Phytosociological studies in the northern isles of Shetland

Anne M. Lewis

PHYTOSOCIOLOGICAL STUDIES IN THE NORTHERN ISLES OF SHETLAND

By

Anne M. Lewis
(B.Sc. Dunelm)

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The fieldwork for this project
was carried out with Judith Hilliam
who was studying the vegetation of
the southern 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.

Anne M. Lewis

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CONTENTS.

		Page No.
6.2:	General discussion	237
6.3:	Conclusions	249
6.4:	Conspectus of Associations and other main units	252
Reference	... ...	258

Volume 2. Phytosociological tables.

List of Text Figures.

Tables.

ABSTRACT.

In this thesis an attempt is made to detect, define and characterise, on the basis of their floristic composition, the principal types of vegetation occurring in the Northern Isles of Shetland.

Some 600 samples were taken from as wide a variety of vegetation types as possible, and from as many parts of the Northern Isles as possible. The data was processed using a computer assisted hand-sorting routine (which simulated traditional Zürich-Montpellier methods of analysis), leading to the production of structured species-sample tables.

Fourty-seven Groups were identified and described and compared with related units recognised from Britain and North-West Europe. Thirty-eight of the Groups were arranged into 17 Associations, of which one represents a new syntaxon. The remainder were left as noda of uncertain status. The communities were all classified into higher syntaxa essentially following the scheme used by Westhoff & Den Held (1969).

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

<u>Cakiletea maritimae</u>	Atriplicion littoralis. Open communities (of mainly annual species) of shingle beaches and strandlines.
<u>Agropyretea pungentis</u>	Honkenyo-Crambion maritimae. Open and often unstable communities of biennial or perennial species of shingle beaches and strandlines.
	Agropyrion pungentis. Perennial, generally closed communities of shingle beaches and strandlines.
<u>Ammophiletea arenariae</u>	Agropyrion boreoatlanticum. Fore-dune communities.
<u>Festuco-Brometea</u>	Mesobromion erecti. Semi-dry calcareous grasslands.
<u>Asteretea tripolii</u>	Puccinellion maritimae. Halophyte communities of the lower parts of saltmarshes.
	Armerion maritimae. Halophyte communities of the mid and upper zones of salt-marshes.
	Silenion maritimae. Cliff-top grasslands.
<u>Molinio-Arrhenatheretea</u>	Cyanosurion cristati. Communities of lowland grazed pastures and related habitats.
	Calthion. Fen meadow vegetation.
<u>Parvocaricetea</u>	Caricion davallianae. Low-growing sedge vegetation of base-rich mire.
<u>Scheuchzerietea</u>	Rhynchosporion albae. Communities of bog hollows and pools.

<u>Oxycocco-Sphagnetea</u>	Erico-Sphagnion. Bog communities.
<u>Nardo-Callunetea</u>	Violion caninae. Rough grasslands.
	Ulicion nanae. Heaths.
<u>Caricetea curvulae</u>	Arctostaphyleto-Cetrarion nivalis. Chinophobous montane grass and dwarf-shrub heaths of poor soils.
<u>Thlaspeetea rotundifolii</u>	Arenarion norvegicae. Communities of calcareous montane screes.

The new Association described is the <u>Empetrum-Rhytidiadelphus loreus</u> Association of the Erico-Sphagnion.

A short account of the occurrence and inter-relationships of these vegetation in the Northern Isles is given.

<u>Reference</u>:

Westhoff, V. and Den Held, A. J. (1969). <u>Plantengemeenschappen in Nederland</u>. Zutphen.

CONVENTIONS AND TERMS.

Species nomenclature.

Unless otherwise indicated in the text species nomenclature has followed these authorities:-

Phanerogams:	CLAPHAM, A. R., TUTIN, T. G. & WARBURG, E. F. (1962). *Flora of the British Isles*, 2nd ed. Cambridge.
	Agrostis canina ssp. *montana* is referred to as *Agrostis canina*; *Cerastium arcticum* ssp. *edmonstonii* as *Cerastium edmonstonii*, as in Palmer & Scott (1969). *Dactylorchis maculata* ssp. *ericetorum* as *Dactylorchis ericetorum* and *Tricophorum cespitosum* ssp. *germanicum* as *Trichophorum cespitosum*.
Mosses:	WARBURG, E. F. (1963). *Census Catalogue of British Mosses*, 3rd ed. Brit. Bryol. Soc., Ipswich.
Liverworts:	PATON, J. A. (1965). *Census catalogue of British Hepatics*, 4th ed. Brit. Bryol. Soc., Ipswich.
Lichens:	JAMES, P. W. (1967). *A New Check List of British Lichens*. The Lichenologist 3, 95-153.

Phytosociological tables.

In the phytosociological tables in Volume 2 the species names have been abbreviated. For each table the species have been given a reference number, and in case of confusion or ambiguity the list of the full names of the species, together with their reference numbers for the particular table involved, should be consulted.

In the releve tables the characters displayed refer to cover-abundance values.

In the text, Associations and other comparable syntaxa are underlined with a single dashed line; higher order units (Alliances and above) are underlined with a double dashed line.

ACKNOWLEDGEMENTS.

I should like to thank everyone who has helped with this project. Very special thanks are due to Judith Hilliam for days of enjoyable fieldwork in Shetland and hours of fruitful discussion. Special thanks too, to Mr. and Mrs. R. Tulloch for so much local information about the islands and also for their hospitality. It is impossible to mention everyone in Shetland by name who has helped with this project, but thanks are due to everyone who made the time in Shetland such an enjoyable experience.

In Durham, I should like to thank Dr. D. J. Bellamy, my supervisor, for all his enthusiasm, help and encouragement; Professor D. Boulter for providing the facilities for research; the staff of Durham University Library for their efficiency in tracing many obscure journals; the Reverend G. G. Graham for assisting in the determination of some of the bryophytes; Dr. M. Roberts who determined the saltmarsh algae; J. Skinner who helped with the identification of the majority of the lichens; B. Diaz who helped with some of the computing; and to Mrs. M. Creighton for her co-operation and efficiency in typing the thesis. Very special thanks are due to Dr. B. D. Wheeler of the University of Sheffield, for hours of useful discussion and guidance in the arts of phytosociology and the use of his computer programs. Thanks too are due to my parents and to P. J. Say, for their help in many small ways and much encouragement.

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C H A P T E R 1.

INTRODUCTION.

1. Introduction

1.1. Location

The Shetland archipelago positioned at Latitude 60° North consists of about 100 islands totalling some 1440 km^2 in area. The island group extends 112 km. from north to south. Zetland (the official name of the county) is the most northerly county in Britain, 169 km. from Duncansby Head in northern Scotland. The islands are on the same latitude as the southern tip of Greenland and 354 km. south-east of the Faeroes and the same distance from Bergen in west Norway (see Fig. 1.I).

This study is concerned only with the Northern Isles of Shetland, in particular Yell, Unst and Fetlar, but also including the small islands of the Sounds of Colgrave and Yell.

1.2. The aim of the project

Little has been written about the vegetation (as opposed to the flora) of Shetland and it was felt that the communities of this extreme Atlantic outlier would be of great interest and further the understanding of the vegetation of Europe. With the recent oil developments the need for a comprehensive review of the vegetation types has become increasingly important as a basis for any conservation policy and against which to assess change. It was thus

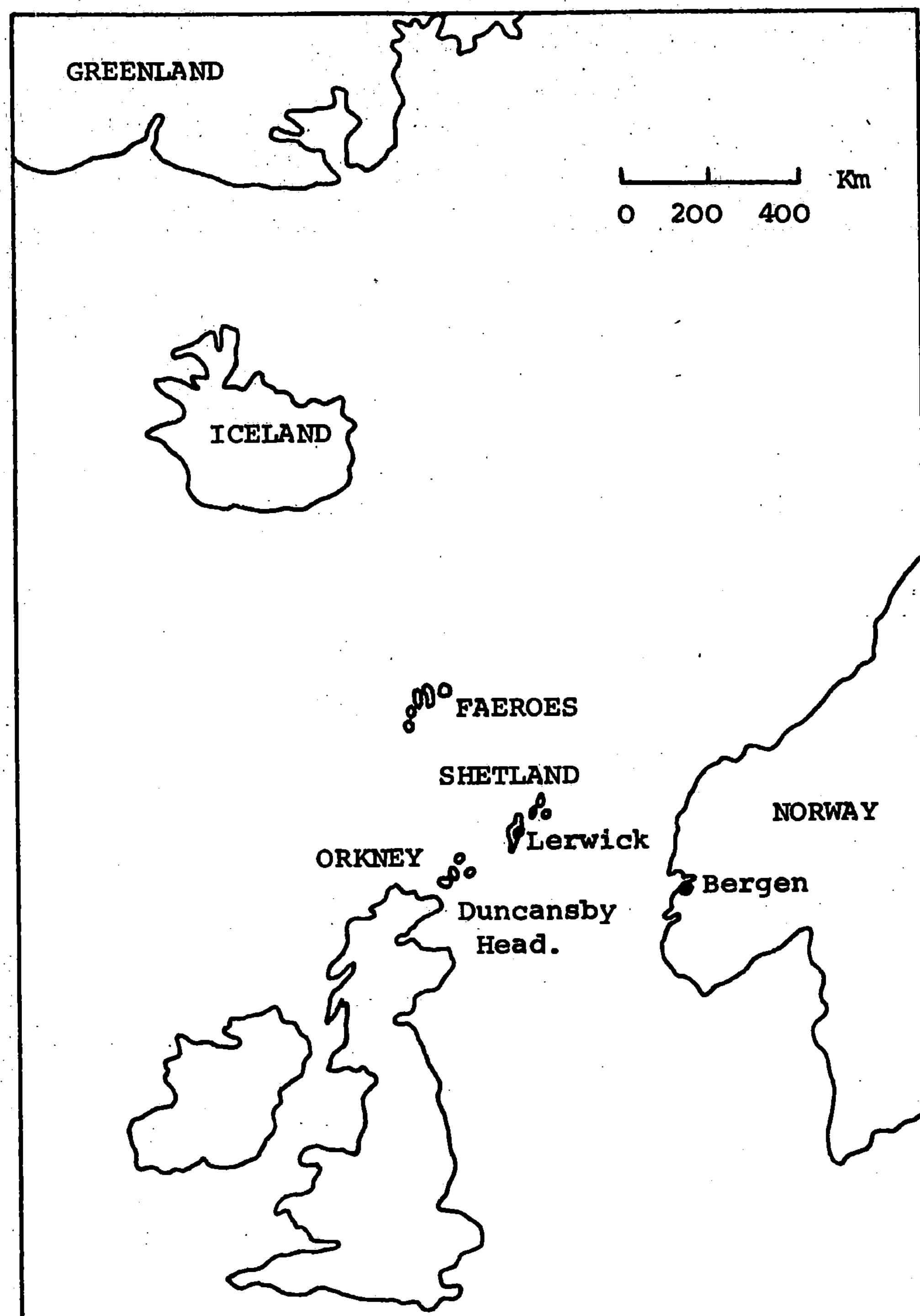


FIGURE 1.I. Map showing the location of Shetland.

felt that the time was opportune for a descriptive survey of the vegetation of the islands to be made.

The precise aim of the project may be summarised as follows: to detect, define and characterise, on the basis of floristic composition, the principal types of vegetation present in the Northern Isles.

It was recognised from the outset that it might be useful to relate the vegetational units distinguished to the system of plant classification used throughout mainland Europe (Oberdorfer, 1957; Westhoff & Den Held, 1969). It was also hoped that this survey might provide a basis upon which the extracted vegetation-types could be further described by criteria other than floristic composition.

The approach was thus essentially floristic, although samples were collected from as wide a range of habitats as possible.

In the survey no attempt was made to describe the entire vegetation of any island. However, in the future it is hoped that this work with Hilliam's from the Mainland (see Chapter 3) might form the basis of a vegetation map for the whole of Shetland.

1.3. The concept of phytosociology

The mass growth of ~~vegetation~~ plants over the earth's surface constitutes vegetation. The "science of vegetation" concerned with the social organisation of plants is phytosociology or phytocoenology, and it may be taken to mean any form of description of vegetation, although in its widest sense it must encompass the whole range of vegetational phenomena: structure, morphology and dynamics as well as the inter-relationships with the associated environment (Wheeler, 1975). A description of vegetation may be an intensive study of a restricted area or it may be an extensive study aimed at describing the inter-relationships between different samples of vegetation. This last approach is often associated with the delimitation and description of vegetation units used in classification and this corresponds with the aim of this survey.

1.3.1. The plant community

The basic unit of all vegetation is the species and thus vegetation may be regarded as an interacting system of populations of various species. The composition and distribution of the populations will be determined by their availability in the area, the ecological conditions of the site and by the mutual relations of the plants therein (i.e. competition, abundance, dominance, sociability etc.). Species - populations are not generally distributed either uniformily or randomly but instead are restricted by certain factors. The recurrence of particular combinations of species in association with one another will impart pattern to vegetation and this patterning has led to the concept of the *plant community* or *Pflanzengesellschaft* (Germ.) (Wheeler, 1975).

The plant community is a basic concept of phytosociology. However, the term is confusingly used even in the phytosociological literature to mean a "real" vegetation sample in the field and also to denote a unit of vegetation in the phytosociological sense which has been abstracted from samples of "real" vegetation or even both (Westhoff, 1951).

1.3.2. *The stand*

A *stand* of vegetation is here defined as an actual area of vegetation in the field from which a plot has been described. According to Z.M.* principles a sample must be taken from a relatively homogenous area of vegetation (see Chapter 3).

The problem of homogeneity has been examined and reviewed quite frequently in the literature (e.g. Dahl & Hadac, 1949; Poore, 1955b; Dahl, 1956; Wheeler, 1975).

occurring

Dahl & Hadac (1949) define homogeneity as being when the individuals used for the characterisation of a community are homogeneously distributed, i.e. when the possibility of finding them is the same throughout the sample area. The varying density of occurrence of different species within a stand may cause patchiness and a "*mosaic*" results which will confuse the uniformity of the stand. This problem is

*Z.M. = the Zürich-Montpellier School (see 3.1.).

fully reviewed by Wheeler (1975). However, as Poore (1962) points out it is often possible to recognise relatively homogenous or uniform stands of vegetation in which the internal variation is small compared to that between stands.

1.3.3. The phytocoenon

Phytosociologists recognise distinct vegetation-types or community-types. The phytosociological community is the phytocoenon and it may be defined as a class of aufnahmen of unspecified rank (Wheeler, 1975). These may be arranged within a hierarchical classification of vegetation and when thus formalised constitute syntaxa.

Not all workers have regarded vegetation as definite units separated by definite boundaries. Poore (1955c) and McVean & Ratcliffe (1962) amongst others, have remarked on the continuous nature of variation in vegetation. Whittaker (1962) suggests that many phytosociological tables show a continuous change of populations through a series of Associations and that the recognition of variants and facies transitional to other community-types tend to confirm this. Wheeler (1975) concludes that the difference between the two viewpoints may in fact be largely one of emphasis.

1.4. Previous work on Shetland vegetation

The first real descriptions of the vegetation of Shetland were by the young, local botanist, Thomas Edmonston in 1841. Edmonston published a first list of the "phanerogamous plants, together with the Cryptogamic Orders, Filices, Equisetaceae and Lycopodiaceae" (1841a). In a second paper (1841b) Edmonston made his first ecological observations and a brief comparison of the Shetland flora with that of Orkney. Edmonston's major work was his flora of Shetland published in 1845. Besides a species list and their localities a brief geological account of the islands was given. Qualitative differences in the flora according to the parent bedrock were noted and in particular attention was drawn to the special flora associated with serpentine. A table of the prevalent plants of the chief rock formations was included. An edited and revised version of the flora appeared in 1903 by Saxby, although really the only interesting addition was a biographical sketch of Edmonston.

In the following years many botanists have visited the islands and published their additions to Edmonston's original flora as well as their own ecological observations including Tate (1866); Craig Christie (1870); Beeby (1887; 1889; 1891; 1892; 1908; 1909) and Johnson (1927; 1928; 1929). West & West (1904) visited Mainland and Bressay recording algae of fresh water. Ostenfeld (1908) contrasts the flora of Shetland with that of the Faeroes and found 265 species common to both, 50 species peculiar to the Faeroes and 110 species to Shetland.

Druce published the Flora Zetlandica in 1922, which was a catalogue bringing together all the previous information. Brief comparisons with the Faeroese flora were made, as well as suggestions as to the origins of the present Shetland flora. This flora was updated by Druce in 1924.

Two early papers stand out as major contributions to the ecological description and classification of the vegetation of Shetland. The first is by West (1912), who visited parts of Unst and central Mainland. As well as a species list he made a number of ecological observations including the occurrence of rare arctic plants at much lower levels than usual. Some basic descriptions of plant associations were made from the Unst serpentine, the west Unst moorland, peaty marshes near Ollaberry and from Ronas Hill. A great number of lichens were identified and listed. The second by Price (1928) gives a table of the major plant communities, together with some general observations.

It was apparently 25 years until the next paper concerning Shetland vegetation was published. A series of papers by Spence published between 1957 and 1970 forms the main basis of present information on the vegetation of Shetland and these are summarised in Spence (1974). In the first (1957) wind and air-temperature as factors in the Shetland environment were described and an analysis of pattern and process on the serpentine debris vegetation of Unst was made. Habitat, floristic and phytogeographical resemblances of the serpentine debris to Faeroese and Icelandic fell field were established for the first time. In the second (1958) results were published of a frequency analysis of the vegetation of Unst in relation to the geology. Composite lists for mica-schists, gneisses, serpentines and greenstones were included as well as a summary of the communities of Unst hill-land. Causes of the restriction of some rarer species to certain types of open ground on Unst serpentine were analysed (Spence, 1959) and in 1963 (Spence & Millar) an experimental study of the chemical causes of the infertility of this soil, implicating phosphorus deficiency, was published. A paper in 1960 described fragments of tall-herb and associated scrub vegetation in some cliff and island sites and the macrophytic vegetation of certain freshwater lochs and associated swamps were described in Spence (1964). The Unst fellfield vegetation was related in Spence (1970) to that on Ronas Hill and elsewhere in north and west Scotland and abroad. Descriptions and floristic lists of grass-heaths, mires and crevice vegetation on Shetland and other Scottish serpentines, and of related _Rhacomitrium_-rich heaths on debris were included. Subarctic debris and scrub vegetation was again reviewed in Spence (1974).

Various accounts of the flora of Foula have been published starting with Turrill's account (1928). Much more recent accounts include Messenger & Urquhart (1959), Hawksworth (1969) and the Brathay report (1971), in which Allot gave a general description of the distribution of the lowland vegetation and Barkham gives a detailed account of the upland vegetation with comparisons with the Associations of McVean & Ratcliffe (1962).

There are a few papers relating to lower plants. In 1954 Dennis & Gray published a first list of fungi for Shetland, together with some notes on their habitats. Accounts of some lichens and their distributions are in Hawksworth (1961; 1966) and Duncan (1961). A good list of bryophytes from Foula appeared in Hawksworth (1968) and Paton published a Hepatic flora/of Shetland/in 1972.

A detailed description of the Kergord plantation is in Stewart (1962) and the trial plantations in Mainland are described in Neustein (1964). Several accounts of the peat deposits in Shetland have been published including Lewis (1911) and Birks & Ransom (1969). More recently an excellent check-list of the flowering plants and ferns of the Shetland Isles has been produced by Palmer & Scott (1969) as a synopsis of a new flora to be published. The check-list has been most useful in this survey. A total of 681 species, sub-species, hybrids and varieties are included.

The only real phytosociological accounts from Shetland (apart from the Foula report) are the descriptions of the Sullom and Baltasound areas by Birse (1973) and Birse & Robertson (1973) respectively, the general report by Goode (1974) and the account of Shetland sea-cliff vegetation by Goldsmith (1975). Further details from these papers are in Chapter 5. As well as the papers by Goode and Spence the Nature Conservancy Council report on the natural environment of Shetland (1974) includes accounts of Shetland habitats (Johnson), the bioclimatic characteristics of Shetland (Birse), the marine vegetation (Irvine), and an account of the freshwater ecology (Britton).

CHAPTER 2.

Environmental background.

2. Environmental background

In this chapter a brief account of some of the physical factors affecting Shetland is given, as well as an outline of the land use of the islands.

2.1. Climate

The northerly latitude of Shetland and the influence of the sea are perhaps the most important factors in determining the climate of the islands. Shetland lies directly in the path of the North Atlantic depressions, which sweep in from the west particularly in winter. The days are often cool, moist and windy with little sunshine, especially in winter. However, high pressure over Scandinavia generally brings dry, bright weather with winds from the east or south-east, and these fine spells may last for some days at anytime of the year (Nicolson, 1972).

The majority of meterological records have been collected at the Lerwick Observatory, although a few are available from Unst. Altitude does have important local effects on the climate and the observatory at an altitude of 82 m. is perhaps more exposed than much of lowland parts of the islands.

2.1.1. Wind

Wind is practically a constant feature of the climate and as a result the vegetation may be seriously stunted.

The figures are high even during the five "calmest" months of the growing season (Spence, 1957). The average wind speed recorded at Lerwick is more than 29 km.p.h. There are winds of moderate strength for at least 40% of the year (Senior & Swan, 1972) and gales are recorded, on average, 58 days in every year (Nicolson, 1972). Apart from the Butt of Lewis, Shetland is the windiest place in the British Isles and at 249 m. the mean annual wind speed is already four-fifths that of the summit of Ben Nevis at 1343 m. (Spence, 1957; Nicolson, 1972).

2.1.2. Salt spray

Associated directly with the wind is salt spray. No part of Shetland is much more than 5 km. from the sea and spray can be carried this distance even in summer. This salt deposition was measured at the Observatory and it was found that the most exposed continental station on the Norwegian coast hardly collected as much salt in one year as Lerwick did in one month, January 1958 (Oddie, 1959).

2.1.3. Temperature

The average temperature figures for the year show no extremes (see Table 2.1). The summers are cool with lower temperatures than those recorded further south. Spence (1957) has shown that mean monthly temperatures during the growing season (conventionally 5.6°C and over) from April to late September, are equivalent to those at 359-762 m. in the

TABLE 2.1.

Monthly and annual averages of air temperature.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Av.
LERWICK													
(1931-1960)	3.1	2.9	3.9	5.5	7.8	10.0	12.0	12.2	10.7	8.2	5.9	4.4	7.3
Height 82 m.													
BALTASOUND													
(1931-1947)	3.5	3.5	4.5	6.2	8.3	10.5	12.5	12.6	11.0	8.6	6.3	4.8	7.7
(1953-1960)													
Height 24 m.													

Source: Meteorological Office reproduced in Senior & Swan (1972).

Central Highlands. He records the climate from sea level to 305 m. as submontane - oceanic and above that, at least in the summer, as subarctic - oceanic. The relatively high winter temperatures (see Table 2.1) reflect the maritime influence. The Gulf Stream continues past Shetland as the North Atlantic Drift bringing warm water to a group of small islands and in conjunction with this the winds off the sea are relatively warm in winter.

2.1.4. Day-length

Associated with the northerly latitude of the islands, greater day-length, as compared with Central Scotland, rises to a maximum of 13% in June but any beneficial effect is much outweighed by the adverse features of the climate. Mist and cloud reduce the average mean percentage of possible bright sunshine to a very low amount, 20-25%, despite the long daylight hours (Stewart, 1962). Between May and September only 670 hours of sunshine are recorded which is 100 hours less than the total recorded for many places in the Inner Moray Firth.

2.1.5. Snow

The high mean temperatures during the winter months and the infrequency of very cold conditions means that despite its northerly position, Shetland does not experience as much frost and snow as the mainland of Scotland. There is snow on 40 days per year on average, but because of the maritime situation it seldom lies for more than 20 days per year (Nicolson, 1972).

2.1.6. Rainfall

Rainfall in Shetland is not excessive (see Table 2.2) and this is, in part, due to the low relief of the island group. The average annual record for Lerwick is about 1000 mm. (40") and 1140 mm. (45") at Baltasound. The highest records are for the area around Ronas Hill, where the annual average is 1270 mm. (50"). The rainfall is well spread through the year with an annual average of 248 rainy days at Lerwick. January and December are the wettest months (see Table 2.2) but even in the driest months of May and June there is still an average of 50.8 mm./ month.

2.1.7. Relative humidity

The relative humidity figures are high. The average mean is 80 to 85% which is higher than anywhere else in Britain and this falls to 75-80% only from April to June (Neustein, 1964). In summer there is a high incidence of cloud cover, as well as frequent fogs. Thunderstorms are rare - an average occurrence of only 3 days/year.

TABLE 2.2

Monthly and annual averages of precipitation (mm.) (1916-1950)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Av.
LERWICK Height 82 m.	114.8	84	78.5	68.8	55.9	53.9	64.3	70.1	95.3	112.8	117.6	112.8	1028.4
BALTASOUND Height 9m.	125.0	98.6	93.5	75.2	60.7	65.3	67.3	73.2	102.9	121.2	130.3	128.3	1141.2

Source: Meteorological Office in Senior & Swan (1972).

2.1.8. Bioclimatic sub-regions

Using thermal zonation as well as moisture balance and oceanicity, Birse (1971) has drawn up bioclimatic sub-regions for Scotland so that the vegetation and soils of an area can be related to the climatic type without direct reference to latitudes and altitude (details of calculations of these in Birse, 1971). This system is extended to Shetland and fully described in Birse (1974). Briefly, Shetland falls within the bounds of four thermal sub-zones. The southern boreal sub-zone (to which the submontane-oceanic zone of Spence (1957) approximately corresponds, see Section 2.1.3), extends to an estimated altitude of 45 m. The limits of the thermal sub-zones are very approximate since exposure plays as important a part as altitude. The lower limit of the orohemiarctic (sub-alpine) sub-zone is put at 150 m. under very exposed conditions which are the most widespread in Shetland. This boundary is more clear since there are corresponding changes in the vegetation. *Carex bigelowii* enters the communities and the blanket bog community *Erico-Sphagnetum magellanici* Moore 68. is replaced by the upland blanket bog type the *Vaccinio-Ericetum tetralicis* Moore 62 (see Chapter 5). The upper oroboreal sub-zone lies between the southern boreal and the orohemiarctic sub-zones but it is often very narrow and indistinguishable from the southern boreal as regards vegetation and soils. One differentiating feature may be that land in this sub-zone is above the limit where cereals can be grown, even for grassfeed. The full oroarctic or alpine zone is only reached on Ronas Hill. As regards moisture all of Shetland falls within the hyperoceanic sub-sector, so that the influence of oceanicity can only be established by comparison with the mainland of Scotland. The greater tendency for peat to be formed than on the mainland can be attributed to the degree of oceanicity (Birse, 1974).

2.2. Geology and Topography

2.2.1. Introduction

Much of the Shetland landscape reflects the character and structure of the underlying rocks. For such a small area the geology is remarkably complicated and a wide variety of rock types occur.

During the Caledonian Orogeny large areas of rock, mainly of sedimentary origin were metamorphosed and intruded by igneous rocks and these form a large part of the islands. Sedimentary and volcanic rocks laid down and folded in the later parts of this Orogeny are also important (Mykura, 1974).

Mykura (1974) divides Shetland into two geologically distinct parts by the Walls Boundary Fault. All the area of the Northern Isles lies east of this fault and the gently rounded north/south trending ridges reflect the underlying metamorphic rock. Only the serpentine and metagabbro areas of Unst and Fetlar have no consistent trends but a landscape characterised by rounded crags and weathering crags of serpentinite. To the west of the fault much more diverse rocks give rise to a more rugged topography with no such distinct trends.

Sixty percent of the land in the islands lies beneath the 250' contour (76.2 m.) (Senior & Swan, 1972). Apart from the south and west parts of Mainland the most extensive lowland and gently undulating country is in the Northern Isles. However, although much of the land is not high many slopes are steep and the land is frequently deeply dissected. Ronas Hill is the highest point in the archipelago (453 m.). It is an area of intrusive igneous rocks in the North Mainland.

2.2.2. Drainage

The relatively high rainfall, low evaporation and generally impermeable rocks in the islands has led to a highly developed surface drainage network (Britton, 1974). There are hundreds of lochs of various sizes ranging from the Loch of Cliff in Unst which is the largest freshwater loch in Shetland, to numerous tiny pools. There are abundant small streams but no rivers.

2.2.3. Glaciation

During the Pleistocene Period Shetland experienced several phases of glaciation by local glaciers and the western margins of the Scandinavian ice cap and this considerably modified the landscape (Small, 1969). It was responsible for the rounding of the topography as well as widening and deepening valleys and voes (long narrow sea inlets). Channels between islands were deepened and many of the lochs now occupy basins scooped out during this period. A blanket of boulder clay was left over much of the lowground.

2.2.4. The coastline

The most characteristic feature of Shetland is its incredibly involuted and varied coastline. The estimated land area of Shetland is about 1440 km^2. The shortest coastline, a single island of this area could have had ~~been~~ is about 135 km long but the actual coastline of Shetland is about 1450 km long (Flinn, 1974). No place in the islands is more than 5 km. from the sea.

Flinn (1974) describes a very old "outer coast" of cliffs plunging to a depth of 80 m. created over millions of years by marine erosion immediately off-shore. This represents the limit of the islands as a feature of the continental shelf and marks the final break of slope at the foot of the partly submerged Shetland hills. This forms less than one-third of Shetland's coast. The remainder, the "Inner Coast" (Flinn, 1974), is more characteristic of sheltered areas in inlets and amongst the islands and is only a few thousand years old, resulting from submergence of the islands only since the Ice Age and the subsequent marine erosion of the drowned land. Gently sloping cliffs are characteristic of this inner coast as are numerous boulder, pebble, gravel, sand or peat beaches. Accumulations of beach material occur as spits, bars, ayres and tombolos (Flinn, 1974). These are most common in the voes sticking out from their sides. In time these features may grow to form a barrier across the voe and eventually a freshwater lake may result. Some of these, in time fill in and become dry land.

Further evidence that Shetland has been drowned fairly recently and is probably still sinking is that peat is often found on the beaches, although it is sometimes covered by a thin layer of gravel. A specimen of peat from a depth of 9 m. beneath the sea off Whalsay has been dated as 5,500 years old (Hoppe, 1965). As the top layer was probably stripped off when the peat was drowned it is probable that in the last 5,500 years Shetland has sunk 9 m. at the very least relative to sea level.

2.2.5. The geology and topography of the Northern Isles

In this section a brief account of the geology and topography of each island in the Northern Isles group will be given (see also Fig. 2.1).

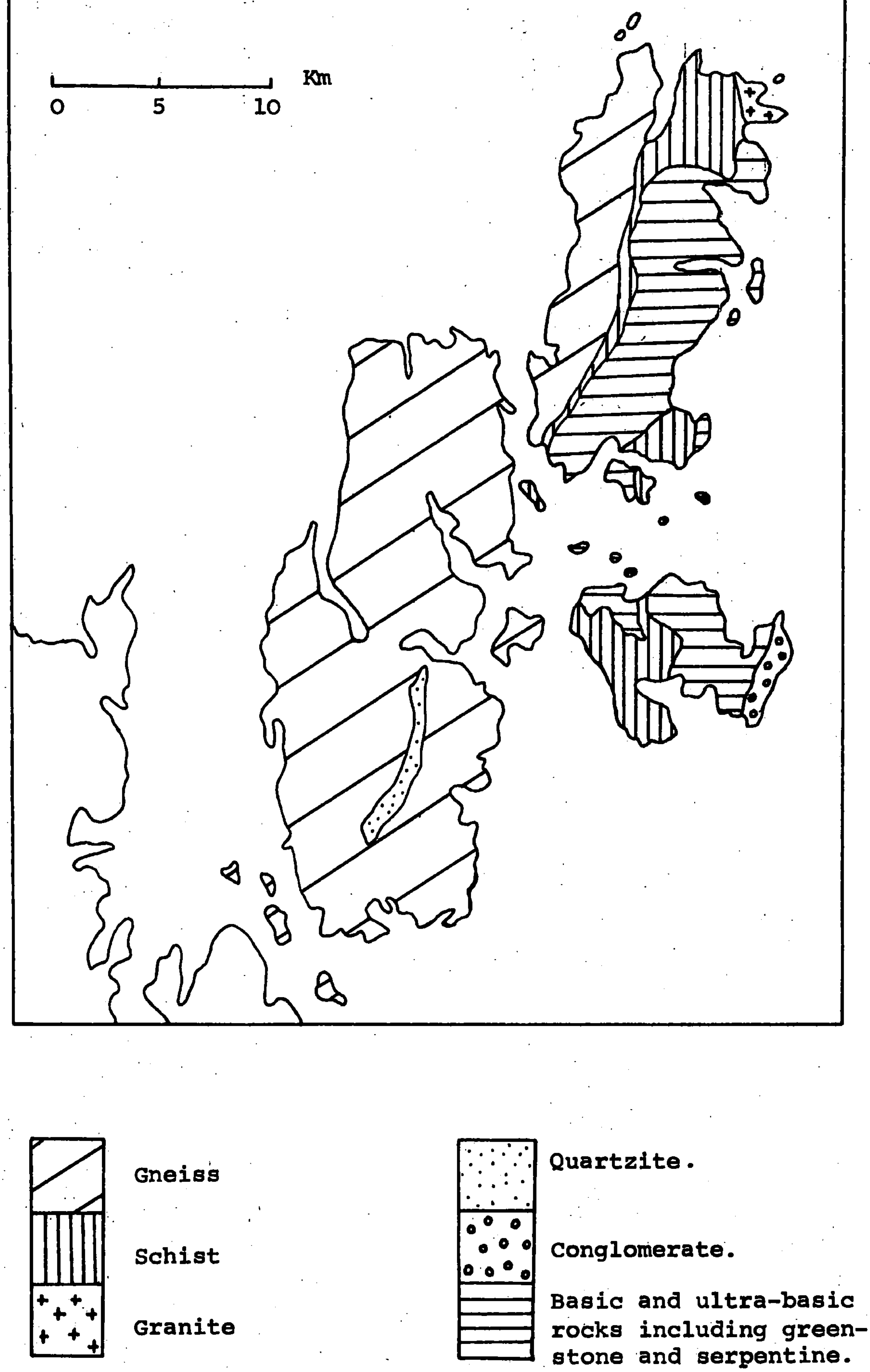
2.2.5.1. Yell

Yell is the largest island of the Northern Isles group, some 215 km^2 in extent, 27 km. long and 11 km. wide at its broadest part. It is separated from the Mainland of Shetland by the Yell Sound.

The geology is relatively simple; predominantly gneiss with some thick bands of quartzite (Mykura, 1974). The only sizeable area of quartzite is between the Hill of Reafirth and the Hill of Arisdale. These metamorphic rocks form a series of gently rounded hills and ridges with a characteristic north/south trend. The highest point is the Ward of Otterswick (205 m.). Over two-thirds of Yell is covered by a blanket of peat of average depth 1.52 m. The Geological Drift Map (1968) shows alluvial deposits beside a few streams and there are small outcrops of boulder clay around Basta Voe, Mid Yell Voe, Whale Firth, Arisdale and Colvister and much larger deposits in the area around Burravoe and West Sandwick. The highest cliffs are along the exposed northwest coast, although low cliffs separate the numerous wicks and voes of the south-west and east coasts.

The desolate central part of Yell as well as the north-

FIGURE 2.I. Simplified geological map of the Northern Isles.



west part is now uninhabited. The majority of the 1,147 population (1971 census) is concentrated along the more hospitable, lower, and more fertile parts of the coastline, particularly along the east coast.

Storm beaches with blown sand are at Breckin, Greenbank, Vatsetter, Copister and West Sandwick, but only at Breckin and West Sandwick are there any real dune systems. There are various tombolos and other depositional features such as at the Ness of Galtagarth and Ness of Sound. The loch at Gutcher is one cut off by the growth of a spit.

2.2.5.2. Kay Holm

This is a very small island (less than 4 ha.) lying in Mid Yell Voe to the south of Kaywick. The island is all below 15 m. and fairly flat. The bedrock is gneiss and is covered by a layer of peat, apart from rocky outcrops around the coastline. There is a boulder beach and a tiny sand beach.

2.2.5.3. Hascosay

This island is in the Colgrave Sound between Yell and Fetlar. Like Yell, the bedrock is gneiss and the majority of the island is covered by blanket peat apart from rocky outcrops at the coast and patches of boulder clay at Housa Wick. There are several sandy and boulder beaches including blown sand at Housa Wick. The island is much larger than Kay Holm, about 1.5 km. wide and up to 2.4 km. in length.

The coastal and central parts of the island are below 15 m. but in the south and north the land rises gently to about 20 m. and is drained by a series of small lochs and streams radiating out to the coast.

2.2.5.4. Fetlar

This is the third largest island of the Northern Isles some 39 km^2 in extent, an average of 5-6 km. in length and about 9 km. wide. It lies to the east of Yell and south of Unst and has thus always been somewhat of an outlier being separate from the main north/south island chain.

The name Fetlar is derived from the Old Norse meaning "fat land" and even today the island is known as the "garden of Shetland" (Thorne, 1974). Much of the croftland is fertile and there is good grazing. This reflects the geology which is different and more complicated than that in Yell. A fairly detailed geological account is given by the B.G.E.S. (Report, 1967) and only a brief summary is given here taken mainly from this account. The western part of the island consists of a low anticlinal axis of schists giving rise to high ground in the peninsula of Lam Hoga and some high cliffs around its coast. The eastern part of the island is of a unique schistose conglomerate. At this coast is a complex series of deep narrow geos with huge stacks out at sea. Over much of the central part of the island gabbro overlies the schists and the majority of this has been metamorphosed to the serpentine form. The highest point on the island, Vord Hill, 59 m., is in this area. Along the north coast are a series of high serpentine cliffs known as the East Neap with associated stacks and natural arches. The cliffs are between 76 m. and 100 m. in height. Much of the island is covered by drift deposited during and after the Pleistocene Ice Age. The valley between Stackaberg and Hamara field is a typical "U" shaped glaciated valley. There are numerous sandy and pebble beaches. At Papil Water there is a large area of sand with a few stable dunes.

Peat of any depth is only found on the Lam Hoga peninsula, West Gallow Hill, The Mires of Oddsetter and a small area around Brough Lodge. A series of lochs and streams drain from the central higher parts of the island to the coast, and as on Yell alluvial deposits are marked on the Geological Drift Map beside some of the larger streams.

The population of about 100 is all centred along the south and east coasts, although not on the Lam Hoga peninsula. Abandoned crofts are to be found in the northern parts.

2.2.5.5. Small islands of the Colgrave Sound

There are several small, interesting, now uninhabited islands in the Colgrave Sound between Yell, Fetlar and Unst.

Most of these have been visited and some sampled. They are all between 4 ha. and 6 ha. in extent, gently undulating and low-lying (mostly under 15 m.). A brief geological description of each follows.

2.2.5.5.1. Daaey

This island lies to the north-east of Urie Ness, Fetlar. The bedrock is the intrusive igneous rock, gabbro but there is a blanket of peat over the top of the island and outcrops of bedrock or mineral soil are only found by the immediate coast.

2.2.5.5.2. Urie Lingey

Similarly, this island is basic gabbro with a peat cap.

2.2.5.5.3. Sound Gruney

The island is about 5.26 ha. in extent and along the rocky shoreline boulders of the bedrock, serpentine, collect in small bays. There is no peat on the island but there is a small area of drift in the central dip of the island.

2.2.5.5.4. Haaf Gruney

This island, which is a National Nature Reserve, is also of serpentine with some drift deposits occurring.

2.2.5.5.5. Wedder Holm

Wedder Holm lies to the south-east of Uyea. The bedrock is schist, an extension of the Muness/Uyea block.

2.2.5.5.6. Linga

Linga lies at the south end of the Blue Mull Sound between the southern tip of Unst and Gutcher, Yell. It is a larger island, over 1.6 km. in length. The bedrock is schist with a very small area of limestone in the extreme south-east. Nearly all the island is covered by blanket peat. This island is to be inhabited again.

2.2.5.6. Yell Sound islands - Brother Isle, Uynarey, Bigga, Samphrey

Of this group of islands lying between the south of Yell and Mainland in the Yell Sound, only Samphrey has been visited. Apparently, geologically they are very similar. The bedrock is gneiss and the majority of each island is peat-covered. At the southern tip of each island a small deposit of drift is marked on the Geological Drift Map and in Samphrey there is another outcrop at the eastern tip of the island, at Bunglan. The islands are now all uninhabited. The highest point of each island is about 30 m., although Brother Isle is only 15 m. The coastline of each is rocky with low cliffs and small bays with boulder or sandy beaches.

2.2.5.7. Unst.

Apart from the Muckle Flugga lighthouse, which lies to the north of Hermaness, Unst is the northernmost inhabited island of the British Isles. It is approximately 19 km. long by some 8 km. wide, 122 km^2 in extent and the second largest island of the Northern Isles. Except in the south-west, Unst is a moderately hilly island rising to a maximum of 286 m. in Saxa Vord in the north, but its extremely irregular outline ensures that only two small areas in the centre of the island area are more than 2.4 km. from the sea. The geology is complicated (see Fig. 2.1). However, several detailed accounts have been given (Read, 1936; Spence, 1958; Wheeler, 1964) and the following brief description is drawn from these.

The predominant north/south grain of the hills indicates the effects of the Caledonian Movements as in Yell. The tectonic history of Unst has produced seven main structural blocks. The Valla Field ridge dominates the block of gneisses, which forms the western part of Unst and runs north for about 11 km. to culminate in Hermaness Hill (200 m.). The average height of the ridge is 152 m. and much of it is blanketed by peat. The gneisses are bound to the east by the Saxa Vord block of limestones and schists which for most of its length forms a narrow valley running north/south from Burrafirth to Belmont (including a series of lochs) but in the north the zone broadens and rises to the highest point of Saxa Vord. The Skaw granite block forms the north-east tip of Unst and gives an impressive cliffed coastline. Most of the south-east peninsula of the island is formed by a belt of schists (Muness Phyllite). Except for the sea cliffs and some of the steepest slopes much of the schist exposures and parts of the granite block are covered in deep blanket peat. Between Haroldswick and Uyeasound lies the rolling countryside of the serpentine and greenstone block. There is no peat accumulation on these ultrabasic and basic rocks but there are large areas of exposed rock and rock debris. The highest points are all under 152 m. There are some lochs and a series of streams draining the area. A fault separates the Clibberswick serpentine block from the main serpentine block and greenstone and serpentine also outcrop at the extreme eastern tip of the Muness peninsula.

Alluvium deposits are found beside some of the larger streams and boulder clay outcrops, particularly in the south around Uyeasound and also at Sandwick and as a band between the schist and serpentine blocks of the Muness peninsula. A narrow strip of boulder clay lies between the impressive sea cliffs and hill slope between Lund Wick and Wood Wick on the west coast. There are a few boulder beaches (for example at Haroldswick), shingle at Baltasound and sandy beaches at Burrafirth, Norwick, Skaw, Sandwick and Lund. The local population is increased by a small R.A.F. station. The main settlement areas are Norwick, Haroldswick, Baltasound and Uyeasound. There are other scattered crofts along the north-east coasts and the Muness peninsula as well as at Westing on the west coast. The large majority of the island is, however, uninhabited.

2.2.5.8. Balta and Huney

These are two greenstone islands lying to the east of Unst at the mouth of Balta Sound. Balta is the larger of the two, about 94 ha. and Huney much smaller, 23 ha. There are large areas of blown sand and small areas of drift on both islands.

2.2.5.9. Uyea

This is quite a large island, about 2 km. wide and 1.6 km. long and 243 ha. in extent. Geologically, it represents an extension of the southern tip of Unst with a serpentine block in the west and the Muness phyllites to the east. The eastern part of the island is covered with boulder clay apart from a stormbeach of blown sand at the south-east tip.

2.3. Soils

These are described briefly in Chapter 5 in conjunction with the discussion of the various vegetation types. Soils in Shetland have not been surveyed in detail and because of the complex geology it is difficult to generalise about them. The soils of the Sullom and Baltasound areas were described briefly by Birse and Birse & Robertson (1973) respectively, in the descriptions of the vegetation of those areas. Senior & Swan (1972) suggest that most of the soils were derived from glacial deposits, although in some areas they were derived from the underlying rock. These latter types tend to be thin and acidic, although on Unst and Fetlar extensive areas of soils derived from basic serpentine and greenstone rocks are quite fertile. The glacial deposits and soils derived from them tend to be very variable in their location, depth and composition. In the main, they occur as small coastal patches and are usually intensively farmed. The most fertile soils tend to be in the Mainland of Shetland, in the south and on the limestone of the Tingwall Valley. There are small areas of machair and particularly on the small islands fertility is increased by guano. Peat (mainly of the blanket bog type) now covers a considerable part of Shetland and forms an almost unbroken blanket over Yell, western Unst and also large parts of central and western Mainland. Much land which would normally be quite fertile because of glacial till or limestone bedrock, is now covered by waterlogged peat of varying depths.

2.4. Land use

The population of Shetland at the time of the 1971 census was 17,327, of which less than 3000 live in the Northern Isles. The county town of Lerwick is in the Mainland.

There are not even any true villages in the Northern Isles. Crofts, the traditional agricultural units with about 2-4 hectares of arable land and right of grazing in the common hill land or scattald, are grouped together in townships of varying size and separated from neighbouring settlements by several miles of hill and moorland. New houses tend to be built around these existing settlements rather than as completely isolated units. The main settlements are shown in Fig. 3.1. Despite a long history of depopulation, the population of Shetland is now rising and with the recent oil developments will probably continue to do so.

The proportion of the population involved in the traditional occupations of fishing and crofting has ~~have~~ declined over the last fifty years with the growth of service industries. However, agriculture is still important. From Sections 2.2. and 2.3. it will be apparent that the most fertile areas where arable crops are grown tend to be around the coast, whilst much of the rest of the islands is scattald. Individual statistics for the Northern Isles are not available but for Shetland as a whole in June 1969, the 142569 hectares of land occupied by either crops, grass or rough grazings were distributed as follows:-

95% (135076 ha.) rough grazings (including 77212 hectares contained in 93 common grazings or scattalds).

4% (5947 ha.) grassland.

1% (1550 ha.) tillage crops (including oats, potatoes, turnips, swedes).

Scattald thus accounts for 50% of the total agricultural land (Senior & Swan, 1972).

Sheep farming is most important with a summer total of 260,000 ewes and lambs for Shetland (Nicolson, 1972). Even the smallest uninhabited islands are stocked with sheep. Cattle stocks are tending to increase now with a 1970 total of 7,033 including 1,135 dairy cattle. Shetland ponies are still important particularly in Unst and Fetlar. Poultry and pigs are kept but are relatively unimportant. In recent years government grants have helped to encourage reclaimation of parts of the scattald by draining, liming, fertilising and surface seeding to give good pasture.

The scattald does not undergo a regular burning regime. Peat cutting for fuel in scattald areas is important and there are vast deposits of peat particularly in Yell. A rough estimate of 203 million tonnes of raw peat or 16 million tonnes of peat solids was made for Yell (Nicolson, 1972). Severe erosion results in areas which are over cut or where the top sod is not properly replaced.

Shetland is virtually devoid of trees. In the Northern Isles they are restricted to sheltered walled gardens and a very few cliff sites. The only large area of woodland is a plantation of about 3.5 hectares at Kergord in the Mainland of Shetland planted between 1909 and 1921.

Despite the variety of minerals occurring in Shetland mining and quarrying are unimportant. This is mainly because few occur in quantities sufficient to make extraction economical. Stone for roads is crushed in Yell and Unst and some talc is still mined in Unst.

In the Mainland of Shetland some land has recently been used for oil related developments. As yet, the Northern Isles are unaffected, although suggestions for developments at both the head of Basta Voe and Baltasound have been made.

CHAPTER 3.

METHODS.

3. Methods

In this Chapter the methods of this survey are described.

3.1. Introduction

A phytosociological project of this kind could be approached using a number of different methods. These various approaches have developed over years of general interest in vegetation description in many parts of the world and are adequately summarised in the literature (e.g. Whittaker, 1962; Shimwell, 1971) and need not be restated here.

This survey has been based on the methods and concepts of the Zürich-Montpellier School (so named after the two centres in which it originated). It is sometimes also referred to as the Braun-Blanquet School after Professor J. Braun-Blanquet, who developed the ideas and methods of this system of vegetation description and classification (Braun-Blanquet, 1921; 1928).

Since its foundation the School has developed a very comprehensive system of phytosociology, details of which are given by Ellenberg (1956), Becking (1957), Moore (1962), Whittaker (1962), Braun-Blanquet (1964), Shimwell (1971), Westhoff & Maarel (1973) etc. Despite criticisms of the methods (e.g. Poore, 1955a,b,c; 1956a) the system has been successfully adopted, particularly in recent years to describe British vegetation (e.g. O'Sullivan, 1965; Ivimey-Cook & Proctor, 1966; Shimwell, 1968; Bridgewater, 1970; Birks, 1973; Jones, 1973; Wheeler, 1975).

The results have been analysed using traditional methods with the aid of a digital computer.

3.2. Methods used.

Wheeler (1975) recognises five stages in a descriptive phytosociological survey:

1. Selection of the vegetational parameters that are to be used for description.
2. Sampling of vegetation.
3. Comparison of samples.
4. Extraction of vegetation units.
5. Characterisation and systematisation of the units.

An excellent review follows of the many ideas and methods in the literature relating to each of these steps and thus this account will be limited to the actual methods used in this survey using the above stages as a framework.

3.2.1. Sampling procedures

Collecting samples, representative of the vegetation at a given site, is the basis to any phytosociological survey. Thus, sampling must be efficient and useful for the project in mind.

Site selection

For the first summer's fieldwork (1973) an essentially objective approach to site selection was attempted. In conjunction with J. Hilliam 300 sites were chosen using randomly selected map coordinates. As all types of vegetation were to be sampled it was felt that this would be a useful method of locating sites all over Shetland and, hopefully, representative of the vegetation. Each of the 300 Grid References were considered as 1 hectare plots to be sampled as described below.

This method proved to form a useful basis to the survey since the sites were well distributed over the islands. However, in the two following field seasons a subjective approach was adopted. The objective location of sites was rejected for a number of reasons:

1. The vast majority of sites fell on blanket bog - as would be expected in islands where this is the predominant vegetation. After collecting many samples from bog communities in the first field season, it was felt that too many obvious and interesting vegetation types were being omitted by random sampling and that the survey would be more useful if some of the smaller areas of different types of vegetation were selected subjectively and sampled.

2. The actual location of the sites in the field was difficult and possibly often inaccurate. Much of the land

in the Northern Isles lacks good landmarks and thus the random coordinates were difficult to find in the field and location was time-consuming.

3. In addition, sites were often several miles apart and frequently a long way from the road or other points of easy access, and thus again the method was thought to be too time-consuming and, therefore, inefficient.

4. A few sites fell on small islands which are not always easily accessible. The small islands are interesting and it was felt best to visit as many as possible whenever the opportunity arose, ignoring whether they were "marked" or not.

It is interesting that Moore _et al_. (1970) had previously made similar conclusions in their study. Wheeler (1975) favoured a subjective sampling strategy as the only feasible method of visiting a large number of sites in a period of three years.

Subjective sampling

In order to record a wider selection of communities in the summer months of 1974 and 1975, ten major vegetation types which had been seen were listed and an attempt was made to take samples of each from areas of gneiss, schist, quartzite, granite, serpentine and greenstone, the major bedrock types in the Northern Isles, and to visit as many parts of the Northern Isles as possible.

The ten vegetation types were:-

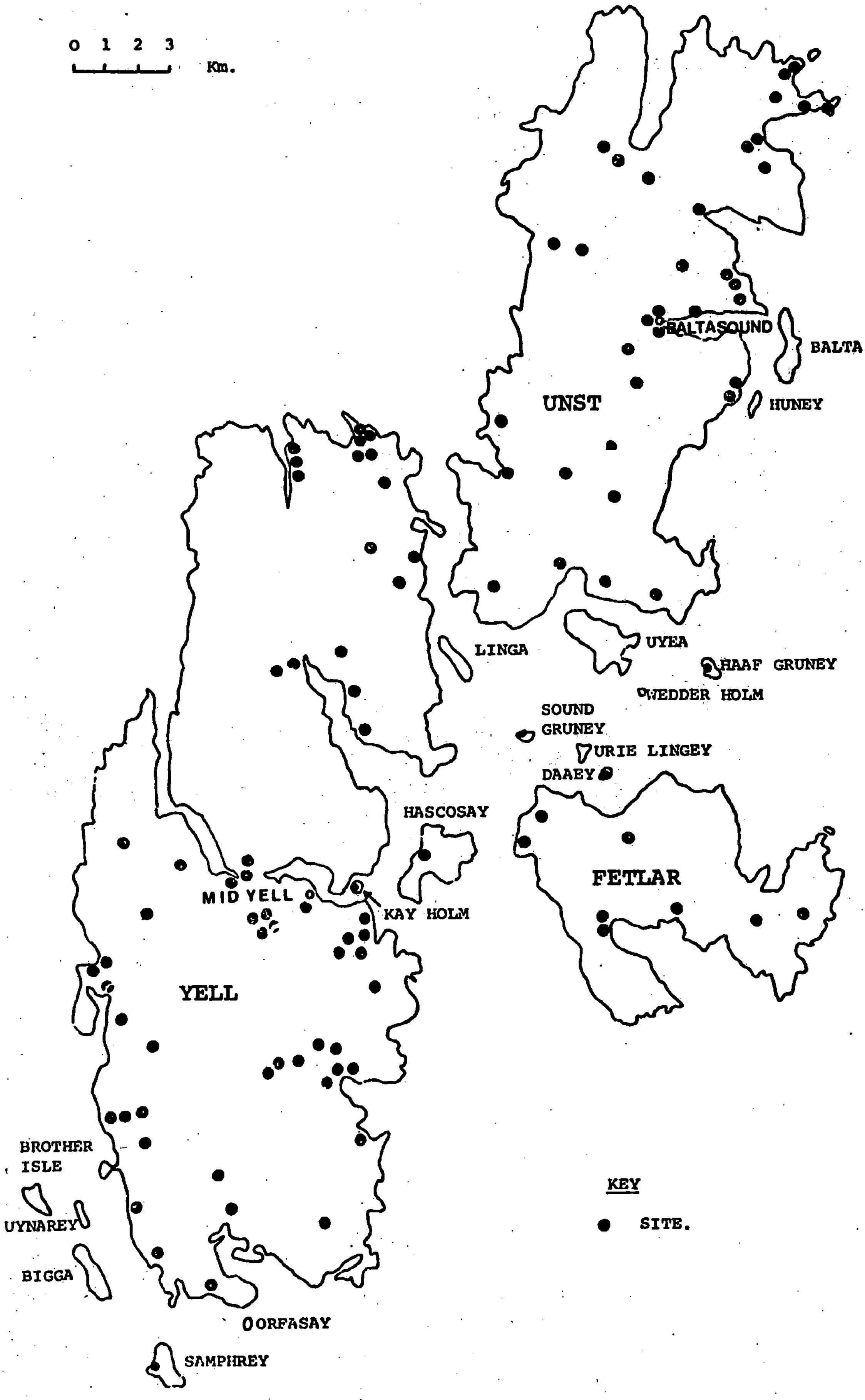
1. Blanket bog.
2. Heath.
3. Grassland.
4. Wet meadow.
5. Saltmarsh.
6. Sand dune.
7. Shingle and boulder beaches.
8. Road-side communities.
9. Streamside communities.
10. Disturbed communities, e.g. areas of old peat cutting etc.

As well as help from Geological Maps and Ordnance Survey maps, much help in locating appropriate sites was given by local people. Once again, an area of 1 hectare was usually sampled, although at particularly interesting sites or where the full expression of the vegetation type was over a larger (or smaller) area the size of the sampling area was adjusted. The sites which were sampled for this survey are shown in Fig. 3.I.

3.2.2. <u>Stand selection at a given site</u>.

At each site samples were taken which represented the full expression of vegetation within the hectare area. Despite the objections to such subjective sampling it seems

FIGURE 3.I. Distribution of sites sampled in the Northern Isles.



that as long as certain criteria are observed it is the most efficient method. Moore et al. (1970) randomly sampled a saltmarsh area and compared the results with those collected using traditional sampling techniques at the same time and found very little difference between them. Many other vegetation surveys by Z.M. workers have been conducted using such subjective sampling and Becking (1957) suggests this may be one of the main reasons for the success of the system, yet it must also be recognised that it is potentially open to more serious criticism than perhaps any other aspect of the system.

Criteria for stand selection.

1. The samples taken must be representative of the different developments of vegetation at a given site. Ellenberg (1956) stresses the need for a thorough reconnaisance of the area before beginning to sample. In an area of about 1 hectare this is feasible and not too time-consuming.

2. The size of the plot must be large enough to show the full expression of the stand, but not too big so as to encroach on a second community. Traditionally a minimal area determination is made (for details see Braun-Blanquet, 1964). In practice, however, it seems that often species-area curves are not asymptotic and there are substantial problems in an exact determination of the "minimal" area of a stand (Hopkins, 1955). Nevertheless, as a rough estimate

the concept of minimal area is apparently useful.

Basically the size of the plot is successively increased until few new species are recorded. A species-area curve can be drawn and this will flatten off at the appropriate size.

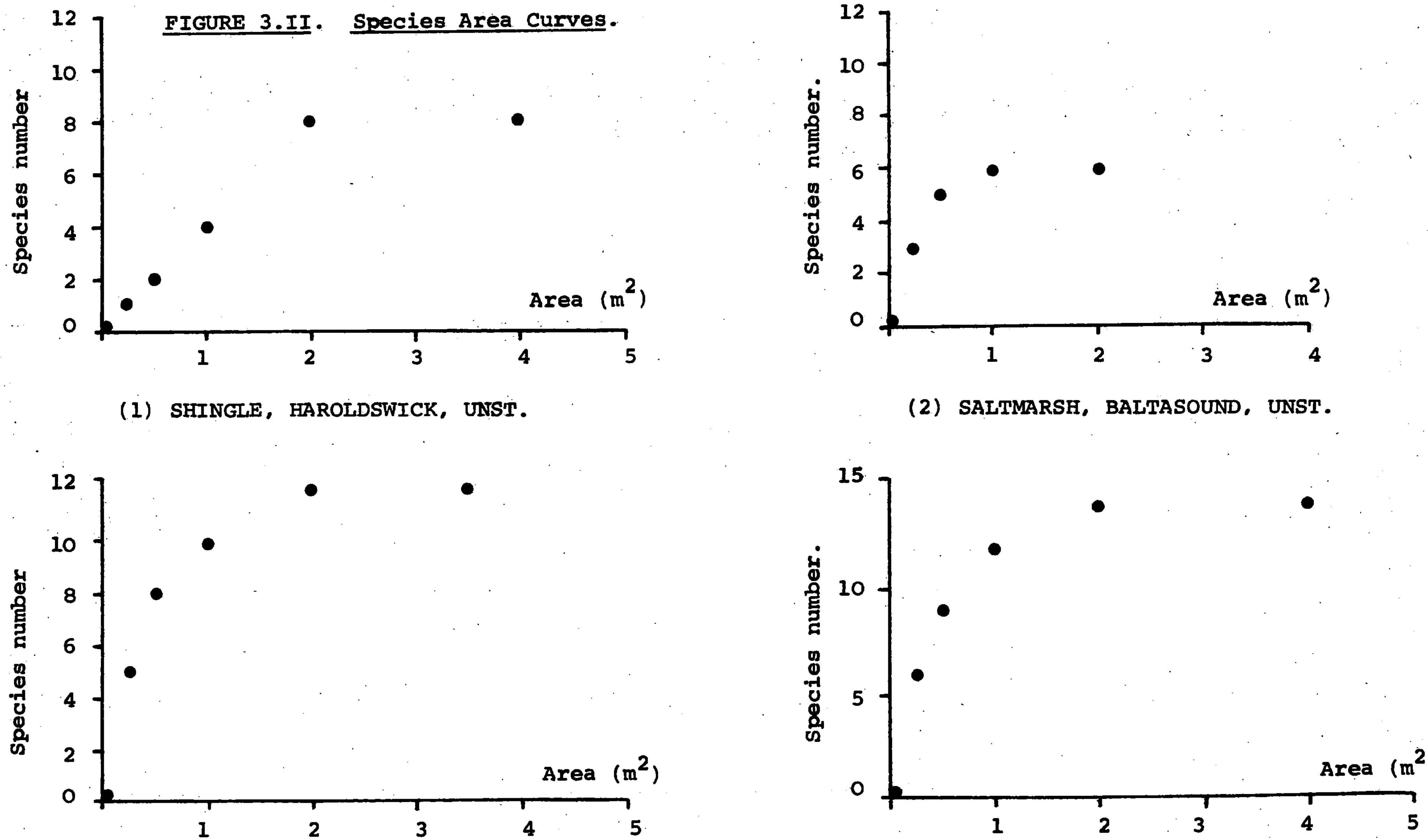
Fig. 3.II gives seven examples of species-area curves made from shingle, saltmarsh, sand dune, grassland, wet meadow, heath and blanket bog. These suggest a minimal area of about 4 square metres for all these types of vegetation except saltmarsh, for which 2 square metres is suitable. This was usually arranged as a square or rectangular quadrat.

3. Uniform stands of vegetation must be chosen for subjective sampling to be successful. The problems of "uniformity" are discussed by Wheeler (1975) and particularly in areas with vegetational mosaics these are quite difficult to resolve. In "hummock" and "hollow" vegetation in blanket-bog most usually two samples were taken, particularly if a different species complement was obvious. Patches formed by local dominance of a particular species were not sampled separately, unless certain additional species were obviously associated with them, or there was an obvious habitat factor difference.

3.2.3. Sample records

Field recording was done with J. Hilliam, who was working on the Mainland of Shetland. This proved to be more

FIGURE 3.II. Species Area Curves.

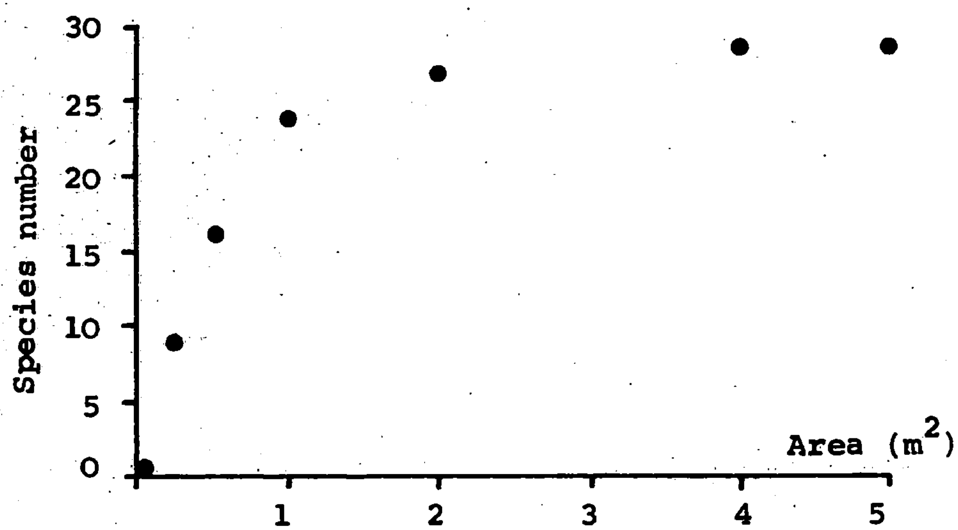


(1) SHINGLE, HAROLDSWICK, UNST.

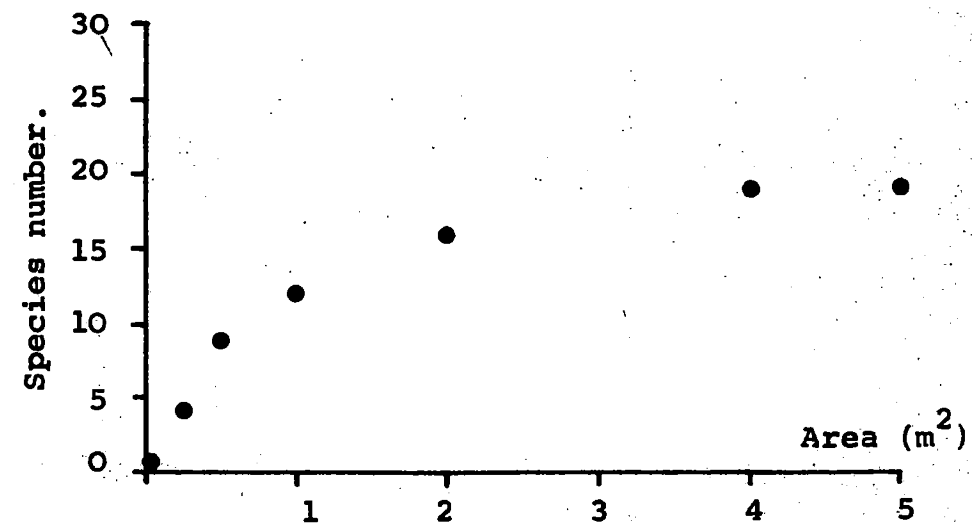
(2) SALTMARSH, BALTASOUND, UNST.

(3) SAND DUNE, WEST SANDWICK, YELL.

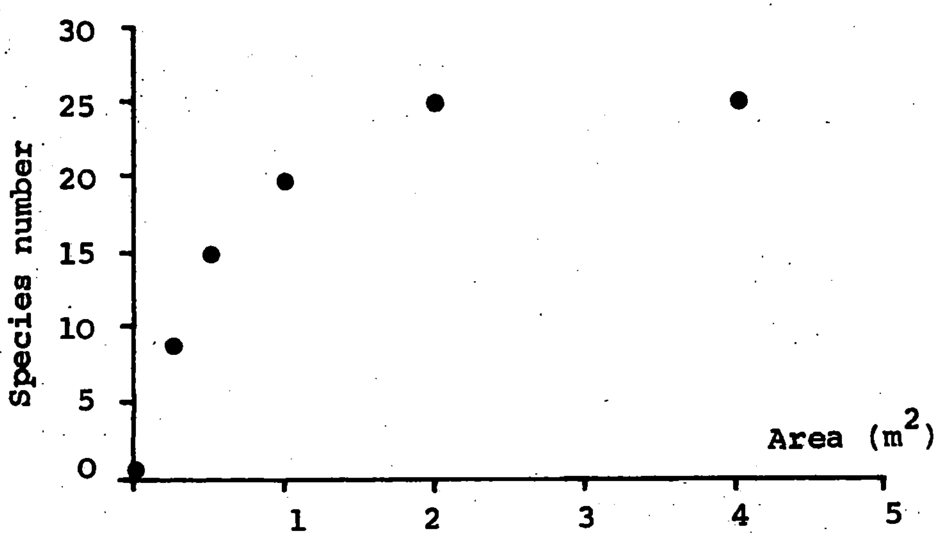
(4) WET MEADOW, MID YELL, YELL.



(5) GRASSLAND, UYEASOUND, UNST.



(6) BLANKET BOG, VATSETTER, YELL.



(6) HEATH, MUCKLEHEOG, UNST.

FIGURE 3.II. (continued)

thorough, more efficient, more enjoyable and more economical as far as transport was concerned.

The standard sampling unit in Z.M. practice is the Aufnahme (German) or relevé (French). A list of species present in the plot is made and additional characteristics of the vegetation and habitat are recorded (see Fig. 3.III; also, Ellenberg, 1956; Braun-Blanquet, 1964; Westhoff & Maarel, 1973).

The sample records were made on record cards printed for this survey. An example is shown in Fig. 3.III.

Species present

In each stand all the phanerogams, bryophytes, lichens and algae (if present) were recorded. Any species which could not be definitely accurately named in the field was collected for subsequent determination. This mainly applied to the algae and some bryophytes. *Carex* species in vegetative form only, presented some problems at first. Non-flowering examples of *Euphrasia* were only referred to genus, although flowering specimens were sent to Dr. P. F. Yeo in Cambridge for identification. Non-flowering specimens of *Hieracium* were usually tentatively referred to as the species recorded for that area by W. Scott (Scott, pers. comm. and Palmer & Scott, 1969). *Lophocolea bidentata* and *L. cuspidata* were not distinguished. All records were assigned to *L. cuspidata*, the most frequent species (Paton, 1972).

FIGURE 3.III. Example of recording card (reduced).

(a) Front.

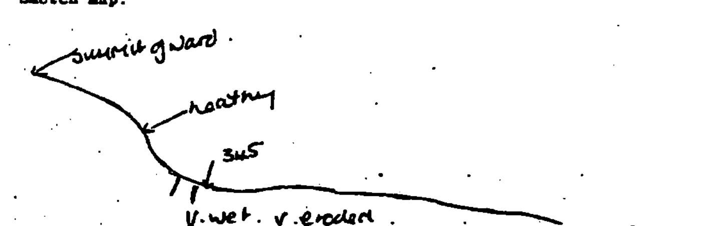
University of Durham.	SHETLAND SURVEY.	Card No. 345
Date. 9.9.73	Locality. WARD OF OTTERSWICK SITE 3.	
Site No. M4019	Ref. No. ⊙	Grid Ref. HU509958

Site Descr. A relatively flat wet area below the steep gentle main hill. Main drainage channel the hill cuts through. Also many deep erosion channels in [illegible]	Area. 2m².	Cover.
	Alt. 107m	Moss 50%
	Aspect. N.E.	Herb 40%
	Slope. 5°	Shrub 10%
Comm. size. Area btw. erosion channels	Veg. type.	Adj. comms.

Comm. Descr. Eriop. / Empetrum / Hylocomium dominated patch above the erosion channels. Fairly flat and extending only a few sq. m. before next channel.

Land use: present. light grazing - sheep.	Soil (parent mat. & text.). Gneiss. Deep peat. Top layer little humified with a lot of Sphagnum.	Sample.
Land use: past. - - -	H_2O level & flow. Very wet. No flow. V. near surface. pH. 4.5	

Sketch map.



(b) Reverse.

Calluna vulgaris	2	1	Hylocomium splendens	2	1	
Empetrum nigrum	1	1	Pleurozium schreberi	2	1	
Eriophorum angust.	2	1	Rhytidiadelphus loreus	1	1	
Juncus squarrosus	+		Hypnum cup. ericetorum	+		
Sieglingia decumbens	+		Lophozia ventricosa	+		
			Sphagnum auriculatum	+		
			" papillosum	+		
			" plumulosum	1	2	
			Cladonia furcata	+		

A few species may have been missed in samples taken at the beginning of the field season. However, the majority of Shetland species would be present in some form between June and September (the months when this survey was undertaken). Ranunculus ficaria is a vernal species which may have been missed.

Hybrids and sub-species were generally not distinguished.

Cover and vegetational records

Brief notes on the structure of the vegetation in each sample were made. Total cover and height of each layer was recorded as well as the cover of each species. The following scale was used for species cover:-

Cover value used.

+ scarce, less than 1%, cover small.

1 1-20%.

2 20-40%.

3 40-60%.

4 60-80%.

5 80-100%.

Any additional species recorded from the community outside the plot were recorded as " - ".

An estimate of sociability of each species was made following Braun-Blanquet (1964).

Sociability values used.

Sociability 1 - plants growing singly within plot.

Sociability 2 - plants grouped or tufted.

" 3 - plants in small patches or cushions.

" 4 - plants in small colonies, in extensive patches, or forming carpets.

" 5 - ± pure populations or great crowds.

These "cover-abundance" scales are obviously imprecise and must be subjectively assessed by the worker. However, they may be quickly recorded and are useful in later description of the vegetation units.

Environmental information.

This information was not to be used in defining the vegetation units, but useful in description of the vegetation types. Features of the plot noted were slope, aspect, nature of the substratum, hydrology , pH, as well as the general features of the surrounding topography and the use of the land.

3.2.4. Extraction of the units of vegetation.

The various methods available for the comparison of stands and detection and extraction of units of vegetation have been discussed by Wheeler (1975), and only comments appurtenant to the methods used in this survey are given here.

As Wheeler describes, raw data may be incorporated into a primary matrix or raw table where columns represent individuals (samples; aufnahmen), and the rows represent the attributes (species) which define them. The intersections contain information (qualitative or quantitative) relating to the occurrence of each species in a given sample. The percentage occurrence of a given species in the data set represents its degree of presence. If the samples are of equivalent size this is referred to as <u>constancy</u> and may be expressed in the terms of percentage class.

Class.	Percentage range.
I	1-20
II	21-40
III	41-60
IV	61-80
V	81-100

3.2.5. <u>Classification by re-arrangement of the raw table</u>

Re-arrangement of the primary matrix to provide "clusters" is the traditional Z.M. method of sorting the raw data set. The positions of rows and columns are re-ordered to reveal "blocks" of correlated species which may be used to define groups of aufnahmen. The technique is subjective and may be difficult at first without the help of a more experienced phytosociologist. Full details of the method are given by Ellenberg (1956), Shimwell (1971) and Westhoff & Maarel (1973), and summarised by Wheeler (1975).

Samples and species are simultaneously classified and the end-point is a <u>differentiated table</u>, in which the contained vegetation units are displayed together with their characterising species.

Such sorting is traditionally by hand and is thus extremely time-consuming and laborious, as well as error-prone. Thus, in this survey the Z.M. table method was used but with the aid of the digital computer.

<u>The Zürich-Montpellier table method using the computer</u>.

Initially the raw data ~~was~~ were left split up into the 10 types discussed in 3.2.1.

The sample data ~~was~~ were arranged according to the "Dublin" format (Moore, 1971) using the same format as specified by Ceska & Roemer (1971) (Wheeler, 1975). For this, only the cover-values of species can be recorded. Program SHUFFLE (Wheeler, 1974) was used, which allows rapid and error-free re-ordering and re-writing of the species-sample matrix. Essentially, it just represents a mechanisation of the traditional Z.M. processes, using the computer as an automatic typewriter.

The 10 tables so produced were examined and it was found that the data of the roadside, streamside and disturbed communities could equally well be redistributed amonst the other 7 tables. It was decided to display pool data and base-rich flush data separately which makes a total of 9 tables, all of which are included in Volume 2.

In traditional Association Tables of the Z.M. School species characteristic of the higher syntaxa are identified. This was not attempted since it was felt that the species-groups identified gave a very clear picture of the structuring of the tables.

In addition, many of the character species of the various syntaxa which have been cited by previous workers, are absent from the Shetland flora.

All the various vegetation units in each table were given temporary "Group" names based upon the most prominent, constant or diagnostic species. These Groups form the basic descriptive units of Chapter 5.

3.2.6. Units of vegetation.

The floristic characterisation of vegetation units. Vegetation units may be defined in terms of their floristic composition.

The characteristic species combination of a syntaxon consists of constant companions, differential species and character species and these are the three types of species used by the Z.M. School to define a unit.

Constant species are species which occur in 81-100% (i.e. constancy Class V) of the aufnahmen of a given vegetational unit.

Differential species ('Differentialart'; 'Trennart') are species with marked affinities to particular vegetational units and may be used to differentiate between them.

Character species ('Charakterart'; 'Kennart') are rather special differential species of narrow sociological amplitude which are more or less restricted to specific vegetation units.

Three categories of character species can be recognised according to their degree of faithfulness to a particular syntaxon (Braun-Blanquet, 1964):-

Exclusive taxa: Fidelity 5; Completely or almost completely restricted to one vegetation unit.

Selective taxa: Fidelity 4; Distinct preference for one vegetation unit but accurring also with a low degree of presence in others.

Preferential taxa: Fidelity 3; in several vegetation units but optimally developed in one.

The faithfulness of a given species to a community-type can only be assessed when data relating to all, or most, of the vegetation of a given area is available. Traditionally, character species have formed an important part of Z.M. methodology, although it seems likely that absolute character species are practically non-existent (Mueller-Dumbois & Ellenberg, 1973) - occurring only as highly specialised plants of extreme habitats, or as endemics or rare species of low presence within their vegetation unit, and thus of limited diagnostic value.

This is because many species have only a limited geographical range and thus a species may only be valid in the particular area where the unit was originally described. Also, the sociological affinities of many species seem to vary with geographical regions. Attempts have been made to accommodate this by the erection of geographical categories of character species (Becking, 1957).

Other possibilities for the floristic characterisation of vegetation units have been explored. For example, Westhoff & Den Held (1969) use "kencombinatie" or combinations of character species which are exclusive to a particular vegetational unit, although none of the individual species need be.

Other means of floristic characterisation are reviewed by Wheeler (1975).

Types of Units.

The Z.M. system is a hierarchical classification in which the Association is the basic unit.

Association: An abstract floristic unit defined by its characteristic species combination. Associations may be fused into higher units or sub-divided into lower units.

Traditionally, a suffix is attached to the name of a unit to show its rank:-

Class	-	etea.
Order	-	etalia.
Alliance	-	ion.
Association	-	etum.
Sub-Association	-	etosum.
Variant		
Sub-Variant	-	no ending.
Facies		

Units above the Association are defined by character species and in general they do possess character species of high fidelity (Westhoff & Maarel, 1973), and normally correspond to well-defined ecological categories.

Differential species distinguish sub-units below the Association, apart from the facies which is characterised by the dominance of a particular species.

Other terms referring to vegetational units in this survey are:-

Nodum: An abstract unit of unspecified rank (Poore, 1955a).

"typicum" or "typical": term used to designate species-poor groups of lower-order units with no differential species of their own.

"inops": (= having a shortage of) term used by Westhoff & Den Held (1969) to refer to species-poor groupings.

3.2.7. Syntaxonomic work.

An attempt has been made to refer the Groups apparent after analysis to pre-existing units previously described by British and Continental phytosociologists.

When a Group obviously fits an established unit it has been assigned to it. Frequently, however, the exact phytosociological relationships of the Group were unclear and the Groups have been left as noda with *ad hoc* names which can identify them until further work clarifies their exact phytosociological position. Rarely, a new unit has been established but only when there is sufficient data available to be certain this is correct and that the vegetation does not merely represent a geographical variant of a previously described unit.

The arrangement of Associations into higher order syntaxa essentially follows the schemes of Oberdorfer *et al*. (1967) and Westhoff & Den Held (1969).

CHAPTER 4.

SYNTAXONOMIC CATEGORIES USED IN THE CLASSIFICATION OF VEGETATION FROM THE NORTHERN ISLES.

4. Syntaxonomic categories used in the classification of vegetation from the Northern Isles.

Introduction

A comprehensive syntaxonomic scheme has been formulated, mainly by continental phytosociologists, in which to order and classify plant communities. The scheme is a hierarchical classification in which the basic units of vegetation (Associations) are grouped into higher order syntaxa - Alliances, Orders and Classes in ascending sequence. Apart from distinctive floristic units these categories generally refer to distinct structural and physiognomic types and frequently to specific habitat conditions. The exact status of a syntaxon is not always clear and the precise meaning of it may be interpreted by different workers in different ways. Various syntaxonomic schemes have evolved over the years and thus naming of a specific unit of vegetation is sometimes difficult.

In this section a brief account of the various higher syntaxa encountered in this survey and which will be referred to in the following sections, is given. In the main, the classification adopted by Westhoff & Den Held (1969) has been followed. In the references to characteristic species of the various syntaxa those species occurring in Shetland are marked. Many of the species have been encountered in this survey but other records are from Palmer & Scott (1969) (flowering plants and ferns); Paton (1972) (Hepatics);

Warburg (1963) (bryophytes).

4.1. Class: CAKILETEA MARITIMAE R. Tx. et Preising 50.

These are open communities of annual halonitrophile species of strand lines and coastal jetsam (Shimwell, 1971). Such communities are found throughout Europe and atlantic North America along sea-shores, estuaries and in salt marshes.

Characteristic species:

The communities are exceptionally species-poor and as a result there are not true Class characters. In the Netherlands Westhoff & Den Held (1969) suggest *Atriplex hastata* as a weak character species.

Gehu & Gehu (1969) describe three Orders in the Class: the *Euphorbietalia peplis* Tx. 50, the *Cakiletalia maritimae* Tx. ap. Oberd. 49 and the *Thero-Suaedetalia* Br.-Bl. & De Bolos 57 em. Beeftink 62. Only the *Cakiletalia* has been recorded from the Northern Isles.

4.1.1. Order: CAKILETALIA MARITIMAE Tx. apud Oberd. 49

The Order encompasses pioneer communities of the sea-shore which may often be covered with sand. The communities are on damp to fairly dry ground above the tide-line and the principal species are phanerogams and brown seaweeds. The Order is found in Europe from North Norway and the Baltic to the West Coast of France.

Character species:

For North-West Europe at least Westhoff & Den Held (1969) suggest:-

Cakile maritima

Salsola kali var. polysarca

Cakile maritima is recorded in Shetland from a number of beaches.

Two Alliances are recognised within the Order. These are the Atriplicion littoralis (Nordh. 40 p.p) Tx. 50 and the Salsolo-Honkenyion peploidis Tx. 50, which was called the Salsolo-Minuartion peploidis. Only the Atriplicion littoralis had definitely been recorded from the Northern Isles.

4.1.1.1. Alliance: ATRIPLICION LITTORALIS (Nordh. 40 p.p.) Tx. 50.

This is the Alliance of strandline communities developed on piles of organic material occasionally mixed with blown sand. The Alliance is widespread - along the West Coast of Europe from north Norway to the north of France and even into eastern Europe.

Character species:

Gehu & Gehu (1969) suggest:-

Atriplex littoralis

A. hastata

and Westhoff & Den Held (1969) add Tripleurospermum maritimum. Atriplex littoralis is not a Shetland species.

4.2. Class: AGROPYRETEA PUNGENTIS GEHU et GEHU 69.

Synon: Artemisietea vulgaris Tx. & Prsg. 50 p.p.
Plantaginetea maioris Tx. & Prsg. 50 p.p.
Cakiletea maritimae Tx. & Prsg. 50 p.p.

Within this Class are perennial communities of the halonitrophile strand boundary zone which are most frequently found in exposed situations (Shimwell, 1971). Such communities are found along the Atlantic and Mediterranean coasts. The Class was created by Gehu & Gehu (1969) to accommodate communities previously placed in the Agropyro-Rumicion crispi Nordh. 40 of the Plantaginetea maioris and in the Convolvulion sepii Tx. 47 ap. Oberd. 49 of the Artemisetea vulgaris, but which showed allegiance also to the Cakiletea maritimae because of the presence of certain halonitrophile species. The associations were perennial communities and so could not be satisfactorily accommodated in the Cakiletea, which is a Class of often unstable communities with mainly annual species.

Characteristic species:

Gehu & Gehu (1969) suggest:-

Agropyron pungens

Agropyron acutum

Crambe maritima

Suaeda vera

As differential species from the Plantaginetea and the Artemisietea the following are listed:-

Species of the Cakiletalia:

Atriplex hastata var. salina +

Atriplex littoralis

Cakile maritima +

and certain biennials or perennials:

Beta vulgaris ssp. perennis

Lavatera arborea

Those species marked + have been recorded in Shetland. (N.B. Varieties were not distinguished). The Class is divided into two Orders: the Honkenyo-Crambetalia maritimae Gehu & Gehu 1969, and the Agropyretalia pungentis Gehu & Gehu 1969. Both have been described from the Northern Isles.

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

This essentially an Order of the North-Atlantic and the Baltic. Only one Alliance is recognised within the Order and this is the Honkenyo-Crambion maritimae Gehu & Gehu 1969.

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

This Alliance is found along semi-protected to quite exposed coasts. The communities are open and fairly simple and composed of halonitrophilic biennials and perennials. The communities are often not very stable. The substratum may be coarse sand or pebbles mixed with abundant organic material.

Characteristic species:

Gehu & Gehu (1969) list:-

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

Those species marked + are recorded from Shetland.

4.2.2. Order: AGROPYRETALIA PUNGENTIS GEHU et GEHU 69.

The distribution of this Order is in Mediterranean and Atlantic regions. The Order encompasses the vegetation of closed well-stratified communities above the level of 4.2.1. The substratum is diverse but generally enriched with organic matter. There is one Alliance within the Order and this is the Agropyrion pungentis Gehu & Gehu 1969.

4.2.2.1. Alliance: AGROPYRION PUNGENTIS GEHU et GEHU 69.

Since there is only one Alliance the characteristics of the Alliance are as the Order.

Characteristic species:

Gehu and Gehu (1969) list:

Agropyron pungens
Agropyron acutum
Suaeda vera
Lepidium latifolium

None are Shetland species.

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

In this Class are grouped the communities of embryonic and mobile dunes from the Mediterranean and Atlantic coasts of Europe.

Characteristic species:

Agropyron junceiforme	Eryngium maritimum
Ammophila arenaria	Euphorbia paralias
Calystegia soldanella	

Agropyron and Ammophila are recorded from Shetland.

A new division of the Class into three Orders was proposed by Gehu & Gehu (1969). The three Orders they suggested were the Elymo-Ammophiletalia arenariae Gehu & Gehu 1969, the Euphorbio-Ammophiletalia Arenariae Gehu & Gehu 1969 and the Ammophiletalia arundinaceae (Br.-Bl. 33) Tx. & Oberd. 58. Only the Elymo-Ammophiletalia was encountered in Shetland.

4.3.1. Order: ELYMO-AMMOPHILETALIA ARENARIAE GEHU & GEHU 69.

Synon: Elymetalia arenarii Br.-Bl. & Tx. 43 p.p.

The distribution of this Order of young dune vegetation is essentially Nordic and Baltic extending to the French Channel coast.

Characteristic species:

Those proposed by Gehu & Gehu for the Order were:-

Ammophila arenaria +
Agropyron junceiforme ssp. boreoatlanticum +
Calamagrostis baltica

As differential species from the other two Orders the following were suggested:-

Elymus arenarius +
Lathyrus maritimus +

Those species marked + have been recorded in Shetland, although subspecies were not identified.

The Order was subdivided into two Alliances: the Agropyrion boreoatlanticum Gehu & Gehu 69, and the Ammophilion borealis Tx. 55 p.p. em. Gehu & Gehu 69. The Northern Isles vegetation was tentatively assigned to the Agropyrion boreoatlanticum.

4.3.1.1. Alliance: AGROPYRION BOREOATLANTICUM GEHU & GEHU 69.

Synon: Agropyro-Honkenyion peploidis Tx. 55 p.p.

Communities of this Alliance represent the first in the sand dune sequence which may still very occasionally be immersed briefly by the sea.

Characteristic species:

Agropyron junceiforme ssp. boreoatlanticum is the only characteristic species of the Alliance listed by Gehu & Gehu (1969), and Elymus arenarius is given as a differential. However, the exact status of this last species is uncertain since it is also listed with Lathyrus maritimus as a differential of the Ammophilion.

4.4. Class: FESTUCO-BROMETEA Br.-Bl. et Tx. 43 em. Tx. 61.

Dry, anthropogenic, base-rich grasslands are placed in this Class (Shimwell, 1971a). Details of the distribution of the Class and of related Classes are given by Shimwell (1971a). Most of the species-rich grasslands on calcareous soils in central and western Europe can be referred to this Class.

There are two Orders of the Festuco-Brometea in central and western Europe. One, the Festucetalia vallesiacae Br.-Bl. & Tx. 43 is absent from Britain. The other is the Brometalia erecti Br.-Bl. 36.

4.4.1. Order: BROMETALIA ERECTI Br.-Bl. 36.

Dry and semi-dry anthropogenic grasslands on base-rich soils with a little humic material are placed in this Order. These grasslands are referred to as "sub-Mediterranean and sub-Atlantic" (Westhoff & Den Held, 1969), but in fact extend through south and east England to the Atlantic coasts of Wales and Ireland. In western Europe the distribution of the Order is much the same as the Class, from the Mediterranean region and the Alps to south Scandinavia and northern England (Shimwell, 1971a).

Grasslands within this Order are characteristically dominated by coarse grasses such as Bromus erectus, Festuca ovina and Helictotrichon pratense and hemicrytophytic herbs such as Plantago lanceolata and Ranunculus bulbosus (Shimwell, 1971a).

Character species:

Since the Order is the only one represented in Britain the character species for the Class and Order are the same. From Shimwell's survey of British calcareous grassland (1968) the following character species for the Class and Order are suggested in Shimwell (1971a):-

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

Only those species marked + have been recorded in Shetland.

Two Alliances are recognised in the Order. The Bromion erecti Br.-Bl. (1925) 36. encompasses the open, dry, thermophilous, chiefly primary, communities of rocky limestone ground with a centre of distribution in central and southern Europe. In the British Isles it is restricted to a small number of localities in Somerset and Devon (Shimwell, 1971a). The second Alliance, and the only one described here is the Mesobromion erecti Br.-Bl. & Moor 38 em. Oberd. 49.

4.4.1.1. Alliance: MESOBROMION ERECTI Br.-Bl. & MOOR 38 em. Oberd. 49.

This Alliance contains most of the British chalk and limestone grassland communities, as well as some communities of stabilised, calcareous dune systems. In comparison with

Bromion communities these closed communities are semi-dry, secondary in nature, more mesophilous and contain many species which can tolerate a damper local climate and the pressures of grazing (Shimwell, 1971b).

The soils are moderately dry, loamy and vary from chalk-containing to chalk-rich or base-rich (Westhoff & Den Held, 1969).

The Alliance has its optimal development in the sub-Mediterranean regions but it extends also into sub-Atlantic and Atlantic zones and, thus, reaches from southern Scandinavia to Spain, as well as into England and Ireland (Westhoff & Den Held, 1969). In the northern part of its range its occurrence is usually limited to warm places such as south-facing slopes, river valleys and sand dunes.

Character species:

None of the 27 *Mesobromion* character species which Shimwell (1968) lists are present in the Shetland communities. This might raise doubts as to the correct classification of these communities. This is discussed further in Chapter 5. In fact, it was only suggested that the Shetland community showed some relationships with one Association of the *Eu-Mesobromion* Oberd. 1957 Sub-Alliance of the *Mesobromion*. The Shetland community with its extreme northern position must lie well outside of the normal range of the Alliance and is outside the geographical range of many of the character species. A similar situation was encountered in Teesdale by Jones (1973). Despite the lack of general character species several of the species cited by Shimwell (1971b) as differentials of the Mesobromion from the Sub-Alliance of the Bromion found in Britain, the Xerobromion, are present in the Shetland community. These species are usually indicative of various grazing pressures. These are:-

Carex flacca
Plantago lanceolata
Succisa pratensis

A more or less continuous grazing regime is indicated by the presence of Molinio-Arrhenatheretea character species such as Holcus lanatus, Poa pratensis and Cynosurus cristatus.

Two Sub-Alliances are defined within the Alliance. One, the Seslerio-Mesobromion Oberd. 1957 is a montane sub-Alliance. The second, the Eu-Mesobromion Oberd. 1957 includes almost all the lowland Mesobromion communities. Within the Mesobromion there is an almost continuous variation in floristic composition and the Associations recognised by Shimwell are mainly delimited on the bases of phytogeography and community structure. A list only of differential species of the Seslerio-Mesobromion from the Eu-Mesobromion is given (Shimwell, 1968), but none of the species have been recorded from Shetland.

4.5. Class: ASTERETEA TRIPOLII WESTHOFF & BEEFTINK 62.

This Class comprises the vegetation of saltmarshes and of some cliff grasslands. Most frequently it is found on clay and sandy soils in the upper littoral zone between the average highwater mark and the stormline. These communities are mostly closed and grassy and hemicryptophytes are prominent within them. In Europe the Class is found from the Arctic to the west Iberian coast, as well as in parts of eastern Europe. It is probably present in Japan and a rather poorer example of the Class is found along the Atlantic coast and even to North America (Westhoff & Den Held, 1969).

Character species:

Westhoff & Den Held (1969) list:-

Aster tripolium
Plantago maritima
Triglochin maritima

All are present in Shetland, although Aster tripolium is restricted to the cliffs of Isbister Holm, off Whalsay.

The Class is divided into three vicariant Orders: the Carici-Puccinellietalia Beeftink & Westhoff 65 found in the Arctic; the Glauco-Puccinellietalia Beeftink & Westhoff of the Atlantic and Baltic and the Puccinellietalia Soo 40 em. Vicherek 62. of Eastern Europe. All the Shetland communities fall within the Glauco-Puccinellietalia.

4.5.1. Order: GLAUCO-PUCCINELLIETALIA BEEFTINK & WESTHOFF 62.

This Order is found in Western Europe, the West Baltic and Central Europe. Three character species are given by Westhoff & Den Held (1969). Of these, Spergularia media is found in Shetland but Limonium vulgare ssp. vulgare and Parapholis strigosa are not recorded. Until recently four Alliances were recognised in the Order. These were the **Puccinellion maritimae** Christiansen 27 em. Tx. 37, the **Armerion maritimae** Br.-Bl. & De Leeuw 36, the **Puccinellio-Spergularion salinae** Beeftink 65 and the **Halo-Scirpion** (Dahl & Hadac 41) Den Held & Westhoff 69. The **Armerion** and the **Puccinellion** are present in Shetland as well as a relatively new Alliance assigned to the Order, the **Silenion maritimae** Malloch 71.

4.5.1.1. Alliance: PUCCINELLION MARITIMAE CHRISTIANSEN 27 em. Tx. 37.

These communities are characteristically found in the lower parts of the shore in the zone from the mean high water mark to a little below the mean spring high water mark. The soils are usually clay-like and frequently covered by the tides.

Characteristic species:

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

Puccinellia maritima (transgr.)

Cochlearia anglica

Halimione portulacoides

Bostrychia scorpioides

Catenella opuntia

Only Puccinellia is a Shetland species.

Ivimey-Cook & Proctor (1966) in the Burren and Birks (1973) in Skye, consider that the presence of Puccinellia effectively distinguishes the Puccinellion from the Armerion.

4.5.1.2. Alliance: ARMERION MARITIMAE Br.-Bl. et De Leeuw 36.

In the middle and upper parts of some saltmarshes which are less frequently immersed by the sea, as well as on stony ground at the landward edge of saltmarshes or on wave-scarred rock platforms of lowsea-cliffs, this Alliance is found (Birks, 1973). The soil which is frequently silty is usually fairly dry or at most temporarily wet. The Alliance is found along the coasts of West Europe from Norway, Great Britain and Ireland, probably as far as south-west France (Westhoff & Den Held, 1969).

Character species:

The following are given as character species by Westhoff & Den Held (1969):-

Armeria maritima var. maritima (transgr.) +

Festuca rubra +

Glaux maritima +

Juncus gerardii +

Alopecurus bulbosus

Hordeum marinum

Carex distans var. vikingensis

Agrostis stolonifera var. compacta +

Those species marked + have been recorded in Shetland, although varieties have not been distinguished.

4.5.1.3. Alliance: SILENION MARITIMAE MALLOCH 71.

Malloch (1971) erected this Alliance to encompass the maritime cliff-top grasslands. Such communities had previously been placed in the Armerion but this was felt to be unsatisfactory as this is really an Alliance of upper saltmarsh vegetation characterised by such species as Glaux maritima and Juncus gerardii, which are absent from cliff grasslands. In addition, a variety of species of cliff grasslands such as Anthyllis vulneraria and Lotus corniculatus are never or rarely found in saltmarshes. The Alliance was described from Cornwall and it is unclear yet how widely distributed the Alliance is. The mineral soils are characteristically well drained.

Characteristic species:

From Malloch's (1971) account four species are apparently most typical of the Alliance, but not confined to it. These are:-

Armeria maritima
Festuca rubra
Daucus carota ssp. gummifer
Silene maritima

Daucus carota is not a Shetland species.

The Silenion is an Alliance which essentially falls between two Classes, the Asteretea tripdium and the Molinio-

Arrhenatheretea. It is distinguished from other saltmarsh communities by the presence of certain Molinio-Arrhenatheretea species and likewise it is distinguished from Molinio-Arrhenatheretea communities by the presence of certain saltmarsh species.

4.6. Class: MOLINIO-ARRHENATHERETEA Tx. 37.

Many lowland grassland communities of Western Europe, as well as certain semi-natural communities of mires and river banks are encompassed by this Class. Generally, such vegetation is created by clearance of the deciduous forest and maintained as a plagioclimax by mowing and grazing. In Shetland, these communities are again essentially man-made by the drainage and improvement of land previously covered by blanket bog vegetation.

In this vegetation grasses (or grasses and rushes) dominate a rather low-growing sward in which mosses are usually poorly developed.

Soils on which the Class is found vary from moist to wet; fairly nutrient-rich to highly nutrient-rich; mildly acidic to basic; unmanured to manured. The Class is found in various parts of Europe wherever the ground is sufficiently moist - in the Euro-Siberian region and in northern parts of the Mediterranean.

Character species:

O'Sullivan (1965) and Shimwell (1968) have both studied the Class in the British Isles. The following character species have been suggested by them:-

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

The species marked * are also recognised by Westhoff & Den Held (1969) as character species in Holland. These further suggest:-

Centaurea pratensis	Fritillaria meleagris
Climacium dendroides +	Prunella vulgaris +
Colchicum autumnale	Rhytidiadelphus squarrosus +

Only those species marked + have been recorded in Shetland.

At least three Orders have been recognised in the Class. The Holoschoenetalia Br.-Bl. 31 is confined to the northern Mediterranean. The two main Orders for western Europe are the Arrhenatheretalia Pawlowski 28, which includes the fertile anthropogenic grasslands on moist, but well aerated, nutrient-rich, manured soils, and the Molinietalia Koch 26, which includes a variety of communities of wetter habitats comparatively little affected by man.

4.6.1. Order: MOLINIETALIA Koch 26.

This Order includes a wide range of communities developed on a substratum which is typically wet (at least periodically) but varies from nutrient-poor to nutrient-rich and which may be unmanured or manured.

O'Sullivan (1965) suggests that the communities may be considered semi-natural since they are less subject to the influences of many than those of the Arrhenatheretalia. He also suggests that the wet conditions may be maintained by the existence of a high water-table level, by the presence of turf or clay soils, by regular high rainfall or by a combination of all three factors.

Character species:

As Order character species O'Sullivan (1965) and Shimwell (1968) suggest:-

Cirsium palustre *+	Lotus uliginosus
Angelica sylvestris *	Filipendula ulmaria +
Deschampsia caespitosa *+	Juncus acutiflorus +
Achillea ptarmica *+	J. conglomeratus +
Equisetum palustre *+	Myosotis caespitosa +
Galium uliginosum *	Lychnis flos-cuculi +
Juncus effusus +	Hypericum tetrapterum

Those marked * have also been suggested by Westhoff & Den Held (1969). These further suggest:-

Lathyrus palustris	Ophioglossum vulgarum +
Cirsium oleraceum	Rhinanthus glaber
Dactylorhiza praetermissa	Sanguisorba officinalis
Lathyrus palustris	Thalictrum flavum (transgr.)
Lysimachia vulgaris	
Hieracium caespitosum	Valeriana dioica

Those marked + have been recognised in Shetland. The distribution of the Order follows that of the Class except that it is absent from the Mediterranean region, where the Holoschoenetalia occurs.

Various Alliances are included within this Order. These include the Deschampsion caespitosae Horvatic 30, the

Alopecurion pratensis Passarge 64 and the Cnidion venosi Balatova-Tulackova 65, all of which contain communities of periodically flooded grassland; the Junco (subuliflori)-Molinion Westhoff 69 which contains communities of unmanured wet meadows and mires in which Molinia caerulea is usually an important component; the Filipendulion (Duign. 46 p.p.) Segal 66 which contains some river-bank and alluvial flood plain communities and the Calthion palustris Tx. 37 of nutrient-rich nitrogenous wet meadows. Only the Calthion is described from the Northern Isles and will be considered here.

4.6.1.2. Alliance: CALTHION PALUSTRIS Tx. 37.

Communities of nutrient-rich nitrogenous meadows which are constantly, or at least periodically, wet and may develop both on clays and peats are included within this Alliance. As well as the vegetation of artificially manured wet meadows, the communities of the edges of streams and brooks and the vegetation of certain spring mires which may be developed under the influence of laterally moving, nutrient-rich water are included. In wet meadows the water-table may be high throughout the year; in the case of spring mires and streamsides inundation may be only periodic.

Character species:

The following character species were proposed by O'Sullivan (1965) and Shimwell (1968):-

Caltha palustris *+	Myosotis scorpioides +
Crepis paludosa *	Polygonum bistorta
Senecio aquaticus +	Bromus racemosus

Those marked * are also recognised by Westhoff & Den Held (1969). These further suggest:-

Carex disticha	Lychnis flos-cuculi +
Lotus uliginosus	Scirpus sylvaticus
Luzula multiflora +	Taraxacum hollandicum

Those species marked + have been recorded in Shetland. Polygonum bistorta is recorded in Shetland but only as a garden escape.

4.6.2. Order: ARRHENATHERETALIA ELATIORIS Pawlowski 1928.

This Order includes the vegetation of cultivated meadows and white clover pasture in rich agricultural land, as well as some of the communities of rough grassland. The substratum is characteristically a loam or clay soil which is basic to slightly acidic and nutrient-rich. This Order is found throughout Europe where there is a temperate, moist climate but is only fragmentary in the north and Mediterranean regions.

Character species:

Character species recognised by O'Sullivan (1965) and Shimwell (1968) are:-

Achillea millefolium +
Arrhenatherum elatius +
Bellis perennis +
Bromus mollis
Chrysanthemum leucanthemum
Dactylis glomerata +
Daucus carota
Heracleum spondylium +
Knautia arvensis
Taraxacum sect. vulgaris +
Trifolium dubium +
Trisetum flavescens
Veronica officinalis +
V. chamaedrys +

Those marked + have been recorded in Shetland.

Character species from Westhoff & Den Held (1969) are not included since only one Alliance is recognised in Holland and thus Order and Alliance character species are identical. In Britain three Alliances have been recognised. Rich meadow communities are accommodated in the *Arrhenatherion elatioris* Koch 26; lowland pastures in the *Cynosurion cristati* Tx. 47 and northern, sub-boreal damp meadows and pastures in the *Ranunculo-Anthoxanthion* Gjaerevoll 56 em. Shimwell 68. Only the *Cynosurion* has been described in this survey from Shetland.

4.6.2.1. Alliance: CYNOSURION CRISTATI Tx. 47.

This Alliance was erected by Tüxen (1956) to include the manured perennial ryegrass-white clover pastures of moist but well-drained, often loamy, soils. The Alliance is confined to the western part of Europe, from north-west Germany to Holland and Belgium and the British Isles (Shimwell, 1968).

Character species:

As character species O'Sullivan (1965) suggests:-

Cynosurus cristatus +
Phleum pratense +
Senecio jacobea
Trifolium repens +

Shimwell (1968) uses the same character species apart from Senecio jacobaea which is excluded.

As differential species from the Arrhenatherion O'Sullivan (1965) and Shimwell (1968) suggest:-

Achillea millefolium +   Lolium perenne +
Cirsium arvense +

The species marked + have been recorded from Shetland. Senecio jacobaea is recorded by Palmer & Scott (1969) only as a "rare colonist , long established at Scalloway."

4.7. Class: PARVOCARICETEA Den Held & Westhoff 69.

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

Division of the old Scheuchzerio-Caricetea fuscae (Nordh. 36) Tx. 37 created two new Classes. One was the Parvocaricetea and the other the Scheuchzerietea Den Held, Barkman et Westhoff 69. Communities encompassed by the Parvocaricetea are those of mires in which the herb layer is comprised of low-growing grasses, sedges and rushes and the ground layer (which is well developed) is dominated by sphagnaceous or hypnaceous mosses.

The substratum is frequently peat but may be mineral soil. Throughout most of the year the water-table is high - at, or just below ground-level. This irrigating water varies from oligotrophic to eutrophic and from base-poor to base-rich but it is always minerotrophic and normally with only low levels of nitrogen and phosphorus (Wheeler, 1975).

These communities are found in a wide variety of sites; both topogenous and soligenous; associated with springs and areas of water seepage; in flat, expansive peaty fens; in the "lagg" zone of ombrotrophic mires; in dune-slacks etc. (Wheeler, 1975).

The Class is found throughout the euro-Siberian region but it is most widespread in the north where it may occur at all altitudes. In the south it is mainly found in montane areas.

Character species:

Westhoff & Den Held suggest the following character species:-

Calamagrostis neglecta
Carex demissa +
C. diandra
C. lasiocarpa
Epilobium palustre +
Hydrocotyle vulgaris +
Pedicularis palustris +
Potentilla palustris +
Stellaria palustris
Acrocladium cordifolium +
Drepanocladus exannultus +
D. sendtneri
Riccardia pinguis +

They also list five species which they consider differentiate the Parvocaricetea, together with the Scheuchzerietea from all other Classes. These are:-

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

The following species are listed as differentials of the Parvocaricetea from the Scheuchzerietea:-

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

Those species marked + have been recorded in Shetland.

The Class has been divided into two Orders: the Caricetalia nigrae Koch 26 em. Nordh. 36 denuo em. Tx. 37 and the Tofieldietalia Prsg. apud Oberd. 49.

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

This Order includes the vegetation of poor fens (sensu Du Rietz, 1949) in which low-growing sedge species are prominent. Only one Alliance is usually recognised within the Order. This is the Caricion curto-nigrae Koch 26 em. Nordh. 36.

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

Synon: Parvocaricion canescentis-fuscae Duvign. et Vanden Berghen 45

Contained in this Alliance are small-sedge communities of oligotrophic to mesotrophic sites growing in nutrient-poor wet ground where the water-table is close to the surface for much of the year. The communities are fairly species-rich and the ground layer is well developed. Species of Sphagna may be prominent. They may be found in a variety of places including in soligenous mires, alongside streams, in the "lagg" zone of ombrotrophic mires and in dune-slacks where there are low levels of calcium (Wheeler, 1975). The distribution of the Alliance is as that of the Class except that it is absent from alpine regions.

<u>Character species</u>:

As Order and Alliance character species Westhoff & Den Held (1969) suggest:-

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

Those species marked + are present in Shetland. <u>Sphagnum recurvum</u> is recorded but not at sub-species level.

4.7.2. <u>Order: TOFIELDIETALIA Prsq. apud Oberd. 49</u>.

Synon: Caricetalia davallianae Br.Bl. 49.

Communities of rich fen (sensu Du Rietz, 1949) are placed in this Order. Such communities are from relatively nutrient and base-rich mires. Hypnaceous mosses usually predominate in the bryophyte layer and Sphagna are infrequent.

The area of distribution of this Order is the same as the Class and it is found from sea level to montane/alpine levels.

<u>Character species</u>:

Wheeler (1975) gives a list of character species for the Order compiled from the work of Oberdorfer (1957), Shimwell (1968) and Jones (1973). The character species of Westhoff & Den Held (1969) are not followed since these authors are only concerned with one Alliance within the Order and hence only a joint Order and Alliance character species list is given. Those listed by Wheeler are:-

Bartsia alpina	Juncus alpinoarticulatus
Carex dioica +	Campylium chrysophyllum +
C. flava +	C. stellatum +
Equisetum variegatum	Drepanocladus revolvens +
Eleocharis quinqueflora +	Scorpidium scorpioides +

Only those species marked + have been recorded in Shetland.

Two Alliances are generally recognised as distinct entities within the Order. The Caricion bicoloris-atrofuscae Nordh. 36 is an Alliance of subarctic and subalpine to alpine regions. The other, the Caricion davallianae Klika 34 has been recognised in Shetland.

4.7.2.1. Alliance: CARICION DAVALLIANAE Klika 34.

Synon: Schoenion ferruginei Nordh. 36
Eriophorion latifolii Br.-Bl. et Tx. 43
Epipacto-Schoenion ferruginei

This Alliance encompasses the vegetation of natural or semi-natural species-rich communities of moist to wet habitats of neutral to alkaline character. Low-growing species of Carex usually dominate the herb layer and the moss layer is distinguished by the abundance of pleurocarpous species. The substratum is normally an oozing peat, irrigated by calcareous ground water (Wheeler, 1975). The water-table is often high throughout the year; however, in dune-slacks in particular this is not always the case and the water-table may fluctuate a great deal.

The altitudinal range of the Alliance is from sea-level to montane regions. In the subarctic and subalpine-alpine zones it is replaced by vicariants.

Character species:

The following species have been cited by Westhoff & Den Held (1969) and Oberdorfer (1957) as character species of the Alliance:-

Carex lepidocarpa +	Cinclidium stygium
Dactylorhiza incarnata +	Drepanocladus lycopodioides
Eriophorum latifolium	D. vernicosus
Epipactis palustris	Fissidens osmundioides +
Liparis loeselii	Mnium cinclidioides
Parnassia palustris +	M. pseudopunctatum
Taraxacum limnanthes	M. rugicum +
Acrocladium giganteum +	M. seligeri +
Bryum pseudotriquetrum +	Pellia endivifolia +
Campylium elodes +	P. neesiana +
C. polygamum +	Riccardia multifida +
Camptothecium nitens	R. sinuata +
Catascopium nigritum +	Sphagnum contortum
	S. platyphyllum

Those species marked + have been recognised in Shetland.

4.8. Class: SCHEUCHZERIETEA Den Held, Barkman et Westhoff 69.

This Class was created to accommodate the remaining Order (the Scheuchzerietalia palustris Nordh. 36) after the division of the Scheuchzerio-Caricetea fuscae (Nordh. 36) Tx. 37 to form the Parvocaricetea (see 4.7.). It contains communities of hollows and pools in wet bogs and fens where the stagnant or slowly moving water forms a constantly high water-table. The Class is widely distributed with a centre of distribution in the boreo-subatlantic region. Westhoff & Den Held (1969) recognise only one Alliance within the Order. This is the Rhyncosporion albae Koch 26.

4.8.1.1. Alliance: RHYNCHOSPORION ALBAE Koch 26.

This widely distributed Alliance comprises the vegetation of wet depressions in ombrotrophic mires and poor fens. Characteristically the herb layer is species poor and poorly-developed, although the bryophyte layer is usually well-developed in which species of Sphagna, especially Sphagnum cuspidatum, are prominent. The herbs which are found are usually species of the Cyperaceae, Gramineae and Scheuchzeriaceae.

Character species:

As character species of the Class, Order and Alliance Westhoff & Den Held (1969) suggest:-

Cladopodiella fluitans
Rhynchospora alba
  (transgr.)
Sphagnum apiculatum
S. cuspidatum +
S. lindbergii +
S. majus
S. pulchrum +
Various fungal species.

As differential species of the Class from the Parvocaricetea they list:-

Oxycoccus palustris
Sphagnum tenellum +
S. papillosum +

Those species marked + have been recorded in Shetland.

A second Alliance the Caricion lasiocarpae Vanden Berghen 49 is sometimes included in the Scheuchzerietalia. This Alliance is found in association with more mesotrophic water of higher base status than the Rhynchosporion (see Wheeler, 1975). Westhoff & Den Held (1969) do not recognise the Caricion lasiocarpae as a valid syntaxon and suggest the communities of it can be satisfactorily partitioned between the Rhynchosporion and Alliances of the Parvocaricetea.

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

This Class encompasses the vegetation of ombrophilous bogs (Bellamy, 1967) and of wet heaths. Characteristically, the vegetation is dominated by dwarf shrubs such as Calluna vulgaris, Erica tetralix and Empetrum nigrum, often interspersed with Eriophorum and Tricophorum species. The ground layer is well developed and frequently dominated by Sphagnum species.

The substratum is highly acidic, waterlogged peat which may range in depth from quite shallow to many metres deep and varies from moderately to very oligotrophic in nature.

The distribution of the Class is chiefly in the euro-siberian region with optimal development in the north-western part. In the more southern parts it is chiefly confined to the mountain zone. Miyawaki (1968) however, believes the Class to be also present in Japan and Oberdorfer (1957) and Westhoff & Den Held report that the Class may be present in North America, although these authors suggest that this vegetation might be better placed in a different Class.

Character species:

Moore (1968) suggests six character species for the Class. All are present in Shetland. These are:-

Drosera rotundifolia	Lepidozia setacea
Aulacomium palustre	Sphagnum capillaceum
Calypogeia trichomanes	S. tenellum

Jones (1973) adds Dactylorchis maculata ssp. ericetorum from Westhoff & Den Held (1969). Additional character species are cited by these authors and Oberdorfer (1957), but since Moore (1968) uses them for an Order or Alliance this restricted interpretation is followed here too.

Moore (1968) subdivided the Class into two Orders on an ecological-floristic basis. These are the Ericetalia tetralicis which encompasses the vegetation of damp heaths on shallow peat in the atlantic sector, and the Sphagnetalia magellanici which includes the bogs with dominant Sphagna on deeper peat present in both the atlantic and the continental parts of Europe.

The aufnahmen from the Northern Isles were all assigned to the Sphagnetalia.

4.9.1. Order: SPHAGNETALIA MAGELLANICI (Pawlowski 28 p.p.) Moore (1964) 1968.

This Order encompasses the vegetation of hummock and hollow forming blanket and raised bogs which has developed on oligotrophic peat, which is always very deep. The ground layer is characterised by the abundance of Sphagnum species, especially Sphagnum magellanicum and Sphagnum rubellum. Such species as Eriophorum vaginatum, Andromeda polifolia and Vaccinium oxycoccus are frequent in the field layers. Westhoff & Den Held (1969) suggest close successional relationships in both formation and decay of these communities with those of soligenous blanket bog channels which are usually placed in the Scheuchzerietea Den Held, Barkman & Westhoff 69 (see 4.8.).

Westhoff & Den Held (1969) give the distribution of the Order as confined to eurosiberian regions with the centre of distribution in subatlantic and continental parts. However, Miyawaki (1968) has tentatively placed some communities of Japanese raised bogs within this Order.

Character species:

Those suggested by Moore (1968) are followed in this account. These are:-

Andromeda polifolia	Mylia anomala +
Carex pauciflora	Pohlia nutans +
Eriophorum vaginatum +	Polytrichum alpestre
Vaccinium oxycoccus	Sphagnum magellanicum +
Calypogeia sphagnicola +	S. recurvum +
Cephalozia connivens +	S. rubellum
C. macrostachya	

Only those species marked + have been recorded in Shetland.

Moore (1968) recognises two Alliances within the Sphagnetalia: the Erico-Sphagnion for the atlantic regions where snow lies on the bogs for only a short time in winter, and the Sphagnion fusci of the continental and boreal parts with more harsh winters. Only the Erico-Sphagnion has been described from the Northern Isles.

4.9.1.1. Alliance: ERICO-SPHAGNION MOORE (1964) 1968.

Westhoff & Den Held (1969) describe the distribution of these bog communities as boreo-atlantic to boreo-subatlantic, i.e. from central Ireland to western Germany and southern Sweden.

Character species:

Moore (1968) suggests the following character species:-

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

As differential species from the Sphagnion fusci, Moore (1968) suggests:-

Erica tetralix +	Campylopus flexuosus +
Eriophorum angustifolium +	Hypnum cupressiforme +
Molinia caerulea +	Leucobryum glaucum +
Rhynchospora alba	Cladonia impexa +

Those species marked + are present in Shetland.

4.10. Class: NARDO-CALLUNETEA Preising 49.

This Class includes both the vegetation of poor, rough grassland and of heaths. Such communities are frequently man-made and they may be replacements of forest communities. They are maintained by such practices as burning, mowing, trampling and light grazing. In more extreme habitats such as in rocky places, in sand dunes and in alpine regions, these communities may be the natural vegetation. This vegetation may be species-poor or species-rich but generally, the moss layer is well developed and the communities are frequently rich in lichen species.

The substratum is characteristically nutrient-poor, somewhat acid and varies from moderately dry to damp. It may be strongly podsolised.

In Europe the Class is found in the atlantic, sub-atlantic and subcontinental parts of the euro-siberian region from sea-level to montane regions. An impoverished form is found in more continental parts and it is also found in the high mountains of the Mediterranean region (Westhoff & Den Held, 1969).

Character species:

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

Calluna vulgaris +
Carex pilulifera +
Cuscuta epithymum
Potentilla erecta +
Sieglingia decumbens +

Oberdorfer (1957) adds:-

Hieracium pilosella
Veronica officinalis +

Jones (1973) considers Potentilla erecta and Sieglingia decumbens invalid as character species for the Class in Britain, but in Shetland they appear to be satisfactory. Those species marked + have been recorded in Shetland.

The exact composition of the Class remains under dispute (see Bridgewater (1970) and Jones (1973)). However, two Orders are definitely represented in Shetland. These are the Nardetalia (Oberd. 49) Preising 49 and the Calluno-Ulicetalia (Quantin 35) R. Tx. 37.

4.10.1. Order: NARDETALIA (OBERD. 49) PREISING 49.

This Order of rough grasslands shows the same distribution as that of the Class, except it is absent from the Mediterranean region.

Character species:

Westhoff & Den Held (1969) do not distinguish between Order and Alliance characters, since only one Alliance is represented in the Netherlands. This differentiation is made by Oberdorfer (1957) but not all his species are suitable (Jones, 1973). From Oberdorfer's list, Jones suggests for use in Britain the following four species, all of which are found in Shetland:-

Antennaria dioica +
Botrychium lunaria (transgr.) +
Gentianella campestris +
Nardus stricta +

Four Alliances are currently recognised within the Order by Westhoff & Den Held (1969), although others have been suggested in different classificatory schemes (e.g. Passarge, 1964).

These Alliances and their distribution patterns are:-

Violion caninae Schwick (41) 44 em. Prst. 49 - subatlantic.

Nardion Br.-Bl. 26 em. Prsg. 49 - upper montane - subalpine.

Nardion boreale Prsg. 49 - northern.

Nardo-Agrostidion Sill 33 - continental.

The most widespread, if not the only Alliance of the Order in Britain, is the Violion caninae (Jones, 1973).

4.10.1.1. Alliance: VIOLION CANINAE Schwick (41) 44 em. Prsg. 49.

Synon: Nardo-Galion saxatilis Prsg. 49.

These herb-rich rough grasslands are maintained in their secondary state by trampling, grazing and mowing. These communities develop on acidic loams and sometimes clays. The soils are generally more nutrient-rich than those of the heath communities of the Class. The Alliance occurs at altitudes from sea-level to the submontane/montane zone and it is best developed in the hilly regions of sub-oceanic western Europe, i.e. north-west France, Belgium, the Netherlands, Denmark and western and central Germany.

Character species:

As with the Nardetalia characters some of the character species of the Alliance suggested by Oberdorfer (1957) and Westhoff & Den Held (1969) are non-British species or only present in Britain on calcareous soils. Jones (1973) considers the following to be valid in Britain:-

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

The classificatory syntaxonomic hierarchy for heaths has been under some dispute but in this account the classification of Rivas Martinez (1968) is followed as described in Bridgewater (1970) and Jones (1973). Under this scheme all the British heaths are assigned to the Calluno Ulicetalia.

4.10.2. Order: CALLUNO-ULICETALIA (QUANTIN 35) R. Tx. 37.

This Order comprises the vegetation of dwarf-shrub heath communities which are rather species-poor, although notably rich in mosses and lichens. Such vegetation is rarely primary in origin but more usually an anthropogenic replacement community, often of forest vegetation and maintained by grazing, trampling, mowing and, in contrast to the Nardetalia, burning. The soils are usually acidic, nutrient-poor and somewhat dry (Westhoff & Den Held, 1969). The main distribution of the Order is in the atlantic and sub-continental parts of the euro-siberian region, i.e. over an area stretching from north Sweden, Finland and north-west Russia to south-east France, central Italy, Yugoslavia and Hungary and extending to northern France and across the British Isles to western Ireland. Throughout much of this area the Order covers a wide altitudinal range but in the south it is restricted to the montane and subalpine parts.

Character species:

Oberdorfer (1957) lists:-

Calluna vulgaris +	Sarothamnus scoparius
Hynum ericetorum +	

Westhoff & Den Held (1969) do not recognise the Calluno-Ulicetalia. Instead they use the Vaccinio-Genistetalia Schubert 60, which is equivalent to the Calluno-Ulicetalia without the Alliance the Ulicion Duvign. 44 em. Vanden

Berghen 58 (see Jones (1973) for details of the syntaxonomy of the Order). For the Vaccinio-Genistetalia Westhoff & Den Held recognise Calluna vulgaris, Hypnum ericetorum and Arctostaphylos uva-ursi as character species, and Jones (1973) tentatively suggests that Arctostaphylos might be added to Oberdorfer's list of character species.

As differential species of the Calluno-Ulicetalia from the Nardetalia Jones (1973) lists the following (compiled from Oberdorfer (1957) and Westhoff & Den Held (1969)):-

Dicranum spurium	Juniperus communis +
D. undulatum	Ptilidium ciliare +

Those species marked + are found in Shetland.

Rivas-Martinez recognised four Alliances within the Order. These are:-

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

The Shetland communities are placed in the Ulicion nanae.

4.10.2.1. Alliance: ULICION NANAE DUVIGN. 44 em. Vanden Berghen 58.

Bridgewater (1970) describes the distribution of this "Erica cinerea Heath" as centered on the south and west of England and Wales; although some component vegetation is found in western Scotland. It is a particularly eu-atlantic vegetation type being virtually confined to Britain, Ireland and extreme western France.

Character species:

Bridgewater (1970) does not give character species as such. As defining species Erica cinerea, Calluna vulgaris and Potentilla erecta are named. Two further species (not present in Shetland) are typically confined to this type of heath. They are Ulex gallii and (in the south) Agrostis setacea. Because this heathland is so oceanic and as Britain is the focus of the Atlantic heathland development, there is much variety within the Alliance and consequently few defining species (Bridgewater, 1970).

Braun-Blanquet & Tüxen (1952) describe the Alliance from Ireland and as character species they give Erica cinerea and Festuca vivipara.

4.11. Class: CARICETEA CURVULAE BR.-BL. 48.

This is the Class of alpine heaths and grass heaths above the tree limit in Europe (Shimwell, 1971). The classification of Dahl (1956) is followed where both grass and dwarf-shrub heaths are united in a single Order, the Caricetalia curvulae Br.-Bl. 26 rather than the scheme of Nordhagen (1936) which, primarily on physiognomy, grouped the grass heaths into the Caricetalia curvulae and the dwarf-shrub heaths into the Rhodoretalia ferruginei. The optimum development of the Class lies in the alpine zone between 2600 and 3000 m. (Oberdorfer, 1957).

4.11.1. Order: CARICETALIA CURVULAE BR.-BL. 26.

Within this Order two Alliances have sometimes been recognised. The Juncion trifidi scandinavicum Nordh. 43 comprised the mid-alpine grass heaths, whilst the dwarf-shrub heaths were placed in the Loisleurieto-Vaccinion uliginosi Nordh. 36. Because of the close connections of the two, Dahl (1956) combined the two into a single Alliance, the Arctostaphyleto-Cetrarion nivalis, which is followed in this account.

4.11.1.1. Alliance: ARCTOSTAPHYLETO-CETRARION NIVALIS DAHL 56.

Synon: Loisleurieto-Arctostaphyllion Nordh. 43 + Juncion trifidi scandinavicum Nordh. 43.

Empetrion emyrtillosum Du Rietz 42 + Juncion trifidi Du Rietz 42.

This Alliance comprises chionophobous, oligotrophic to eutrophic, weakly acidophilous to strongly acidophilous upland heath communities. Characteristically, there is no water-logging or ice cover in winter. Podsolation is absent or weak, humus production is slight and the humus layer, if present, is often sandy (Dahl, 1956).

Characteristic species:

Details of characteristic species (many of which are regionally characteristic) as well as differential species from other non-British Alliances are given in Dahl (1956). The species listed as general characteristic species are:-

Arctous alpinus +
Cesia coralloides
Rhacomitrium lanuginosum +
Cornicularia aculeata
C. divergens
Parmelia physodes +
Sphaerophorus fragilis +
Haematomma ventosum
Ochrolechia tartarea

Those species marked + have been recorded in Shetland.

4.12. Class: THLASPEETEA ROTUNDIFOLII Br.-Bl. 47.

This Class encompasses some pioneer plant communities of areas of scree, rubble or boulders. The chief distribution of the Class is in the high mountains where such vegetation makes a welcome change from rocks and snow (Oberdorfer, 1957).

Character species:

Oberdorfer (1957) lists seven species, none of which are present in Shetland:-

Rumex scutatus
Silene alpina
Gypsophila repens
Galeopsis ladanum
Linaria minor
L. alpina
Leontodon hispidus var. u.a.

Within the Class Oberdorfer (1957) includes three Orders: the Thlaspeetalia rotundifolii Br.-Bl. 26 of calcareous scree; the Androsacetalia alpinae Br.-Bl. 26 of siliceous scree; and the Epilobietalia fleischer Moor 55 mscr. of alluvial gravels. It is the Thlaspeetalia which is represented in Unst.

4.12.1. Order: THLASPEETALIA ROTUNDIFOLII Br.-Bl. 26.

As character species of this Order of communities of limestone scree Oberdorfer (1957) lists:-

Thelypteris robertiana	Campanula cochleariifolia
Arabis alpina	Moehringia muscosa

None of these species are found in Shetland. However, it is to the Arenarion norvegicae Nordhagen 36 (placed in this Order) that Spence (1970) relates the serpentine scree vegetation in Unst.

4.12.1.1 Alliance: ARENARION NORVEGICAE Nordhagen 36.

Nordhagen (1936) describes this subalpine-alpine Alliance from such rock types as limestone, dolomite and slate. As characteristic species he suggests the following:-

Arenaria ciliata subsp. pseudofrigida	Artemisia norvegica
A. norvegica +	Agropyron latiglume
Braya linearis	Papaver radicatum
B. purpurascens	
Cardaminopsis petraea +	

Those species marked + are present in Shetland.

CHAPTER 5.

THE PLANT COMMUNITIES OF THE NORTHERN ISLES.

5. The plant communities of the Northern Isles.

In this Chapter an account is given of the communities which have been distinguished in each of the major vegetation types in the Northern Isles. The Chapter is subdivided into 9 sections according to the following vegetation types:-

- 5.1. Shingle and boulder beaches.
- 5.2. Sand dune and associate vegetation.
- 5.3. Saltmarsh.
- 5.4. Grassland.
- 5.5. Wet meadow.
- 5.6. Blanket bog.
- 5.7. Blanket bog pools.
- 5.8. Heath.
- 5.9. Heath flushes.

Each section is treated in the same way. A general introduction is followed by a series of descriptions of the Groups which have been distinguished within each type of vegetation and their characterising species are listed. Then follows a discussion of the synsystematic placement of each Group, and lastly there is a synopsis of the proposed classification of all the Groups of that particular vegetation type. A summary of all the main syntaxa recognised is at the end of Chapter 6. Where the authorities name is not given after a particular syntaxon, it may be found in Chapter 4 or in the synopsis at the end of each section.

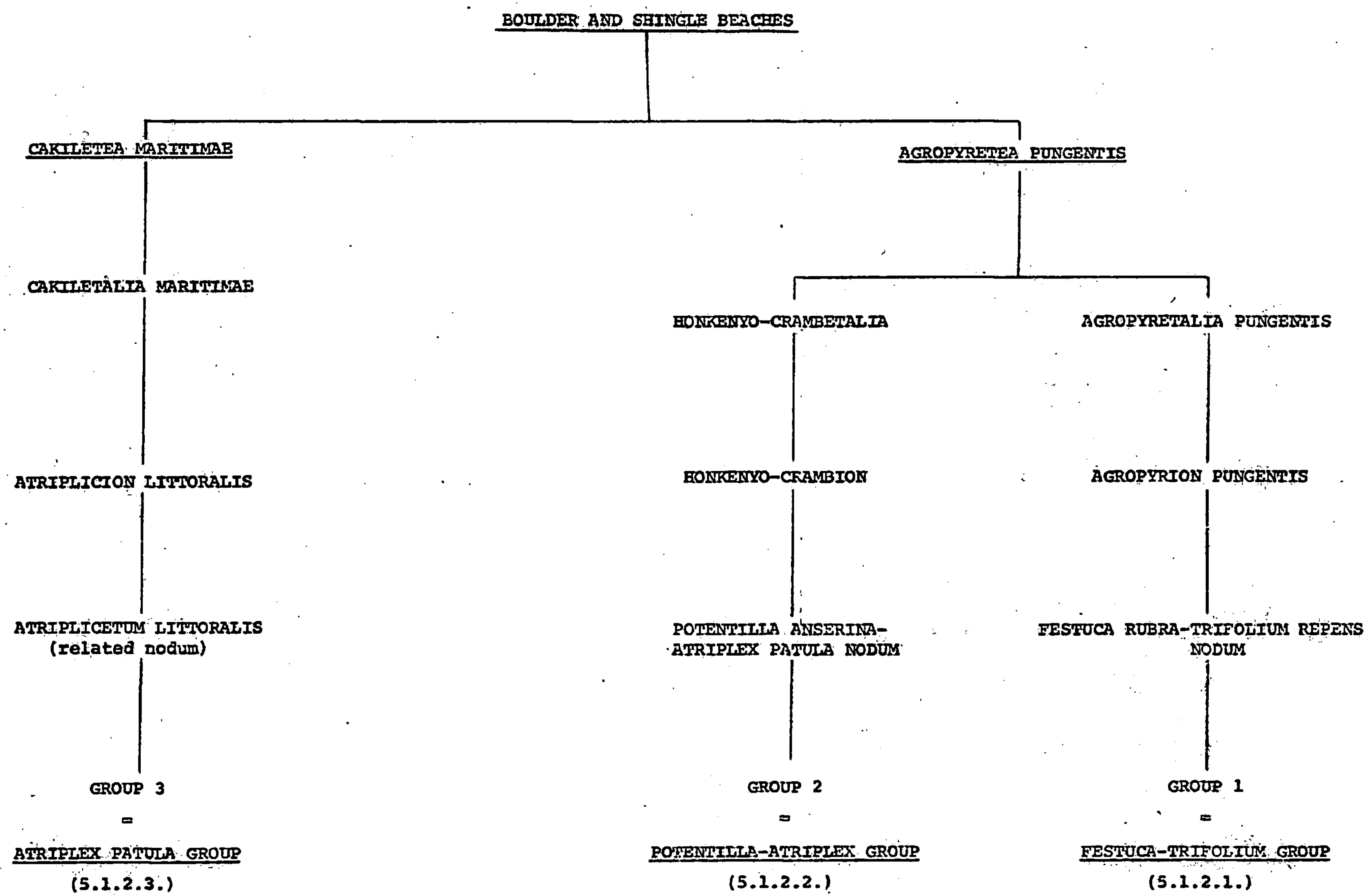


FIGURE 5.1. Synoptic classification of the vegetation of boulder and shingle beaches in the Northern Isles.

5.1. Shingle and Boulder Beaches in the Northern Isles - Table 1.

5.1.1. Introduction.

A synopsis of the classification of the vegetation of the Northern Isles is shown in Fig. 5.1.

Shingle beaches in the form of shingle spits and bars are numerous in the Northern Isles. Shingle as a fringing beach occupying a narrow strip at the top of a sandy beach is less common. However, boulder beaches, sometimes with areas of shingle behind them, are frequent on more exposed coasts and on many of the small islands.

The communities and vegetational sequence of boulder beaches and shingle beaches are essentially similar in Shetland and the two are described together.

Typically, both types of beaches may be quite barren with patches of little or no vegetation. This is because the habitat is so unstable, being very open to wave action. With increasing stability a greater degree of plant cover is possible.

Initially, only a few annual species or rapidly growing perennials are found. The species are usually nitrophilous and are particularly developed in association with organic drift deposited by the tides. With the accumulation of more soil matter, and increased stability of the habitat, a more diverse and structured community develops.

5.1.2. Community types.

5.1.2.1. Festuca rubra-Trifolium repens Group = Group 1.

Characterising species:- Festuca rubra, Trifolium repens, Potentilla anserina.

Description:- This is the characteristic community of more stable spits and shingle and boulder fringing beaches. The sites are typically well colonised (herb cover averages over 80%) and species composition is quite varied.

Aufnahmen have been recorded from dry, flat sites on gneiss and serpentine in Yell, Unst, Haaf Gruney and Samphrey. Typically, there is a shallow, brown, mineral rich soil, of pH range 6.6-8.0, amidst the boulders and pebbles.

The average height of the herb layer is over 203 mm. apart from on spits where the community may be heavily grazed. Bryophytes are usually absent.

The community is dominated by Festuca rubra and sometimes Potentilla anserina interspersed with Trifolium repens, Agrostis stolonifera, Agropyron repens, Poa annua, Cerastium holosteoides, Plantago lanceolata, Stellaria media and Rumex acetosa. A great variety of other herbs may be present including Ranunculus acris, R. repens, Silene maritima, Trifolium pratense and Myosotis arvense.

From three more sandy sheltered sites Honkenya peploides was recorded.

5.1.2.2. Potentilla anserina-Atriplex patula Group = Group 2.

Characterising species:- Potentilla anserina, Atriplex patula, Stellaria media.

Description:- Above the open vegetation of Group 3, but before or interspersed with the more stable and more mature vegetation of Group 1, this community is characteristically found. Aufnahmen have been recorded from gneiss and serpentine spits and fringing beaches on Yell, Unst, Daaey and Sound Gruney. The community develops on the side as well as the top of fringing beaches. Very little soil is found between the boulders or smaller stones. There may be a little sand or dark humus from decaying plant material. The pH range of the scanty substratum varies between 6.8 and 7.8. The community is frequently quite open but herb cover does vary from 30% to 100%. Bryophytes are absent.

Only the characterising species are constant but Agrostis stolonifera, Agropyron repens, Galium aparine, Poa annua and Tripleurospermum maritimum are all frequent and Festuca rubra, Plantago lanceolata, Rumex acetosa, R. crispus and R. longifolium occasional. From two sheltered beaches on Yell Mertensia maritima has been recorded. At the more sandy Otterswick site Honkenya peploides is recorded.

5.1.2.3. Atriplex patula Group = Group 3.

Characteristic species:- Atriplex patula.

Description:- This extremely species-poor community represents the initial stages of colonisation of both shingle spits and fringing beaches and boulder beaches. Aufnahmen from Yell and Unst are shown in Table 1. Again the parent bedrock is either gneiss or serpentine. The sites are all fairly flat and dry. At Westing and Greenbank there is very little rooting substratum between the large boulders apart from decaying plants. At Haroldswick and Balta Sound there is some sand but mainly small pebbles with a little sandy silt between. A pH range of 6.6 to 8.0 has been recorded from sites where readings were possible. All the sites are fairly exposed and less stable than those associated with the two previous Groups. The community may be quite open with herb cover of only 20% or fairly dense with cover of up to 100%. The average height of the community varies from only 50 mm. to 0.5 m., where Sonchus asper is recorded.

Atriplex patula is the only constant or abundant species; in fact, stands may consist only of this species. Other species which are recorded occasionally include Agropyron repens, Galium aparine, Rumex crispus and Tripleurospermum maritimum.

5.1.3. Synsystematics.

5.1.3.1. Introduction.

Only brief descriptions of a few shingle beach communities in the British Isles have been made. The most detailed account of such vegetation is from the Atlantic coast of France (Gehu & Gehu, 1969). Based on this system Adam (1976) has described old shingle and driftline communities in his salt-marsh survey of the British Isles. The exact phytosociological relationships of the Northern Isles vegetation are unclear, although some tentative suggestions can be made. The naming authorities of the higher syntaxa are given in Section 4.1. and 4.2.

5.1.3.1. Synsystematic placing of Group 3.

Open communities of mainly annual, halonitrophile species of driftlines, foredunes and shingle beaches are assigned to the Class Cakiletea maritimae. Group 3 is assigned to the Atriplicion littoralis of the Cakiletalia maritimae. This assumption is based on general comparison of the Group with descriptions in the literature since no character species of Class, Order or Alliance are present, apart from Tripleurospermum maritimum, a variety of which is quoted by Westhoff & Den Held (1969) as a character of the Atriplicion. Vegetation of a second Alliance of the Cakiletalia, the Salsolo-Minuartion peploidis is described from Ireland (Braun-Blanquet & Tüxen, 1952; Ivimey-Cook & Proctor, 1966). However, Gehu & Gehu (1969) describe the habitat of such vegetation as much more sandy, whilst the substratum on which the Atriplicion develops is organic material, little mixed with sand - much more like that of Group 3. Vegetation of Group 4, the Atriplex patula-Cakile maritima Group, described in the sand-dune section (5.2.2.4.) as a community of sandy foreshores, is more similar to the Salsolo-Minuartion, since the differential species of the Alliance, Honkenya peploides is present. However, the Group is assigned to the Elymo-Agropyretum by the presence of Elymus arenaria and Ammophilia arenaria (see Section 5.2.3.3.).

Within the Atriplicion only one Association is described, the Atriplicetum littoralis (Warming, 1906) Westhoff & Beeftink 50. The character species of the Association, Atriplex littoralis and Atriplex hastata are not present in Group 3. Adam (1976) describes the Association as floristically heterogeneous. Apart from the two character species he mentions other dominants including, Tripleuro-spermum maritimum, Sonchus arvensis, Stellaria media, Urtica dioica, Cirsium arvense and Beta maritima. Tripleurospermum and Stellaria media are present in Group 3. Atriplex littoralis is not recorded in Shetland and Atriplex hastata is rare (Palmer & Scott, 1969).

For the present this Group is best regarded as an Atriplex patula nodum of uncertain synsystematic status. It is related to the Atriplicetum littoralis, but it is a northern type distinguished by the absence of typical species. With more information the nodum may ultimately be regarded as an "inops" variant of the Atriplicetum or a new Association which is a geographical vicariant.

Synsystematic placing of Groups 1 and 2.

With increasing stability of the environment perennial species are able to colonise the habitat. The communities are still often very open and a number of species of the annual communities of less stable areas (cf. Group 3) are still found. These communities of predominantly perennial species on drift lines and shingle beaches were accommodated by Gehu & Gehu (1969) in a new Class, the Agropyretea pungentis. The communities of Groups 1 and 2 are assigned to this Class.

Within the Class Gehu and Gehu described two Orders. One the Honkenyo-Crambetalia maritimae encompassed open halonitrophile communities which are relatively unstable and grow on a rough substratum of sand or pebbles mixed with lots of organic material. Only two of the eight character species of the Order are present in Groups 1 or 2. They are Honkenya peploides and Rumex crispus. The only Alliance in the Order is the Honkenyo-Crambion maritimae, so the character species are the same for the Alliance as the Order.

The second Order is the Agropyretalia pungentis which encompasses the more permanent perennial vegetation of upper shingle beaches often in the form of a dense, generally closed grassland with more structure in both the community and the substratum than the last Order. None of the Order characters are present in Shetland. As with the Honkenyo-Crambetalia there is only one Alliance within the Agropyretalia (the Agropyrion pungentis Gehu & Gehu 1969), so there are no additional Alliance species.

The phytosociological relationships of Groups 1 and 2 are unclear. It would seem that Group 1, the more established community, is related to the Agropyretalia, while Group 2 which is more closely related to Group 3 and with less structure than Group 1, is probably related to the Honkenyo-Crambetalia. The data of both Groups ~~is~~ are unlike previously described Associations.

Adam (1976) describes a Potentilla anserina nodum of uncertain phytosociological status but possibly related to the Agropyretalia. In this nodum Potentilla anserina and Agrostis stolonifera are dominant and Festuca rubra and Trifolium repens are frequent; species composition thus resembles Group 1.

In conclusion, it is very tentatively suggested that Group 1 is described as a Festuca rubra-Trifolium repens nodum within the Agropyrion pungentis, and Group 2 a Potentilla anserina-Atriplex patula nodum within the Honkenyo-Crambion maritimae.

5.1.4. Synopsis of Shingle Community Types.

CAKILETEA MARITIMAE Tx. & Prsg. 50

CAKILETALIA MARITIMAE Tx. apud Oberd. 49

ATRIPLICION LITTORALIS (Nordh. 40) Tx. 50

Atriplicetum littoralis (Warming 06) Westhoff & Beeftink 50

Nodum of uncertain status related to the Atriplicetum = GROUP 3 (5.1.2.3.).

AGROPYRETEA PUNGENTIS Gehu et Gehu 69

HONKENYO-CRAMBETALIA Gehu et Gehu 69

HONKENYO-CRAMBION MARITIMAE Gehu et Gehu 69

Potentilla anserina-Atriplex patula nodum = GROUP 2 (5.1.2.2.).

AGROPYRETALIA PUNGENTIS Gehu et Gehu 69

AGROPYRION PUNGENTIS Gehu et Gehu 69

Festuca rubra-Trifolium repens nodum = GROUP 1 (5.1.2.1.).

- SAND DUNE
  - AMMOPHILETEA ARENARIAE
    - ELYMO-AMMOPHILETALIA
      - AGROPYRION BOREOATLANTICUM
        - ELYMO-AGROPYRETUM JUNCEIFORME
          - GROUP 2 = POTENTILLA ANSERINA-AGROSTIS STOLONIFERA GROUP (5.2.2.2.)
          - GROUP 3 = AMMOPHILA GROUP (5.2.2.3.)
          - GROUP 4 = ATRIPLEX PATULA-CAKILE MARITIMA GROUP (5.2.2.4.)
  - FESTUCO-BROMETEA
    - BROMETALIA ERECTI
      - MESOBROMION ERECTI
        - CAMPTOTHECIO-ASPERULETUM CYANICHAE
          - GROUP 1 p.p. = FESTUCA-ACHILLEA MILLEFOLIUM GROUP (5.2.2.1.)
  - MOLINIO-ARRHENATHERETEA
    - ARRHENATHERETALIA
      - CYNOSURION CRISTATI
        - LOLIO-CYNOSURETUM
          - GROUP 1 p.p. = RUMEX ACETOSA VARIANT (5.2.2.1.1.2.)

FIGURE 5.2. Synoptic classification of sand dune communities in the Northern Isles.

5.2. Sand dune systems in the Northern Isles - Table 2.

5.2.1. Introduction.

A synopsis of the classification of the vegetation of sand dune systems in the Northern Isles is shown in Fig. 5.2.

Dune systems are poorly developed in Shetland and only at Quendale at the south of Mainland are there all the features of a typical hindshore dune system, including a full successional sequence of communities, a dune loch and well developed dune slacks. In the Northern Isles foreshore communities are quite frequent in sandy sheltered bays and more occasionally a limited development of mobile dunes rising steeply from the shore is encountered. Such a dune system is only poorly developed; small in extent and with no true dune slacks. The dunes quickly give way to a closed community - fixed dune pasture often on blown sand, i.e. machair. The largest area of machair in Shetland is at Breckin, Yell. Overgrazing, rabbit damage and wind action have led to some severe erosion of the machair in this area. Grazing influences are however, important formative agencies of the machair communities (Ranwell, 1974). In true machair, psammophilous dune grasses have been eliminated and this separates machair from fixed dune (Vose *et al*., 1957). The species composition of the foreshore communities, dunes and machair is fairly similar to those in other parts of Scotland, including dune systems in Tiree (Vose *et al*., 1957) in Harris (Gimingham et al., 1948) and the Monach Isles (Randall, 1972).

5.2.2. Community types.

5.2.2.1. Festuca rubra-Achillea millefolium Group = Group 1.

Characterising species: Festuca rubra, Achillea millefolium, Plantago lanceolata, Ranunculus acris, Trifolium repens.

Description: The majority of aufnahmen in this Group are from fixed dune vegetation and small areas of machair. The species-poor subgroup however, are stands from more open vegetation often in eroding areas amidst fixed dunes. Sites in Yell, Unst and Fetlar have been sampled in areas of gneiss, schist, granite, serpentine bedrock. At all sites the substratum is predominantly sand, although in older systems a sand/soil mixture is common. The pH range is between 7.2 and 8.8 and the sand may be dry, damp or even wet. The sites are all low - under 6 m. apart from Breckin where machair covers several hectares inland at altitudes up to 45 m. The more inland machair pastures from this, the largest area of blown sand in Shetland, are included in the Grassland Section 5.4. Group 4.

This vegetation is intensively grazed by sheep, cows, ponies and many rabbits.

The community is a species-rich sward in which herbaceous species may have 100% cover, although the layer varies in height from about 25 mm. to over 203 mm. Bryophytes are often absent, although in damper hollows cover may be 50%. Lichens and shrubs are absent.

Festuca rubra is the dominant species and may be very abundant. Plantago lanceolata, Trifolium repens, Ranunculus acris and Achillea millefolium are all constant species in the community. Other very common forbs include Cerastium holosteoides, Bellis perennis and Leontodon autumnalis, and the grasses Poa subcaerulea, Holcus lanatus, Agrostis tenuis and Agrostis stolonifera. More occasional species in the turf include Ammophila arenaria, Poa annua, Lolium perenne, Cynosurus cristatus, Anthoxanthum odoratum, Potentilla anserina, Cirsium vulgare and the bryophytes Brachythecium rutabulum and Tortula ruraliformis.

5.2.2.1.1. Subgroup with Lotus corniculatus and Euphrasia species - Subgroup 1.

Characterising species: Lotus corniculatus and Euphrasia species.

Description: This subgroup is extremely species-rich and typical of the fixed dune and machair areas.

Plantago maritima and Prunella vulgaris, together with the characterising species are abundant, as well as occasional Vicia cracca, Gentianella campestris, Scilla verna, Trifolium pratense, Luzula campestris, Carex flacca, Equisetum palustre and E. arvense, Armeria maritima and Plantago coronopus.

The community is very attractive and colourful, particularly in spring and early summer.

5.2.2.1.1.1. Variant with Rumex acetosa.

A distinct variant of the subgroup characterised by Rumex acetosa and the constancy of Agrostis tenuis is recorded from some lush grassy communities.

5.2.2.1.1.2. Variant with Carex arenaria.

Some patches within the stable dunes are characterised by Carex arenaria (which may be locally abundant). Viola riviniana is apparently associated with this species.

5.2.2.1.1.3. Typical variant.

The characteristic species of both the Group and sub-group are present. Mnium punctatum is occasionally recorded and the moonwort, Botrychium lunaria.

5.2.2.1.2. Species-poor subgroup = Subgroup 2.

As previously described this is a more open community (although plant cover does remain over 60%), typical of eroded areas within the more stable dune system. The characteristic species of subgroup 1 and its variants are lacking.

5.2.2.2. Potentilla anserina-Agrostis stolonifera group = Group 2.

Characterising species: Agrostis stolonifera, Potentilla anserina, Stellaria media and Cirsium vulgare.

Description: On open sandy patches behind a dune ridge or from eroded patches between poorly formed dunes or sandy patches near a voe side (such as at Gloup) this community characterised by certain nitrophilous species has been recorded. The sites are often sheltered and frequented by sheep, rabbits, cows and even nesting birds, all of which probably increase the nitrogen content of the substratum. The sites (all from Yell and Unst) are all flat, dry, below 9 m., and from gneiss, granite and serpentine areas. The pH range of the sandy substratum ranges from 7.1-8.4. Herb cover varies from 40-70% and the plants in height from an average of 50 mm. to 152 mm. Bryophytes are usually absent or with low cover value.

The community is species-poor and only the characterising species of the group are at all frequent. More occasional species include Poa subcaerulea, P. annua, Cerastium holosteoides, Trifolium repens and Ranunculus acris.

There are two variants within the Group:- one (5.2.2.2.1.) a Bellis perennis, Festuca rubra variant with occasional Tortula ruraliformis is perhaps more similar to the species-poor subgroup of the previous Group. In the second (5.2.2.2.2.) Agropyron repens is constant and Plantago lanceolata occasional.

5.2.2.3. Ammophila Group = Group 3.

Characterising species: Ammophila arenaria.

Description: This community has been recorded from foredunes, from open areas behind the main ridge and before the stable meadow communities and from sandy beaches where no true dunes have formed.

Vegetation in Yell and Unst from areas of gneiss, granite, and schist bedrock at low altitudes - below 15 m./ has been sampled. The substratum is dry sand and the pH ranges from 7.4-8.5.

The community is open and less species-rich than the meadows of Group 1. Herb cover varies from 30-70%. The majority of plants are rarely above 76 mm. in height apart from Ammophila and two other grasses, Elymus arenaria and Agropyron junceiforme, which may reach 1 m. Bryophytes are usually absent, only a Bryum species is rarely recorded.

Only Ammophila is constant and species composition varies at each site. Honkenya peploides, Elymus arenaria, Festuca rubra, Plantago lanceolata, Poa subcaerulea, Vicia cracca, Trifolium repens, Agrostis stolonifera and Potentilla anserina, are all quite common and Luzula campestris, Agropyron junceiforme, Ranunculus acris, Achillea millefolium, Plantago maritima and Leontodon autumnalis are encountered infrequently.

5.2.2.4. Atriplex patula-Cakile maritima Group = Group 4.

Characterising species: Atriplex patula, Cakile maritima, Honkenya peploides.

Description: From the strand and first dunes at Norwick, Unst, this very species-poor open community has been recorded. Each site is dry and bare sand patches are common. The pH is 8.5. Large rounded boulders are found on the actual beach but the plants are rooted in the sand between. Bryophytes are absent and herb cover varies from 10 to 60%.

The few species recorded are all typical of open sandy habitats:- Atriplex patula, Cakile maritima, Honkenya peploides, Ammophila arenaria, Elymus arenaria and Agropyron repens.

5.2.3. Synsystematics.

5.2.3.1. Introduction.

A lack of phytosociological description of British sand dunes combined with comparatively little data from only very poor dune systems in the Northern Isles makes the precise synsystematic placement of the Shetland dune systems very difficult. Information from the Quendale system on the Shetland Mainland may help clarify the position of the impoverished Northern Isles systems.

5.2.3.2. Synsystematics of Group 1 - Festuca rubra-Achillea millefolium Group.

From the little that has been written about the grass turf of dune systems it is apparent that such vegetation is often transitional in synsystematic status between the Mesobromion and the Koelerion albescentis Tx. 37 (Braun-Blanquet & Tüxen, 1952; Ivimey-Cook & Proctor, 1966; Shimwell, 1968).

In the Northern Isles stands no character species of either Alliance are present. Galio-Koelerion (Tx. 37) Den

Held & Westhoff 69 characters include Festuca rubra var. arenaria and Galium verum var. maritimum (Westhoff & Den Held, 1969). This Alliance is synonomous with the Koelerion but although Galium and Festuca were recorded, varieties of species have not been distinguished in this survey. Character species of the respective Order and Class of each Alliance are also absent. The exact phytosociological status of the Group is thus unclear. Comparison at the Association level has been made with Braun-Blanquet & Tüxen's Irish data (1952), the Burren data of Ivimey-Cook & Proctor (1966) and with Shimwell's general survey of calcareous grassland in the British Isles (1968).

Species composition is most similar to the Mesobromion Association, the Camptothecio-Asperuletum cyanichae Br.-Bl. & Tx. 52., or the Galium verum-Asperula cyanchica nodum Ivimey-Cook & Proctor 66. The nodum is essentially the same as the Association without the Sesleria sub-association which Braun-Blanquet and Tüxen described. However, none of the character species of the Association given by Braun-Blanquet and Tüxen are Shetland species - Koeleria cristata, Entodon orthocarpus, Gentiana verna, Neotinea intacta and Teucrium chamaedrys, but the general physiognomy of the Group is similar to the described Association. The Association develops from the Viola curtisii-Syntrichia ruralis Association Br.-Bl. & Tx. 52 of the Koelerion and in the Burren is distinguished from this second Association by the presence of species indicative of grazing, such as Cerastium holosteoides, Hypochaeris radicata and Trifolium repens, and a much reduced bryophyte layer. Luzula campestris is also more or less faithful to the Camptothecio-Asperuletum. Ivimey-

Cook and Proctor describe the Koelerion Association as an open community of calcareous "grey dunes" (Tansley, 1949), characterised by a thin cover of Festuca rubra, a limited but characteristic group of other herbs including Koeleria cristata, Thymus drucei and Lotus corniculatus, a carpet of xerophilous mosses and often a number of small annual species. Such communities represent a successional stage between the mobile communities of the Ammophiletea and closed calcareous dune grasslands of the Mesobromion. It is probable that between the Ammophiletea communities and those of the closed dune grassland that at least small stands of the Viola curtisii-Syntrichia ruralis Association will occur but in general the Shetland communities are not of the type described for the Association, apart from occasional Tortula ruraliformis, acrocarpous mosses are rare, annuals are rare and the community is usually a closed one, in addition, the abundance of grazing species is more typical of the Camptothecio-Asperuletum cyanichae and Luzula campestris is an occasional species of the Group. Shimwell includes Agrostis stolonifera as a differential species of this Association from other Mesobromion Associations. This species is occasional throughout Group 1.

With accumulation of organic matter and leaching in time the Camptothecio-Asperuletum gives way to more general grassland communities such as the Lolio- Cynosuretum. Birse (1973) lists one aufnahme from degraded fixed dune vegetation in

Unst and assigns this to a Koelerion Association but until further information is available on this Euphrasio-Festucetum arenariae Association, it is felt that all the Group 1 stands, apart from the Rumex variant of the Lotus subgroup, are best for the present united in the Camptothecio-Asperuletum acknowledging relationships with communities of the Koelerion albescentis. This tentative proposal may have to be revised if a thorough study of machair grasslands is made in the future.

Braun-Blanquet and Tuxen originally described three subassociations of the Camptothecio-Asperuletum. As previously described in this section, Ivimey-Cook and Proctor felt the Sesleria subassociation was better placed in their Antennaria dioica-Hieracium pilosella nodum. Of the two remaining sub-associations (one of Rhytidiadelphus squarrosus and one of Carex arenaria), it is felt that all of Group 1 (apart from the Rumex acetosa variant) is probably synonomous with the Carex arenaria subassociation. As differential species of the subgroup Shimwell (1968) lists Poa pratensis, Carex arenaria, Tortula ruraliformis and Sedum acre. These are not particularly well represented in Group 1, although Carex arenaria is constant to subgroup 5.2.2.1.1.2., and Tortula ruraliformis is occasional throughout.

Comparison of the aufnahmen with Rumex acetosa and Agrostis tenuis with those of Group 4 of the general Grassland (Section 5.4.2.4.) - the Trifolium repens-Bellis perennis Group -

emphasises the transitional nature of both these communities between the dune grassland and more general grassland community of the Lolio-Cynosuretum. For similar reasons as those expounded in Section 5.4.3.6. the Rumex acetosa variant of Group 1 is placed in the Lolio-Cynosuretum.

5.2.3.3. Synsystematic placing of Groups 2, 3 and 4.

Gehu & Gehu (1969) describe sand dune vegetation from the Atlantic coast of France (see 4.3.). Within the Order Elymo-Ammophiletalia arenariae foreshore vegetation and communities of young sand dunes which are occasionally still subject to the effects of high seas, are placed within the Agropyrion boreoatlanticum, whilst communities of mobile dunes above these are placed in the Ammophilion borealis.

Essentially vegetation of the Agropyrion represents the first stages of the successional dune sequence. The two Alliances are obviously closely related. Ammophila, although characteristic of the Ammophilion is also a frequent species of the Elymo-Agropyretum junceiforme Tx. 55 of the Agropyrion. This Association exists in a series of different stages beginning with many annual species more typical of the Cakiletea maritimae communities (see 4.1.) through a typical phase with dominant Elymus arenaria and terminating with a community which Ammophila arenaria is important.

With so little data from such fragmentary dune systems, the exact phytosociological affinities of the Northern Isles data are unclear, since there are obvious relationships with both the Agropyrion and the Ammophilion. Since many of the aufnahmen are from the foreshore and the rest are from young dunes very much subject to marine influence, the communities of Groups 2, 3 and 4 are placed tentatively in the Elymo-Agropyretum. Of the Class, Order and Alliance characters only Ammophila arenaria, Elymus arenaria, Honkenya peploides, and more rarely Agropyrum juceiforme, are present.

Group 4 corresponds to an early stage of the community characterised by Cakile maritima. This Group is quite closely related to Salsolo-Minuartion peploidis Tx. 50 communities within the Cakiletea maritima (see Section 5.1.). Group 3, a typical phase more transitional to the Ammophilion and Group 2, is a more nitrophilous community. The characterising species of Group 2 are not described in the French vegetation although Agrostis stolonifera, Potentilla anserina and Cirsium vulgare are present in the two lists from foredunes in Skye, which Birks (1973) placed in the Agropyrion boreoatlanticum. Comparison of this Group with both the Festuca-Trifolium repens Group and the Potentilla anserina Group of shingle beaches (see 5.1.) shows obvious similarities, and with more data this Group might prove to be better placed in the Agropyretea pungentis Gehu & Gehu 69.

5.2.4. Synopsis of sand dune communities in the Northern Isles.

AMMOPHILETEA ARENARIAE Br.-Bl. & Tx. 43.

ELYMO-AMMOPHILETALIA ARENARIAE Gehu & Gehu 69.

AGROPYRION BOREOATLANTICUM Gehu & Gehu 69.

Elymo-Agropyretum junceiforme Tx. 55
= GROUPS 2, 3 and 4 (5.2.2.2.; 5.2.2.3.; 5.2.2.4.).

FESTUCO-BROMETEA Br.-Bl. et Tx. 43 em. Tx. 61.

BROMETALIA ERECTI Br.-Bl. 36.

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

Camptothecion-Asperuletum cyanichae Br.-Bl. et Tx. 52.

Carex arenaria sub-association Br.-Bl. et Tx. 52.
= GROUP 1 (5.2.2.1.) without (5.2.2.1.1.2.).

MOLINIO-ARRHENATHERETEA Tx. 37.

ARRHENATHERETALIA Pawlowski 28.

CYNOSURION CRISTATI Tx. 47.

Lolio-Cynosuretum (Br.-Bl. et de Leeuw 36) Tx. 37.
= Rumex acetosa variant GROUP 1 (5.2.2.1.1.2.).

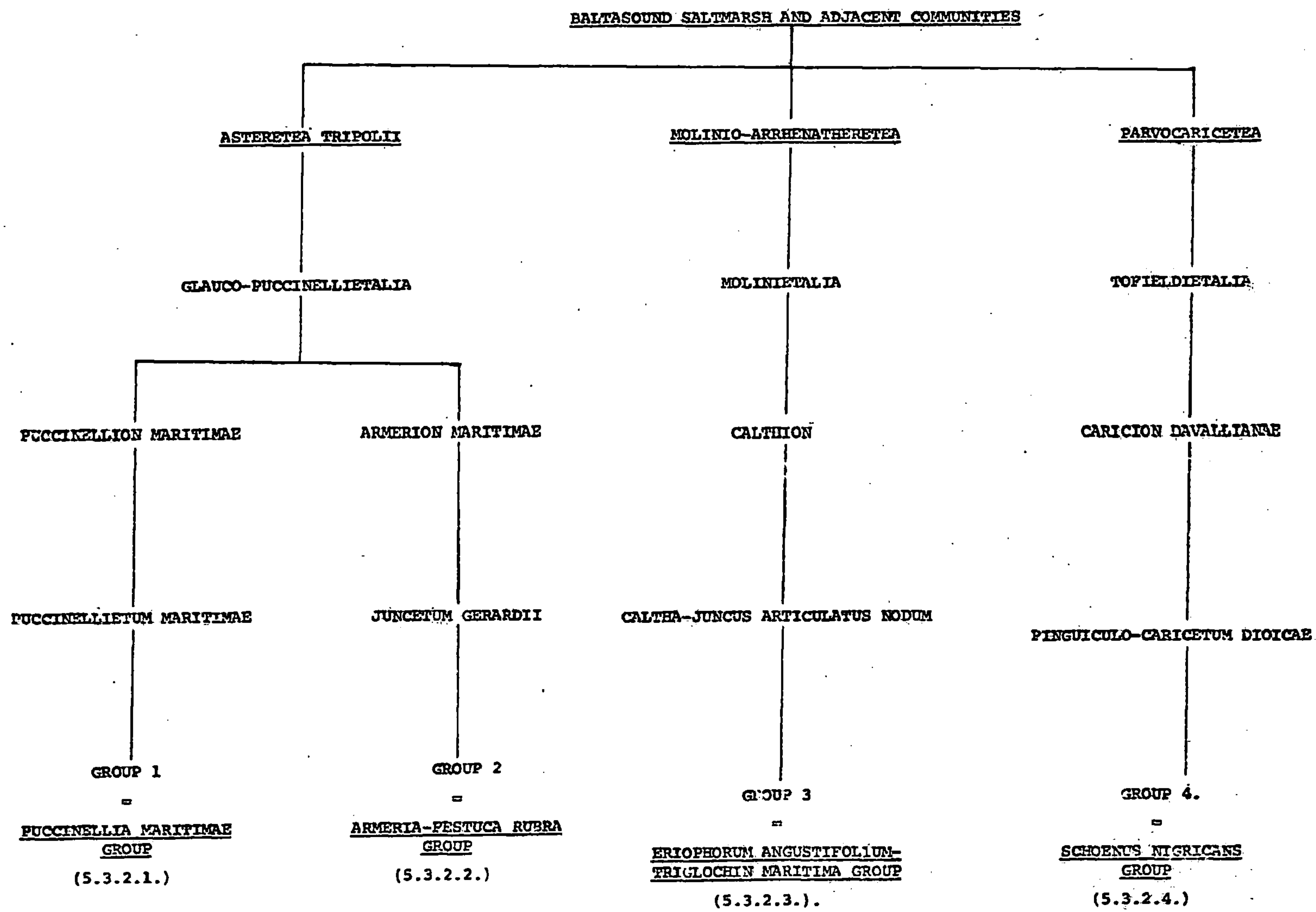


FIGURE 5.3. Synoptic classification of the communities of the Baltasound Saltmarsh area.

5.3. Saltmarsh in the Northern Isles - Table 3.

5.3.1. Introduction

A synopsis of the classification of the Baltasound saltmarsh area is shown in Fig. 5.3.

There are no large saltmarshes in Shetland. Small pockets of species-poor saltmarsh vegetation are however, frequent behind bars and spits on the border of brackish lochs and also on fluvial and glacial deposits at the head of Voes (Johnston, 1974). In Yell, for example, beside Mid Yell Voe there are tiny patches of *Armeria maritima* and *Plantago maritima* rich, short turf with occasional *Festuca rubra*.

At the head of Balta Sound there is a larger area of saltmarsh. The bedrock of the area is serpentine. This was sampled and the results are shown in Table 3. A brief description of the same area is made by Birse & Roberton (1973). The general saltmarsh communities give way to small patches of wet meadow and *Schoenus* flushes at the head of the Sound. A few of these are included in Table 3 and in the following description to show the gradation of communities in the area.

5.3.2. Species Groups.

5.3.2.1. *Puccinellia maritima* Group = Group 1.

Characteristic species: Puccinellia maritima.

Description: A species-poor community dominated by *Puccinellia maritima* was recorded from gravelly areas along the south edge and at the head of the Sound. The soil is a coastal saline grey, flooded daily by the tide (Birse & Robertson, 1973), with an average pH of 7.5. Herb cover is over 90% and at some sites algal cover is 50%.

Characteristically lush stands of Puccinellia are interspersed with Spergularia media and Plantago maritima. Algal species include Fucus vesiculosus, Enteromorpha sp., Oscillatoria sp., and Rhizoclonium sp.

Armeria maritima, Glaux maritima, Triglochin maritima and Juncus gerardii are amongst other species recorded.

5.3.2.2. Armeria maritima-Festuca rubra Group = Group 2.

Characterising species: Armeria maritima, Agrostis stolonifera, Festuca rubra.

Description: A large area of the saltmarsh where the soils, coastal saline gleys (of average pH 7.6), are periodically inundated by the highest spring tides (Birse & Robertson, 1973) is characterised by this community.

Herb cover is 90% but varies in height from 50 mm. to over 304 mm. towards the edge of the area characterised by the community.

Armeria maritima is constant. Glaux maritima, Plantago maritima, Festuca rubra, Agrostis stolonifera, Juncus gerardii and Cochlearia officinalis are recorded in three of the four aufnahmen. Eleocharis quinqueflora is recorded in two stands.

Aufnahme 614 with Eriophorum angustifolium is transitional to the vegetation of Group 3.

5.3.2.3. Eriophorum angustifolium-Triglochin maritima Group = Group 3.

Characterised by Triglochin maritima, Eriophorum angustifolium and Ranunculus flammula.

Description: At the extreme head of the Sound amidst the wet pools and streams flowing to the sea true saltmarsh gives way to small patches of wet meadow-type vegetation. The soft wet brown substratum (average pH 7.0), although frequently subject to salt spray would only be inundated very infrequently by the very highest tides or roughest seas.

The herb layer, of average height 203 mm., varied in cover from 50-100%. Two species of bryophyte, Eurhynchium praelongum and Campylium polygamum were recorded but cover was low.

The characteristic feature of the community was the constancy of Triglochin maritima. The other most frequent species included Agrostis stolonifera, Eriophorum angustifolium, Holcus lanatus, Juncus articulatus, Ranunculus flammula, Carex nigra and C. panicea.

This Group could have been placed with other wet meadow aufnahmen in Table 5, but has been left in this Section to show the transition from saltmarsh to pasture vegetation. The presence of Triglochin shows affinities with saltmarsh communities. Aufnahme 572, more species rich and lacking this species is more typical wet meadow and included in Table 5.

5.3.2.4. Schoenus nigricans Group = Group 4.

Characterised by Schoenus nigricans, Carex flacca, Molinia caerulea.

Description: Three aufnahmen at the head of the saltmarsh in the gravelly area beside one of the streams entering the Sound have been recorded, distinguished by the abundance of Schoenus nigricans tussocks. Average pH of the shallow gravelly soil was 7.6. Herb cover varies from 30% to 80% and the tussocks from 152-203 mm. in height. Bryophyte cover is about 5%.

Tussocks of Molinia caerulea, Eleocharis quinqueflora and Juncus kochii are also characteristic, interspersed with Agrostis stolonifera, Plantago maritima, Carex flacca, Pinguicula vulgaris, Succisa pratensis and Selaginella selaginoides.

Riccardia pinguis is constant and Amblystegium serpens is recorded from two aufnahmen.

5.3.3. Synsystematics

5.3.3.1. Introduction

There are various accounts of saltmarsh communities in the literature (e.g. Beeftink, 1966; Ivimey-Cook & Proctor, 1966; Birks, 1973). The most recent account is a detailed study of the British saltmarshes by Adam (1976), although Shetland was not included in this survey. Further details of wet meadow and Schoenus flush vegetation are in Sections

5.5. and 5.9. respectively. The syntaxonomic units are discussed in Chapter 4.

5.3.3.2. Synsystematic placing of Group 1.

The vegetation of the lower parts of saltmarshes is generally assigned to the Puccinellietum maritimae (Warming, 1890) Christiansen 27 of the Puccinellion maritimae. The vegetation in southern Britain may be more species-rich than the Scottish communities. The Balta Sound data with Armeria maritima, Glaux maritima and Plantago maritima, as well as Puccinellia maritima, is similar to the community described from Skye, which is assigned to the Puccinellietum (Birks, 1973). Plantago maritima and Triglochin maritima (both occasional in the Balta Sound stands) are Asteretea tripolii character species and Spergularia media is an Order character (see 4.5.). The occurrence of Armeria and Glaux relates the community to the Armerion (see 6.3.3.3.) but on the presence of Puccinellia and the general physiognomy of the community Group 1 is assigned to the Puccinellietum.

5.3.3.3. Synsystematic placing of Group 2.

This Group is assigned to the Juncetum gerardii Warming 1906 of the Armerion maritimae. The absence of Puccinellia maritima apparently effectively distinguishes the Armerion from the Puccinellion (Ivimey-Cook and Proctor, 1966; Birks, 1973). Armerion character species are well represented in the Balta Sound stands - Armeria maritima, Glaux maritima and Juncus gerardii. Westhoff & Den Held (1969) also list varieties of Festuca rubra and Agrostis stolonifera. Both species are present in Group 2, although varieties have not been distinguished.

The Juncetum gerardii is the most extensive Armerion community in Britain and from the description of Adam (1976) the Balta Sound data may represent part of his Festuca-Glaux nodum, in which Juncus gerardii, Festuca rubra, Plantago maritima and Glaux maritima are constant, and Agrostis stolonifera, Triglochin maritima and Armeria are frequent.

5.3.3.4. Synsystematic placing of Group 3.

The overall species composition of this Group is very similar to the Ranunculus flammula variant of the Caltha-Juncus articulatus nodum described in the wet meadow Section 5.5. Group 3 is distinguished by the lower constancy of Caltha palustris and the constant occurrence of Triglochin maritima and the more frequent occurrence of Carex panicea. The presence of Triglochin relates the Group to saltmarsh communities of the Asteretea tripolii, to which it is adjacent in the field.

The Group is best described as a Triglochin maritima subvariant of the Ranunculus flammula variant of the Caltha-Juncus articulatus nodum. For the reasons put forward in

Section 5.5., this nodum is assigned to the Calthion within the Molinietalia of the Molinio-Arrhenatheretea.

5.3.3.5. Synsystematic placing of Group 4.

Communities of base-rich flushes and mires were united by Jones (1973) in a new Association - the Pinguiculo-Caricetum dioicae, and it is suggested that Group 4 is synonomous with part of this Association. Jones described the Association using Widdybank Fell data as well as community types recognised from Scotland by McVean & Ratcliffe (1962) and Birks (1969) and from elsewhere by Shimwell (1968). The Association belongs to the Caricion davallianae. No Alliance character species are present in the Balta Sound stands (see 4.7.). Eleocharis quinqueflora is a Tofieldietalia character and Riccardia pinquis and Carex demissa are Parvocaricetea character species. As character species of the Association Jones (1973) uses the Order character Carex dioica, the Alliance characters Tofieldia pusilla and Carex lepidocarpa, together with Triglochin palustris and Kobresia simpliciuscula. Of these species Tofieldia and Kobresia are not Shetland species. Despite the absence of all these species from Group 4 there are close similarities between the Balta Sound data and the composite data of Jones.

The concept of the Pinguiculo-Caricetum was expanded by Wheeler (1975) and the internal structure of the Association re-organised to avoid confusion between the sub-association molinietosum and a Succisa subvariant of a second sub-association, the eleocharetosum, which were defined by several of the same species, Eriophorum latifolium, Molinia caerulea and Succisa pratensis. Wheeler had noted that frequently species which differentiated the variant Saxifrago-Scorpidium, to which the Succisa subvariant belonged, were often poorly represented or absent altogether in communities of the subvariant. Wheeler proposed that those aufnahmen with these species all be united in the molinietosum and the aufnahmen with the differential species of the eleocharetosum form an Eleocharis variant of the molinietosum. This new scheme fits the Northern Isles data well since of the Saxifrago-Scorpidium differentials, only Erica tetralix was recorded and only in one aufnahme.

The Balta Sound data is species-poor and none of the species which typically characterise the Association are present. However, Molinia caerulea and Succisa pratensis are molinietosum differential species and Eleocharis quinqueflora, Eriophorum angustifolium, Carex demissa and Juncus kochii characterise the Eleocharis variant.

Because of the constancy of Schoenus nigricans the Group is assigned to a Schoenus subvariant.

The vegetation is closely related to the Schoenus flushes of the Burren (Ivimey-Cook & Proctor, 1966) and to the vegetation of the Schoenetum nigricantis W. Koch 1926. Jones differentiates the Pinguiculo-Caricetum from these other vegetation types by the presence of Carex pulicaris and Plantago maritima. Although Wheeler does not consider these as good differential species, the presence of Plantago maritima and overall species composition of Group 4 does differentiate it from these similar types and the Group is thought to be satisfactorily described as part of the Pinguiculo-Caricetum dioicae.

5.3.4. Synopsis of the saltmarsh and adjacent communities.

5.3.4.1. True saltmarsh.

ASTERETEA TRIPOLII Westhoff & Beeftink 62.

GLAUCO-PUCCINELLIETALIA Beeftink & Westhoff 62.

PUCCINELLION MARITIMAE Christiansen 27. em. Tx. 37.

Puccinellietum maritimae (Warming 1890) Christiansen 27.

= GROUP 1 (5.3.2.1.).

ARMERION MARITIMAE Br.-Bl. et de Leeuw 26.

Juncetum gerardii Warming 1906.

? Festuca-Glaux nodum Adam. 76 = GROUP 2 (5.3.2.2.).

5.3.4.2. Adjacent wet meadow.

MOLINIO-ARRHENATHERETEA Tx. 37.

MOLINIETALIA Koch 26.

CALTHION Tx. 37. em. 51.

Caltha-Juncus articulatus nodum.

Ranunculus flammula variant.

Triglochin maritima subvariant = GROUP 3 (5.3.2.3.).

5.3.4.4. Schoenus flush at Sound head.

PARVOCARICETEA den Held & Westhoff 69.

TOFIELDIETALIA Prsg. apud Oberd. 49.

CARICION DAVALLIANAE Klika 34.

Pinguiculo-Caricetum dioicae Jones 73 em Wheeler 75.

molinietosum Jones 73 em Wheeler 75.

Eleocharis variant.

Schoenus subvariant = GROUP 4 (5.3.2.4.).

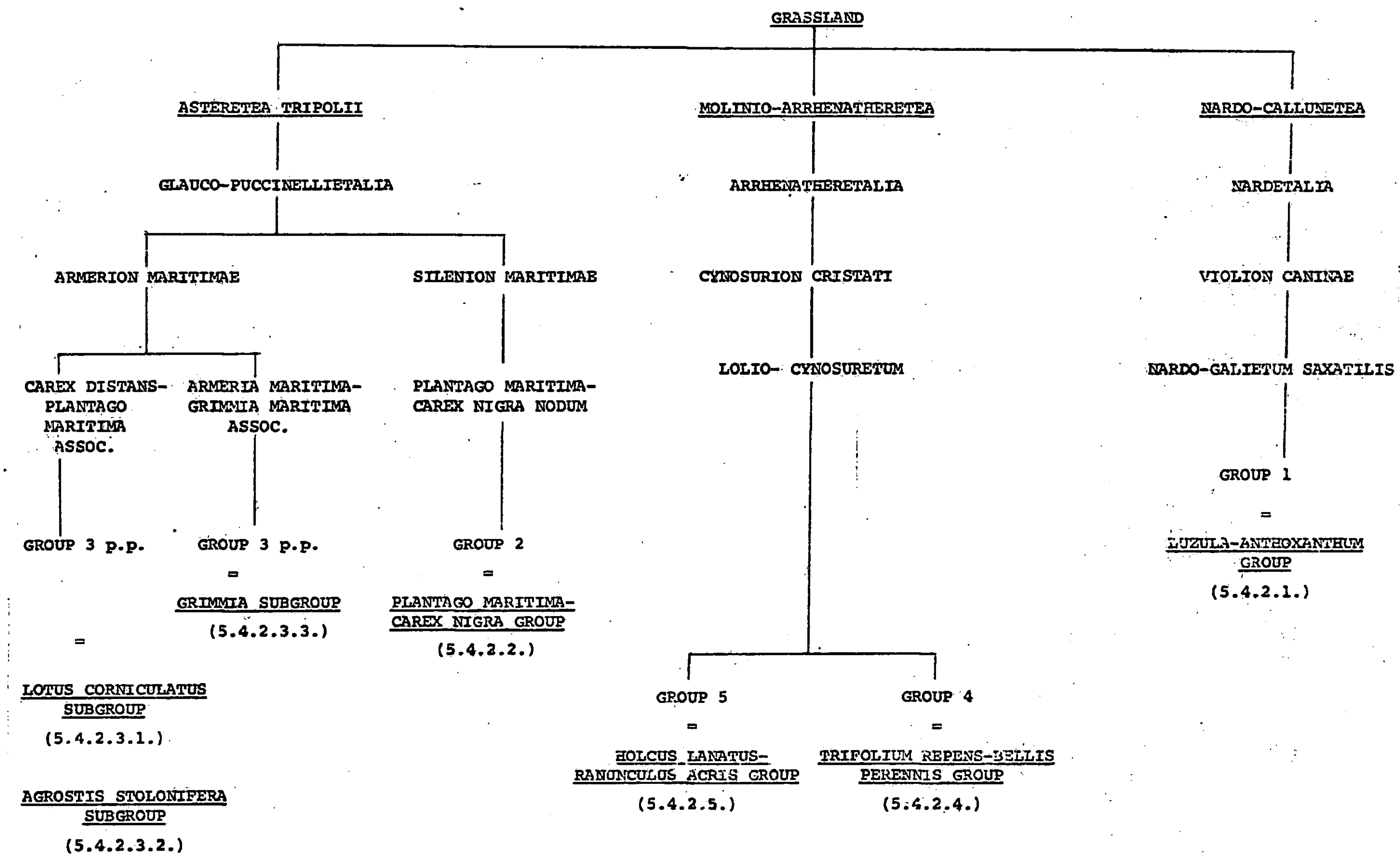


FIGURE 5.4. Synoptic classification of grassland communities in the Northern Isles.

5.4. Grassland - Table 4.

5.4.1. Introduction.

A synopsis of the classification of grassland communities is shown in Fig. 5.4.

Grassland, which is vegetation dominated by grass species and forbs covers a relatively small proportion of land in the Northern Isles but includes a number of interesting communities. The majority of aufnahmen are from cliff-tops, maritime grassland, roadsides and permanent pasture. The latter has usually been cultivated at some time in the past and includes bog land which has been drained and reseeded. A very few aufnahmen are from grassland forming part of a rotational sequence.

In sown pastures, *Phleum pratense*, *Lolium perenne* and *Poa trivialis* are abundant as they are part of the seed mixture (Birse & Robertson, 1973). With ageing of the pasture *Phleum* dies out but *Lolium perenne* and *Poa trivialis* remain abundant with heavy grazing and fertilizing. *Trifolium repens* also flourishes with intensive grazing (O'Sullivan, 1965). If the grazing pressure decreases *Lolium* and *Poa trivialis* decrease in abundance and *Festuca rubra*, *Holcus lanatus*, *Anthoxanthum odoratum* and *Agrostis tenuis* are the dominant species. Eventually the pasture may be so degraded as to be transitional to an acidic grassland with abundant heath species.

If drainage is greatly impeded the pasture communities may degrade into wet meadow types similar to those of Section 5.5.

On blown sand behind dunes such as at Breckin Yell there are quite large areas of machair type grassland which is intensively grazed by both sheep and rabbits (see also 5.2.).

A zone of short grass turf is found at most cliff tops probably maintained by wind and spray, as well as grazing. Maritime grassland is characteristic to the shore-line of many small islands as well as round the lower parts of the coast line of Yell, Unst and Fetlar. The majority of the small islands have been inhabited in the past and especially around croft remains old permanent pasture communities are typical.

Where grass areas have been adopted by breeding and roosting birds the species composition of the grassland may be quite modified by the establishment of nitrophilous species such as Potentilla anserina or Stellaria media.

5.4.2. Community types.

5.4.2.1. Luzula-Anthoxanthum odoratum Group = Group 1.

Characterising species: Anthoxanthum odoratum with a variety of species more typical of heath communities including Luzula multiflora.

Description: From a wide variety of different sites in Yell, Unst, Daaey and Kay Holm a community dominated by grass species but with a variety of herbs typical of heath vegetation has been recorded.

A dense herb-layer 152 mm. average height (always with 50% cover and often nearer 100%) is interspersed with bryophytes which vary from 5 to 90% in cover. Lichens have low cover if present at all. Occasional Peltigera canina or Cladonia species are the only commonly recorded species. Very rarely where the community borders with heath or bog Calluna has been recorded.

The community may form a lush band behind the typical low sward of many cliff tops such as at Vatsetter Yell. On the small islands of Daaey and Kay Holm these grassy patches are interspersed with bog types and are most common above the beaches on the low cliffs. In parts of Yell and Unst the community is found amidst better pasture of reseeded meadows perhaps reflecting the tendency of the vegetation to revert to heath and bog if not properly maintained. At Ordale, Unst, the community was found beside an abandoned croft. The community is also typical of some roadsides. The sites vary between 9-36 m. in altitude and apart from the steep edges of Gloup Voe the community is only found on virtually flat ground with slopes of less than 5^{o}.

Although the bedrock may vary - gneiss, schist, serpentine, greenstone or granite - the soil has always been recorded as a dry or damp, dark brown, silty soil, sometimes shallow and stoney. The pH values in areas of basic rock are higher but an average is 5.4.

Every site, whether scattald or enclosed land, is grazed by sheep.

Various Gramineae dominate the herb layer with Anthoxanthum odoratum constant and Festuca rubra, Holcus lanatus, Nardus stricta, Festuca vivipara and Agrostis tenuis, very frequent. Cynosurus cristatus is rare.

Luzula multiflora is constant and Leontodon autumnalis, Potentilla erecta, Galium saxatile, Viola palustris, Scilla verna, Cerastium holosteoides and Rumex acetosa are common throughout the Group. From Table 4 it will be apparent that although there is not a strict division into two sub-groups there is a trend from "more heathy " to "less heathy ". In the first Nardus and Festuca vivipara are more common, as well as Viola riviniana, Polygala serpyllifolia, Deschampsia flexuosa, Carex nigra, C. panicea, Succisa pratensis and Aira praecox and the mosses, Thuidium tamariscinum, Dicranum scoparium and Polytrichum juniperinum and the lichen, Peltigera canina. In the "less heathy" group Ranunculus acris and Trifolium repens are more frequent. Where the Group has been recorded from roadsides, it tends to be this "less heathy" type.

Throughout the whole group Lophocolea cuspidata, Mnium hornum, Polytrichum formosum and Rhytidiadelphus squarrosus are frequent in the bryophyte layer.

5.4.2.2. Plantago maritima-Carex nigra Group = Group 2.

Characterising species: Festuca rubra, Carex nigra, Plantago lanceolata, P. maritima.

Description: This community has been recorded from several cliff top sites varying in altitude between 1 m. and 42 m. in Yell, Unst and Fetlar, as well as the small islands Daaey and Kay Holm, where the soil is usually shallow, dark, mineral-rich and sometimes sandy. The substratum is dry or at most damp and the pH varies between 5.4 and 8.6, according to the parent bedrock which includes schist, gneiss, granite and serpentine. The sites are all flat or at most gently sloping.

The same community was recorded from meadows in Unst and Fetlar not far from the sea, where the soil was shallow and rocky outcrops were frequent. Every site would be grazed even if only lightly by sheep.

Typically the community is a dense grassy sward, where herb cover is often nearly 100%. Although in meadows the herbs may average 178 mm. in height, typically at cliff top sites the sward averages 51 mm. Bryophyte cover is low, averaging under 20% and lichens, apart from occasional Peltigera canina, are virtually absent.

Festuca rubra and Plantago maritima are constant in the turf and often very abundant. Plantago lanceolata is also constant but only scattered plants were recorded in each aufnahme. Species which occur very frequently include

Anthoxanthum odoratum, Holcus lanatus, Carex nigra, Euphrasia species, Leontodon autumnalis, Trifolium repens, Ranunculus acris, Bellis perennis and Sagina procumbens. A variety of other herbs are interspersed occasionally with these species to form a dense sward, including Agrostis tenuis, Luzula multiflora, Potentilla erecta, Cerastium holosteoides, Rumex acetosa, Potentilla anserina, Armeria maritima, Plantago coronopus, Lophocolea cuspidata, Rhytidadelphus squarrosus, Eurhynchium praelongum and Mnium hornum.

Small tussocks of Nardus stricta and plants of Carex demissa, C. panicea and C. flacca are rare.

5.4.2.2.1. Subgroup with Lotus corniculata us = Sub-group 1.

From some of the true cliff top sites a varient of the community with Lotus corniculat~~a~~us, Scilla verna, Thymus drucei and Prunella vulgaris, was recorded. Mnium hornum and Potentilla erecta are more frequent in this sub-group.

5.4.2.2.2. Typical sub-group = Subgroup 2.

The remaining aufnahmen lacked the characteristic species of subgroup 1 and were generally more species-poor. Agrostis stolonifera, Poa annua and Juncus articulatus were recorded occasionally in this group.

5.4.2.3. Plantago maritima-Armeria maritima Group = Group 3.

Characterising species: Plantago maritima, Armeria maritima, Festuca rubra.

Description: This Group includes vegetation from a hotchpotch of sites including cliff tops in Unst and Yell; a low, rocky cliff-like outcrop at Gossabrough Yell; vegetated ledges in a steep cliff at Gloup Voe, Yell; almost machair-like meadows near the sea at West Sandwick, Yell, as well as patches amidst rocky shorelines of some of the small islands including Daaey, Kay Holm, Sound Gruney and Haaf Gruney.

The cliff sites may be over 22 m. in height but the majority of the small island sites are below 12 m. and often much nearer sea level. The substratum varies from a quite deep, dark, rich, brown soil to a much sandier soil at Gossabrough and West Sandwick. Some sites are dry, others much wetter and pH ranges from 5.4 to 8.2 according to the parent bedrock which includes gneiss, granite and serpentine. Despite this tremendous variety in habitat a community is easily distinguished as similar at all these sites. Although the community is comparatively species-poor herb cover is always over 50% and often 100%. A low grazed sward less than 50 mm. high is common, although an herbaceous layer of up to 152 mm. in height is also frequent. Bryophytes are frequently absent and when present cover is never more than 10%. Lichens are uncommon; only Lepraria incana, Ramalina silignosa and R. subfarinacea are recorded.

Plantago maritima dominates the community with abundant Festuca rubra and Armeria maritima. Cochlearia officinalis and Plantago coronopus are occasional, and Scilla verna and *Juncus gerardii* rare. *Eurynchium praelongum* is the only common bryophyte. Three subgroups are apparent, although the ecological factors responsible for them are unclear.

5.4.2.3.1. Subgroup with *Lotus corniculatus* = Subgroup 1.

This subgroup is most species rich with a greater variety of herbs recorded including:- *Plantago lanceolata*, *Lotus corniculatus*, *Euphrasia species* and *Sagina procumbens*, *Trifolium repens* and *Cerastium holosteoides* are more frequent in this subgroup.

5.4.2.3.2. Subgroup with *Agrostis stolonifera*.

This subgroup is distinguished by the presence of *Agrostis stolonifera*, *Stellaria media* and occasional *Holcus lanatus* and *Potentilla anserina*.

5.4.2.3.3. Subgroup with *Grimmia maritima*.

Each of these four aufnahmen was recorded from small patches of vegetation growing on small pockets of shallow soil amidst the rocky outcrops of the shore of Kay Holm, Sound Gruney, Haaf Gruney and at Gossabrough Yell.

Each was species-poor with virtually only the characterising species of the group as well as tiny clumps of the moss, *Grimmia maritima*. *Puccinellia capillaris* was recorded from the Sound Gruney site and *Puccinellia maritima* from the Haaf Gruney site.

5.4.2.4. Trifolium repens-Bellis perennis Group = Group 4.

Characterising species: Festuca rubra, Plantago lanceolata, Trifolium repens, Ranunculus acris, Cerastium holosteoides, Bellis perennis, Achillea millefolium.

Description: This species rich community has been recorded from dry, gently sloping machair-type meadows, in Yell and Unst and general pasture land in Fetlar and Unst and from the small islands of Haaf Gruney and Samphrey. A similar rather impoverished type of the community has been recorded from some roadsides. A shallow, dark soil but with much sand in it, is typical of pH range 5.4 to 8.3. The altitudinal range of the sites varied from 5 m. on Haaf Gruney to 27 m. at Breckin, Yell. The bedrock types include serpentine, gneiss, granite and schist.

The herb layer of this Group is dense with over 90% cover and varies in height between 50 and 152 mm. Bryophytes may be absent or with less than 20% cover and lichens, apart from very occasional Peltigera canina, are absent.

A great variety of herbs make an often colourful turf with the characterising species of the Group all constant components and Agrostis tenuis, Lolium perenne, Cynosurus cristatus, Rumex acetosa, Lotus corniculatus and Plantago maritima all very frequent. Occasional species include Anthoxanthum odoratum, Holcus lanatus, Poa subcaerulea, Leontodon autumnalis, Euphrasia species, Trifolium pratense, Luzula campestris, Lophocolea cuspidata and Brachythecium rutabulum.

Breckin meadows are very rich with Scilla verna making a colourful display in June, as well as Prunella vulgaris, Heracleum sphondylium, Rhinanthus minor, Honkenya peploides and many other herbs.

These species rich meadows are grazed quite heavily by both sheep and cows and rabbits.

5.4.2.5. Holcus lanatus-Ranunculus acris Group = Group 5.

Characterising species: Holcus lanatus, Agrostis tenuis, Trifolium repens, Ranunculus acris and Cerastium holosteoides.

Description: This community has chiefly been recorded from quite damp old croft land, which has been cultivated in the past for pasture or, more recently, reseeded land. Bog or wet meadow types are frequently adjacent to this community which is heavily grazed by sheep and cows. The aufnahmen are from Yell, Unst, Samphrey, Daaey, Sound Gruney and Haaf Gruney from fairly flat sites at altitudes between 6 m. and 76 m. The vegetation has only been recorded on gneiss and serpentine and the pH range varies accordingly between 5.4 and 8.2. The substratum is always a dark, soft soil, but varies in depth, occasionally with boulders exposed.

The community is dominated by Holcus lanatus and Agrostis tenuis and the herb-layer has usually over 80% cover of average height about 102 mm., but with much higher clumps of Iris pseudacorus or Juncus effusus at some sites.

Bryophytes may be absent or form a ground layer 13 mm. in height with 4% cover. Lichens are absent.

Trifolium repens, Ranunculus acris, and Cerastium holosteoides are constant components of the community and Poa subcaerulea, Rumex acetosa, Sagina procumbens, Montia fontana and Eurhynchium praelongum are very frequent. Species recorded occasionally include Festuca rubra, Anthoxanthum odoratum, Lolium perenne, Cynosurus cristatus, Poa annua, Alopecurus geniculatus, Juncus effusus, Cardamine pratensis, Bellis perennis and Ranunculus repens. Leontodon autumnalis, Trifolium pratense, Potentilla anserina, Carex flacca and Lophocolea cuspidata are recorded rarely. Juncus bufonius and Carex ovalis are recorded from Otterswick, Yell. Iris pseudacorus is recorded from Samphrey.

5.4.2.5.1. Subgroup with Agrostis stolonifera = Subgroup 1.

This subgroup is distinguished by the presence of Carex nigra and Agrostis stolonifera.

5.4.3. Synsystematics.

5.4.3.1. Introduction.

A wide variety of phytosociological descriptions of different types of grassland in the British Isles are available in the literature. Those which have been most useful for the Shetland data are Shimwell (1968), O'Sullivan (1965), Jones (1973) and Malloch (1971).

5.4.3.2. Synsystematic placing of Group 1 - Luzula-Anthoxanthum Group.

The general character of this community is typical of vegetation of the Nardo-Callunetea, which encompasses the vegetation of poor rough grassland as well as of heaths. Of the Class character species (see 4.10.), Potentilla erecta is frequent and Carex pilulifera and Sieglingia decumbens are present.

Comparison of the data with lists in Shimwell (1968) and Jones (1973) suggests the Group is synonymous with the Association Nardo-Galietum saxatilis Preising 49. This community is a member of the Violion caninae, the Alliance of herb-rich rough grasslands. The Association as seen by Shimwell (1968) comprises acidic grassland dominated by Nardus, Deschampsia flexuosa, Festuca spp., Agrostis spp., Potentilla erecta and Galium saxatile. Apart from the absence of Deschampsia flexuosa the general character of the Group corresponds well with the Nardo-Galietum saxatilis. Nardus stricta is the only Nardetalia character present. Luzula multiflora, Galium saxatile, Dactylorchis ericetorum and Juncus squarrosus, which are represented in Group 1, are Violion caninae characters. The relationships of this Association with the related Nardo-Juncetum squarrosi are discussed in the heath section 5.8.3.3.

A few species of the Molinio Arrhenatheretea are present, especially in the "less heathy" stands, and Holcus, for example, is quite frequent. However, Violion character species dominate and the general physiognomy is that of the Nardo-Galietum saxatilis. Birse & Robertson (1973) describe a Potentilla facies of Agrostis-Festuca meadow grassland and suggests this represents older pastures where some of the sown-out species have died out and those that remain, such as Holcus, have formed a stable community with the natural grasses. Many of the sites from which Group 1 have been recorded would have been more frequently manured and better managed in the past when crofting was more intensive and probably do now represent stands of older pastures.

5.4.3.3. Synsystematic placing of Group 2 - Plantago maritima-Carex nigra Group.

The majority of these aufnahmen are from cliff top stands. The most detailed phytosociological account of cliff top grasslands is the description of Cornish maritime vegetation by Malloch (1971).

The majority of cliff top grasslands with Festuca rubra, Armeria maritima, Daucus carota spp. gummifer and Silene maritima were placed in a new Alliance, the Silenion maritimae Malloch 71. Within the Alliance Malloch described three Associations. A large majority of ungrazed and grazed grassland was encompassed by the Festuco-Armerietum rupestris. Ungrazed, species poor grassland described as a "Festuca rubra mattress" with Armeria maritima and Daucus carota spp.

gummifer also of high constancy and Silene maritima, Lotus corniculatus and Agrostis stolonifera frequently formed a typical sub-association of the Festuco-Armerietum. Vegetation with Crithmum maritimum and low Daucus carota was described as the sub-association with Crithmum maritimum. A Holcus-Dactylis variant of the typical sub-association was described which contained species more typical of the second Association - the Festuco-Dactyletum maritimae, including Holcus lanatus, Dactylis glomerata, Rumex acetosa, Plantago lanceolata and Scilla verna, although Festuca rubra was still the dominant species.

Where the maritime grassland is grazed by sheep and cattle a short turf with Festuca rubra, Armeria maritima, Daucus carota spp. gummifer and Plantago coronopus is constant, Holcus lanatus, Scilla verna, Leontodon taraxacoides and Lotus corniculatus very frequent, and Silene maritima, Agrostis stolonifera, Plantago lanceolata and Anthyllis vulneraria frequent, was the characteristic vegetation and this was described as a Plantago coronopus sub-association of the Festuco-Armerietum. Similar vegetation recorded from the Burren by Ivimey-Cook & Proctor (1966) as a Cerastium atrovirens-Plantago coronopus Association was included within this new sub-association.

The Festuco-Dactyletum maritimae vegetation was characteristically rough, tussocky, ungrazed grassland forming a zone inland of the typical sub-association of the *Festuco-Armerietum* and characterised by the constant presence of seven species:- *Festuca rubra*, *Daucus carota*, *Holcus lanatus*, *Dactylis glomerata*, *Rumex acetosa*, *Plantago lanceolata* and *Scilla verna*. More non-maritime species were recorded in this Association than in the others.

The third Association, the *Endymio-Armerietum maritimae* accommodated vegetation in which the bluebell, *Endymion non-scriptus* was constant.

Comparison of Group 2 vegetation with the descriptions and tables of Malloch indicates most similarity with the grazed subassociation of the *Festuco-Armerietum*, in which species of the *Festuco-Armerietum* (*Festuca rubra*, *Armeria maritima* and *Agrostis stolonifera*), as well as some of the *Festuco-Dactyletum* (*Holcus lanatus*, *Plantago lanceolata* and *Scilla verna*) are present. *Rumex acetosa* (a characteristic species of the *Festuco-Dactyletum*) is occasional in Group 2.

However, although *Festuca rubra* is constant in Group 2 neither *Armeria maritima* or *Plantago coronopus* (both constant in the grazed Cornish vegetation) are particularly common. In addition, *Plantago maritima* is both constant and often abundant. Malloch described a *Plantago maritima* nodum of grazed grassland from the Lizard and Land's End area, in which the sward was dominated by *Plantago maritima* with *Festuca rubra*, *Armeria maritima*, *Plantago coronopus* and a few other species, including Holcus lanatus and Trifolium repens. This vegetation was placed in the Carex distans-Plantago maritima Association of Ivimey-Cook and Proctor (1966) despite the absence of Carex distans. This vegetation as described from the Burren consisted of a turf in which Festuca rubra was dominant, Carex distans, Agrostis stolonifera, Plantago maritima and P. coronopus constant, and a number of grassland species, in particular Trifolium repens, present. Scilla verna, although absent from the Irish data was present in the Cornish data. A number of other species frequent in Group 2 are present in the Carex distans-Plantago maritima Association, including Leontodon autumnalis, Cerastium holosteoides and Euphrasia species. However, Plantago lanceolata and Holcus lanatus are absent.

A number of species common in Group 2 such as Anthoxanthum odoratum, Agrostis tenuis, Potentilla erecta, Carex nigra and Sagina procumbens are absent from both the Carex distans-Plantago maritima Association and the Festuco-Armerietum. This, together with the intermediate position of the Shetland data between the two Associations, as well as the presence in Group 2 of a few Nardo-Callunetea species of Group 1 and Molinio-Arrhenatheretea species, suggests the Group is best for the present considered as a nodum within the Silenion maritimae. With more data from the south of Shetland it is possible that a new Association might be proposed most probably as part of the Silenion. The two subgroups, the typical subgroup and the subgroup with Lotus corniculatus are for the present considered as variants of the nodum. The presence in Group 2 of a very few aufnahmen from rather inland grassland probably reflects the extreme maritime environment of Shetland and thus the existence inland of vegetation more usually present at the coast.

5.4.3.4. Synsystematic placing of Group 3 - the Plantago maritima-Armeria maritima Group.

This Group is much less species-rich than Group 2. From the discussion in the last Section of the Festuco-Armerietum and the Carex distans-Plantago maritima Association the general species composition of subgroups 1 and 2, and in particular the constancy of Festuca rubra, Plantago maritima and Armeria maritima and no other species, suggests that both the subgroup with Lotus corniculatus and the subgroup with Agrostis stolonifera are part of the Carex distans-Plantago maritima Association. The occasional presence of Glaux maritima and Juncus gerardii (both character species of the Armerion maritimae, in which the Association is placed) emphasises this.

The more species-rich subgroup with Lotus corniculatus in which Plantago lanceolata is constant is a community closer in composition to the nodum of Group 2. The presence in subgroup 2 (the subgroup with Agrostis stolonifera) of Stellaria media and Potentilla anserina, suggests nitrogen enrichment probably from guano of birds breeding in Sound Gruney.

Birks (1973) described an open maritime *Armeria maritima-Grimmia maritima* Association from rock crevices and ledges, in which *Festuca rubra*, *Plantago maritima*, *Armeria maritima* and *Grimmia maritima* were constant. Subgroup 3 with *Grimmia maritima* is very similar in species composition to the Skye community. The lichens *Anaptychia fusca* and *Ramalina siliquosa* exclusive to the Association in Skye are recorded in the aufnahme from Kay Holm. Two aufnahmen from Subgroup 3 however contain *Puccinellia* species and *Puccinellia maritima* is a differential species of the *Puccinellion maritimae* from the *Armerion*. Birk's Association is placed in this latter Alliance, although he suggests the Association is distinctive enough in floristic composition to justify the delimitation of a new Alliance. Despite the presence of *Puccinellia* in the absence of more data it is proposed that for the time subgroup 3 with *Grimmia maritima* is best accommodated in the *Armeria maritima-Grimmia maritima* Association (Birks, 1973).

5.4.3.5. Synsystematic placing of Group 5 - *Holcus lanatus-Ranunculus acris* Group.

Group 5 consists mainly of stands of vegetation from permanent pasture, some of which may have been reseeded in the past.

Birse (1973) and Birse & Robertson (1973) assigned communities of rotational grassland and more heavily grazed pastures from Sullom and Balta Sound to the Lolio-Cynosuretum Br.-Bl. and De Leeuw 36 an Association of the Cynosurion cristati within the Molinio-Arrhenatheretea.

The Association has been described in great detail from Ireland by O'Sullivan (1965), and it is proposed that Group 5 is synonymous with at least part of this Association. O'Sullivan defines the Association on a negative basis by the absence of character and differential of a second Cynosurion Association, the Centaureo-Cynosuretum Br.-Bl. et Tx. 52. Of these species only Luzula campestris is recorded in Group 5 and only in two stands, and thus there is no possibility of confusion with this second Association.

Class character species are well represented in the Group. Holcus lanatus, Ranunculus acris and Cerastium holosteoides are constant and Poa subcaerulea, P. trivialis, Rumex acetosa, Trifolium pratense and Cardamine pratensis are all quite common.

Order character species are uncommon. The only Arrhenatheretalia species at all frequent is Bellis perennis. Trifolium repens is a character species of the Cynosurion and is constant to the Group. Cynosurus cristatus, another character species of the Alliance, is rare.

Within the Association O'Sullivan describes three sub-associations. One from extremely well-drained soils is differentiated by Ranunculus bulbosus (a species not recorded for the Northern Isles). The typical subassociation on free-draining and moderately drained soils lacks differential species and the third subassociation, which is found on soils with some drainage impedence is distinguished by a group of species (including Juncus effusus), whose optimum development is in the wetter communities of the Molinietalia. This third subassociation is further divided into a typical variant without differential species and a variant with Iris pseudacorus distinguished by the abundance of Iris itself.

Slightly impeded drainage at many of the sites from which Group 5 was recorded has resulted in the presence of species typical of wetter pastures, including Molinia caerulea, Iris pseudacorus, Juncus effusus and J. kochii, which suggests this Group is synonymous with the third subassociation of O'Sullivan.

Subgroup 1 with Agrostis stolonifera is a local variant of the subassociation.

5.4.3.6. Synsystematic placement of Group 4 - Trifolium repens-Bellis perennis Group.

The difficulties in classification of machair grasslands were discussed in the sand dune Section 5.2.3.2. The majority of aufnahmen in Group 4 are from such meadows but they are all from older communities, further away from the main dune ridges than those included in 5.2.3.2. It was suggested that this latter group, the Festuca rubra-Achillea millefolium Group, belonged to, or was related to a Mesobromion Association - the Camptothecio-Asperuletum cyanichae.

With the accumulation of organic matter as well as leaching of the substratum this community gives way to general grassland communities such as the Lolio-Cynosuretum described in the last section. It is proposed that Group 4 as well as the Rumex acetosa variant of the Festuca-Achillea Group, are assigned to the typical subassociation of the Lolio-Cynosuretum, since they are heavily grazed, older communities in which Molinio-Arrhenatheretea species are well established and such species at Tortula ruraliformis and Carex arenaria are virtually absent. The successional sequence is not marked by clear-cut divisions and there are obvious transitions between the Camptothecio-Asperuletum and the Lolio-Cynosuretum. This classification may well have to be revised if a comprehensive study of machair grasslands is made in the future.

In Group 4 - the Trifolium-Bellis Group - Molinio-Arrhenatheretea character species are very well represented including Ranunculus acris, Cerastium holosteoides, Poa subcaerulea, P. trivialis, Rumex acetosa, Trifolium pratense, Festuca rubra, Plantago lanceolata and Rhinanthus minor. Achillea millefolium and Bellis perennis are very frequent and Heracleum spondylium is occasional. All three species are Arrhenatheretalia characters. Trifolium repens and Cynosurus cristatus are character species of the Cynosurion and both are very common in the Group.

Certain species such as Plantago maritima and Scilla verna suggest the Group may be a maritime variant of the Association. Very rare occurrences of such species as <u>Carex arenaria</u> indicate a relationship of the community with those of the <u>Mesobromion</u> and even the <u>Ammophiletea</u>.

5.4.4. <u>Synopsis of grassland community types</u>.

ASTERETEA TRIPOLII Westhoff & Beeftink 62.

GLAUCO-PUCCINELLIETALIA Beeftink & Westhoff 62.

ARMERION MARITIMAE Br.-Bl. & de Leeuw 36 = GROUP 3 (5.4.2.3.).

Carex distans-Plantago maritima Assoc. Ivimey-Cook & Proctor 66
= SUBGROUP 1 and SUBGROUP 2 and GROUP 3 (5.4.2.3.1. and 5.4.2.3.2.)

Armeria maritima-Grimmia maritima Assoc. Birks 73 = SUBGROUP 3 (5.4.2.3.3.).

SILENION MARITIMAE Malloch 71.

Plantago maritima-Carex nigra nodum = GROUP 2 (5.4.2.2.)

Lotus corniculatus variant = SUBGROUP 1 (5.4.2.2.1.).

typical variant = SUBGROUP 2 (5.4.2.2.2.).

MOLINIO-ARRHENATHERETEA Tx. 37.

ARRHENATHERETALIA ELATIORIS Pawlowski 28.

CYNOSURION CRISTATI Tx. 37.

Lolio-Cynosuretum (Br.-Bl. et De Leeuw 36) Tx. 37.

sub-association with Juncus effusus = GROUP 5 (5.4.2.5.)

Agrostis stolonifera variant = SUBGROUP 1 (5.4.2.5.1.).

typical sub-association = GROUP 4 (5.4.2.4.).

NARDO-CALLUNETEA Preising 49.

NARDETALIA (Oberd. 49) Preising 49.

VIOLION CANINAE Schwick (41) 44 em. Preising 49.

Nardo-Galietum saxatilis Preising 49 = GROUP 1 (5.4.2.1.).

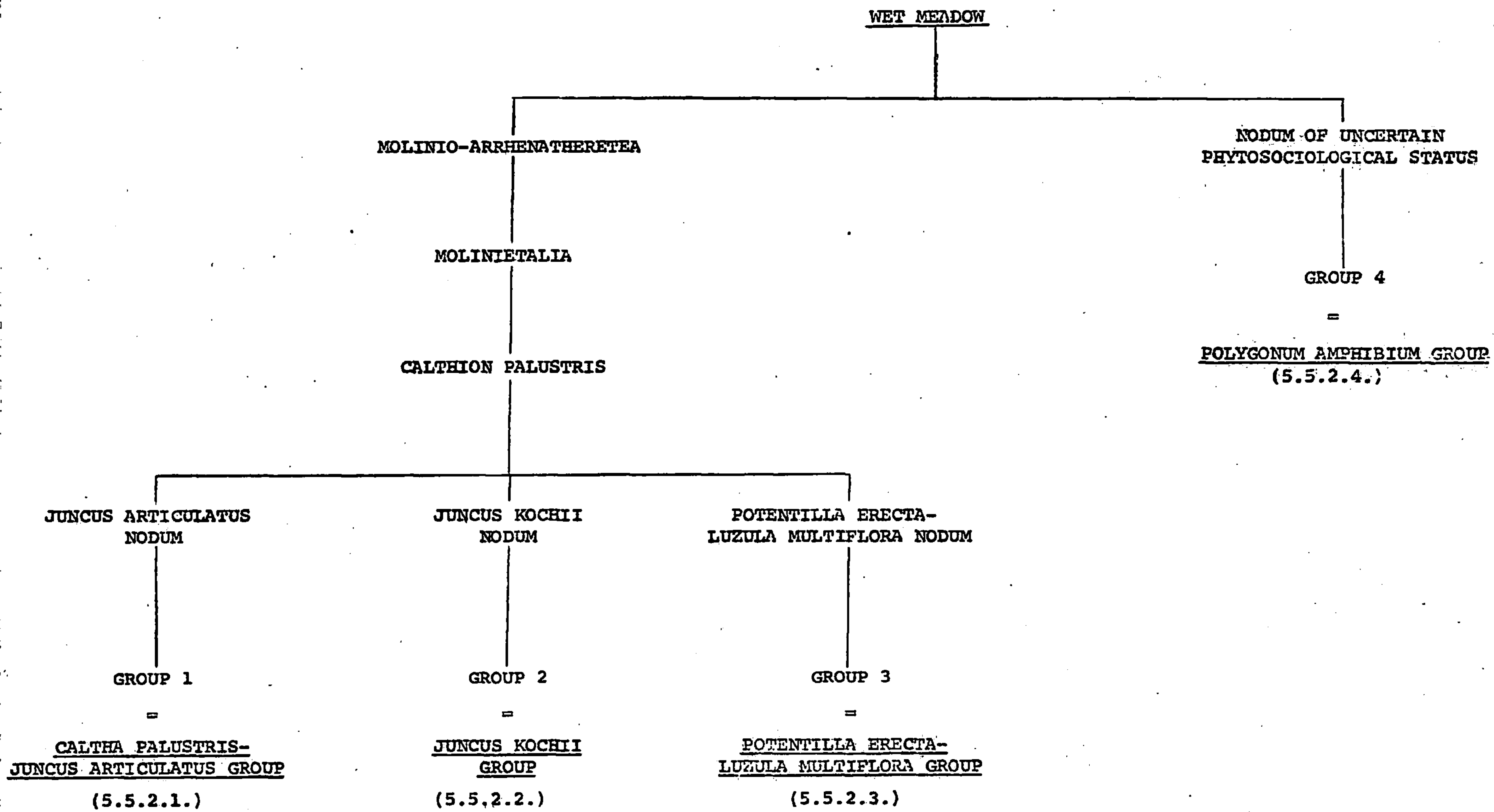


FIGURE 5.5. Synoptic classification of wet meadow vegetation in the Northern Isles.

5.5. Wet Meadow Vegetation = Table 5.

5.5.1. Introduction.

A synopsis of the classification of wet meadow vegetation in the Northern Isles is shown in Fig. 5.5.

Wet meadow is a rather general term used to describe wetland vegetation in the Northern Isles dominated by rushes, sedges and grasses, although frequently it is the more colourful species such as Caltha palustris which makes the vegetation so distinct from the surrounding blanket bog or heath. The vegetation includes both poor fen meadow and transitional rich fen (sensu Du Rietz, 1954) where the water-table is most usually at or close to the surface and the ground is under the influence of minerotrophic water. Such wet meadow communities are characteristic of the lowland flood plains of streams and some streamsides as well as in waterlogged parts of old croftland or uncultivated parts of cultivated croftland. Fragmentary stands of similar vegetation occur in some road-side ditches.

Compared with true rich fen such meadows are of comparatively low base status or mesotrophic and the fertility is maintained now more by seasonal flushing than the influence of man. These meadows would have been managed more intensely in the past when crofting was more important. They would have been manured and cut for hay regularly. Now, they are cut infrequently if at all, but light grazing by sheep or cows is still important.

Carex nigra and *Holcus lanatus* are constant components of the communities interspersed with *Juncus* species and other grasses. Various forbs may be dominant in different stands such as *Menyanthes trifoliata*, *Caltha palustris*, *Potentilla palustris* or *Iris pseudacorus*, giving each site an individual character. Bryophytes are generally poorly represented and only *Acrocladium cuspidatum* is at all abundant and some thallose liverworts such as *Pellia* species creeping over the wet, peaty surfaces.

5.5.2. Community types.

5.5.2.1. Caltha palustris-Juncus articulatus Group = Group 1.

Characterising species: Caltha palustris, Juncus articulatus.

Description: This is the most characteristic community of the wet meadows of the Northern Isles and in spring they are a colourful contrast to the surrounding blanket bog and heath. Aufnahmen have been collected from sites in Yell, Unst and Fetlar on various rock types including gneiss, schist, serpentine and granite. The community is more frequent than the number of samples might suggest and many very similar wet meadows have been visited, although not sampled, particularly in Yell. All the sites are below 30 m. and most are below 15 m. The community is characteristic of badly drained, moderately mesotrophic valley bottoms and some stream-sides, as well as croft infield. The Balta Sound community was sampled at the head of the Sound adjacent to saltmarsh types (see 5.3.). All the sites were wet and virtually flat. Standing water was common in at least parts of the fields, especially in old drainage ditches. The substratum varied in colour from an orange-brown to a much darker brown, but was generally a soft, gley soil with a pH range of 5.0 to 6.2. Because the substratum is so wet trampling is very evident at most sites, although grazing by sheep and more occasionally cows is usually only light.

A fairly lush herb layer, 152 to 304 mm. in height of over 50% cover and often much more is characteristic, whilst bryophytes vary in abundance from 80% cover at some sites to total absence in parts of others. Typically, the vegetation is bright green intermingled with the blue-green of Carex nigra. Caltha is constant and may be dominant at some sites. Interspersed with it are spikes of Juncus articulatus, Carex nigra, Holcus lanatus and Anthoxanthum odoratum, all with high constancy. Other frequent herbs include Cardamine pratensis, Trifolium repens, Ranunculus acris, Rumex acetosa, Lychnis flos-cuculi, Dactylorchis purpurella, Cerastium holosteoides and Rhinanthus minor. Agrostis stolonifera and Poa trivialis are occasional. Individual sites vary, although the basic species composition is similar. Euphrasia species are locally abundant in parts of the Greenbank meadow; Iris pseudacorus forms colourful patches in the Mid Yell meadow and there are small clumps of Juncus effusus at Greenbank, Ulsta and Houbie. The number of bryophytes recorded is low. Acrocladium cuspidatum is abundant, Eurhynchium praelongum is frequent and thallose liverworts such as Pellia epiphylla, P. neesiana and Riccardia pinguis are occasional and may have high cover values in the stands where they occur.

5.5.2.1.1. Ranunculus flammula subgroup = Subgroup 1.

Characteristic species: Ranunculus flammula.

Description: Particularly in more muddy meadows Ranunculus flammula is constant. Associate species are Potentilla palustris and spikes of Eriophorum angustifolium. Menyanthes trifoliata is abundant in Mid Yell meadows. Leontodon autumnalis is frequent. Equisetum fluviatile and Acrocladium stramineum are occasional and Molinia caerulea rare.

5.5.2.1.1.1. Carex echinata variant.

In the Mid Yell wet meadow system Carex echinata is associated in this subgroup.

5.5.2.1.2. Typical subgroup = Subgroup 2.

Characterised by:- the absence of Ranunculus flammula.

Description: This subgroup lacks the characteristic species of subgroup 1. Drier conditions are suggested by the presence of Rhinanthus minor, Agrostis tenuis, Bellis perennis and occasional Deschampsia cespitosa and the absence of Ranunculus flammula, Potentilla palustris, Menyanthes trifoliata and Eriophorum angustifolium.

5.5.2.2. Juncus kochii Group = Group 2.

This is a rather miscellaneous Group characterised by the presence of *Juncus kochii*. The aufnahmen are from fairly level serpentine wet meadows in Fetlar, Unst and Daaey and an altitude of about 10 m. and from some streamsides in Yell on gneiss and in Unst on granite. The substratum is usually a dark brown, soft, gley soil which is always wet. At some sites there is standing water. Trampling and grazing by both sheep and cows is very evident, especially at Muness.

In general appearance this Group is much less attractive than Group 1 with rather fewer forbs and more bryophytes. Both layers in fact average about 70% and the herb layer varies from 50 mm. to 304 mm. in height. *Holcus lanatus* and *Carex nigra* are the only two constant species. *Agrostis stolonifera*, *Cardamine pratensis*, *Ranunculus flammula* and *Eriophorum angustifolium* are frequent as are tussocks of *Juncus squarrosus* and the moss *Mnium hornum*. *Pellia* species are occasional on the surface of the substratum. There is a general transition of species from the wetter to drier sites. *Epilobium palustre*, *Drepanocladus fluitans* and *Sphagnum* species are recorded from wetter sites, whilst at drier sites *Trifolium repens*, *Cerastium holosteoides*, *Bellis perennis*, *Sagina procumbens* and *Leontodon autumnalis* are recorded. However, the transition is not clear-cut and the data have been left as one Group for the present.

5.5.2.3. <u>Potentilla erecta-Luzula multiflora Group = Group 3.</u>

<u>Characteristic species</u>: Potentilla erecta, Luzula multiflora,

Anthoxanthum odoratum.

Description: This community forms lush patches in slightly drier parts of wet meadows on gneiss, schist or serpentine. These stands are all from Yell and Fetlar and are usually adjacent to vegetation of Group 1 or Group 2. All the sites are between 9 m. and 22 m. and fairly flat. The substratum is a damp, soft, dark-coloured, rocky, peaty gley soil, of pH between 5.2 and 6.4. Sheep and cows graze the meadows.

Herbs vary between 60-100% cover and in height from 152 mm. to much more where flags are growing at Ulsta. Bryophyte cover varies but averages about 40%. Carex nigra is again constant and Holcus lanatus is very frequent. Grasses dominate the community with Anthoxanthum odoratum constant and with high cover values and Festucarubra, Poa trivialis, Agrostis tenuis and tussocks of Nardus stricta occasional. Potentilla erecta and Luzula multiflora are both constant and differential species of the Group. Lophocolea cuspidata is frequent in the ground layer, Mnium hornum and M. undulatum are occasional and Rhytidiadelphus squarrosus rare. Other forbs which are occasional in the Group include Trifolium repens, Dactylorchis ericetorum, Carex panicea, Euphrasia species Ranunculus acris and Rumex acetosa. Eriophorum angustifolium and Potentilla palustris are rare.

Some stands are transitional between this Group and Group 2. Acrocladium cuspidatum, Leontodon autumnalis, Juncus squarrosus and Mnium hornum are amongst the species common to both Groups.

5.5.2.4. Polygonum amphibium Group.

Two aufnahmen from Norwick, Unst, of this type have been recorded:-

Norwick, Unst. HP 648145.

Cover: Moss: 0%. Herbs: 80%.

	629	633
Polygonum amphibium.	3,1	1,1
Myosotis caespitosa	1,1	1,1
Alopecurus geniculatus	+	1,1
Agrostis stolonifera	1,1	1,1
Eleocharis palustris	2,1	
Mimulus guttatus	+	+
Phalaris arundinacea		3,1
Potentilla palustris		+
Poa annua		+
Rhinanthus minor	+	
Caltha palustris	+	

The bedrock of the area is schist and the height 6 m. The ground is quite flat, damp and the soil a dark brown, rocky, peaty gley of pH 6.3.

Bryophytes are absent but the herb layer is lush, although species-poor. The average height is over 300 mm. Polygonum amphibium and Eleocharis palustris dominate, although there are large patches of Phalaris arundinacea.

5.5.3. Synsystematics.

An apparent lack of very similar vegetation in the literature has made a hierarchical classification according to traditional continental units most difficult. Shetland wet meadows encompass vegetation of low minerotrophic status, that is really transitional between wet grassland and poor fen. The most detailed survey of rich fen systems in England and Wales is the study by Wheeler (1975). McVean & Ratcliffe (1962) mention "poor fens" in Scotland (p.126), but no analyses were made. From the most relevant literature available (e.g. Westhoff & Den Held, 1969; O'Sullivan, 1965; Jones, 1973; Wheeler, 1975 etc.) some tentative conclusions have been drawn, although with further data these may be modified.

5.5.3.1. Synsystematic placing of Groups 1, 2 and 3.

A large number of species present within these Groups - (the Juncus articulatus Group, the Juncus kochii Group and the Potentilla-Luzula Group) - are characteristic species of the Molinio-Arrhenatheretea. Holcus lanatus is constant, Cardamine pratensis, Rumex acetosa, Cerastium holosteoides, Ranunculus acris, Rhinanthus minor and Rhytidiadelphus squarrosus are all well represented and Poa trivialis, P. subcaerulea, Festuca rubra and Trifolium pratense are recorded. As these species are well developed throughout each of the Groups it seems appropriate to assign these three Groups to the Molinio-Arrhenatheretea.

Wet semi-natural communities are accommodated within the Molinietalia and although the character species are not well represented (only Lychnis flos-cuculi is at all frequent) the Groups have been assigned to the Calthion Alliance of this Order. Other Molinietalia characters which are present although only occasionally include Cirsium palustre, Angelica sylvestris, Deschampsia cespitosa, Equisetum palustre and Juncus effusus. The only Calthion character species present are Caltha palustris and rarely, Senecio aquaticus.

The Groups have been left as separate noda within this Alliance since the vegetation is apparently unlike any previously described Associations. With additional data from the Shetland Mainland the precise relationships to existing units may be more obvious. For the present it is felt that it is most satisfactory to describe the Groups as noda rather than attempt to define new units with so little data.

5.5.3.2. Discussion.

As may be apparent, the previous section is rather an over-simplification of the case. There are, in fact, complicated interrelations with at least one other Class, the Parvocaricetea, and in particular with the Alliance the Caricion curto-nigrae.

Potentilla palustris is a weak Parvocaricetea character and is well represented in Group 1. Other Class character species which are infrequently recorded are Riccardia pinguis, Carex demissa, Hydrocotyle vulgaris and Epilobium palustre. Caricion characterswhich are present include Carex nigra which is constant, Ranunculus flammula which is very frequent and occasional Carex echinata and Viola palustris.

The often indistinct boundaries between Molinietalia and Caricion communities have been referred to frequently in the literature; for example, Adam et al. (1975) found the phytosociological affinities of the "general fen" unit at Malham Tarn unclear with species of the Molinietalia present (e.g. Equisetum palustre and Angelica sylvestris), as well as species characteristic of either the Parvocaricetea or the Caricion curto-nigrae such as Carex diandra, Potentilla palustris, Ranunculus flammula and Viola palustris.

Similarly in Skye, Birks (1973) notes the debatable phytosociological position of his Juncus acutiflorus-Filipendula Association. This Association is the most similar equivalent to the Shetland wet meadows found in Skye, although it is much more species-rich and classified within the Filipendulo-Petasition Br.-Bl. 47. Birks' Association shows floristic affinities with the hay meadows and pastures of the Arrhenatheretalia (for example, in the presence of Holcus lanatus, Ranunculus repens and Trifolium pratense) and with the lowland poor- and intermediate-fens of the Caricetalia nigrae (for example, Carex echinata, C. nigra and Lychnis flos-cuculi.

Vegetation of soligenous mires dominated by such species as Carex echinata, C. pulicaris, C. nigra, C. demissa, C. panicea, C. rostrata, C. aquatilis, C. rariflora, Juncus effusus, J. acutiflorus, J. articulatus, Festuca ovina, Nardus strica and Anthoxanthum odoratum and certain Sphagna including Sphagnum recurvum, S. palustre, S. teres, S. warnstorfianum, S. papulosum and S. russowii were united in a new Association by Jones (1973) - the Violo-Epilobetum palustris characterised by Viola palustris, Carex echinata, Epilobium palustre and Juncus kochii. There are similarities between the Shetland Groups and the sub-association of eu- to mesotrophic mires, the caricetosum pulicaris. The typical subvariant of the Juncus effusus variant is most similar. The variant is differentiated by Holcus lanatus, Trifolium repens and Thuidium tamariscinum. Anthoxanthum odoratum and Galium saxatile are prominent. As part of this variant Jones suggested the species-rich Juncetum effusi described from Moor House N.N.R., Westmorland, by Eddy et al. (1969). This vegetation of gley soils was originally classified by Eddy et al. within the Molinietalia. However, because of the absence of certain of the character species of Jones, as well as the absence of Sphagnum and the paucity of bryophytes, as well as the physiography of the wet meadows, it is felt that at least for the present Groups 1, 2 and 3 are better placed within the Molinio-Arrhenatheretea than the Parvocaricetea.

Birse & Robertson (1973) list one aufnahme from croft land with Caltha from the Baltasound area. The vegetation is essentially similar to that described in this survey and was also assigned to a Calthion community. Birse & Robertson suggest that although Caltha is abundant in peaty alluvial tracks of old croft land and uncultivated parts of presently cultivated crofts, that no community clearly stands out as there is considerable variation in the specific composition of the vegetation.

5.5.3.4. <u>Synsystematic placing of Group 4 - the Polygonum amphibium Group</u>.

The phytosociological status of this Group is unclear as no description of very similar vegetation was encountered in the literature. The presence of such species as <u>Caltha palustris</u>, <u>Potentilla palustris</u>, <u>Rhinanthus minor</u> and <u>Agrostis stolonifera</u> links the vegetation with the previous wet meadow Groups of the <u>Molinio-Arrhenatheretea</u>. However, from Oberdorfer (1962) some species are more typical of the <u>Agropyro-Rumicion crispi</u> Nord. 40. em. Tx. 50 of the <u>Plantaginetea majoris</u> Tx. & Prsg. 50 and more especially of the <u>Phragmitetea</u> Tx. & Prsg. 42. This latter Class encompasses a whole range of plant communities characterised by the dominance of tall-growing telmatic grasses and sedges. The Class is fully reviewed by Wheeler (1975) and as character species he suggests <u>Equisetum fluviatile</u>, <u>Rumex hydrolapathum</u>, <u>Alisma plantago-aquatica</u>, <u>Berula erecta</u>, <u>Iris pseudacorus</u> and <u>Sparganium erectum</u> ssp. <u>microcarpum</u>, none of which are present at Norwick, although in fact only <u>Iris</u> and <u>Equisetum</u> are Shetland species. However, within the Class Passarge (1964) describes an Alliance, the <u>Phalaridio-Glycerion</u> to which the Norwick vegetation is rather similar in a very impoverished form. The Alliance is described from shallow water at the edge of nutrient rich flowing and stagnant water and is characterised by <u>Glyceria maxima</u>, <u>G. fluitans</u>, <u>Acorus calamus</u> and <u>Phalaris arundinacea</u>. <u>Polygonum amphibium</u>, <u>Agrostis</u>

stolonifera, Eleocharis palustris, Alopecurus geniculatus, Caltha palustris and Phalaris arundinacea are all present in the communities described for the Alliance. However, the majority of species listed by Passarge in Table 16, p.45 are absent in the Northern Isles, including the character species of the Order - Nasturtio-Glycerietalia Pignatti 53. em. Segal 69. The species generally recognised for the Order are:- Nasturtium microphyllum, Sparganium erectum ssp. neglectum, Glyceria plicata, G. fluitans, Myosorus scorpioides, Veronica beccabunga (Wheeler, 1975). In addition, the Alliance is not generally considered a valid unit for the lowlands of north-west Europe (Westhoff & Den Held, 1969). Thus, it seems that until this community and the syntaxon are investigated more thoroughly in Britain as a whole, Group 4 must remain as a Polygonum amphibium nodum of uncertain phytosociological status, since it is not possible to draw more definite conclusions from only two aufnahmen.

5.5.4. Synopsis of wet meadow communities.

MOLINIO-ARRHENATHERETEA Tx. 37.

MOLINIETALIA Koch 26.

CALTHION PALUSTRIS Tx. 37.

Juncus articulatus nodum = Group 1 (5.5.2.1.).

Juncus kochii nodum = Group 2 (5.5.2.2.).

Potentilla erecta-Luzula multiflora nodum = Group 3 (5.5.2.3.).

Polygonum amphibium nodum of uncertain phytosociological status = Group 4 (5.5.2.4.).

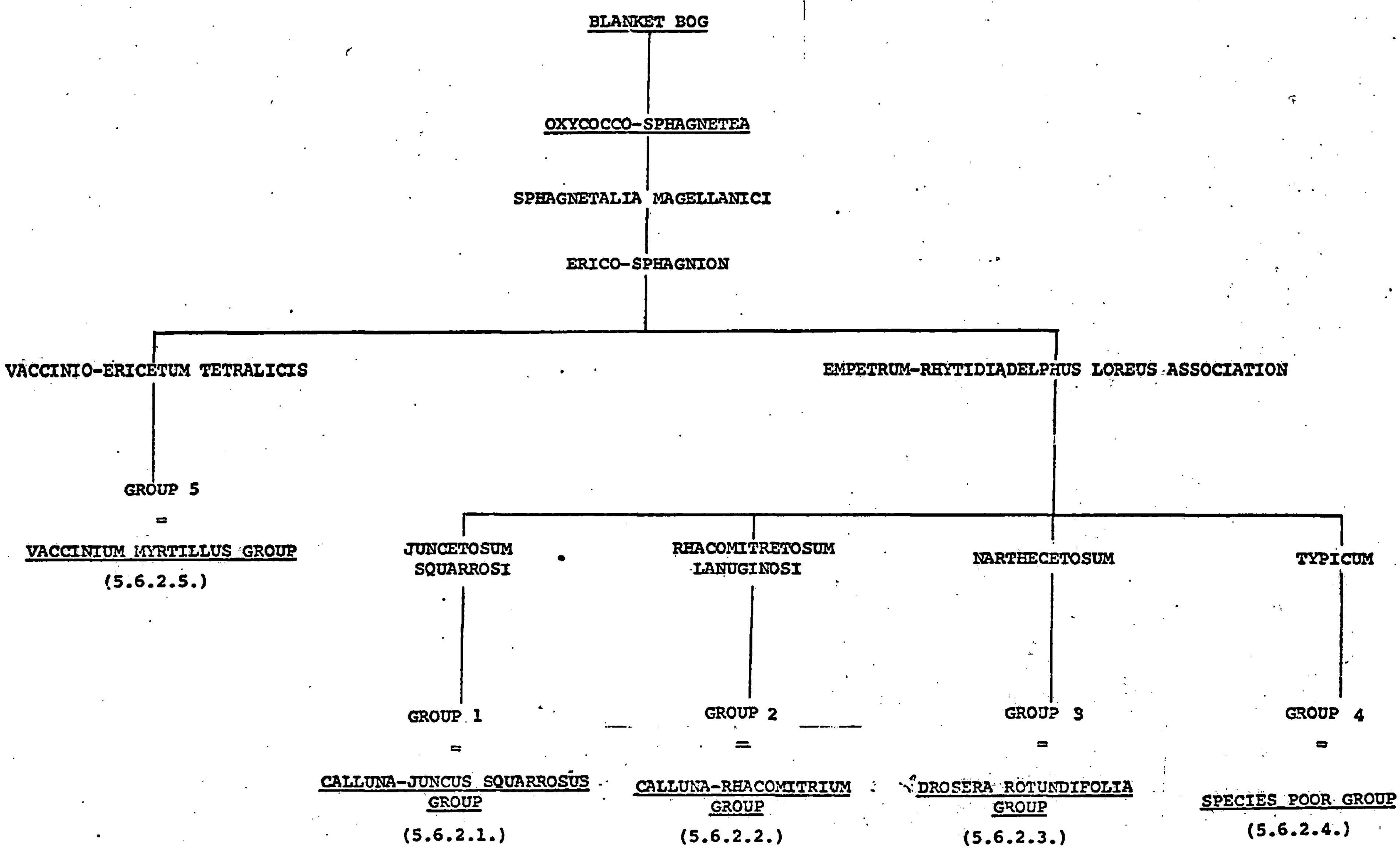


FIGURE 5.6. Synoptic classification of blanket bog vegetation in the Northern Isles.

5.6. Blanket Bog -Table 6.

5.6.1. Introduction.

A synopsis of the classification of blanket bog in the Northern Isles is shown in Fig. 5.6.

Bog is ombrotrophic peatland where a permanently high water-table is maintained solely by rainfall on the bog itself with virtually no influence from minerotrophic water. Blanket peat is not topogenous in origin but rather represents a peat mantle covering often huge areas of gently undulating land including flat areas and slopes of up to 15^{o} or occasionally even more in areas of extreme oceanic climate. Generally, however, on steeper slopes the better drainage means that the high water-table is not maintained and it is essential that ground moisture remains almost continuously in excess of that lost by evaporation for blanket peat formation. Blanket bog is in fact restricted to areas of high rainfall (over 127 cm.) and is favoured in regions with a cool climate where evaporation is low. Waterlogging leads to anaerobic conditions and the ground is of low base status, since it is dependent solely on rainfall for its source of nutrients, thus the substratum is highly acidic. Microbial activity in such conditions is low and hence accumulation of plant remains as peat is favoured.

5.6.1.1. Vegetation.

Plant which can grow in such unfavourable circumstances are necessarily restricted and their root systems, at least, must be adapted to waterlogging and the associated anaerobic, acidic environment. Various species of Sphagnum, ericoid shrubs and monocotyledons (particularly species of the Cyperaceae) are most typical, dominant and also the chief peat formers.

Frequently, blanket bogs show a hummock/hollow topography. Where the hollows are deeper than the water-table pools result (see 5.7.). Sphagnum lawns and hummocks may form a complete carpet with other vascular plants forming an open community rooted in the Sphagnum and upper peat layer. Vascular plants are more dominant in bogs which for some reason have begun to dry out. Rhacomitrium lanuginosum is also particularly common in bogs which are drying out in highly humid areas of the north and west (Ratcliffe, 1964). A sharp transition from blanket peat and associated vegetation to more mineral soil is rare and usually there is a wide transition band of shallower peat with associate intermediate wet heath or wet grassland communities.

5.6.1.2. Erosion.

Blanket bogs are extremely susceptible to erosion. This may be because such bogs are most frequent in areas of extreme climate and the peat may have been accumulating on quite appreciable slopes for a long time. Tallis (1964) investigated four neighbouring sites in the southern Pennines in an attempt to elucidate the relationship between topography and erosion. His conclusions were that erosion had been underway for many centuries and there was no single cause but rather that the process of erosion in a continuous peat blanket may be brought about by a variety of agencies. Since erosion of Shetland bogs is so widespread it seems fitting to summarise these factors here:-

1. Erosion of the peat blanket by streams developed prior to peat formation may be initiated by:-

(i) increased climatic wetness;

(ii) increased discharge after deforestation;

(iii) increased surface run-off over the peat blanket; this may be because ~~of~~ a break in a continuous cover of Sphagnum is replaced by vegetation whose plant remains form a relatively impermeable skin to the peat, for example Eriophorum vaginatum, which may increase dramatically in abundance as a result of human interference. Surface run-off is also increased over bare peat since dry peat, especially if it is well humified, is very difficult to rewet. This increased surface run-off results in an increased discharge into streams after heavy rain and this may accelerate the headward erosion of streams.

2. An undisturbed peat blanket is likely to develop a drainage system of its own with short, intermittent streams draining local areas of the margin of the peat blanket, especially where "bursts" have occurred as a result of increasing

instability of the accumulating peat. This may produce locally intense dissection if linked to the major stream course. Systems of gullies produced by erosion of any type are generally known as haggs.

3. If the vegetation cover is continuous, surface channelling of peat by running water is generally negligible. However, if the cover is disrupted an intricate pattern of drainage channels may develop determined initially by irregularities in the bog surface and linking ultimately to the major stream courses. Disruption of the vegetation cover may be due to a number of causes:-

(i) biotic modifications such as grazing; burning; draining; peat cutting.

(ii) wind action, especially if the peat is dry or frozen (Osvald, 1949).

(iii) frost action.

(iv) shrinking and drying of the surface peat after drought, producing local centres which may be acted upon subsequently by running water.

4. Wind action can lead to widespread sheet erosion where large areas are denuded of their surface layers of peat producing extensive peat "flats". Small bare peat areas between tussocks of for example *Eriophorum vaginatum*, are acted on by wind and rain, so that the tussock is eroded away

in time giving local or more extensive areas of bare peat. The edges of pools are frequently denuded by wind and the resulting scouring action of water (Tallis, 1964; Ratcliffe, 1964).

5.6.1.3. Blanket bog in the Northern Isles.

Robertson & Jowsey (1968) estimate that 53% of the surface of Shetland is covered by peat and the majority of this is blanket peat. Approximately 66% of Yell is covered by blanket peat of average depth 1.5 m. Much of western Unst, parts of Fetlar (in particular the Lam Hoga peninsula) and some of the small islands of the Yell Sound and Colgrave Sound are covered by blanket peat.

5.6.2. Community types.

5.6.2.1. Calluna-Juncus squarrosus Group = Group 1.

Characterising species: Calluna vulgaris, Empetrum nigrum, Juncus squarrosus, Plagiothecium undulatum, Rhytidiadelphus loreus.

Description: From a variety of sites on the Yell and Hascosay gneiss and the Unst schist a blanket bog community rich in Juncus squarrosus has been recorded. A damp, dark, well humified acidic peat underlies the community, of average pH 4.4. Such vegetation generally forms patches amidst less-species-rich bog communities and the bright green Juncus tussocks break the monotony of the dull-coloured moor around. It may be found in a variety of sites including hollows (some of which probably originated from old peat cuttings) adjacent to streamside communities or on gently sloping, often eroded, hillsides.

Calluna, the dominant shrub, forms a dense mosaic interspersed with smaller amounts of *Empetrum nigrum* and *Erica cinerea*. *Eriophorum angustifolium* is constant and *E. vaginatum* tussocks are in about half the aufnahmen recorded. The amount of *Juncus squarrosus* varies but it is often quite dense. Other herbs which are almost constant include *Tricophorum cespitosum*, *Listera cordata*, *Luzula multiflora* and *Potentilla erecta*. *Nardus stricta*, *Carex nigra*, *Agrostis canina*, *Anthoxanthum odoratum* and *Dactylorchis ericetorum* are frequent and *Narthecium ossifragum* and *Pinguicula vulgaris* occasional. The combined herb and shrub layer varies between 150 and 300 mm. in height and cover averages 80%. The bryophyte layer is well developed with at least 60% cover and often much more. Low *Sphagnum* hummocks are typical amongst the *Calluna* mosaic. The most frequent species are *Sphagnum capillaceum*, *S. rubellum* and *S. papillosum*. The pleurocarpous mosses *Rhytidiadelphus loreus*, *Hylocomium splendens* and *Pleurozium schreberi* are constant in the community. *Hypnum ericetorum* is very frequent and *Rhytidiadelphus squarrosus* occasional. *Plagiothecium undulatum* and *Mnium hornum* are constant and *Dicranum scoparium*, *Aulacomium palustre* and *Campylopus flexuosus* frequent. A variety of liverworts are recorded including *Lophocolea cuspidata*, *Calypogeia muellerana*, *Lophozia ventricosa*, Scapania gracilis and Diplophyllum albicans. Lichens are unimportant in the community. Cladonia species on Calluna are recorded.

5.6.2.2. Calluna-Rhacomitrium Group = Group 2.

Characterising species: Calluna vulgaris, Eriophorum angustifolium, Tricophorum cespitosum, Hypnum ericetorum, Scapania gracilis, Rhacomitrium lanuginosum.

Description: This community is characteristic of very large areas of Yell on both gneiss and quartzite and it has been recorded from small areas of granitic rock in Unst. Characteristically, a deep blanket of peat smothers gently undulating land and such country may stretch for miles broken only by pools, channels and haggs - the latter the result of severe erosion. Typically, the peat is dark and well humified of average pH 4.4. The top layers of peat may dry out after prolonged periods of good weather, but more usually the peat is wet or at least damp. This vegetation forms much of the Yell scattald which is grazed by sheep and ponies.

The community is generally species-poor, dominated by a mosaic of Calluna vulgaris and Rhacomitrium lanuginosum interspersed with Eriophorum angustifolium and Tricophorum cespitosum. Calluna may reach 300 mm. in height and the bushes are often old and very woody. Sphagnum capillaceum hummocks are important, particularly where Calluna cover is lower. Hypnum ericetorum is constant amongst the Calluna. Cladonia species are constant, particularly Cladonia uncialis and C. impexa. Scapania gracilis is frequent throughout the Group in small amounts and Carex panicea, Diplophyllum albicans and Frullania germana are occasional. The liverwort Pleurozia purpurea is rare. Combined shrub and herb cover in the Group is high varying between 60% and 90%, depending on the abundance of Calluna in the stand. Bryophyte cover averages 70% and the layer 76 mm. high. Although Cladonia is constant, lichen cover is low.

Two subgroups are identified within the Group.

5.6.2.2.1. Listera-Pleurozium Subgroup = Subgroup 1.

Characterising species: Listera cordata, Hylocomium splendens, Pleurozium schreberi.

Description: In this subgroup one or more of the three characterising species are present. They are all absent from subgroup 2. Listera cordata is never abundant but frequently a single plant may be found even in the thickest Calluna. Calluna is in fact very abundant in this subgroup. In stands where Calluna cover is particularly high Rhacomitrium lanuginosum cover is reduced. Several species are constant or frequent in this subgroup but absent or rare in subgroup 2. These include Empetrum nigrum, Eriophorum vaginatum, Carex binervis, Rhytidiadelphus loreus, Dicranum scoparium, R. squarrosus and Calypogeia muellerana.

A variant of this subgroup has been recorded from drier eroding sites. Erica tetralix, Cladonia impexa and Cladonia impexa and C. uncialis are absent (although Cladonia sp. is recorded in a few aufnahmen). Carex nigra is occasional.

5.6.2.2.2. Species-poor subgroup.

Characterised by: the absence of Listera cordata, Hylocomium splendens, Pleurozium schreberi and Eriophorum vaginatum. Empetrum nigrum and Rhytidiadelphus loreus are much reduced.

Description: Apart from the absence or reduced abundance of species mentioned above this subgroup is also distinguished from the last by constant Erica cinerea and occasional Cetraria islandica. Again, there is a lichen-poor variant in which Erica tetralix is also absent.

5.6.2.3. Drosera rotundifolia Group = Group 3.

Characterising species: Eriophorum angustifolium, Calluna vulgaris, Drosera rotundifolia.

Description: This bog community is most typical of the vegetation of wet hollows, infilling erosion channels and beside pools. Seepage from the surrounding peat influences the environment at each of these sites. The substratum is a wet, dark, humified, acidic peat (average pH 4.1) sometimes with a less well humified Sphagnum-rich layer at the top. Aufnahmen have been collected at altitudes between 22 m. and 140 m. but always from where the ground is flat or at most very gently sloping. The sites are all on Yell (from gneiss and quartzite) apart from one aufnahme from the Unst schist. Generally, grazing pressures are low or absent, since the ground is too wet for sheep.

The species composition is closely related to Group 2. In fact, this community is frequently adjacent to the Rhacomitrium Group. A shrub layer of 60-70% cover consisting mainly of Calluna vulgaris and smaller amounts of Empetrum nigrum, Erica tetralix and occasional Erica cinerea intermingles with Sphagnum species to form a mosaic. Sphagnum capillaceum, S. rubellum and S. papillosum are most frequent, S. cuspidatum occasional, and S. plumulosum, S. palustre and S. subsecundum var. inundatum rare. Odontoschisma sphagni is a constant species found intermingled with the Sphagnum. Bryophyte cover is thus high - at least 80%. Other important species are Rhytidiadelphus loreus, Hypnum ericetorum, Rhacomitrium lanuginosum (present only in small amounts), Dicranum scoparium, Aulacomium palustre and a little Plagiothecium undulatum. Scapania gracilis is virtually constant and Diplophyllum albicans is apparently associated with this species. Pleurozia purpurea occurs in about 30% of the aufnahmen. Eriophorum angustifolium is constant within the community and Eriophorum vaginatum and Tricophorum cespitosum frequent. Drosera rotundifolia is constant and this is apparently the most typical habitat for this species in the Northern Isles. Narthecium ossifragum, recorded from about 50% of the stands may be very abundant. Lichen cover is low although Cladonia uncialis and C. impexa are common.

5.6.2.4. Species poor Group = Group 4.

Characterised by:- dense Calluna. Generally species-poor.

Description: This is a rather monotonous blanket bog community which has been recorded from sites on the Yell gneiss and quartzite and the Unst schist. A very damp, humified, dark peat, occasionally with a less well humified Sphagnum rich layer on top is the characteristic substratum, of average pH 4.3. Aufnahmen have been collected from altitudes between 20 and 140 m. from sites including gentle hillsides and general eroded undulating moorland areas. The community is found amongst the more widespread bog types.

Calluna vulgaris is the dominant species with dense cover - almost 100% at some sites. Empetrum nigrum is the only other shrub of importance. Erica tetralix and E. cinerea are both rare. Empetrum is more abundant in this community than in the other types. The shrub layer averages 300 mm. in height and is always over 60% in cover. Herb cover is much less - at most 20%. Only Eriophorum augustifolium is constant. Eriophorum vaginatum is frequent and Juncus squarrosus rare. Few other herbs are recorded. A bryophyte layer 76 mm. in height and with 70% cover is mainly composed of Rhytidiadelphus loreus and Hypnum ericetorum. These two species may form quite dense patches amidst the Calluna. Dicranum scoparium and Rhytidiadelphus squarrosus occur less frequently. Sphagnum capillaceum is frequent and adds a little colour to the community. Sphagnum papillosum,

S. rubellum and S. plumulosum are rare. Lichen cover is low - small amounts of Cladonia impexa and C. furcata may be present. Two subgroups may be identified within the Group.

5.6.2.4.1. Hylocomium-Pleurozium subgroup = Subgroup 1.

Characterising species: Listera cordata, Hylocomium splendens, Pleurozium schreberi.

Description: Pleurozium and Hylocomium form dense patches with Rhytidiadelphus loreus and Hypnum ericetorum amidst the Calluna. Listera cordata is present in 50% of the aufnahmen frequently as isolated plants.

5.6.2.4.2. Species-poor Subgroup.

This subgroup is characterised by the absence of the characterising species of the previous subgroup. The vegetation is particularly species-poor. Each site is very wet and Sphagnum hummocks are more dominant than in Subgroup 1.

5.6.2.5. Vaccinium myrtillus Group = Group 5.

Two aufnahmen from the summit of the Ward of Otterswick, Yell, have been assigned to this Group. Similar vegetation has been seen on the Mainland of Shetland. The stands were both above 190 m., on quartzite, on gently sloping land, and the substratum was a dark peat of pH 3.9. A mosaic of shrubs, Vaccinium myrtillus, Empetrum nigrum, Erica cinerea and Calluna vulgaris is interspersed with Eriophorum species, Carex pilulifera and the bryophytes Rhacomitrium lanuginosum, Pleurozium schreberi, Hypnum ericetorum and Diplophyllum albicans. Lichens such as Cornicularia muricata, Cladonia arbuscula and C. impexa are well represented.

5.6.3. Synsystematics of the blanket bog communities.

5.6.3.1. Introduction.

The difficulties which have arisen over the classification of bogs and wet heaths are discussed by Jones (1973). In this account the division of the Oxycocco-Sphagnetea Br.-Bl. & Tx. 43. as proposed by Moore (1968) is followed (see 4.9.). Moore's survey was based on data collected by him and other workers from the whole of northern and central Europe.

5.6.3.2. Discussion.

Sphagnum capillaceum is the only Class character species proposed by Moore (1968) which is well represented throughout all the blanket bog types in Shetland. Drosera rotundifolia is constant only in Group 3 and Aulacomium palustre is mainly restricted to Groups 1 and 3. Dactylorchis ericetorum quoted by Westhoff & Den Held (1969) as an additional character species, shows a similar distribution to Aulacomium. Lepidozia setacea is rare as is Sphagnum tenellum, although the latter species may have been under-recorded. Moore (1968) divides the Class on ecological-floristic grounds into two Orders. The first, the Ericetalia tetralicis Moore (64) 68 encompasses the vegetation of damp heaths on shallow peat, and the second, the Sphagnetalia magellanici Moore (64) 68 covers the vegetation of bogs on deeper peat. Despite the fact that within at least some of the Northern Isles communities Ericetalia character species as suggested by Moore (1968) are present (e.g. Erica tetralix, Tricophorum cespitosum and Juncus squarrosus) the vegetation is all assigned to the Sphagnetalia since the bogs are all on deep peat with abundant Sphagna. Sphagnetalia character species which are well represented are Eriophorum vaginatum and Sphagnum rubellum. Mylia anomala, Sphagnum magellanicum, S. recurvum and Cephalozia connivens are all recorded. Erica tetralix and Tricophorum cespitosum are widespread in the Erico-Sphagnion Moore (64) 68 of the Sphagnetalia in Moore's data and several differential species of this Alliance are present within the Ericion tetralicis Schwick 33 (the only Alliance of the Ericetalia). However, Sphagnetalia characters are virtually absent from the Ericion. Thus, the species composition and general physiognomy of the vegetation satisfactorily places all the Groups described within the Sphagnetalia though, clearly, similarities with the Ericion tetralicis must be acknowledged. As described in 4.9. the Sphagnetalia is composed of two Alliances - the Erico-Sphagnion Moore (64) 68, and the Sphagnion fusci Br.-Bl. (15) 20. em. Moore (64) 68. This second Alliance encompasses many communities of boreal peatlands but in a species-poor form it has been recorded from more Atlantic regions including Scotland. Moore (1968) assigns 36 aufnahmen, previously placed by McVean & Ratcliffe (1962) in their

Calluneto-Eriophoretum and Empetro-Eriophoretum, in the Sphagnion fusci. However, although in these communities some Erico-Sphagnion species are present in low quantities (e.g. Sphagnum papillosum, S. plumulosum, Eriophorum angustifolium and Hypnum cupressiforme); Sphagnion fusci character and differential species are much more abundant - Sphagnum fuscum, Empetrum nigrum, E. hermaphroditum, Rubus chamaemorus, Cladonia rangiferina, C. sylvatica, Vaccinium uliginosum, V. vitis-idea, Betula nana, Oxycoccus microcarpus, Cetraria islandica and C. squamata. As Association character and differential species Rhytidiadelphus loreus, Plagiothecium undulatum, Cornus suecia, Ptilidium ciliare, Carex bigelowii and Hylocomium splendens are quoted, indicating some close similarities with the Shetland communities. However, the general scarcity of Sphagnion fusci characters in these Shetland communities as well as the abundance of Erico-Sphagnion characters and differentials means the vegetation has been assigned to the Erico-Sphagnion. The overlap between Ericion and Erico-Sphagnion species has already been mentioned. From Table 1, p.315 in Moore (1968) this overlap is not apparent with the Sphagnion fusci. Jones (1973) describes the upland blanket bogs of north England and north Wales, as related to the Sphagnion fusci, but members of the Erico-Sphagnion, and this is, therefore, also true of the Shetland vegetation.

Erico-Sphagnion character species present in the Northern Isles vegetation are Sphagnum papillosum, S. plumulosum, Odontoschisma sphagni and Narthecium ossifragum. Recorded differential species are Molinia caerulea, Eriophorum angustifolium, Hypnum cupressiforme, Campylopus flexuosus and Cladonia impexa.

5.6.4.3.1. Associations.

Three Associations are distinguished by Moore (1968) within the Erico-Sphagnion. These are the Erico-Sphagnetum magellanici Moore (64) 68; the Pleurozia purpurea-Erica tetralix Association Br.-Bl. & Tx. 52 em. Moore (64) 68 and the Vaccinio-Ericetum tetralicis Moore 62.

1. The Pleurozia purpurea-Erica tetralix Association.

The Pleurozia purpurea-Erica tetralix Association as described by Moore (1968) was the vegetation of low-level blanket bog of west Scotland and west Ireland, developed over flat areas of siliceous rock. Within this Association species more typical of wet heath may be recorded, but the large proportion of Sphagnetalia characters which are present means that the Association is placed within the Erico-Sphagnion rather than the Ericion. As character species of the Association Moore suggests Rhacomitrium lanuginosum, Pleurozia purpurea, Schoenus nigricans, Pinguicula vulgaris, P. lusitanica and Rhytidiadelphus loreus. Group 2 shows some similarities with this Association in the presence of Rhacomitrium lanuginosum but in the absence from the Group of so many species such as Potentilla erecta, Pinguicula vulgaris and Campylopus atrovirens, which occur with high constancies in Moore's data for the Association, it has been decided not to place any of the Northern Isles data within this Association. However, further data from the Mainland (Hilliam, pers. comm.) may show this Association to be present in Shetland.

2. The Erico-Sphagnetum magellanici.

As first described by Moore (1968) the Erico-Sphagnetum magellanici encompassed much of the vegetation of the "flats" and hummocks of west European raised bogs not blanket bogs. This topographical description has since been enlarged (see Jones, 1973). It was to this Association that Birse (1973) assigned the majority of the Sullom Voe blanket bog accrediting the vegetation as a Shetland race distinguished from its Scottish Mainland counterpart by the abundance of Eriophorum angustifolium throughout the vegetation even on drier convex slopes; the higher constancy of Scapania gracilis and the low frequency of Narthecium ossifragum. Neither Birse or Moore give definite character species for the Association. Birse (1973) felt that although Empetrum nigrum and Rhytidiadelphus loreus occurred with high constancy values thus linking the vegetation with the Vaccinio-Ericetum tetralicis, the absence of Vaccinium myrtillus and the constancy of Odontoschisma sphagni, Sphagnum tenellum, Eriophorum angustifolium and Pleurozium schreberi meant the vegetation was better placed within the Erico-Sphagnetum magellanici. Presumably this decision was made on phytosociological knowledge of blanket bog in other parts of Scotland since from Moore (1968), Sphagnum tenellum is a Class character species, Odontoschisma sphagni an Erico-Sphagnion character species, Eriophorum angustifolium an Erico-Sphagnion differential species and Pleurozium schreberi a companion species well represented in all Associations of the Class and thus each of the four species would equally well be expected in the Vaccinio-Ericetum tetralicis or the Erico-Sphagnetum magellanici.

3. The Vaccinio-Ericetum tetralicis.

The Vaccinio-Ericetum tetralicis encompasses the vegetation of upland blanket bogs generally between 381 m. and 762 m. (Jones, 1973). The water-table is generally lower at Vaccinio-Ericetum sites than at Erico-Sphagnetum magellanici ones and communities of the Vaccinio-Ericetum tetralicis can develop on slopes up to 15° (rarely 25°), as well as flat summit plateaux rather than in infilled basins as does the Erico-Sphagnetum (Jones, 1973).

Moore (1968) describes the affinity of such communities with those of the Sphagnion fusci, although the bulk of Erico-Sphagnion character and differential species are present, and so the Association is placed within this Alliance. Birse (1973) describes one aufnahme from the highest altitude in the Sullom Area from Dale Scord Hill (225 m.). Despite the absence of Erica tetralix and the lack of Sphagnum species apart from S. capillaceum, Birse considers a Shetland form of the Association does exist. Vaccinium myrtillus, Empetrum nigrum and Diplophyllum albicans were suggested as Kennarten of the Association in the blanket bog of the Wicklow Mountains (Moore, 1962), Empetrum and Diplophyllum are important throughout the Northern Isles vegetation and Vaccinium is present in some communities at the highest altitudes (Group 5).

Jones (1973) gives an excellent table (Table XXXII) comparing vegetation she considers may now be assigned to either the Erico-Sphagnetum magellanici or the Vaccinio-Ericetum tetralicis. Association differential species are suggested to clarify the differences between the two Associations. Narthecium ossifragum, Drosera rotundifolia and Sphagnum magellanicum are suggested for the Erico-Sphagnetum, all of which are also abundant in the Pleurozia purpurea-Erica tetralix Association. Comparison of the Northern Isles data with that of Moore (1968) and Jones (1973) suggests that Group 3 is closest to the Erico-Sphagnetum and is possibly transitional to it. However, unlike Birse (1973) it has been decided that the main bulk of at least the Northern Isles data does not lie within this Association. As differentials of the Vaccinio-Ericetum Jones (1973) suggests Rhytidiadelphus loreus, Ptilidium ciliare, Plagiothecium undulatum, Rubus chamaemorus, Hylocomium splendens, Juncus squarrosus, Vaccinium vitis-idea and V. myrtillus. From Moore (1968) Empetrum nigrum (a Sphagnion fusci differential) is recorded as constancy III within his data of the Vaccinio-Ericetum. Tricophorum cespitosum and Sphagnum rubellum have high constancy values and other species such as Drosera rotundifolia, Molinia caerulea and Sphagnum magellanicum are recorded at lower values than in the Erico-Sphagnetum magellanici. Despite the virtual absence of Vaccinium myrtillus, the Northern Isles vegetation is apparently much closer to the Vaccinio-Ericetum than to the Erico-Sphagnetum.

Goode (1974) suggests that the majority of blanket bog in Shetland should be assigned to the upland Association or Vaccinio-Ericetum, since in his experience the Shetland vegetation is more similar to the upland blanket bog of more Southern districts than to the west coast (Erico-Sphagnetum) type in both physiognomy and in the abundance of dwarf shrubs such as Empetrum and Calluna, together with Rhytidiadelphus loreus, Pleurozium schreberi and Sphagnum capillaceum. However, Goode recognises a considerable overlap between the two Associations. The clear-cut definitions of Associations as shown by Moore (1968) are lost with the additional data of Jones (1973). Jones suggests that transitional communities between the Erico- Sphagnetum and the Vaccinio-Ericetum may be caused by the effects of increasing altitude and/or a lower water-table. Birse (1973) suggests the presence of Erica cinerea even in the wetter blanket bog might be due to the hyperoceanic climate with water deficit prevailing for part of the summer and thus a lower water-table.

Comparison of the Shetland data with that from Skye (Birks, 1973) indicates most similarity with the vegetation assigned to the Calluneto-Eriophoretum McVean & Ratcliffe 62. This Association is distinguished from the Tricophoreto-Eriophoretum McVean & Ratcliffe 62 in Skye by the abundance and constancy of Empetrum nigrum, Eriophorum vaginatum, Calluna vulgaris, Hylocomium splendens, Pleurozium schreberi and Sphagnum capillaceum and by the absence of Drosera anglica, Myrica gale and Narthecium ossifragum. Hypnum ericetorum and Rhytidiadelphus loreus are both frequent in the Calluneto-Eriophoretum. This again emphasises the affinities of the Shetland vegetation with the Vaccinio-Ericetum, since the Calluneto-Eriophoretum is partly comprised of the Vaccinio-Ericetum,rather than to the Erico-Sphagnetum or the Pleurozia purpurea-Erica tetralix Association, both of which are included in the Tricophoreto-Eriophoretum. In Skye the Calluneto-Eriophoretum is only recorded above 122 m.

Goode (1974) comments that the differences between bog vegetation in Shetland and in other parts of Scotland (i.e. the relatively small proportion of Sphagnum in the ground layer in Shetland, whilst Rhacomitrium lanuginosum, Rhytidiadelphus loreus and Scapania gracilis may be very abundant and the existence in the bogs in Shetland of certain species such as Carex binervis, Erica cinerea, Luzula sylvatica, Nardus stricta and Juncus squarrosus) might warrant a new Sub-Association or

Association to be set-up for Shetland. After comparison of the Northern Isles data with other descriptions in the literature (e.g. Moore, 1968; Birks, 1973; Jones, 1973) it would appear that the Shetland data, apart from Group 5, would in fact be most satisfactorily assigned to a new geographical vicariant Association - the *Empetrum nigrum-Rhytidiadelphus loreus* Association.

5.6.3.2.2. The *Empetrum nigrum-Rhytidiadelphus loreus* Association

The Association is clearly closely related to the *Vaccinio-Ericetum tetralicis* but it is distinct from it in that:-

1. It is a low-level blanket bog community occurring in an area of hyperoceanic climate even to sea-level.

2. The species combination is unlike any previously described Association being most similar to the *Vaccinio-Ericetum tetralicis* but transitional in some ways to both the *Erico-Sphagnetum magellanici* and the *Pleurozia purpurea-Erica tetralix* Association.

3. One of the most important character species of the *Vaccinio-Ericetum tetralicis*, *Vaccinium myrtillus*, is not present in any Group apart from Group 5. This, *Vaccinium myrtillus* Group is assigned to the *Vaccinio-Ericetum*, since in Yell it has only been recorded at high altitudes (as at Sullom, Birse, 1973). It seems likely that upland blanket bog in its more traditional form would exist in Shetland were there higher hills.

4. As Goode (1974) points out certain unusual species for blanket bog are present in Shetland communities distinguishing the vegetation from Mainland types. Birse (1973) too recognises the vegetation as a local race because of the abundance of Eriophorum angustifolium, the high constancy of Scapania gracilis and the low frequency of Narthecium ossifragum. Within the Vaccinio-Ericetum tetralicis Moore (1962) recognised three sub-associations: a Juncus squarrosus sub-association differentiated by Juncus squarrosus, Calypogeia trichomanis, Plagiothecium undulatum and Deschampsia flexuosa; a typical sub-association and a Narthecium sub-association differentiated by Narthecium ossifragum, Cladonia uncialis, C. arbuscula, Rhacomitrium lanuginosum and Andromeda polifolia. Similar sub-units are apparent in the new Empetrum-Rhytidiadelphus loreus Association. The divisions, however, are not as clear as in Moore's data, again emphasising the continuous variation in Shetland vegetation and the sub-associations must be defined by a combination of species, each of which is most constant within that sub-group but not completely exclusive to it.

5.6.3.2.3. Synsystematic placing of blanket bog Groups 1-5.

1. Group 1 - the Calluna-Juncus squarrosus Group.

Group 1 - the Calluna-Juncus squarrosus Group is described as the juncetosum squarrosi of the new Association. Two of Moore's (1962) differential species, Juncus squarrosus and Plagiothecium undulatum hold good for this sub-association too, although both are also recorded in Group 3. Deschampsia flexuosa is only recorded once in Group 1 and so is not considered valid. Calypogeia trichomanis is not recorded and the closely related C. muellerana is not considered valid since it is recorded across the table. Two other differential species are proposed in combination with Juncus and Plagiothecium. These are Luzula multiflora and Mnium hornum. This Group shows some similarities with the Nardo-Juncetum galietosum of the Nardo-Callunetea (see 5.8.).

2. Group 3 - the Calluna-Drosera Group.

Group 3 - the Calluna-Drosera Group is described as the narthecetosum of the new Association. As differential species Drosera rotundifolia, Odontoschisma sphagni and Narthecium ossifragum are suggested. This Group is most similar to the Erico-Sphagnetum magellanici. Drosera is virtually confined to this Group but Narthecium and Odontoschisma are occasionally recorded in other blanket bog communities. In the parallel sub-association of the Vaccinio-Ericetum, as well as Narthecium, Moore (1962) uses the following differential species: Cladonia uncialis, C. arbuscula, Andromeda polifolia and Rhacomitrium lanuginosum. Andromeda is not a Shetland species and Cladonia arbuscula is recorded once in Group 2. Rhacomitrium and Cladonia uncialis are not valid for the narthecetosum of the Empetrum-Rhytiadiadelphus loreus Association, since these two species are more constant in Group 2

3. Group 2 - the Calluna-Rhacomitrium Group.

Group 2 comprises the third sub-association, the rhacomitretosum lanuginosi. The community is often adjacent to vegetation assigned to the narthecetosum and thus similarities are to be expected. As differential species Rhacomitrium and Erica cinerea are suggested, despite their occurrence in Group 3. No confusion should arise since the narthecetosum differential species are virtually absent from Group 2. A third differential, Carex binervis, is proposed which is one of the species mentioned by Goode (1974) as unusual in blanket bog vegetation. The two sub-groups of Group 2 are described as variants of the sub-association. Thus, Subgroup 1 is the Listera-Pleurozium variant and Sub-group 2 the typical variant. Both have lichen poor facies.

4. Group 4 - species-poor Group.

Group 4 is the typical sub-association with no defining species and in which the differential species combinations of the other sub-associations are absent. Subgroup 1 comprises the Hylocomium-Pleurozium variant and subgroup 2 the typical variant of the sub-association.

5. Group 5- Vaccinium myrtillus Group.

Group 5 as previously mentioned is assigned to the Vaccinio-Ericetum tetralicis. The data is very similar to the vegetation described from Sullom by Birse (1973). The three character species of Moore (1962) are present - Vaccinium myrtillus, Empetrum nigrum and Diplophyllum albicans. In addition, Rhytidiadelphus loreus, Plagiothecium undulatum, Hylocomium splendens and Juncus squarrosus are recorded and these species are amongst the differentials suggested for the Association against the <u>Erico-Sphagnetum magellanici</u> by Jones (1973).

5.6.4. Synopsis of the blanket bog community types.

OXYCOCCO-SPHAGNETEA Br.-Bl. et. Tx. 43.

SPHAGNETALIA MAGELLANICI (Pawlowski 28 p.p.) Moore (64) 68.

ERICO-SPHAGNION Moore (64) 68.

Vaccinio-Ericetum tetralicis Moore 62 = GROUP 5 (5.6.2.5.).

Empetrum-Rhytidiadelphus loreus Association ass. nov.

juncetosum squarrosi = GROUP 1 (5.6.2.1.).

rhacomitretosum lanuginosi = GROUP 2 (5.6.2.2.).

Listera-Pleurozium variant = SUBGROUP 1 (5.6.2.2.1.).

Lichen-poor facies.

Typical variant = SUBGROUP 2 (5.6.2.2.2.).

Lichen-poor facies.

narthecetosum = GROUP 3 (5.6.2.3.).

typicum = GROUP 4 (5.6.2.4.).

Hylocomium-Pleurozium variant = SUBGROUP 1 (5.6.2.4.1.).

Typical variant = SUBGROUP 2 (5.6.2.4.2.).

POOLS

SCHEUCHZERIETEA

SCHEUCHZERIETALIA PALUSTRIS

RHYNCHOSPORION ALBAE

ERIOPHORUM ANGUSTIFOLIUM-SPHAGNUM CUSPIDATUM ASSOC.

GROUP 1

=

ERIOPHORUM ANGUSTIFOLIUM-SPHAGNUM CUSPIDATUM GROUP

(5.7.2.1.)

FIGURE 5.7. Synoptic classification of the vegetation of blanket bog pools in the Northern Isles.

5.7. Blanket Bog Pools - Table 7.

5.7.1. Introduction.

A synopsis of the classification of blanket bog pools in the Northern Isles is shown in Fig. 5.7.

The topography of blanket bog was described in 5.6. Wherever hollows in the bog surface are below the level of the water-table a pool results. These pools can vary in size from less than a metre in diameter to considerably more. The sides are often eroded by wind and water (5.6.1.). The vegetation is generally species-poor, often with only a carpet of *Sphagnum* and scattered spikes of such species as *Eriophorum angustifolium* and *Carex nigra*. Similar vegetation is found in some revegetated erosion channels.

5.7.2. Vegetation.

Only one Group has been identified and this is the *Eriophorum angustifolium-Sphagnum cuspidatum* Group.

5.7.2.1. Eriophorum angustifolium-Sphagnum cuspidatum Group = Group 1.

Characterising species: Eriophorum angustifolium, Carex nigra, Sphagnum cuspidatum.

Description: This community is most characteristic of pools and revegetated erosion channels. These narrow channels may form a mosaic dissecting the general bog surface, and there may be some slight flow through them. Such vegetation is very frequent in Yell, Hascosay and some of the small peat-covered islands such as Daaey, and also in parts of Unst on the schist and granite, where there is blanket bog. Aufnahmen have been collected at altitudes between 12 m. and 122 m.

At each site a carpet of Sphagnum is interspersed with spikes of Eriophorum angustifolium and Carex nigra, which are usually less than 152 mm. in height. Sphagnum cuspidatum is most frequent often with small tufts of Sphagnum rubellum and S. subsecundum var. auriculatum. In some stands Sphagnum papillosum, S. palustre, S. magellanicum or S. subsecundum var. inundatum may dominate. Rarely Sphagnum cuspidatum is totally absent.

Beneath the surface Sphagnum there may be standing water or very wet dark peat. The pH of the water averages 4.4 but may be as low as 3.3. Lichens are absent and shrubs virtually so. At the drier sites where infilling is more advanced an occasional plant of Calluna vulgaris may have established itself. Bryophyte cover is always over 50% and where the Sphagnum carpet is complete it is 100%. No other bryophytes have high cover value, although Aulacomium palustre, Odontoschisma sphagni, Scapania gracilis and Lophozia ventricosa are occasional and Pellia epiphylla rare.

Herbs apart from the character species are unimportant and herb cover is usually only 10% or at most 40%. Occasional species include Agrostis tenuis, Tricophorum cespitosum, Juncus squarrosus, Potentilla erecta and Narthecium ossifragum. Juncus kochii is frequent and Ranunculus flammula occasional at the peaty edges of the pools or channels.

Grazing of this community is insignificant since the ground is too wet.

5.7.3.. Synsystematics.

Sphagnum dominated communities of ombrogenous bog pools and flats are generally assigned to the Rhynchosporion albae Koch 26 of the Scheuchzerietea Den Held, Barkman & Westhoff 69. Sphagnum cuspidatum is abundant in Group 1 and this species is listed by Westhoff & Den Held (1969) as a Class, Order and Alliance character species. Comparison of the data with pool vegetation previously ascribed to the Rhynchosporion (e.g. Braun-Blanquet & Tüxen, 1952; Ivimey-Cook & Proctor, 1966; Birks, 1973) shows some similarities (especially with the Skye data of Birks) in the constancy of Eriophorum angustifolium, the presence of Narthecium ossifragum and Sphagnum species such as S. subsecundum but Rhynchospora alba and other Alliance character species (see 4.8.) are absent from Group 1. The Group does show some allegiance to the Caricion curto-nigrae of the Parvocaricetea (see 4.7.) in the presence of Carex nigra and Ranunculus flammula (character species of the Caricion) and Potentilla erecta (a differential species of the Parvocaricetea from the Scheuchzerietea). These species are not present in the Skye communities. Thus, the precise phytosociological status of the community is unclear. Tentatively, however, on the general physiognomy of the vegetation and habitat the community is assigned to the Skye community - the Eriophorum angustifolium-Sphagnum cuspidatum Association Birks 73, acknowledging transitions towards the Caricion curto-nigrae, particularly at drier sites.

5.7.4. Synopsis of the synsystematic placing of Group 1.

SCHEUCHZERIETEA Den Held, Barkman & Westhoff 69.

SCHEUCHZERIETALIA PALUSTRIS Nordh. 36.

RHYNCHOSPORION ALBAE Koch 26.

Eriophorum angustifolium-Sphagnum cuspidatum
Association Birks 73 = GROUP 1 (5.7.2.1.).

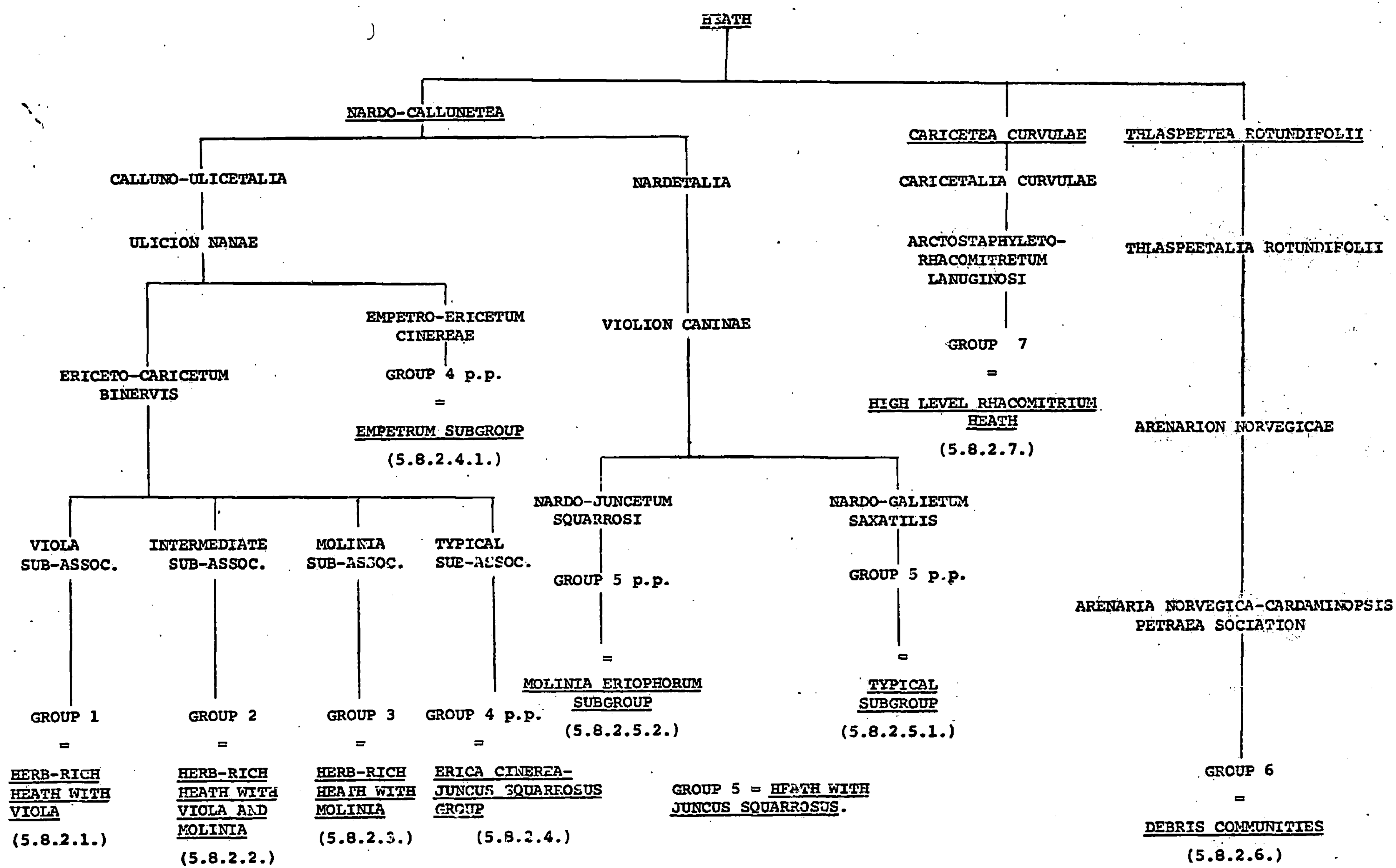


FIGURE 5.8. Synoptic classification of heath communities in the Northern Isles.

5.8. Heath - Table 8.

5.8.1. Introduction.

A synopsis of the classification of heath in the Northern Isles is shown in Fig. 5.8.

Heaths are evergreen chamaephyte communities dominated by ericoids. *Calluna vulgaris* is usually the dominant under-shrub, although *Erica*, *Empetrum* or *Vaccinium* species may be present or even dominant in some areas. Phytogeographically, heathlands are restricted to regions with an oceanic climate, although they occur in a wide variety of habitats. Soils are generally infertile, for in more fertile areas grassland communities would succeed, especially with the added influence of grazing. In less exposed parts than Shetland, in the absence of grazing or burning, forest would be the expected natural replacement community.

In extreme hyperoceanic regions (such as Shetland) blanket peat development is favoured and various bog communities generally replace heath types. The latter become restricted to more freely drained sites such as the steeper slopes.

In such peat areas, a series of interrelated communities can be distinguished from the "dry heaths" of freely drained sites through "wet heath types", where drainage is more impeded to bog communities of waterlogged areas where peat growth is active (Gimingham, 1964).

Apart from this effect of drainage Gimingham suggests numerous other "directions of variation" discernable within heathlands. Increasing oceanicity further north and west in the British Isles sees the increase of a number of species, many of which are important in Shetland heaths, such as, *Erica cinerea*, *Carex binervis*, *Hypericum pulchrum*, *Empetrum nigrum*, *Selaginella selaginoides*, *Rhacomitrium lanuginosum* and *Rhytidiadelphus loreus*. Bryophytes such as *Isothecium myosuroides*, *Mnium hornum* and *Frullaria tamariscinum*, which in the east are found only on rocks and in woods, become frequent components of the heaths of more oceanic parts.

North/south trends of species distributions are apparent (possibly, partly attributable to changing climatic severity). Thus, the frequency of *Empetrum nigrum* increases northwards, whereas the occurrence, for example, of *Ulex minor* dies out. A similar effect is seen with increasing altitude and corresponding increase in climatic severity. However, in Shetland extreme exposure brings even alpine species down to sea-level.

In general, heath communities are floristically poor. Litter from *Calluna* (usually the dominant species) produces acidic, moisture retaining humus which is badly aerated. It is only locally where the bedrock allows the development of a much more nutrient rich soil that species composition increases with such herbs as *Anthoxanthum odoratum*, *Sieglingia decumbens*, *Carex panicea*, *Antennaria dioica*, *Prunella vulgaris*, *Succisa pratensis* and *Thymus drucei*, all of which are frequent in the heaths of base-rich areas in the Northern Isles, as are *Plantago maritima*, *Armeria maritima* and *Festuca rubra*, species which tend to increase in occurrence with proximity to the sea.

Thus, Gimingham concludes that heathlands must show a "continium of variation" and any named units will reflect only the more commonly occurring groups of species.

5.8.1.1. Heath in the Northern Isles.

The Shetland climate favours the development of bog communities even in topographically unfavourable circumstances. Hence, the distribution of heaths is rather restricted. In Yell and some ofthe small islands,heath occurs only on steep slopes, summits of the higher hills, beside streams in the hills, and where land has been drained but reclamation to good pasture is incomplete.

Only in Unst and Fetlar on the basic and ultrabasic rock are heaths of any extent found. Birse & Robertson (1973) suggest that it is the base status of the rocks and possibly their open-jointed nature, which counteracts the climatic tendency towards peat development.

5.8.2. Community types.

5.8.2.1. Herb-rich heath with Viola riviniana but lacking Molinia = Group 1.

Characterising species: Very species-rich community - Calluna vulgaris, Potentilla erecta and Rhacomitrium lanuginosum. Viola canina, Plantago maritima, Carex flacca, Thymus drucei, Antennaria dioica, Festuca vivipara, Carex pulicaris and Selaginella selaginoides.

Description: These are the most herb-rich heath communities in Shetland and are found particularly in Fetlar and Unst associated with the areas of basic and ultrabasic rock. The soil is thus generally base-rich - characteristically pH 6-7, usually well-drained and shallow, 76-152 mm. in depth. Rocks and boulders are frequently exposed. The community occurs on level or gently sloping ground and these aufnahmen were recorded at altitudes between 30 m. and 90 m. The heath is subjected to light grazing by sheep and ponies.

A low windswept shrub layer - rarely over 203 mm. high and usually less than 152 mm. - of mainly Calluna vulgaris and occasional Erica cinerea and even less frequent Erica tetralix is interspersed with the silvery Reindeer moss, Rhacomitrium lanuginosum. Only very occasionally, such as at Funzie, Fetlar, does the Rhacomitrium form any appreciable hummocks. The bryophyte layer is not so richly developed as in many heath communities. The layer is about 25 mm. high and cover averages 30%. The most frequently occurring species are Hylocomium splendens, Dicranum scoparium and Frullania tamariscinum. Peltigera canina and various Cladonia species are occasional but in general lichen cover is low.

Potentilla erecta, Viola riviniana, Plantago maritima, Carex flacca, Antennaria dioica & Thymus drucei are constant and Festuca vivipara, Carex pulicaris and Selaginella selaginoides almost so. There are fewer Nardus tussocks than in less well-drained heaths but at Funzie Narthecium and Pinguicula indicate a rather wetter community. A very great variety of other herbs may be present such as Sieglingia decumbens, Agrostis tenuis, Anthoxanthum odoratum, Festuca rubra, Hypericum pulchrum, Succisa pratensis, Prunella vulgaris and many others.

5.8.2.1.1. Scilla verna Subgroup.

The community is as Group 1, but the spring squill, Scilla verna, is constant. Thalictrum alpinum and Carex pilulifera are occasional.

5.8.2.2. Herb-rich heath with Viola riviniana and Molinia caerulea = Group 2.

Characterising species group is similar to Group 1 but Molinia caerulea is constant.

Description: Basically, this is a similar type of vegetation to the last but Molinia caerulea becomes a constant species of the heath. Potentilla erecta and Viola canina remain constant and Plantago maritima, Carex flacca, Antennaria dioica, Succisa pratensis and Festuca vivipara almost so. Scilla verna, Carex pulicaris, Selaginella and Sieglingia decumbens are less frequent. Agrostis tenuis and Carex panicea as well as Nardus tussocks are common.

Once again the shrub layer consists of rather low (rarely more than 152 mm. high), windswept Calluna varying in cover from 10-60%. Amidst the shrub branches Cladonia species vary from occasional to frequent in occurrence. Apart from those mentioned in the subgroups bryophytes are relatively unimportant.

These communities are frequent in gently rolling countryside most usually where there is at least some slight degree of flushing. The presence of Molinia as well as the more frequent occurrences of Narthecium ossifragum, Pinguicula vulgaris and Tricophorum cespitosum reflect at least slightly wetter conditions than those of Group 1.

Again the bedrock is most frequently the serpentine/ greenstone group and some rocks may outcrop. The substratum although usually shallow varies from a brown, minerally soil, with a pH often over 7 to a much damper, stickier, peaty brown/grey soil, with a correspondingly lower pH - about 5.6. Grazing by sheep and ponies and, more occasionally, cattle is light but constant.

Two subgroups are apparent, although in the field the communities are intermingled and there are many overlaps between them.

5.8.2.2.1. Rhacomitrium lanuginosum subgroup = Subgroup 1.

Calluna cover is higher in this community and Rhacomitrium is present, although never very abundant. Tricophorum cespitosum and Narthecium ossifragum are more frequent in this subgroup.

Hypericum pulchrum and Thalictrum alpinum are only recorded in this subgroup and Scilla verna is virtually confined to it thus linking the community with the Scilla variant of Group 1. Erica cinerea is of higher constancy in this group and bryophytes such as Hylocomium splendens, Frullania tamariscinum and Hypnum ericetorum are moderately constant in the ground layer.

5.8.2.2.2. Subgroup lacking Rhacomitrium = Subgroup 2.

The vegetation of this group tends to be less "heathy" in appearance with lower *Calluna* cover values and much less *Antennaria dioica* and *Carex flacca*, but increased *Festuca vivipara* and *Sieglingia decumbens*. However, the subgroup is not well characterised and there is considerable overlap with subgroup 1. Near Ordale, Unst, *Salix repens* is recorded in the community as well as *Sphagnum palustre* and a little *S. capillaceum*.

5.8.2.3. Heath with Molinia = Group 3.

Characteristic species: Molinia caerulea; more frequent *Tricophorum cespitosum* and *Erica tetralix*. Species-rich *Viola riviniana* group of Groups 1 and 2 lacking.

Description: These wetter heath communities occur in similar sites to the last. In Yell the community may form peaty patches amidst pastureland, which has in the past been drained but is now degraded to a more heathy type again.

Grazing pressures are similar - sheep, ponies and sometimes cattle being kept on the land.

These aufnahmen have been recorded at altitudes between 18 m. and 60 m. The bedrock is more varied including quartzite, granite and gneiss, as well as the serpentine/ greenstone group. Soil is often shallow and usually rooty, peaty and damp. Lower pH values were recorded than for the last two Groups - some even under 5, a few over 7 and an average of about 5.4.

Calluna is again the dominant shrub, although both Erica species are recorded especially Erica tetralix. The herb layer has an average cover value of 50% but both this and the shrub layer decrease where Sphagnum species are more frequent. The bryophyte layer varies in height from 25 mm. to 101 mm. The average cover value is 60%, although this varies from 20% to 95%. Lichens are unimportant. Peltigera and Cladonia species are very rarely recorded.

The main difference between this community and the last two heath groups is the absence of the Viola riviniana species group. Molinia caerulea is constant and Juncus squarrosus virtually so, indicative of the increasingly impeded drainage. Tricophorum cespitosum is occasional. Other important associates include Eriophorum angustifolium, Anthoxanthum odoratum, Luzula multiflora and Succisa pratensis. Dactylorhiza ericetorum is most frequent in this heath community.
In this Group the bryophyte layer is richly developed. Mnium hornum is constant and Rhytidiadelphus loreus and Hypnum ericetorum are important.

Too few aufnahmen have been collected to distinguish subgroups or even variants, but there are local differences with grass species such as Holcus lanatus becoming important at some sites or Sphagnum species (particularly S. plumulosum and _S_. _capillaceum_) at others.

5.8.2.4. _Erica cinerea-Juncus squarrosus Group = Group 4_.

Characteristic species: Calluna vulgaris, Nardus stricta, Erica cinerea, Juncus squarrosus.

Description: This is a rather ill-defined Group with affinities to various of the other Groups to which they might have been possibly equally well assigned. For example, aufnahme 273 shows similarities with the upland _Rhacomitrium_ heath group and aufnahme 1082 (= 082) with Group 3 - Heath with _Molinia_. However, there are similarities between the aufnahmen which suggest a natural grouping.

The communities have been recorded from a variety of altitudes (although mainly over 61 m.) from a wide variety of sites, steep hillsides, patches in wet meadows or rolling moorland, and from areas of different bedrock including quartzite, serpentine and the Funzie conglomerate. The soil tends to be damp, brown and peaty, at most 152 mm. in depth. In Yell it is acidic (pH 3.6) but in Fetlar pH values may even be 8.0.

The heath is species-poor but healthy with a dense mosaic of _Calluna_, at least 152 mm. in height, interspersed with tussocks of _Nardus stricta_ and _Juncus squarrosus_. The shrub layer has an average cover value of 50% to which as well as _Calluna_, _Erica cinerea_ also contributes quite considerably. Apart from _Potentilla erecta_ no other herbs are constant, although a variety of sedges and grasses may be present including Carex nigra, C. binervis, C. pilulifera, Agrostis tenuis, Anthoxanthum odoratum and Festuca rubra.

Bryophyte cover varies from as much as 80% to only 20% . The most commonly recorded species are Hypnum cupressiforme, Rhytidiadelphus loreus, R. squarrosus and more occasionally, Rhacomitrium lanuginosum.

Cladonia species are the only lichens found at all frequently and cover is negligible.

5.8.2.4.1. Subgroup with Empetrum.

The community is as above but Empetrum nigrum is constant and may form appreciable clumps.

5.8.2.5. Heath with Juncus squarrosus = Group 5.

Characteristic species: Juncus squarrosus.

Description: These are lush but generally species-poor heaths totally lacking the Viola riviniana species-rich group, as well as all shrubs except Calluna, which itself may even be absent.

The shrub layer has an average 20% cover, although this is much higher on Daaey where this vegetation covers large parts of the island. In Yell and Unst it is more frequently found as patches in badly drained meadows and beside streams in the hills. The herb layer, of average height 252 mm. and average cover 60% is dominated by Juncus squarrosus tussocks with Sieglingia decumbens, Anthoxanthum odoratum, Luzula multiflora and Holcus lanatus. Potentilla erecta is constant through the community.

Bryophyte cover varies from 10% to 90% and a variety of species are recorded, although only _Rhytidiadelphus squarrosus_ is frequent throughout the whole community. _Polytrichum_ species are frequent in the streamside stands. Once again lichen cover is low or absent. _Cladonia_ species and _Peltigera canina_ are those most frequently encountered.

These communities have been recorded from Yell, Unst and Daaey over a wide variety of rock types - gneiss, granite and greenstone, generally at low altitudes between 9 m. and 27 m. The soil is damp, brown and peaty, sometimes stoney and fairly acidic with an average pH 4.8.

5.8.2.5.1. _"Typical" Subgroup = Subgroup 1_.

This type occurs in slightly drier habitats than subgroup 2. It is occasional along streamsides. _Calluna_ is more abundant than in subgroup 2. _Rhacomitrium lanuginosum_ occasionally is recorded.

5.8.2.5.2. _Molinia-Eriophorum subgroup = Subgroup 2_.

In set meadows or the wetter parts of Daaey, _Molinia caerulea_ and _Eriophorum angustifolium_ are constant components of the association. _Sphagnum_ hummocks (particularly _S. plumulosum_ and _S. capillaceum_) occur and _Succisa pratensis_, _Dactylorchis ericetorum_ and the moss _Mnium hornum_ are associate species. A very similar community has been recorded from some streamsides, although _Molinia_ is lacking. _Eriophorum_ *angustifolium* is present amidst hummocks of *Sphagnum papillosum* and *S. palustre* as well as *S. capillaceum* and *S. recurvum*. *Carex echinata* is occasional as is *Empetrum nigrum*. In these streamside stands *Polytrichum commune* and *P. formosum* are frequent.

5.8.2.6. Debris communities = Group 6.

Characterisation: Open community with clumps of plants. Plantago maritima, Thymus drucei, Agrostis stolonifera; any of:- Arenaria norvegica, Cardaminopsis petraea, Cerastium edmonstonii, Silene acaulis.

Description: Large areas of highly unstable debris are characteristic of the Unst serpentine. Spence (1957) estimates debris covers about 809 ha. of the serpentine outcrop from sea level to 152 m. Such habitats are very exposed to wind and liable to frost heaving. The vegetation is sparse and Spence (1957) suggests similarities with Faeroese and Icelandic fellfield. Debris is sparsely colonised substratum. The surface is flat composed mainly of small angular stones of about 100-300 mm. diameter overlying much finer material. Edaphic and physiographic factors prevent the development of more stable, deeper organic soils over these outcrops. The raw soils are base-rich with a pH of about 7.4.

The community is essentially a very open one with large areas of uncolonised debris interspersed with small patches of clumps of plants,very windswept and stunted through exposure. Herb cover varies between 10 and 50% and individual plants are rarely more than 50 mm. in height. Some of the species of the _Viola riviniana_ rich heath group are present, particularly _Plantago maritima_, _Thymus drucei_, _Viola riviniana_, _Carex flacca_, _Antennaria dioica_, _Festuca vivipara_ and _Scilla verna_. _Agrostis stolonifera_ is constant ramifying between the small stones.

It is in this community that pioneer species such as _Arenaria norvegica_, _Cardaminopsis petraea_, _Silene acaulis_, _Sagina nodosa_ and the serpentine endemic _Cerastium edmonstonii_ are found. Shrubs are virtually absent apart from a very occasional small stunted _Calluna_ plant. Bryophytes too are rare and are more frequent only where _Rhacomitrium lanuginosum_ has managed to establish itself in small clumps.

The leaves of debris species are frequently tinged purple - a symptom of phosphorus deficiency (Spence & Millar, 1963).

5.8.2.7. High Level Rhacomitrium Heath = Group 7.

Characterising species: Rhacomitrium lanuginosum mat. Occasional Empetrum nigrum and Vaccinium myrtillus. Carex bigelowii; Carex pilulifera.

Description: At higher levels, for example in Yell above 183 m. on the Ward of Otterswick, a _Rhacomitrium_ rich heath develops on a shallow, dark, acid, peaty substratum (pH 3.9) replacing bog communities common at lower altitudes. Characteristically the summits of these hills are gently rolling plateau areas broken only by exposed rocks and a few small pools.

The low windswept mats of Rhacomitrium (25-50 mm high) give the vegetation a silvery appearance. Polytrichum formosum is the only other moss with any appreciable cover, although the liverwort Lophozia ventricosa is often present. Empetrum nigrum and Vaccinium myrtillus form a sparse shrub layer. Carex pilulifera, C. bigelowii, and Galium saxatile are the only important herbs apart from occasional Nardus tussocks and Festuca vivipara and Deschampsia flexuosa. Eriophorum species infiltrate the community near wetter pool areas.

Lichen cover may be as high as 60%. Cladonia species particularly C. impexa, C. furcata and C. uncialis are the most important.

5.8.3. Synsystematics of the heath communities.

5.8.3.1. Introduction.

Gimingham (1964) comments that various classification systems for heath would be feasible and possibly equally useful. Bøcher (1940; 1963) used the numerous "directions of variation" (see 5.8.1.) in an attempt to classify the North-Atlantic heath formation. The large component of northern and oceanic species in Shetland heath would mean that it belonged to Bøcher's euoceanic series. However, as Gimingham (1969) and Prentice & Prentice (1975) remark, a classification based on geographical distributions of component species is unsatisfactory compared with one based on phytosociological criteria alone, since communities containing species of varied distributions might be difficult to assign.

Bridgewater (1970) attempted a phytosociological description of the British Heath Formation but Shetland was not included. The northern, oceanic aspect of Shetland, combined with the fact that in the Northern Isles the largest areas of heathland occur on the ultrabasic and basic rocks of Unst and Fetlar, means that the synsystematics of the heathland are complicated and difficult to relate to other areas.

Coombe & Frost (1956) described the heaths of the Lizard peninsula - the largest outcrop of serpentine rock in England but there are few similarities between this southern vegetation and the exposed heathlands of Shetland.

Some of the communities show resemblances to those described by McVean & Ratcliffe (1962) for the Scottish Highlands, and by Birks (1973) for Skye. Most useful in attempting to sort out the data are the descriptions of the vegetation of the Sullom Voe (Birse, 1973) and Baltasound (Birse & Robertson, 1973) areas of Shetland.

5.8.3.2. Synsystematic placing of:-

Group 1 - Species-rich heath with Viola riviniana Group.

Group 2 - Species-rich heath with Viola riviniana and Molinia.

Group 3 - Heath with Molinia.

Group 4 - Erica cinerea-Juncus squarrosus Heath.

Birse & Robertson (1973) recognising the difficulty of assigning the heath vegetation of the serpentine and greenstone areas to any previously described unit suggest that eventually a new Association may be set up to include it. For the present, however, Birse & Robertson assigned the majority of the Balta Sound scattald either to the Ericeto-Caricetum binervis - the Association of Atlantic Heather Moor, within the Nardo-Callunetea (Preising, 1949) set up by Braun-Blanquet and Tüxen in 1950 in their survey of Irish plant communities or to an Erica tetralix-Carex pulicaris community (Birse & Robertson, 1973) of the Parvocaricetea. The interrelations of these two Associations will be considered later in this Section.

Braun-Blanquet and Tüxen's Association character species, Erica cinerea is present, although not constant throughout Groups 1-4. Of the Nardo-Callunetea Class characters Calluna vulgaris and Potentilla erecta are constant, Carex pilulifera occasional and Sieglingia decumbens present in all but the Molinia heath (Group 3).

Braun-Blanquet and Tüxen did not distinguish between Class and Order character species but from their composite list for the Nardo-Callunetea and the Calluno-Ulicetalia (Quantin 35) Tx. 37. Hypnum ericetorum, Rhacomitrium lanuginosum and Luzula multiflora are important in these communities. The Association is placed within the Ulicion nanae (Duvigneaud 44) for which Braun Blanquet and Tüxen quote Carex binervis and Festuca vivipara as character species. Carex binervis is recorded occasionally and Festuca vivipara is common in all but the Molinia heath.

Birse & Robertson (1973) describe three sub-associations previously encountered on the Scottish Mainland. These were:-

1. Sub-association with Viola riviniana.
2. Sub-association with Molinia caerulea.
3. Typical sub-association.

They consider all three sub-associations to be present in Shetland and recorded examples of each from Balta Sound but from Sullom only the Molinia sub-association. They recognise that extreme oceanic conditions, unusual bedrock, and lack of regular burning regimes leads to slight variations from the Mainland equivalents. For example, higher proportions of plagiotrophic mosses are recorded in Shetland because of the virtual absence of regular burning of the heaths.

Birse & Robertson suggest that the Unst vegetation might represent a Rhacomitrium phase of the Association - the "Rhacomitrito-Ericetum cinereae" but since Rhacomitrium is only of moderate abundance in this data this nomenclature has not been adopted.

1. Sub-association with Viola riviniana.

This sub-association is differentiated by three species, Viola riviniana, Thymus drucei and Hypericum pulchrum, which are all present in the Group 1, the species-rich heath. A similar complement of associate species is found in the Group and Birse & Robertson's (1973) data, and thus the species-rich heath - Group 1 - is assigned to this sub-association.

Birse & Robertson recognise the community from "flushed brown soils derived from metagabbro and on brown magnesian soils"; from magnesian soils a Scilla verna variant is recognised, with which the Scilla subgroup of Group 1 is synonymous. Birse & Robertson suggest that the frequent and constant occurrence of Carex pulicaris and Selaginella selaginoides within this Group link it with communities of the Parvo-Caricetea, since these species are two of their character species for the Caricion davallianae, an Alliance of this Class. Birse & Robertson, in fact, place much of the scattald heathland within an Erica tetralix-Carex pulicaris community (Birse & Robertson 73). Within this community it is suggested that the releve's with Scilla and Thalictrum might be combined with the similar ones of the Atlantic Heather Moor, forming a new Association. Comparison of Birse & Robertson's tables for the two Associations shows numerous similarities between them and no clear differential species, rather, just changes in the abundance of individuals. Carex panicea and Agrostis canina quoted as Parvocaricetea character species are constant in both communities, Molinia caerulea is constant in the Erica tetralix-Carex pulicaris community but so it is in the Molinia sub-association and in the overlap between the two sub-associations.

It is proposed that within this work all the species-rich heath, with or without Molinia, remain as part of Braun-Blanquet and Tüxen's Ericeto-Caricetum binervis, acknowledging transitions towards the Parvo-Caricetea community, but in the absence of any clear differential species it is thought best, for at least the time being to unite all the stands in the same Association. The communities obviously show a continuum of variation, some tending far more towards true dry heath than those with additional Caricion davallianae or Parvo-Caricetea character species.

2. Sub-association with Molinia caerulea.

Birse & Robertson record this sub-association typically from gley soils (including magnesian gleys) and as differential species of the sub-association quote Molinia caerulea, Erica tetralix, Tricophorum cespitosum and for the Sullom vegetation Leucobryum glaucum. The latter species is present in two aufnahmen from Yell placed within Group 3 - Molinia heath, and it is thought that this community is synonymous with this sub-association. Erica tetralix is only occasional in Group 3 but Tricophorum and Molinia constant.

Braun-Blanquet and Tüxen described a Molinia sub-association from Ireland in which Leucobryum was a differential species. They also used Erica tetralix and Molinia which indicates affinities between the vegetation of the two areas but their other differential species do not hold true for Shetland. Carex panicea, for example, is common throughout the heathlands and Sieglingia decumbens is a characteristic species of the rich Shetland heath not the Molinia heath.

Birse & Robertson recognised a group of aufnahmen (mainly on magnesian gleys) which were intermediate between the two sub-associations, both blocks of differential species being present. Group 2 - Species-rich heath with Molinia - is synonymous with this intermediate block, the Rhacomitrium sub-group is closer to the true species-rich Viola riviniana sub-association, and the second subgroup (with fewer of the rich heath species) closer to the Molinia sub-association.

Thus, Group 2 is not clearly enough defined to be a separate sub-association but rather demonstrates the continuous nature of variation between the heathland units.

3. Typical Sub-association.

This sub-association which has no differential species, was recorded mainly at altitudes above 100 m. Little data corresponding to it has been collected in this survey. The constancy of Erica cinerea in Group 4 has decided its placing provisionally in this sub-association, although the presence of Juncus squarrosus indicates similarities too with the vegetation of Group 5.

Empetro-Ericetum cinereae Association (Birse & Robertson 73).

This Association of Boreal Heather Moor is very closely related to the Ericeto-Caricetum binervis, but distinguished from it by the differential species Empetrum nigrum. At Sullom, Birse distinguished three variants, one with Carex nigra and Mnium hornum, a second with Rhacomitrium lanuginosum, and a third, the typical variant with no differential species.

The Empetrum subgroup of Group 4 has tentatively been placed in this Association, although with only two aufnahmen no further distinctions can be made.

Braun-Blanquet and Tüxen distinguish an Empetrum sub-association of the Ericeto-Caricetum binervis in Ireland but in the Shetland vegetation many of their differential species are lacking, for example Vaccinium myrtillus, Jasione montana, Sphagnum nemoreum, Eriophorum vaginatum and Blechnum spicant. This is presumably why Birse & Robertson described a new Association rather than relate the vegetation to the Irish sub-association of the Ericetum-Carici binervis.

The lack of similarity between the Unst and Fetlar serpentine/greenstone vegetation and that of the Lizard peninsula has been mentioned. Bridgewater (1970) describes an oceanic Erica cinerea heath synonymous with the Ulicion, with Erica cinerea, Calluna vulgaris and Potentilla erecta as defining species. He describes a Thymus drucei complex as the most widespread type of this heath circumscribing vegetation from south-west Cornwall to the Outer Hebrides. The Shetland vegetation represents a northern extension of this type of community, since many species are common to both. The Shetland vegetation also shows some resemblance to the species-rich Callunetum vulgaris (McVean & Ratcliffe 62) of base-rich soils. Bridgewater placed this vegetation within the Thymus drucei complex. Birks (1973) designated this herb-rich facies of the Callunetum vulgaris as a new Association - the Calluna vulgaris-Sieglingia decumbens Association, in which the following species are constant:- Erica cinerea, Calluna vulgaris, Agrostis canina, Festuca ovina, F. vivipara, Sieglingia decumbens, Carex pulicaris, Lotus corniculatus, Potentilla erecta, Hylocomium splendens and Pleurozium schreberi. Such species as Viola riviniana, Rhacomitrium lanuginosum, Antennaria dioica, and Molinia caerulea are also recorded but at much lower frequencies than in the Shetland vegetation. Prentice & Prentice (1975) recorded a similar vegetation from Hoy, Orkney.

Despite obvious similarities with the above Association, it is felt, for the present, that the Northern Isles vegetation is best related to the work of Birse & Robertson following Braun-Blanquet and Tüxen in Ireland.

5.8.3.3. Synsystematic Placing of Group 5 - Heath with Juncus squarrosus.

The affinities of these communities must be with the Nardetalia (Oberd. 49) Preising 49. of the Nardo-Callunetea in the Alliance Violion caninae Schwick (41) em. Preising 49. Nardus stricta, an Order character is constant and although present in other heath communities it is in vegetation of this Order that it is most abundant. None of the Alliance character species which Westhoff & Den Held (1969) quote are very frequent, although Luzula multiflora, Galium saxatile and Dactylorchis ericetorum occur. Juncus squarrosus is constant and is one of their Alliance character species.

There are similarities between the Shetland vegetation and both the Nardetum sub-alpinum McVean & Ratcliffe 62 and the Juncetum squarrosi McVean & Ratcliffe 62, and also superficially with the Nardo-Juncetum squarrosi Association (Birks 73) found in Skye, where Nardus, Galium saxatile and Potentilla erecta were constants. However, Jones (1973) made a very detailed comparison of all these communities and others from Britain and her work has been most useful at the Association level. Jones showed two Associations to be involved, the Nardo-Juncetum squarrosi Bük 42 and the Nardo-Galietum saxatilis Preising 49. McVean & Ratcliffe's Associations showed affinities with the second Association of Preising, whereas the Skye vegetation and Jones' noda from Widdybank Fell showed more affinity with the Nardo-Juncetum squarrosi. From Widdybank,Jones proposed two new sub-associations of the Nardo-Juncetum, one the galietosum saxatilis sub-association, and a second, the empetrosum sub-association.

The sub-association galietosum saxatilis is distinguished from the sub-association empetrosum by the presence of several species which are also present in the Nardo-galietum saxatilis. These are:- Galium saxatile, Luzula multiflora (both

Alliance characters), Anthoxanthum odoratum, Luzula campestris, Carex binervis and Carex pilulifera (a Class character species). The empetrosum is distinguished from the galietosum by Empetrum nigrum, Erica tetralix and Narthecium ossifragum.

The Nardo-Juncetum can be separated from the Nardo-galietum saxatilis by a number of differential species: Carex nigra, Eriophorum angustifolium and E. vaginatum, Aulacomium palustre, Calypogeia trichomanis, Sphagnum papillosum, S. recurvum and S. capillaceum, Polygala serpyllifolia and Carex echinata.

The second Association is also found on drier, more freely draining soils than the Nardo-Juncetum (Shimwell, 1968). It is proposed that both the Nardo-galietum saxatilis and the sub-association galietosum saxatilis of the Nardo-Juncetum, are represented in the data from the Northern Isles but not the sub-association empetrosum. The Nardo-galietum is also discussed in the Grassland Section 5.4.3.1., since degraded pastureland has been assigned to this Association.

Between the two Associations are obvious transitions but of Group 5 the typical subgroup of generally drier sites is assigned to the Nardo-galietum saxatilis and the Molinia-Eriophorum subgroup is assigned to the galietosum sub-association of the Nardo-Juncetum, because of the constancy of Eriophorum angustifolium. In general, apart from this species the differential species of the Association are not abundant, although Carex nigra, C. echinata, Eriophorum vaginatum, Aulacomium palustre, Sphagnum papillosum, S. recurvum and S. capillaceum are occasionally recorded. Those aufnahmen from streamsides in which Empetrum was recorded are transitional to the empetrosum. However, galietosum differentials, though much reduced, are still occasional and no Narthecium or Erica tetralix was recorded, so for the present the stands are left united in the galietosum.

In general physiognomy, the Shetland form of the Nardo-galietum saxatilis is obviously more like the typical form of the Nardo-Juncetum, described by Jones as an Association "dominated by rosettes of Juncus squarrosus and tufts of Nardus stricta between which is a variety of other species", than the general form of the Nardo-galietum saxatilis, which Jones, following Shimwell (1968), described more as "acidic grasslands dominated by Nardus, Deschampsia flexuosa, Festuca spp., Agrostis spp., Potentilla erecta and Galium saxatile. However, since Nardo-Juncetum squarrosi differential species are absent, subgroup 1 is assigned to the drier Nardo-galietum saxatilis.

Birse (1973) from Sullom assigns similar vegetation to a new Association, the Junco squarrosi-Festucetum tenuifoliae (Birse & Robertson 73), which he describes as a Juncus squarrosus phase of Nardus grassland. In his aufnahmen however, Calluna is absent. The community is found on flushed degenerate peat and some peaty gley soils and Birse suggests it may have been derived from wet heather moor or blanket bog by heavy grazing. The hierarchical placing is the same - within the Violion caninae with Galium saxatile as a character species. For the Association, Nardus, Juncus squarrosus and Luzula multiflora are given as character species with Polytrichum commune and Plagiothecium undulatum as differential species and Mnium hornum as a local differential species.

The data for the Northern Isles, however, seems adequately placed within the Associations, more thoroughly documented by Jones and so the new Association has not been adopted.

5.8.3.4. Synsystematic placing of Group 6 - Debris communities.

The difficulties arising from vegetation of the unusual rock type in Unst have been mentioned. However, Spence (1957; 1959; 1960; 1970) has studied both the Unst serpentine and other Scottish serpentine vegetation very thoroughly. He considers the Unst debris vegetation to belong to an Arenaria norvegica-Cardaminopsis petraea sociation, typical of unstable mineral rich substrata which represents an extension to Scotland of the Faeroese and Icelandic fellfield. A sociation is the basic unit of the Uppsala School of Phytosociology (see Shimwell, 1971). Spence (1970) notes strong resemblances with the vegetation of Sunmöre in Western Norway (Bjørlykke, 1939), which was placed in the oceanic Arenarion norvegicae subarcticum Nordhagen 36, an Alliance of Braun-Blanquet's alpine and subalpine scree vegetation Class, the Thlaspeetea rotundifolii (1947). Arenaria norvegica and Cardaminopsis petraea are character species of the Arenarion.

McVean & Ratcliffe (1962) describe a Juncus trifidus-Festuca ovina, markedly chinophobous nodum of some very exposed ground of ridges and cols in the Scottish Mountains usually at altitudes 608-1125 m. Many physical factors resemble those in Unst. Fairly level, wind-eroded ground is strewn with rock fragments of various sizes and solifluction phenomena, such as stone stripes and polygons, similar to those found by Spence (1957). The soil is an "alpine Hamada Rawmark of Kubiena" (1953), again which Spence records for Unst, although the Unst substratum is more base-rich and higher pH values are recorded.

A similar vegetation pattern is found with completely bare areas intermingled with sparsely vegetated areas (the debris communities) and Rhacomitrium heath patches in slightly less exposed sites.

Of the constant species of the McVean & Ratcliffe nodum only Festuca ovina and Rhacomitrium lanuginosum are frequent in the Unst vegetation; Salix herbacea, Juncus trifidus and Alchemilla alpina are absent, although present in a very similar community to the Scottish one on Ronas Hill on the Shetland Mainland. However, many of the associate species are in common with those of the Unst vegetation, such as Plantago maritima, Armeria maritima and Thymus drucei.

The occurrence of fellfield type vegetation at such low levels in Shetland, Spence (1970) attributes to the common factors with more upland regions of a cool summer climate combined with extreme exposure, particularly in winter. Birks (1973) records a Festuca ovina-Luzula spicata nodum very similar to the McVean & Ratcliffe nodum. Again open communities on skeletal soils occurring amongst more species-rich Rhacomitrium heath are maintained largely by exposure and, in turn, soil instability. In this community however, Juncus trifidus is lacking. Birks recognises similarities with the high level Rhacomitrium heath and places the nodum within the Arctostaphyleto-Cetrarion nivalis (Dahl 56) of the Caricetea curvulae (Br.-Bl. 48).

Despite affinities of the Unst debris with these two noda, the presence of such species as Arenaria norvegica, Cardaminopsis petraea and Cerastium edmonstonii links the vegetation with the West Norway communities. Few aufnahmen were collected from such areas since Spence had completed such detailed work and it is considered best to follow him in placing the vegetation in the Arenaria norvegica-Cardaminopsis petraea sociation.

5.8.3.5. Synsystematic Placing of Group 7 - High level Rhacomitrium Heath.

High level Rhacomitrium heath has been described frequently in the literature. Dahl (1956) (and it is his classification which is followed here) gives numerous references to vegetation similar to his Rhacomitreto-Caricetum bigelowii Association of the Rondane area of Southern Norway. In his Association Carex bigelowii, Festuca ovina and vivipara, Polytrichum strictum, Rhacomitrium lanuginosum, Cetraria islandica, Cladonia amaurocraea, C. gracilis var. chordalis and C. uncialis are constant. McVean & Ratcliffe (1962) describe a Cariceto-Rhacomitrium lanuginosum Association, in part very similar to Dahl's Association, in which Vaccinium myrtillus, Deschampsia flexuosa, Carex bigelowii, Galium saxatile, Rhacomitrium lanuginosum and Cladonia uncialis are constant but Rhacomitrium lanuginosum is always dominant. The same Association is described by Birks (1973) as the main summit heath vegetation in Skye. Birks followed Dahl in assigning the vegetation to the Arctostaphyleto-Cetrarion nivalis (Dahl, 56) within the Caricetalia curvulae Br.-Bl. 26 of the Caricetea curvulae Br.-Bl. 48.

Because of the similarity of character species of the Shetland vegetation and McVean & Ratcliff's Association, Group 7 vegetation is assigned to their Association rather than Dahl's community.

In Yell such vegetation occurs at much lower altitudes than for example in Skye, where it is recorded between 456 m. and 787 m.

Birse (1973) described a Rhacomitrium heath from the summit of Oxnabool Hill, Sullom, which he named the Agrostis montana-Rhacomitrium lanuginosum Birse 73. This is undoubtedly very similar vegetation to the Yell data but in the absence of more data it is felt that the summit heath vegetation is adequately placed within McVean & Ratcliffe's community. On the Ward of Otterswick the vegetation grades into upland blanket bog - the Vaccinio-Ericetum tetralis Moore 62 (see 5.6.).

5.8.4. Synopsis of the Heath Community Types.

NARDO-CALLUNETEA Preising 49.

CALLUNO-ULICETALIA (Quantin 35) Tx. 37.

ULICION NANAE Duvigneud 44.

Ericeto-Caricetum binervis Br.-Bl. et Tx. 50

Sub-association with Viola riviniana Birse & Robertson 73 = GROUP 1 (5.8.2.1.).

Sub-association with Molinia caerulea Birse & Robertson 73 = GROUP 3 (5.8.2.3.).

Intermediate Viola/Molinia sub-association Birse & Robertson 73 = GROUP 2 (5.8.2.2.).

Typical sub-association Birse & Robertson 73 = GROUP 4 (but not subgroup 1) (5.8.2.4.).

Empetro-Ericetum cinereae Birse & Robertson 73 = SUBGROUP 1 of GROUP 4 (5.8.2.4.1.).

NARDETALIA (Oberd. 49.) Preising 49.

VIOLION CANINAE Schwick (41) 44 em. Preising 49.

Nardo-Juncetum squarrosi Bük 42.

galietosum saxatilis Jones 73 = GROUP 5 SUBGROUP 2 (5.8.2.5.2.).

Nardo-Galietum saxatilis Preising 49 = GROUP 5 SUBGROUP 1 (5.8.2.5.1.).

CARICETEA CURVULAE Br.-Bl. 48.

CARICETALIA CURVULAE Br.-Bl. 26.

ARCTOSTAPHYLETO-CETRARION NIVALIS Dahl 56.

Cariceto-Rhacomitretum lanuginosi McVean & Ratcliffe 62 = GROUP 7 (5.8.2.7.).

THLASPEETEA ROTUNDIFOLII Br.-Bl. 47.

THLASPEETALIA ROTUNDIFOLII Br.-Bl. 27.

ARENARION NORVEGICAE Nordhagen 36.

Arenaria norvegica-Cardaminopsis petraea sociation (after Spence, 1970) = GROUP 6 (5.8.2.6.).

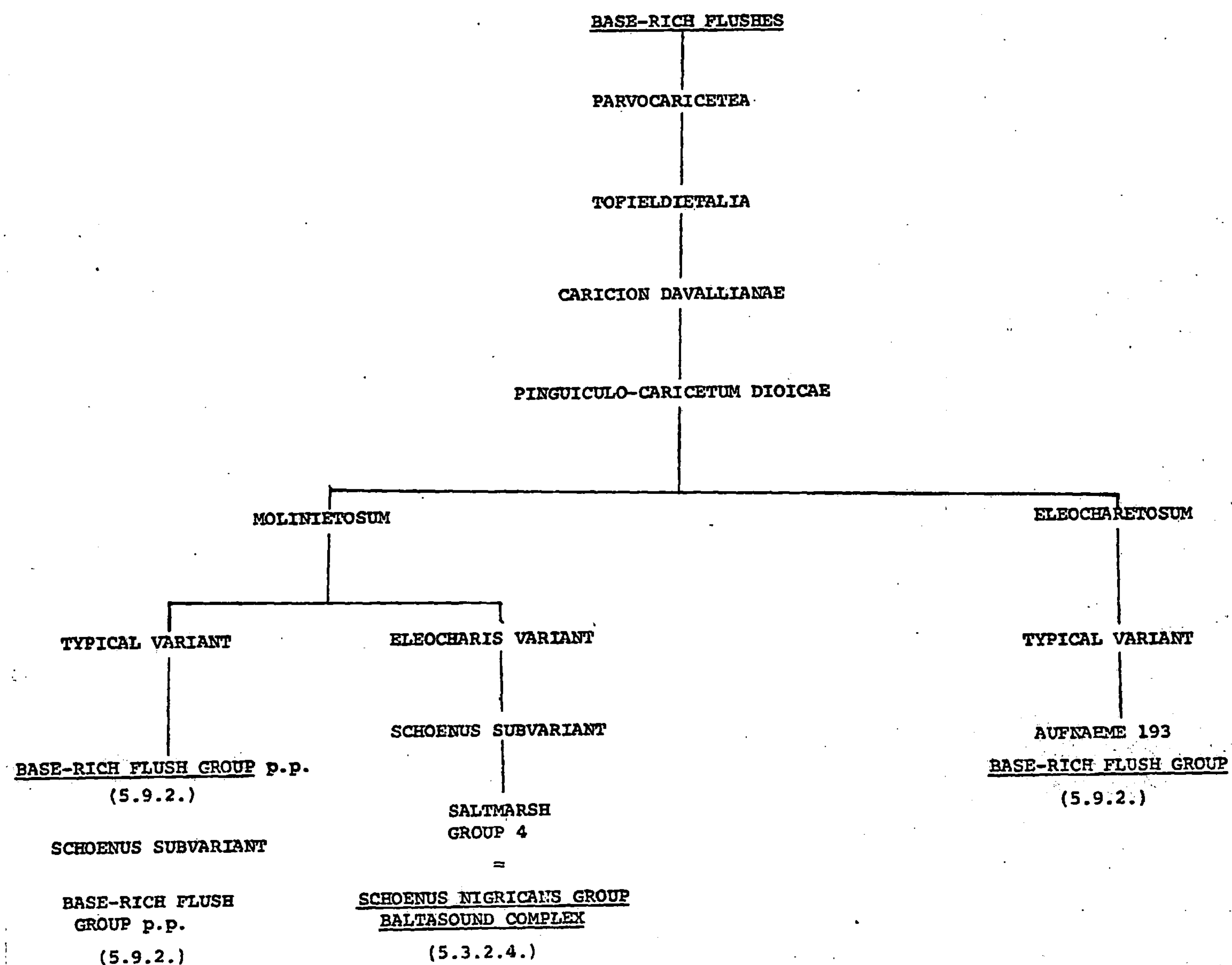


FIGURE 5.9. Synoptic classification of base-rich flush vegetation in the Northern Isles.

5.9. Base-rich flush vegetation - Table 9.

5.9.1. Introduction.

A synopsis of the classification of base-rich flush vegetation in the Northern Isles is shown in Fig. 5.9.

From amidst the heath communities of the greenstone and serpentine areas of Unst and Fetlar, on gentle seepage slopes flushed with base-rich water, a distinct community has been recorded. This vegetation is most similar to the calcareous fen communities of the rest of Great Britain. True rich fen is rare in Shetland. Wet meadow vegetation is described in 5.5.

These areas are always damp and at wetter times of the year the water-table is above the surface and trickling water is obvious. The substratum is often skeletal. Stoney clays and muds or more occasionally thin,peaty gleys are typical. The pH range recorded is between 6.0 and 7.5. Accumulation of organic material is restricted to the surrounding ground away from the main flow of water. These flush areas may be quite small or form larger, open, stoney areas, interspersed with "islands" supporting heath communities like those on the hills surrounding the flushed areas (see 5.8.). Sites were found at various altitudes ranging from 6 m. to 100 m. A related stand of vegetation was recorded from a flush in a quartzite area on Unst.

Trampling by sheep and ponies grazing the surrounding heathland scattald is frequent.

5.9.2. Vegetation description.

Monocotyledons dominate this community. Carex hostiana, C. panicea, Molinia caerulea, Nardus stricta and Juncus kochii are very frequent. Carex flacca, C. demissa, C. dioica, Juncus articulatus and Schoenus nigricans are occasional components, whilst Juncus squarrosus, Tricophorum cespitosum, Anthoxanthum odoratum and Holcus lanatus are rare. Eleocharis quinqueflora is recorded from one Fetlar site.

Straggling bryophytes such as Scorpidium scorpioides, Drepanocladus revolvens, Acrocladium cuspidatum, Campylium stellatum and Riccardia pinguis are frequent in the stoney, open areas. Bryum pseudotriquetrum and Sphagnum subsecundum var. auriculatum are less frequent.

Other herbs include Ranunculus flammula, Pinguicula vulgaris, Plantago maritima, Potentilla erecta, Succisa pratensis, Leontodon autumnalis and Narthecium ossifragum. Species typical of the surrounding heaths such as Calluna vulgaris Erica tetralix, Selaginella selaginoides, Antennaria dioica, Thymus drucei, Thalictrum alpinum, Festuca vivipara and Hylocomium splendens are local components.

Bryophyte cover varies tremendously from less than 10% at some sites to over 50% at others. Typically herb cover varies between 30% and 70%.

5.9.3. Synsystematics.

Three stands recorded from the head of the Balta Sound saltmarsh complex (described in 5.3.) are clearly related to this Group and might equally well have been placed with these aufnahmen. The synsystematics of this Schoenus nigricans Group were described in 5.3.3. Despite the absence of character species this Group was assigned to part of the Pinguiculo-Caricetum dioicae Jones 73 em. Wheeler 75. of the Caricion davallianae. Wheeler (1975) does, in fact, comment that many of the character species suggested for the Association by Jones (1973) are of much wider ecological tolerance and perhaps only Carex dioica is a useful character species. Similarly, the two differential species Carex pulicaris and Plantago maritima, are widespread in other related Associations. Wheeler concludes that despite the lack of good diagnostic species the Association should be retained, although in time with additional data the Association may be split into a number of more precisely defined Associations.

From the base-rich flush communities two Parvocaricetea characters are common - Carex demissa and Riccardia pinguis. Carex dioica, Eleocharis quinqueflora, Scorpidium scorpioides and Campylium stellatum are Tofieldietalia characters and Carex hostiana a Caricion davallianae character. The Association characters which Jones suggested are Tofieldia pusilla, Carex lepidocarpa, Carex dioica, Triglochin palustris and Kobresia simpliciuscula. Only the Order character previously mentioned, Carex dioica, is present in the flush Group. Jones described four sub-associations, the molinetosum, the equisetosum variegati, the thalictro-saxifragetosum and the eleocharetosum, the latter two with several variants and facies. The concept of the Association was enlarged and the internal structure revised by Wheeler (1975) and the changes relevant to this discussion are described in 5.3.3.

On general species composition the flush Group is apparently similar enough to the description of the Association to be assigned to the Pinguiculo-Caricetum, although the frequency of Ranunculus flammula, a Caricetalia nigrae character species must distinguish these rather impoverished flush communities from those described from other parts of Britain. The flushes probably represent very poor Caricion davallianae communities, which are virtually transitional to those of the Caricion nigrae. For the present, however, it is felt that the Group is best assigned to the Pinguiculo-Caricetum until further work clarifies the exact phyto-sociological relationships of the Group.

Jones quoted Molinia caerulea, Succisa pratensis, Eriophorum latifolium and Parnassia palustris as differential species of the molinietosum. On the constancy of Molinia, all Group 1, apart from aufnahme 193, are assigned to this sub-association. Succisa is occasional in the Group, Eriophorum latifolium is not a Shetland species and Parnassia is not present in this community in the Northern Isles.

Eleocharis quinqueflora was present in the Balta Sound stands and hence those aufnahmen were assigned to the Eleocharis variant of the molinietosum, and on the presence of Schoenus nigricans to the Schoenus sub-variant.

In the flush Group molinietosum communities, Eleocharis is absent and so the vegetation is placed in the typical variant. The three aufnahmen with Schoenus are described as a Schoenus sub-variant of the typical variant.

Aufnahme 193 lacks Molinia but Eleocharis quinqueflora is present. As differential species of the eleocharetosum Jones lists Eleocharis quinqueflora, Eriophorum angustifolium, Carex nigra, Juncus kochii, Equisetum palustre, and Carex demissa. Juncus kochii is abundant in the stand 193 but this species is in fact frequent in those assigned to the molinietosum and so it cannot be regarded as a good differential species in Shetland. However, on the presence of Eleocharis and the absence of Molinia aufnahme 193 is assigned to the typical variant of the eleocharetosum. Two aufnahmen lack both Molinia and Eleocharis, although otherwise the species composition is very similar to the majority of aufnahmen assigned to the molinietosum, and they are, therefore, left with these in the molinietosum for the present.

5.9.4. <u>Synopsis of the synsystematic status of the Group.</u>

PARVOCARICETEA den Held & Westhoff 69.

TOFIELDIETALIA Prsg. apud Oberd. 49.

CARICION DAVALLIANAE Klika 34.

Pinguiculo-Caricetum dioicae Jones 73 em. Wheeler 75.

molinietosum Jones 73 em. Wheeler 75.

typical variant (5.9.2 pp).

Schoenus sub-variant (5.9.2 pp).

eleocharetosum Jones 73 em. Wheeler 75.

typical variant (5.9.2. pp).

CHAPTER 6.

DISCUSSION.

6. Discussion.

6.1. A brief synopsis of the vegetation types of each of the Northern Isles.

6.1.1. Yell.

A large proportion of Yell is covered with blanket bog much of which has been assigned to the Empetrum-Rhytidiadelphus loreus Association. All four sub-associations are found. The rhacomitretosum lanuginosi and the typical sub-association are most extensive. The juncetosum squarrosi is frequent in hollows used by sheep for shelter, beside streams or in areas of old peat cuttings. The narthecetosum is restricted to drainage channels and pool sides. The hummock/hollow topography is broken by pools of various sizes with abundant Sphagnum species and Eriophorum angustifolium (assigned to the Eriophorum angustifolium-Sphagnum cuspidatum Association). Large areas of the bog have been severely eroded with a resulting pattern of deep gullies and peat haggs.

On the highest hill tops there may be a limited development of the upland blanket bog Association, the Vaccinio-Ericetum tetralicis. However, in these situations peat is rarely well developed and more frequently a wind swept Rhacomitrium mat is characteristic which is assigned to the Cariceto- Rhacomitretum lanuginosi.

Heath communities, in general, are of only limited occurrence. On some of the steeper slopes and in some degenerating meadows the typical or Molinia sub-associations of the Ericeto-Caricetum binervis may be encountered.

Nardo-Galion communities are frequent beside the numerous streams draining from the hills to the coast and the bright green species-rich vegetation provides a welcome break in the rather monotonous blanket bog. Both the Nardo-Juncetum squarrosi and the Nardo-Galietum saxatilis have been recorded.

Good farmland is found only at the coast. Reclaimation of bog-land has provided relatively good pasture, much of which is assigned to the Lolio-Cynosuretum as is some of the established machair grassland at Breckin. Badly drained land especially in valley bottoms, may support colourful Calthion communities. There is a band of maritime grassland at the top of the cliffs around much of Yell and most of this has been assigned to a Plantago maritima-Carex nigra nodum of the Silenion maritimae or to the Carex distans-Plantago maritima Association of the Armerion. True saltmarsh communities are rare in Yell. There are small patches of Armeria and Plantago rich vegetation at the head of most of the voes, which may be referred to an Armerion community, usually the Juncetum gerardii. At Breckin and West Sandwick there are relatively well developed sand dune systems with associated machair particularly at Breckin. The dune vegetation is species-poor and assigned to the Elymo-Agropyretum junceiforme. Younger stages of the machair grassland may represent an impoverished form of the Camptothecio-Asperuletum cyanichae.

Shingle and boulder beaches are frequent all round the coast of Yell. The initial communities are assigned to the

Atriplicetum littoralis or a related nodum, whilst the more established vegetation belongs to communities of the Agropyretea.

6.1.2. Kay Holm.

The central part of Kay Holm supports a limited development of blanket bog which is rich in Juncus squarrosus and thus belongs to the juncetosum sub-association of the Empetrum-Rhytidiadelphus loreus Association. This is interspersed with the typical sub-association. Above the cliffs is a wide band of maritime grassland which as in Yell is assigned to either the Silenion or the Armerion. This may degenerate to a rough heath grassland of the Nardo-Galietum saxatilis between the true maritime grassland and the bog vegetation. Amongst the rocky foreshore small pockets of vegetation are attributable to the Armeria maritima-Grimmia maritima Association.

6.1.3. Hascosay.

Vegetationally, Hascosay is rather similar to Yell. The central part of the island is covered with blanket peat which shows the full expression of the Empetrum-Rhytidiadelphus loreus Association. There are numerous pools and small lochs, some supporting the Eriophorum angustifolium-Sphagnum cuspidatum Association.

The streams draining the area are bordered by Nardo-Galion communities which also form a transitional band between the true bog and the maritime grasslands around the edge of the island. Blown sand at Housa Wick supports impoverished machair-type vegetation and the boulder beaches at the shore have limited development of the Atriplicetum littoralis.

6.1.4. Fetlar.

The vegetation of Fetlar is varied and could warrant a more extensive survey. There is a lush band of maritime grassland around the cliff tops which is ascribed as before to the Carex distans-Plantago maritima Association or to a Plantago maritima-Carex nigra nodum of the Silenion. This generally degenerates further inland into a Nardo-Galietum community.

The Lam Hoga peninsula is covered with blanket peat which again supports the Empetrum-Rhytidiadelphus loreus Association.

Around the southern and eastern croasts of the island there is good farmland, some of which supports species-rich Lolio-Cynosuretum communities. In wet areas there is rich Calthion vegetation.

There is limited dune development at Papil Waterwith impoverished Elymo-Agropyretum vegetation. Boulder beaches are fairly frequent around the coast with the nodum related to the Atriplicetum being the most usual community.

Large parts of the island (where there is greenstone or serpentine bedrock) supports heath vegetation, the majority of which may be assigned to a species-rich form of the Ericeto-Caricetum binervis. All the various sub-associations are found and flushed areas may support Pinguiculo-Caricetum dioicae communities. On the highest hills small patches of a wind-swept Rhacomitrium mat are attributable to the Cariceto-Rhacomitretum lanuginosi. A network of streams drain the hillsides and the edges of these are bordered by Nardo-Galion communities.

Many of the cliffs are high and frequented by numerous sea birds. The guano-enriched substratum supports vegetation rich in nitrophilous species.

6.1.5. Islands of the Colgrave Sound.

6.1.5.1. Daaey, Urie Lingey, Linga and Wedderholm.

These islands are all quite similar in community structure, although only Daaey was sampled. A rocky foreshore with small patches of the Armeria maritima-Grimmia maritima Association gives way to more extensive maritime grasslands of the Silenion and Armerion. There is a fairly wide transition band of Nardo-Galietum type vegetation before the peat cap of the island which supports a limited development of Juncus and Nardus rich blanket bog.

6.1.5.2. Sound Gruney and Haaf Gruney.

These two islands are characterised by lush maritime grasslands and Lolio-Cynosuretum pastures. There is no peat and thus bog types are lacking. Patches of the Armeria maritima-Grimmia maritima Association are found between some rocks at the shore and on a stack off Sound Gruney a Puccinellia-rich stand is related to saltmarsh vegetation of the Puccinellion.

Sound Gruney communities in particular show an increase of nitrophilous species as the result of guano-enrichment of the soil by sea birds.

6.1.6. The Yell Sound islands - Brother Isle; Uynarey; Bigga; Samphrey.

Of these islands only Samphrey was visited or sampled but essentially each island is fairly similar vegetationally (Tulloch, 1975, pers. comm.). Much of Samphrey is covered by blanket bog of the Empetrum-Rhytidiadelphus Association with a transition band of Nardo-Galion communities before maritime cliff top grasslands. Near the old settlement at Bunglan there is quite extensive Lolio- Cynosuretum pastures.

6.1.7. Unst.

This island is rich vegetationally and the majority of the communities which have been described in this survey are found in Unst.

The Valla Field ridge of gneisses in the West, the Skaw granite and the Muness schists support blanket bog of the Empetrum-Rhytidiadelphus Association and as in Yell all four sub-associations are encountered. Steep slopes and stream-sides support Nardo-Galion communities such as the Nardo-Galietum saxatilis and the Nardo-Juncetum.

Around the whole of the island there is a band of maritime cliff top grassland of the Carex distans-Plantago maritima Association or the Plantago maritima-Carex nigra nodum of the Silenion.

Particularly in the eastern part of the island and to some extent at Westing, there are good Lolio-Cynosuretum pastures, although some are degraded and transitional to the Nardo-Galietum saxatilis. There are also rich Calthion wet meadows in these areas including the large Norwick complex, part of which supports the Polygonum amphibium nodum of rather uncertain phytosociological status.

At Norwick and Lund there are impoverished dune systems with vegetation assigned to the Elymo-Agropyretum junceiforme. Limited machair at Burrafirth has been tentatively assigned to a Mesobromion community and to the Lolio-Cynosuretum.

Shingle and boulder beaches are numerous with all three of the successional stages which have been identified. Species-poor open vegetation ascribed to a nodum related to the Atriplicetum littoralis is most frequent. This may give way to the Potentilla anserina-Atriplex patula nodum of the Honkenyo-Crambion and the Agropyrion pungentis community - the Festuca rubra-Trifolium repens nodum.

The only extensive saltmarsh in Shetland is at Balta Sound and the Puccinellietum maritimae and the Juncetum gerardii have been identified.

Most interesting however, must be the heath communities of the serpentine and greenstone. Large areas of eastern Unst are covered by heath communities of the Ericeto-Caricetum binervis. Three sub-associations have been identified. The

Viola riviniana sub-association is most extensive but it is replaced by the Molinia sub-association wherever there is even a slight degree of flushing. The typical sub-association is also found in the wetter sites particularly on the greenstone, but this sub-association is more extensive on slopes in the west too steep for blanket bog development.

Flushes amidst the heath support communities of the Pinguiculo-Caricetum dioicae and both the molinietosum and the eleocharetosum are encountered.

Parts of the serpentine and in particular on the Keen of Hamar, support debris vegetation which is assigned to the Arenaria norvegica-Cardaminopsis petraea sociation.

6.1.8. Balta and Huney.

These islands were not visited but from a distance they apparently support lush maritime grassland and Lolio-Cynosuretum communities. Extensive dunes and machair type vegetation form part of Balta.

6.1.9. Uyea.

This island was not visited but apparently the central part of the island is peat covered with blanket bog and heath communities, whilst there are maritime grasslands and some dunes at the coast (Tulloch, 1975; pers. comm.).

6.2. General Discussion.

Of the many factors in the ecosystem which determine the occurrence, the relative abundance and the distribution of the various plant communities described in Chapter 5, probably the interactions of the extreme regional climate, the varied geology and topography and the different types of land use, are most important. These three factors vary quite considerably in the relatively small area of the Northern Isles.

It is indeed difficult to separate the effects of climate and geology. The climate of Shetland is extremely oceanic (see Chapter 2). It is wet and cool, and this, combined with the fact that there are large areas of relatively impervious bedrock, means that there is water-logging of the substratum, which leads to extensive peat formation. There is a close correlation between bedrock type and peat development. Deep peat is abundant in the parts of the islands where the bedrock is gneiss, schist or granite, but peat is absent from areas of base-rich rocks such as serpentine or greenstone. The topography of much of the Northern Isles is suitable for blanket peat formation and large parts of the islands are in fact covered by a deep blanket of peat.

The influence of the Northern climate is seen in the blanket bog communities themselves. Species such as Rhytidiadelphus loreus, Scapania gracilis and Empetrum nigrum are more frequent than on the Scottish Mainland.

The presence of Rhytidiadelphus and Empetrum link the vegetation with the Vaccino-Ericetum tetralicis but the character of the communities was thought to be individual enough to warrant a new vicariant Association, the Empetrum-Rhytidiadelphus loreus Association. In the rhacomitretosum lanuginosi, Rhacomitrium may be very abundant at the expense of Sphagnum species. Anywhere, where there is at least a slight degree of flushing the narthecetosum is the characteristic sub-association and the juncetosum squarrosi is typical in areas where there has been some disturbance such as old peat cuttings or in parts of the bog much frequented by sheep, perhaps because there is a slight hollow affording some shelter. The typical sub-association is found extensively, intermingled with the Rhacomitrium sub-association.

Wherever the surface of the bog is below the level of the water-table pools will result and the Eriophorum angustifolium-Sphagnum cuspidatum Association of the Scheuchzerietea may be recorded. At the very edge of some pools the narthecetosum of the Empetrum-Rhytidiadelphus loreus Association may be recorded.

Amidst the blanket bog where there are slopes too steep for deep peat to accumulate and also in the areas of base-rich bedrock, the characteristic vegetation type is heath most usually of the Ericeto-Caricetum binervis. On the serpentine and greenstone a very rich assemblage of species is found which is assigned to the Viola riviniana sub-association. Where there is a slight degree of flushing the Molinia sub-association is more characteristic and the typical sub-association is most usually found amidst the blanket bog. Where flushing is more extensive, particularly on the serpentine, a type of fen community may develop which is assigned to the Pinguiculo-

Caricetum dioicae.

Exposure is perhaps the climatic element whose effect is most readily observable in Shetland. The average wind speed at Lerwick is 7.3 m/s and this may severely stunt the Calluna of both the blanket bog and the heath communities.

The effects of oceanicity are not really understood, since little work has been done on this subject. It is, however, generally accepted that the frost-sensitivity of oceanic south-western plants such as Narthecium ossifragum, restricts them to areas with relatively high winter temperatures (Conolly and Dahl, 1970). Birse (1973) suggests that the unusually high frequency of Erica cinerea is the blanket bog communities of Shetland might be attributed to the hyper-oceanic climate of the islands with a marked water deficit prevailing for part of the summer.

A species is not limited by a single climatic factor all round its range, but rather its distribution depends on a multi-dimensional interaction of factors. Although correlations between a limit to the distribution of a species and some climatic factor may be seen, it is difficult to prove. A climatic effect which truly affects the distribution or growth of a species must in some way act on the physiological processes in the plants which constitute that species (Conolly & Dahl, 1970) Conolly & Dahl also believe that the occurrence of such species as Arenaria norvegica, Thalictrum alpinum, Cerastium edmonstonii and Silene acaulis and types of vegetation such as the Arenaria norvegica-Cardaminopsis petraea sociation, the Vaccinio-Ericetum tetralicis and the Cariceto-Rhacomitretum, at relatively low levels, as compared with parts of the Scottish Highlands, may be partly attributable to the low summer temperatures. They prove that the distribution limits of most British arctic and montane species are correlated, towards warmer regions, with an isotherm for maximum summer temperature. For most species close correlation with a particular limiting isotherm is maintained only within a limited geographical region. The values attached to the isotherms fall progressively in the following order - central and/or southern England, northern England and Wales, Highland Scotland and Ireland, which suggests that oceanicity exercises a modifying influence on the control of plant distribution by maximum summer temperature. Species may also be found growing at even lower altitudes than one would expect because the local climate may be cooler than indicated by the regional climate alone. Where air temperatures are the same Conolly & Dahl believe that plants may be expected to reach higher temperatures in moist oceanic air than in dry continental air. Prentice & Prentice (1975) suggest that in Orkney, treelessness resulting from either climatic or historical factors or a combination of both, may indirectly favour the lowering of the altitudinal range of many species and communities.

The inhospitability of the large areas of peat land has meant that most of the islands' population is distributed along the coast where there is flatter land and often better soils for cultivation. Although some reseeding of hill land is now encouraged the majority of pasture communities such as those of the Lolio-Cynosuretum are found near the coast. True, good pasture is never very extensive and quickly gives way to the heath and blanket bog types of the scattald. Along flat flood plains of streams, which are near the end of their courses and also in wetter pasture land, colourful Calthion communities are frequent. Such vegetation is little managed now but in the past when crofting was more important it would have been manured and cut. Although much good pasture has been reclaimed from areas of bog, it must be carefully managed to be maintained. If the drainage is not entirely efficient rush species, and in particular *Juncus conglomeratus*, may readily become established and the pasture will rapidly begin to degenerate to wet meadow types or even rough heath grassland of the Violion caninae, and eventually bog communities may reestablish themselves.

Along the coast the effect of strong winds carrying large quantities of sea spray is very obvious. There is an area of maritime grassland extending over almost the entire cliff top with the exception of the highest and most sheltered cliffs. Silenion and Armerion communities are characteristic of these relatively well-drained soils, rich in salts. Characteristically, this grassland is intensively grazed to a low, dense sward. Where the density of sheep is less, such as on some of the smaller islands plant growth may be more luxuriant.

Goldsmith (1975) considers all of Shetland to be sub-maritime, since few locations are more than 5 km. from the sea and thus virtually everywhere must receive some salt-spray. Individual maritime plants such as *Plantago maritima* and *Armeria maritima* are in fact scattered all over the islands in many vegetation types. The abundance of *Carex panicea* on the Shetland blanket bogs is interesting, although whether the distribution of this species is in any way affected by local enrichment from spray is not known. The frequency of this species in the Shetland bogs certainly finds a parallel with certain Irish blanket bogs (Bellamy & Bellamy, 1965). It is interesting however, that *Schoenus nigricans*, which Bellamy and Bellamy record frequently from bogs in Ireland where there are more than 250 rain days/year, is not found in the Shetland blanket bogs. Indeed, in Shetland as a whole *Schoenus* is only found in a very stunted form in the base-rich flushes of serpentine and limestone areas, and is never even found in transition mire systems (*sensu* Bellamy, 1968).

In Ireland *Schoenus* occurs most frequently in the *Pleurozia purpurea-Erica tetralix* Association (Braun-Blanquet & Tuxen, 1952), and this Association has not been recorded from the Northern Isles, although the *narthecetosum* of the

Empetrum-Rhytidiadelphus loreus Association shows some relationships with it.

Further from the intense spray zone and where drainage becomes more impeded the maritime grasslands are replaced by a transition zone of poorer heath grasslands of the Violion caninae. These in turn frequently grade into blanket bog types of the Empetrum-Rhytidiadelphus loreus Association or true heath communities of the Ericeto-Caricetum binervis.

Although the climate favours the development of blanket bog wherever possible, there are some clearly defined minor habitats where only specific vegetation types can exist. These include natural or semi-natural habitats such as salt-marsh, strand, sand dune and springs and also artificial habitats such as trampled paths and roadsides. Most of these types exist only in impoverished forms in Shetland and are never extensive. Much of the immediate coast is too exposed for any type of beach development since where wave action is most severe all the soil is eroded away. However, with decreasing severity the number of particles and percentage of the finer soil fractions remaining increases, and the following sequence is encountered - boulders-shingle-sand-mineral silt-organic silt. The foreshore communities are generally sparse and poorly charactersed in the Northern Isles. Grazing is probably an important factor leading to the dominance in saltmarsh communities of dwarf rosette forms of Plantago maritima and Armeria maritima and depressing the growth of palatable grasses such as Puccinellia maritima, Festuca rubra and Agrostis stolonifera (Gillham, 1955).

In Shetland, as in north-west of the Scottish Mainland, Skye and Mull (see Gillham, 1957) the change from acid moor to alkaline saltmarsh may take place within a distance of a few metres often through a transitional band of heath grassland. As soon as exposure increases wave action is too great for silt accumulation and saltmarsh disappears. Saltmarsh in the Northern Isles is found only at the heads of the most sheltered voes.

Calcicolous vegetation is characteristic of dune and machair pasture. In this situation, however, the light shell fragments are distributed easily by the wind and there is therefore, a more gradual transition to acid moor than with the waterlogged silts of saltmarshes where mitigation of acidity depends on the constant renewal of sea salt and is not inherent in the soil itself (Gillham, 1957).

The alkaline reaction of the substratum of machair pasture promotes the rapid decay of vegetable matter in the sand and thus organic matter accumulates only slowly and there is little humus in the soil. Communities typical of limestone grasslands belonging to or related to the Festuco-Brometea are able to develop.

A rather paradoxical situation exists whereby a monoclimax situation of blanket bog is favoured by certain aspects of the extreme climate, yet bog itself must be regarded as a sub-climax since the climate is too severe to allow tree growth. The strong winds with high salt concentrations do not favour tree growth and trees are restricted to only the most sheltered sites around crofts. In experimental plantations set up by the Forestry Commission, there have been high losses (Neustein, 1964). Normal methods of establishment produced a fully stocked plantation which in general appearance resembled a crop of half its age in a more sheltered area.

Although climate is the overriding factor determining the sub-climax, grazing must be important in maintaining it. Sheep are ubiquitous on the hills and cliff faces and must have done much to change the Calluna heath. Shrubs such as Salix aurita, Sorbus aucuparia and Juniperus nana, were probably frequent in the past, whilst now they are virtually absent and such species as Nardus, Tricophorum and Juncus squarrosus have greatly increased (Johnston, 1974). Now, only on islands, in lochs and in ravine and crag sites is there an indication of the composition of the vegetation before the introduction of sheep by man.

Some investigations into the previous vegetation of Shetland have been made. Lewis (1905, 1906, 1907, 1911) made investigations in Scottish peat bogs including Shetland. On the basis of the macroscopic plant remains in the bogs he erected the following stratigraphic sequence for Shetland, which Samuelsson (1910-11) correlated with Sernander's Scandinavian zones (from Johansen, 1975).

Lewis	Sernander	Characteristic plants
Upper Turbarian	Subatlantic	Tricophorium, Eriophorum
Upper Forestian (Lacking in Shetland)	Subboreal	
Lower Turbarian	Atlantic	Tricophorium, Eriophorum
Lower Forestian	Boreal	Betula verrucosa Sorbus aucuparia Alnus glutinosa
First arctic bed	Preboreal	Betula nana, Salix reticulata, S. herbacea

Hawksworth (1969) investigated micro- and macroscopic plant remains on the island of Foula. He found twigs of *Betula* and *Juniperus* in the peat and a single fruit of *Betula* pubescens. Arboreal pollen never appeared to have exceeded 11% of the total pollen count.

Johansen (1975) constructed two pollen diagrams, one from Murraster on the Shetland Mainland and one from the Faeroes. Both localities were former lakes which have been infilled and sedimentation was dated to have started 10,000 years ago. The Shetland pollen diagram was divided into three zones. The first was a *Rumex*-*Gramineae* zone with pollen characteristic of a fresh unstable soil. Species included *Rumex acetosa*, *Oxyria*, various Gramineae species, *Salix* species including *S. herbacea*, *S. polaris* and *S. reticulata*, *Sedum*, *Artemisia*, *Cerastium*, *Sagina* and *Lycopodium selago*.

In the second, a *Betula*-*Rumex* zone, *Betula* immigrates. Both *Betula nana* and tree birches were recorded, although herbs were still important.

The immigration of *Corylus*, marked the third *Betula*-*Corylus* zone. In this period Shetland was most widely tree-covered. Lewis (1911) in fact stated that Shetland was covered by forests in post-glacial times even in exposed areas. Johansen (1975) envisaged a landscape of islands with abundant copses with Betula, Corylus, Juniperus and Salix. Unlike Lewis, Johansen believes that Alnus was not present in Shetland, or if it was only in sterile copses. However, tree and shrub pollen was never greater than 50% of the total pollen count. Herbs were still abundant with new species such as Filipendula and Potentilla and also some ferns.

Above this third zone the lake was infilled by peat sediment and from this level up to the present surface the pollen flora was characterised by Cyperaceae growing locally on the bog surface.

Johansen (1975) comments that from his diagram it is impossible to say when the birches and hazel became extinct but that probably man and grazing animals were very important, the islands having been inhabited for 3500-4000 years (Calder, 1964).

Man has affected the vegetation of Shetland in other ways besides introducing grazing animals. Peat cutting has modified the vegetation of some parts of the bogs. If the top sod is not properly replaced severe erosion may result. After correct peat cutting either the juncetosum blanket bog community or even a Nardo-Galion community is apparently the most characteristic vegetation to develop.

Man has introduced some plant species to the islands but mostly these are confined to agricultural and developed areas. Two spectacular examples which have escaped from cultivation and recently established themselves are Senecio smithii and Poa flabellata.

The most recent threat from man to the Shetland environment are the rapidly expanding oil developments. Although most of the installations are in areas of bog or heath, the pressure of people is almost certain to effect the relatively unstable communities such as the sand dunes at Breckin and West Sandwick, or the serpentine heaths in Unst. Warren & Harrison (1974) have published a nature conservation plan for Shetland and the Nature Conservancy have published a report on the natural environment of Shetland (1974) as a basis for future investigations.

6.3. Conclusions.

From the previous account it will be obvious that there are many intergradations between the various communities, and an attempt to display some of this is shown in Fig. 6.I.

Palmer & Scott (1969) list 681 vascular plants for Shetland including species, subspecies, hybrids and varieties. The paucity of the Shetland flora can be seen from the fact that only about 400 of these are native to Shetland compared with a total of 2,241 species which are native to Britain (Dandy, 1958). This means that many character species suggested for syntaxa in Europe are absent from Shetland,

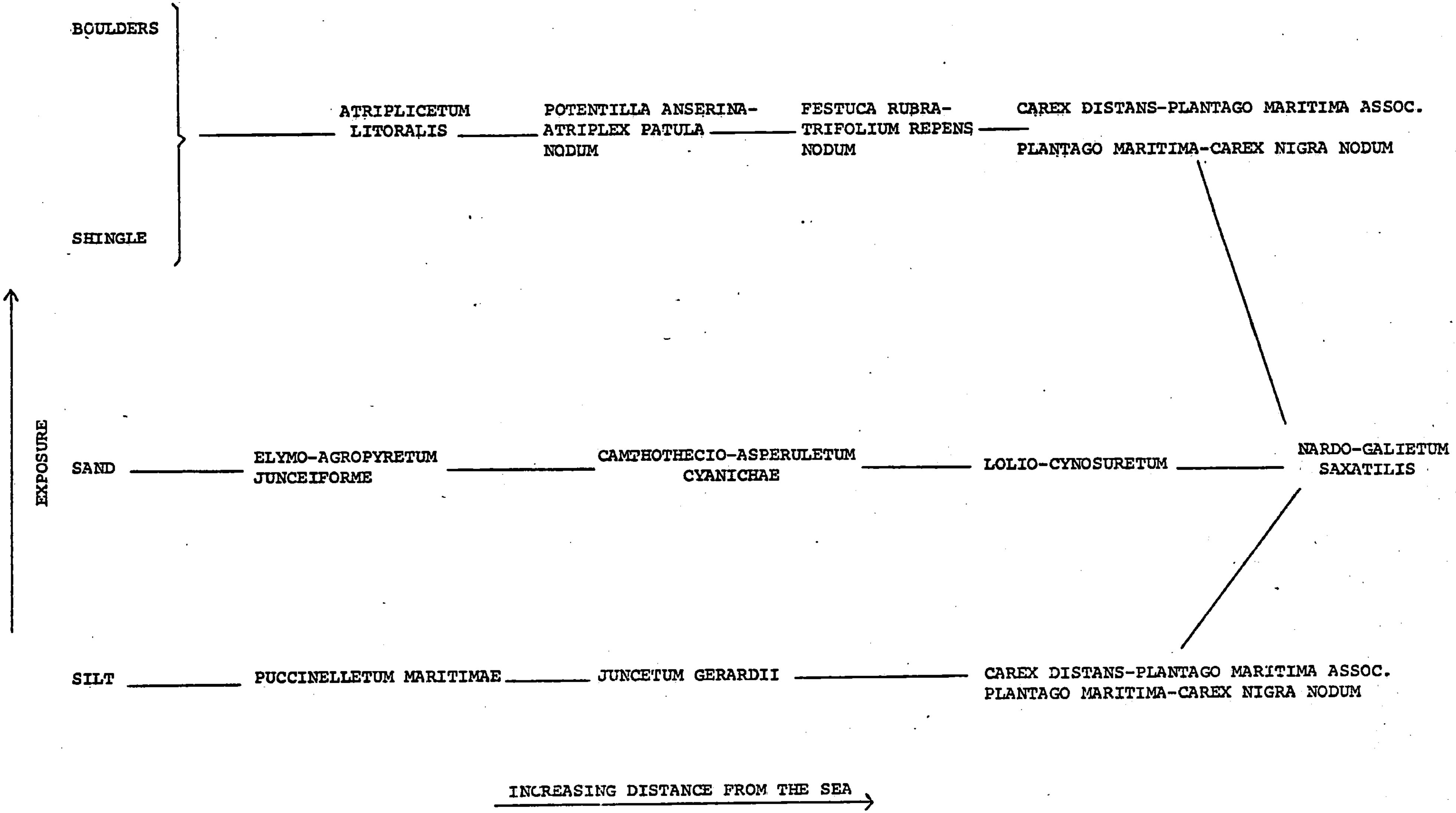


FIGURE 6.I. General trends and interrelationships in the development of Shetland vegetation.

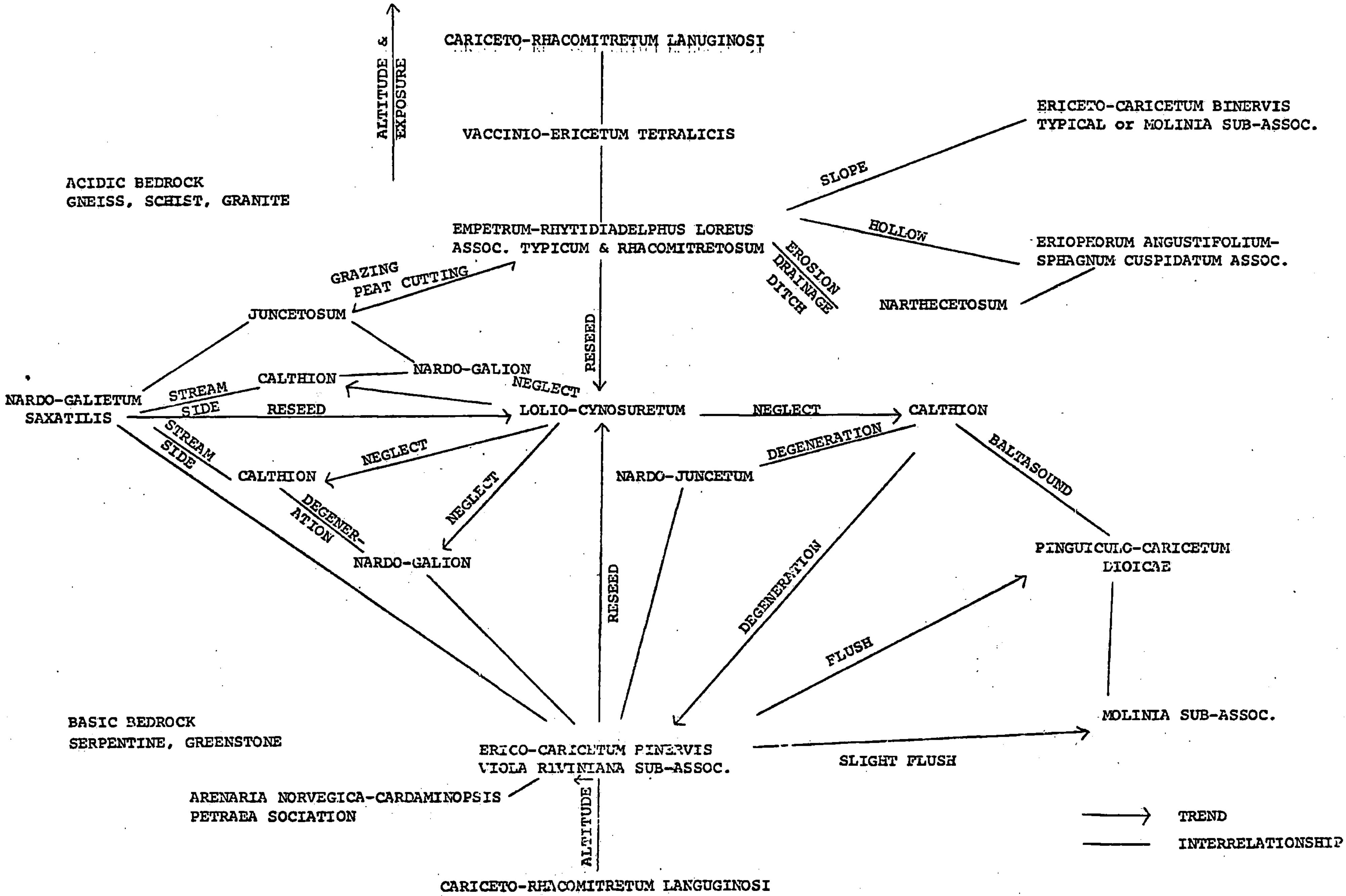


FIGURE 6.I. continued.

and the general impoverished nature of many communities in this extreme Atlantic outpost has often made comparison with existing units difficult. The machair pasture was particularly difficult to describe phytosociologically since no Festuco-Brometea or Brometalia characters were present in the Shetland community. A variety of species which are frequent in the bogs and heaths of mainland Scotland are absent or rare in Shetland including Myrica gale, Rubus chamaemorus, Arctostaphylos uva-ursi and even Vaccinium species.

However, despite the paucity of species generally it is felt that the Zurich-Montpellier techniques of phytosociology have provided a successful method of investigating and characterising the vegetation types of the Northern Isles.

In a relatively small area a surprisingly varied number of communities and syntaxa are encountered. A few vegetation types were not sampled such as spring communities of the Montio-Cardaminetea Br.-Bl. et Tx. 43 (although data is available in Birse & Robertson (1973)), or some farmland types of the Plantaginetea majoris Tx. et Prsg. 50. Some small water communities were not sampled but these are generally very local in Shetland due to exposure.

Only a limited expression of saltmarsh, sand dune and shingle communities is found in Shetland and this is largely attributable to extreme exposure (see Section 6.2.).

Fen communities such as those of the Phragmitetea or the *Tofieldietalia* are perhaps not as widespread as might be expected but this is largely due to the lack of suitable base-rich conditions and not to the extreme environment. Upland blanket bog communities are not well developed since the altitudinal range of Shetland is only small. Ronas Hill, the highest hill on the Mainland of Shetland, is only 453 m. However, the lowland blanket bog has proved most interesting and a new Association has been set up to encompass the differences between these communities and those of the Scottish Mainland.

Comparisons of the species Groups were most usually made with communities previously described from Western Europe, since these are most readily available and extensive in the literature. However, it is felt that perhaps in the future some useful, detailed, comparative studies might be made with the Faeroes and also the rest of Scandinavia.

It is also felt that it would be most interesting to attempt to discover some of the reasons why so many species and also communities such as the *Pleurozia purpurea-Erica tetralix* Association, which one might expect to find in the Northern Isles, are, in fact, only poorly developed or missing altogether.

The lack of information on the effects of oceanicity and other aspects of an extreme environment highlights the need for much ecological work as regards distribution of vegetation types as related to climate, and it is felt that Shetland would be an ideal place to pursue these investigations.

The importance of the Shetland flora and vegetation as well as the ecology have come more critically under review with the recent oil developments. The most important vegetation type in Shetland in a British context is certainly the Unst serpentine vegetation. Floristically, phyto-geographically and in habitat, this vegetation resembles Faeroese and Icelandic fellfield. Frost shattering and striping occur below 61 m. and montane species are conspicuous, for example, Cardaminopsis petraea and Arenaria norvegica are frequent, and both of these species have restricted distributions in the British Isles. Cerastium edmonstonii is a species confined to Shetland and in Shetland to the Keen of Hamar.

Other vegetation types are most probably more important in their role in the survival of the very rich and varied bird and animal life of the islands (see Venables & Venables, 1955) and it is hoped that they will not be destroyed irrevocably.

6.4. Conspectus of Associations and other Main Units.

CAKILETEA MARITIMAE Tx. & Prsg. 50.

CAKILETALIA MARITIMAE Tx. apud Oberd. 49.

ATRIPLICION LITTORALIS (Nordh. 4) Tx. 50.

Atriplicetum littoralis (Warming Ob) Westhoff & Beeftink 50.

Nodum of uncertain status related to the Atriplicetum (5.1.2.3.).

AGROPYRETEA PUNGENTIS Gehu et Gehu 69.

HONKENYO-CRAMBETALIA Gehu et Gehu 69.

HONKENYO-CRAMBION MARITIMAE Gehu et Gehu 69.

Potentilla anserina-Atriplex patula nodum (5.1.2.2.).

AGROPYRETALIA PUNGENTIS Gehu et Gehu 69.

AGROPYRION PUNGENTIS Gehu et Gehu 69.

Festuca rubra-Trifolium repens nodum (5.1.2.1.).

AMMOPHILETEA ARENARIAE Br.-Bl. et Tx. 43.

ELYMO-AMMOPHILETALIA ARENARIAE Gehu et Gehu 69.

AGROPYRION BOREOATLANTICUM Gehu et Gehu 69.

Elymo-Agropyretum junceiforme (5.2.2.2.; 5.2.2.3.; 5.2.2.4.).

FESTUCO-BROMETEA Br.-Bl. et Tx. 43 em. Tx. 61.

BROMETALIA ERECTI Br.-Bl. 36.

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

Camptothecio-Asperuletum cyanichae Br.-Bl. et Tx. 52.

Carex arenaria sub-association Br.-Bl. et Tx. 52 (5.2.2.1.).

ASTERETEA TRIPOLII Westhoff & Beeftink 62.

GLAUCO-PUCCINELLIETALIA Beeftink & Westhoff 62.

PUCCINELLION MARITIMAE Christiansen 27 em. Tx. 37.

Puccinellietum maritimae (Warming 1890) Christiansen 27 (5.3.2.1.).

ARMERION MARITIMAE Br.-Bl. et de Leeuw 36.

Juncetum gerardii Warming 1906 (5.3.2.2.).

Carex distans-Plantago maritima Assoc. Ivimey-Cook & Proctor 66. (5.4.2.3.1. & 5.4.2.3.2.).

Armeria maritima-Grimmia maritima Assoc. Birks 73 (5.4.2.3.3.).

SILENION MARITIMAE Malloch 71.

Plantago maritima-Carex nigra nodum (5.4.2.2.).

Lotus corniculatus variant (5.4.2.2.1.).

typical variant (5.4.2.2.2.).

MOLINIO-ARRHENATHERETEA Tx. 37.

ARRHENATHERETALIA ELATIORIS Pawlowski 28.

CYNOSURION CRISTATI Tx. 47.

Lolio-Cynosuretum (Br.-Bl. et de Leeuw 36). Tx. 37. (5.2.2.1.1.2.).

sub-association with Juncus effusus (5.4.2.5.).

Agrostis stolonifera variant (5.4.2.5.1.)

typical sub-association (5.4.2.4.).

MOLINIETALIA Koch 26.

CALTHION Tx. 37 em. 51.

Caltha-Juncus articulatus nodum (5.5.2.1.).

Ranunculus flammula variant.

Triglochin maritima subvariant (5.3.2.3.).

Juncus kochii nodum (5.5.2.2.).

Potentilla erecta-Luzula multiflora nodum (5.5.2.3.).

POLYGONUM AMPHIBIUM NODUM OF UNCERTAIN PHYTOSOCIOLOGICAL STATUS (5.5.2.4.).

PARVOCARICETEA den Held & Westhoff 69.

TOFIELDIETALIA Prsg. apud Oberd. 49.

CARICION DAVALLIANAE Klika 34.

Pinguiculo-Caricetum dioicae Jones 73 em. Wheeler 75.

molinietosum Jones 73 em. Wheeler 75.

Eleocharis variant.

Schoenus subvariant (5.3.2.4.).

typical variant

Schoenus sub-variant (5.9.2.).

eleocharetosum Jones 73 em. Wheeler 75.

typical variant (5.9.2.).

SCHEUCHZERIETEA Den Held, Barkman & Westhoff 69.

SCHEUCHZERIETALIA PALUSTRIS Nordh. 36.

RHYNCHOSPORION ALBAE Koch 26.

Eriophorum angustifolium-Sphagnum cuspidatum Association Birks 73 (5.7.2.1.).

OXYCOCCO-SPHAGNETEA Br.-Bl. et Tx. 43.

SPHAGNETALIA MAGELLANICI (Pawlowski 28 p.p.) MOORE (64) 68.

ERICO-SPHAGNION Moore (64) 68.

Vaccinio-Ericetum tetralicis Moore 62 (5.6.2.5.).

Empetrum-Rhytidiadelphus loreus Association ass. nov.

juncetosum squarrosi (5.6.2.1.).

rhacomitretosum lanuginosi (5.6.2.2.).

Listera-Pleurozium variant (5.6.2.2.1.).

typical variant (5.6.2.2.2.).

narthecetosum (5.6.2.3.).

typicum (5.6.2.4.).

Hylocomium-Pleurozium variant (5.6.2.4.1.).

typical variant (5.6.2.4.2.).

NARDO-CALLUNETEA Preising 49.

NARDETALIA (Oberd. 49) Preising 49.

VIOLION CANINAE Schwick (41) 44 em. Preising 49.

Nardo-Galietum saxatilis Preising 49 (5.4.2.1.) (5.8.2.5.1.).

Nardo-Juncetum squarrosi Bük 42.

galietosum saxatilis Jones 73 (5.8.2.5.2.).

CALLUNO-ULICETALIA (QUANTIN 35) Tx. 37.

ULICION NANAE Duvigneud 44.

Ericeto-Caricetum binervis Br.-Bl. et Tx. 50.

Sub-association with Viola riviniana Birse & Robertson 73 (5.8.2.1.).

Sub-association with Molinia caerulea Birse & Robertson (5.8.2.3.).

Intermediate Viola/Molinia sub-association (5.8.2.2.).

Typical sub-association Birse & Robertson 73 (5.8.2.4.).

Empetro-Ericetum cinereae Birse & Robertson 73 (5.8.2.4.1.).

CARICETEA CURVULAE Br.-Bl. 48.

CARICETALIA CURVULAE Br.-Bl. 26.

ARCTOSTAPHYLETO-CETRARION NIVALIS Dahl 56.

Cariceto-Rhacomitretum lanuginosi Assoc. Mc.V & R. 62. (5.8.2.7.).

THLASPEETEA ROTUNDIFOLII Br.-Bl. 47.

THLASPEETALIA ROTUNDIFOLII Br.-Bl. 27.

ARENARION NORVEGICAE Nordhagen 37.

Arenaria norvegica-Cardaminopsis petraea sociation (5.8.2.6.).

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