is not common.

The data given by Adam (1976) have generally greater species diversity than the present group, but this probably relects the overall paucity of the Shetland flora.

5.3.2.4. Spergularia marina community Relevés 866-496

In open areas beside the lagoons and channels, and subject to periodic inundation by the sea small patches of a community containing Spergularia marina and a fucoid alga are found.

Festuca rubra, Plantago maritima, Armeria maritima and Glaux maritima form a mosaic with about 70% cover, while in the more vegetated areas Juncus gerardii or Triglochin maritima may occur.

The fucoid alga may be accompanied by Blue-green algae e.g. Nostoc spp. and their cover is as high as 70% at some sites. The soil tends to have more mineral content than the surrounding zones, when judged by eye, and has mean pH 6.7.

Spergularia marina is frequent in saltmarsh vegetation in Shetland (Palmer & Scott 1969) and appears to be exclusive to this community, with the single exception of an appearance in related vegetation of group 5.3.2.1.2.

This community is similar to that of the Puccinellietum distantis

Feekes (34) 45, and described by Adam (1976). In disturbed sites or where fluctuations in soil salinity occur this association has constant Spergularia marina and Puccinellia maritima. The latter species is not widespread in Shetland and it would seem that this fragmentary community can only be tentatively assigned to the alliance Puccinellio-Spergularion salinae Beeftinck 66

In the presence of fucoid algae it is clearly related to the Puccinellietum maritimae, although the open nature of this Spergularia community separates it from the Festuca-Turf. fucoid nodum Adam 1976.

It has been named Spergularia marina - nodum within the Puccinellieto-spergularion salinae.

5.3.2.5. Algal communities Releves 532-877

In large areas of the saltmarshes at low levels, where sea-water inundation is regular, the vegetation is species-poor and dominated by algae.

The Festuca rubra, Plantago maritima and Armeria martima occur as tussocks or patches, while Glaux maritima is common in the landward parts. Occasional plants of Agrostis stolonifera, Juncus gerardii, J.kochii and Plantago coronopus occur.

Representative algae specimens were collected and identified later. Fucus vesiculosus was recognised, while the genera found were Nostoc, Rhizoclonium, Aphanocapsa and Gleocapsa; the latter two were not distinguished and in tables are recorded as Aphanocapsa spp.

Three facies of this algae community were found and appear to be local variants based on the relative dominance of these algae. However the limited number of samples of each prevents any more than tentative suggestions about their distribtuion being made.

The variants are:

5.3.2.5.1. Nostoc and Rhizoclonium variant

5.3.2.5.2. Nostoc, Rhizoclonium and Fucus variant

5.3.2.5.3. Aphanocapsa/Gleocapsa and Fucus variant

Since the sites were visited in the space of 16 days at the end of July 1974 it is unlikely that a temporal change in dominance could explain the variants. Further sampling over a longer period of time would be necessary to verify this.

5.3.2.5.1. Variant with Nostoc and Rhizoclonium Releves 532-563

Six releves, from Colla Firth and Dales Voe, North, were recorded and they show a constant species composition. Festuca rubra, Plantago maritima, Armeria maritima, Glaux maritima, Nostoc sp. and Rhizoclonuim sp occur in all of them.

The herb mat is quite dense - up to 80% cover in places. Generally the community is restricted to the borders of channels and lagoons, but at Colla Firth, where the Triglochin maritima zone and the species-poor upper saltmarsh community are absent, this vegetation constitutes most of the marsh.

Algae cover is an average of 40%; Nostoc and Rhizoclonium are dominant although Vaucheria sp. and Polyides sp. (a member of the Rhodophyta) were identified at Dales Voe, North.

The "soil" is a wet, dark, soft silt, and at these two sites receives enrichment from sheep-grazing and large opulations of sea birds.

5.3.2.5.2. Variant with Nostoc, Rhizoclonium and Fucus Releves 563-699

This variant, recognised at Burra Voe, Dales Voe, North and Tresta Voe is closely related to the Spergularia marina community (group 5.3.2.4) but is differentiated from it by the absence here of Spergularia marina and rarity of Glaux maritima, while having a dense turf of the three algae.

Festuca rubra, Plantago maritima and Armeria maritima are constant with Nostoc, Rhizoclonium and Fucus vesiculosus. Adam (1976) believes that there is a correlation between the abundance of Glaux and sandy substrates. Such variation between sites could explain its virtual absence here.

The present community is covered at each high tide, and at Burra Voe forms a large part of the marsh vegetation. Species-poor upper salt

marsh vegetation (5.3.2.2.) is absent from this site. Cover is variable, but algae always cover about three times the area occupied by higher plants, i.e.70-90%.

5.3.2.5.3. Variant with Aphanocapsa/Gleocapsa and Fucus Releves 867-877

This variant was recorded only at the Bixter and Bridge of Firth sites. It is characterised by a reduction in the cover and abundance of Plantago maritima and Glaux maritima with constant and co-dominant Fucus vesiculosus and the blue-green algae. Festuca rubra is constant and Armeria maritima rosettes are commonly found in an open mosaic of the grass.

Vegation cover is higher than in the latter variant; algae ocver on average 80%, higher plants - 70%.

These communities dominated by algae have been placed in new Festuca-Turf-fucoid nodum of the Puccinelliet.um maritimae.

Communities containing algae have not been clearly classified because of the difficiulties of identification. Birks (1973) describes a Puccinellia maritima - Ascophyllum nodosum subassociation on Skye from a zone which is submerged for at least 8 hours a day, and where Puccinellia maritima is dominant. This species also dominates the Puccinellia-Turf fucoid nodum Adam 1976 which that author considers characteristic of salt marshes with organic, peaty soils.

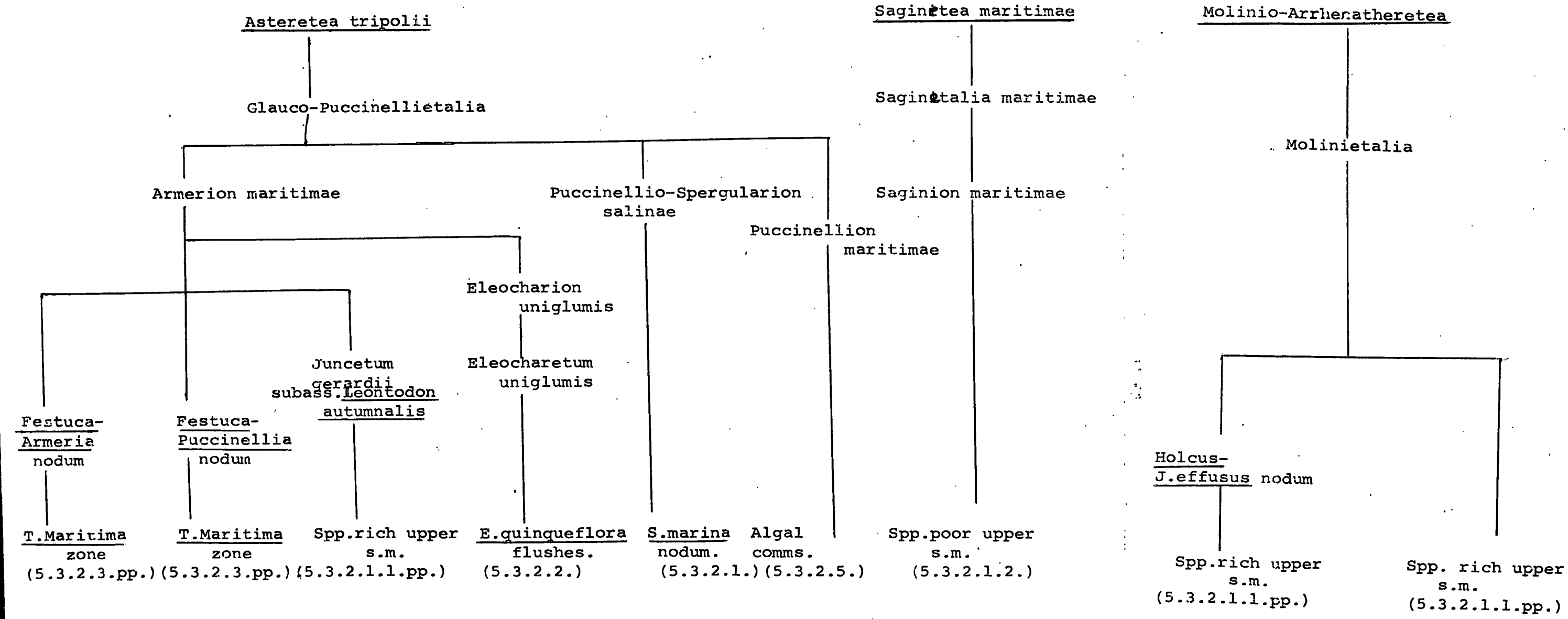
In Shetland, however, Puccinellia maritima is "local" (Palmer & Scott 1969) and was not frequently recorded during this survey. It appears, however, to be replaced by the ubiquitous Festuca rubra, and this Festuca Turf-fucoid nodum is in all other ways identical with the nodum established by Adam.

5.3.3. Comparison with Northern Isles (Figure 5.3.1.)

There are very frew large areas of saltmarsh in Northern Shetland, so that the groups distinquished by Lewis (1976) represent only the vegetation at Balta Sound on Unst. This is unique in many ways. It is the only saltmarsh on serpentine bedrock and is the only site for Salicornia sp. Further, it probably represents the most northerly

Fig. 5.3 Synoptic classification of salt marsh communities of the Southern Isles.

Salt marsh.



saltmarsh in the British Isles.

For all these reasons it is perhaps not surprising that the syntaxa recognised there are not similar to those recorded from the Southern Isles. Puccinellia maritima is common at Baltasound giving the clear distinction of the Puccinellietum maritimae in its typical form. The Juncetum-gerardii was also recognised.

Vegetation of the surrounding flushes and meadows were placed in the Parvocaricetea and Molinio-Arrhenatheretea respectively.

Those wet meadow areas assigned by Lewis (1976) to the latter class have been placed in the Eleocharion uniglunis in the southern releves so seem to contain more maritime species than the Baltasound vegetation e.g. Juncus gerardii, Glaux maritima, Plantago maritima.

5.4. GRASSLAND

Table 5.4

5.4.1. Introduction

The appearance of vegetation allocated to this group originally (see 3.3.1.) was that of areas dominated by grasses and non-ericaceous flowering herbs on, generally, light and dry soils, to which were added for analysis, those relevés recorded from wet flushes through such areas, as well as cliff top and ruderal communities. Only a very few relevés were described from the latter group.

The results after computer and hand-sorting of all data are shown in Table 5.4. The overall abundance and constancy of the Gramineae is immediately visible, 21 species being represented on the table.

Festuca rubra, Anthoxanthum odoratum, Holcus lanatus and Agrostis tenuis are the only ones which ever achieve great cover value (maximum value 2, $< 80\%$) possibly due to the effects of constant grazing by sheep, rabbits and occasionally, cattle, as well as competition from herbs which may be better able to tolerate the high levels of salt in the air, e.g. Plantago maritima, Scilla verna.

No relevés were recorded from arable land, (it was felt that this fell outside the original plan of studying natural and semi-natural vegetation, and would warrant too great a proportion of sampling time).

The only group representing 'managed' land is thus 5.4.2.7, the Holcus-Trifolium meadows.

Seven main groups of communities can be distinguished in the drier grasslands of Southern Shetland. They are:

5.4.2.1. Base-rich Festuca grassland.

5.4.2.2. Agrostis stolonifera maritima grassland.

5.4.2.3. Scilla verna - Carex flacca maritime grassland.

5.4.2.4. Linum - Silene acaulis grassland

5.4.2.5. Flushed grassland

5.4.2.6. Nardus grassland

5.4.2.7. Holcus-Trifolium meadows.

A synopsis of their classification is given in Figure 5.4.

5.4.2. Vegetation groups

5.4.2.1. Base-rich Festuca grassland Releves 805-806

This is a species poor grassland (average 14 spp.per releve) found on shallow sandy soils, and all within 100m of the sea. 9 releves have been placed in this group, being recorded from relatively dry soils in pH range 7.6-8.4.

It would seem that this higher base status is derived from a high soil calcium content due to the sandy nature of the ground.

Festuca rubra, Plantago lanceolata, P maritima, Lotus corniculatus and Holcus lanatus are constancy V to this community while Trifolium repens, Carex flacca and Cerastium holosteoides are common.

Only Festuca and Plantago lanceolata achieve any degree of dominance in terms of cover. The herb layer is generally dense, between 3 and 15 cm high. Moss cover is low on the whole, increasing only in the open areas around rocks, or where the soil becomes damper as in slight hollows.

This grassland forms a sward on more or less level ground, merging (where they exist) with the Ammophilion communities of stabilising sand-dunes on the seaward side, and with links, on the landward. Links or machair are not well described phytosociologically, but consist of grazed meadows on sand over peat (see also 5.2).

This Festuca grassland however appears to be at some intermediate point along the transition from dunes to fixed grassland. They are grazed, but are rich in flowering herbs such as Parnassia palustris, Galium verum, and Achillea millefolium. Ammophilion species are present, e.g.Ammophila and Honkeya peploides.

The low species number (average only 15 per releve) makes it difficult to align with other "machair" communities.

Dominant and constant are Festuca rubra, Holcus and P.lanceolata, which are characteristic Molinio-Arrhenatheretea species, but also important are

Lotus corniculatus, Galium verum and Ammophila which Braun-Blanquet & Tuxen (1952) show in their Irish Viola curtisii-Syntrichia ruralis Association in the Sedo-Scleranthetea. The two naming species, however, are not present in these Shetland lists. The data also have similarities with the Ditrichum flixicaule - Thymus drucei nodum placed by Ivimey-Cook and Proctor (1966) within the above Association, in that Bellis perennis, Agrostis stolonifera, Carex flacca and Trifolium repens are common. But once again the naming species are absent. Neither of these Irish communities indicate as regular an occurrence of Achillea millefolium as is found in Shetland.

Randall (1972) describes machair on the Monach Isles, where the following species have frequency values greater than 80%:

Bellis perennis 100%	Achillea millefolium 91%
Festuca rubra 96%	Carex arenaria 85%
Plantago lanceolate 93%	Galium verum 83%

This is certainly similar to the Shetland community, with the exception of Carex arenaria, but in common with other examples, it has a much greater species diversity.

Birks (1973) gives two lists from 'grey dune turfs' in Skye where a sward of Festuca rubra and Galium verum includes Lotus, Achillea, and Thalictrum minus - these, in the absence of sufficient information, he places in the Ammophilion Borealis (R.Tuxen 55) Gehu and Gehu 1969.

The association Camptothecio-Asperuletum cyanchicae Br.Bl.& Tx.1952, described from Ireland (Braun-Blanquet & Tuxen 1952) and by Shimwell (1968) is placed in the Eu-mesobromion sub-alliance in the Festuca-Brometea. This is an association of stable calcareous dunes, usually merging with communities of the Galio-Koelerion. This Shetland community has similarities in the constancy of Festuca rubra, Plantago lanceolata and Poa pratensis (including P.subcaerulea) but does lack the Alliance and Order species quoted by Shimwell (1968).

It appears overall that the Festuca base-rich grasslands are at a stage in dune succession close to the formation of true machair. (Succession on sand dunes in Shetland is discussed in section 5.2.1.). They have been tentatively assigned therefore to the alliance which does cover such dune grasslands - the Eu-Mesobromion. It is not felt that this data alone is sufficient to place them in any established association nor create a new one.

5.4.2.2. Agrostis stolonifera maritime grasslands Releves 723-938

In this community, found adjacent to the following one along the cliff tops of S.Shetland, the abundance of Molinio-Arrheratheretea species is noticeable but with a greater part being played by Agrostis stolonifera.

Scilla verna, Thymus drucei and Carex flacca are absent, while the mean species number per releve is lower than 5.4.2.3 (15 here as opposed to 21). The soil pH is 6.2 mean, while the soils are generally damp and of a dark brown and gritty nature.

The vegetation tendsto be taller than the other coastal vegetation described (in groups 5.4.2.1 and 5.4.2.3.); the bryophyte layer is important - Eurynchium praelongum having constancy V, although Sagina procumbens probably replaces mosses in many cases.

The only Shetland record of Sea Aster (Aster tripolium) occurs in releve 723 from Isbister Holm. Although a common constituent of British saltmarsh and coastal vegetation, in Shetland it is confined to a section of ungrazed, steep cliffs on the south-east side of this small island, and where it grows in crevices in the rocks. The releves is placed in this community although on the content of only 4 herbs this can only be a tentative placing.

A similar problem occurs with releve 934 from Mousa; the cliff-top site had been fenced off, and exclusion of sheep had resulted in a lush mat of Festuca rubra, Agrostis stolonifera and Agrostis tenuis, seen no-where else during the survey. On species content alone this releve was placed with the Agrostis stolonifera grasslands on the table

although the luxuriant grass growth made it quite distinctive.

Relevé 164, from Strom, is interesting in that it is about 1½ miles from the sea, but within 10m of a brackish loch. The influence of such a modified maritime environment is sufficient to produce vegetation which is closely related to this community.

This vegetation is very similar to and have been placed in, the Carex distans-Plantago maritime Association described by Ivimey-Cook and Proctor (1966) from the Burren. It has the Armerion maritimae Br.-Bl.& de Leeuw 36 character species in Armeria maritima, Festuca rubra, Agrostis stolonifera and Plantago maritima (all constancy V) and occasional Juncus gerardii and Glaux maritima. Carex distans is not recorded at all in Sheltnad, but the abundance of the first group of species along with Lotus corniculatus, Plantago cornopus and Trifolium repens all parallel closely the composition of the Irish community.

The only two inland records of Juncus gerardii (relevés 938 and 940), recorded on Mousa, are found in this community.

One relevé from a similar community was recorded by Birse & Robertson (1973) at Baltasound (Unst), while the "Maritime grassland nodum" found in Skye (Birks 1973) has an equally high constancy of Agrostis stolonifera and lack of Squill.

5.4.2.3. Scilla verna - Carex flacca maritime grasslands Relevés 221-954

These maritime grasslands occur on soils of generally neutral pH (range 4.8 - 8.4 mean 6.7) with much less sand content than those of 5.4.2.1. Base rock strata sampled were old red sandstone, gneiss, granite or limestone.

The community is characterised by a dense sward of Festuca rubra, Plantago maritima, P.lanceolata, and Lotus corniculanus, with which Armeria Maritima, Plantago coronopus and Scilla verna are found. It is differentiated from the latter group (the Agrostis stolonifera grassland) by the presence

Carex flacca and Scilla verna, and reduced cover here of Agrostis stolonifera.

Grazing by sheep and rabbits maintains the herb layer below 40 mm on average, while the damp ground and deeper soil (approximately 80mm) allows moss such as Hypnum cupressiforme, Rhytidiadelphus squarrosus, Eurynchium praelongum, Mnium hornum (ubiquitous in Shetland), with the liverwort Lophocolea cuspidata, to occur freely.

The community is found on level or gently sloping cliff tops, or (as in relevé 991 from Bressay) as patches in grazed, rough meadows near the sea. It usually merges into the coastal grasslands of 5.4.2.2. to which it is closely related, on the seaward side, when found on cliff tops.

In other sites, e.g.Mousa (relevé 943) and Sumburgh (731) the community is surrounded by grassy heaths, these accounting for the occasional presence of the moss Dicranum bonjeanii and heath lichens of the genus Cladonia. On Bressay (relevé 991), Trondra (relevé 33) and White Ness (relevé 338), the surrounding grassland is rich in characteristic Molinio-Arrhenatheretea species, such as Festuca rubra, Bellis perennis, and Rumex acetosa, which thus occur in this community.

Malloch (1971) described a Lizard varient (a Plantago maritima nodum) of the Carex distans - Plantago maritima Association (Ivimey Cook and Proctor 1966) but had insufficient data to make further conclusions as to its status.

This Shetland Scilla-Carex flacca community seems to fit very closely to this Plantago maritima nodum. The character spcies of the Armerion are represented by Armeria maritima and Festuca rubra; and Plantago maritima, a class character species has constance V. They differ in that Daucus carota, an important species in the Lizard vegetation, is absent altogether from Shetland, while Plantago lanceolata has constancy V, and Euphrasia agg.IV here compared with II and a single occurrence in Cornwall. Malloch does explain, however, that his relevés are generally low in species number (11 per relevé, compared with 21 in Shetland lists).

A "Plantago sward" has also been described from Soay (Barkley 1953) Sanday (Asprey 1947), Hirta (McVean 1962) and Ireland (Ivimey-Cook and Proctor 1966). Each of these has local variations, particularly in the amount of Plantago coronopus, present. In the Shetland data, it has a constancy IV (as it does in Cornwall) while C.flacca is an interesting component found here with constancy III, but not elsewhere.

The Shetland community thus seems to be most similar to the Cornwall variant based upon present descriptions, but even from this it has distinctions. Perhaps the greatest of these is geographical separation and thus a relatively narrow range of shared species. On this basis it is possible only to designate it as "Shetland variant" of the Plantago maritima nodum of the Carex distans - Plantago maritima Association.

5.4.2.4. Linum-Silene dry grassland Relevés 892-330

This is a community of well-drained, light soils on slopes up to 80°, recorded only on base rock of limestone or sandstones.

It is differentiated from all other grassland communities by the joint presence of Silene acaulis, Festuca vivipara, and Linum catharticum. Of constancy V are Thymus drucei, Plantago maritima and P.lanceolata, while Viola riviniana is an important constituent.

The community is open, in many places found on shallow soil where rocks outcrop. Thymus drucei, an important pioneer of open ground such as this has higher cover values in this group than elsewhere in grassland communities, while Aira praecox is often found. Many of the bryophytes recorded are found on the stonier parts of the community, e.g.Barbula recurvirostra, Tortella tortuosa and Trichostomum crispulum.

In coastal areas it is found in patches of rocky outcrops among the low dense Scilla-Carex flacca grasslands, but elsewhere merges into the base-rich Festuca grasslands. The soils are slightly acidic (mean pH 6.7), possibly due to the leaching effect on such slopes, while the average species number is high, (27 per relevé). This probably due to the enrichment from outcropping rocks.

The community was recorded between 5m and 30m above sea level.

At many sites these slopes had rich, flushed patches, fed by spring water from the hillsides. Relevés from these areas are included in Table 5.4 (syntaxa 32-34), but there is an evident overlap in species as seen in releve 330, where Carex pulicaris and Riccardia pinguis are found in an area of dry grassland.

This community forms some of the most attractive Shetland vegetation, being rich in brightly-flowering herbs - Silene acaulis, Primula vulgaris, Thymus drucei, Bellis perennis, Lotus corniculatus, Euphrasia agg., Jasione montana.

The vegetation is always less than 25mm tall. It is possible that the open, exposed nature of the habitat, endorsed by a high constancy of Festuca vivipara, maintains this dwarfed appearance with the aid, of course, of sheep and rabbits.

A relevé recorded on gneiss at Ling Ness (see below) fits more closely with this community although it lacks the differential species given above. It is typical of the vegetation around such rocky outcrops, having patches of the lichens Xanthoria parietina, Parmelia sulcata and Physcia sp.

Relevé: 946 Ling Ness, Nesting, Mainland.

$2m^2$ Slope: 5^o altitude: 5m

Festuca rubra	1	Camptothecium lutescens	1
Poa subcaerulea	1	Ulota phyllantha	1
Thymus drucei	+	Grimmia maritima	1
Euphrasia sp.	+	Scapania gracilis	1
Plantago lanceolata	+		
P.maritima	+	Xanthoria parietina	+
Galium verum	+	Parmelia sulcata	1
Anthoxanthum odoratum	+	Physcia sp.	+
Bellis perennis	+		
Lotus corniculatus	+		
Gentianella campestris	+		
Ranunculus acris	+		
Carex nigra	+		
Holcus lanatus	+		
Prunella vulgaris	+		

The pioneer communities of acidic, dry, sandy soils are assigned by Westhoff and Den Held (1969) to the Koelerio-Corynephoretea Klika apud

Kilka and Novak 41. Of the character species they give, Cladonia pyxidata, Peltigera sp, Rhacomitrium canescens, Galium verum and Festuca ovina are found in this community. Only two others in their lists (Carex arenaria and Polytrichum piliferum) are recorded at all in Shetland.

This Shetland community is species rich, particularly in lichens and bryophytes, and open, and thus fits into the Festuco-Sedetalia Tx.51. Jasione montana and Aira praecox, both Order character species are common, while Sedum acre, although not included in any lists here, does occur in similar habitats in Nesting, Mainland.

Ivimey-Cook and Proctor (1966) describe a community of limestone pavement and rocky crevices which is dominated by annuals and bryophytes such as Camptothecium spp. and Tortella tortuosa. This they place in the Koelerion albescentis (Galio-Koelerion (R.Tx37) Den Held & Westhoff 1969).

Although the Shetland community is not exactly the same as theirs, particularly in habitat, and being found on deeper soils, it does share the high species number, the prevalence of therophytes such a Linum catharticum and Euphrasia spp., and the abundance of lichens genera Cladonia and Peltigera.

Westhoff and Den Held's alliance character spcies include only six that are found in Shetland; of these, five - Festuca rubra, Anthyllis vulneraria, Galium verum, Jasione montana and Cladonia rangiformis are recorded in this community.

From Ireland Braun-Blanquet and Tuxen (1952) describe the association Antennarietum hibernicae from which Shimwell (1968) removes their sub-association with Sesleria caerulea and then differentiates by the presence of Antennaria dioica and Polygala oxyptera. (By many taxonomists this is included under Polygala vulgaris) The German authors placed this association in the Order Festuco-Sedetalia within the Festuco-Brometea.

Shimwell's description of the Association from Britain has many similarities with the Shetland data. Linum catharticum has constancy V

in both, while Plantago maritima, Bellis perennis, Carex flacca, Succisa pratensis, Prunella vulgaris, Festuca rubra, Thymus drucei, Achillea millefolium Viola riviniana and Cladonia spp are equally common. Of the alliance and order character species he gives only one, Anthyllis vulneraria appears in this community (but only one other, Gentianella amarella is recorded in Shetland.) Antennaria dioica is found throughout in Shetland but is more common on heaths.

The constancy of Silene acaulis in this community is slightly anomalous. Throughout Shetland, this plant is found down to sea-level in exposed habitats although it is confined to mountains in mainland Britain.

Thus this vegetation seems to be of a nodum confined to Shetland, although further investigation may prove its presence in Orkney or the Hebrides where Silene acaulis also descends to low levels.

It seems to be most closely related to the Antennarietum hibernicae Br.-Bl.& Tx., but further information must be collected before it can be more than tentatively assigned there.

5.4.2.5. Flushed Grassland Relevés 252-558

Three separate types of flushes have been distinguished within this community, although the low number of records for each means that only tenuously can their affinities be given.

All three are found on gently sloping ground, at low altitudes (5m-18m). The whole group is extremely species-rich (average 28 per relevé), probably due to the enriched nature of the soils due to flushing with water or from the base rocks.

Ranunculus flammula, Plantago maritima, Leontodon autumnalis, Carex nigra, C.flacca, Juncus kochii and Molinia caerulea are constant to the community, although none are in class V. Bryophyte cover and abundance are high, especially Acrocladium cuspidatum, Drepanocladus revolvens, Bryum pallens and Pellia spp.

5.4.2.5.1. Limestone flushes Relevés 252-241

Of the seven relevés forming this group, six were recorded from sites on limestone, where very wet conditions prevailed; either in almost-standing water or where flow was visible. The seventh (Catfirth, relevé 252) was at the base of a grassy bank and, although only damp at the time of recording, does seem to have close floristic affinities with both this group and 5.4.2.4. It has, therefore, been placed "on the border" between the two.

Herb cover is quite low, in spite of the high number of species present, and in most places is exceeded by bryophyte cover. The vegetation thus appears as a mosaic of mosses and liverworts, such as Cratoneuron filicinum, C.commutatum, Acrocladium cuspidatum, Drepanocladus revolvens and Philonotis fontana, with spikes of the higher plants forming an open sward upon that.

This group is differentiated from the rest of group 5.4.2.5. vegetation by Cratoneuron filicium, which also has high cover values. Other species which seem to have their grassland optimum within this group are Carex lepidocarpa, Caltha palustris, Philonotis fontana and Riccardia pinguis.

Soils are waterlogged and dark clays, with, sometimes, a fine gravelly appearance.

Because of the influences of surrounding vegetation, the phytosociological relationships of this community are not immediately clear.

Species of the Caricion davallianae Klika 34 are common, especially Carex lepidocarpa, Bryum pseudo triquetrum and Pellia neessiana, and Parvocaricetea character species such as Riccardia pinguis and Epilobium palustre are present.

But the influence of the base-rich water table gives an overriding influence of species representative of the Montio-Cardaminetea, and in it to the alliance Cratoneurion Koch 28 that these limestone flushes have been allocated. Cratoneuron filicinum is constant in the Shetland communities and C.commutatum is common.

The community described, on Skye, (Birks 1973) as a Cratoneuron

commutatum-Saxifraga aizoides nodum McV.& R 1962, is similar, but the Shetland records lack Saxifraga aixoides. The species diversity is greater in Shetland, (mean 25spp.per relevé, as opposed to 19 on Skye), but in both places Festuca rubra, Pinguicula vulgaris, Bryum pseudo - triquetrum, Cratoneuron commutatum, Ctenidium molluscum, Drepanocladus revolvens and Riccardia pinguis are common.

Ivimey-Cook and Proctor (1966) describe calcareous spring communities from the Burren, which Jones (1973) equates with her 'typical' subvariant of the Cratoneuron filicinum variant of the Cardaminetosum pratensis in a new association found in Teesdale - the Cratoneurietum - commutati.

This has a high species number and shares with the Shetland communities the presence of bryophytes such as Acrocladium cuspidatum, Brachythecium rivulare, and Fissidens adianthoides, as well as Ranunculus flammula.

Due to the scarcity of suitable limestone outcrops in Shetland, and thus only 7 available relevés, this community is only tentatively assigned to the Teesdale sub-variant.

5.4.2.5.2. Species-rich flushes Relevés 217-830

This group of species-rich relevés (average 36 per relevé) represents a more herbaceous vegetation type than the latter, although the bryophyte content remains high.

The soils, which are rich brown-black mineral soils, are generally damp to wet, and pH range 5.4.7.4 (mean 5.9).

These were all recorded from hollows or drainage channels, slope 10^{o}, through meadows and fields, and in their species content reflect the vegetation surrounding them.

Trifolium repens, Ranunculus acris, Cerastium holosteoides, Anthox - anthum odoratum and Bellis perennis are of constancy V while Ranunculus flammula, Cirsium vulgare, Cardamine pratensis and Rhtidiadelphus squarrosus are in 5 of the 6 relevés.

Two relevés, 489 and 830, do not fall clearly into either this group or into 5.4.2.5.3, the species-poor flushes. They are clearly not species-poor, but contain only isolated individuals of certain species, e.g. Angelica sylvestris, Potentilla palustris, and Iris pseudacorus in 489 at Gluss, and Narthecium ossifragum and Carex hostiana in 830 at Sandness. Such anomalous spcies as these in a grazed grassland context made the affinities of these releves unclear. However, in view of the overall floristic similarity in the presence of the species of constancy V to 5.4.2.5.2., it was decided to omit these from the species-poor grouping.

These flush communities have been placed in the Caricion curto-nigrae Koch 26 em Nordh.36 due to their richness of species and the presence of numerous sedges such as Carex nigra, C.pulicaris, C.dioica, C.panicea, C.flacca and C.echinata. Ranunculus flammula, Viola palustris and Epilobium palustre are given by Westhoff and Den Held (1969) as alliance character species, and all are common in the Shetland communities. Other Parvocaricetea species, such as Caltha paustris, Equisetum palustre and Cardamine pratensis are common.

Jones (1973) has described an α -nodal group with Carex nigra and C.pulicaris in Teesdale. The Shetland community here seems to have strong affinities, particularly in the high sedge cover and the occasional presence of species such as Nardus stricta, Eriophorum angustifolium and Juncus effusus.

This Jones places in a subassociation caricetosum pulicaris of a new association, the Violo-Epilobietum palustris, whose character species are Viola palustris, Carex echinata, Epilobium palustre and Juncus kochii. On this basis the Shetland species-rich, flushed grassland community is placed in the above association. With further information, it may be possible to distinguish the bryophyte variant found in Teesdale, where Riccardia pinguis, Fissidens adianthoides and Ranunculus flammula grow together.

This group could be defined as the typical form of flushed vegetation in grazed grassland in S.Shetland. Although only recorded from Catfirth, Gluss, Sandness and White Ness on Mainland, such channels were seen in areas of South Mainland and on Bressay, where suitable grassland habitats occurred.

5.4.2.5.3. Species-poor flushes Releves 989-558

This name "species-poor" given to this group is only in relation to the other flushed vegetation groups. The mean number of species per releve of 22 is higher than many of the grassland groups.

Found on gritty, dark shallow soils or shallow peat the average pH is 5.9, (range 5.2-6.4) and these flushes are found merging with swards of acidic grassland (see 5.4.2.7) and lack many species characteristic of the Molinio-Arrhenatheretea.

Plantago maritima, Leontodon autumnalis, Juncus kochii, Parnassia palustris, Pinguicula vulgaris, Molinia caerulea, Carex pulicaris, C.panicea, Drepanocladus revolvens, and Selaginella selaginoides are constant, and, along with Ranunculus flammula, tend to form the major part of the community. These flushes are sedge-rich, open areas, on more or less level to gently sloping ground, with bare, gravelly patches and high bryophyte cover, especially of Drepanocladus revolvens and Campylium stellatum cushions. In Sandness, releve 832, the only 'grassland' record of Schoenus nigricans is seen.

This group is obviously closely related to the heath flushes (see Heath Group 5.8.2.6., Table 5.8) in the presence of Carex spp. Molinia, Schoenus and Pinguicula vulgaris, and to the previous community. Its distribution in S.Shetland seems to be limited to higher land, (range recorded 20m-85m), where heath and grassland boundary is present. Since the shallow soil on which it occurs does not often support grassland, this group is uncommon.

These three releves, appear to be the grassland form of the Carex

panicea-Campylium stellatum Association.McV.& R.1962. The constancy of C.panicea,Pinguicula vulgaris, Selaginella selaginoides and Campylium stellatum is common to both these Shetland lists and those from Skye (Birks 1973), while other Tofieldietalia species common are Carex dioica, C.pulicaris,Drepanocladus revolvens. Such vegetation was placed by Jones (1973) in the Pinguiculo-Caricetum dioicae and it is to this association that the present vegetation is assigned.

5.4.2.6.Nardus grassland Relevés 990-675

Much of the grassland of S.Shetland falls into this vegetation group, where the average soil pH was 5.7, and soils were either moderately humified peats or light, brown, shallow mineral soils.

The grassland is grazed heavily by sheep and rabbits. It is uneven, and has not been subjected to improvement by the addition of fertilizers by farmers.

It is characterised by the constant and dominant grasses Nardus stricta, Anthoxanthum odoratum and Holcus lanatus, although nowhere does any have extensive cover higher than 40%. Juncus squarrosus is a further important component of the herb layer, while scattered plants of Potentilla erecta are almost always present. The grassland is quite rich in species (ave. 26 per relevé), a great deal of these being mosses such as Dicranum bonjeanii, Hylocomium splendens, Rhytidiadelphus squarrosus and the ubiquitous liverwort,Lophocolea cuspidata.

Two groups have been recognised within these acidic grasslands:

5.4.2.6.1. Sphagnum rich

5.4.2.6.2. typical.

5.4.2.6.1.Sphagnum-rich Nardus grasslands Relevés 990-233

The 14 relevés brought together here are differentiated from all other grassland groups by the presence of Carex binervis, Diplophyllum albicans, Rhytidiadelphus loreus and Sphagnum papillosum. These are all typically heath species. It is believed that these releves show clearly the over-riding tendency of all Shetland vegetation to form heath or

blanket bog, rather than simply reflecting the species content of surrounding vegetation.

The grasses Nardus, Anth oxanthum, Holcus, Agrostis tenuis, Festuca rubra, F.vivipara and Sieglingia decumbens are commonly found, Nardus and Anthoxanthum having constancy V. Bryophyte cover is generally high, approximately 60%, and with a wide range of species. Sphagnum recorded are S.papillosium, S.capillaceum, S.plumulosums and S.rubellum, and other important components of the moss layer apart from those mentioned earlier are Polytric.h um formosum and Barbilophozia floerkii.

This community is quite lush with herb layer up to 300mm in places where sedges or Molinia escape grazing sheep.

The rooting layer is always damp, supplied by flowing water. All examples recorded were found on slopes (up to 45°) on hillsides where they would receive water from the land above. Similarly the ground would be leached, making it moderately acidic (pH mean 5.2, range 4.1-5.8). Limestone, schist and quartizite bedrocks were noted, these being porous enough to allow leaching and not becoming waterlogged sufficiently to produce true blanket bog cover.

The community is found from 5m-70m above sea-level where the right hydrological and soil conditions occur.

While Nardus stricta and Potentilla erecta are common throughout the Shetland heaths and blanket bog (see 5.6.5.7), nowhere else are they found with such a high cover of other grass spcies.

Close to streams Festuca rubra becomes less important within the community, while Juncus squarosus, J.effusus and Polytrichum commune attain local dominance.

This community has been found in many parts of Britain, and is the Nardo-Juncetum squarrosi (Nordh 20) Birk 1942.

The class character species of the Nardo-Callunetea Preising 1949 are represented by a regular occurrence of Calluna vulgaris and Carex pilulifera,

while of the Violion caninae Schwick em. Preising 1949 alliance species suggested by Jones (1973), Polygala serpyllifolia, Luzula multiflora, Galium saxatile and Pedicularis sylvatica are present.

Jones (1973) assigns her "α-nodal group with Nardus and Juncus squarrosus" to this association; she separates it from the Nardo-Galietum saxatilis Preising 1949 on the absence from the latter of Carex nigra, Eriophorum angustifolium, Sphagnum papillosum, S.capillaceum, Polygala Serpyllifolia and Carex echinata, all of which are found in this Shetland community. She describes, too, a "nodum with Galium saxatile and Sphagnum papillosum" in the subassociation galietosum. On the limited records from Shetland it is not possible to definitely assign the community to this level, but with the similar components of Sphagnum capillaceum, Barbilophozia floerkii, Equisteum palustre and Mnium hornum, a parallel between the two is suggested.

The community described by Birks (1973) on Skye is again similar, but the Shetland form lacks many of the mosses he finds predominant e.g. Polytrichum alpinum and Rhacomitorium lanuginosum.

At Sullom, Birse (1973) recorded from a Nardus grassland - Juncus phase, within the Junco-squarrosi-Festucetum tenuifoliae (Birse & Robertson 1976) for which he gives Polytrichum commune, Plagiothecium undulatum, Mnium hornum, Nardus, Juncus squarrosus and Luzula multiflora as characteristic.

As with the present data, Anthoxanthum odoratum, Agrostis tenuis, Lophocolea cuspidata, Rhytidiadelphus squarrosus and Hylocomium splendens are constant. The difference between the Nardo-Juncetum squarrosi (Nordh 20) Buk 1942 and the association of Birse & Robertson seems not to be recorded, but from Birse's Shetland lists it lacks Carex binervis and the Sphagnum spp. of the former.

The Sphagnum-rich Nardus grasslands are therefore assigned to the Nardo-Juncetum squarrosi (Nordh.20) Buk 1942.

4.2.6.2. Typical Nardus grasslands Releves 210-675

This is a community recorded from all parts of the area except the extreme south of Mainland and Mousa. It was found on North Mainland,

Bressay and Whalsay and appears to be the most widespread acidic grassland through the islands although usually not extending over large areas at each site.

It is characterised by high constancy of Galium saxatile and Polytrichum formosum with Nardus and Juncus squarrosus. These species usually being in clumps within an open sward of Holcus and Anthoxanthum up to 80mm high. It is always heavily grazed. In many places such as Setter (Bressy 210), on Whalsay (706) and Laxo (431) there was evidence of disturbance to the land, either by crofting or former peat-cutting activities. The presence of Rumex acetosa may reflect this.

Other community associated species are Festuca rubra, Agrostis tenuis, Juncus effusus, Rhytidiadelphus squarrosus, Succisa pratensis and Agrostis stolonifera. Moss cover is only about 25%, while the herbs from a dense 100% cover in most cases.

pH range is 4.4 -6.8 (mean 5.6) and the soils are usually shallow, ginger-brown earths, having root remains or some minerals visible. On Whalsay this community grows on shallow peat. Ground water conditions range from dry to damp.

This community is not exactly similar to any established syntaxon. It seems to combine the characteristic species of the Violion caninae (e.g. Nardus, Galium saxatile, Luzula multiflora, and Calluna) with Molinio-Arrhentheretea species such as Trifolium repens, Holcus lanatus, Anthoxanthum odoratum and Festuca rubra.

It most closely resembles the Agrosto-Festucetum (species poor) Ass. McV. & R. 1962, as found on Skye (Birks 1973). In his community (as compared to the Mainland) Festuca spp. are replaced by Agrostis spp. as dominants. In Shetland the replacement seems to be by Holcus and Anthoxanthum.

This association includes parts of the Nardo-Caricetum binervis Br.-Bl. & Tx. 50. From Ireland, Braun-Blanquet and Tuxen (1952) describe this community characterised by Nardus and Luzula multiflora with Succisa and Carex binervis as differentials. Succisa is not common and Carex

binervis is absent from this Shetland vegetation.

The Shetland community also has similarities with the Nardus grasslands described from Scotland by Birse and Robertson (1976) although Holcus lanatus does not appear in their list of constants, while Deschampsia flexuosa is more abundant there than in these Isles. Vaccinium myrtillus, a constant in their Nardus grassland, is not found in Shetland grassland at all. The distribution of this plant however is much limited in the Islands and is found only on heaths.

The constant presence of Polytrichum formosum appears to be unique to the association in Shetland. Elsewhere, Polytrichum commune is common, and Birse & Robertson (1974) even erect a facies of their Nardus grasslands based upon its presence. It seems then that this is a Polytrichum Formosum nodum of the species-rich Agrosto-Festucetum.

Three smaller groups can be recognised within these meadows:

5.4.2.7.1. Species-rich meadows

5.4.2.7.2. typical

5.4.2.7.3. species-poor meadow community

All relevés of group 5.4.2.7. have been placed in the Cynosurion cristati R.Tx.37, of the Arrhenatheretalia Pawlowski 28; an alliance of grazed, lowland pastures having some management.

Holcus lanatus, Festuca rubra, Cerastium holosteoides and Rumex acetosa are Molinio-Arrhenatheretea Tx.37 character species which occur with constancy V in the vegetation, while Ranunculus acris and Bellis perennis, with constancy IV are characteristic of the Arrhenatheretalia. The higher rainfall experienced in Shetland may account for the occasional presence of Molinietalia species such as Equisetum palustre, Deschampsia caepitosa and Angelica sylvestris, in a group otherwise typical of drier soils.

Of the species given by O'Sullivan (1965) as characterising the Cynosurion cristati in Ireland, only Cynosurus and Trifolium repens are

found, commonly, in Shetland. But with these are found his alliance differentials Lolium perenne, Achillea millifolium and Cirsium arvense, as well as Poa spp. Thus these Holcus-Trifolium meadows can be assigned to the Cynosurion.

All fall within the Lolio-Cynosuretum, although the three groups recognised can be considered as different forms of the association.

5.4.2.7.1. Species-rich meadows Releves 338-690

These are the meadows, found on all the major rock types, except granite, which are most closely related floristically to the acidic grasslands of groups 5.4.2.6. They have the characteristic meadow species of Arrhenatheretalia and Cynosurion, and Potentialla erecta and Luzula multiflora are common. They have an average of 22 spp./releve.

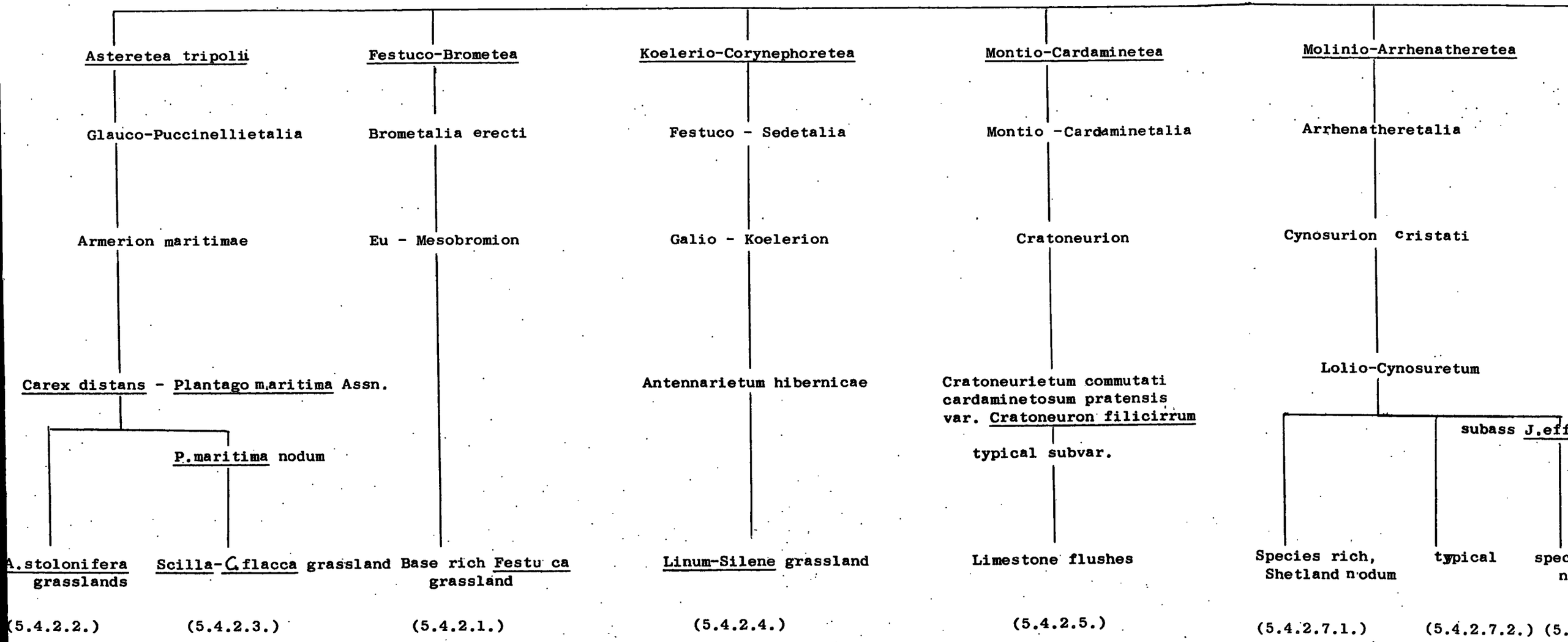
They consist of a lush carpet, up to 120mm deep of Holcus, Anthoxanthum, Trifolium repens, Festuca rubra and Rumex acetosa, in which other Gramineae such as Cynosurus cristatus, Agrostis tenuis and Poa subcaerulea are scattered. Important herbs are Viola spp., Succisa pratensis, Lotus comiculatus and Plantago lanceolata. Moss cover is only about 5%. consisting mainly of Rhytidiadelphus squarrosus and Mnium spp.

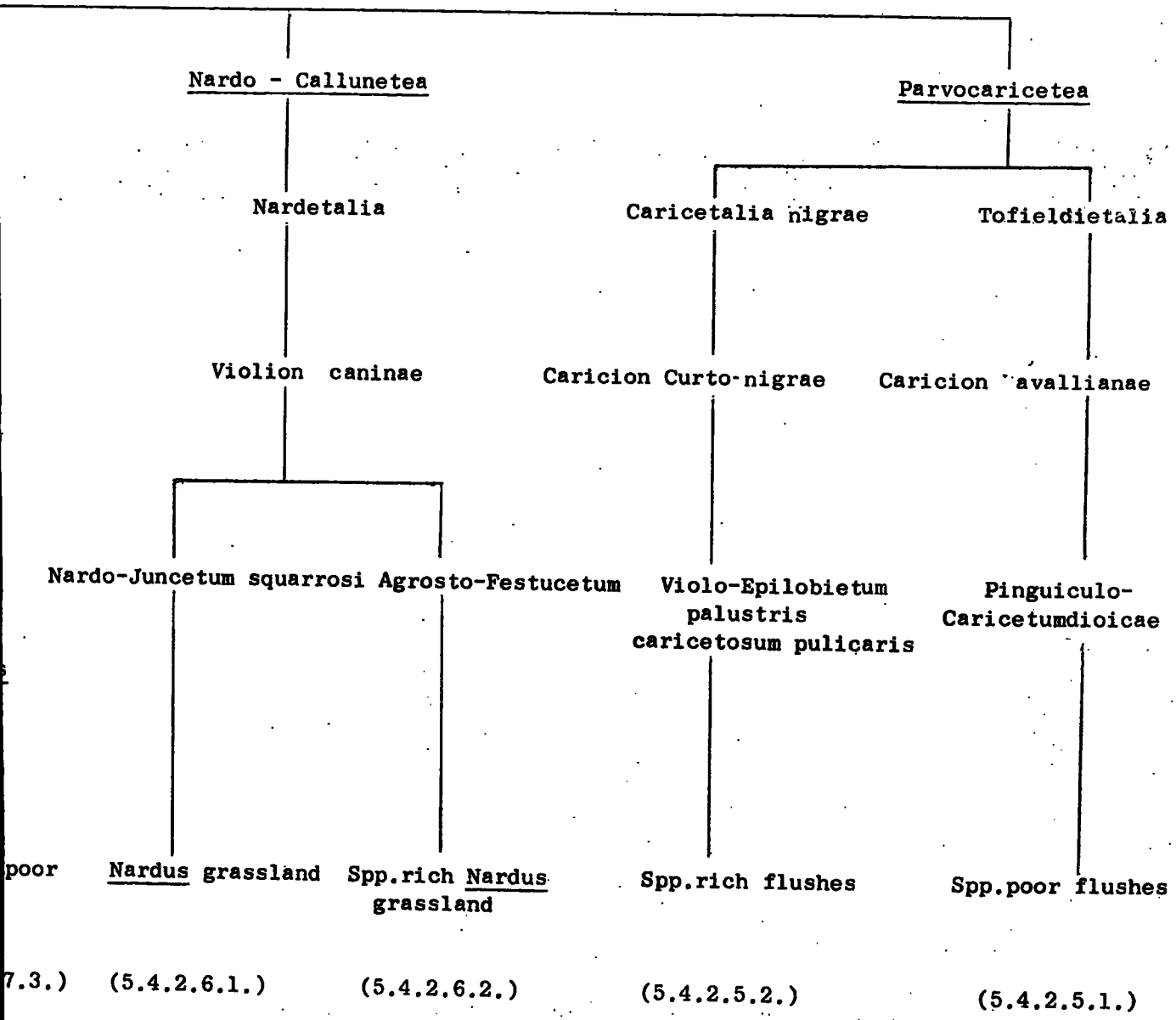
Soils are light, crumbly and dry, being deep and quite rich in minerals. pH range is 5.4-6.6 (mean 5.9) and the community is found on level to gently sloping ground.

It was recorded from the more northerly parts of Mainland, and Mousa; in the southern half of the Mainland and on Whalsay and Bressay the other communities of this group seem more common.

The phytosociological relationships of these species-rich meadows are not clearly defined. In that they have little fertilization, as far as is known, and have correspondingly low quantities of Lolium and Cirsium arvense it may appear that they fall within the Centaureo Cynosuretum Br.-Bl. and Tx.1952. This association has been recorded from Skye (Birks 1973) and is widespread in Ireland (O'Sullivan 1965).

Figure 5.4. Synoptic classification of Grassland Communities of the Southern Isles




Nardo - Callunetea
Parvocaricetea
Nardetalia
Caricetalia nigrae
Tofieldietalia
Violion caninae
Caricion Curto-nigrae
Caricion avallianae
Nardo-Juncetum squarrosi
Agrosto-Festucetum
Violo-Epilobietum palustris caricetosum puliçaris
Pinguiculo-Caricetumdioicae
poor
Nardus grassland
Spp.rich Nardus grassland
Spp.rich flushes
Spp.poor flushes
7.3.)
(5.4.2.6.1.)
(5.4.2.6.2.)
(5.4.2.5.2.)
(5.4.2.5.1.)

However the dominance and abundance of grasses - Holcus lanatus, Anth.oxanthum odoratum, Festuca rubra, Cynosurus and Agrostis tenuis, along with species indicative of pasturing such as Trifolium repens and Rumex acetosa are much more charactertistic of the Lolio-Cynosuretum Br.-Bl.& de Leeuw 36. This association has a generally low species average (20 per releve in O'Sullivan's Irish pastures) due to the proliferation of grasses and a limited number of species able to tolerate intensive pasturing. These grow to the exclusion of many of the poverty-indicators of the Centauro-Cynosuretum, e.g.Luzula campestris, Lotus corniculatus and Rhytidiadelphus squarrosus.

The presence of Potentilla erecta, Luzula multiflora and Leontodon autumnalis in the Shetland communities indicates the influence of surrounding heaths on this association and are not seen in the Irish examples (O'Sullivan 1965) or widely on the Continent (Williams & Varley 1967).

Birse (1973) recorded 4 relevés from the Sullom Voe area, which, in spite of the absence of Lolium perenne he placed in the Lolio-Cynosuretum. One, he regarded as a form transitional to more acidic grassland, while the other three were allocated to the subassociation with Luzula campestris However Birse regarded all as being closely related to Agrostis-Festuca acid grasslands.

It was decided then that these species rich Holcus-Trifolium meadows are a Shetland form of the Lolio-Cynosuretum.

5.4.2.7.2. Typical Meadows Relevés 553-220

This grassland community is characterised by constant Trifolium repens, Festuca rubra, Plantago lanceolata, Holcus lanatus, Sagina procumbens, Bellis perennis, Agrostis tenuis and Rumex acetosa and the absence of most of the heath species found in the latter group. These eight species form the major part of a carpet up to 100mm high, and of very dense cover, in which Cerastium holosteoides, Leontodon autumnalis, Cynosurus and Lolium perenne appear. There were only 16 spp.per relevé on average, and the only moss

found with regularity was Hrynchium praelongum Bryophyte cover was low, Sagina procumbens replacing the "moss" layer.

Cynosurus cristatus and Poa subcaerulea have their grassland optima in terms of cover and abundance in this community.

Soils are light, minerally and crumbly and the pH range is 5.0-7.0 (mean 5.9), giving rise to the best grazing land found in Shetland. This community was found from sea-level to only 23m (on Whalsay) above which height the heath species seem to advance and the vegetation of groups 5.4.2.7.1. is found.

This community follows most closely the examples described by other authors as Ryegrass-Crested dog's tail pastures. Lolium perenne and Cynosurus cristatus are both common in pastures dominated by Trifolium repens, Holcus lanatus and Festuca rubra. The high constancy of Agrostis tenuis, and the increased presence of Poa annua and P.subcaerulea are both noted by O'Sullivan (1965) in Ireland.

Streams cutting through this community are flanked with essentially the same vegetation. Caltha palustris, Equisetum palustre, Primula vulgaris and Lotus corniculatus may be particularly prominent locally.

Beside metalled roads a variant of this community is found in which species adapted to trampling, grazing and disturbance assume greater importance. Most such roads in Shetland are comparatively recently built, and hence the vegetation at their edges reflects the change. Sheep use the verges as tracks and resting places. Poa annua, Bellis perennis, Plantago major, P.lanceolata and Stellaria media form a dense sward and at the road/vegetation border acrocarpous mosses such as Barbula fallax, B.recurvirostra, Dichodontium pellucidum, Ceratodon purpureus and Bryum argenteum are found.

.4.2.7.3. Species-poor meadow community Relevés 238-089

This vegetation is differentiated from the rest of the group by the absence of Festuca rubra, Plantago lanceolata and the heath species,

growing in much taller vegetation form.

These species-poor areas are patches within, usually, the latter type of vegetation, where the herbs are tall (e.g. Iris up to 0.6.m)

In addition to the meadow (5.4.2.7) characteristic species, Ranunculus acris, Cerastium holosteoides and Lolium perenne have high constancy. Overall species content is low (average 14 per relevé) and these two groups of species dominate the vegetation. Also of significance are Poa annua, which with Lolium indicates extensive grazing, Bellis and Rumex acetosa.

The low, grazed typical sward has patches of Iris pseudacorus, Juncus effusus, J.conglomeratus, Cirsium vulgare and Senecio aquaticus, and it is in and around such clumps that this community is found.

As in the latter community, soils are rich, brown and crumbly, with mean pH 5.8.

Both the typical and species-poor areas of grassland are found throughout Southern Mainland. The typical form was also recorded on Whalsay, Bressay, Mousa and Isbister Holm. The species-poor community appears to be restricted to the areas of intensive grazing such as Kergord, Tingwall Valley and Noss (near Spiggie, S.Mainland), where high manuring rate may encourage its growth.

O'Sullivan (1965) describes a Juncus effusus subassociation within the Lolio-Cynosuretum in which many species found optimally in the Molinietalia occur. The Shetland species-poor community appears similar to this. Juncus conglomeratus, J.effusus, Iris pseudacorus, Alopecurus geniculatus, Stellaria alsine, Montia fontana and Carex nigra all occur in this vegetation, forming distinct patches within typical Lolio-Cynosuretum, and with which very few other species can grow.

5.4.3. Comparison with the Northern Isles

Essentially the same groups of grassland vegetation exist throughout the Shetland Isles and this is endorsed by comparison of the two sets of data available.

Maritime grasslands lying within the Glauco-Puccinellietalia are common,

dominated by Festuca rubra, Armeria maritima and Plantago maritima and generally placed in the Armerion maritimae. Lewis (1976) places her Plantago maritima - Carex nigra group in the Silenion maritimae, intimating that a new association of Shetland maritime grasslands may be recognised. This would parallel the work by Malloch (1971) in Cornwall. However, it is felt that Southern Shetland data, rich in character species must remain in the Armerion, and that not until a survey of maritime grasslands over the whole of Britain has been made, can the communities of these extremes be linked.

The other difference between Northern and Southern Isles data is the description for the Northern area of a number of reseeded pastures which have been reclaimed from bog or heath. Because of the content of the seed mixture used these pastures fall into the Lolio-Cynosuretum and may be particularly rich in Juncus effusus.

The base rich Festuca grassland (5.4.2.1.), the Linum catharicum-Silene acaulis grasslands (5.4.2.4.) and the flushed limestone grasslands (5.4.2.5.1.) were not sampled in the Northern Isles.

5.5.WET MEADOWS

Table 5.5

5.5.1.Introduction

The communities described under this vegetation type are those in which Caltha palustris and sedges play an important part, or in which the water table is less than 100mm below the ground surface.

Due to the temporary nature of some wetting, e.g.during floods, or waterlogging, it was not always easy to recognise this vegetation in the field, and there are some overlaps with releves of the grassland type.

"Marsh" and "mire" are used ysnonymously to include waterlogged ground on clay or silt, while "fen" indicates waterlogging due to topogenic factors on peat.

Most of the Shetland wet meadows fall into the Molinietalia although their definition is not always exactly true to type. This is particularly true of the Potentilla palustris - dominated areas in group 5.5.2.3.

Those releves collected from the edges of lochs are referred to the Phragmitetea while two more-enriched types fall into the Parvocaricetea. One group on acidic ground has been tentatively placed in the Violion caninae.

A summary of the syntaxa found is given in Figure 5.5.

Reed swamps are uncommon in Shetland(Johnston 1974), and extensive mesotrophic wetlands seem to be limited ot the Spiggie-Brow complex, Culswick and Hillwell in the Southern Isles, and Lund on Unst.

Caltha palustris is very common in Shetland, forming extensive golden carpets in June and July, and being accompanied by dense purple spikes of Dactylorchis maculata spp.Purpurella. These sites tend to be in the wetter parts of croft land or beside ditches and streams. Flag forms dense patches, in the latter habitat particularly, where drainage is freer.

5.5.2.Vegetation groups

5.5.2.1.Waterside Community

Releves 714-093

This is a community found at the edge of lochs and open waters in

marshes where the pH is neutral, or only mildly acidic. (Average pH of the 8 relevés grouped here is 7.1, and the range 4.8 - 8.7).

The plants are not growing in standing water, but at a stage in the hydroseral development where mud and silt give a stable substrate with a constantly high water table.

It is not particularly well-defined floristically, because of the overlap between stages of succession. Open water species, such as Littorella uniflora, Glyceria fluitans and Eleocharis multiflora are present alongside Agrostis stolonifera, Juncus articulatus, and Ranunculus flammula. The latter three indicate more waterlogged soil conditions.

Generally, the edge of a loch has this community characterised by Agrostis stolonifera, Hydrocotyle vulgaris and Carex nigra, with either Juncus kochii or Juncus articulatus, depending, it seems, on the degree of stability of substrate. Juncus kochii, in Shetland, is an early colonist of open water. Senecio aquaticus, Ranunculus flammula and Mentha aquatica are found in the drier parts, further from the water's edge. It is possible that, on more evidence, two distinct communities could be identified, but on the releves grouped here such a division can only be tentative.

Bryophyte cover increases with distance from the open water. Acrocladium cuspidatum being common, and forming an open carpet in places.

This community is differentiated floristically from other wet meadow groups mainly on negative characteristics - the absences of Anthoxanthum odoratum (present in all but this and group 5.5.2.2.). Holcus lanatus and Leontodon autumnalis.

The releves 793 and 090 were collected from opposite ends of the Loch of Spiggie, Mainland. Here, substrate was a fine gravel, and while this is reflected in the presence of possibly, Potentilla anserina and Stellaria media, the characteristic species of succession and water-logged soils remain. These two releves also contain occasional occurrences of Spergula arvensis, Equisetum arvensis and Matricaria matricarioides from nearby

arable land. They are placed in this group, however, because of their similarity with these waterside releves.

The community was recorded from Mainland and Whalsay. In acidic conditions it appears to be replaced by a Sphagnum-rich, blanket bog antecedant, whereas round calcareous or limestone pools a denser, more species-rich vegetation is found.

With an average of only 13 species per releve it is difficult to place this community definitively within the classes of hydroseral development.

Character species of the Molinio-Arrhenatheretea are not well well represented, although most are present in the vegetation. However, Caltion species do play a more important role e.g Caltha palustris and Senecio aquaticus. Myosotis scorpidioides, given by O'Sullivan (1965) as a European character species for this alliance is only infrequently recorded in Shetland. Myosotis secunda, M.caespitosa and individuals not identifiable to the species level were common in these waterside areas.

It would seem, then, that the community falls into the Calthion palustris Tx.37,em 1951, and that it is a grassland vegetation type where the high water table is maintained by proximity to lochs etc., from which some nutrient enrichment may also be obtained.

These releves seem to be related to the Irish Senecioni-Juncetum acutiflori Br.-Bl.& Tx.1952 described by O'Sullivan (1955). Both are found on soils where drainage is impeded and have species characteristic of this in Ranunculus flammula, Agrostis stononifera and Galium palustre.

The Shetland community lacks some of the rush and grass species found in Shetland, viz: Juncus acutiflorus, J.effusus, Poa trivialis, Bromus racemosus and Holcus lanatus, which seems to indicate that the former is influenced by the 'open water' effects, and less by grassland surrounding. Both O'Sullivan (1965) and Braun-Blanquet and Tuxen (1952) have Angelica sylvestris, Filipendula ulmaria and Iris pseudacorus in their examples of association. In Shetland these species are confied to drier, or more aerated soils.

It is possible that, with more information, some of the subassociations and variants distinguished by O'Sullivan could be recognised here. His subassociation with Ranunculus flammula, with constant Hydrocotyle vulgaris Juncus articulatus and Mentha aquatica, is similar floristically to the last 5 releves in the Shetland Table (Table 5.5).

In conclusion then, these S.Shetland waterside communities seem to represent a part of the Calthion palustris which, due to severe waterlogging is not fully able to develop into the characteristic grassland sward.

5.5.2.2. Carex rostrata - Menyanthes community Releves 778-777

This is a very distinctive, species-poor community found at the edge of open water, either near lochs, or pools within marsh or fen. This emergent vegetation is very open, usually consisting of spikes of Carex rostrata, Eleocharis multicaulis or Juncus articulatus intermingled with Menyanthes and Potamogeton polygonifolius. Other flowering species occasionally found were Myosotis caespitosa, Mimulus guttatus and Galium palustre, while moss cover was virtually nil. (Only at one site was a bryophyte, Sphagnum subsecundum var.inundatum, recorded.)

These plants grow up to 1m tall in standing water, the high water level being present throughout the year, and having a mean pH 6.7 (range 5.2-6.8).

This vegetation was only recorded from Spiggie-Brow fen complex and near the Loch of Flatpunds in Walls. Most open stretches of water in Shetland are extremely acidic and nutrient poor (Britton 1974) so that the right habitat for the community would seem to be limited.

Open water and pioneer communities are generally referred to the Class Phragmitetea, and those of more or less stagnant water to the Magnocaricion elatae W.Koch 1926 (Birks 1973).

The Shetland community appears very similar to that of the Carex-rostrata Menyanthes trifoliata Association described on Skye. These nominal species are constant while Equisetum fluviatile and Ranunculus flammula are the only

other species being at all common. In Shetland both Eleocharis palustris and E.multicaulis occur, although only the former is recorded in Skye. The loch at Flatpunds has one of the few Islands' records of Nymphaea alba; Birks includes this species in his lists, but at Flatpunds it grew further into open water than indicated on Skye.

Spence (1964) describes a Carex rostrata - Menyanthes trifoliata Sociation of shallower water (mean level about 190 mm) which is clearly related to this association.

5.5.2.3. Potentilla palustris communities Releves 774-842

Although Potentilla palustris does occur in other wet meadow vegetation, it has its optimal development in the mesotrophic meadows and marshes as seen in the Spiggie-Brow complex. Almost all the releves in this groups were recorded there. The Lochs of Spiggie and Brow, lying along a fault in granite provide some of the most extensive and best developed mestotrophic marsh in Shetland. The habitat is rare in the island, one other major example being found at Culswick.

The scope of this community embraces a heterogenous collection of releves from which any divisions cannot be more than tentatively drawn.

All are characterised by a high cover and constancy of Potentilla palustris, with Equisetum fluviatile, Agrostis stolonfera and Holcus lanatus. These are accompanied by Carex nigra, Rhinanthus minor agg., Rumex acetosa, Hydrocotyle vulgaris, and Leontodon autumnalis, which have constancy IV.

The vegetation is quite tall, 1m where Angelica, Iris or the ungrazed grasses are luxuriant. Soils are rich, dark muds with mean pH 6.0 (range 4.6 to 7.2).

Two groups can be distinguished on species diversity and the soil moisture.

.5.2.3.1. This appears to be a community of very wet or periodically wet parts of the marsh, characterised by Acrocladium cuspidatum, Rhinanthus minor agg., Festuca rubra and Juncus articulatus. It often is found in hollows or

channels through the marsh.

Herb cover is 100%, and vegetation is tall, being ungrazed. Moss cover, up to 50% in places is dominated by Acrocladium species.

Within the bounds of this group, a further division may be made. At a number of sites Menyanthes trifoliata, Acrocladium cordifolium and Equisetum fluviatile dominate the vegetation. These seem to be the wetter areas, while these species are absent from relatively drier parts. The first group, 5.5.2.3.1.1., occasionally contains species of open water pioneer hydroseral succession such as Eleocharis multicaulis, Mimulus guttatus and Polygonum amphibium, while the second group, 5.5.2.3.1.2., has a higher bryophyte cover and diversity, as well as the increased presence of 'wet meadow' plants, e.g. Senecio aquaticus and Caltha palustris.

Both these groups of vegetation have a greater species average than 5.5.2.3.2.(20 per relevé mean, as opposed to 11).

.5.2.3.2.A species-poor group characterised by the absence of the Acroc ladium cuspidatum species group mentioned above. The relevés were collected from sites very near to the open water, but growing on stable damp soil as opposed to rooty mud or plant mat. They differ from the wet meadows of 5.5.2.3.1. by the species paucity and lack of grazing, and hence, natural enrichment. Only four relevés were collected, making it extremely difficult to assign this community with any confidence.

It has proved difficult to assign any of these communities. All the Shetland fen vegetation containing large amounts of Potentilla palustris appears to fall between the hollows and pools communities of the Scheuchzerietea, the small sedge communities of the Parvocaricetea and the wet meadows of the Calthion palustris. The main problem, then, was the delimitation of the border, if present, between the classes involved.

Character species of the Parvocaricetea present, and with constancy III, IV or V to the whole of group III are:

Potentilla palustris V
Hydrocotyle vulgaris III
Acrocladium cordifolium III

while Epilobium palustre is occasional, Potentilla and Hydrocotyle are, however, regarded as only weak character species (Jones 1975, Westhoff and Den Held 1969). There is also a lack in the Shetland communities of small sedges such as Carex demissa.

Molinio-Arrhenatheretea character species with constancy III,IV or V are:

Holcus lanatus	V
Rhinanthus minor agg.	IV
Rumex acetosa	IV
Festuca rubra	III
Ranunculus acris	III
Anthoxanthum odoratum	III

with regular occurrences of Cerastium holosteoides and Cardamine pratensis.

These Potentilla communities closely resemble some of the Calthion palustris described by O'Sullivan (1965) in Ireland, with the irregular incidence of Caltha itself in meadows, but with common Agrostis stolonifera and Senecio aquaticus. This vegetation, however, tends to occur on rich, brown earths and silt rather than the organic muds supporting the Southern Shetland community. The regular appearance of Lychnis flos-cuculi in Shetland marshes agrees with the list of Calthion character species given by Westhoff and Den Held. (Also, of their Molinietalia characters, Angelica sylvestris and Cirsium palustre are represented.)

The Scheuchzerietea has no class character species but for the alliance Caricion lasiocarpae Vanden Berhen 49 a number are given (Wheeler 1976). Of these, Carex rostrata occurs three times in the Potentilla communities while Menyanthes trifoliata, Equisetum fluviatile and Potentilla palustris are common. On Skye, Birks places his "mud-bottom" communities in this alliance, and they have affinities with the present vegetation in the importance of the four character species mentioned above. However, many of the sedges, e.g.Carex lasiocarpa,C.limosa are not, or rarely, recorded in Shetland. The Skye syntaxa appear to represent an area of the alliance dependent on high water table in a less vegetated stage of succession.

The true "floating mat" vegetation of the Parvocaricetea and the

Scheuchzerietea was not recorded in southern Shetland. It seems to be replaced by this community growing in standing water, up to 1m deep, rooted in a fine, organic, mud or silt.

The vegetation has not been assigned to any established association but placed in the Caricion lasiocarpae.

Group 5.5.2.3.1.1., with constant Menyanthes, Acrocladium cordifolium, Equisetum fluviatile and Potentilla palustris is perhaps most typical of the alliance, and closely resembles an Equisetum fluviatile-Acrocladium cordifolium Sociation described by Spence (1964). This, however, is sometimes found in Scotland, in willow carr. The Scottish and Shetland communities do share a dense herb cover with limited bryophyte variety viz: Acrocladium spp., Riccardia pinguis and Eurynchium praelognum. It is possible that if shrubs and trees were able to develop in these Northern Isles the Scottish Sociation would develop fully.

5.5.2.4. Grassland flushes Releves 337-672

These flushed grassland communities are closely related to the Grassland group of 5.4.2.5, but are placed in the Wet Meadow section because of the more important part played by ground water in their delimitation. Here ground conditions are always very wet, the substrate being dark brown or black mud or soil. pH is slightly acidic to neutral (range 5.6-7.2, mean 6.2) and the community was found on schist, limestone and granite base rock. Although only a small number of releves fall into this group, it does appear that the community is limited to these rock types. On sandstone, drainage tends to be more efficient thus giving rise to the Grassland group, while on gneiss the widespread peat formation seems to preclude this community.

Carex panicea is constant to the community while Ranunculus flammula, Juncus kochii, Eriophorum angustifolium, Leontodon autumnalis and Senecio aquaticus have constancy IV. In no other community of wet meadows does this combination of Carex panicea and Eriophorum angustifolium occur

Other common species are Pellia epiphylla, Hydrocotyle vulgaris, Carex hostiana, Pedicularis palustris, Riccardis pinguis, Campylium stellatum and Narthecium ossifragum. Characteristic Molinio-Arrhenatheretea species, such as Holcus lanatus, Anthoxanthum odoratum, Festuca rubra and Rumex acetosa, are only occasionally represented.

The community is found in channels or patches on gently sloping ground up to 30m above sea-level. It merges with Molinio-Arrhenatheretea dry grassland communities or, more usually, with heath grasslands of the Violion caninae. The sedges and cotton grass form an open mat, up to 0.3m tall with a bryophyte layer covering up to 80% of the ground; Pellia epiphylla, Drepanocladus revolvens and Campylium stellatum accounting for most of this. A high species diversity (mean 22 species per relevé) includes a number of single or irregular occurrences within these patches, e.g. Blysmus rufus, Triglochin maritima, T.palustris, Sagina nodosa, Eleocharis quinqueflora, Carex dioica, C.echinata, C.pulicaris and C.demissa.

At all sites recorded, there was grazing of the community by sheep or cows.

The dominance of small sedges here indicates that the flushed grasslands lie in the Parvocaricetea. Class characters Pedicularis palustris, Epilobium palustre, Carex demissa, Hydrocotyle vulgaris, Riccardia pinguis and Acrocladium cordifolium are all present.

Character species of both orders within this class are represented. Of the Caricetalia nigrae, Carex nigra, C.echinata, Ranunculus flammula and Epilobium palustre are present with constancy III, but the Tofieldietalia species C.dioica, Campylium stellatum, Eleocharis quinqueflora, Scorpidium scorpidioides and Drepanocladus revolvens have only occasional occurences.

The Tofieldietalia, includes generally more base rich, communities than the other order and has less Sphagum cover. Further, the alliance characters of the Caricion davallianae are represented by Pellia neesiana and Pellia fabbroniana, and abundant Carex spp.

These Shetland flushes have many similarities with the Skye vegetation allocated by Birks (1973) to the Eriophorion latifolii (Br.-Bl.& Tx.1943) especially in the domiance of the vegetation by Eriophorum angustifolium.

His Carex panicea-Campylium stellatum Association is most similar, except that the Shetland examples seem to have greater cover of Eriophorum angustifolium.

Braun-Blanquet and Tuxen (1952) have one aufuahme from Ireland in a "Carex hostiana community", which seems to be related to these relevés and which they have placed in the Caricion davallianae Klika 34.

This association has been included by Jones (1973) in her association of flushes, the Pinguiculo-Caricetum dioicae Jones 1973.

This is characterised by a Carex dioica, C.lepidocarpa and Triglochin palustris. C.pulicaris and Plantago maritima are differentials. C.lepidocarpa is not present here but all other of these species are common in the flushes, as well as Pinguicula vulgaris and it would seem that the vegetation is representative of the new association. Tentatively it is proposed that it lies within the subassociation Eleocharetosum typicum em Wheeler 76, because of the prominence of Eriophorum angustifolium, Carex nigra and C.demissa and absence of Molinia.

5.5.2.5.Acidic wet meadows Relevés 263-267

This is a community, delimited here by a small number of releves, where grassland species play an important role, but where characteristic of waterlogging are noticeable components. It occurs usually at the boundary between blanket bog and grazed meadows or covering large areas in standing water.

The group has been divided into two on this basis.

All samples have, however, Potentilla erecta, while Holcus lanatus and Anthoxanthum odoratum also have constancy V. Carex nigra, Eriophorum angustifolium and Viola palustris are common. Potentilla erecta, and the absence of Caltha palustris differentiates this from all other wet meadow and Grassland communities.

5.5.2.5.1. Viola palustris community Releves 263-087

This is the 'border' community found on slightly drier ground conditions than the following type, and where the pH ranges from 3.8-5.9 (mean 4.8).

Only 6 releves were recorded, over limestone, gneiss and granite, but they are characterised by the presence of Nardus stricta, Viola palustris, Lophocolea cuspidata and Potentilla erecta. Grasses form an almost closed carpet on dark or gingery brown, clarty soil and are interspersed with spikes of the flowering plants. Heather species make occasional occurrences, particularly Galium saxatile, Rumex actosella, Eriophorum vaginatum, Festuca vivipara, Sieglingia decumbens and in the moss layer Hylocomium splendens, Sphagnum palustre and S.capillaceum.

It has been described from North and South Mainland and Whalsay, but this cannot signify its absence on Bressay or the smaller islands.

This is a heterogenous community and proved difficult to assign. Holcus lanatus and Anthoxanthum odoratum both have constancy V to the community and indicate affinity with the Molinio-Arrhenerathertea. However heath species, and the acidic soil conditions, as well as general ecological factors place the vegetation closer to the acidic grassland of the Nardetalia than the meadows of the former syntaxon. But Nardo-Callunetea and Nardetalia character species, e.g. Nardus stricta, Sieglingia decumbens, Carex pilulifera and Calluna vulgaris are poorly represented. Potentilla erecta, although constant here, is regarded as only a weak class character species (Jones 1973).

The community has, however, been placed in the Caricion curto-nigrae. Westhoff and Den Held (1969) give the following alliance character species:

Carex nigra	Viola palustris
Carex curta	Juncus filiformis
Carex echinata	Epilobium palustre
Ranunculus flammula	Sphagnum recurvum
	ambly phyllum

Juncus filiformis and Carex curta are not recorded in Shetland (Palmer and Scott 1969) and Ranunculus flammula and Sphagnum recurvum were

not found in the present community. However all the other character species are present and it would seem that these acidic flushes may be embraced by this rather ubiquitous alliance.

5.5.2.5.2. Sphagnum recurvum community Releves 264-267

Only six releves fall into this group, one of acidic water. The mean pH recorded was 3.8 (range 3.0 to 5.8) and where "soil" could be examined was found to be dark, soft mud or peat.

Apart from the species typical of the whole group, this community is characterised by an open sward of Carex echinata and Juncus effusus with Sphagnum recurvum. With these species are found Carex nigra, Ranunculus flammula, and a variety of bryophytes, notably Sphagnum papillosum, S.rubellum, S.palustre, Acrocladium stramineum, Drepanocladus revolvens, Chiloscyphus polyanthus, and the rare Sphagnum fimbriatum.

The vegetation is tall, 0.6m and is not accessible for sheep, rabbit or cow grazing.

This community was recorded from only two sites, Toft (North Mainland) and between the Lochs of Spiggie and Brow. Large areas of this type of vegetation are not widespread, once again due to the lack of entrophic water masses in Shetland. It may be present at Culswick in Walls (but flooding prevented full sampling of this site).

A Carex-Sphagnum recurvum nodum, within the Caricion curto-nigrae, has been described from Skye, and is clearly similar to this community. As here, the dominants are Sphagnum spp., Eriophorum angustifolium and Carex echinata, although Holcus lanatus and Anthoxanthum odoratum are more prominent in the Shetland community. Hydrocotyle vulgaris and Potentilla palustris are Parvocaricetea characters found here frequently, while order and alliance species, such as Carex nigra, Viola palustris Ranunculus flammula and Sphagnum recurvum (the latter having constancy V) are present.

Sphagnum fimbriatum is one of the differential species listed by Westhoff and Den Held (1969) for the Sphagno-caricetum lasiocarpae

(Gadeceau 09) Steffen 31 em Westhoff. This is present in one relevé, while Polytrichum commune, Aulacommium palustre, Drosera rotundifolia and Sphagnum palustre (also listed by these authors) have infrequent occurrences. However, on the basis of the absence from Shetland of Carex lasiocarpa, and from these releves of a number of Sphagnum species this community is aligned with that from Skye. It is possible that with further investigation of the wet hollows and mesotrophic marsh at Culswick in particular, a more definitive connection could be made.

5.5.2.6. Caltha meadows Releves 898-132

The average of 27 species per relevé makes this small community one of the most diverse recorded in Southern Shetland. The soils, average pH 5.9, are rich and dark brown earths supporting these grazed and mown meadows.

Carex nigra, Holcus lanatus, Ranunculus acris, Cardamine pratensis, Succisa pratensis, Lychnis flos-cuculi, Cerastium holosteoides and Trifolium repens all have constancy V and in the dense sward they form, Caltha palustris, Anthoxanthum odoratum, Carex echinata and Luzula multiflora are common. The moss layer is well developed; particularly important are Minium undulatum, Acrocladium cuspidatum, and Rhytidiadelphus squarrosus.

These meadows are floristically differentiated by the joint presence of Carex echinata and Rhytidiadelphus squarrosus and the absence of Juncus conglomeratus.

The vegetation is lush; up to 1m tall, where Angelica sylvestris, Filipendula ulmaria and Juncus spp. occur. (Dactylorchis)maculata ssp. purpurella has its optimum in this community.

There is always some enrichment of the soil, whether by neutral manuring, e.g. Tingwall (relevé 769) where the meadow is heavily grazed by cows, or from the surrounding rocks and soil, e.g. White Ness (013) where the relevé was collected from the base of a limestone grassland bank.

This, very distinct, community seems to lie floristically between the Calthion palustris and the Molinion caeruleae alliances, within the Molinio-Arrhenatheretea. (The presence of class character species such as Potentilla palustris, Triglochin palustris and Acrocladium cordifolium in some of the relevés here points to the relationship of this community to the Parvocaricetea. However, the overall constancy of Molinio-Arrhenatheretea species, particularly some of the Molinietalia, viz. Equisetum palustre, and Cirsium palustre suggest that this is only a tendency seen where the meadows contain patches of small sege mire in hollows.

The Calthion includes manured moist meadows while the Molinion covers the un-manured and seldom grazed communities, including some of those on acid soils (O'Sullivan 1965).

Caltha palustris, Senecio aquaticus, Luzula multifora and Lychnis flos-cuculi are Calthion species all well represented in this community, although the low frequency of Agrostis stolonifera and Galium palustre (waterlogging indicators seen in the other Shetland Calthion community, group 5.5.2.1) suggests a well-aerated soil less typical of the alliance. The constancy of Rhytidiadelphus squarrosus and Mnium hornum, indicators of low soil base status, could be due to the relatively low level of manuring carried out, or to high leaching by rainfall.

The Shetland community does appear to be related to the Junco-acutiflori-molinietum Tx.& O'Sull.62, found in the Irish Molinion (O'Sullivan 1965). Of the differential species he names, Carex echinata, C.nigra, C.panicea, Rhyhdiadelphus squarrosus, Mnium undulatum and Succisa pratensis are frequent in the Shetland group. The alliance, along with the Junco-molinion Westhoff 69, is considered to be closely related to heath communities by Westhoff and Den Held (1969)

The Molinion, however, has only been described from Ireland within the British Isles.

In view of the overwhelming abundance of alliance character species, and the widespread distribution of the alliance in Britain this community has been assigned to the Calthion palustris.

5.5.2.7. Wet Grasslands Releves 122-854

This community is found growing alongside the latter one throughout the Islands. It is generally lower in species numbers than other Molinio-Arrhenatheretea groups described, and this makes it difficult to relate to already described syntaxa.

The vegetation is tall, although grazing was observed at most sites. The whole group is identified on rather a negative basis; the cover of many of the grasses is reduced, particularly Festuca rubra, Agrostis stolonifera and A.tenuis, while Rumex acetosa has its optimum for Shetland wet meadow communities.

Brought together in this group are two communities united by having tall herbs forming dominant vegetation.

5.5.2.7.1. Juncus conglomeratus community

5.5.2.7.2. Species-poor community.

5.5.2.7.1. Juncus conglomeratus community Releves 122-428

This community is related to the last group (Caltha meadows) alongside which it is often found.

It consists of a mat of grazed Holcus, Anthoxanthum , Ranunculus acris Rumex acetosa, and Equisetum fluviatile in which are clumps of Juncus conglomeratus, Caltha, Carex echinata and Carex nigra. Soils are always wet, although the patchy and hummocky nature of this community suggests that it may be slightly drier than other Caltha communities. The soils are rooty, mineral-rich and brown, mean pH is 5.4 (range 4.9 - 6.2).

The herb layer can be up to 0.6m tall and is rather open, while bryophyte cover is about 30%, the absence of Acrocladium cuspidatum and M nium undulatum being indicative of some drying out.

Equisetum fluviatile, is constant to this community. Although it is

more commonly a plant of river and lake margins in the south, in Shetland it is often found in marshes and meadows.

Grazing by sheep and cattle occurs at all sites.

These two communities, the Caltha meadows and this Juncus conglomeratus patches have been recorded from all parts of Mainland, and Whalsay. They probably occur on Bressay where wet Caltha meadows were seen but not recorded. The base-rock type seems immaterial to the formation of these meadows, more important being the impeded drainage of the sites.

This community must be placed in the Molinietalia on the abundance and dominance of Holcus lanatus, Ranunculus acris, Anthoxanthus odoratum and Rumex acetosa, with other characteristic species accompanying them, e.g. Equisetum palustre, Deschampsia flexuosa, Achillea ptarmica and Lychnis flos-cuculi. Juncus conglomeratus, a Molinietalia character species (O'Sullivan 1965) has constancy V to this group. O'Sullivan (1965) points out the infrequent occurrence of this species in Ireland, and therefore does not recognise any association containing it. Although Juncus conglomeratus is given by Westhoff and Den Held (1969) as a Junco-subuliflori-molinion character species, it appears that this community should be placed in the Calthion. The former alliance is not common in Britain (Wheeler 1975), and generally includes rush-rich meadows which contain a higher percentage of heath species than is found here.

Possibly due to the slightly drier nature of the ground of these releves, Calthion character species are presented only by Caltha palustris itself. Further releves from Juncus conglomeratus and Equisetum fluviatile - dominated areas are necessary before a more positive designation can be made.

5.5.2.7.2. Species-poor community Relevés 429-854

Within the Caltha meadows, and the Holcus-Trifolium meadows (5.5.2.6. and 5.4.2.7) there are patches of tall vegetation dominated physiognomically by Iris pseudacorus.

The average species number drops (here 12.5 per relevé) and the vegetation is characterised by the dominant species with Holcus lanatus,

Ranunculus acris, Rumex acetosa, Trifolium repens and Equisetum fluviatile. Agrostis stolonifera, Poa annua and P.subcaerulea are also common. There are almost no mosses, except an occasional strand of Eurynchium praelongum or Brachythecium rivulare amongst the dense grassy mat.

Like those of the surrounding meadows the soils are rich, dark and crumbly, being only periodically very wet, but a generally high water content is indicated by the occurrences of Alopecurus geniculatus and Phalaris arundinacea (pH mean 6.3, range 5.2-7.2). Many meadow species more widespread in Britain have some of their only Shetland occurrences in this community, e.g.Dactylis glomerata, Festuca pratensis, Stachys palustris and Arrhenatherum elatius.

Releves from this community were collected only from the Mainland.

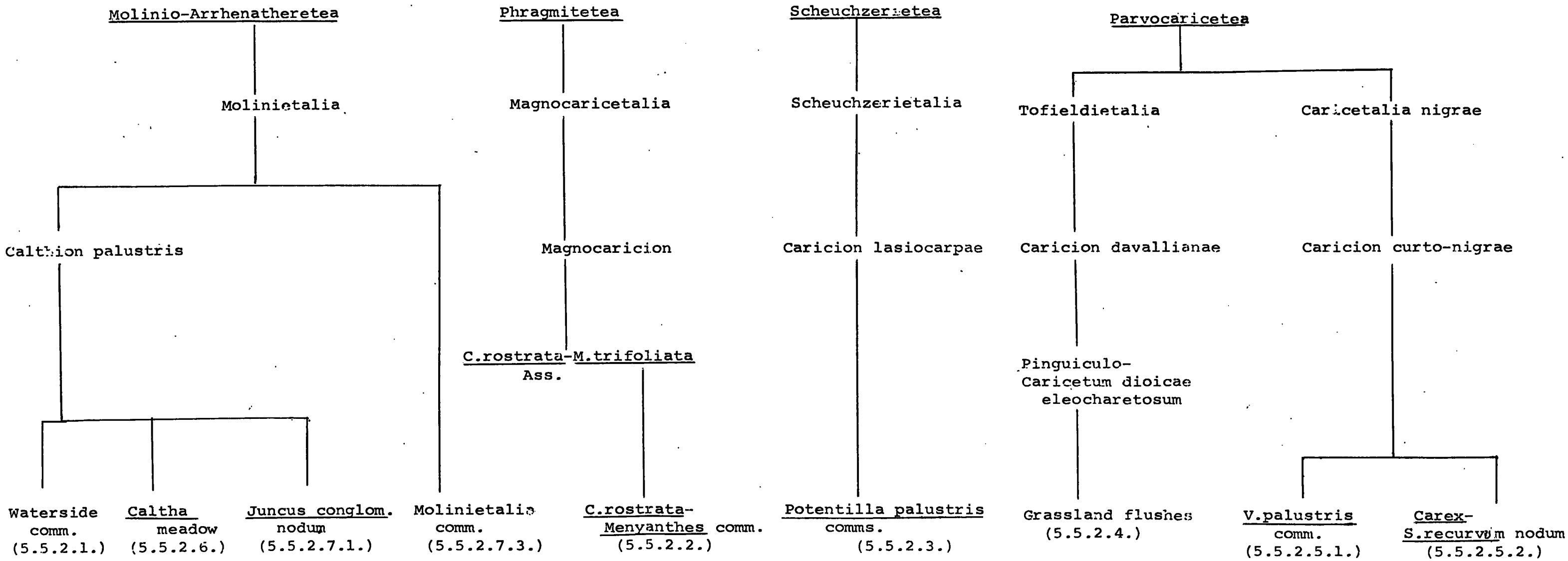
Both Braun-Blanquet and Tuxen (1952) and O'Sullivan (1965) refer some of their Irish data to a "Molinietalia community" in the absence of a satisfactory established alliance. Because of the low species content, in particular, it is possible only to refer this community to a similar grouping.

Molinio-Arrhenatheretea character species are well represented in Holcus lanatus, Ranunculus acris, Cerastium holosteoides and Rumex acetosa, although Molinetalia species have only occasional occurrences, e.g.Juncus effusus, Cirsium palustre and Cardamine pratensis

The Shetland group does appear to have two sub-groups. The first six relevés in Table 5.5 containing Equisetum fluviatile have slight similarities with a variant within his Senecion-Juncetum actutiflorus Association, placed by O'Sullivan (1965) in the Calthion. But the Shetland releves are found on moderately well drained soils and species paucity prevents their being allocated elsewhere.

The remaining relevés lacking E.fluviatile have constant Iris Pseudacorus and Trifolium repens and in this respect closely parallel the Irish Molinietalia communities.

Fig. 5.5 Synoptic classification of the wet meadow communities of the Southern Isles



5.3.3. Comparison with the Northern Isles

From the Northern Isles no data was collected from rich mesotrophic marshes such as those seen at Spiggie and Brow, nor from open waterside communities. Hence the syntaxa recognised there fall (with only one exception - the Polygonum amphibium group) in the Calthion and broadly correspond with the Caltha palustris meadows (5.5.2.6.) and the Wet grasslands (5.5.2.7) found in the Southern Isles.

However those communities in which Potentilla palustris plays an important role have also been included in the Northern Isles Calthion, while in the south they seem referable to the Caricion lasiocarpae. This difference is interesting since in the South, Potentilla palustris is accompanied frequently by Menyanthes trifoliata, Equisetum fluviatile, Acrocladium cordifolium, and Senecio aquaticus, particularly at Spiggie. These species are not at all common in the Northern wet meadows.

The difference between the sets of data lies probably only in the high proportion of releves collected from the one site - the Spiggie-Brow complex. Although this covers a very large area it represents a single type of rich mesotrophic marsh, not sampled elsewhere. Conversely many of the Northern sites were from rich, drainage hollows and channels amid blanket bog and consequently the data reflects this.

5.6.BLANKET BOG Table 5.6

5.6.1.Introduction

The term 'blanket bog' was intended to include all vegetation of deep peat where water table affects the floristic composition and where Sphagnum spp. dominate the moss layer (McVean and Ratcliffe 1962; Moore 1968). That is, to encompass in this type, all bog types whether truly the "blanket" peat of Scotland and the Pennines, or "raised" or "valley" bogs. Because of the broad base-line adopted it has also embraced the wet heath vegetation of the Ulicion nanae and thus overlaps with the communities of "Heaths" (Table 5.8).

Four main groups have been recongised for Shetland bog vegetation. These are summarised on Figure 5.6.

Group 5.6.2.1., a Juncus squarrosus community indicates the affinities of the vegetation with those of heath and underlines the fact that the deepening of peat means that a gradual transitional to blanket bog takes place. This community would seem to be on the borderline of any division made between "deep" and "shallow" peat.

The remainder have all been assigned to Moore's Class Oxycocco-Sphagnetea. He defines his "bog" vegetation by the dominance of a Sphagnum on a water-logged peat of ph 3.0-5.0. Of the class character species he gives, Drosera rotundifolia is common here, although absent from the drier parts, Aulacomnium palustre is recorded only twice, Lepidozia setacea thrice, Sphagnum capillaceum is widespread, but Sphagnum tenellum, and Calypogeia trichomanis are not recorded in the present survey. However, the constancy of Calluna, Eriophorum angustifolium, Erica tetralix and Trichophorum cespitosum prove the existence of the class.

The position of a number of species is interesting.

Throughout all this vegetation the Empetrum nigrum, Listera cordata and Rhytidiadelphus loreus are constant, and often achieve high degrees of cover.

On the basis of the constant occurrence of Empetrum, Rhytidiadelphus

loreus and Eriophorum angustifolium, with frequent Erica cinerea, Listera cordata and Scapania gracilis, Lewis (1976) created a new association to embrace all blanket bog of the Northern Isles of Shetland.

While this asociation has been recognised to a large extent in the Southern Isles, a number of her taxa were not found. This may indicate that the blanket bog of Southern Shetland, extending to higher altitudes than many sites in NorthernShetland, has some closer affinities with blanket bog on the British mainlaind.

Moore (1968) placed a number of releves from Swedish mires which resembled the Erico-Sphagnetum magellanici, but having a number of Sphagnion fusci character species, into the latter alliance. Empetrum nigrum and Cetraria islandica are the only two such species recorded here, but it is felt that their presence is outweighed by the Erico-Sphagnion character species also found.

The constancy of Empetrum and the two pleurocarpous mosses is felt to be a reflection of the oceanic nature of the Shetland climate. Birse (1973) describes it as hyperoceanic, with moisture conditions which would promote peat formation "to a greater degree than in the less oceanic regions of the Scottish mainland". Gimingham (1964a) believes that the Scottish heath vegetation belongs to the more oceanic groups of heath communities, and cites a number of species indicative of this. Of these Carex binervis Listera cordata, Empetrum nigrum, Erica cirerea and Rhytidiadelphus loreus are certainly widespread in S.Shetland.

Goode (1974) points out differences between Shetland bog vegetation and that of Scotland: a) small amount of Sphagnum in the bryophyte layer, b) the presence of "oceanic" species such as Carex binervis and Erica cinerea, c) the presence in bogs of atypical species such as Luzula sylvatica, Juncus squarrosus and Nardus stricta, d) the abundance of Rhacommitrium langinosum, Rhytidiadelphus loreus and Scapania gracilis.

5.6.2. Vegetation Groups

6.5.2.1. Juncus squarrosus community Releves 344-320

This is a community of sloping ground and hollows found as patches in more extensive blanket bog vegetation. It was recorded between 46m and 122m on gneiss, schist and granite.

Calluna and Juncus squarrosus are co-dominant with Nardus tussocks, Potentilla erecta, Agrostis tenuis and Eriophorum angustifolium well represented. Overall herb and dwarf shrub cover is high (about 80%) and as high as 15mm where Calluna is well developed. Of the equally high bryophyte cover, Rhytidiadelphus loreus, Hylocomium splendens, Hypnum cupressiforme var. ericetorum and Mnium hornum are major constituents. Listera cordata is found widely in this vegetation.

The community is recognised by the dense cover of Juncus squarrosus rosettes, with Calluna. It is differentiated from the similar groups within Heath vegetation (group 5.8.2.1.) by this dense cover, and the reduced abundance of Polytrichum formosum and Carex pilulifera here.

It is distinguished from other blanket bog vegetation by the absence of Eriophorum vaginatum, Cladonia impexa, C. tenuis and Drosera rotundifolia.

The peat on which this occurs is usually not well humified, medium brown in colour and Ph 5.0 (range 3.3 to 6.0).

Two releves from the Burn of Valayre (327 and 320) have been placed in this community, although they are considerably more species-rich than the norm for this vegetation. (42 and 32 per releve; average for community 22).

They both contain Oxalis acetosella, a woodland species of very limited distribution in Shetland. It is probably found at this site due to the freedom from grazing afforded by the steep slope from which this releve was recorded. The Burn of Valayre is an S.S.S.I. partly because of its relict scrub vegetation and is discussed further in Chapter 6. These two releves also appear to have enriched soils; the presence of Pinguicula vulgaris, Carex demissa and Equisetum palustre indicate affinities with the

the Parvocaricetea, while releve 327 includes one of the few records of Sphagnum fimbriatum for Shetland. Overall, it appears that these releves represent a transition between the Juncus squarrosus community and the flushes of shallow heath (group 5.8.2.6.)

The community was only recorded in North Mainland. On the other islands it seems to be represented by the Polytrichum formosum heath communities of shallower peat (group 5.8.2.1.).

Although included within the table of bog communities this group lacks the character species of the Oxycocco-sphagnetea and appears to lie closer to the Nardo-Callunetea.

This community has been ascribed to the Ericeto-Caricetum binervis Br.-Bl.et Tx.(50) 1952.

Erica cinerea, Molinia caerulea, Sieglingia decumbens, Pleurozium schreberi, Erica tetralix, Carex pallicea, Frullania tamarisci, Festuca vivipara and Carex binervis are species whichcharacterise the association in Ireland (Braun Blanquet & Tuxen 1952) and which are present in this Shetland community. The high constancy of Calluna vulgaris, Nardus stricta Juncus squarrosus and Potentilla erecta indicate its position within the Calluno-Ulicetalia of the Nardo Callunetea.

In his work in the Sullom Voe area Birse (1973) found a similar vegetation which he assigned to the Molinia caerulea subassociation, as the presence of Molinia, Trichophorum cespitosum and Leucobryum glaucum. Only two of the present releves contain Molinia, although Trichophorum is relatively common. No division of this data to subassociation is felt possible.

He also found a high frequency of Agrostis canina ssp.montana and A.tenuis in the vegetation, a feature not seen in the Irish community.

Those releves containing Mnium hornum and Empetrum nigrum appear to be transitional to the Empetro-Ericetum cinereae. Birse and Robertson 1976, but have been left in the Ericeto-Caricetum binervis because they also contain Carex binervis, Trichophorum cespitosun, and Potentilla erecta.

A similar community in the Northern Isles was placed by Lewis (1976) in her juncetosum squarrosi subassociation of the Empetrum-Rhytidiadelphus Association. However, the southern Juncus squarrosus community is richer in grass heath species such as Agrostis tenuis, Carex binervis and Nardus stricta while lacking Drosera rotundifolia and Eriophorum vaginatum and is therefore not assigned to that subassociation.

5.6.2.2. Calluna vulgaris community Releves 171-155

This is the most widespread type of blanket bog community of Southern Shetland, found on deep, well humified peat. It covers larger expanses of gently undulating land between 51m and 149m.

Calluna vulgaris is dominant, with Empetrum nigrum, Eriophorum angustigolium and E.vaginatum having high constancy and cover with the vegetation. Trichophorum cespitosum has constancy IV, while the mosses Rhytidiadelphus loreus, Hypnum cupressiforme, Pleurozium schreberi, Hylocomium splendens and Rhacomitrium lanuginosum are widespread. The latter bryophyte appears to be confined to the slightly drier representatives of this community. Once again Listera cordata is common.

Lichen cover is relatively high, and a wide range of species is found including Cladonia impexa, C.tenuis, C.furcata, C.gracilis, and Cetraria islandica.

It is differentiated from the other deep peat communities described by the presence of Pleurozium schreberi, Hylocomium splendens, Listera cordata with Eriophorum vaginatum.

The peat is generally damp, not wet, mean pH 5.3 (range 3.8 - 5.7), and found in areas where peat cutting has taken (or takes) place, although not at the sites recorded. This, and natural erosion and hagging, break up this community, and give rise to patches of the next two types of blanket bog (groups 5.6.2.3.1. and 5.6.2.3.2.)

The community was only recorded from sites in Mainland and north of Lerwick. It is probably present on the gentler slopes of the Clift Hills and on Scousbrough in Souther Mainland, although releves were not

recorded there.

This is a community poor in species (17 per relevé) and is the Shetland form of the Highland Callunetum McV. & R.1962 p.p. and the Calluneto-Eriophoretum McV.& R.1962 p.p.

Moore's (1968) revision of the Oxycocco-Sphagnetea created the Erico-Sphagnion, to emcompass all parts of raised bog vegetation, divided only on geographical distribution. Thus, the Southern Shetland data would fall within his "subatlantic race". The alliance character species (Moore 1968) are only infrequently found, viz: Narthecium ossifragum, Sphagnum papillosum, S.plumulosum and Odontoschisma sphagni, but the association is recognised by Birse (1973) at Sullom Voe, by the abundance of Calluna, Rhacomitrium languginosum and Eriophorum angustifolium. He feels that this is a Shetland race or variant of Western European blanket bog, characterised by low frequency of Narthecium combined with high constancy of Scapania gracilis and abundant Eriophorum angustifolium. These observations are endorsed by the present data from a much wider area of Shetland.

It would appear also that the constancy and occasional high cover of Pleurozium schreberi and Hylocomium splendens, accompanied by Listera cordata are Shetland chracteristics. The orchid was not recorded in Jones' summary of the association, nor in the data given for Southern Scotland (Birse and Robertson 1976) or by Moore (1968).

Pleurozium schreberi is given as a companion species to both the Erico-Sphagnetum magellanici and the Vaccinio-Ericetum tetralicis, with slightly higher constancy with Cladnonia uncialis of the Erico-Sphagnetum magellanici on the presence of this lichen with C.arbuscula and Rhacomitrium lanuginosum. Although a number of the lichens of Cladonia genus in this community have remained indterminate at the specific level, it is not felt that there is sufficient information to follow this course. This is especially so when the "Shetland" variation from the typical association has to be considered.

The community differs from Pennine blanket bog (Calluneto-Eriophoretum McV.& R.1962) in the absence of Vaccinium myrtillus, Rubus chamaemorus and Oxycoccus microcarpus, while it contains a higher proportion of oceanic species such as Carex binervis, Empetrum nigrum and Erica cinerea.

The Callunetum vulgaris McV.& R.1962 tends to be a similarly species-poor community, maintained as such by burning and grazing. In Shetland where management burning does not occur, the dominance of Calluna is reduced by Empetrum nigrum, Trichophorum cespitosum Eriophorum vaginatum and in the latter, by Jones (1973). It occupies a similar position in Moore's (1968) data although in his original (1962) description of the Vaccinio-Ericetum tetralicis was only recorded once. Birse and Robertson (1976) and Birse (1973) give it companion species status. It thus appears to be of uncertain indicative value.

Hylocomium splendens is found widely in Scottish vegetation. It is constant to Birks' (1973) Calluneto-Eriophoretum on Skye, and to a related community described by McVean and Ratcliffe. This latter vegetation is a combination of their Calluneto-Eriophoretrum and Empetreto-Eriophoretum associations assigned by Moore (1968) to the Sphagnion fusci. It is virtually absent from the Erico-Sphagnetum magellancici of Jones (1973) and Birse and Robertson (1976). However Birse (1973) does record it from Sullom Voe blanket bog. Its British distribution is northerly (Gimingham 1964a) and the species is common in Norway (Dahl 1956). This high frequency in Shetland seems to reflect this increase in more northerly latitudes.

Birse (1973) also noted the absence of Drosera rotundifolia from his recordings and accounted for this by his early time of recording. It is interesting to note that Drosera does not occur in the present community although the relevés were taken from June to September. This species is widespread on Shetland but is best developed in the Erica tetralix communities of blanket bog (group 5.6.2.3.). Although found at Sullom by Birse on numerous occasions, Sphagnum magellanicum was not recorded at all in Southern Shetland during the present survey. It was however seen

on Ronas Hill, and on Yell.

Birse (1973) assigned most of his blanket bog data for the area to the subassociation Rhacomitrium langinosum. The effect of peat cutting appears to be only to halt the cycle of moor development, causing recommencement of growth by pioneer species such as Aira praecox and Polytrichum juniperinum. There is no advantage gained by Calluna in such a situation and hence a monoculture tends not to be formed.

Lewis (1976) discusses fully the differences between the blanket bogs of the northern Isles of Shetland and those already described from Scotland and Europe. She concludes that they are sufficiently different from others to warrant their separation into a new association rather than remaining as merely "races" or "variants". This association, the Empetrum-Rhytidiadelphus Association, has been recognised in the Southern Isles although it is not so strongly characterised here. Although Calluna and Eriophorum angustifolium are constant throughout Southern Shetland bogs, the other two characteristic and defining species Empetrum nigrum and Rhytidiadelphus loreus are not so widespread. Similarly, many of the species differentiating the subassociation and variants within the association appear to have less restricted distributions in the Southern Isles. Thus for example, Rhacomitrum langinosum, Erica cinerea and Erica tetralix occur sporadically in all bog communities rather than being confied to blanket bog. Neither do these species have such frequent occurrences. It would appear then, that blanket bog of the southern part of Shetland is intermediate to some extent between the Empetrum-Rhytidiadelphus Association and the Erico-Sphagnion communities of Scotland.

Bearing in mind the above modifications to the new association, the present Calluna vulgaris community has been placed in the rhacomitretosum langinosum subassociation, Listera-Pleurozia variant. Lichens do not attain the constancy seen in the northern isles, but are not infrequent enough to warrant placing in the lichen-poor facies.

This community is very similar to Lewis' original conception of the variant, although neither Scapania gracilis (which she regards as characteristic of the Shetland association) or Dicranum scoparium attain the frequency seen in the Northern Isles.

5.6.2.3. Erica tetralix communities Releves 920-123

This is the bog vegetation to which Erica tetralix attains its optimum development in Shetland. The communities develop on slopes of hummocks and in channels and hollows in the Calluna vulgaris blanket community (group 5.6.2.2.) where the peat is still dark and well-humified but where the ground is considerably wetter than the surroundings. There is often water run-off from the more raised bog and it is at these points that the Erica tetralix communities flourish.

Calluna remains the dominant species, with Eriophorum angustifolium and Rhacomitrium lanuginosum still common. However the abundance of Rhytidiadelphus loreus is reduced. Drosera rotundifolia and Carex panicea are widespread.

The community has two distinct facies. In the species poor facies with Sphagnum capillaceum, this moss is dominant in the bryophyte layer, and S.rubellum is absent. Empetrum nigrum is common. In the second, species-rich facies with Molinia, Molinia caerulea has its optimum while Empetrum and Eriophorum vaginatum are virtually absent.

Both these Erica tetralix communities have been assigned to the Erica-Sphagnion although to different associations. The Spagnum capillaceum facies has been placed in the Empetrum-Rhytidiadelphus Association Lewis 1976, while the Molinia caerulea facies is in the Erico-Sphagnetum magellanici Moore, 1968.

The distinction between the two facies and, hence, the two associations is not always clear.

However, Erico-Sphagnion character species Eriophorum angustifolium, Molinia caerulea, Sphagnum papillosum, S.plumulosum, Hyprum cupressiforme,

Odontoschisma sphagni, and Cladonia impexa are all well represented in both facies.

5.6.2.3.1. Sphagnum capillaceum facies Relevés 920-154

This community has constant Eriophorum angustifolium, Calluna vulgaris, Rhytidiadelphus loreus, Empeteum nigrum, Trichophorum cespitosum, Hyprum cupressiforme var. ericetorum and Sphagnum capillaceum, while Eriophorum vaginatum, Rhacomitrium lanuginosum and Erica tetralix have constancy IV. It is characterised by the joint presence of S.capillaceum and Empetrum nigrum in the absence of Pleurozium schreberi and Listera cordata. pH is lower than the other blanket bog communities (mean 5.0, range 4.2 - 5.7) and the peat is well humified and often waterlogged. In many instances it is extremely smelly when disturbed!

Herb and dwarf shrub cover can vary a great deal from as low as 20% to complete Calluna canopy. Moss cover is always high (average 70%), being mainly Sphagnum capillaceum or, on the hummocks in particular, Rhacomitrium lanuginosum. It is in this community that the maximum cover by this moss on blanket bog is attained.

Lichens are well represented particularly Cladonia spp., including C.uncialis, C.tenuis, C.furcata, C.impexa, C.squarrosa,var.squarrosa, C.gracilis and C.coccifera.

The community is found between 27m and 225m and was recorded widely throughout North Mainland. It is always subject to light grazing by sheep.

The vegetation has been placed in the typical variant of the Rhacomitretosum lanuginosi subassociation of the Empetrum-Rhytidiadelphus Association, Lewis 1976.

It has affinities with the Vaccinio-Ericetum tetralicis in the high frequency of Rhytidiadelphus loreus and Empetrum nigrum,but the absence of Vaccinium myrtillus and Pleurozium schreberi underline the ecological differences between the present community and true upland blanket bog.

These were among the criteria on which Lewis established her association for the Northern Isles.

Birse (1973) places most of his blanket peat vegetation from Sullom Voe into the Erico-Sphagnetum magellanici, Cladonia uncialis subassociation, but that with high Sphagnum cover to the typical subassociation. However, he constantly refers to this as a Shetland form of upland blanket bog, and is the vegetation now included by Lewis in the Empetrum-Rhytidiadelphus Association.

It closely resembles her typical variant of the Rhacomitretosum lanuginosi except for the important role played by Sphagnum capillaceum in the Southern Isles community, while almost absent from the Northern Isles. Conversely, in the north, lichens and Scapania gracilis, occur much more frequently than in the south.

.6.2.3.2. Molinia caerulea facies Releves 254-123

This is a species rich (22 per relevé) community in which Erica tetralix plays characteristic part - it does not at any site have great cover but has constancy IV to the community.

Only three species Calluna, Carex panicea and Hyprum cupressiforme var.ericetorum are constancy V to the community, but a large number occur seven or more of the releves (constancy IV). These are Eriophorum angustifolium, Trichophorum cespitosum, Rhacomitrium lanuginosum, Potentilla erecta, Nardus stricta and Erica tetralix. This, plus the great species diversity suggests that it may be possible to recognise further division within the community. However, on present data, this has not been done and the presence of Molinia caerulea is a number of the releves has been used to characterise the facies. It is further differentiated from the Sphagnum capillaceum facies by the frequency of Sphagnum rubellum, Carex panicea, Potentilla erecta, Nardus stricta and Agrostis canina.

Found on deep, dark, well humified peat with damp, but not obviously waterlogged rooting layer the vegetation has occasional occurrencies of typically 'heath' species, e.g. Polygala serpyllifolia (releves 437, 090,

120 and 160) Sieglingia decumbens (437, 090, 120) Galium saxatile (254) and Festuca vivipara (111, 090).

Herb and dwarf shrub cover is approximately 70%, generally about 200 mm high while moss cover is lower.

This community contains the only record made during the survey of Acrocladium sarmentosum, in a releve showing affinities with the Parvocaricetea (releve 837), viz. Riccardia pinguis, Drepanocladus revolvens and Carex pulicaris. Lycopodium selago is common and lichens of the Cladonia genus are abundant.

This community was recorded from all parts of Mainland, and is closely related to the Agrostis tenuis heaths (Heath group 5.8.2.4.1.).

This vegetation has been placed in the Molinia subassociation of the Erico-Sphagnetum magellanici, one of flushed sites on blanket peat. The encriched nature of the present community has been indicated by the presence of species of the Parvocaricetea and heath communities while Molinia caerulea, although not abundant, is found in many releves.

Following Moore's (1968) original concept of the subatlantic race of this association, Narthecium is quite common here, although Sphagnum recurvum was only recorded once.

Jones (1973) provided further data for the association. Of her other two character and differential species, Sphagnum magellanicum is absent, but Drosera rotundifolia is common here. Some of her examples again show the closeness of this vegetation to that of the Vaccinio-Ericetum tetralicis Moore 1962, in the constancy of Rhytidiadelphus loreus, Vaccinium myrtillus and Plagiothecium undulatum. This is particularly the case of the data from the Berwyn mountains (Tallis 1969), from Southern Scotland (Birse and Robertson 1967) and from Moor House, Westmorland (Eddy, Welch and Rawes, 1969).

Rhytidiadelphus loreus and Empetrum nigrum are much reduced in frequency in the Molinia caerulea facies and it has therefore not been included in the Empetrum-Rhytidiadelphus Association.

It has been assigned therefore on the abundance of Erica tetralix, Molinia caerulea, Narthecium ossifragum, Carex panicea and Sphagnum spp. not seen in the above association.

Birse and Robertson (1976) give Molinia and Potentilla erecta as differentials of the Molinia caerulea subassociation. Mention has been made of the first, while Potentilla erecta is constant to the present vegetation.

In his data from Sullom, Birse (1973) gives only three releves for this subassociation but Carex panicea is recorded in all. The high constancy of this species is again found in these data from a wider area.

This community is perhaps the most representative of the association as originally described in the relatively low frequencies of Rhytidiadelphns loreus and Empetrum nigrum with increased Sphagnum rubellum and one record of Sphagnum recurvum. (Order character species, Jones (1973)).

5.6.2.4. Pleurozia purpurea community Releves 093-158

This is a small but distinctive community of higher altitudes in Southern Shetland. (53m - 289m). It is an open vegetation characterised by the higher cover of bryophytes (<80%) and the constant presence of the liverwort, Pleurozia purpurea.

It is found as small patches, hollows, or channels within blanket bog or montane heath where the peat is thin and there is some degree of flushing by water through the soil or over the surface.

It has been recorded only over granite and gneiss, but this is probably only a reflection of the lack of other rock types at these altitudes.

Of constancy V to the community are Pleurozia purpurea, Erica tetralix, Sphagnum capillaceum, Trichophorum cespitosum, Calluna vulgaris and Eriophorum angustifolium, while Rhacomitrium languinosum, Potentilla erecta and Diplophyllum albicans occur in more than half the releves.

Releves 161 (from Vatster) is closely related to the Parvocaricetea,

having a number of species indicative of nturient enrichment, viz: Pinguicula vulgaris, Ranunculus flammula, Carex dioica and C.demissa. Releve 910 (from Roga Field, North Mainland) has affinities with the Nardo-Juncetum squarrosi in Nardus stricta and Juncus squarrosus have high cover.

The community was recorded from a variety of sites in North Mainland. In the present survey Pleurozia purpurea was not recorded south of Lerwick.

This community is that originally described in Ireland as the Pleurozia purpurea - Erica tetralix Association Br.Bl.et Tx.1952 and placed in the Ericion tetralicis. This follows the work of Birse(1973) as opposed to that of Moore (1968) who places the association in the Erica-Sphagnion.

The reasons for this are based on the constancy of Erica tetralix and Trichophorum cespitosum to the present community. These are widely recognised Ericetalia character species, while Sphagnetalia character species such as Eriophorum vaginatum and Sphagnum rubellum are reduced in frequency here.

Similarly Erico-Sphagnion character species Sphagium papillosum, S.plumulosum and Odontoschisma sphagni are less frequent than in other Shetland bog communities. Narthecium ossifragum is constant however, but Moore (1968) shows this species is found in both orders. Furthermore, this Shetland community is found on shallow peats and soils more typical of the Ericetalia tetralicis.

Most of the Shetland releves appear to fall within the subassociation with Molinia caerulea. Although this species is only present in two releves, the other differentials given by Braun-Blanquet and Tuxen (1952), i.e. Sphagnum capillaceum, Trichophorum cespitosum and Cladonia sylvatica are present, Schoenus nigricans, widespread in the Irish community, is not recorded here. Moore (1968) suggested that this species might be replaced by Eriophorum vaginatum in Scotland. E.vaginatum is found in

in the Shetland community but not with the high cover values indicated for Schoenus in Ireland.

Birse and Robertson (1973) give only two releves from this community recorded from Baltasound. Campylopus atrovirens, Pinguicula vulgaris, Breutelia chrysocoma and Sphagnum subsecundum var auriculatum occur in both, and with Pleurozia purpurea are regarded as differentials by those authors.

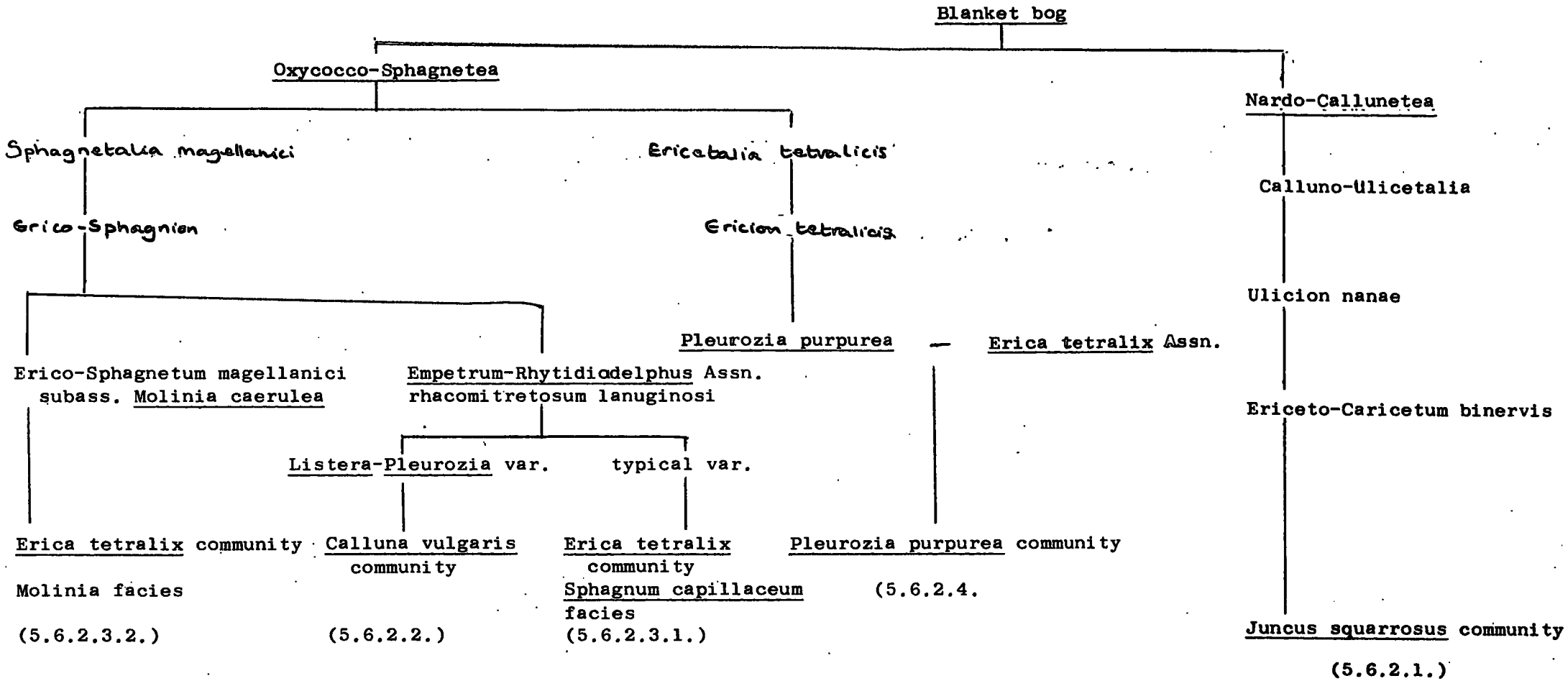
In the present survey the only blanket bog record of Campylopus atrovirens is found here. Pinguicula vulgaris occurs occasionally on flushed sites within most of the communities, while Breutelia and Sphagnum auriculatum occur in the Molinia-facies of the Erica tetralix communities, and the Sphagnum cuspidatum communities of bog pools (Group 5.7) respectively.

Four of the releves in Table 5.6 appear to be transitional to the subassociation with Empetrum nigrum described from drier peat in Ireland, (Releves 118, 087, 910, 159) since they contain both Empetrum and Rhytidiadelphus loreus. These, with Pleurozium schreberi are quoted as differentials of the subassociation by the German authors and indicate the relationship between it and the Vaccinio-Ericetum tetralicis in the Erico-Sphagnion.

It appears to resemble the Trichophoreto-Eriophoretum caricetosum McV. and R.1962, of the Scottish Highlands, but this association of flushed Trichophoreto-Callunetum blanket bog has abundant Molinia caerulea and has little Pleurozia.

On Hoy, Prentice and Prentice (1976) distinguish a Narthecium-Campylopus atrovirens nodum which they place within the Caricetalia fuscae of the Scheuchzerio-Caricetea fuscae, while relating it to the Trichophoreto-Eriophoretum caricetosum. Only once was Pleurozia recorded there.

Figure 5.6. Synoptic classification of blanket bog communities of the Southern Isles



5.6.3. Comparison with the Northern Isles

All Northern Isles blanket bog (with only one minor exception) was placed in a new association, the Empetrum-Rhytidiadelphus Association to express fully the Northern and oceanic nature of the vegetation.

In the Southern Isles this distinction was followed to a certain extent, but it was felt overall that many of the Scottish mainland associations were present and could be recognised. In this respect the bog vegetation of the two areas differs considerably.

A small heath-like community is placed in the Ericeto-Caricetum binervis (group 5.6.2.1.) and it is felt that the Pleurozia purpurea-Erica tetralix Association occurs on the higher ground of North Mainland. Further, the ideas of Birse (1973) are followed in placing some of the bog vegetation in the subatlantic race of the Erico-Sphagnetum magellanici.

The new association, however, does hold true for much of the blanket bog vegetation of the Southern Isles, if the reduced constancy of Empetrum nigrum and Rhytidiadelphus loreus there is noted. It would seem that the association covers the lowland Shetland blanket bog vegetation. At the higher altitutdes above about 55m, communities recognised in the lower Scottish regions are found. Thus the effect of increasing latitude and increasing oceanity seems to be to produce a lowland, oceanic, high latitude association.

5.7 BOG POOLS

5.7.1. Introduction

Table 5.7

This term is used for the areas of standing water found within areas of bog or heath. As is further discussed later, the process of infilling of these pools in the hummocks and hollows of the blanket bog is a continual process in which it is difficult to define the end-point of "pool" and the starting point of "bog".

The pools are dominated by Sphagna notably Sphagnum cuspidatum. They are all extremely low in species number (mean 13 per relevé) and the soil, peat or ground water has mean pH 4.7 (range 3.9 to 5.3).

Herb cover is very low (approximately 20%), consisting usually of Eriophorum angustifolium, Nardus stricta, Juncus kochii and/or Carex nigra.

The companion species found with these four and Sphagnum cuspidatum usually reflect the surrounding vegetation which may be Calluna vulgaris blanket bog (group 5.6.2.2.) or wet heaths. In spite of this variety, two distinct facies can be recognised. One, on wet peat, is herb rich, while the second, usually found in standing water on the bog surface is almost a monoculture of Sphagnum cuspidatum with Eriophorum angustifolium.

Both groups have been placed in the Rhyncosporion albae W.Koch 26, an alliance bog hollows and pools within the Scheuchzerietea. Many authors (including Duvigneaud 1949, Birks 1973) have discussed the difficulties in delimiting the border between infilling pools and bog. It is an ongoing process, and as such cannot definitively be divided into natural stages. These two groups recognised in Shetland must be considered as end-points in a dynamic succession.

A synopsis of the classification of bog pool communities is given in Figure 5.7.

5.7.2.1. Herb-rich pools

Relevés 919-172

The five relevés forming this community are all recorded from hollows in blanket bog where a high water table is maintained in a Sphagnum

cuspidatum carpet. They appear to represent a late stage of pool infilling, where species from the surrounding vegetation are able to encroach.

Nardus stricta, Potentilla erecta, and Juncus squarrosus are present in all five releves, while Eriophorum angustifolium, Calluna vulgaris, Sphagnum papillosum and S.cuspidatum are recorded in four. The Sphagna form an almost complete carpet through which the other species protrude. Agrostis tenuis, Carex nigra and C.echinata are also common in the community.

Generally the releves are richer in species than the next group (mean 15 per releve as opposed to 11) and of lower pH (4.6 e.g.4.9). The substrate is a decomposed- Sphagnum peat.

Although the vegetation was recorded only in North Mainland it is common whenever deep peat occurs and pool-infilling of advanced stages is found.

No established association or nodum appears to correspond with this vegetation, possibly because it represents a stage in the bog hollow development that has not been regarded as definitive by other workers.

In the Scottish Highlands McVean and Ratcliffe (1962) include similar vegetation within their Trichophoreto-Eriophoretum, as simply a wetter phase of bog development. However Sphagnum cuspidatum is only rarely rarely recorded by them, suggesting that their data is from a later stage.

It has floristic affinities with the Nardo-Juncetum squarrosi Association on Skye (Birks 1973) in the constancy of Nardus, Juncus squarrosus and Potentilla erecta. Once again, however, Sphagnum cuspidatum is less well represented, while the Skye association is recorded from well established heathlands.

It has therefore been designated a Nardus stricta nodum of the Rhyncosporion albae.

5.7.2.2. Blanket bog pools — Relevés 342-008

These releves represent some of the most species poor vegetation recorded, having only 11 spp/releve on average. They were recorded from hollows in blanket peat where there was either open water or Sphagnum cuspidatum cover. Cover by other species was always low, only Eriophorum angustifolium, Juncus kochii and Carex panicea being constant to the community. Nardus stricta occurs in small amounts at drier edges of many pools, and Carex demissa and Pinguicula vulgaris show the relationship of some of the releves to the flushed peat communities of the Parvocaricetea.

The substrate is a decomposing Sphagnum "humus" or a silty peat mean pH 4.9 (range 3.9 to 5.2).

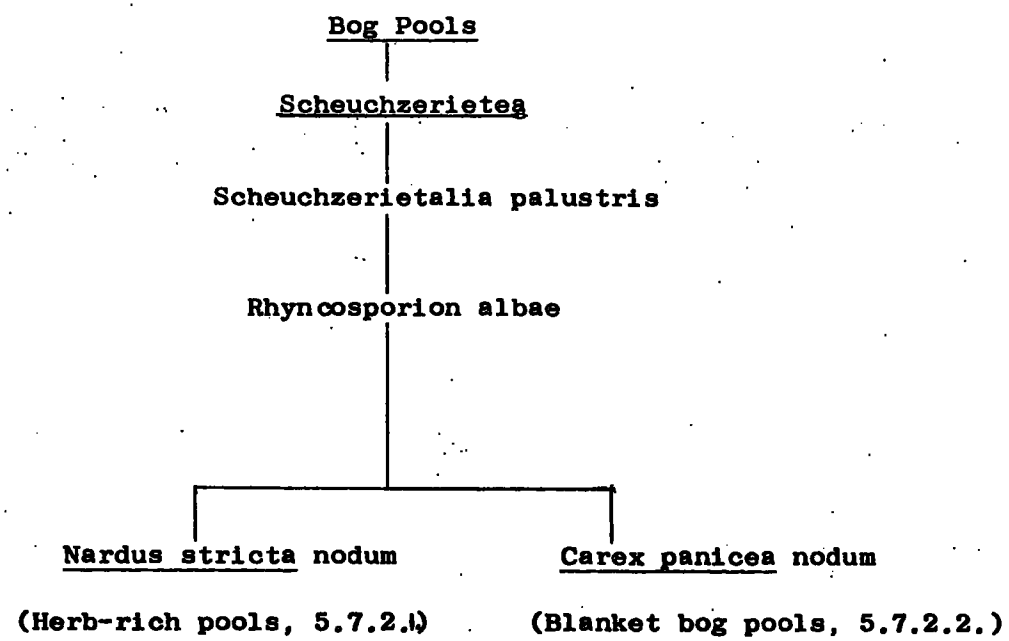
The community is found throughout Mainland and Bressay, wherever hollows in deep blanket peat collect water. It was recorded between 4.5m and 128m.

The community closely resembles the Eriophorum angustifolium - Sphagnum cuspidatum Association described on Skye (Birks 1973) although Rhyncospora alba, Carex limosa, Cladopodiella fluitans and Sphagnum pulchrum are not present in Shetland releves. Of these species only Carex limosa is recorded in the islands where it is rare (Palmer and Scott 1969). The Skye pool vegetation occurs in more acidic parts than the Shetland vegetation. This is also true of similar pools described in Southern Sweden (Malmer 1965).

The constancy of Carex panicea to this community may be indicative of the higher pH of these pools compared to that encountered usually on the surface of peat.

Because of the low species content, and the difficulties in describing points on a continum described previously this group is regarded as a Carex panicea nodum of the Rhyncosporion albae.

Figure 5.7. Synoptic classification of bog pool communities of the Southern Isles



5.7.3. Comparison with the Northern Isles

Lewis (1976) assigns all her pool vegetation to the Eriophorum - angustifolium - Sphagnum cuspidatum Association, Birks 1973. This vegetation does not show the dominance of Carex panicea and Nardus stricta seen in the Southern Isles and thus does resemble the typical association much more closely.

5.8.HEATH Table 5.8

5.8.1.Introduction

At the onset of sampling in the field, the vegetation type 'heath' was defined as that dominated by ericaceous dwarf shrubs on peat up to 1m deep (see Chapter 3). The terms "wet heath", and "dry heath" were originally used, but the categories were later combined for analysis purposes.

The final table for all heath data (Table 5.8) shows that the distinction is quite clear between wet heaths with Trichophorum cespitosum, Erica tetralix and some Nathecium ossifragium (5.8.2.3. and 5.8.2.3.) and the drier areas lacking these species.

Southern Shetland heaths are dominated by Calluna vulgaris with constant Nardus stricta and Potentilla erecta. In the frequent occurrence of Nardus, with other grasses e.g.Agrostis tenuis, Festuca vivipara and Sieglinga decumbens these heaths differ from those described on the Scottish Mainland (McVean and Ratcliffe 1962) and in Wales (Ratcliffe 1959). In the latter two regions there is regular burning of the moors which encourages a monoculture of Calluna at the expense of members of the Gramineae.

Empetrum nigrum, Rhacomitrium langinosum, Rhytidiadelphus loreus, Carex panicea, C.binervis, C.pilulifera and Cladonia spp. occur regularly in the vegetation.

In the field, peat depth was not alwasy easily determined which has led to some overlap in the results with data from the "blanket bog" vegetation type. This has been indicated where relevant in the sections dealing with separate communities.

The Heath data encompasses four phytosociological classes - the Oxycocco-Sphagnetea Br.-Bl.et R.Tx.43, the Nardo-Callunetea Preising1949, the Caricetea curvulae and the Parvocaricetea.

Groups 5.8.2.2. and 5.8.2.3. lie within the Oxycocco-Sphagnetea being heaths characterised by Trichophorum cespitosum, Eriophorum angustifolium and Sphagnum capillaceum. Empetrum nigrum is common.

The Nardo-Callunetea covers the heath groups 5.8.2.1, 5.8.2.4 and 5.8.2.5. p.p. Group 5.8.2.1. heaths (Polytrichum formosum community) lie within the Nardetalia, but it is felt that the remaining communities are more closely aligned to the Calluno-Ulicetalia, an order of species-poor heaths on dry, acidic soils. Jones' (1973) character species Calluna vulgaris, Hypnum cupressiforme and Arctostaphylos uva-ursi are present although Sarothamnus scoparius is found only where planted on Unst. They are assigned to the Ulicion na nae. Duvigneaud 44 on the absence of Empetrum and Vaccinium spp. which characterise the Empetrion nigri Bocher 1943 em Schubert 60, (Jones 1973).

The flushed heath areas group 5.8.2.6, have been placed in the Parvocaricetea.

A synopsis of the classification of heath communities is given in Figure 5.8.

5.8.2.1. Polytrichum formosum heaths Releves 849-703

This is a form of heath dominated by Nardus stricta tussocks with which Potentilla erecta, Luzula multiflora and Polytrichum formosum have constancy V. The latter two rarely have high cover values, appearing usually as single spikes in the dense moss carpet which is characteristic of this group. The bryophytes are widely represented, especially Hylocomium splendens (which has constancy IV to the group), Dicranum scoparium, Mnium hornum Aulacomnium palustre, Polytrichum juniperinum Sphagnum spp., Lophocolea cuspidata, Frullania tamarisci, Diplophyllum albicans and Scapania gracilis, all of which are recorded from five or more releves. Herb and dwarf shrub cover is generally not high, about 70%, with frequent Calluna, Juncus squarrosus, Festuca vivipara and

Sieglingia decumbens, and only where Calluna is well-developed does it attain a height of 0.3m. The community is found, usually, on shallow, well-humified peat or shallow soils, with pH range 4.0 to 6.6 (mean 5.1). Due to the great bryophyte diversity, this is a relatively species-rich vegetation with 22 species per releve.

This type of heath was only recorded from Mainland and Whalsay, at altitudes up to 76m. It generally occurs above 30m, being found at sea-level only near Loch of Strom (releves 165, 169).

The Grassland group 5.4.2.6.2.(Nardus grasslands, typical) is very closely related to this community and appears to replace it at low altitudes generally.

Along roadsides, a form of this heath, usually lacking Polytrichum formosum, is found. Essentially the characteristic species are present, but due to the disturbing effects of sheep and vehicles, the vegetation tends to be a short-cropped sward of grasses such as Agrostis tenuis, Nardus stricta, Festuca vivipara and Sieglingia decumbens, with the acrocarpous mosses which can exist on the thin soils at the edge of the roadside, e.g.Bryum argenteum, Barbula fallax and Polytrichum urnigerum.

It appears that this community should be placed in the Violion caninae Schwick (41) em.Prsg.49.

The Nardo-Callunetea class character species (Jones 1973) are well represented in Nardus, Sieglingia decumbens, Potentilla erecta, Calluma vulgaris and Carex pilulifera. The alliance to which they have been assigned embraces those herb (as opposed to dwarf shrub) - rich heaths which are nutrient enriched (even if only slightly) and is characterised by Polygala serpyllifolia, Luzula multiflora, Galium saxatile and Juncus squarrosus. These are all present in these Polytrichum formosum heaths. Jones (1973) gives other character species (see Chapter 4) but all have very limited occurrences in Shetland except for Carex ovalis which is found in enriched grassy habitats, and Dactylorchis maculata ssp.ericetorum which occurs in wetter, more acidic heath than this.

The placing of these heaths within an association proved rather difficult due to overlap between written accounts but they have been tenuously assigned to the Nardo-Juncetum squarrosi (Nordh.20) Buk 42, vegetation dominated by Nardus tufts and Juncus squarrosus rosettes. In Britain this association is subatlantic/atlantic in extent, and has been recorded on Fair Isle (Jones 1973). It is possible that these Shetland heaths may include some drier examples of the Nardo-Galietum saxatilis, a closely related community of drier soils, but only further data could make this clear.

The Nardo-Juncetum squarrosi Association described by Birks on Skye (1973) combines the Nardo-Juncetum squarrosi Buker 42, with the Nardetum subalpinum McVean and Ratcliffe 1962, and the Juncetum squarosi Nordhagen 22. It resembles the Shetland form in the codominance of Nardus and Juncus squarrosus, with constant Galium saxatile and Potentilla erecta, but has higher abundance of Rhacomitrium lanuginosum Av. accinium myrtillus, Viola riviniana Agrostis tenuis and Polytrichum alpinum. In the Shetland lists, the latter two seem to be replaced by Agrostis canina and Polytrichum formosum respectively.

The constancy of A.canina is seen in the Nardetum subalpinum and the Juncetum squarosi Association (McVean and Ratcliffe 1962) but in mainland Scottish heaths Rhytidiadelphus squarrosus plays a much greater part than it does in Shetland heaths, where R.loreus is constant throughout most types. R.loreus is found in the wetter Juncus squarrosus communities of the Scottish Highlands. These latter communities are richer in bryophytes, and hence more similar to the Shetland vegetation, than is the Skye data.

The Deschampsia flexuosa grassland nodum found on Hoy (Prentice & Prentice 1975) may be part of the Polytrichum formosum heaths, where Nardus is replaced by D.flexuosa. Further data is necessary to make this clear.

The association described by Jones on Widdybank Fell provides the closest lists for this heath. Although there is insuffient data to distinguish her subassociation, it is probable that the subassociation

Galietosum saxatiles is found.

These heaths have thus been assigned to the same association as the Sphagnum-rich Nardus grasslands (Grassland group 5.4.2.6.1.). The grassland representatives of the association however, are found at lower altitudes and have frequent occurrences of species more typical of Molinio-Arrhenatheretea communities, e.g. Eurynchium praelongum, Saginaprocumbens Acrocladium cuspidatum, Succisa pratensis and Rhytidiadelphus squarrosus.

The present heaths, conversely, have Empetrum nigrum, Trichophorum cespitosum and Cladonia spp., indicating their alliances with the wetter heath and blanket bog communities.

5.8.2.2. Wet heath — Releves 665-311

This small group is representative of a very distinctive Shetland community found on more or less level ground on well humified shallow peat.

It is characteristically found in small patches, in hollows or strips in areas of blanket bog, where the peat is not as deep, and slight flushing of the soil surface can occur.

A large number of species have constancy V; Nardus stricta, Potentilla erecta, Calluna vulgaris, Trichophorum cespitosum, Narthecium ossifragum, Erica tetralix, Carex panicea and Sieglingia decumbens, while Molinia caerulea, Eriophorum angustifolium and Diplophyllum albicans are all common (constancy Iv).

This combination of the constant species differentiates the community from all other heath ones, as does the presence of occasionally of blanket bog species such as Pleurozia purpurea, Campylopus flexuosus and Sphagnum spp.

The vegetation is a carpet of bryophyte cushions of Campylopus flexuosus C.brevipilus and Sphagnum capillaceum being particularly prominent with the grassland herbs interspersed. It is an extremely species-rich form of heath, average per releve being 29, and was recorded between 7.6m and 45m on granite (releve 665) and sandstone. The "granite" releve was recorded from the upper altitudinal limit found for this community - lichens, Rhacomitrium

lanuginosum and Pleurozia purpurea have increased cover, and the releve is clearly related to the "Montane" heaths of groups 5.8.2.5 and to the flushes group 5.8.2.6.

It was recorded from Mainland, Bressay and Whalsay; it is probably not very common at all in the Islands. On shallow peat generally, better drainage gives rise to the communities described later, while deep peat supports true blanket bog flushes (see group 5.6.2.4).

This community has been assigned to the Narthecio-Ericetum tetralicis Moore (1964)1968. It is a type of vegetation found on shallow, well humified peat and thus fits into Ericion tetralicis Schwick.33, but has a number of species more typical of deeper peat communities of the Erico-Sphagnion, viz: Sphagnum rubellum, Rhacomitrium lanuginsoum, Pinguicula vulgaris. Moore (1968) also gives a group of species which occur in both the Ericion and the Pleurozia purpurea-Erica tetralix Association Br.-Bl et Tx.1952 (i.e.his Table 1, columns 1-4, 7-9). Of these a number are found in this Shetland vegetation: Potentilla erecta, Carex panicea, Polygala serpyllifolia, Pedicularis sylvatica and Succisa pratensis are all common, while Carex panicea is one of the differentials of the community. It has constancy IV to the releves assigned by Moore to the Narthecio-Ericetum tetralicis.

However, character species of the Ericion-tetralicis have higher constancy in Shetland wet heath than those of the Erico-Sphagnion, e.g. Erica tetralix, Trichophorum cespitosum and Juncus squarrosus, while Sphagnetalia character species are virtually absent. Sphagnum rubellum, a characteristic species of the latter order does occur in the Narthecio-Ericetum tetralicis (Moore 1968). Sphagnum compactum, an Ericetalia character species, was not recorded in the present survey.

Jones (1973) describes a "nodum with Erica and Trichophorum" on Widdybank Fell. She finds similar difficulties in differentials between Ericion and Erico-Sphagnion communities there, but places the nodum within

the Narthecio-Ericetum tetralicis.

This nodum resembles the Shetland community in the differential species group including Erica tetralix, Trichophorum cespitosum, Narthecium ossifragum, Calluna vulgaris, Eriophorum angustifolium, Cladonia uncialis, Juncus squarrosus and Nardus stricta. It is different, however, in that Sphagnum tenellum and Rhacomitrium lanuginosum are common in Teesdale, while rare in the Shetland heath. Conversely the latter community has a much higher cover of Molinia caerulea, Carex panicea, and Sieglingia decumbens. The first two species are typical Ericion tetralicis members, while the abundance and frequency of Sieglingia in this and other communities of the present study appears to be a Shetland characteristic. Clapham,Tutin and Warburg (1962) give its habitat as "acid grassland: locally on damp, base-rich soils ... less peaty habitats than Nardus" . It appears that in Shetland it occurs in very similar habitats to Nardus, although it is more common where flushing of the soil or peat takes place. In this case it may reflect the closeness of this community to the flushes of group 5.8.2.6 in the Caricion davallianae.

This community is closely related to McVean and Ratcliffe's Molineto-Callunetum (McVean and Ratcliffe1962). Their vegetation of hollows and bog flats however has less Nardus, Carex panicea and Sieglingia than the Shetland heath, with an overall species number that is also lower (18 against 29 species per releve).

There is greater similarity to this association as found on Skye (Birks 1973) and Hoy (Prentice and Prentice 1975). In the former description the presence of "fen plants" such as Carex panicea is noted as indicative of some water movement, as seems also to be the case in Shetland.

The Molinieto-Callunetum Association has been placed within the Narthecio-Ericetum tetralicis (Jones 1973); this would support the placing of the Shetland wet heaths.

5.8.2.3. Calluna-Eriophorum "heaths" Relevés 115-709

This is the most widespread type of heath found in Shetland, recorded from 25m up to 225m. Calluna and Eriophorum angustifolium are constant and often co-dominant in the herb and shrub layer and Sphagnum spp. (especially Sphagnum capillaceum), Hypnum cupressiforme var.ericetorum, Rhytidiadelphus loreus and Scapania gracilis form a dense bryophyte layer. Trichophorum cespitosum and Erica tetralix are common.

Two groups can be distinguished dependent on the ground water. In the drier parts, where the more sloping ground allows run off of surface water, a community dominated by Sphagnum capillaceum, Calluna and Empetrum nigrum is found (group 5.8.2.3.1.), while the hollows and channels support a vegetation with less species diversity but where Rhacomitrium languinosum and Calluna are dominant (group 5.8.2.3.2.)

Both are extensively grazed by sheep and, in some cases, by ponies.

.8.2.3.1. Sphagnum capillaceum community Relevés 115-365

As mentioned earlier the drier, sloping areas of the Calluna-Eriophorum heathland have a high cover of Sphagnum capillaceum. Cushions of this moss and clumps of Scapania gracilis and Hylocomium splendens form a dense, hummocky moss layer (<80% cover) over which a number of constant species form a lush and relatively tall herb cover (<0.3m). Of constancy V to this community are Nardus stricta, Potentilla erecta, Calluna vulgaris, Plagiothecium undulatum, Sphagnum capillaceum, Empetrum nigrum, Juncus squarrosus, Calypogeia muellerana, and Eriophorum angustifolium. Empetrum nigrum, although present in Group 5.8.2.3.2. and Group 5.8.2.3.5. has its optimum in this community forming extensive patches in places.

The mean pH of the rooting layer is 5.2 and the community is found between 25m and 82m. Below this altitude Nardus cover increases and Nardus grassland or Polytrichum formosum heaths are found, while at higher altitudes blanket bog and the drier, montane heaths form.

The peat dries out at times and is shallow (>1m deep) and not well humified.

The community has been recorded from North Mainland (including Walls) and Bressay. A very similar blanket bog community has been recorded from other parts of S.Shetland (see Blanket Bog, Group 5.6.2.3.1.).

This is a difficult community to identify with respect to other, established groups of vegetation. As has been pointed out, it is found on drier, borders of blanket bog and Shetland Calluna-Eriophorum heath, and as such has many of the characteristic species of both types of vegetation, i.e. of the Erico-Sphagnion Moore 1968, and the Calluno-Eriophoretum and Empetreto-Eriophoretum Associations of McVean and Ratcliffe (1962) placed within the Sphagnion fusci Br.-Bl.(15 20 em.Moore (1964)1968 (Jones 1973).

Sphagnetalia magellanici species are not well represented, possibly because the community is found on shallower peat than is typical of the order. Of the list given by Jones (1973) only Eriophorum vaginatum and Sphagnum recurvum occur and these rarely, while Calypogeia muelleriana (c.f. C.sphagnicola in Moore's lists) is constant.

McVean and Ratcliffe's Calluneto-Eriophoretum (in particular as found on Skye (Birks 1973)) has a characteristically high constancy of Sphagnum capillaceum, as well as Calluna, Hylocomium splendens, Pleurozium schreberi, Empetrum nigrum, Eriophorum vaginatum and Rhytidiadelphus loreus, with the absence of Narthecium ossifragum, Trichophorum cespitosum and Eriophorum angustifolium of the wetter Trichophoro-Eriophoretum (Erico-Sphagnetum magellanici Moore 1968 see 5.8.2.3.2.). In the Shetland community there is very little Eriophorum vaginatum, but Eriophorum angustifolium is constant, while the vegetation as a whole does not cover the large areas recognised for the Scottish communities.

Rubus chamaemorus is constant in the list given by Moore (1968, Table 1 coloumn 21) for the combined Calluno-Eriophoretum and Empetreto-Eriophoretum McVean and Ratcliffe 1962. This is a Sphagnion fusci differential but was not recorded in the Shetland survey.

The community has closer affinities with the Erico-Sphagnion, the following character species and differentials of which are present (Moore 1968):

	Constancy
Sphagnum papillosum	II
Molinia caerulea	II
Eriophorum angustifolium	V
Hyprum cupressiforme	V
Cladonia impexa	-
Narthecium ossifragum	-
Sphagnum plumulosum	-
Campylopus flexuosus	-

Birse (1973) records one releve from the Mainland of Shetland that he assigns to a Shetland race of the Vaccinio-Ericetum tetralicis. This community he describes as having abundant Sphagnum capillaceum but lacking Erica tetralix.

Jones (1973) cites the similarities between this association and the Erico-Sphagnetum magellanici, but differentiates the former by the presence of Juncus squarrosus, Rhytidiadelphus loreus, Plagiothecium undulatum, Ptilidium ciliare and Hylocomium splendens. Of these only Ptilidium does not occur in the community; the remaining three have their optimal development here. She gives the altiduinal range of the association as 381m to 762m; due to the climatic changes mentioned in Chapter 2. This limit must be extended to 24m for a Shetland race.

This group, however, mostly closely resembles the juncetosum squarrosi subassociation of Lewis' Empetrum-Rhytidiadelphus Association 1976. As outlined in Chapter 5.6 this new syntaxon embraces the vegetation described by Birse as "a Shetland race" of the Vaccinio-Ericetum tetralicis.

The juncetosum squarrosi is differentiated in the Northern Isles by Juncus squarrosus, Plagiothecium undulatum, Luzula multiflora and Mnium hornum. In the Southern Isles however these do not hold so consistently. Juncus squarrosus is present throughout the heathcommunities that have been assigned to the Oxycocco-Sphagnetea, and is also constant to the following group (5.8.2.3.2.) which has been assigned to the subassociation rhacomitretosum

lanuginosi of this same association. Mnium hornum and Luzula multiflora are common but not exclusive to the subassociation. Plagiothecium undulatum, however, is a true differential between this and the following group, and thus between the two subassociations within heath vegetation.

.8.2.3.2. Wet, Rhacomitrium heath Releves 376-709

Rhacomitrium lanuginosum appears to have optimal development in two quite distinct habitats and communities in Shetland. One is at high altitudes, where it forms dense, hummocky carpets, while the second is the present situation on wet, humified peat.

This vegetation is characteristic of hollows or channels in the drier, more extensive heaths where drainage is impeded and, to some extent, waterlogging occurs. Mean pH is 4.7 and species average is only 19 per releve, of which the Gramineae, Juncaceae and Erioporum spp. form a consistent proportion.

Of constancy V are Calluna vulgaris (which is usually dominant), Potentilla erecta, Eriophorum angustifolium and Rhacomitrium lanuginosum, while Trichophorum cespitosum, Erica tetralix, Empetrum nigrum and Juncus squarrosus are all common. The herb/dwarf shrub layer is generally an open carpet of heather, with a dense moss layer in which tufts of Rhacomitrium lanuginosum predominate over a scattering of diverse bryophytes. Lepidozia pinnata, Odontoschisma sphagni, Calypogeia muellerana, Mylia anomala, M.taylori, Lophozia ventricosa and Frullania tamarisci are liverworts which appear frequently in this community.

Lichens are commonly found, although with low cover, usually present as straggling threads among the mosses. Cladonia impexa, C.uncialis and C.tenuis are the most frequently recorded.

These heaths extend over wide areas, recorded between 24m and 225m from N.Mainland, Bressay and Whalsay, on granite, sandstone and gneiss.

The character anddifferential species of the Erico-Sphagnion are well represented in this community. Those given by Moore (1968), and

present, are listed below, with their constancies in this Shetland heath:

	Constancy
Sphagnum papillosum	-
S.plumulosum	-
Hyprum cupressiforme	IV
Campylopus flexuosus	II
Odontoschisma sphagni	II
Molinia caerulea	II
Eriophorum angustifolium	IV
Narthecium ossifragum	III
Cladonia impexa	II

Empetrum nigrum and Rhacomitrium languginosum can occur in both alliances of the Sphagnetalia (Moore 1968, Table 1).

Birse (1973, pers.comm.) assigns most of the blanket bog vegetation he examined near Sullom Voe to the Erico-Sphagnetum magellanici Moore 1968. This association was created to embrace all forms of "flats" and hummock-forming raised bog, and appears to be similar to that represented by this community.

(Birse 1973) finds that this Western European blanket bog is dominated by either Calluna or Rhacomitrium or both, and distinguishes the vegetation in Shetland by the abundance of Eriophorum angustifolium, the constancy of Scapania gracilis and the low frequency of Narthecium ossifragum. He also notes the constancy of Empetrum nigrum and Rhytidiadelphus loreus in Shetland vegetation. All these points are endorsed by the data from the present heath community.

Jones (1973) describes a "nodum with Empetrum and Sphagnum recurvum", which is differentiated by a number of bryophytes including Lophozia ventricosa, Sphagnum recurvum, Plagiothecium undulatum, Anlacomnium palustre, Rhytidiadelphus loreus, Hyprum ericetorum, Pleurozium schreberi, Ptilidum ciliare and Campylopus flexuosus. These are all present in this Shetland community, and the whole nodum appears to resemble the latter closely. This was placed by Jones in the Erico-Sphagnetum magellanici although its similarity to the Pleurozia purpurea-Erica tetralix Association and the Vaccinio-Ericetum tetralicis was noted.

The Trichophoreto-Calunetum McV.et R.1962 in the Ericion tetralicis, and Tallis' Rhacomitrium-Cladina and Drosera-Narthecium Nodum (Tallis 1969) appear to have similar constants, but they have greater dominance by Sphagna and lower Empetrum cover and frequency.

Lewis (1976) describes a rhacomitretosum languinosi subassociation within her Empetrum-Rhytidiadelphus Association. Although clearly related to the present heat vegetation, there are a number of vital differences between the subassociation and the present data, which lead to placing the latter in the Erico-Sphagnetum magellanici.

a) Reduced frequency of Empetrum and Rhytidiadelphus here.

b) Virtual absence of Erica cinerea, which is constant to the subassociation in the North.

c) Abundance of Juncus squarrosus and Molinia caerulea, which are absent in the North.

Moore (1968) divides the Erico-Sphagnetum magellanici into three races, of which the sub-atlantic form with Narthecium and Sphagnum recurvum is present in Britain. (The extreme atlantic race occurs in Ireland.)

This widespread Rhacomitrium heath can tentatively be divided into the three subassociations recognised by Birse (1973) at Sullom. At a number of flushed sites there are Molinia caerulea and Carex panicea which characterise the "subassociation with Molinia" (releves 374-370); the typical subassociation, with dominant Sphagna is occasional (releves 178-708); the remainder fall into the Cladonia uncialis subassociation with Cladonia spp. and Rhacomitrium. This also follows the description for lowland Scottish vegetation given by Birse and Robertson (1976).

5.8.2.4. Agrostis tenuis heaths Releves 232-704

This group contains a variety of communities which have been brought together for descriptive purposes by the constancy of Potentilla erecta, Calluna vulgaris, Festuca vivipara, F.rubra and Agrostis tenuis in all types.

With locally frequent Sieglingia decumbens, Nardus stricta, Agrostis canina, Holcus lanatus, Anthoxanthum odoratum and Aira praecox they are essentially grass-rich heaths, although, in places, Calluna bushes may dominate the structure of the community.

This is the most widespread of Shetland heaths, being recorded from all parts of Mainland, Whalsay, Muckle Roe and Mousa in one or more of its forms.

.8.2.4.1. Species-poor community Releves 232-667

This is a community which seems difficult to characterise. It is found on steep slopes or over thin peat or soil where it appears that Calluna vulgaris and Festuca rubra can become dominant or co-dominant while other species occur only sparsely. Only these two plants have constancy V to the community with Potentilla erecta and Agrostis tenuis constancy IV.

The heather usually forms dense clumps (vegetation 0.3m high was recorded) among, and below, which herbs such as Jasione montana, Thymus drucei, Potentilla erecta, Galium saxatile and Viola riviniana, and the bryophytes Hylocomium splendens, Eurhynchium praelongum and Mnium hornum are scattered.

The land is not always easily accessible to sheep and in their absence a number of species of limited Shetland distribution can thrive, e.g. Oxalis acetosella and Lonicera periclymenum.

This community was recorded from the slopes above the Burn of Valayre, Mainland. This site contains a number of species falling into the latter category and a further releve, not included in the table also contains many unusual bryophytes.

Releve: 325 Burn of Valayre. HU 369 693

$2m^2$ slope 80^o altitude 45m

Viola riviniana	1	Sphagnumplumulosum	1
Thymus drucei	1	S capillaceum	1
Thalictrum alpinum	1	S palustre	1
Blechnum spicant	1	Pellia fabbroniana	1
Oxalis acetosella	1	Amphidium mougeoti	2

Deschampsia flexuosa	1	Brachytheciumplumulosum	1
Anthoxanthum odoratum	1	Minium hornum	1
Potentilla erecta	1	M.punctatum	1
Carex pulicaris	1	Polytrichum commune	1
Calluna vulgaris	+	P.epiphylla	1
Pinguicula vulgaris	+	Rhytidiadelphus loreus	+
Luzula multiflora	+	Hylocomium splendens	+
Festuca vivipara	+	Philonotis fontana	+
F.rubra	+	Bryum pallens	+
Galium saxatile	+	Anoectangium compactum	+
Sagina procumbens	+	Blindia acuta	+
Tavaxacum sp.	+	Saccogyna viticulosa	+
Veronica officinalis	+	Frullania tamarisci	+
Carex lepidocarpa	+	Breutelia chrysocoma	+
Euphrasia agg.	+	Dicranum bonjeanisi	+
		Hypnum ericetorum	+
Selaginella selaginoides	+		

The soil is always damp and thin, over gneiss, sandstone, granite or limestone. Mean pH recorded was 5.7 (range 5.0 -6.7).

This appears to be a community defined ecologically rather than wholly floristically, the releves being united by their unusual situations, and hence the limited types of plants which can occupy them. These seem generally to be "pioneer" species which can enter and grow in difficult habitats.

The community has been ascribed to the Ericeto-Caricetum binervis Br.-Bl. et.Tx (50).1952. It closely resembles the Callunetum vulgaris McVean and Ratcliffe 1962 in that it has a low species number, is dominated by Calluna and has occurrences of herbs such as Lotus corniculatus and Jasione montana. Erica cinerea is occasional & Nardus stricta is reduced in abundance, thus agreeing with the descriptions of this association from Scotland (McVean and Ratcliffe 1962) and Skye (Birks 1973). It differs in the absence of the bryophytes Pleurozium schreberi and Hypnum cupressiforme var.ericetorum which are constant to the previous descriptions.

Birse (1973) described the typical subassociation of the Caricibinervis-Ericetum cinereae from Baltasound and a further subassociation low in species numbers, differentiated by the presence of Viola rivinana, Thymus drucei and Hypericum pulchrum.

It is felt that both these subassociations may be found within this small community; the differentials of the second do occur, but there is

insufficient data to be conelusive.

Releves 318, 322 and 232 seem most similar to the subassociation with Viola riviniana.

Nardo-Callunetea class characters are poorly represnted although all given by Birse (1973) do occur. This is probably due to the heterogeneous nature of this community. With further releves from Calluna-dominated communities it would probably be possible to separate that part of the vegetation representing truly atlantic heather moor from that part which is transitional to vegetation of block screes and cliffs. It is significant that within the Ericion cinereae, Prentice and Prentice (1975) distinguish an association of Calluna dominated vegetation on block scree. Their ordination analysis shows a close relationship between this and Callunetum vulgaris.

.8.2.4.2. Carex pilulifera community Releves 912-046

This is the typical middle altitude "dry" heath found in southern Shetland, and recorded throughout North Mainland. Between 38m and 115m the thinner peat is covered by rolling expanses of vegetation dominated by Calluna vulgaris, but where Carex pilulifera, Agrostis tenuis, and Festuca vivipara are common. The community was found on Muckle Roe at only 18m, but here Carex pilulifera is absent.

This releve is related to the Maritime heaths in the next group, but has been placed here on its lower species number and lack of a number of the "maritime" indicators.

The vegetation is low (<76mm) with open patches; herb cover averages only 70% while bryophytes only cover about 40% ground usually. Grazing by sheep in quite intensive; pH mean is 5.4.

Apart from the constant species mentioned above few others occur at all regularly, viz. Potentilla erecta, Galium saxatile, Agrostis canina ssp.montana and the bryophytes Hypnum ericetorum, Diplophyllum albicans and Hylocomium splendens.

Among the more uncommon Shetland species occurring in this community are Vaccinium myrtillus, Sagina subulata, Leucobryum glaucum and Polytrichum piliferum.

Lichens are frequent and varied, chiefly Cladonia spp.(especially, Cladonia impexa, C.furcata, C.uncialis, C.coccifera) and Cornicularia muricata.

This community was recorded only on granite and sandstone; this probably reflects simply the geological base of the land at this altitude in S.Shetland and not the preferential rock type of the community. It is probably present in South Mainland, e.g. in the Scousbrough area on thin peat and where the effects of the sea do not have great influence.

This vegetation of any heaths has been assigned to the Ericeto-Caricetum binervis Br.-Bl.et Tx.(50)1952, following the works of Birse (1973) at Sullom Voe. He only published three releves from the area, all of which he ascribed to the subassociation with Molinia caerulea.

However, at Baltasound, on the thinner soils and peat, Birse and Robertson (1973) distinguish further subassociations, with a number of releves clearly transitional, possessing various permutations of the differential species.

It is possible that only releve 668 from the present study could be placed in the subassociation with Molinia caerulea, and 661 in the subassociation with Viola riviniana but it is felt that the parent association, only, can be defined at present.

The Atlantic, Eu-oceanic dwarf shrub heaths assigned to the Ericion cinereae by Bøcher 1943, are characterised by high constancies of 'atlantic' species such as Carex binervis, Empetrum nigrum, Dactylorchis maculata ssp. ericetorum, Selaginella selaginoides, Rhacomitrium lanuginosum, Rhytidiadelphus loreus, Pleurozia purpurea and Erica cinerea (Gimingham 1964a). Of these, only Carex binervis is at all common in this community, although all occur at least once.

It would appear, then, that these heaths are not sharply defined within Bøcher's classification.

The Callunetum vulgaris Association McVean and Ratcliffe 1962, includes the Ericeto-Caricetum binervis Br.-Bl.et Tx.1952 in part, but is dominated by Calluna. Potentilla erecta, Hypnum cupressiforme var.ericetorum and Pleurozium schreberi are constant with Carex binervis and Agrostis tenuis. (Birks 1973) The Skye vegetation assigned to this Scottish nodum is much more similar to that in Shetland than is that of the original description in particular by its higher grass cover, viz: Agrostis canina, A.tenuis, Festuca rubra and F.vivipara, but the absence of Nardus stricta and Carex pilulifera from Birks' description is important. These are distinctive features of the Shetland community. Nardus is present in the Callunetum on Hoy (Prentice and Prentice 1975). The increased grass cover in Shetland may be indicative of greater grazing pressure, and the community's relationships with the Agrosto-Festucetum McV. & R.1962.

It is however, the virtual absence of Erica cinerea, Pleurozium schreberi and Dicranum scoparium from the Shetland community that distinguishes it from other descriptions within relation groups. This seems to indicate that the community is less strongly oceanic than one might expect to find in Shetland. It is noticeable that Erica cinerea is reduced in abundance in many communities, e.g.Callunetum vulgaris (group 5.8.2.4.1.).

The description of the Ericeto-Caricetum binervis (Pethybridge and Praeger 1905) Br.-Bl.et Tx.50, by the German authors in 1952 places it within the Ulicion ranae Duvigneaud 44, an alliance of heaths of Southern Britain and Northern Europe with high constancy of Erica cinerea and Ulex gallii. This alliance is equivalent to the Erica cinerea heath of Bridgewater (1970), the distribution of which is extended by that author to include Eu-atlantic vegetation of Western Scotland.

The Carex pilulifera heath community, then, does not fit definitively into the Ericeto-Caricetum binervis, but appears to be a Shetland race of the same.

.8.2.4.3.Maritime heaths Relevés 834-704

This type of heath can occur over a range of base rocks (sandstone, schist, limestone or granite) and on damp to dry soils or shallow peat. It was recorded from 12m to 118m, but in all cases the habitat and vegetation were exposed to sea spray either directly or wind carried over a short distance.

Calluna, Plantago maritima and Agrostis stolonifera characterise the community forming a low, dense mosaic in which patches or spikes of other species occur. Also constant are Nardus stricta, Potentilla erecta, Calluna vulgaris, and Luzula multiflora while Holcus lantaus, Lotus corniculatus and Anthoxanthum odoratum have constancy IV. The vegetation is herb rich; Euphrasia spp., Leontodon autumnalis, Scilla verna, Thymus drucei, Jasione montana, Achillea millifolium and Armeria mariti m·a are common components with a variety of bryophytes, especially Eurynchium praelongum, Mnium hornum Rhytidiadelphus squarrosus and Dicranum bonjeanii, Cladonia furcata, C.tenuis, C.impexa, C.uncialis are the most frequent of a diverse lichen flora. Overall, there are 24 species per relevé.

Herb cover is usually 100%, but only grows to about 75 mm tall, due both to grazing and wind exposure. Mean soil pH is 5.3.

The community is very common it was recorded from Mainland, Whalsay and Mousa. At lower altitudes it grades into the maritime grasslands described earlier (Groups 5.4.2.2. and 5.4.2.3.) and on higher land is replaced by the montane heaths on shallow soil or blanket bog communities on deeper peat.

At Catfirth a series of relevés were recorded which indicate a streamside variant of this group. All the characteristic species of the maritime heaths hold true, but Pinguicula vulgaris, Primula vulgaris and Cirsium vulgare are common. Philonotis fontana, Mnium punctatum and Cratoneuron commutatum were recorded from a spot very close to the flowing water.

In common with the previous two heath groups this community falls within the Ulicion nanae Duv.44. However no similar vegetation has been described and this Shetland group is designated a Plantago maritima nodum.

Within the Ericion cinereae Bøcher 1943 a number of similar descriptions of maritime herb-rich heaths exist.

On Skye (Birks 1973) and Hoy (Prentice and Prentice,1975) a Calluna-vulgaris-Sieglingia decumbens Association is found which has similar constants to the Shetland community, i.e.Calluna, Sieglingia, Agrostis canina, Festuca vivipara, Potentilla erecta and Hylocomium splendens. It, in in addition, includes some of the more "oceanic" species which are typical of the Ericion, e.g.Erica cinerea and Pleurozium schreberi. It is maritime, but lacks many of the species constant and chracteristic of the Shetland heath, viz: Plantago maritima, Agrostis stolonifera and Scilla verna. A similar vegetation however has been described in Shetland by Spence (1960).

Birks and Prentice and Prentice liken their association to the herb-rich facies of the Callunetum vulgaris McVean and Ratcliffe,1962. Although this has a number of the Shetland constant species, in particular gaining the grasses Holcus lanatus and Anthoxanthum odoratum it, too, lacks Agrostis stolonifera, Armeria maritima and Squill.

Malloch (1971) created a new association to describe the Cornish maritime heaths; this Calluneto-Scilletum vernae he placed in the Ericion cinereae. There are not surprisingly, a number of differences between the Cornish and Shetland maritime heaths, due to the limits of species' distribution (e.g.Carex pallescens and Dactylorchis fuchsii are not recorded in Shetland) but there is a close resemblance between this present community and the Armeria maritima subassociation found on the Lizard.

Agrostis stolonifera, A.tenuis, Plantago maritima, Scilla verna, Lotus corniculatus, Festuca vivipara, Thymus drucei and Calluna vulgaris are common in both Cornish and Shetland releves, although dwarf shrubs

are more prominent at the former site.

Malloch relates this association to the Calluna vulgaris-Sieglingia decumbens Association and suggests that the differences between them may related to the damper Skye climate.

Birse and Robertson's data (1973) from Baltasound place similar species rich heaths to these into the Ericeto-Caricetum binervis, sub-association with Viola riviniania. There are, however, a number of distinct points on which their vegetation differs from the Southern Shetland form

a) High constancy of Rhacomitrium lanuginosum, Viola riviniana, Thymus drucei, Hypericum pulchrum, Antennaria dioica in Unst is not seen in these maritime heaths. These species are present only on the shallower soils in S.Shetland.

b) High constancy of Anthoxanthrum odoratum, Holcus lanatus, Plantago maritima, Lotus corniculatus, Luzula multiflora and Festuca rubra, in the present group, not reflected in their Unst data.

Overall, however, the Association characteristics are similar - Carex binervis and Nardus stricta are both common.

8.8.2.5. Montane heaths — Releves 094-913

Since all land in Shetland lies below 453m it is slightly anomalous to call these heaths, recorded from 45m to 289m truly montane by standards of mainland Britain. However, due to the northerly latitude of Shetland, many of the species found in these communities are regarded as British montane, e.g. Loiseleuria procumbens. Clapham, Tutin and Warburg (1962) give the altitudinal range of this plant as "from 1300' (386.5m) in Orkney to over 4000'(1220m)". In Shetland it was recorded at 453m.

These heaths are open communities found on thin, gritty soils and peat; and on granite, gneiss and limestone. Mean pH is 5.0. A large proportion of the releves were recorded from Collafirth and Roga field, two "shoulders" of Ronas Hill, and some of the highest land in Shetland.

The community is species poor (average 16 per releve). The

climate in some of these sites is the most severe experienced by any parts of the Islands; wind speeds are high (see Chapter 2.2) and vegetation is usually limited to low patches of Ericaceous species. Herb and dwarf shrub cover, generally about 70% can drop as low as 20%, while bryophytes follow the same pattern. Open gravelly spaces are commonly associated with the vegetation.

The vegetation is dominated by Calluna vulgaris and Rhacomitrium lanuginosum which have constancy V to the community, while Potentilla erecta Erica cinerea, Deschampsia flexuosa and Festuca vivipara have constancy IV. Also well represented are Empetrum nigrum, Carex panicea, C.pilulifera, C.binervis, Lycopodium selago and Cladonia uncialis. It is possible that with more extensive sampling further groups, based on the altitudinal ranges of some of this latter group of species could be determined.

A number of species are limited to this community in Shetland, e.g. Arctostaphylos uva-ursi, Salix herbacea, Carex bigelowii and Loiseleuria procumbens.

The community was only recorded from Mainland. It is similar to the Salix herbacea Association recorded from Foula (Barkham 1968) but lacks the abundant Luzula sylvatica found there.

Four smaller groups can be distinguished on floristic characters which correlate with altitudinal zones to some extent. The number of releves recorded in each of these smaller communities was low so that they can only be tentatively assigned to the established taxa indicated.

Groups 5.8.2.5.1, 5.8.2.5.2 and 5.8.2.5.3. have been placed in the Arctostaphyleto-Cetrarion nivalis Dahl 1956. His alliance includes a wide range of chionophobous heath communities on shallow or sandy soils.

A series of 11 releves (094-917, Table 5.8) were recorded between 55m and 289m and are dominated by Calluna and Rhacomitrium lanuginosum. Erica cinerea is constant and lichens of the genus Cladonia are well represented. Empetrum nigrum, Carex pilulifera, C.panicea, Festuca vivipara

and Hypnum cupressiforme var ericetrum are common.

Vegetation cover is open, usually forming hummocks or a mosaic of hummocks over a gravelly or gritty soil. At higher altitudes vegetation cover is reduced to mere strips running along the contours of the hills - these are the 'risers' described by Ball and Goodier (1974) on Ronas Hill.

There is light sheep grazing, but exposure to the wind is probably a more effective pressure; at all sites the dwarf shrubs were noticeably wind swept.

It is felt that all this vegetation falls within the Arctostaphyleto-Cetrarion nivalis Dahl.1956. It is not possible to assign it to any of the associations he describes in Rondane (1956). His high altitude heaths lie above the upper limit of Calluna with Arctic-Alpine species such as Loiseleuria procumbens, Diapensia lapponica, Juncus trifidus and Carex bigelowii playing greater roles in the vegetation than they do in Shetland.

Instead, these heaths have been assigned to associations described by McVean and Ratcliffe in Scotland (1962), Birks (1973) on Skye and Prentice and Prentice (1975) on Hoy, Orkney.

Six relevés (094-114) correspond to the Cladineto-Callunetum typicum McV.& R.1962. Calluna, Rhacomitrium lanuginosum and Erica cinerea are constant and lichens of Cladonia genus are common. The herb and shrub cover is approximately 70% and this vegetation is found between 55 and 225 m in Shetland.

In Scotland, McVean and Ratcliffe indicate that Carex bigelowii is constant to the association, but in the present data Carex binervis appears to be more often. This is probably a reflection of the overall oceanic nature of the island climate in Shetland.

Arctostaphylos uva-ursi occurs in relevé 094, indicating the transitional position of this relevé to the Arctoeto-Callunetum McV.& R. 1962. This latter association has not been recorded in the present survey. Arctuous alpinus occurs only locally in Shetland often with Arctostaphylos

uva-ursi (Palmer and Scott 1969) and probably there the Arctoeto-Callunetum may be recognised.

McVean and Ratcliffe (1962) and Prentice and Prentice (1975) discuss the difficulty in separating the arctostaphyletosum facies of the Cladineto Callunetum from the Arctoeto-Callunetum and indicate that such a separation is articial.

Releves 099-917 appear to form such transitional data. They were recorded at 55m and 950m in North Mainland, and Salix herbacea is constant with Calluna. Empetrum nigrum, and Rhacomitrium langinosum. Deschampsia flexuosa, Carex pilulifera and Festuca vivipara and Lycopodium selago are common. Loiseleuria procumbens occurs in two of the releves, and, with Salix herbacea, indicates the affinities of this vegetation to the Arctoeto-Callunetum. The Shetland data however lack the high lichen frequency indicated by McVean and Ratcliffe. It is more clearly related to the association as described from Hoy (Prentice and Prentice 1975), differing in the absence in this Shetland data of Arctuous alpina.

Releve 180 appears to be the only true representative of the facies sylvaticosum of the Cladineto Callunetum. Recorded at 68m on thin peat, the vegetation has 20% lichen cover. Lecidea uliginosa and Cornicularia muricata are present in addition to five other species - Cladonia furcata, C.impexa, C.tenuis, C.uncialis and Cetraria islandica.

The remaining four releves of these montane heaths were all recorded at 289m on Roga Field (Ronas Hill) and have been assigned to the Viola riviniana subassociation of the Ericeto-Caricetum binervis Br.-Bl.et Tx. 1952. This is a herb-rich form of the heat association with Antennaria dioica, Hypericum pulchrum, Thymus drucei and Viola riviniana. The latter three species are used to differentiate the subassociation by Birse and Robertson (1973) in their Baltasound, Unst data.

Sieglingia decumbens, Nardus stricta, Calluna vulgaris and Erica cinerea indicate the affinities of this community to the Calluno-Ulicetalia. No similar vegetation was recorded by McVean and Ratcliffe (1962) or Prentice and Prentice (1975).

The montane heaths described are not fully representative of the heaths occurring in Shetland, particularly in North Mainland. Due to under-sampling, especially at altitudes above 290m on Ronas Hill, a number of associations established in Scotland, Hoy and at Sullom Voe have not been recorded.

The highest parts of North Mainland must, it is felt, afford suitable habitats for the true 'moss heaths' dominated by Rhacomitrium lanuginosum. Birse (1973) recorded an Agrostis montana - Rhacomitrium langinosum community which is probably present in sheltered areas, while the role of the Arctoeto-Callunetum has already been mentioned. The Cariceto-Rhacomitretum lanuginosi McV. and R.1962 is likely to be found near the summit of Ronas Hill, where Carex bigelowii is at a more optimal altitude. Spence (1970) describes a "Festuca vivipara-Juncus trifidus open sociation" between 244 and 305m on Ronas Hill which form a mosaic" with a Rhacomitrium-rich Loiseleuria procumbens - Calluna heath." This latter type he also records from other parts of North Roe, and Sandness Hill (West Mainland).

The vegetation of Ronas Hill is discussed in Chapter 6.1. The lowering of altitudinal limits for species in Shetland when compared to the main of Scotland has already been mentioned. It is notable that the limits of the Cladineto-Callunetum in the Highlands are 671m to 976m (McVean and Ratcliffe 1962) while here it has been recorded as low as 55m. This lowering does seem to be accompanied by a reduction in the lichen species present - further sampling would be required before any casual relationship between the two facts could be established.

The distribution of these 'montane' heaths is, then, limited to the land in Southern Shetland above 55m, but they occur widely only above 200m. Thus they are confined to North Mainland where the suitable altitudes and granite debris substrates combine to allow their development.

5.8.2.6. Wet heath flushes — Relevés 214-835

This community consists of a carpet of Drepanocladus revolvens, Scorpidium scorpioides, Selaginella selaginoides, Riccardia pinguis and other bryophytes in which Carex panicea, C.demissa, Juncus kochii, Pinguiculavulgaris and Nardus stricta flourish (sedges up to 200mm were recorded). Cushions of Campylopus flexuosus, C.atrovirens, Blindia acuta, Breutelia chrysocoma also are common with a wide range of small sedges, C.demissa, C.hostiana, C.dioica, Carex pulicaris, C.echinata, C.nigra and C.flacca. The ground is subject to constant surface water flow, although this may be only slight at times and the peat is, as a result, dark, clarty and well-humified. The community was recorded on sandstone, limestone and gneiss.

These flushes are the typical habitat of Schoenus nigricans in Shetland, although this species is here recorded only from Strom and Hirda Field, Mainland. The Schoenus nigricans releves are shown below:

Relevé 168: Strom, Mainland.

Grid ref: HU401492 Alt: 3m Slope: 15°

pH:6.8

	Cover value		Cover value
Molinia caerulea	1	Scorpidium scorpioides	3
Ranunculus flammula	1	Acrocladium cuspidatum	1
Equisetum palustre	1	Ceratodon purpureus	1
Carex demissa	1	Drepanocladus revolvens	1
Narthecium ossifragum	1	Riccardia pinguis	1
Carex panicea	1		
C.echinata	1		
Juncus articulatus	1		
Schoenus nigricans	1		
Juncus kochii	1		
Nardus stricta	1		

+ Pinguicula vulgaris, Potentilla erecta, Carex nigra.

This is a site close to the edge of Loch of Strom, a brackish loch in a limestone valley. The vegetation is therefore influenced by salt spray.

The second relevé is:

(cont'd on next page)

Relevé: 666 Hirda Field, North Mainland

Grid ref: HU 337702 Alt: 45m. Slope 2°

pH: 6.0

	Cover value		Cover value
Schoenus nigricans	2	Scorpidium scorpioides	2
Potamageton polygonfolius	1	Campylium stellatum	1
Carex hostiana	1		
C.dioica	1		
Drosera rotundifolia	1		
Nardus stricta	1		
Juncus kochii	1		
Eleocharis quinqueflora	1		
Molinia caerulea	1		

\+ Euphrasia spp., Agrostis canina, Carex echinata, Erica tetralix, Narthecium ossifragum, Pinguicula vulgaris, Blindia acuta, Riccardia pinguis, Euryrinchium praelongum, Rhacomitrium fasciculare Selaginella selaginoides

This site is an open, gravvely flush beside a pool.

The habitat itself has only a limited distribution, forming small channels or patches in more extensive wet heaths. These releves were collected from Mainland and Bressay.

There appear to be two distinct facies in the twelve relevés shown in Table 5.8. The first six are species-rich, characterised by constant Nardus stricta, Carex demissa, Pinguicula vulgaris and C.panicea with Ranunculus flammula, Juncus kochii, Potentilla erecta and Selaginella selaginoides in constancy class IV.

The second group, of only six relevés, is species poor, 13 per releve, with only Carex hostiana constant. On such a small amount of data it was possible only to allocate the two facies to the same association. Thus the following syntaxonomic discussion applies to all twelve releves shown in Table 5.8.

The Shetland data seems to include data assigned by Birse and Robertson (1976) to a Carex echinata-Carex panicea community or a Carex dioica-Eleocharis quinqueflora community. They assign the former to the Caricion-curto-nigrae since it is high in alliance character species. Of these, Ranunculus flammula is constant to the Shetland vegetation, but seems to be

outweighed by character species of the Tofieldietalia.

Birse and Robertson (1973) recorded both these communities at Balta-sound and Birse (1973) noted them near Sullom.

They closely resemble the Carex panicea-Campylium stellatum nodum McV.& R.1962, although Campylium stellatum is recorded only once. Juncus kochii appears to replace J.articulatus of the Scottish mainland data as a constant.

Similar vegetation was recorded on Skye (Birks 1973) where Breutelia chrysocoma has a more important role, and on Hoy, Orkney (Prentice and Prentice (1976).

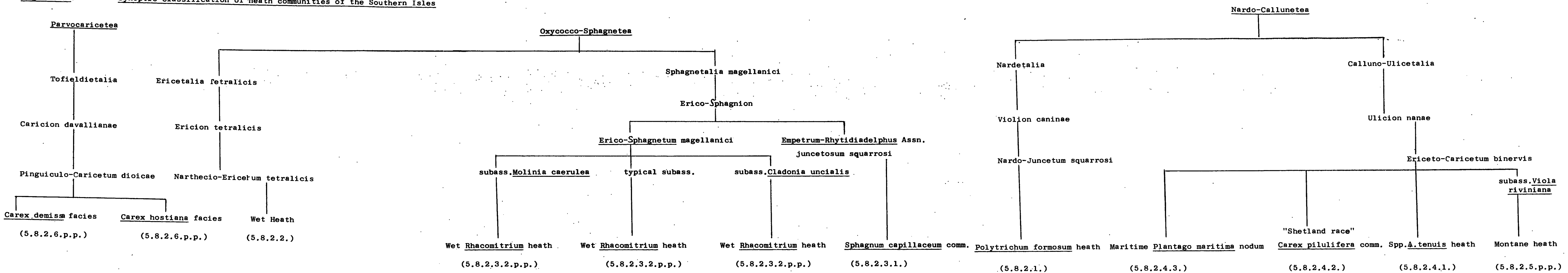
Wheeler's (1975) Scorpidium nodum has several shared species with the present data although his records are from more open, calcarous sties.

However all descriptions of related vegetation of soliginous flushes except those by Birse and Birse and Robertson (1973) have been brought together within Pinguiculo-Caricetum dioicae Jones 1973, and it is to this association of the Tofieldietalia that the present vegetation is assigned.

Wheeler (1975) modifies Jones' tentative list of character species because he feels that many of them are not truly exclusive to the association. He also amends her original concepts of two of her sub-associations, by transferring communities with Elecharis quinquelflora, Molinia caerulea. Succisa pratensis and Eriphorum latifolium from the Eleocharetosum to the Molinietosum. Since Molinia is present in four releves and Elecharis quinqueflora is only one in the present data, it is felt that Jones' scheme should be followed here.

The community has then been assigned to her Eleocharetosum sub-association. It shares the high constancy of Carex panicea, Seleginella selaginoides, Potentilla erecta and Pinguicula vulgaris seen in her synoptic data for the association as well as the presence of sub-association differentials Eleocharis quinqueflora, Eriophorum angustifolium

Figure 5.8. Synoptic classification of heath communities of the Southern Isles



5.8.3. Comparison with the Northern Isles

Three very obvious differences are apparent between the Northern and Southern Heath communities. First, due to some sampling idiosyncrasy a large group of Southern "heath" communities are referable to the Oxycocco-Sphagnetea while none were described in the northern Isles. Second, the debris communities of the Unst fall into the Thlaspetea rotundifolia a class not encountered in the south. Finally, the montane heaths recorded from Ronas Hill and other high land in North Mainland were only recorded from equally high ground on Yell; this simply reflects the absence of suitable sites for such Caricetea curvulae communities in the Northern Isles.

Otherwise very similar vegetation has been described, allocating it to both common British orders of the Nardo-Callunetea.

Lewis (1976) describes a series of 'base-rich flushes', assigned to the Pinguiculo-Caricetum dioicae, from the greenstone and serpentine heaths of Fetlar and Unst. These are much more rich in species than the Heath flushes (5.8.2.6.) recorded in the southern Isles. Similar vegetation was, seen, however in North Mainland and on a small serpentine outcrop on Hoo Fell, S.Mainland.

CHAPTER 6

DISCUSSION

6.DISCUSSION

6.1.SYNOPSIS OF THE VEGETATION OF THE SOUTHERN ISLES

This gives a brief description of the major vegetation types found on the islands in the Southern part of Shetland. It is compiled from the relevé data recorded supplemented by detailed notes made during the three fieldwork sessions.

It is not intended to give a small-scale picture of the complex Shetland vegetation, (a much larger study would be necessary for that) but simply to indicate the overall patterns on islands and the close way in which topography, geology and the vegetation are linked.

Local areas of botanical interest are noted.

6.1.1.MAINLAND

The Mainland has representatives of all the vegetation groups and communities described in Chapter 5. For ease of description it has been divided into the areas delimited in 2.1.

6.1.1.1.North Mainlaind

The most northerly part of Mainland is on granite bedrock which gives the landscape of relatively high rugged hills and many small lochs. These are covered in wet heath communities of the Ericetalia tetralicis and and the wet Rhacomitrium heaths. Small, open patches of small granite rocks and gravels support flushes of the Pinguiculo-Caricetum dioicae.

It is on the higher parts of the Beorgs of Skelberry, the Beorgs of Housetter and of Collafirth and Roga Field, as well as the open debris of Muckle Roe, that dry heaths of the Caricetalia curvulae extend with Salix herbacea, Arctuous alpina and Arctostaphylos uva-ursi.

The highest parts of Ronas Hill, from which releves were not collected, closely resemble the Icelandic and Faroese fellfields with a mosaic of vegetation on the sparse, base-poor soils.

Up to about 230m a Calluna-Eriophorum heath is found which at its upper limit may contain Loiseleuria procumbens, Vaccinium uliginosum and

Arctuous alpina (Johnson 1974).

Above this height frost heaving damages the ground to such an extent thatonly a more open vegetation can exist, mainly communities of the Arctostaphyleto-Cetrarion nivalis.

A number of arctic-alpine species are virtually confined to this area in Shetland; they are Oxyria digyna, Juncus trifidus, Alchemilla alpina, Saussurea alpina and Lycopodium alpinum.

On the west side of Ronas Hill a number of streams cut down to the sea, and in their inaccessible and sheltered gullies single plants of Sorbus aucuparia and Betula pubescens are found (R.Tulloch pers.comm.).

The lochs support the Carex rostrata-Menyanthes trifoliata communities at their edges giving way to wet heath and Erico-Sphagnion communities on the raised edges.

The most extensive area of blanket bog in this section is over the Esha Ness region. There, the cliff top grasslands of the Carex distans-Plantago maritima Association grade into maritime heaths and finally to deep blanket peat supporting a range of Erico-Sphagnion communities. In parts actively growing raised bogs of the Erico-sphagnetum magellanici are found.

Along the east side of this northern sector and extending into Fethaland in the extreme north, the lower-lying land supports agricultural land. Established grazing infield supports the Holcus-Trifolium meadows while reclaimed heath has the Juncus effusus subassociation of the Lolio-Cynosuretum. Wetter patches in fields and ditches are colonised by Calthion communities while the wetter slopes on low heath covered hills have Narthecium-rich flushes of the Narthecio-Ericetum tetralicis.

6.1.1.2. Walls

The sandstone bedrock gives this area a very characteristic topography, described in 2.1.1.2.

Shallow peat covers much of the centre of the region, where rocky

outcrops protrude and large lochs are common. The heaths of the Calluna-Eriophorum and Agrostis tenuis groups are particularly widesspread although on the higher parts of Sandness Hill and The Wards, communities of the Cladineto-Callunetum are found.

The lochs support a number of species which are limited in Shetland to this western region e.g. Isoetes setacea, Ranunculus trichophyllus ssp. trichophyllus, Subularia aquatica and Nymphaea alba. This is probably due to the permanent nature of these lochs when compared to the temporary 'winter' lochs forming in hollows on blanket bog elsewhere.

To the South and West of the area the peat deepens, to 2m or more in places and cutting for fuel is common.

The coastline to the north and west is extremely precipitous, supporting maritime grasslands and heaths at the top of the cliffs. Opposite Papa Stour, at Melby a more gentle slope to the sea occurs giving sandy beaches and a long strip of shingle with Atriplex patula communities.

Around Melby, near Dale, and in Aith sting to the east, rich agricultural land is found. Holcus-Trifolium meadows are widespread with the ubiquitous Calthion communities in wetter hollows.

The lochs of both Wales and North Mainland contain numerous small holms on which sheep are not found. The effect of lack of grazing on the vegetation has been described by Spence (1960). It appears that the communities of the holms are more closely related to woodland which must have once covered the areas than to the blanket bog or heaths on the adjacent land. Some species are now almost confined to such holms, e.g. Osmunda regalis is West Mainland, Corylus avellana in North Mainland (and Catfirth,Nesting) and Salix lapponum in North Roe.

6.1.1.3. Delting

This, central, area of Mainland supports some of the deepest blanket peat seen in Southern Shetland. From Voe, to Calback Ness and Toft, and to Laxo in the east, the region is covered by eroding blanket bog. Cutting

is of course equally widespread.

To the east of Laxo, in the Lunning peninsula, thinner soil gives rich grazing land, of the Lolio-Cynosuretum, and on the rugged coastal areas Polytrichum formosum heaths.

The coastline of this section is mainly composed of sheer cliffs with long voes, e.g. Sullom, Vidlin, Dales Voe. At the head of these are salt marshes and shingle spits.

A notable site is the Burn of Valayre, a rocky ravine through which a stream runs to enter Voxter Voe. Because of the inaccessible nature of the ravine sides, a number of species, remain as evidence of the once forested nature of the islands, viz: Lonicera periclymenum, Sorbus aucuparia, Rosa spp., and Oxalis acetosella.

6.1.1.4. Central Mainland

Again, in this generally low, undulating region, blanket peat communities dominate, particularly along Pettadale and the Kames, where erosion channelling and patterns are evident. There the average depth is 3m over 563 acres (Nicholson 1972).

On top of East Hill of Voe and Weisdale Hill (where Druce is once reported to have recorded Dryas octopetala (Palmer and Scott 1969)) communities of the Ericeto-Caricetum binervis are found.

The valleys of Tingwall and Weisdale are rich agricultural land, being influenced by the limestone bedrock into which they are cut as is the White Ness Peninsula. Although the truly arable land was not sampled, the grazing meadows of the Lolio-Cynosuretum are widespread. Along streamsides the species rich Shetland nodum of this association is found, while the waterlogged edges to the lochs of Tingwall and Asta support various Calthion communities.

At the junction between lowland reclamation and hill peat there is generally a transition zone of Nardo-Juncetum squarrosi heaths and grasslands.

The limestone again outcrops at Catfirth where semi-natural Linum - Silene acaulis grassland of the Galio-Koelerion is found. Here too is a spring area referable to the Cratoneurion commutati, and the second site in Shetland of Coryllus avellan a in the ravine there.

The coast of this area has rather low cliffs and rocky outcrops supporting maritime grasslands. At Ling Ness a stretch of sandy beach has communities of the Ammophiletea, the Koelerio-Corynephoretea and, possibly, the Festuco-Brometea.

6.1.1.5. South Mainland

This is the most important area of Shetland which large scale reclamation has produced a considerable area of fields in which oats (mainly), turnips, swedes and potatoes are grown. This "agricultural" area extends from Cunningsburgh, along the east side of the Dunrossness region to Sumburgh, where it spreads westwards around the Loch of Spiggie and to Hillwell. Here the Cynosurion communities have their optimum Shetland development; the same must apply to ruderal vegetation of farmyards and trampled areas, placed in the Plantaginetea majoris although this was not sampled.

The enrichment, by manuring and fertilization, of many fields gives species-rich Calthion communities along streamsides, colourful swards of Iris being particularly noticeable in July and August.

The area around Quendale has already been mentioned (5.2.) because of the extensive dune system there. The blown sand from the Quendale beach extends a good way inland, so that Galio-Koelerion and Ammophiletea communities are found as far from the beach as Hillwell.

Hillwell loch is considered to be the only truly machair loch on calcareous sand in Shetland (Johnston 1974) and is the only location of Myriophyllum spicatum in Shetland.

The wet meadow complex of the Lochs of Spiggie and Brow has representatives

of most of the wet meadow communities, and is a particularly good example of the Potentilla palustris communities.

To the west of the agricultural zone, and extending as far north as Scalloway is a series of hills, from Fitful Head and along the Clift Hills, covered in deep blanket peat and topped with open Rhacomitrium heath communities. The blanket peat extends westwards north of Cunningsburgh stopping only near the coast, where maritime grass and heath communities are found.

The coastline of South Mainland is extremely varied, lacking only the deep voes seen in the north, and thus the associated saltmarshes. Shingle and boulder beaches are common and, therefore, Agropyrion pungentis communities.

Mousa. This small island has a coastal fringe of maritime grassland and heaths on top of low cliffs. The centre of the island is covered by a wet heath of the Erico-Sphagnion while the grazed and trampled area aound the Broch is a grass-rich Agrostis stolonifera maritime grassland.

6.1.2. BRESSAY AND NOSS

The Ward of Bressay and other high ground on the Island is covered in deep, eroded blanket peat. Below this a Nardo-Juncetum squarrosi heath develops which has been grazed and reclaimed at lower levels around crofts. Where drainage in such situations is impeded, Juncus conglomeratus and J.effusus stands occur.

In the infield areas, Cynosurion communities predominate with the Juncus effusus subassociation particularly common.

Noss has a low, sandy grassland vegetation along its western edge with thistles in a Galio-Koelerion community. Rising to the east this changes to a Nardetalia heath, while on the extreme cliff edges, a more maritime heath is seen. Trientalis europaea has one of its few Shetland locations on the Island.

6.1.3. WHALSAY AND ISBISTER HOLM

Whalsay is predominantly covered by a wet, Calluna-Eriophorum heath where all the facies and flush types described may be recognised.

Along the coastal margins of the west and south-west, reclamation has taken place and Cynosurion communities form infield grazing areas. The associates wetter parts have Calthion wet grassland and wet meadow vegetation.

Isbister Holm is unique in the occurrence of Aster tripolium there in crevices on south facing cliffs, but in other ways it is typical of the small islands off Whalsay. (R.Tulloch pers.comm.). Its margins of low-grazed maritime grassland grade into wet Calluna-Eriophorum heath and Nardo-Juncetum squarrosi heaths.

6.1.4. OUT SKERRIES

These small islands have only a very thin soil covering in most places; there are large areas of scree-like flushes bearing communities of the Parvocaricetea. Schoenus nigricans is recorded there (I.Robertson pers.comm.)

Most of the islands are covered by short, grazed Agrostis tenuis or Nardus heath. There are small areas cultivated and some Lolio-Cynosuretum meadows.

Only on Housay is there any extent of marshy ground, where Calthion communities can develop.

6.1.5. BURRA AND TRONDRA

The islands of East and West Burra have a thin peat covering supporting a maritime heath in which Scilla verna and Salix repens are two notable components. The vegetation is open and patchy, and only towards Meil and Hamnavoe has extensive reclamation produced grassland communities. At Meil a stretch of Maritime grassland, with patches of Linum-Silene acaulis grassland, extends behind an impressive beach.

Trondra is more obviously "cultivated" having a higher proportion of Holcus-Trifolium meadows, with Calthion patches in wet hollows, and less, wetter heath.

6.1.6. GENERAL POINTS

In the foregoing sections some of the local characteristics of Southern Shetland vegetation have been described.

However some vegetation types which were not or rarely sampled are similar throughout the area.

Maritime cliffs support a rich, and colourful flora Armeria maritima Lotus corniculatus, Silene dioica spp.Zetlandica, Cochlearia officinalis and Primula vulgaris flourish when out of reach of sheep, and these may be accompanied by Ligusticum scoticum and Sedum rosea.

Similarly, roadside ditches produce a display of Mimulus guttatus with Caltha palustris, Dachylorchis maculata ssp.ericetorum and D.maculata ssp.ericetorum purpurella.

6.2. GENERAL DISCUSSION

The aim of the project as outlined in Chapter 1 was to use conventional phytosociological methods to survey the vegetation of an island group, and relate this vegetation to that of Europe.

A number of methodological problems were encountered that were perhaps not unexpected when the size of the area covered is considered. Moore et al (1970) concluded that Braun-Blanquet's classical method held good for a general or large-scale survey, recognising that it is the most efficient way of using time and energy. At the onset of Shetland work, a completely random site choice was made, and this proved extremely time consuming, in that it produced oversampling of blanket bog and heath vegetation at the expense of the rarer and more localised types. It was thus felt justified in delimiting the site using personal knowledge of the area, and then applying Braun-Blanquet's criteria for selection of a stand. Poore (1955a) suggests that as an investigation progresses knowledge of the vegetation being dealt with allows one to ignore areas not exhibition all the characteristics of that vegetation. However it was felt that on such a large-scale survey no obviously different vegetation stand could be ignored even though it resulted in a small number of "borderline" samples that could not be placed comfortably in the groups defined.

The choice of analysis method was not entirely satisfactory. With almost 500 relevés to compare and tabulate, the availability of computer techniques to perform these operations appeared ideal. The wide range of mathematical procedures available for comparison of releves was summarised in Chapter 3. Work by Frenkel and Harrison (1974) and Wheeler (1975) suggested that no single numerical classificatory method is superior to all others. All, it seems, are unable to deal with the "quirks of nature" encountered when dealing with natural vegetation. The continuous nature of plant communities (the continuum) and their seral relationships in both time and space have always been recognised

(see Tansley 1939) and classification of these communities is, after all, simply an exercise of convenience. The phytosociologist is only delimiting points along a continuum so that he may be sure of using the same name for his association as another worker in a different area. It is not surprising then that rigid mathematical formulae cannot encompass this multi-dimensional variation of plant communities to which is added the effects of numerous factors, each of different weightings, e.g.climate, soil, grazing, animal activity.

Having selected what seemed after due consideration the best of these mathematical techniques for the work to hand, Ward's "Error Sum of Squares" the computer was used to compare then tabulate the data. Here the very practical problem of insufficient computer storage space and time was encountered, as well as data limits to the program. This made it impossible to compare each releve collected with every other one and the subjective usage of major vegetation types had to be continued.

On the whole this method has been successful, although rather confusing name anomalies occur (e.g. Blanket-bog vegetation of the Empetrum-Rhytidiadelphus loreus Ass.appears on the "Heath" table). It does prove reassuring, however, that at the end of computer processes, such a group can be identified clearly from the data.

The Braun-Blanquet methodology has thus been applied successfully to an environment which is extremely impoverished both floristically (see this chapter) and geologically (see chapter 2.1.).

In delimiting the higher vegetation units (classes, orders, alliances) this system appears to have been satisfactory. Many of the character and differential species used for the Continent, and even Southern Britain, are absent from Shetland, e.g. Festuco-Brometea class character spcies; but usually sufficient are found there to distinguish such syntaxa. At the association or nodum level these absences become more noticeable and it is generally difficult to relate to established groups.

By following the interpretation of Westhoff and Den Held (1969) of

using a combination of characteristic species, rather than the requisition of a character species presence, this problem has been overcome.

In North Scotland only Skye (Birks 1973) and part of Hoy (Prentice and Prentice 1975) have been described in similar detail by Braun-Blanquet's methods. These are the nearest descriptions, geographically, (in Britian) with which Shetland vegetation can be compared. Many similarities with both have been found, particularly the Orkney vegetation (see Chapter 5).

While the absences are notable, there are a number of species which play more prominent roles in Shetland than elsewhere and may be considered as character and differential species of local noda. e.g.Erica cinerea and and Polytrichum formosum in Heath communities; Caltha palustris and Potentilla palustris in wet meadows.

It is hoped that in the future the data from Northern and Southern Isles will be combined, and that some of the noda described may then be raised to the rank of association. Thus information on British communties could be extended to the northern extreme.

An extremely wide range of phytosociological classes are represented in Southern Shetland, and samples have been obtained from most of them.

It was never intended to sample open freshwater vegetation although some emergent communities of the Phragmitetea were recognised. (The limited variety of lochs in Southern Shetland has already been mentioned.) Potamogeton spp.are common in lochs of Shetland (Palmer & Scott 1969) and it is probable that the Class Potametea is well-represented in the islands. Chara aspera is present in some of the mesotrophic lochs in agricultural areas (e.g.Loch Tingwall) and would probably indicate communities of the Charetea.

Sampling in strictly ruderal areas was limited to those stands bordering on natural vegetation or where the influence of crofting proved difficult to assess, e.g. in the dune grassland situation. Croft infields contain communities of the Plantaginetea majoris, while the

farmyards reflect the constant trampling and manuring. In the Dunrossness area of Mainland, in particular, a large number of alien and weed species thrive, e.g. Matricaria matricarioides, Trifolium dubi um, T. hybridum ssp. hybridum, Carum carvi. These would indicate the predominance of predominance of agricultural management in the area and, possibly the introduction of species in seed. South-east Mainland is, however, slightly warmer than the rest of Southern Shetland (see 2.2.) and it is possible that this encourages the survival of such species. It is interesting to note that plants associated with crops are also common on Fethar, the most fertile of the Northern Isles.

A third habitat that was not sampled was that of the maritime cliffs, described in 6.1.6. The Sedo-Scleranthetea is a class of stonecrop, sand and rock vegetation (Birse & Robertson 1976) which although not recognised in the present work may include some of the closed herb vegetation of sea-cliffs. The Crithmo-Limonetea is the usual class of southern maritime rock crevice communities (Shimwell 1971) but it is probable that Shetland sea cliff vegetation, dominated by Armeria maritima, Lotus corniculatus and Cochlearia officinalis could be placed in the Silenion maritimae Malloch 71. Although obviously a northern variant of those communities they resemble some described from the Lizard (Malloch 1971). It would then be possible to reconsider the position of the cliff-top grasslands in Southern Shetland, at present placed in the Armerion maritimae, although Lewis (1976) assigned those of the Northern Isles tentatively to the Silenion martimae. The absence of so many characteristic southern cliff species from Shetland vegetation would seem to warrant the creation of a new syntaxon. However, the Lizard and Shetland are such geographical extremes that further work on the other intermediate cliffs must be done before their relative positions can be fully assessed.

Inland, cliff or rock crevice communities are extremely fragmentary in

in nature and were not sampled. Typically they support small shrubs such as Salix spp., Juniperus communis spp. nana, Lonicerea peryclymenum or Rosa spp. and, more rarely, Sorbus aucuparia, Coryllus avellana and Populus tremula. Many ferns have their sole Shetland stations in the granite crevices of North Marvine, e.g. Thelypteris phegopteris (Palmer and Scott 1969).

Whole classes of British vegetation may be limited in extent or absent from Shetland altogether, due to a number of reasons.

The physical isolation of the islands has restricted the flora numerically. Palmer and Scott (1969) list 681 vascular plant species for the islands of which only 400 are native to the islands (c.f. 2 241 spp. native to Britain (Dandy 1958)). This paucity is maintained by a small range of bedrock, being mostly acidic, and the oceanic nature of the climate which has encouraged the blanketing of most of the islands by peat.

Conversely, the high latitude allows certain arctic-alpine species to grow at low altitudes at which they would not be found in Mainland Britian. This 'squashing' of altitudinal range certainly permits growth of a wide range of arctic-alpine communities at the same time creating anomalies such as the Linum-Silene acaulis group on lowlying grassland.

The presence of serpentine rock on Unst and Fetlar, (and a very small outcrop in South Mainland) produces the unique debris community containing Cerastium nigrescens, assigned by Lewis (1976), to the Thlaspetea rotundifolii.

Shetland at the extreme north of Britain and, not surprisingly, represents the northern limits of many species, e.g. Sagina maritima, Ranunculus baudautii.

Goode (1974) analysed the Shetland flora in terms of Matthews' phytogeographical elements and found that the most common elements in the flora were:

Widespread.....	46.6%	common species, not introduced
Widespread, sub-atlantic..	17.0%	" "
Northern continental.....	12.3%	" "
Atlantic.....	11.6%	" "

He points out that the first three groups embrace 76% of Shetland's common species, while noting that the proportion of the arctic-alpine element is much lower than that of Faeroe (6.2% as opposed to 14.7%) of total native flora.

However, in comparing the figures for Shetland and Skye it is notable that while the percentages involved are similar, the flora of Skye is far richer than Shetland (588 spp.as opposed to 399.)

Thus, classes of vegetation centred on species of mainland Britian and even Northern Scotland, would not necessarily extent to Shetland.

The overall character of Shetland vegetation is shaped by a number of factors.

The climate is hyperoceanic (Birse 1973) with humid to very humid moisture conditions. Exposure is severe over most parts of Southern Shetland and the highest areas are "extremely exposed" in terms of Birse and Robertson (1970)'s scale. The humid, hyperoceanic conditions allied to the undulating landscape of much of central Mainland promotes peat development to a great extent (Birse 1973). Individual bog and heath species thriving on this extreme oceanic climate have been mentioned in Chapter 5 and it can only be noted here that the prominence of such species in the vegetation is not seen elsewhere in Britain, even on the West Scottish islands, and thus places the Shetland communities in a unique phytosociological position.

Exposure is particularly important. It has precluded natural tree growth in all but the most sheltered garden situations. Plantation experiments at Kergord indicated that with care and "nursing" Sitka spruce might survive in Shetland, but it would prove an uneconomical crop (Stewart 1962). Since careful mangagement ended, the plots are now visibly wind-shaped and decreasing in size.

Constant and high-speed winds have caused the evolution of a particularly dwarfed and hairy form of Plantago maritima, characteristic of the Unst debris and the higher parts of Ronas Hill. Insect pollination must be limited, for

the insect fauna of Shetland is similarly restricted. Could the evolution of a subsp. Zetlandica of Silene dioica, having heavy seeds, be an adaptation to aid successful seed dispersal in a windy environment? It may be that heavier seeds are not blown as far from the parent plant as lighter ones, and thus tend to land in a proven suitable area. No study of the effect of the Shetland climate on its native species has been made but there would appear to be a number of possible subject species.

Similarly the daylight regime of the Islands may affect plant growth especially of crop species. In mid-summer there is daylight for 24 hours while in mid-winter there is darkness for almost 18 hours.

Isolation from mainland Britain has been mentioned with respect to plant communities and certain individual species and distributions. Berry (1974) has shown that the Shetland Islands contain unique populations of Apodemus spp. and Amathes glareosa, evolved through limited genetic resources of island populations. In the botantical field, Hieracium spp., Silene dioica, Luzula sylvatica, and Cerastium nigrescens are examples of locally evolved taxa. Shetland would thus seem an ideal location for the plant geneticist to study inbreeding.

A notable character of any Shetland blanket peat landscape is the peat-cutting. The peat is cut in spring and stacked to dry over summer before being taken to the homes in autumn. If the top sod is removed and replaced carefully the vegetation is little disturbed. The great depth of peat still below ensures that the habitat is little changed. But if the top is not replaced after cutting the surface soon becomes eroded by wind and rain, to the bedrock in shallow peat areas, and expanses of moorland lose their vegetation cover. The process is then a creeping one, since the eroded surface and edge of the cutting will then "eat way" beneath the surrounding areas. Tallis (1964) explains how even the slightest disturbance to blanket peat surface causes the natural drainage patterns to alter, and leads to channelling of the

peat as streams cut through.

The ubiquitous sheep have also had a profound effect on the Shetland vegetation in that since their introduction these animals have grazed freely on almost every part of the Islands. Only a few holms in lochs, cliff faces and small sea stacks have escaped their teeth and can give evidence to the more natural Shetland vegetation. Rabbits, too, have had noticeable effect, particularly in burrowing in sandy areas. Seals, the only other large mammal (besides man, sheep and rabbits) occurring in large numbers do haul up on beaches, particularly Mousa in the Southern Isles, but they have not had the impact on vegetation seen for example, on the Farne Islands, off the Northumbrian coast.

Finally, the effect of the sea spray on island vegetation must be considered. Aided by high winds, salt spray is carried far inland. The ionic concentrations of sodium and chloride in Shetland freshwater lochs was mea s ured by Britton (1974). He found that at similar distances from the sea, Shetland lochs have higher ionic concentrates than comparable lochs on mainland Scotland. On Shetland itself theconcentration of sodium is directly proportional to proximity to the sea. This could affect the distribution of some species. For example, Charophytes, which are generally restricted to high calcium waters colonise waters of a lower trophic status. (Britton 1974)

Goldsmith (1975) believes that all Shetland is sub-maritime because no part is further than 5.5 km from the sea (Britton 1974). Maritime species such as Plantago maritima and Armeria maritima are found throughout the islands.

As shown by Gillham (1957) on Mull and Iona, the tranisiton from maritime communities to blanket bog through a maritime heath vegetation can take place in a very few metres - such is the overwhelming tendency of most Shetland vegetation to form blanket peat (see Lewis 1976).

The extremely localised nature of certain vegetation types within the

Southern Isles has been emphasised throughout the study. Information from the Northern Isles does not extend the cover of most types. Sand-dunes and machair vegettion are seen at Westsandwick and Breckin on Yell, and on Unst, but there is only one large saltmarsh, at Baltasound. There are no limstone outcrops in the Northern Isles, nor any meso- or entrophic lochs.

These, then, are vegetation types, reprentative of the Northern extent of their British distribution, and before 1970 unlikely to be under any threat of damage.

But since that date there has been a great increase in the number of people in Shetland, both as tourists and residents.

Unfortunately it is the most vulnerable areas that appear to be the most attractive to Homo sapiens.

Gas and oil exploration in the North sea started in the late 1950's, but it was not until 1971 when the huge Brent field was discovered that the interest of the companies transferred from the Scottish mainland to Shetland.

First thoughts on the prospects for the Islands were all favourable - increased wealth, jobs and technology. It was probably not until 1973 that the disadvantages were considered. Chief among these is the threat to the environment, through pollution and physical destruction of areas. The effect of any large oil spillage would primarily be on the marine flora and fauna although oil would damage any foreshore communities with which it came in contact. Thus the limited saltmarsh and sand vegetation is at risk, especially those with rarer species such as Mertensia maritima, Cakile maritima and Spergularia marina.

Physical damage could be either through building permanent or temporary structures or through trampling and human leisure activities, e,g.picnicking. The population of Shetland increased by almost 2.5% p.a. between 1971 and 1974 (Z.C.C.1975) and this figure must be growing larger. Many of these people are, naturally, attracted to the sandy shores and

maritime grasslands, rather than the drab moorlands for recretation. In addition thousands of tourists visit the Islands annually, and all these trampling feet place pressure on rare vegetation types.

A number of steps have been taken to ensure planning and protection of these sites. Perhaps the most detailed and constructive was a report by Warren and Harrison (1974) who made a number of proposals for specific sites in Shetland. A Nature Conservancy Council report published the same year brought together much of the information already collected on the islands.

But conservation in Shetland has not taken many practical steps. Monitoring schemes, particularly by the Sullom Voe Environmental Advisory Group hope to plot the "before" and "after" effects of the oil-related changes taking place. It is to be hoped that the 12-year predicted oil production period is not passed before the changes are recognised and irreparable damage is done.

6.3. CONCLUSIONS

The Zurich-Montpellier system has been used successfully to describe the vegetation of southern Shetland. Even though the area is floristically impoverished, and the system is essentially making floristiccomparision between releves, sufficient similarities and dissimilarities between examples were found to make it possible to delimit vegetation groups. In many cases these were only regarded as noda, in the absence of British data on related vegetation types (e.g.communities of Armerion maritimae and Silenion maritimae).

The Shetland flora as a whole is undoubtedly unusual because of the isolated nature of the Islands and their northern oceanic environment. The presence of species such as Cerastium nigrescens and Cardaminopsis petraea add to their singularity.

The vegetation types described here, and by Lewis (1976) also reflect this unusual environment. A new blanket bog association has been described from the Islands (Lewis 1976) characterised by species of particularly oceanic distribution. The heaths of southern Shetland cover both oceanic types of the (Ericeto-Caricetum binervis) and montane of the (Arctostaphyleto-Cetrarion nivalis). Those of the latter group are found at much lower altitudes in Shetland than in the Scottish Highlands.

Communities of dry, light soils are extremely restricted, e.g.Festuco Brometea, Koelerio-Corynephoretea, generally limited to sandy shores and coastal grasslands.

Generally Shetland provided the most northerly, but floristically degenerate, examples of vegetation found in Britain, e.g.saltmarshes lacking lower marsh communities.

There is a clear pattern of inter-relationship between different Shetland communities, controlled mainly by human management (drainage, peat cutting, reclamation), grazing (sheep, cattle, ponies, rabbits), peat

depth, altitude, exposure, and distance from the sea. Due to the heavy rainfall (248 raindays per year, 1000mm average annual rainfall) on an undulating topography in a temperate area, there is an over-riding tendency for blanket peat to form on all suitable land. This may extend to sea-level, and sea-shores in places, and species normally characteristic of blanket bog extend into other types of vegetation where the boundaries occur.

At present the Shetland Isles are subject to the interest of conservationists concerned by the prospects of oil-related developments. Only the coastal communities are in danger from oil spillage accidents, although the attractive dune grasslands should be protected from trampling and pressures of visitors.

It is hoped that this survey and the work of Lewis (1976) on the Northern Isles will procude a base-line from which more detailed studies may be made. The heaths of Ronas Hill and other high ground would be suitable for a study comparing them with Scandinavian and British montane vegetation.

The Islands have for a long time been considered interesting for their bird and small mammal fauna; it is hoped that their botanical and in particular phytosociological, value will now be developed.

6.4. CONSPECTUS OF ASSOCIATION AND OTHER UNITS

CAKILETEA MARITIMAE Tx. & Prsg.50
CAKILETALIA MARITIMAE Tx.apud Oberd.49.
ATRIPLICION LITTORALIS (Nordh.40) R.Tx.40
Mertensia maritima nodum (5.1.2.3.)
Atriplicetum littoralis (Warming 06) Westhoff & Beeftink 50.
Atriplex patula community p.p.(5.1.2.4)

AGROPYRETEA PUNGENTIS Gehu et Gehu 69.
HONKENYO-CRAMBETALIA MARITIMAE Gehu & Gehu 69.
HONKENYO-CRAMBION MARITIMAE Gehu & Gehu.69
Honkenya peploides nodum (5.1.2.2.)

AGROPYRETALIA PUNGENTIS Gehu & Gehu 69
Arrhenatherum elatius nodum (5.1.2.5.)

AGROPYRION PUNGENTIS Gehu & Gehu 69.
Atriplex patula community p.p.(5.1.2.4.)

AMMOPHILETEA Br.-Bl.et Tx.45
ELYMO-AMMOPHILETALIA ARENARIAE Gehu & Gehu 69
AGROPYRION BOREOATLANTICUM Gehu & Gehu 69.
Elymo-Agropyretum junceiforme Tx.55
Cakile maritima nodum (5.2.2.1.1.)

AMMOPHILION BOREALIS Tx.55
Elymo-Ammophiletum arenariae Br.-Bl.& Deh.36 (5.2.2.1.2.)

Potentilla anserina nodum (5.2.2.1.3.)

PLANTAGINETEA MAJORIS R.Tx.& Prsg. 50
PLANTAGINETALIA MAJORIS R.Tx.(47.)50.
AGROPYRO-RUMICION CRISPI Nordh.40 em.R.Tx.50
Poo-Lolietum D.M.de Vries & Westhoff n.n.apud.
A.Bakker 1965. (5.2.2.4.)

PHRAGMITETEA R.Tx. & Prsg.42
MAGNOCARICETALIA Pignatti 53
MAGNOCARICION ELATAE Koch 26.
Carex rostrata - Menyanthes trifoliata Association
Birks 73. (5.5.2.2.)

KOELERIO-CORYNEPHORETEA Klika apud Klika & Novak 41.
FESTUCO-SEDETALIA ACRIS R.Tx.51.
GALIO-KOELERION (R.Tx.37) Den Held & Westhoff 69 n.n.
Ammophila sociation (5.2.2.2.1.)

Antennarietum hibernicae Br.-Bl.et Tx.52 emShimwell 68.
Silene acaulis nodum £5.4.2.4.)

Viola curtisii-Syntrichia ruralis Assn.Br.-Bl.& Tx.52
subass. Peltigera canina
var.with Camptothecium lutescens (5.2.2.2.2.pp)
var.with Ditrichium flexicaule (5.2.2.2.2.pp)

FESTUCO-BROMETEA Br.Bl.& R.Tx.43.em R.Tx.61
BROMETALIA ERECTI Br.-Bl.36
MESOBROMION ERECTI Br.-Bl.& Moor 38, em Oberd.49.
Base-Rich Festuca grassland (5.4.2.1.)

SAGINETEA MARITIMAE Westhoff,van Leeuwen & Adriani 62.
SAGINETALIA MARITIMAE Westhoff,Van Leeuwen & Adriani 62.
SAGINION MARITIMAE Westhoff,Van Leeuwen & Adriani 62.
Species poor,upper salt marsh community (5.3.2.1.2)

ASTERETEA TRIPOLII Westhoff & Beeftinck 62
GLAUCO-PUCCINELLIETALIA Beeftinck & Westhoff 62.
PUCCINELLION MARITIMAE Christiansen 27 em Tx.37
Festuca-turf fucoid nodum (5.3.2.5.)

ARMERION MARITIMAE Br.-Bl.& De L.36
Festuca-Armeria nodum Adam 76.
Triglochin maritima zone pp.(5.3.2.3.)

Festuca-Puccinellia nodum Adam 76
Triglochin maritima zone pp.(5.3.2.3.)

Juncetum gerardii Warming 06
subass.Leontodonautumnalis
Species-rich upper saltmarsh community pp (5.3.2.1.1.)

Carex distans - Plantago maritima Ass.Ivimey-Cook & Proctor 66 (5.4.2.2.)

Plantago maritima nodum Malloch 71. Shetland variant (5.4.2.3.)

ELEOCHARION UNIGLUMIS Siira 70.
Eleocharetum uniglumis Siira 70.
Elecharis quinquelflora nodum (5.3.2.2.)

PUCCINELLIO-SPERGULARION SALINAE Beeftinck 65.
Spergularia marina nodum (5.3.2.4.)

MOLINIO-ARRHENATHERETEA Tx.37
MOLINIETALIA Koch 26
Holcus-Juncus effusus nodum Adam 76. (5.3.2.1.1.pp)
Molinietalia-community (5.5.2.7.2.)
Agrostis tenuis nodum (5.1.2.1.,5.3.2.1.1.pp)

CALTHION PALUSTRIS Tx.37
Waterside community (5.5.2.1.)
Caltha meadows (5.5.2.6.)
Juncus conglomeratus nodum (5.5.2.7.1.)

ARRHENATHERETALIA ELATIORIS Pawlowski 28.
CYNOSURION CRISTATI Tx.47.
Achillea nodum (5.2.2.3.)
Lolio-Cynosuretum (Br.-Bl.& Del36).R.Tx.37 em.Van Leeuwen & Westhoff apnd Bakker .65. (5.4.2.7.2.)
subass.J.effusus O'Sullivan 65. (5.4.2.7.3.)
Spp.rich Shetland nodum (5.4.2.7.1.)

MONTIO-CARDAMINETEA Br.-Bl.& Tx.43.
MONTIO-CARDAMINETALIA Pawlowski 28.
CRATONEURION COMMUTATI Koch 28.
Cratoneuretum commutati Jones 73.
Cardaminetosum pratensis
var.Cratoneuron filicinum
typical subvariant (5.4.2.5.1.)

PARVOCARICETEA den Held & Westhoff 69.
CARICETALIA NIGRAE Koch 26 em.Nordh.36 denuo em.Tx.37
CARICION CURTO-NIGRAE Koch 26 em.Nordh.36
Viola paluistris community (5.5.2.5.1.)

Violo-Epilobietum palustris Jones 73.
Caricetosum pulicaris (5.4.2.5.2.)

Carex-Sphagnum recurvum nodum Bks.73.(5.5.2.5.2.)

TOFIELDIETALIA Prsg.apud Oberd.49.
CARICION DAVALLIANAE Klika 34.
Galium palustre nodum (5.2.2.5.1.)
Carex maritima nodum (5.2.2.5.2.)

Pinguiculo-Caricetum dioicae Jones 73.em.Wheeler 75.
Carex demissa facies (5.8.2.6.pp)
Carex hostiana facies (5.8.2.6.pp)
elecharetosum typicum (5.5.2.4.)

SCHEUCHZERIETEA Den Held,Barkmann,& Westhoff 69.
SCHEUCHZERIETALIA PALUSTRIS Nordh.36
RHYNCOSPORION ALBAE Koch 26.
Nardus stricta nodum (5.7.2.1.)
Carex panicea nodum (5.7.2.2.)

CARICION LASIOCARPAE Vanden Bergen 49.
Potentilla palustris communities (5.5.2.3.)

OXYCOCCO-SPHAGNETEA Br.-Bl. & Tx.43
ERICETALIA TETRALICIS Moore (64)68.
ERICION TETRALICIS Schwick.33.
Narthecio-Ericetum tetralicis Moore (64)68.(5.8.2.2.)

Pleurozia purpurea-Erica tetralix Ass.(Lid.29) Br.-Bl.& Tx.50.
(5.6.2.4.)

SPHAGNETALIA MAGELLANICI (Pawlowski 28p.p.) Moore (64)68.
ERICO-SPAGNION Moore (64)68.
Empetrum-Rhytidiadelphus loreus Ass. Lewis 76.
Juncetosum squarrosi (5.8.2.3.1.)
rhacomitretosum lanuginosi
typical variant (5.6.2.3.1.)
Listera-Pleurozia variant (5.6.2.2.)

Erico-Sphagnetum magellanici Moore (64)68
subass.Molinia caerulea (5.8.2.3.2.pp., 5.6.2.3.2.)
subass.Cladonia uncialis (5.8.2.3.2.pp)
typical subass. (5.8.2.3.2.pp)

NARDO-CALLUNETEA Prsg.49
NARDETALIA (Oberd.49). Prsg.49
VIOLION CANINAE Schwick (41)44 em.Prsg.49
spp.rich Agrosto-festucetum, Shetland var.(5.4.2.6.2.)
Nardo-Juncetum squarrosi (Nordh.20).Bu k.42. (5.4.2.6.1.,5.8.2.1.)

CALLUNO-ULICETALIA (Quantia 35) Tx.37
ULICION NANAE Duvign.44.em Vanden Bergen 58.
Ericetum-Caricetum binervis Br.-Bl.& Tx.52. (5.6.2.1., 5.8.2.4.1.)
Shetland race (5.8.2.4.2.)
Plantago maritima nodum (5.8.2.4.3.)

Subass.Viola riviniaana (5.8.2.5.pp)

CARICETEA CURVULAE Br.-Bl.48
CARICETALIA CURVULAE Br.-Bl.26.
ARCTOSTAPHYLETO CETRARION NIVALIS Dahl.56.
Cladineto-Callunetum typicum McV.& R.62 (5.8.2.5.pp).
Cladineto-Callunetum sylvatreosum McV & R.62 (5.8.2.5.pp)
transitional Cladineto-Callunetum typicum
Arctoeto-Callunetum McV.& R.62 (5.8.2.5.pp)

REFERENCES

ADAM,P.(1976). Plant sociology and habitat factors in British Saltmarshes. Ph.D. thesis Cambridge.

ADAM,P.,BIRKS,H.J.B.,HUNTLEY,B and PRENTICE,I.C. (1975). Phytosociological studies at Malham Tarn Moss and Fen. Vegetatio 30, 117-132

ASPREY,F.G.,(1947). The vegetation of the Islands of Canna and Sanday, Inverness-shire. J.Ecol.34, 182-93.

ATKINSON,G.C.(1832) An excursion to the Shetland Isles. Unpublished.

BALL D.F.& GOODIER,R.(1974).Ronas Hill, Shetland: A preliminary account of its ground pattern features resulting from the action of frost and wind. In: The Natural Environment of Shetland (ed.R.Goodier), pp 89-106. The Nature Conservancy Council, Edinburgh.

BARKHAM,J.P.(1971).Report on the upland vegetation of Foula (August 1968). In: Brathay Exploration Group Report No.11.

BARKLEY,S.Y.(1953). The vegetation of Soay, Inner Hebrides. Trans.Bot. Soc.Edin. 36, 119-131.

BECKING,R.W.(1957). The Zurich-Montpellier school of phytosociology. Bot.Rev.23, 411-488.

BEEBY,W.H.(1887-8, 1889-90). On the flora of Shetland. Scottish Naturalist 1890, 212-217.

BEEBY,W.H.(1891, 1892). On the flora of Shetland. Scottish Naturalist 25-30 and 51-55.

BEEBY,W.H.(1907, 1908, 1909). On the flora of Shetland. Anns.Scot.Nat. Hist.,165, 110-117, 103-107.

BEEFTINCK W.G.(1966). Vegetation and habitat of the saltmarshes and beach plains in the south-western part of the Netherlands. Wentia 15, 83-108.

BERRY,R.J.(1974). The Shetland fauna; its significance or lack thereof. In: The Natural Environment of Shetland (ed.R.Goodier).pp.151-163. The Nature Conservancy Council, Edinburgh.

BIRKS, H.J.B.(1973). Past and present vegetation of the Isle of Skye; a palaeoecological study. Cambridge.

BIRKS,H.J.B. & RANSOM,M.E.(1969). An inter-glacial peat at Fugla Ness, Shetland. New Phytol.68, 777-96.

BIRSE,E.L.(1971). Assessment of climatic conditions in Scotland. 3) The bioclimatic sub-regions. The Macaulay Institute for Soil Research. Aberdeen.

BIRSE,E.L.(1973). Vegetation of the Sullom Voe area, Shetland Unpublished report.

BIRSE,E.L.(1974). The bioclimatic characteristics of Shetland. In: The Natural Environment of Shetland (ed.R.Goodier). pp.24-32. The Nature Conservancy Council, Edinburgh.

BIRSE, E.L. & DRY, F.T. (1970). Assessment of climatic conditions in Scotland. I. Based on accumulated temperature and potential water deficit. The Macaulay Institute for Soil Research, Aberdeen.

BIRSE, E.L. & ROBERTSON, J.S.(1967). Vegetation. In: The soils of the country round Haddington and Eyemouth, pp.115-152. Mem.Soil Survey of Great Britain, Edinburgh.

BIRSE,E.L. & ROBERTSON, J.S.(1970). Assessment of climatic conditions in Scotland. II. Based on exposure and accumulated frost. The Macaulay Institute for Soil Research, Aberdeen.

BIRSE, E.L. & ROBERTSON, J.S. (1973). Report on the vegetation of the Baltasound area, Shetland. Unpublished report.

BIRSE, E.L. & ROBERTSON, J.S. (1976). Plant communities of the lowland and southern upland regions of Scotland. The Macaulay Institute for Soil Research, Aberdeen.

BOCHER, T.W.,(1943). Studies on the plant geography of the North Atlantic heath formation. II. Danish dwarf shrub communities in relation to those of Northern Europe. K.danske Videnske Selskr.,Biol.Skr. 2 (7),129 pp.

BRATHAY (1971). Field studies on Foula. Brathay Exploration Group Report,No.11.

BRATHAY (1974). Field studies on Foula. Brathay Exploration Group Report, No.27.

BRAUN-BLANQUET,J. (1921). Prinzipien einer Systematic der Pflanzengesellschaften ang floristicher Grundlage. Jahrb. St.Galien Naturw. Ges. 57, 305-351.

BRAUN-BLANQUET,J.(1932). Plant Sociology : a study of plant communities. Translated, revised and edited by G.D.Fuller and H.S.Conrad, London.

BRAUN-BLANQUET, J. & TUXEN, R.(1952). Irische Pflanzengesellschaften. In: Die Pflanzen welt Irlands (ed.W.Lu di).pp.224-415. Bern.

BRIDGEWATER, P.(1970). The phytosociology and community boundaries of the British heath formation. PhD. thesis, Durham.

BRITTON, R.H.(1974). The freshwater ecology of Shetland. In: The Natural Environment of Shetland (ed.R.Goodier). pp 119-129. The Nature Conservancy Council, Edinburgh.

CESKA, A. & ROEMER,H.(1971). A computer programme for identifying species-releve groups, in vegetation studies. Vegetatio 23, 255-77.

CHAPELHOW, R.(1965). On the glaciation of North Roe, Shetland. Geog.J. 131, 60-70.

CHARLESWORTH,J.K.(1956). The late-glacial history of the Highland and Islands of Scotland. Trans.Roy.Soc.Edin. 62, 769-928

CLAPHAM,A.R.,TUTIN,T.G.& WARBURG, E.F. (1962). Flora of the British Isles. 2nd ed. Cambridge.

CRAIG-CHRISTIE, A.(1870). Notes on a botanical excursion to Shetland 1868. Trans.Bot.Soc. Edin. 1870, 165-70.

CURRIE, A.(1960). Further notes on the flora of Fair Isle. Proc.B.S.B.I. 4, 38-39.

CURRIE, A.(1961). Notes on the lichen flora of Fair Isle. Trans. Bot. Soc. Edin. 39, 236.

DAHL, E.(1956). Rondane Mountain vegetation in south Norway and its relation to the environment. Str.norske Vidensk.-Akad.I. Mat.-Nat. No.3. 1-374.

DAHL,E. & HADAC,E. (1941). Strandgesellschaften der Insel Ostoy in Oslofjord. Nytt Mag.Naturr. 82, 251-312.

DAHL,E. & HADAC,E. (1949). Homogeneity of plant communities. Studia bot. Cechosl. 10, 159-176.

DANDY, J.E. (1958). List of British Vascular Plants. British Museum (Nat. Hist.) & B.S.B.I., London.

DENNIS, R.W.G. & GRAY, E.G. (1954). A first list of fungi of Zetland. Trans. Bot. Soc. Edin. 36, (III), 215-223.

DIGHT, F.H.(1965). Windiness in Shetland. Meteorological Magazine 94, 231-236.

DRUCE, G.C.(1920). Plantago maritima. Bot.Exch.Club Br.Is. 6, 36-41.

DRUCE, G.C.(192L). Flora Zetlandica. Supplement to Rep.of Bot.Soc.& Exch. Club for 1921.

DRUCE, G.C.(1924). Additions to Flora Zetlandica. Secretary's Report. Bot. Soc. & Exch. Club.Br.Is, pp. 629-57

DUNCAN,U.(1961). A visit to the Shetland Isles. Lichenologist. 1 (5),267-268.

DUNCAN,U.(1963). A list of Fair Isle lichens. Lichenologist 2, 171-178.

DU RIETZ, G.E. (1936). Classification and nomenclature of vegetation units, 1930-1935. Svensk. bot.Tidskr. 30, 580-589.

DUVIGNEAUD, P. (1949). Classification phytosociologique des tourbieres de l'Europe. Bull.Soc.r.Bot.Belg. 81, 58-129.

EDDY, A.,WELCH,D & RAWES,M.(1969). The vegetation of the Moor House National Nature Reserve in the Northern Pennines, England. Vegetatio 16, 239-84.

EDLIN,H.L.(1957). Spruce in pre-histroic Shetland. Scottish forestry 11,(1) 42-43.

EDMONSTON,T. (1841). List of phanerogamous plants together with the Cryptogamic Orders Filices, Equisetaceae and Lycopodiaceae observed in the Shetland Islands. Anns. & Mag.Nat.Hist. (Mag.200.& bot.) 7, 287-295.

EDMONSTON, T.(1842). Remarks on the botany of Shetland. Trans.Bot Soc.Edin. 1841-1843, 185-188.

EDMONSTON,T. (1903). Flora of Shetland. 2nd ed.(ed.C.F.Argyll Saxby), London and Edinburgh.

ERDTMAN,G. (1924). Studies in the micropalaeontology of post-glacial deposits in North Scotland and the Scotch Isles, with especial reference to the history of the woodlands. J.Linn Soc.Lond. Bot. 46, 449-504.

FITTER, R.S.R.(1959). Addenda to the flora of Fair Isle. Proc.B.S.B.I. 3, 172-173.

FLINN,D.(1974). The coastline of Shetland. In: The Natural Environment of Shetland (ed.R.Goodier). The Nature Conservancy Council, Edinburgh.

FRENKEL, R.E. & HARRISON, C.M. (1974). An assessment of the usefulness of phytosociological and numerical classificatory methods for the community biogeographer. J.Biogeog.1, 27-56.

GEHU,J.N. & GEHU,J.(1969). Les associations vegetales des dunes mobiles et des bordures des plages de la cote Atlantique Francaise. Vegetatio 18, 122-66.

GILLHAM,M.E.(1957). Coastal vegetation of Mull and Iona in relation to salinity and soil reaction. J.Ecol.45, 757-78.

GIMINGHAM,C.H.(1964). Maritime and sub-maritime communities. In: The Vegetation of Scotland (ed.J.H.Burnett), pp.67-142.

GIMINGHAM,C.H.(1964a). Dwarf shrub heaths. In: The Vegetation of Scotland (ed.J.H.Burnett), pp.232-287.

GOLDSMITH,F.B.(1975). The sea-cliff vegetation of Shetland. J.Biogeol. 2, 297-308.

GOODE,D.(1974). The flora and vegetation of Shetland. In: The Natural Environment of Shetland (ed.R.Goodier), pp.50-72. The Nature Conservancy Council, Edinburgh.

GRAVES, F.S.(1899). Wilson's Filmy Fern on Foula. Anns.Scot.Nat.Hist. 8, 243.

HANSEN,K.(1966). Vascular plants in the Faroes. Horizontal and vertical distribution. Dansk Botanisk Arkiv 24 (3), 1-141.

HAWKSWORTH,D.L. (1961). Notes on Shetland lichens, 1. Trans.Bot.Soc.Edin. 40 (III), 283-287.

HAWKSWORTH,D.L (1966).Lichen flora of Foula. Lichenologist 3 (II), 218-223.

HAWKSWORTH,D.L. (1969a). Notes on the flora and vegetation of Foula, Zetland Proc.B.S.B.I. 7, 537-547.

HAWKSWORTH, D.L.(1969b). Bryophyte flora of Foula. Rev.Bryol.et Lichen. 36, 213-218.

HOLBOURN,S.C.(1961). Further additions to the flora of Foula. Trans.Proc. Bot.Soc.Edin. 39, 236-236.

HOPPE G.(1965). Submarine peats in the Shetland Islands. Geografiska Annaler 47(A)(4), 195-203.

HOWIE,A.(1945). Agriculture in Shetland. Scott. J.Agric. 45, 87-94.

IVIMEY-COOK,R.B. & PROCTOR,M.F. (1966). The plant communities of the Burren, Co.Clare. Proc.Roy.Ir.Acad.B. 64, 211-301.

JAMES,D.W.(1965). A new check-list of British Lichens. Lichenologist.3 95-153.

JOHANSEN,J.(1975). Pollen diagrams from the Shetland and Faroe Islands. New Phytol. 75, 369-387.

JOHNSTON,H.H.(1927). Additions to the flora of Shetland. Trans. Bot.Soc. Edin. 29, 429-430.

JOHNSTON,H.H. (1928, May 1929, Dec.1929). Additions to the flora of Shetland. Printed privately, Edinburgh.

JOHNSTON, .L. (1974). Shetland habitats:An outline ecological framework. In: The Natural Environment of Shetland (ed.R.Goodier).pp.33-49, The Nature Conservancy Council, Edinburgh.

JONES, A.V.(1973). A phytosociological study of Widdybank Fell in Upper Teesdale, PhD.thesis, Durham.

LAMBERT, J.M. & WILLIAMS, W.T.(1966). Multivariate methods in plant ecology. VI Comparision of information analysis and association analysis. J.Ecol.54, 635-664.

LEWIS, A.M.(1976). Phytosociological studies in the Northern Isles of Shetland. PhD thesis, Durham.

LEWIS, F.J.(1911). The plant remains in the Scottish peat mosses. IV. Scottish Highlands and Shetland. Trans.Roy.Soc.Edin. 47, 793.

LOHMEYER, W. etalii (1962). Contribution a l'unification du systeme phytosociologique pour l'Europe moy enne etnord-occidentale. Melhoramento 15, 137-51.

LOW,G. (1829). A tour through Orkney and Shetland, 1774. Kirkwall.

MALLOCH,A.J.C. (1971). Vegetation of the maritime cliff-tops of the Lizard and Land's End Peninsulas, West Cornwall. New Phytol. 70, 1155-97.

MALMER,N. (1965). The Souther mires. In: The plant cover of Sweden. Acta Phytogeogr.suecic. 50, 149-158.

McALLUM, Rev.D.(1829). Journal of an Excursion to the Shetland Isles. In: Memoirs of Rev.D.McAllum pp.85-116, London.

McVEAN,D.N.(1962). Flora and vegetation of the Islands of St.Kilda and North Rona, in 1958. J.Ecol.49, 39-54.

McVEAN,D.N. & RATCLIFFE,J. (1962). Plant communities of the Scottish Highlands. London.

MESSENGER, K.G. & URQUHART, J.G. (1958). Additions to the flora of Foula. Trans. Bot. Soc. Edin. 37, 276-278.

METEOROLOGICAL OFFICE (1952). Climatological atlas of the British Isles. H.M.S.O. London.

METEOROLOGICAL OFFICE (1953). Averages of temperatures for Great Britain and N.Ireland, 1921-1950. M.O.571. H.M.S.O. London.

METEOROLOGICAL OFFICE (1958). Averages of rainfall for Great Britain and Ireland, 1916-1950. M.O. 635. H.M.S.O. London.

MONTEITH, R. (1711). Description of Orkney and Zetland, 1633. Edinburgh.

MOORE, J.J. (1962). The Braun-Blanquet system: a reassessment. J.Ecol. 50, 761-9.

MOORE, J.J. (1968). A classification of bogs and wet heaths of Northern Europe. (Oxycocco-Sphagnetea Br.-Bl.et Tx.43). Ber. Int.Symp. Pflanzensoc. system., Stolenzan/Weser 1964, 306-20.

MOORE, J.J.(1971). PHYTO - a suite of programs in Fortan IV for the manipulation of phytosociological tables according to the principles of Braun-Blanquet.

MOORE, J.J.,FITZIMMONS,P, LAMBE,G and WHITE,J.(1970). A comparison and evaluation of some phytosociological techniques. Vegetatio 20, 1-20.

MUELLER-DOMBOIS, D. & ELLENBERG, H. (1973). Aims and methods in vegetation ecology. New York.

MYKURA,W.(1974). The geological basis of the Shetland environment. In: The Natural Environment of Shetland (ed.R.Goodier) pp.1-12. The Nature Conservancy Council, Edinburgh.

NATURE CONSERVANCY COUNCIL (1974). The Natural Environment of Shetland. (ed. R.Goodier) 178pp Edinburgh.

NEUSTEIN,S.A.(1964). A review of pilot and trial plantations established by the Forestry Commission in Shetland. Scott Forestry 18 (3), 199-211.

NICHOLSON, J.R. (1972). Shetland. David & Charles, Newton Abbot.

NICHOLSON, J.R. (1975). Shetland and Oil. Wm.Luscombe.

NORDHAGEN,R.(1936). Versuch einer neuen Einteiling der subalpinen-alpinen Vegetation Norwegens. Bergen Mus. arb.Naturvid. Rekke. 7, 1-88.

OBERDORFER, E.(1957). Suddeutsche Pflanzengesellschaften. Jena.

ORLOCI, L. (1968). Information analysis - phytosociology : partition, classification and prediction. J.theor.Biol. 20, 271-284.

O'SULLIVAN,A.M.(1965). A phytosociological survey of Irish lowland meadows and pastures. PhD thesis, Dublin.

PALMER, R.C. & SCOTT,W.(1965). Yet more additions to the flora of Fair Isle. Proc.B.S.B.I. 6, 43-45.

PALMER,R.C. & SCOTT,W.(1969). A check-list of the flowering plants and ferns of the Shetland Islands. Scalloway and Oxford.

PATON, J.A.(1965). Census catalogue of British hepatics. 4th ed. Brit.Bryol. Soc., Ipswich.

PATON,J.A.(1972). Hepatic flora of the Shetland Islands. Trans. Bot. Soc. Edin. 42, 17-29.

PASSARGE,H.(1964). Pflanzengesellschaften des Nordostdeutschen Flachlands. I. Pflanzensoz. 13, 1-324.

PEACH, B.N. & HORNE,J. (1879). The glaciation of the Shetland Islands. Quart J.Geol.Soc.Lond. 35, 778-811.

POORE, M.E.D.(1955a,b,c; 1956). The use of phytosociological methods in ecological investigation (I-IV). J.Ecol. 43, 226-244; 245-269; 606-651. 44, 28-50).

PRAEGER, R.L.(1911). Clare Island survey. 10. Phanerogamia and Pteridlophyta. Proc.Roy. Ir.Acad. 31.

PRENTICE,H.C. & PRENTICE,I.C.(1975). The hill vegetation of North Hoy, Orkney, New Phytol.75, 313-367.

PRICE,W.R.(1928). Notes on the vegetation of Zetland,1928. Bot. Soc. & Exch. Club.Rep. 8, 770-781.

PRITCHARD,N.M.(1957). Notes on the flora of Fair Isle. Proc.B.S.B.I. 2, 218-225.

RANDALL,R.E. (1972). Vegetation in a maritime environment: The Monach Isles. PhD thesis, Cambridge.

RANWELL, D.S.(1959). Newborough Warren, Anglesey. I. The dune system and dune slack habitat. J.Ecol. 47, 571-601.

RANWELL,D.S.(1960). Newborough Warren, Anglesey.II. Plant associes and succession cycles of the sand dune and dune slack vegetation. J.Ecol. 48, 117-141.

RANWELL, D.S.(1974). Sand dune machair. Seminar report.N.E.R.C., Norwich.

RATCLIFFE,D.A.(1959). Vegetation of the Carneddau, N.Wales. I.Grassland, heaths and bogs. J.Ecol. 47, 371-413.

RIVAS-MARTINEZ, S.(1968). Scheme des groupements vegetaux de l'Espagne. Mimeo.Report for the Colloquium Internationale sur la syntaxonomie Europeane. Rinteln.

ROBERTSON,J.S. & BIRSE,E.L.(1974). Vegetation. In: Soils of the country round Perth, Arbroath and Dundee. Mem.soil survey of Great Britain, Edinburgh.

SENIOR,W.H.& SWAN,W.B.(1972).Survey of agriculture in Caithness, Orkney and Shetland. Highland Development Board, Special Report No.8.

SHIMWELL, D.W.(1968). The phytosociology of calcareous grasslands in the British Isles. PhD.thesis, Durham.

SHIMWELL, D.W.(1971). Description and classification of vegetation. London.

SHIMWELL D.W.(1971a,b). Festuco-Brometea Br.-Bl.& Tx.43 in the British Isles; the phytogeography and phytosociology of limestone grasslands. Parts I & II. Vegetatio, 23, 1-28; 29-60.

SNEATH, D.H.A. & SOKAL,R.R.(1973). Numerical Taxonomy. San Francisco.

SPENCE,D.H.N.(1956). Studies on the vegetation of Shetland. PhD. thesis, Glasgow.

SPENCE,D.H.N.(1957). Studies on the vegetation of Shetland I. The serpentine debris vegetation in Unst. J.Ecol. 45, 917-945.

SPENCE, D.H.N.(1958). Flora of Unst in relation to the geology. Trans. Bot.Soc.Edin. 37, 163-173.

SPENCE,D.H.N.(1959). Studies on the vegetation of Shetland II. Reasons for restriction of exclusive pioneers to serpentine debris. J.Ecol. 47, 641-649.

SPENCE,D.H.N.(1960). Studies on the vegetation of Shetland.III.(Scrub in Shetland and South Uist, Outer Hebrides.) J.Ecol. 48, 73-95.

SPENCE D.H.N.(1964). The macrophytic vegetation of lochs, swamps and associated fens. In: The Vegetation of Scotland (ed.J.H.Burnett), pp.306-425. Edinburgh.

SPENCE,D.H.N.(1970). Scottish serpentine vegetation. Oikos 21, 22-31.

SPENCE,D.H.N.& MILLAR,G.A.(1953). An experimental study on the infertility of a Shetland serpentine soil. J.Ecol. 51, 333-343.

STEWART,G.C.(1962). Kergord plantations, Shetland. Forestry 35, 35-36.

TALLIS,J.H.(1964). Some studies on Southern Pennine peats.II. The pattern of erosion.J.Ecol. 52, 333-344.

TALLIS,J.H.(1969).The blanket bog vegetation of the Berwyn Mountains,North Wales.J.Ecol. 57, 765-787.

TANSLEY,A.G.(1939). The British Isles and their vegetation. Cambridge.

TATE,R.(1966).Upon the flora of Shetland. J.Bot. 4, 2-15.

TRAIL,J.W.H.(1906). The flora of Fair Isle.Ann.Scot.Nat.Hist. 57, 165-170.

TURRILL,W.B. (1928). Flora of Foula. Bot.Exch.Club.Rep. 8, 838-850.

TYLDESLEY,J.B.(1973). Long-range transmission of tree-pollen to Shetland. I.Sampling and trajectories; II. Calculation of pollen deposition, III. Frequencies over past 100 years. New Phytol. 72, 175-181; 183-190; 691-697.

VOSE,P.B., POWELL,H.G. & SPENCE,J.B.(1957). The Machair grazings of Tiree, Inner Hebrides. Trans. Bot. Soc. Edin. 37, 89-110.

WARBURG, E.F.(1963). Census catalogue of British Mosses. 3rd ed. Brit. Bryol. Soc. Ipswich.

WARD,J.H. (1962). Hierarchical grouping to optimize an objective function. J.Amer. Stat.Ass. 58, 236-244.

WARREN,A. & HARRISON,C.M. (1974). A nature conservation plan for Shetland. Discussion papers in Conservation No.7. University College, London.

WEST, W.(1912). Notes on the Flora of Shetland with some ecological observations. J.Bot. 50, 265-275; 297-306.

WESTHOFF,V. & DEN HELD,A.J.(1969). Plantengemeenschappen in Nederland. Zutphen.

WHEELER,B.D.(1975). Phytosociological studies of rich fen systems in England and Wales. PhD.thesis, Durham.

WHITTAKER,R.H.(1962). Classification of natural vegetation. Bot.Rev. 28, 1-239.

WHITTAKER R.H.(1973), (ed.). Handbook of vegetation science.V. Ordination and classification of communities. Den Haag.

WILLIAMS,W.T.& LAMBERT,J.M.(1959). Multivariate methods in plant ecology. I. Association analysis. J.Ecol. 47, 83-101.

WILLIAMS,W.T.& LAMBERT,J.M.(1960). Multivariate methods in plant ecology. II. Use of a computer for association analysis.J.Ecol.48, 689-710.

WILLIAMS,W.T.& VARLEY,Y.W.(1967). Phytosociology of some British grasslands. 1.Upland pastures in northern England.Vegetatio 15, 169-189.

WISHART,D.(1969). CLUSTAN IA. User manual. St.Andrews.

ZETLAND COUNTY COUNCIL (Z.C.C.) (1975). Shetland in statistics. Lerwick.