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The peatland vegetation of Lewis

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Synopsis

The vegetation of the peatland of Lewis is described. Several different types of mire are distinguished according to their morphological features. The gradual transition from minerotrophic conditions within valley mires to fully ombrotrophic conditions in the blanket mires of watersheds is demonstrated. Whilst most of the blanket mire of Lewis is affected by severe peat erosion, examples were chosen to demonstrate the nature of the flora and vegetation within those mire systems at present unaffected by erosion, as well as the more characteristic eroded peatland.

Introduction

A very large proportion of the Isle of Lewis is covered by peat. According to the Scottish Peat Surveys report (DAFS 1965), the peat deposits of Lewis were estimated in 1910–11 by the International Survey Company as covering approximately 595 km^2, averaging 1·5 m in depth. It is not easy to produce an accurate figure for the total extent of peat in Lewis because large areas in the south of the island have very irregular topography where peat fills numerous hollows and depressions in the gneiss. In the north of the island, however, the peat is much more continuous, blanketing all but the steepest slopes and covering most of the interior. By using air photographs it is estimated that in this northern plateau of Lewis peat covers approximately 430 km^2 representing about 79% of the island north of the main road (A858) from Stornoway to Callanish.

The peatland of Lewis is predominantly blanket mire developed as a result of the strongly oceanic, cool wet climate; the onset of development in Lewis occurred about 6500 years BP (Birks, pers. comm.). In areas of gentle relief blanket peat has developed up to 5 m in depth obliterating small irregularities in the underlying bed-rock and drift deposits. In the irregular areas of ice-moulded gneiss in the south of Lewis, the peat formation is influenced to a considerable extent by topography. Valley mires, with a central drainage axis, are well developed in this type of terrain, but there are also other intermediate types of mire which occupy the hollows within the gneiss. Such mires are like glaciers, filling shallow depressions and merging into one another to form a complex of mires which often lead down into well defined valley mires.

The only detailed description of the vegetation of peatlands in Lewis is by Osvald (1949) in his 'Notes on the vegetation of British and Irish mosses'. This includes photographs of eroded peat taken in 1931. He suggested that erosion was due to both wind and water, and illustrated how erosion patterns might develop. This included a brief note on the plant associations of the eroded blanket mire. The vegetation of a small valley mire near Little Loch Roag was recently described as an example of oceanic mire vegetation (Ratcliffe 1977).

This work is based partly on an unpublished description of the blanket and valley mires of Lewis (Goode 1968) together with a more detailed recent analysis of the blanket mire vegetation. Small areas of mesotrophic mire vegetation developed within the machair along the western seaboard of Lewis are not included.

Blanket Mire

General Features

Most of the northern plateau of Lewis is covered by an almost continuous expanse of blanket peat. Occasional hills, such as Beinn Bhrogair and Beinn Mholach, rise abruptly above this vast tract of peat which is otherwise broken only by the numerous peaty lochans and deeply incised streams. Most of this plateau lies between 50 and 150 m above sea level. In general the ground slopes very gently with broad almost level watersheds or low rounded hills, and very shallow valleys. The peat varies in depth according to local topographic conditions. A detailed survey of a section of Barvas Moor by the Scottish Peat Surveys (DAFS 1965) shows that the average depth of peat in that area is 2·3 m with a maximum depth of 5·1 m where peat had developed in a shallow basin within the underlying gneiss. On gently sloping or flat-lying areas the peat is generally 2–3 m deep and only 1–1·5 m on steeper slopes.

The blanket peat of this northern part of Lewis, though continuous, can be separated into two distinct morphological types. These are valleyside mires and watershed mires (Goode 1972). The first type is relatively restricted in extent and forms almost level expanses of peat, often much deeper than average, alongside the main streams or rivers. Such mires fill the shallow valleys except for the narrow, sharply incised channel occupied by the river (see Plate 1). In contrast the watershed mires cover extensive areas of the plateau including gentle slopes of the watersheds and low rounded hills.

Over most of the plateau both valleyside and watershed mires are subject to severe peat erosion. This is well illustrated in Plate 1. The vegetation of such eroded areas of peat is described later. There are, however, areas of the plateau where peat erosion is only relatively slight and such areas provide an indication of the type of vegetation which must have prevailed prior to the onset of peat erosion. Both the valleyside and watershed mires have well developed surface patterns of pools and ridges. Patterns such as these are commonly developed on blanket and raised mires of western and northern Scotland and the processes by which such patterns develop have been the subject of considerable debate (e.g. Boatman and Armstrong 1968; Goode 1970; Moore 1977; Ratcliffe 1964). Watershed mires have numerous rounded or irregularly shaped pools scattered over the surface. These are most abundant where the mire surface is virtually level. Most of the pools are more than 0·4 m deep and have only a sparse vegetation cover. Where the gradient of the mire surface is greater the pools are orientated at 90° to the direction of slope so that there is a series of alternating pools and ridges. This type of pattern occurs in places around the margins of watershed mires and on some of the valleyside mires which have not been subject to erosion. It is referred to as linear pool and ridge patterns to distinguish it from the more irregular patterns of the watershed mires. In these linear patterns the pools are generally less than 0·4 m deep and are frequently covered by aquatic species of *Sphagnum*.

In addition to the watershed and valleyside mires there is a third morphological type of blanket mire in Lewis which occupies the hollows within the ice-moulded gneiss. It is

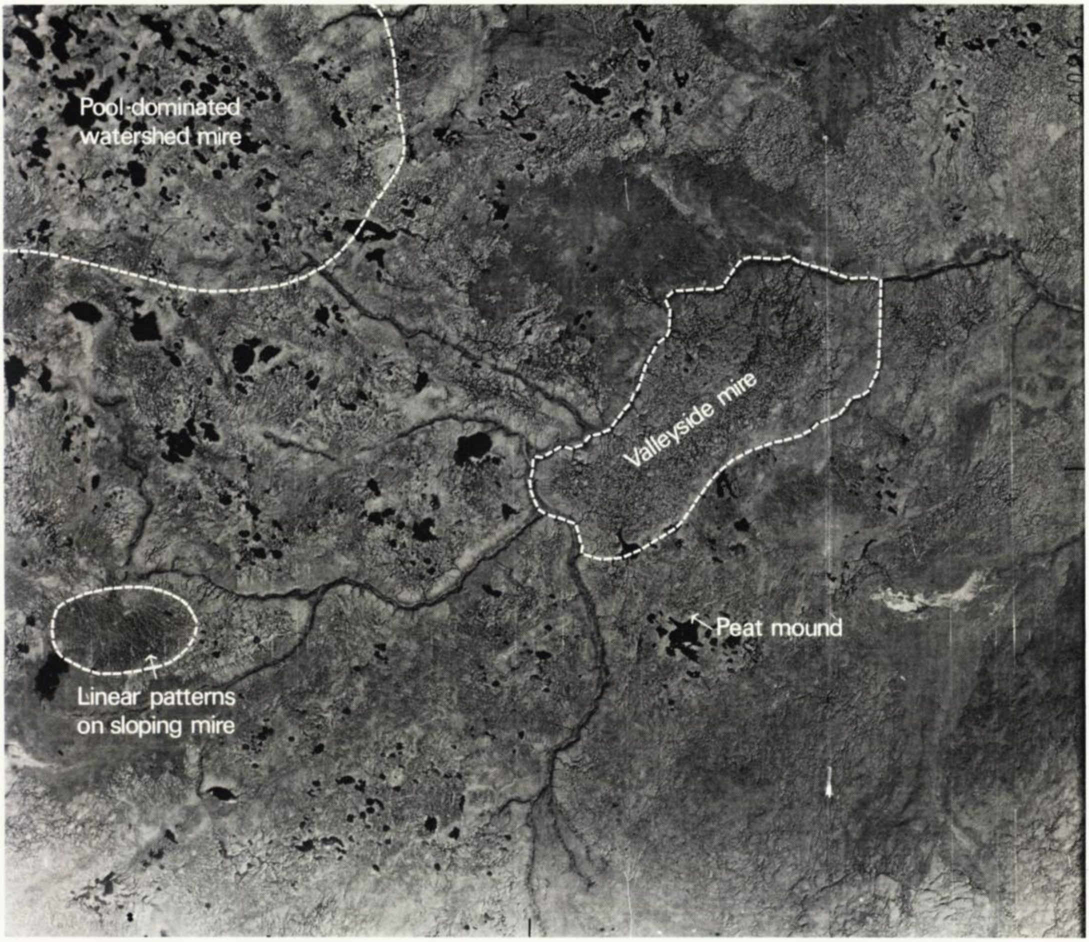

PLATE 1.—Air photograph showing pool-dominated watershed mire and severely eroded areas of valleyside mire alongside the Abhainn Geiraha stream. Small areas of gently sloping mire with linear patterns occur in places. (Photo: Crown Copyright.)

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PLATE 2.—Blanket mire with a pool and hummock pattern near Achmore. Pools are separated by narrow ridges of peat. Strings of islands across the pools are the remains of earlier ridges. Pools are deep and steep edged with little vegetation.

PLATE 3.—Pool and hummock pattern on blanket mire near Lochganvich. There are shallow pools with *Eleocharis multicaulis* and *Carex limosa*. Pools are linked together by overflow channels across the ridges.

proposed that such mires be referred to as 'sloping mires'. The gradient of the mire surface is usually more than 1 in 30 which is much steeper than that of the other types described above and surface patterns are only developed occasionally where the mire surface is locally more gently sloping. These 'sloping mires' occur most frequently within the central and southern parts of Lewis rather than the northern plateau and are often associated with valley mire systems (see Plate 5). Surplus water is channelled through these mires because they fill depressions between the gneiss, and whilst there may be no definite 'water track' the vegetation shows distinct indications of flushing.

*Vegetation of Blanket Mire**

This description of the blanket mire vegetation of Lewis is based on a broad examination of the peatlands of Lewis (Goode 1968) together with a recent analysis of the vegetation in two areas, both of which include a wide range of mire morphology and surface patterns. These are Blar nam Faoileag (NB 475525) in the centre of the northern plateau (see Plate 1) and an area of blanket mire within the more dissected landscape south of Achmore (NB 305280).

The vegetation in these two areas was described by means of a series of 160 reléves, each 1 m^2, which were placed randomly within each of the five main elements of the surface microtopography of the mires concerned: (1) deep, largely unvegetated pools; (2) shallow *Sphagnum*-covered pools; (3) solid mire surface (or intervening ridges where patterns formed alternate pools and ridges); (4) areas of water movement across ridges in linear patterns; and (5) eroded mire. One example of a sloping mire was included within the sampling under category 3. A minimum of 20 reléves was recorded in each of these main elements and the results are expressed as frequency of occurrence for each species at different localities (Table 1). As field work was carried out early in the year some species (e.g. *Drosera*) are under-recorded.

Deep Pools

On the flat expanses of watershed mires the deep pools are generally 20-50 m in extent and many exceed 100 m. Small pools are usually rounded in outline but there is evidence that adjacent pools coalesce to form larger irregular pools, as described by Boatman and Armstrong (1968). Where linear patterns occur in gently sloping mires individual pools are rarely more than 40 m long as they are confined by the slope. Such pools are generally about 1–3 m wide. Some of the larger pools developed on watershed mires are more than 1 m deep but most are less than 0·5 m and those of the linear patterns are only 0·3–0·4 m. The general form of such pools is shown in Plates 2 and 4. The edges are usually abrupt with a firm margin of *Sphagnum* (notably *S. rubellum*) above the water level and a steeply shelving margin of peat below. This peat surface is generally covered by a layer of filamentous algae, including *Batrachospermum* sp. and *Zygogonium* sp. together with leafy liverworts such as *Gymnocolea inflata*. A narrow zone of aquatic *Sphagnum* occurs in places especially where irregularities in the pool produce less exposed conditions. Both *S. cuspidatum* and *S. subsecundum* var. *inundatum* occur in such situations. The most abundant species in such pools is *Menyanthes trifoliata* which commonly forms a dense mat of vegetation in the centre of the pools.

* Plant nomenclature follows Clapham *et al.* (1962); Paton (1965); and Warburg (1963).

TABLE 1

Vegetation of blanket mire (percentage frequency)

Species*	Deep pools: linear patterns Achmore	Deep pools: watershed flow Blan-nam-Faoileag	Shallow pools: linear patterns Achmore	Shallow pools: linear patterns Blar-nam-Faoileag	Shallow pools: watershed flow Blar-nam-Faoileag	Overflows: linear patterns Achmore	Sloping blanket mire: Garynahine	Ridges: linear patterns Achmore	Ridges: linear patterns Blar-nam-Faoileag	Ridges: watershed flow Blar-nam-Faoileag	Eroded blanket mire: Blar-nam-Faoileag
Menyanthes trifoliata	100	50	38			25	10	10			
Batrachospermum sp.		80				5					
Sphagnum compactum		20									
Gymnocolea inflata		20									
Carex rostrata		20									
Sphagnum cuspidatum	20	50	88	100	88	90	70	20			
Carex limosa	50	10	100	58		70					
Potamogeton polygonifolius			13								
Eleocharis multicaulis	20	20	63	100	29	20	40	10			
Sphagnum subsecundum†	10	20	88	100	59	90	20				
Drosera anglica	10	10	88	58	71	55		60	16	10	
Sphagnum subsecundum‡		20	50		82	20	30	10			
Juncus kochii					6						
Eriophorum angustifolium	10	90	88	100	84	100	100	100	89	70	79
Sphagnum papillosum		50		8	29		30	80	53	25	
Narthecium ossifragum	10	30	13	92	71	70	80	70	79	80	4
Trichophorum cespitosum		20	13		24	95	80	50	89	60	71
Pleurozia purpurea	10			8	24		10	40	74	75	44
Zygogonium sp.						40					
Rhynchospora alba			38			75	20	50	5		
Campylopus atrovirens				25	24	20	30	20	5		
Polytrichum alpestre							10				
Sphagnum imbricatum								10			
S. tenellum					6		30	80	68	50	21
Erica tetralix			13		24	65	70	100	95	85	57
Carex nigra					41		60		11	65	18
Eriophorum vaginatum					12			50	95	85	57
Molinia caerulea					35	10	30	50	79	50	86
Mylia taylori				8	6			40	58	45	4
Cladonia uncialis				8	18	25	80	90	79	100	82
Campylopus flexuosus					6		10		5		
Polygala serpyllifolia			13			15	60		47		21
Pedicularis sylvatica									11		
Sphagnum rubellum					18		50	100	84	85	18
Rhacomitrium lanuginosum					71	30	40	50	89	95	93
Cladonia arbuscula					6				53		7
Hypnum cupressiforme					6		50	80	79		14
Rhytidiadelphus loreus					6		10		5	20	7
Cladonia impexa				8	18	15	20	90	100	100	93
Mylia anomola					12			80	53	70	4
Sphagnum plumulosum							10	30			4

Potentilla erecta		5	60	30	89	25	46
Calluna vulgaris	24	30	80	100	100	100	100
Hylocomium splendens				10	5		
Sphagnum fuscum				20	32	10	
Listera cordata						15	
Cladonia furcata						5	
Sphagnum magellanicum						5	
Erica cinerea			10		5	50	86
Odontoschisma sphagni				40	84	55	7
Cladonia pyxidata						15	14
Empetrum nigrum				10	63	45	14
Pleurozium schreberi				10	5	15	71
Lycopodium selago						5	4
Dicranum scoparium							4

* The species list has been arranged to demonstrate the gradual change in floristic composition from the deep pools to the dry hagg tops of eroded blanket mire.
† Var. *inundatum.*
‡ Var. *auriculatum*

Other species associated with this include *Carex limosa, Eleocharis multicaulis, Eriophorum angustifolium* and occasionally *Carex rostrata.* It appears that these depend upon the floating mat of *Menyanthes* as they do not occur elsewhere in the deep pools.

Numerous small islands occur within the pools and these are of interest in that the vegetation is rather different from the continuous blanket mire vegetation around the pools. There is a more robust growth of Ericaceous species including both *Calluna vulgaris* and *Erica tetralix,* and the growth of hummock-forming *Sphagna* appears to be more vigorous.

Shallow Sphagnum-covered Pools

These occur most frequently within linear patterns. They are characterized by a continuous carpet of *Sphagnum cuspidatum* and *S. subsecundum* vars. *inundatum* and *auriculatum,* together with a number of species which are frequent associates notably *Carex limosa, Eriophorum angustifolium, Eleocharis multicaulis, Drosera anglica* and *Narthecium ossifragum* (see Plate 3). Other species of note which occur occasionally in this habitat are *Rhynchospora alba* and *Potamogeton polygonifolius.*

Small *Sphagnum* covered pools within the watershed mires are liable to dry out more frequently than those of the linear patterns where there is more continuous through-flow of water. The margins of such pools tend to be colonized by some of the less hydrophilous species (as indicated in Table 1) notably *Rhacomitrium lanuginosum.*

The vegetation of both deep and shallow pools described above falls within the *Eriophorum angustifolium–Sphagnum cuspidatum* association (Birks 1973). The species composition is similar to that described for other parts of western Scotland but *Sphagnum pulchrum* and *Rhynchospora fusca* appear to be absent from the mires of Lewis.

Mire Surface

The vegetation of the blanket mire surface can be attributed to the Trichophoreto–Eriophoretum association (McVean and Ratcliffe 1962). The most frequently occurring species are *Calluna vulgaris, Erica tetralix, Sphagnum rubellum, Cladonia uncialis* and *C. impexa*. In many places this vegetation has been subject to replacement by a drier *Rhacomitrium*-dominated facies but where the water-table is high there is generally a continuous cover of *Sphagnum* species including *S. tenellum, S. papillosum* and *S. plumulosum*, with occasionally *S. imbricatum* and *S. fuscum*. Large hummocks of *Rhacomitrium lanuginosum* occur frequently throughout these mires (see Plate 4) but this species is not as abundant within the ground layer of the intact areas of mire vegetation, as it is in the eroded areas.

The vegetation of the sloping mires (Plate 5) is of a wetter kind with an abundance of *Sphagnum cuspidatum* within the ground layer. *Trichophorum cespitosum* and *Narthecium ossifragum* are both very abundant and some of the species normally restricted to pools also occur within this vegetation notably *Eleocharis multicaulis*. Other species of note are *Campylopus atrovirens, Rhynchospora alba, Carex nigra* and *Polygala serpyllifolia*, all of which are abundant. Full details of the floristics and vegetation of the mire surface are given in Table 1.

The level expanses of watershed mire in northern Lewis sometimes have large 'peat-mounds' scattered across the surface (see Plate 4). These are up to 2 m high and 5–10 m across. The vegetation is a dry facies of blanket mire dominated by *Calluna vulgaris* with *Empetrum nigrum, Eriophorum vaginatum* and mosses such as *Pleurozium schreberi* and *Hypnum cupressiforme*. There is generally a zonation from damp margins with *Sphagnum* spp. and *Erica tetralix* to a dry summit dominated by *Calluna*. Some of these mounds have been affected by peat erosion exposing the core of the mound which is entirely composed of peat. Occasionally, such mounds have been eroded by wind action and all that remains is a circular or crescentic outer edge, the centre being occupied by a shallow pool. Similar 'peat-mounds' have been described from North Roe in Shetland (Spence 1974) and we have observed such mounds on exposed areas of blanket mire in Orkney. Such peat mounds have not been described from elsewhere in Scotland and their origin is uncertain.

Areas of Water Movement Across Ridges

Within the linear patterns water moves downslope from pool to pool by flowing across relatively restricted sections of the intervening ridges (Goode 1970). An examination of these 'overflow sites' shows that the vegetation is more hydrophilous in character than the normal ridge vegetation. The aquatic *Sphagna* are particularly frequent together with *Drosera anglica, Carex limosa, Menyanthes trifoliata, Trichophorum cespitosum* and *Rhynchospora alba* (see Plate 3). In some ways this is comparable with the vegetation of the sloping mires described above, which are also subject to throughflow of water. There is abundant evidence that the development of 'overflow sites' leads to cessation of peat formation on the ridges at those points and this ultimately gives rise to the gaps in the pattern of ridges, and the strings of islands which are so characteristic of the linear patterns on these mires (Goode 1970).

Peat Erosion

Much of the blanket mire in northern Lewis is severely eroded. Deep interconnecting gullies have cut into the peat resulting in the hagg topography of peat-covered plateaus elsewhere in Britain (Bower 1962; Tallis 1964, 1965). In some parts of the plateau this

PLATE 4.—Large circular pools on a level expanse of watershed mire. Pools are up to 1 m deep, with steep edges. Ridges have pronounced hummocks of *Rhacomitrium lanuginosum*. Large peat mounds can be seen on the horizon. Blar-nam-Faoileag.

PLATE 5.—Blanket mire filling depressions between outcrops of gneiss near Neipaval. Steep rocky slopes have *Calluna* whilst the deep peat is dominated by *Eriophorum angustifolium* and *Trichophorum*.

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PLATE 6.—Eroded blanket mire on a moderate slope near Blar-nam-Faoileag. Erosion channels running downslope are clearly visible, as are large *Rhacomitrium* hummocks dominating the dry hagg tops.

PLATE 7.—Severely eroded blanket mire at Blar-nam-Faoileag. Erosion is most pronounced on the windward side of the hummocks.

type of erosion is restricted to areas alongside stream courses, but in other parts it is more widespread covering entire watersheds. Where the slope is steepest, e.g. alongside streams, rivers or lochs, deep linear gullies have formed down the slope. On the broad flat watersheds the pattern of erosion is much less obvious. In such areas the gullies form an anastomosing network with no clearly defined direction of drainage. A number of stages can be recognized in the process of gulley erosion.

In the early stages narrow steep-sided gullies are developed but the majority of the peat surface is still vegetated. The gullies are generally 1·5–2 m deep but may reach a depth of 4 m. Erosion gullies gradually expand laterally exposing a wider area of bare peat. Some may coalesce leaving isolated areas of the original peat surface as islands. Between the gullies, intervening areas retain a capping of vegetation but the original mire vegetation becomes dominated by species which can tolerate the drier conditions. Where the erosion is particularly severe intervening islands of vegetation are completely lost and bare peat prevails, or occasionally the underlying mineral soil is exposed where the peat has been totally removed. Where erosion across watersheds has cut into pool complexes many of the pools have been completely drained exposing flat expanses of bare peat. The vertical edges of the pools are now exposed as peat faces generally 0·5–1 m in height. The pattern of erosion in such areas is quite different from that produced solely by gulley erosion, as the original pattern of pools determines the extent of bare peat, at least in the initial stages of erosion. Where pool complexes are affected in this way by erosion it is common to find many small pools which are apparently unaffected, retaining their normal water-table despite the drainage of large pools nearby.

The vegetation of eroded areas of blanket peat on Lewis forms a dry *Rhacomitrium*-dominated facies of either Trichophoreto-Callunetum as described by Birks (1973) from Skye or a *Rhacomitrium*-rich facies of Trichophoreto-Eriophoretum as described by McVean and Ratcliffe (1962). The form which this vegetation takes is illustrated in Plates 6 and 7. Low hummocks or continuous sheets of *Rhacomitrium lanuginosum* form the predominant vegetation cover but a number of other species occur throughout the vegetated areas, the most frequent being *Calluna vulgaris, Erica cinerea, Cladonia impexa, C. uncialis, Molinia caerulea, Eriophorum angustifoliun, Trichophorum cespitosum, Eriophorum vaginatum* and *Pleurozium schreberi* (see Table 1). Most of these species are to be expected as they occur in the drier hummocks of blanket mire, but the abundance of *Erica cinerea* is of interest as this species does not generally occur on deep peat. It is, however, recorded by Birks (1973) as a component of this association on Skye and is abundant within similar vegetation on peat haggs in Shetland (Goode 1974). McVean and Ratcliffe (1962) record this species from Trichophoreto-Callunetum along the western seaboard of Scotland but not in the Central Highlands of Scotland. It appears that *Erica cinerea* occurs on areas of eroded peat or actively growing blanket peat only in the most oceanic districts of Britain. Other species of interest are *Sphagnum compactum* and *Lycopodium selago* which seem to favour areas of peat erosion. Though not always abundant they are, nevertheless, characteristic of this habitat.

There is generally very little *Sphagnum* on the peat haggs, its place being taken by *Rhacomitrium lanuginosum,* but *Sphagnum rubellum* and *S. tenellum* occur where conditions are not too dry, and there are also occasional hummocks of *Sphagnum fuscum*. A similar kind of vegetation on eroded peat, in which *Rhacomitrium* is dominant was described in Caithness by Crampton (1911) who pointed out that 'all stages in the replacement of *Sphagnum* cushions by *Rhacomitrium* may be found in some of the bogs, and *Sphagnum* may sometimes be detected under the fully formed *Rhacomitrium* cushions by digging'. The *Rhacomitrium*-rich facies is regarded by Ratcliffe (1964) as characteristic of disturbed and rather dry areas of blanket peat in western Scotland. Birks (1973) suggests that 'it appears to reflect drying of the bog surface resulting from a complex of factors including repeated moor-burning, grazing and subsequent gulley and sheet erosion'. Stratigraphical evidence has shown that *Rhacomitrium lanuginosum* is a normal component of actively growing raised and blanket mire vegetation in western Scotland (Goode 1970; Moore 1977). Under such conditions it forms occasional pronounced hummocks scattered across the mire surface. Erosion of the peat appears to favour the spread of *Rhacomitrium* which then becomes dominant throughout.

The process of peat erosion was attributed by Osvald (1949) to the action of both wind and water. He suggested that erosion could be initiated by wind action even on flat expanses of bog, and also demonstrated that erosion along the sides of the gullies was most pronounced in situations exposed to the prevailing westerly winds. The sides of hummocks exposed to the wind tended to develop bare peat faces whilst the lee sides retained their vegetation cover. There is little doubt that wind action does contribute to the erosion process. In his studies of the peat erosion in the Southern Pennines, Tallis (1965) suggests that 'on exposed summits and ridges, and on flat areas with a considerable depth of peat, erosion probably originated independently of stream drainage by the action of wind, rain and frost on a non-uniform bog surface'. Tallis distinguishes between stream erosion and summit erosion, the former resulting directly from the action of water and the latter resulting from the combined effects of wind, rain and frost described above. The patterns of erosion on Lewis are essentially similar to those described by Tallis, with widespread areas of anastomosing shallow gullies equivalent to summit erosion and well defined deep gullies, linking directly with stream courses, which are the result of water erosion.

A quite different form of peat erosion occurs locally and dramatically in the form of bog-bursts. Such an occurrence is described by Bowes (1960) from an area in Lewis near Kinlochresort. In this particular case, after a period of heavy and continuous rain, an area of peat which had previously formed an impermeable barrier 2 m thick below a small loch, became saturated with water and slid away down a 15° slope. The weight of water in the loch probably contributed to the slippage. As the peat gave way it allowed the water to flood out from the loch carrying blocks of peat for a considerable distance. This example of a bog burst involved a relatively thin layer of peat and the erosion was largely due to the release of water. A similar example of such a 'peat slide' has been described from the northern Pennines (Crisp *et. al.* 1964). Most bog-bursts occur when deep peat becomes saturated with water after unusually wet conditions. With rupture of the peat surface the whole mass of liquid peat flows out into the neighbouring valleys. Such extreme forms of bog-burst are unlikely to occur on Lewis as the peat is generally too thin, but localized peat slides may well be more common than is generally realized.

Valley Mires

General Features

Where peat formation occurs in small valleys and hollows a distinct type of mire system develops which is quite different from blanket mire. The fundamental difference is that whilst blanket mires are entirely dependent on rainfall for their nutrient supply (ombrotrophic), valley mires receive water from the surrounding areas of mineral soil and this brings with it some degree of chemical enrichment. Such mires are referred to as minerotrophic. Valley mires are particularly frequent in the low-lying area of ice-moulded gneiss in the south of Lewis between Loch Roag and Loch Erisort. Most of these mires are small, rarely exceeding 15 ha and, being confined by ridges of gneiss, they are rather variable in their morphology, each mire developing in response to local geomorphological conditions. In some cases the mires merge into surrounding areas of blanket mire but more often rocky outcrops of gneiss form an abrupt margin to the mire system.

In these mires a distinct 'water track' (Ingram 1967) follows the long axis of the valley and there is a well defined zonation of vegetation communities between this and the margins of the mire. The central 'water track' is subject to considerable through-flow of water and the vegetation along it is strongly influenced by the relatively high availability of nutrients. In this zone the vegetation consists of oligotrophic poor-fen communities. Away from this central water track the vegetation becomes progressively more acidic as the direct influence of water movement is reduced. Towards the margins of such mires the vegetation is generally of a drier facies and is similar to that of blanket bog. Along the central water track the water-table is frequently level with or above the mire surface but towards the edges of such mires it generally lies 15–25 cm below the mire surface. The distribution of vegetation facies is determined by the combined effects of the chemical status of the mire water, the amount of water passing through the mire system and the depth of water-table.

The following description of the vegetation types found on valley mires in Lewis is based on an examination of six valley mire systems in different parts of the island (Goode 1968). The precise locations of the valley mires are as follows: Loch Scarrasdale 19495504; Little Loch Roag 19141248; Loch nan Eilean 19237234; Loch an Tomain 19254209; Loch an Earball 19225262 and Uig 19064338. The vegetation has not been examined quantitatively. Floristic variation between different zones of the valley mires is demonstrated in Table 2. Major components of the vegetation are shown as physiognomic dominants and the presence of species is indicated where they occur in other communities. In this table the species order has been arranged to demonstrate the variation from wet to dry conditions from the centre to the edge of the valley mire systems.

Vegetation of the Central Water Track

In most cases water tracks are obvious channels 0·5–5 m wide with clearly defined edges, but in some of the larger valley mires areas of water movement may be 50–100 m across and the boundary with other vegetation facies may be less obvious. Water tracks are characterized by a rather sparse open growth of vegetation within a soft iron-stained substrate of organic detritus. This substrate may be covered by a film of filamentous algae such as *Zygogonium*. These channels support a most distinctive plant community. *Sphagnum subsecundum* (including vars. *auriculatum* and *inundatum*) is always present within the organic substrate and may at times form an almost continous ground layer. Three other species are constant associates—namely *Carex limosa*,

TABLE 2

Vegetation of valley mires

Species*	Water track (*Carex* fen community)	Water track (mud-bottom community)	Hummocks in water track	*Carex*–*Sphagnum* lawn	Hummock—hollow community. 1. *Sphagnum* lawn	Hummock–hollow community. 2. Hollows and pools	Hummock–hollow community. 3. Hummocks	Marginal dry facies
Potentilla palustris	0							
Polytrichum commune	/							
Equisetum fluviatile	0							
Ranunculus flammula	0							
Nymphaea alba	/							
Carex nigra	/				/			
C. panicea	/			/				
Sphagnum palustre	0							
S. recurvum	0					/		
Zygogonium sp.		0				/		
Batrachospermum sp.		/				/		
Potamogeton polygonifolius		0		/				
Eleocharis multicaulis		/		/				
Schoenus nigricans		0	0			/		
Carex rostrata	0	0				/		
C. limosa	0	0	0	0		/		
C. lasiocarpa	0	0		/				
C. dioica		/		/				
Menyanthes trifoliata	0	0	/	0		0		
Drosera anglica		0	0	0	0	/		
Sphagnum subsecundum†		0	/	0		/		
Sphagnum var. *inundatum*		0				/		
Trichophorum cespitosum		0	0	0	0		/	
Molinia caerulea		/	/	/	0		0	
Utricularia minor		/				0		
Eriophorum angustifolium	/	/	0	0	0	0	/	
Narthecium ossifragum		/	0	0	/	/		
Pinguicula vulgaris			0	0				
P. lusitanica			/					
Selaginella selaginoides			/					
Sphagnum plumulosum			0	0			/	
S. cuspidatum			0	0	/	0		
S. tenellum			0	0	0			/
S. papillosum			0	0	0	0	/	/
S. magellanicum				0	0			
Carex pauciflora			/	/				
Erica tetralix			0	0	0		/	
Rhynchospora alba				0	/	/		
Drosera rotundifolia			/	/			/	
Sphagnum rubellum			0	0	0	/	0	0
Calluna vulgaris			/		/		0	0
Polygala serpyllifolia			/		/		/	/
Potentilla erecta			/	/			0	/
Pedicularis sylvatica					/		/	/

Eriophorum vaginatum	0	0
Empetrum nigrum	0	/
Rhytidiadelphus loreus	/	
Pleurozium schreberi	0	/
Cladonia impexa	0	/
C. arbuscula	/	
Hypogymnia physodes		/
Aulacomnium palustre	/	
Rhacomitrium lanuginosum	0	0
Hypnum cupressiforme	/	/

0 = Physiognomic dominant.
/ = Additional species present.
* The species list has been arranged to demonstrate the gradual change in floristic composition from the water track to the drier margins of the mire.
† Var. *auriculatum*.

Potamogeton polygonifolius and *Menyanthes trifoliata.* In the upper parts of the water tracks these species form a rather low sward 10–20 cm in height and this contrasts with the much more vigorous growth of *M. trifoliata* at the lower end of such mires. A number of other species commonly occur in this habitat and some, notably *Carex rostrata, C. lasiocarpa, Drosera anglica, Schoenus nigricans* and *Trichophorum cespitosum* are locally abundant. Other species occurring less commonly are *Carex dioica, Utricularia minor,* and *Eleocharis multicaulis. Eriophorum angustifolium* is often present, particularly along the margins of the water tracks together with species such as *Carex rostrata* and *C. lasiocarpa.* Others which occur sporadically in this habitat are *Molinia caerulea* and *Narthecium ossifragum.*

Water tracks may in places form deeper channels 1–2 m wide and 0·5 m deep which wind across the mire surface. *Utricularia minor* is abundant in such channels, together with floating mats of *Sphagnum subsecundum* var. *auriculatum* and filamentous algae such as *Batrachospermum* sp. These channels are bordered by *Carex rostrata* or dense mats of *Menyanthes trifoliata.*

Sedge-dominated communities are often developed towards the lower end of the valley mire systems, including dense stands of *Carex rostrata* and *C. lasiocarpa* together with extensive mats of *Menyanthes trifoliata.* In these areas there may also be additional species which are indicative of a rather higher nutrient status than the vegetation communities hitherto described. This is due to a gradual increase in chemical status which occurs along the length of the mire system. Such species include *Nymphaea alba, Ranunculus flammula, Potentilla palustris, Sphagnum recurvum, Polytrichum commune* and *Equisetum fluviatile.*

The vegetation of the water tracks described above is clearly of a kind which is influenced by throughflow of water but the flora is remarkably poor in species. It seems that the communities developed in these water tracks are only slightly enriched in mineral nutrients. The vegetation has close affinities with the *Carex lasiocarpa–Menyanthes trifoliata* association (Birks 1973) which is characteristic of fen hollows on the Isle of Skye. The communities in Lewis, however, lack many of the species indicative of a slightly higher base-status, e.g. *Acrocladium giganteum, Scorpidium scorpioides* and *Drepanocladus fluitans.* Some of the more oligotrophic species listed for this association by Birks are also apparently absent from the water tracks on Lewis, e.g. *Juncus kochii* and *Sphagnum recurvum.* On the other hand certain species which are locally abundant in the water tracks are more characteristic of the mud bottom communities of bogs, e.g. *Drosera anglica* and *Utricularia minor*, and it seems that the species-poor associations of the water tracks on Lewis have affinities with the *Eriophorum angustifolium–Sphagnum cuspidatum* association (Birks 1973).

Hummocks Within Water Tracks

Sphagnum-dominated hummocks are frequently developed within the water tracks. They vary from small cushions, 5–10 cm high, to pronounced hummocks often 20–30 cm high and 50–75 cm across. Some of the tallest are 0·5 m high and tend to have almost vertical sides. These hummocks have a distinctive flora quite different from that of the water track. Around the base of the hummocks there is a zone in which *Schoenus nigricans, Sphagnum plumulosum, Carex limosa* and *Eriophorum angustifolium* are abundant. Other species of *Sphagnum* including *S. cuspidatum, S. subsecundum* and *S. tenellum* may also occur in this basal zone. Above this the hummocks are generally dominated by *Sphagnum papillosum* and *S. rubellum* together with a wide range of higher plants, some of which are very abundant. *Pinguicula vulgaris* and *Drosera anglica* are particularly abundant on these small hummocks where they may at times form the dominant vegetation. Other species which occur frequently in this situation are *D. rotundifolia, Narthecium ossifragum, Trichophorum cespitosum* and *Carex limosa.* Occasionally *Selaginella selaginoides, Pinguicula lusitanica* and *Carex pauciflora* occur on these hummocks. The higher parts of the hummocks are often *Sphagnum*-dominated but *Calluna vulgaris, Erica tetralix, Polygala vulgaris* and *Potentilla erecta* may occur.

Hummocks such as these are in effect 'miniature bogs' (Bellamy and Rieley 1967) having grown above the influence of the water moving through the water track. In the centre of the water track they tend to be small and abruptly terminated around the base but towards the margin of the water track they are generally broader, 1–2 m in width, and may have a gently sloping *Sphagnum*-dominated margin.

Sphagnum/Carex Lawn Community Alongside Water Tracks

Towards the margins of the broader water tracks *Sphagnum*-dominated hummocks increase in extent until they merge to form a distinct marginal community. In other cases narrow well defined channels are bordered by this community. It is characterized by an almost continuous carpet of *Sphagnum* (see Table 2) the most abundant species being *S. papillosum, S. cuspidatum* and *S. magellanicum*. This community contains a characteristic group of species which often occur in abundance; notably *Drosera anglica, Carex limosa, Menyanthes trifoliata, Erica tetralix, Trichophorum cespitosum, Rhynchospora alba* and *Narthecium ossifragum*. Other species which occur occasionally in this community are *Carex pauciflora, Molinia caerulea* and *Eriophorum angustifolium*. In some places *Pinguicula vulgaris* is very abundant.

This zone of *Sphagnum*-dominated vegetation often forms a flat expanse with few distinct hummocks, unlike the pronounced hummocks developed within the water track. It is comparable with the extensive *Sphagnum* lawns developed locally within pool and hummock bogs but the abundance of *Carex limosa* is indicative of a throughflow of water.

Hummock and Hollow Vegetation

Away from the direct influence of moving water there is a zone of vegetation with a well defined microtopography of hummocks and hollows and an abundance of *Sphagnum*. The flatter parts are dominated by various species of *Sphagnum*, especially *S. papillosum*, *S. magellanicum* and *S. rubellum*, together with *Trichophorum cespitosum*, *Drosera anglica*, *Erica tetralix*, *Molinia caerulea* and *Eriophorum angustifolium*. Hummocks are generally dominated by *Sphagnum rubellum* or *Rhacomitrium lanuginosum*, with a rather drier vegetation facies including *Empetrum nigrum*, *Calluna vulgaris*, *Eriophorum vaginatum*, *Rhytidiadelphus loreus*, *Pleurozium schreberi*, *Polygala serpyllifolia*, *Potentilla erecta* and *Pedicularis sylvatica*. In places lichens are abundant on the hummocks—especially *Cladonia impexa*. Pools occur frequently within this vegetation zone, some of which are deep and only sparsely vegetated whilst others are shallow and covered by a carpet of *Sphagnum*. The deeper pools frequently contain *Menyanthes trifoliata*, *Carex rostrata*, *Eriophorum angustifolium* and *Utricularia minor*, whilst the *Sphagnum*-dominated hollows are characterized by *Sphagnum cuspidatum*, *Carex limosa*, *Sphagnum papillosum*, *Menyanthes trifoliata* and occasionally *Sphagnum recurvum*. The presence of *Schoenus nigricans* locally in such pools may indicate areas of water movement through the peripheral areas of the mire system. Further details of species are given in Table 2.

This vegetation is very similar to that of flat-lying areas of blanket mire but there is a greater abundance of *Sphagnum* in the valley mires. The communities of the hollows fall within the *Eriophorum angustifolium–Sphagnum cuspidatum* association (Birks 1973) whilst the *Sphagnum* lawns and hummocks can be ascribed to the *Trichophoreto–Eriophoretum* association (McVean and Ratcliffe 1962). The *Sphagnum*-rich communities of the valley mires contrast strongly with the surrounding blanket mire vegetation. It seems that the continuously high water-table of the valley mires affords greater protection against burning, which has had such a profound effect on bog vegetation over much of Lewis. *Sphagnum magellanicum* is locally dominant in the lawn communities of valley mires but was recorded at only one locality on blanket mire during the present survey. Conversely *Pleurozia purpurea* and *Sphagnum compactum* are locally abundant within the blanket mire vegetation, especially where *Sphagnum* cover is reduced and the peat surface is covered by a layer of algae. These species do not occur on the valley mires. The absence of *Sphagnum imbricatum* and *S. fuscum* from the valley mires may be due to chance factors as these species occur only sparsely on the blanket mire of Lewis.

Marginal Vegetation

Towards the edges of the valley mires and especially where the vegetation grades into blanket mire, hummock-forming species become more abundant and the vegetation tends to be drier in character. *Calluna vulgaris*, *Molinia caerulea* and *Eriophorum vaginatum* are dominant and there is a discontinuous ground layer of *Sphagnum*, predominantly *S. rubellum* and *S. tenellum*. Where flushing of the mire surface occurs alongside rocky outcrops *Molinia caerulea* is locally dominant together with *Erica tetralix*, *Polygala serpyllifolia*, *Potentilla erecta* and *Pedicularis sylvatica*. Drier facies are developed locally, especially where drainage channels or erosion gullies have cut into the edge of the mire, and in such areas *Calluna vulgaris* may be dominant, together with lichens such as *Cladonia impexa* and *Hypogymnia physodes*.

Discussion

Most areas of peatland vegetation in Lewis are profoundly affected by grazing, muirburn, and peat erosion. In addition some areas, especially those close to habitations, are subject to more intensive agricultural improvement and peat is also cut extensively for use as domestic fuel. It is doubtful if any of the places where there is peatland vegetation in Lewis are entirely unaffected by one or other of these influences, as even the wettest mires may be grazed and burnt during dry conditions. Apparently least affected are the valley mires and the central parts of certain watershed mires which have not yet been affected by peat erosion. Areas of peatland vegetation within the undulating gneiss country of south Lewis are also less affected, probably because the numerous lochans provide protection from frequent muirburn.

The most obvious effect of these various factors is an overall reduction in the total number of plant species, the vegetation becoming dominated by a few particularly vigorous species with relatively few associates. In particular the number of *Sphagnum* species is substantially reduced and there is a tendency for *Rhacomitrium lanuginosum* to increase at the expense of these species. This is demonstrated in Table 1. Eroded blanket peat, which forms by far the greatest extent of peatland in Lewis, contains only about half the number of plant species occurring on the intact blanket mires. Many of the plants which do occur are relatively infrequent and the vegetation is composed essentially of a few species which occur with very high constancy (over 80%), for example *Calluna vulgaris, Erica cinerea, Molinia caerulea, Rhacomitrium lanuginosum* and certain lichens. In contrast the relatively intact areas of peatland have a much larger number of species forming the plant communities and there is a greater variety of vegetation structure including the range of conditions from wet hollows to dry ridges demonstrated in Table 1.

Apart from the area of blanket peat erosion the areas described in this paper were chosen as examples of relatively intact peatland on the basis of a broad preliminary survey (Goode 1968). The main features of blanket mire vegetation have been described and are summarized in Table 1. The vegetation shows a marked variation from wet to dry conditions according to the microtopography of the mire surface, and in addition there is a slight development of minerotrophic conditions within the linear patterns where water moves downslope through the pool systems. Species which are most characteristic of this slight nutrient enrichment are *Carex limosa* and *Eleocharis multicaulis* though others are also significant (e.g. *Potamogeton polygonifolius* and *Carex rostrata*). Their presence within the pool systems of these mires is due to the extremely oceanic climate with a very high frequency of wet days and a surplus of precipitation over evaporation for most of the year. Similar climatic conditions occur in north-west Sutherland on the Scottish mainland and it is of interest that the mires in this area have a comparable floristic composition but the minerotrophic indicators become less frequent further to the east and are almost entirely absent from the patterned mires of Caithness. Such patterned blanket mires also occur elsewhere in the Hebrides, e.g. Coladoir Bog on Mull (Jermy and Crab 1978) but not all the oceanic plant species are present. The blanket mires of Lewis, therefore, provide an important indication of the climatic influence on mire vegetation.

The valley mires, being minerotrophic, show a more pronounced nutrient gradient than the blanket mires, but as the bedrock of gneiss provides only slight nutrient enrichment these mires are almost entirely oligotrophic in character. Perhaps because of this very narrow range of nutrient status the distinction between ombrotrophic and minerotrophic elements is very subtle. Nevertheless there is a definite zonation of communities which appears to be associated with a gradual increase in nutrient status of the mire water and the height of the water-table within the microtopography of the mire surface (Table 2). Similar conditions have been described from other valley mires in oceanic areas of Scotland (e.g. the valley mires at Inverpolly, in Ratcliffe 1977).

In view of the importance of those valley mires and blanket mires in Lewis which are still in a relatively natural condition it is desirable that some of the best examples should be protected from detrimental changes in the future. Several of the sites described in this paper have therefore been scheduled as Sites of Special Scientific Interest by the Nature Conservancy Council.

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