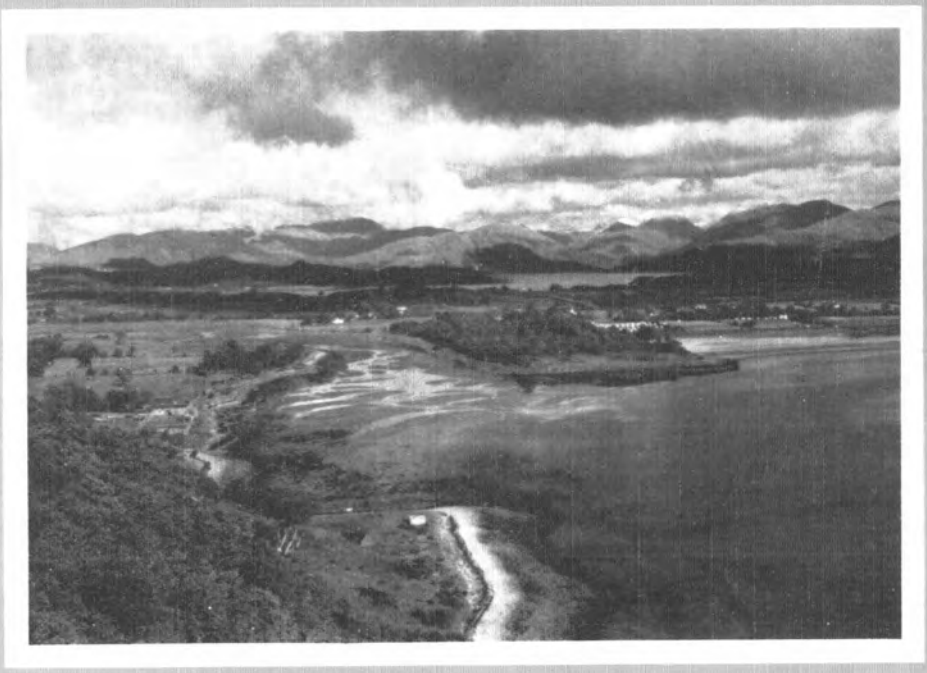
Soil Survey of Scotland

WESTERN SCOTLAND



1:250 000 SHEET 4

The Macaulay Institute for Soil Research
Aberdeen 1982

SOIL SURVEY OF SCOTLAND

Soil and Land Capability for Agriculture

WESTERN SCOTLAND

By J. S. Bibby, BSc, G. Hudson, BSc and D. J. Henderson, BSc
with contributions from C. G. B. Campbell, BSc, W. Towers, BSc and G. G. Wright, BSc

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The cover illustration is of Ardmucknish Bay, Benderloch and the hills of Lorn, Argyll.

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Plates 1 to 15 illustrate various recurrent landform types. Plates 16–20 illustrate various land capability classes.

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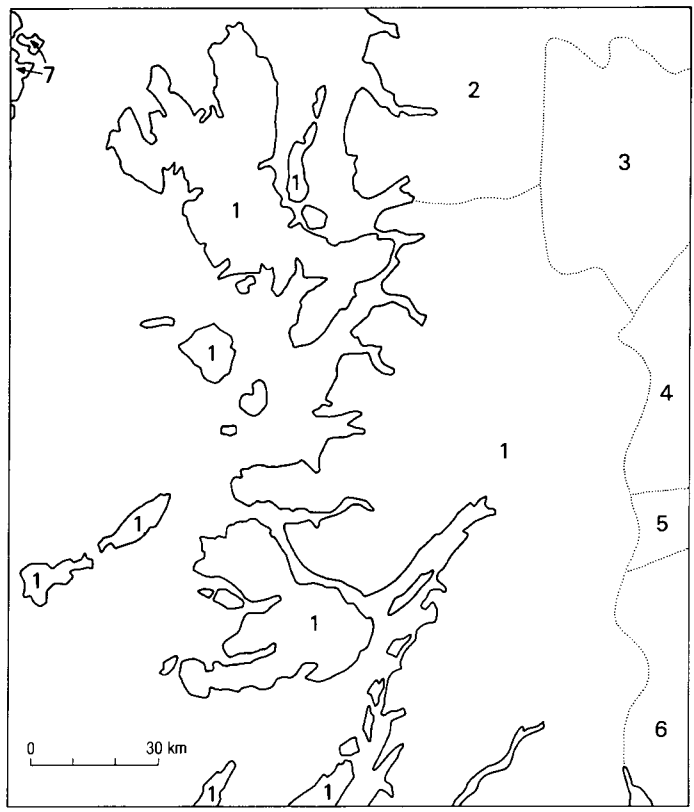
Preface

Soil surveys within the Western Scotland region prior to 1978 were confined to the Island of Rhum, the Island of Mull and Ardnamurchan and Morvern. Upon approval of the proposal for soil survey of the remaining parts of the Highlands at a scale of 1:250 000, mapping was started in 1978 in the Island of Skye by J. S. Bibby, G. Hudson and D. J. Henderson from the Soil Survey Regional Office in Oban. During 1979 and 1980 this party, with the addition of J. A. Hipkin, completed the survey of the remaining islands and central and southern mainland. The overlap with the Northern Scotland region (Sheet 3) was surveyed by D. W. Futty, R. E. F. Heslop, C. G. B. Campbell, W. Towers and A. J. Nolan. The eastern fringe of Sheet 4 lying in the overlap with the Eastern Scotland region (Sheet 5) was surveyed by B. M. Shipley, A. D. Walker, J. H. Gauld, G. G. Wright, J. S. Bell and T. W. M. Brown. The responsibility for mapping is shown in the accompanying figure. Field survey of all areas was completed by the end of 1980. Compilation of the maps and handbooks was carried out during 1981, based on a National Soil Map Legend compiled by B. M. Shipley. The senior authors of the Western Scotland Handbook were J. S. Bibby, G. Hudson and D. J. Henderson with contributions from C. G. B. Campbell, W. Towers, G. G. Wright, D. W. Futty, R. E. F. Heslop and B. M. Shipley. Analytical results quoted in the text were produced at the Macaulay Institute for Soil Research, Aberdeen, mostly in the Department of Mineral Soils. The vegetation assessments were carried out by field staff according to a system designed by E. L. Birse and J. S. Robertson; correlation was the responsibility of the latter. The handbook has been edited by D. W. Futty.

The base map was compiled and drawn by the Soil Survey cartographic section using modified components from Ordnance Survey 1:250 000 scale topographic and administrative maps. The soil map and the land capability for agriculture map were drawn by W. S. Shirreffs and Miss P. R. Carnegie. The diagrams in this book were drawn by A. D. Moir, J. S. Bibby and Mrs R. M. J. Fulton.

Concurrently with the soil mapping, the staff of the Soil Survey Department carried out assessments of land capability for agriculture, using guidelines devised by Bibby, Douglas, Thomasson and Robertson (1982). Advisory groups were established to assist the surveyors in this task. They consisted of representatives of the Department of Agriculture and Fisheries for Scotland, the

Scottish Agricultural Colleges and the National Farmers' Union of Scotland. In addition consultation with the local offices of the various organizations was maintained. The committees proved lively forums for discussion and made valuable contributions to the interpretative maps. The responsibility for the maps remains entirely with the Soil Survey of Scotland however.



1 J. S. Bibby, G. Hudson, D. J. Henderson, J. A. Hipkin

2 D. W. Futty, W. Towers, A. J. Nolan

3 R.E.F. Heslop, C.G.B. Campbell

4 A. D. Walker, G. G. Wright

5 J. H. Gauld, J. S. Bell

6 B. M. Shipley, T.W.M. Brown

7 G. Hudson, W. Towers, J. S. Bell, T.W.M. Brown

Survey teams' map areas

Aerial photographs (scale 1:25 000) and field maps (scale 1:50 000) used in the project may be inspected by prior arrangement with the Soil Survey Department, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen, AB9 2QJ.

ROBERT GRANT
Head of the Soil Survey of Scotland

Acknowledgements

The Soil Survey Department wish to thank the many landowners and farmers who willingly co-operated in the survey by allowing access to their land. The assistance of various other agricultural organizations in the land capability assessments has already been acknowledged, but the Department would like to thank in particular C. G. Davidson, A. W. Henry, F. M. B. Houston, A. MacDonald, D. G. MacLachlan and J. Valentine (DAFS), A. MacLeod and G. E. D. Tiley (WOSAC), J. W. Grant and A. Howie (NOSCA) and G. Brechin, P. E. Durham, K. J. Gill, D. L. Girvan, the late J. Leitch, J. Johnstone, M. Martin and A. MacIntyre (NFU (Scot.)) for their valuable contributions to the two committees who advised on the northern and southern areas of the sheet respectively.

Photographs in the text are by members of the Soil Survey Department and by Aerofilms Ltd., Borehamwood.

1. Description of the Area

The tract of land represented by the map and described in this handbook includes some of the most beautiful scenery in Scotland and much of the most rugged and bleak. From the deeply indented fjords of the west with their steep slopes dotted with birch and oakwoods to the cliffs of northern Skye and the white sand beaches of Tiree and Colonsay, the landscape is one of splendour and variety. It includes the farthest west point of the British mainland, Ardnamurchan Point, and the country's highest mountain, Ben Nevis. Inland, ridge after ridge of mountains separated by deep glens introduce a faintly monotonous note until, in the extreme north-east and south-east, rolling agricultural landscapes begin to make their appearance, precursors of richer lands outwith the boundaries of the map.

Western Scotland includes the southern part of Highland Region, the northern part of Strathclyde Region and smaller areas of western Central and Tayside Regions. A very small part of the Western Isles Islands Area is also included.

Only two towns of any size lie within the confines of the map, Oban and Fort William, both with a strong tourist trade and some industry. There are several smaller villages: Portree and Broadford on the Island of Skye, Tobermory on the Island of Mull, Fort Augustus, Mallaig and Inveraray, the seat of the Dukes of Argyll. Although all of these have considerable tourist attraction, the overall population is sparse and chiefly engaged in agriculture, forestry and fishing.

In such a mountainous area, lines of communication are difficult. Glen More (or Glen Albyn), commonly known as the Great Glen, traverses the area from south-west to north-east. It is followed by a major road linking Oban, Fort William and Inverness and by the Caledonian Canal. The latter was formerly used extensively for commercial traffic but is now increasingly the haunt of pleasure cruisers. The only other canal is the Crinan Canal, connecting the Sound of Jura with Loch Fyne in the extreme south of the region. South-east of the Great Glen, the land has a strong north-east to south-west grain and the principal road routes largely follow the shores of lochs and cross from glen to glen by a series of passes. North-west of the Great Glen the orientation of the land is more strongly east to west. There are few north–south connections except on the coast where steep, winding, single-track roads link small fishing and crofting townships. Historically many of these coastal settlements were supplied by 'puffers', small steam cargo vessels plying from the Clyde, and the

road transport system is relatively recent. Oban and Mallaig retain their rôle as steamer termini for the Hebridean islands, as does Uig on the Island of Skye.

There are two rail routes. In the north, the Highland Railway crosses from east to west via Achnasheen and Glen Carron to Kyle of Lochalsh. From the fishing port of Mallaig, the West Highland line traverses glens made famous by the Rising of 1745 and the exploits of Bonnie Prince Charlie, to Fort William and thence to Glasgow, being joined by the branch line from Oban at Crianlarich. More modern communications systems include the development of air links between Glasgow and Tiree, and a passenger helicopter service from the same city to Oban and Fort William.

GEOLOGY, LANDFORMS AND PARENT MATERIALS

Geologists have been active in the West Highlands for many years and excellent, detailed accounts of various aspects of geology have been published. The British Regional Geology handbooks (Phemister 1960; Richey *et al.* 1961; Johnstone 1966) provide good introductions. The salient features are summarized in Table A, from which it will be seen that rocks with a wide range of age and of many different types are found. in terms of areal extent, however, (Fig. 1) the Dalradian and Moinian schists and gneisses are predominant. Large areas of igneous rocks are also found, the distinction between those of dominantly basic nature (basalts, andesites and epidiorites) and those of acid (granite, trachytes and rhyolites) being important in terms of subsequent soil development. Rocks of Torridonian and Lewisian age form a wedge-shaped mass in the north but occur also on the islands of Coll, Tiree, Iona and Colonsay. Sediments of Triassic to Cretaceous and Old Red Sandstone age are very restricted in extent, although distinctive in the landscape.

The lithology of a rock (especially grain size and degree of cementation), the structures into which it has been formed and its principal chemical characteristics influence its response to geomorphological processes. Undoubtedly the main geomorphological event affecting the development of the landscape of the Western Highlands has been the Pleistocene glaciations. The glaciations, however, acted upon a pre-Quaternary landscape, the evolution of which has long been the subject of investigation and speculation (Geikie 1901; Hollingworth 1939; Linton 1951; George 1966; Sissons 1976). Some elements of this early landscape remain in the scenery of today, influencing the patterns in which soils occur and thus the principal types of map units identified in the survey.

Four landform regions are generally recognized in Western Scotland. These are described by Sissons (1976 p. 12) as follows: 'In the west is an area that, despite very varied geology and relief, has a unity in having been severely affected by glacial erosion to produce an extremely irregular rocky landscape and a highly indented coastline. Yet despite this intense glacial activity, the area retains distinct remains of plateaux on many interfluves. This area, whose variable upper limit does not exceed 600 m gives way eastwards to mountainous country, the junction often being abrupt. The mountain belt, with many summits exceeding 900 m, has been greatly dissected, especially by glacial action: deep valleys separate mountain ridges, each of which is divided by cols, often glacially emphasised, into a series of summits. Although a general accordance of summit level may be noted from a high vantage point, the mountains often culminate in sharp crests or peaks and are often deeply bitten into by corries.

Table A: Principal Geological Formations

PERIODS AND SYSTEMS	SEDIMENTARY ROCKS	EXTRUSIVE IGNEOUS ROCKS	INTRUSIVE IGNEOUS ROCKS
Pleistocene and Recent	Blown sand. Peat Freshwater alluvium Marine alluvium Raised beach deposits Fluvioglacial deposits Moraines. Till		
Tertiary (Oligocene-Miocene?)	Plant beds, lignites, conglomerates, desert sands	Olivine-poor basalts Olivine-rich basalts	Acid and basic cone-sheets, granites, granophyres and gabbros
Jurassic and Cretaceous	Grits, conglomerates, black shales, limestones, quartzites		
Permian and Triassic	Sandstones and conglomerates		
Carboniferous	Sandstones		
Old Red Sandstone	Conglomerates, breccias, sandstones, shales and limestones	Basic, granitic and complex plutons	Andesitic lavas and pyroclastic rocks
Cambrian and Ordovician	Grits, sandstones, shales, mudstones, clays and limestones		
Dalradian	Schists representing: silicious sandstones (quartzites), sandstones, greywacke, shales, limestones, etc.	Metamorphosed lavas, mainly spilitic, and tuffs (the 'epidiorites')	Early basic and granitic plutons
Moinian	Schists and granulites representing: silicious sandstones, (quartzites), sandstones and shales		
Torridonian	Grits, sandstones conglomerates and shales (metamorphosed)		
Lewisian	Gneisses of uncertain or mixed origin, basic dykes and granitic veins		

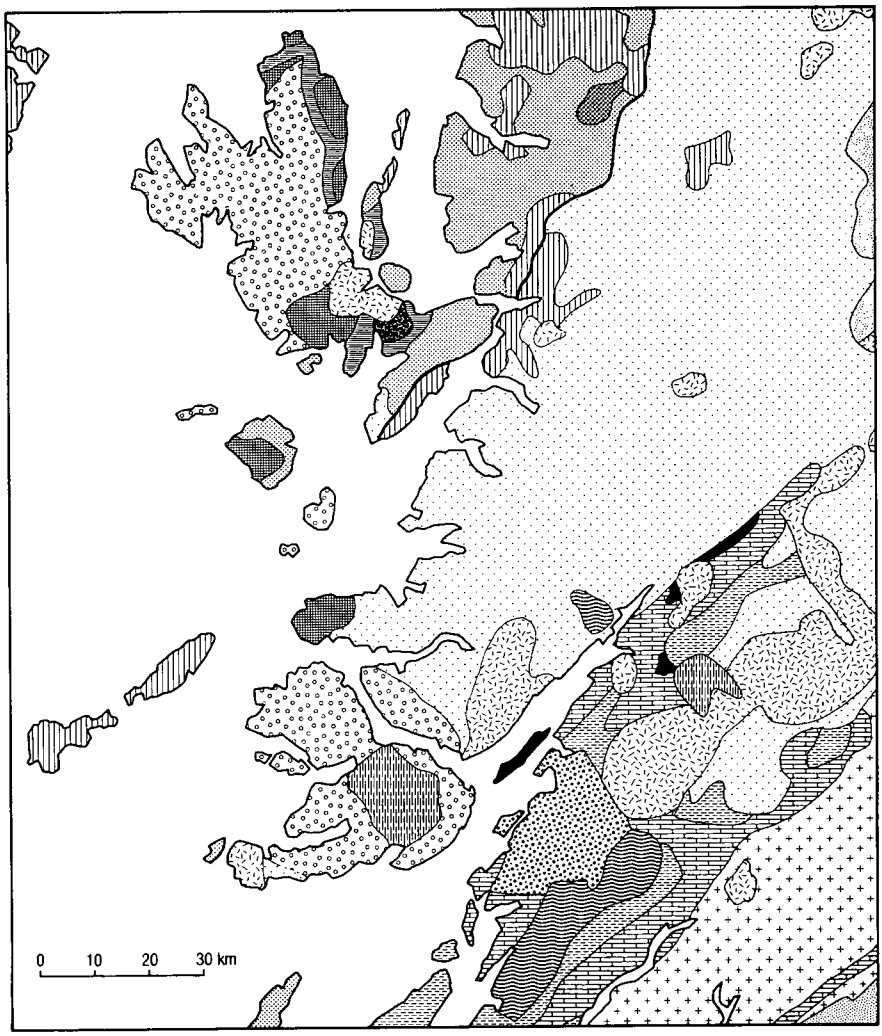
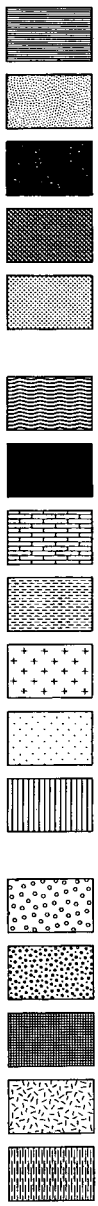


Figure 1. *Geology*


Shales, calcareous sandstones and related sediments
Mesozoic
Sandstones and conglomerates
Old Red Sandstone
Limestones (Skye)
Cambrian/Ordovician
Quartzites
Cambrian
Sandstones and grits
Torridonian
Sedimentary rocks
Metamorphosed igneous rocks (epidiorites and hornblende-schists)
Moine/Dalradian
Calcareous schists and limestone
Slates, phyllites, mica-schists and graphite-schists
Quartzites
Epidote-chlorite-schists and quartz-mica-schists
Dalradian
Granulites, schists and gneisses
Moine
Gneisses
Lewisian
Metamorphic rocks
Basalts
Extrusive (Tertiary)
Andesites, basalts and tuffs
Extrusive (Devonian)
Gabbro and allied rocks
Granites and allied rocks
Acid, intermediate and basic rocks
Intrusive
Igneous rocks
Moine Thrust

'The mountain area is succeeded eastwards, sometimes along an identifiable line, sometimes after a zone of transition, by a much more massive type of relief that is especially well developed in a large area of the Grampians. Plateaux are widespread and ridges and peaks infrequent. In much of the Grampians altitudes in this plateaux country are comparable with those in the western mountains, but in the northern Grampians and still more so in the northern Highlands the general plateau altitude declines northwards.'

Eastern and northern lowlands and basins comprise the fourth type which is of very minor extent in the Western Scotland region (Moray Firth, Glen Spean and Rannoch).

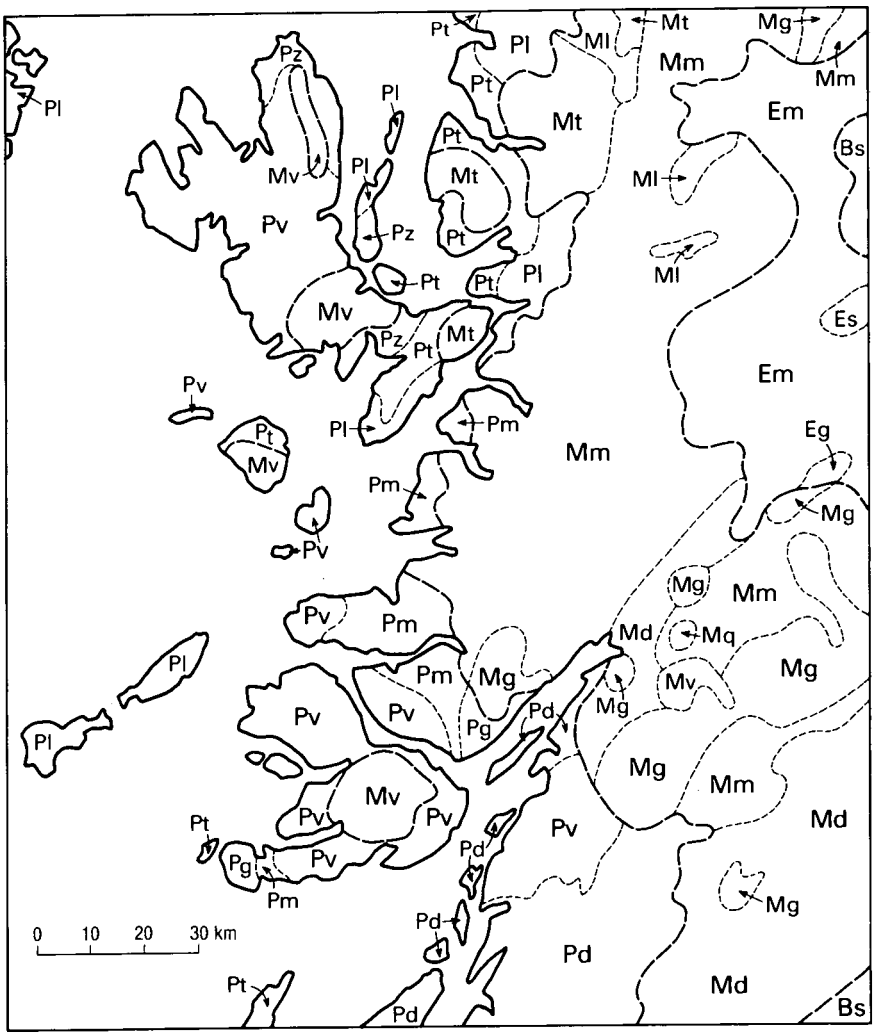
In Fig. 2 the four morphological regions are identified by heavy broken lines, but to explain soil distribution more readily, subregions have been introduced according to principal rock types (light lines). Important parent materials and landscape variations are described with reference to these subregions. The accompanying block diagrams (Figs. 3 to 5) will also assist in identifying the principal landform types.

Western Plateaux and Foothills

The major glaciation of the Pleistocene period was responsible for extensive erosion of a preglacial western plateau (Plate 12), particularly along lines of structural weakness, to form a series of fjord-like valleys, glacially over-deepened and often divided into a series of basins. The retreat of the ice left a very thin, often broken veneer of lodgement till over the landscape with slightly deeper deposits in valleys. During the final glaciation (the Loch Lomond Readvance), glaciers only penetrated the area where they flowed out from the central mountains (e.g. at the head of Loch Awe, in western Loch Etive and near Sligachan, Skye). The western lands were subject to intense periglacial conditions and where rocks susceptible to frost action cropped out, solifluction deposits were produced which clothed the slopes and accumulated in hollows. The landforms of the zone are predominantly a function of the underlying rock structure and its response to shattering by frost.

The areas characterized Pv (Fig. 2) are dominated by Tertiary basalt or Old Red Sandstone andesitic lava flows. The strongly layered rock structure confers a tabular appearance on the landscape due to excavation of weak scoriaceous surfaces and the resistance to erosion of the massive basal parts of the flows (Plate 10). The tabular hills are separated by rectilinear valley systems developed along major joint-planes or fault-lines except in two localities; north Mull (where differential erosion of a dyke-swarm gives a north-west to south-east orientation of features), and the Ardnamurchan vent which is almost completely circular in shape. The latter is alone among the Tertiary volcanic centres in having suffered sufficient erosion to be incorporated into the Western Plateaux and Foothills region.

The Moinian, Lewisian and Torridonian rocks (Pm, Pl and Pt, Fig. 2) differ structurally from the volcanics and the landforms and soil patterns reflect this change (Plates 12 and 14). All three show irregular topography with numerous small basins. The Moinian rocks are strongly metamorphosed and very resistant to comminution by frosts, hence moderately or very rocky landforms are dominant. Although some steep slopes are found they are usually short when compared with those of the Dissected Central Mountains. This slope-and-basin topography, coupled with high rainfall, plays a significant part in the development and thickness of organic horizons. The Lewisian rocks north-west



WESTERN PLATEAUX AND FOOTHILLS

Pd	Dalradian
Pg	granite
Pl	Lewisian
Pm	Moine
Pt	Torridonian
Pv	volcanic
Pz	Mesozoic

EASTERN MOUNTAIN PLATEAUX

Eg	granite
Em	Moine
Es	sandstone

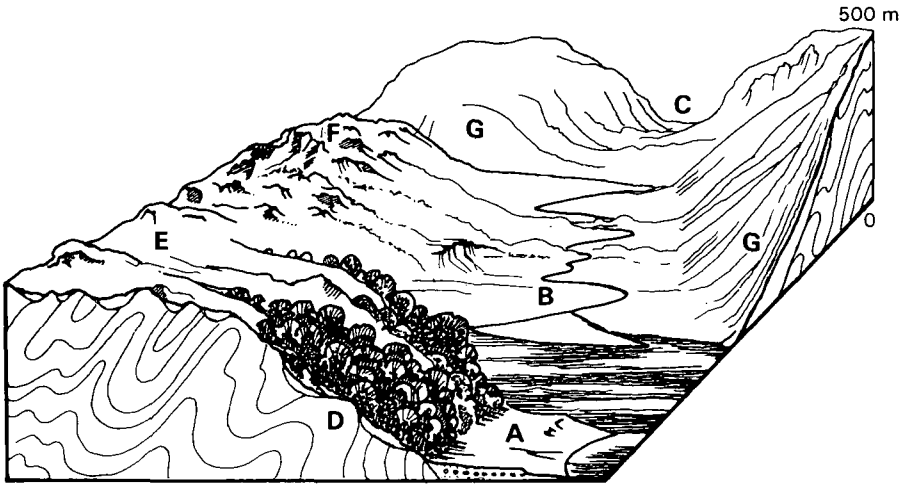
DISSECTED CENTRAL MOUNTAINS

Md	Dalradian
Mg	granite
Ml	Lewisian
Mm	Moine
Mq	quartzite
Mt	Torridonian
Mv	volcanic

EASTERN LOWLAND BASINS

Bs	sandstone

Figure 2. *Physiographic regions*



A Raised beach, variable in form from gravel terraces to sand dune
B Outwash and alluvium, usually terraces and mounds
C Hummocky moraine in U-shaped valleys
D Hill and valley sides with steep slopes; moderately rocky
E Undulating hills with gentle and strong slopes; moderately rocky
F Undulating hills with gentle and strong slopes; very rocky
G Hill and valley sides with strong and steep slopes; non-rocky

Figure 3. *Landforms of the Western Plateaux and Foothills*

of the Moine Thrust are similar and perhaps even more rocky (Plate 5), but those south-east of the thrust are softer. The landscape is characterized by long even slopes around Loch Long and Loch Duich. The landscapes of the Torridonian rocks and the granites resemble the Moinian closely, differing only in the form of the rock outcrops which tend to be tabular, with small scarps, in the Torridonian and more boss-like in the granites.

The extensive outcrops of Mesozoic rocks in Skye and Raasay are strongly bedded and produce a dip-and-scarp topography. In the north (Staffin and Kilvaxter) the hollows are broad, peat-filled and separated by low ridges. Elsewhere sandier, harder rocks predominate and the landscapes respond by approaching more closely the rockier types associated with the Moinian schists and granulites.

The Dalradian rocks in the land between the southern boundary of the map and Loch Linnhe display a very strongly ridged topography. Less resistant strata have been excavated to a marked degree and the north-east to south-west Caledonoid structures accentuated. A variety of rock types make up the Dalradian Assemblage; the epidiorites near Loch Awe form broad ridges which are often very bouldery; the phyllites, slates and quartzites sharp-edged or hog's-back ridges with little rock outcrop but very shallow drifts, while the limestones are similar but with greater rock outcrop. The belt of mica-schists south of Loch Fyne and extending southwards into Cowal and Kintyre produces a broad, rounded hill form with deep valleys.

Although the drifts produced by periglacial action from the majority of the rocks are stony and shallow, and deposits from the major glaciation are

infrequent, the islands of Tiree and Colonsay, and the Ross of Mull have drumlins which are clearly derived from rocks other than those currently exposed in these areas. The drumlins were formed during the maximum extent of the ice and incorporate material from subsea basins including shales, sandstones and limestones of the Mesozoic era. In landform, soil and land use characteristics they are markedly different from any of the surrounding land.

The final goup of landforms characteristic of these western coastal districts comprises raised beaches and outwash terraces (Plates 2, 5 and 6). Around the Sound of Mull, Loch Linnhe and the Firth of Lorne evidence of a preglacial platform cut into rock is present. This landform, although almost continuous, is only occasionally of sufficient width to show on the current maps. More extensive raised beaches are best developed in areas which were supplied with glacial debris brought down by meltwater streams from larger inland valley systems. Occasionally, large outwash terraces formed, as at Connel, Corran and Ballachulish. On coasts exposed to the Atlantic gales, shell-sand machair and sand dunes (Plate 4) are found and form prominent features on Tiree, Iona and the west coast of Colonsay.

As described earlier, over the whole of the Western Plateaux and Foothill region, hill summits are always below 600 metres and rarely reach 500 metres. Only on the more exposed summits do geomorphological features such as frost polygons and stone stripes develop, features which are characteristic of the arctic conditions in the succeeding mountain region.

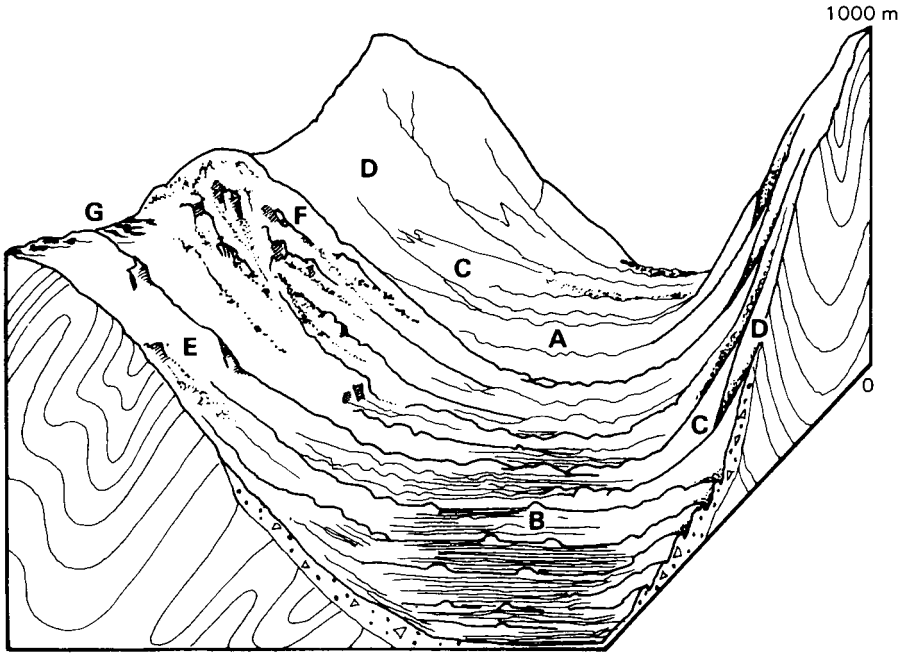
Dissected Central Mountains

The mountain region extends from the northern to the southern edges of the area in a slightly sinuous sweep, and its bens, lochs and glens epitomize the tourist's view of the Western Highlands. The corries and glens were the last places in Britain to retain extensive glaciers and the deeply dissected country bears evidence not only of this but of the action of frost weathering (Plate 15). Throughout the region the retreat of the ice of the last glaciation left deeply excavated, U-shaped valleys, the floors of which are filled with moundy moraines, modified in places by fluvioglacial action (Plate 8). The steep, rocky flanks of the mountains, extending to well over 900 metres in most cases, are clothed, in their lower parts, by indurated and strongly gullied moraine, sharply differentiated from the mounds below and equally sharply from the colluvial slopes of frost-shattered debris above. Many of the mountain summits are points along arêtes or ridges as the frequent use of the words *stob*, *sgùrr*, *druim* and *aonach* in the place names testify, although there are also isolated remnants of a former plateau (e.g. Ben Attow).

North-east of a line trending north-west to south-east and joining the head of Loch Maree, Glen Affric and Glen Roy the hills become less rocky and more rounded, but still retain their highly dissected ridged aspect (Plate 3). Morainic deposits, although widely developed are not so consistently present as farther south. In the region of Loch Broom (to the north of the boundary of Sheet 4), the succeeding Eastern Mountain Plateau region reaches the west coast. This northward change in character of the Moine gneiss landform between Western Scotland (Sheet 4) and Northern Scotland (Sheet 3) is notable. In the former the Moinian rocks are associated with rugged country, in the latter the hills developed from them are only moderately or slightly rocky, while the most rugged land occurs on rocks of Lewisian age.

The Moinian rocks in the mountain zone are very extensive (Mm on Fig. 2). The moraine-filled valleys, long mountain slopes with abundant evidence of

erosion and accumulation caused by both gullying and sheet-wash and the frost shattering and sorting of material into polygons and lobes at high elevations form a pattern that repeats through a large area. The landscapes on Torridonian rocks (Mt) are closely similar but the forms are slightly more tabular, reflecting the bedding of the sandstones. The granites (Mg) produce slabby outcrops (Plate 15) and a more rounded form but also maintain the basic pattern. The gabbros and complex intrusive areas readily develop cliffs and are noted climbing grounds (the Cuillins of Skye and Glencoe).



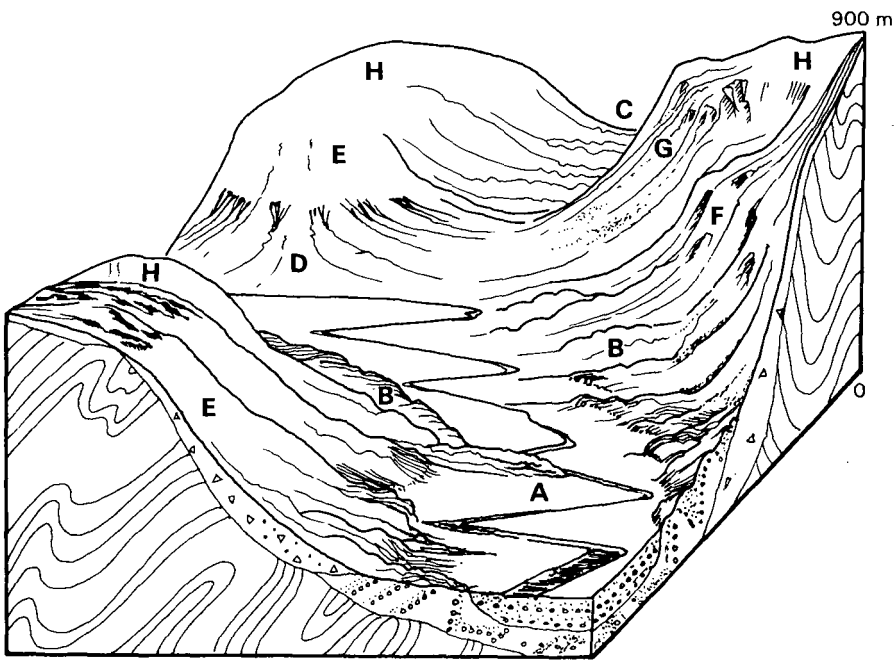
A Hummocky valley moraine
B Hummocky valley moraine with peat flats; occasional alluvium and outwash
C Steep gullied moraine with colluvial debris
D Hill sides with steep and very steep slopes; non-rocky
E Hill sides with steep and very steep slopes; moderately rocky
F Hill sides with steep and very steep slopes; very rocky
G Upper slopes, ridge crests and summits with alpine soils

Figure 4. *Landforms of the Dissected Central Mountains*

The Dalradian rocks of the south of the region (Md) have noticeably less rocky and more rounded mountain forms (apart from an area round Arrochar and Ben Vorlich affected by contact metamorphism) but also continue the theme. In the valleys the moraines are not so sharply defined, less bouldery and the drift texture is finer (higher percentages of fine sand, silt and clay). These aspects become more pronounced when the grade of metamorphism is low and so are particularly noticeable in the Luss Hills, bounded by Loch Long and Loch Lomond (Plate 13). The greater depth of solum on the slopes has an influence on subsurface drainage characteristics which results in an increase of podzolic soils.

Eastern Mountain Plateaux

The landforms of the eastern mountains, steep valley sides with extensive undulating plateaux at high level, only penetrate into Western Scotland in the north-east of the region. During the major glaciation this area suffered less dissection than the western mountains, but it is still deeply eroded and only the concordance of summit levels and flat or gently convex upper hill slopes have led to the use of the term 'plateau'. The valley bottoms are broader and the moundy topography of the moraine fields is replaced by large areas of fluvioglacial sand and gravel terraces, often broken by a central alluvial strath. The hill slopes, too, are gentler although very steep slopes still abound. There is often a marked slope change where the hill summits start to exert their influence. The lowering of the slope angle, more even topography and a cool climate with rainfall in excess of 1000 millimetres produces conditions suited to the accumulation of peat, which often dominates large areas of the mountain plateaux below 700 metres.



A Alluvial flats and terraces
B Outwash mounds, ridges and terraces
C Moraines in mountain valley sites
D Till slopes in foothill and lowland sites
E Hill sides with steep and very steep slopes; non-rocky
F Hill sides with steep and very steep slopes; moderately rocky
G Hill sides with steep and very steep slopes; very rocky
H Rounded hills and plateau summits

Figure 5. *Landforms of the Eastern Mountains Plateaux*

Eastern Lowland Basins

Two small areas of Eastern Lowland Basins occur within the confines of west Scotland, in the north-east and in the south-east. The softer rocks which exist in the lowlands were incorporated into sandy glacial tills that are, relative to the rest of the deposits of the region, deep. Slopes are gentle and strong and this has resulted in agricultural developments at the mouths of Strathconon and Strathglass. In the extreme south-east corner of the area the Old Red Sandstone sediment outcrop is rather hillier. These areas presage the expanses of glacial tills characteristic of east Scotland and the Midland Valley. The Moor of Rannoch is a large upland basin which was the principal centre of accumulation of ice during the Loch Lomond Readvance and probably also played a part in the preceding main glaciation. Although incorporated with the Grampian basins by Sissons (1976 p. 13) it is totally different in character from any other basin in the region, being underlain by granite and almost entirely covered by moraine.

Despite the presence of hard rock at no great depth over most of the area, superficial deposits are widespread. They form the parent material on which the soils of the region have developed. The mineral drifts have been categorized into four groups; shallow drifts (colluvium and solifluction deposits), sands and gravels of raised beach and fluvioglacial origin, moraines, and tills. Their distribution is shown in Fig. 6. Organic deposits form a fifth very distinctive and more uniform group, but since they have developed later than, and are distributed throughout, the first four, for reasons of clarity they have not been included in Fig. 6. The colluvial drifts are the most extensive, accounting for 71 per cent of the region, and are often broken by outcrops of the underlying rocks. Textures are mainly sandy and stone contents are high. The moraines, too, are coarse textured and stony, often exceptionally so, and account for 20 per cent of the region. Bedded sands and gravels account for 4 per cent, as do the tills. The latter are sporadically distributed and have higher clay contents. Areas dominated almost entirely by rock and scree amount to only 1 per cent. Within each of these groups, however, the nature of the parent material can vary within wide limits due to the nature of the rock from which it was derived.

The evolution of the landforms of Western Scotland and the production of the parent materials of its soils are inextricably linked. The prime feature of this evolution has been the modification of the Tertiary landscape by the Pleistocene glaciations. The development of soils from the parent materials is a relatively recent process; the soils are still young and their properties still closely linked to the properties of the parent material. The soil association, a grouping of soil map units upon the same parent material, is used to express this relationship. In the remainder of this handbook, details of individual parent materials will be found under the description of each soil association.

CLIMATE

Geology, landform and climate are inextricably interwoven physical factors which affect soil development in Western Scotland. Climate interacts with parent materials and topography to produce a wide range of soils and affects the agricultural use of single soil types in different areas by the relative severity of its actions. Western Scotland experiences a maritime climate because of its geographical location at the eastern edge of the Atlantic Ocean in a

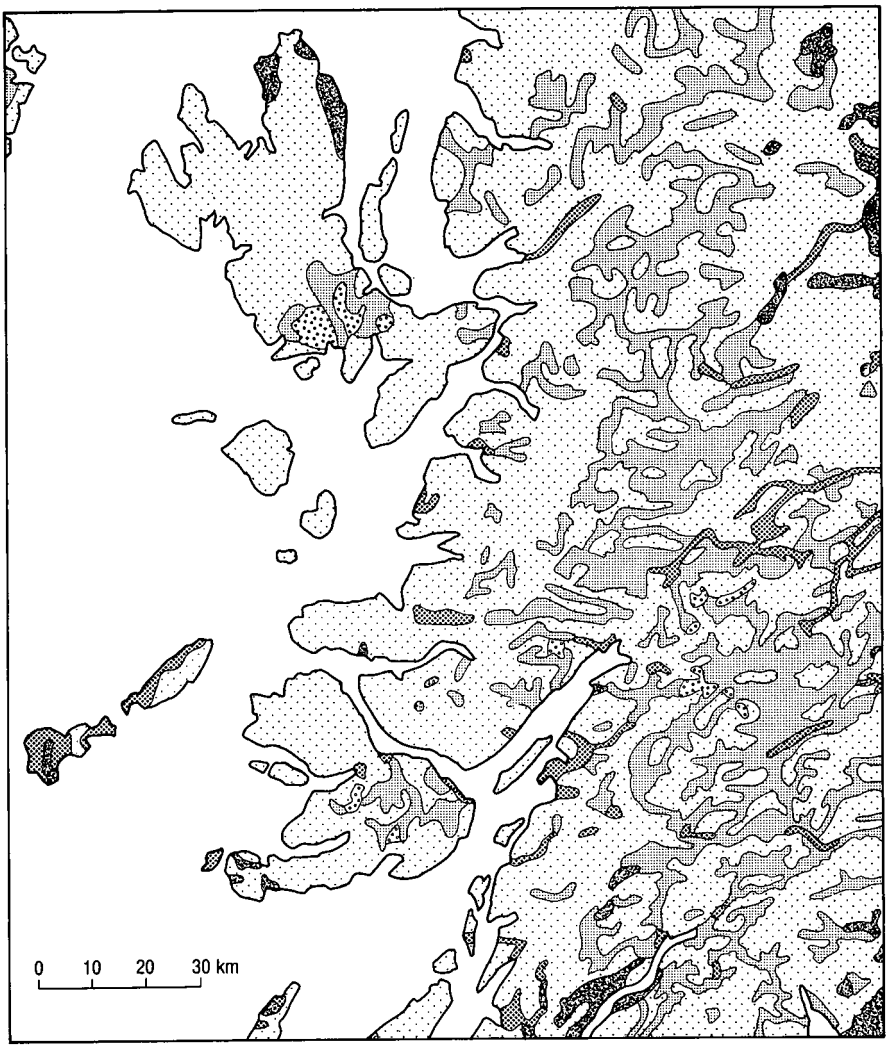


Figure 6. *Parent materials*

predominantly south-westerly air stream. The weather systems are controlled by three main air sources which are extremely variable in intensity and frequency. Warm air originating from the Azores high pressure area arrives in depressions, the fronts of which are often occluded by the time they reach Scotland and produce heavy continuous rain. Cooler, north Atlantic air brings showers to the coastal lowlands and more prolonged periods of rain to the mountains. Thirdly, airstreams from polar regions travel over the continent bringing clear skies and intensely cold weather, with occasional snow. The main features of a maritime climate (Francis 1978) are a small annual variation in mean air temperature, high wind speeds at sea level, and high rainfall fairly evenly spread throughout the year. In the following paragraphs, various aspects of climate are described and the modifying influence of the topography in different physiographic regions (Fig. 2) is discussed. Finally, the function of climate as a soil-forming factor is outlined.

Temperature records are few and far between, but long-term records are available from Oban and Tiree and for a shorter period from the summit of Ben Nevis where an observatory was occupied at the turn of the century. Soil formation and plant growth are affected by temperature; of particular significance are accumulated temperature and average monthly and diurnal ranges. Temperature is affected by altitude and a standard lapse rate of 6°C per 1000 metres is adopted by the Meteorological Office. This steep lapse rate is a result of the high incidence of cold polar and north Atlantic air masses which have the lower layers warmed during their passage over the ocean while the upper layers remain cold.

Accumulated temperature is a measurement of the total temperature above or below selected thresholds over an extended period of time, expressed in day-degrees centigrade (day°C) and is important in terms of biotic activity, especially plant growth. Birse and Robertson (1970) have used accumulated frost (day-degrees below 0°C) as an indication of severity of winter. The high mountain summits accumulate over 470 day°C of frost. The western coastal lowlands have less than 20 day-degrees and the eastern basins 50–110 day-degrees. The coastal lowlands are thus least susceptible to frost, but risk extends over a long period. The average dates of first and last air frost (Meteorological Office 1952) on eastern Mull are 18 October and 25 April for example. These figures apply to ground below 30 metres, air frost in the mountains and upland valleys will begin much earlier and end much later.

Values of accumulated temperature above 5.6°C have been calculated by Birse and Dry (1970). Their results are shown in a simplified form in Fig. 7. This threshold is generally accepted as the point above which plant growth becomes significant, but it is worth noting that many plants, especially those of the mountains, can have a lower growth threshold. The warm category (greater than 1375 days°C) is extensive in the lowlands of the southern half of the area but becomes restricted farther north. The north-eastern lowland basins are classed as fairly warm (1100–1375 day°C) and thus have a shorter but more intense growing season. The Western Plateaux and Foothills (Fig. 2) are mostly fairly warm or cool, while the Eastern Mountain Plateaux and the Dissected Central Mountain regions are in the cool and cold categories with short growing seasons. The growing season is defined as the length of time for which the daily average temperature is above 5.6°C. At sea level in the west this is approximately 250 days and becomes appreciably shorter with increasing altitude. Even the sea level figure is restricted in comparison to southern Britain where Devon and Cornwall have a growing season of 365 days.

Rainfall (including snow and hail) is both orographic and depressional and is derived from the eastward-moving cyclones which dominate Scotland's weather. The moist air passes over the low-lying outer islands and peninsulas, so that annual rainfall on Coll, Tiree, the Ross of Mull and Ardnamurchan is relatively low. (Fig. 8). The intensity and duration increase with altitude and annual rainfall exceeds 2400 millimetres over much of the mountains. The Eastern Lowland Basins have a lower annual rainfall than the Western Plateaux and Foothills because of a pronounced rain-shadow effect. The average annual rainfall at Tiree (1931–60) is 1128 millimetres, Oban (1931–60) 1451 millimetres, Glenquoich (1916–50) 2878 millimetres and at Strathpeffer in the eastern lowlands (1881–1915) is 776 millimetres (Fig. 9). A proportion of annual rainfall comes as snow, which may fall on about 20 days in the western lowlands, rising by about one day per 15 metres to about 300 metres and more rapidly thereafter, lying for up to 170 days on the summit of Ben Nevis.

The western coasts and islands sustain the full force of wind from the north Atlantic, where there are mean wind speeds of 10.3 metres per second in winter and 5.15 metres per second in summer. These are amongst the highest in the world. Average coastal wind speeds can be 50 per cent higher than in sheltered mountain glens. Mountain summits and ridges, however, are exposed and at about 700 metres the velocity over land is about the same as at sea level in the west. An average of 216 gales per annum (wind velocities exceeding 22 metres per second) were recorded at the summit of Ben Nevis. Few places at low altitude, even on the exposed western seaboard, record more than 40 gales per annum. A map of exposure constructed by Birse and Robertson (1970) indicates that while the lowland on islands and mainland peninsulas is very exposed, the lowland on the mainland is more sheltered, presumably by the offshore island chain.

Hours of bright sunlight on Tiree (1450 hours yearly average) are among the highest in Britain. The increased amounts of cloud in the western foothills reduces the number of hours to 1058 at Onich and 1119 at Fort William, while records from Ben Nevis summit give an average of 758 hours.

Humidity attains high levels throughout the year in the west and the mountains, but in the eastern basins there are lower levels during the day-time. High humidity reduces evapo-transpiration and areas where rainfall exceeds potential evapo-transpiration are classed as wet on Fig. 7. A large proportion of the wet area has summer rainfall (April to September) exceeding summer evapo-transpiration by more than 500 millimetres. Drier areas are found in the extreme west and in the eastern basins and are classed as moist or rather dry. Birse (1971) has amalgamated several climatic measures and defined a number of bioclimatic subregions for Scotland. His terminology is frequently used throughout the remainder of this handbook.

The main climatic effects on soil formation are through a combination of temperature and rainfall with wind an important factor in temperature control. Humidity affects soil formation only indirectly through evapo-transpiration and the drying effect of plant roots. Freely and poorly drained mineral soils are predominant in warm and fairly warm accumulated temperature zones, peaty soils and peat in the cool and cold zones, and subalpine and alpine soils in the cold and very cold zones. The high rainfall results in a large number of poorly drained soils, mainly with peaty surface horizons. There are higher proportions of peaty and noncalcareous gleys in the west relative to the east where humus-iron and peaty podzols become

Figure 7. *Climate regions*

warm and moist

warm and wet

fairly warm and moist

fairly warm and wet

cool and wet

cold and wet

very cold and wet

Accumulated Temperature Divisions	
RANGE (day °C)	DESCRIPTION
›1375	warm
1100-1375	fairly warm
825-1100	cool
550-825	cold
0-550	very cold

Potential Water Deficit Divisions	
RANGE (mm)	DESCRIPTION
25-50	moist
‹25	wet

Modified from Birse and Dry (1970)

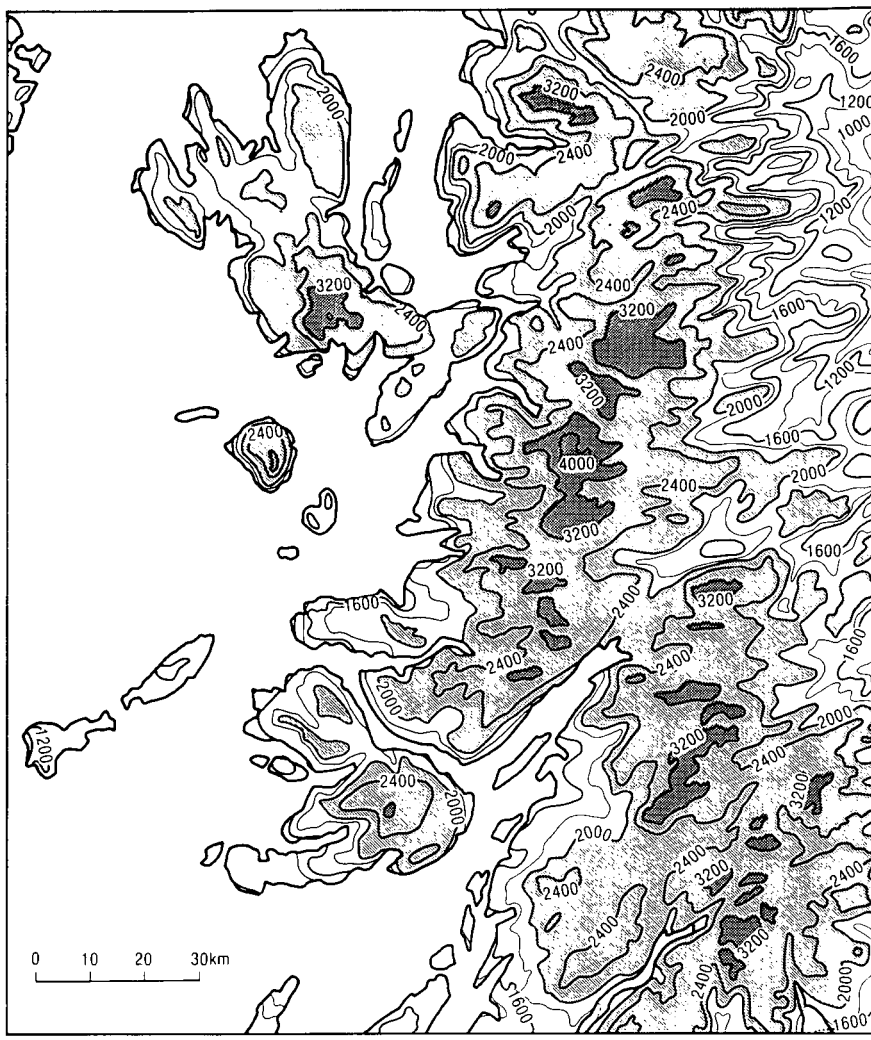
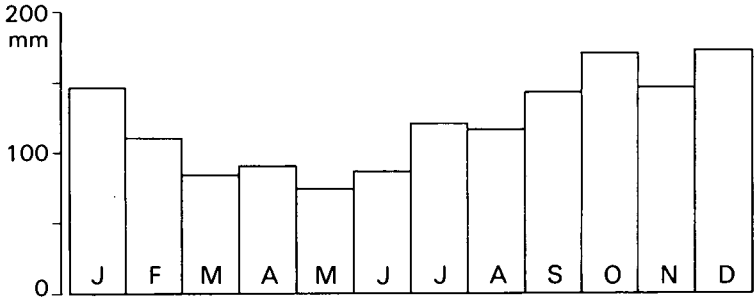


Figure 8. *Rainfall (average annual, mm)*

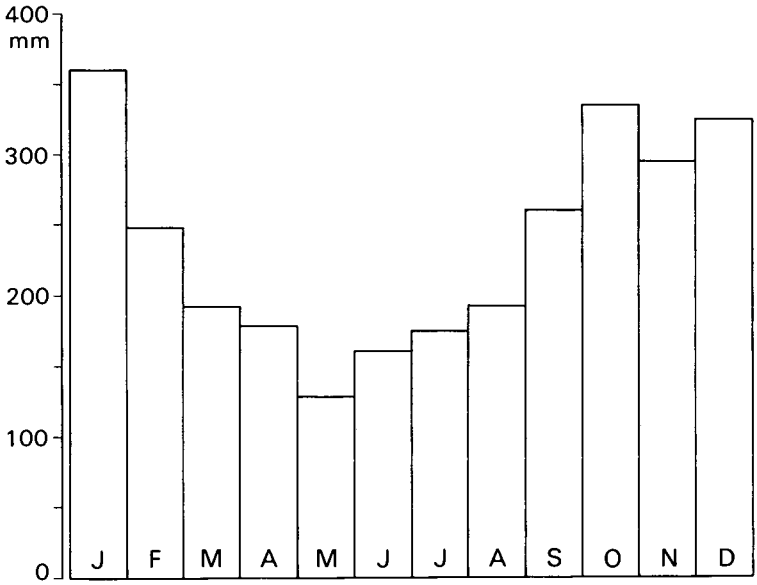
dominant, reflecting lower rainfalls and higher potential water deficits and temperatures. The effect of wind on soil formation is most obvious at high altitudes, where it has an effect on temperature. Alpine soils are found in very exposed ground above about 700 metres in the west, and about 850 metres in the east. Subalpine soils occur above 400 metres in the extreme west, above 500–600 metres a short way inland and above 600 metres in the east of the area.

SOILS

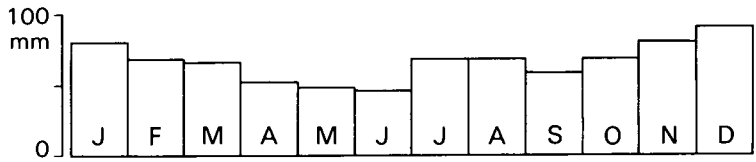
The soil mantle is a continuum that extends over a range of conditions and its properties vary accordingly. Previous sections have outlined the principal environmental factors which determine this variation (geology, landform,



a) Oban (1931-1960). Western Plateaux and Foothills



b) Glenquoich (1916-1950). Dissected Central Mountains



c) Strathpeffer (1881-1915). Eastern Lowland Basins

Figure 9. *Monthly average rainfall at representative stations*

parent materials, time and climate) but they are interdependent and very difficult to categorize or describe simply. Although detailed work on soils and their distributions has only been undertaken for relatively small parts of the area under review (see inset on soil map), it supplements the present survey and enables the major soil trends in Western Scotland to be established with some confidence. This section comprises a discussion of those trends and attempts to highlight differences with other parts of the country. It concludes with a résumé of the major soil groups and subgroups used in establishing the soil map units with particular reference to their characteristics in this region.

PRINCIPAL SOIL TRENDS

Five principal trends have been identified which are described under the following headings: (1) distribution of major soil subgroups, (2) shallowness, (3) soil variation and textural characteristics, (4) organic matter and (5) soil wetness.

1 Distribution of major soil subgroups

The relationship of major soil subgroups to climatic factors in Western Scotland is marked, and was touched upon at the close of the climatic section. Boundaries of climatic zones in Western Scotland form surfaces, inclined gently downwards from south-east to north-west, but with a sharp downward warp at the western seaboard. Different parent materials react at slightly different rates to weathering conditions within the zones, producing variations in the altitudinal limits of the same major soil subgroup. Thus extensive areas of brown forest soils occur on andesites (the Sourhope Association) at altitudes up to 150 metres while adjoining acid rocks (the Strichen and the Countesswells Associations) produce very limited areas and at lower altitudes. The north to south inclination of climatic zones is illustrated by variations in the altitude of the brown forest soil on one parent material, basalt. On the Island of Mull, brown forest soils are recorded from altitudes up to 200 metres, while in Skye 80 kilometres north, they rarely achieve 100 metres. Soils with mineral surface horizons are greater in extent in the south and east of the region than they are in north or west where they are represented by humose variants.

The vertical effects of climate and its association with the distribution of major soil subgroups may be seen on any mountain. The high rainfall and cool conditions in the uplands lead to extensive formation of organic matter (soils with organic surface horizons form about 85 per cent of the total, compared with 15 per cent of mineral soils). The summits of the mountains frequently penetrate the oroarctic climatic zone (Birse 1971) and their soils clearly indicate the effect of repeated freeze-thaw cycles on their surface horizons and lower rates of chemical weathering.

2 Shallowness

The section on geology and landform described the extremely rocky nature of large areas and explained it in terms of landform evolution. Shallowness is exemplified by detailed investigations of a random sample of 681 profiles on mineral and organo-mineral soils on the Island of Mull where 70 per cent were shallower than 80 centimetres. When greater depths of drift are present, soil development is often restricted by the widespread occurrence of an indurated horizon. Induration is most marked in hummocky moraine but also occurs in

other glacial deposits. Its effect is to prevent percolation of water or root penetration and thus curtail biological activity. A similar effect is produced by the high silt and clay contents of some associations (e.g. the Foudland or the Staffin). The result is that the soils of the region are predominantly shallow, probably more so than any other area in Scotland.

3 Soil variation and textural characteristics

A very obvious characteristic of the soils in Western Scotland is their short range variability and a significant contributory factor is the complex topography, especially slope. The combination of variable slope and shallowness creates a wide range of moisture conditions over short distances which influence soil profile development. In particular, thickness of organic horizon is related to slope (Fig. 10). Throughout the region it is only possible to identify uniform bodies of soil at detailed scales of mapping. Even special purpose maps for forestry, at scales of 1:10 000, frequently employ soil complexes (groups of soils closely related in a landscape and occurring in a defined pattern).

The drifts of the West Highlands vary in their stoniness and in their textural characteristics, especially in the proportions of sand and silt. Glaciolacustrine deposits are particularly notorious in this aspect (e.g. the Roy Association) but wide variation is also found on hill slopes. The area as a whole is noted for the coarse texture of its drifts, although there are a number of exceptions. Clay content is usually below 10 per cent and frequently below 5 per cent; slates, phyllites and mica-schists often have slightly higher clay contents and silt fractions over 50 per cent. Drifts derived from the Moine Series and the granites rarely have more than 3 per cent clay and have high percentages of coarse sand.

4 Organic matter

Climatic conditions leading to the formation of organic surface horizons have already received comment. Through most of the area these horizons are amorphous, massive and of a more humus type with pH usually less than 4. In the warmer coastal zones, peat is confined to receiving sites such as hollows or valley bottoms or to sites where impermeable horizons (e.g. thin iron pans) exist. Nevertheless many mineral soils have much higher amounts of humus in surface horizons than is usual in eastern or southern areas of Scotland; 15 per cent is not unusual although this may fall below 8 per cent if the soils are under regular cultivation. In the oroarctic zone, frost is responsible for creating a loose and often fluffy consistence in the organic horizons which are also mixed with mineral material.

Over most of the area the organic surfaces are amorphous and poorly structured and much of the rainfall is shed by surface run-off. Substantial amounts of water still percolate through the soils however. Accumulation of organic matter in the profile, or very considerable staining by it occurs above impermeable horizons, usually rock head or indurated horizons but occasionally above iron pans. Very dark brown or black horizons are characteristic. Active water-flow through these horizons can be detected after heavy rain and it frequently takes a sub-surface channel form due to lateral flow down slopes. Sudden changes in profile morphology can take place from dry, relatively high chroma, freely drained horizons to low chroma horizons containing seeping water. Soil colours as a whole are sombre; low values (3 or less) and chromas (4 or less) are common. Mottle colours are obscured by organic staining and E horizons are usually darker than in eastern or southern Scotland although a

similar trend is observed in northern areas. An exception is the Durnhill Association which maintains a characteristically thick, grey or white, sugary E horizon.

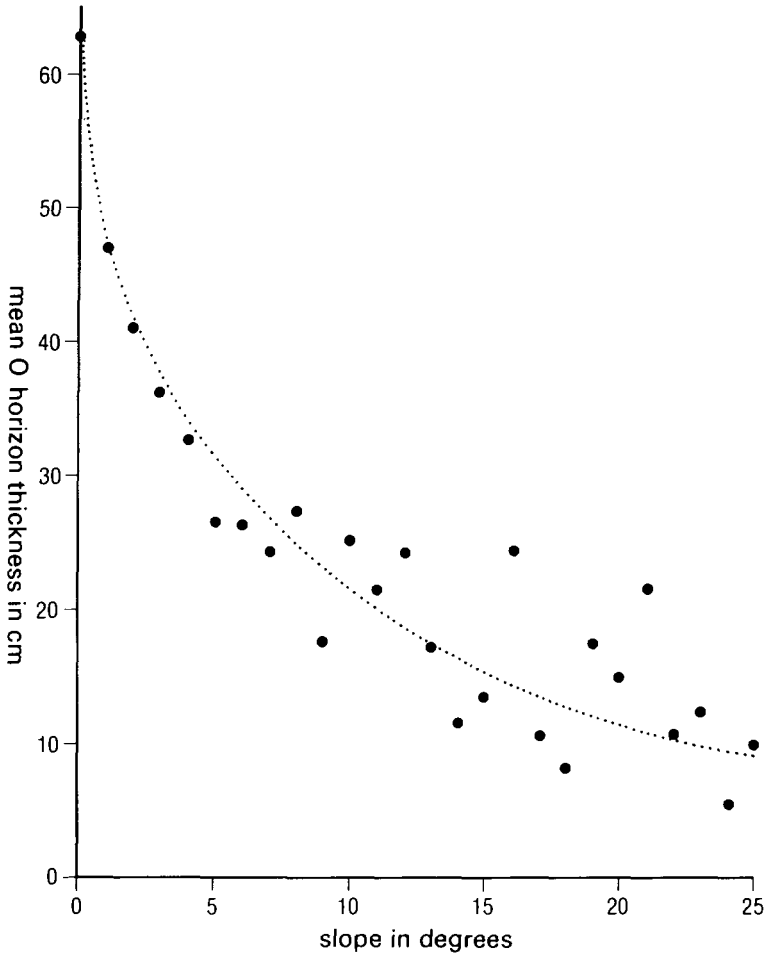


Figure 10. *The relationship of mean thickness of organic horizon to surface slope in the Island of Mull (averages of 790 grid observations)*

5 Wetness

Soil wetness is one characteristic of the region which requires little explanation. The contributory causes of high rainfall, shallow soils and high organic-matter contents have all been previously mentioned and Western Scotland can lay claim to the title 'Home of the Peaty Gley'. The even, seasonal distribution of rainfall and the high water-holding capacity of organic matter means that large areas remain at field capacity for much of the year. Tensiometer measurements of a peaty gley on raised beach gravel (Gruline Association) at an altitude of only 10 metres and with a rainfall of 1600 millimetres are given in Fig. 11. The

soil is drier than field capacity (suction 0.05 bar or more) for only 50 days in the year. At higher elevations it is likely that this period will be the same or shorter. Even coarse-textured, freely drained soils remain close to field capacity for up to five months in the year, although no water stands in test wells at any time in this period. The long periods of soil wetness and lack of any strong annual drying cycle result in very weak structural development.

The massive, amorphous, organic surface horizons coupled with extensive slope areas leads to both sheet run-off and gullying during high rainfall. The former produces surface flushing which is reflected in the vegetation. Flash flooding of valley floors in mountain areas is not uncommon due to the low rain acceptance of the soils. More work is necessary for quantification.

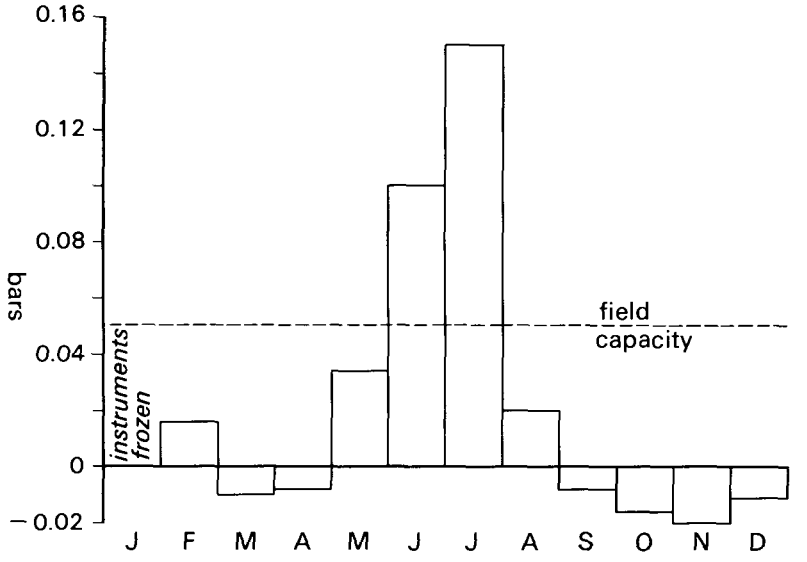


Figure 11. *Soil suction at 15 cm depth in a peaty gley of the Gruline Association (monthly averages, 1977 and 1978)*

The environment of Western Scotland is characterized by wet, shallow, coarse-textured soils with high organic-matter contents and low pH. There are however notable exceptions caused by differences in parent material; soils originating from basic materials show these trends to a less marked degree than those from acid rocks. The variations are discussed further under association headings in Chapter 2.

SOIL CLASSIFICATION

The classification used by the Soil Survey of Scotland is outlined in Handbook 8 of this series. It is based on the recognition of central concepts and is therefore typological rather than definitional (Butler 1980). In the former the allocation of soils to various groups depends on the skill and experience of the surveyors to a larger extent than in the latter, but is more appropriate to broad scale surveys where detailed information is limited. This is the case in Western Scotland, and it is therefore also appropriate to review the soil groups within the context of the region as interpreted by the surveyors.

DIVISION 1. IMMATURE SOILS

Major soil group 1.1 Lithosols

Lithosols are associated with very rocky areas and are defined as unconsolidated material less than 10 centimetres thick overlying hard rock. They are closely interspersed with rankers.

Major soil group 1.2 Regosols

Regosols are immature soils only recognized on unconsolidated aeolian deposits. They are extensive.

Subgroup 1.2.1 Calcareous regosols are always included within the Fraserburgh Association. They are the calcareous sands and dunes of the machairs of the Western Isles. They exhibit an A horizon, often with a high humus content, over grey or white calcareous sand. Some humus banding may occur within the profile, often representing buried surface horizons.

Subgroup 1.2.2 Noncalcareous regosols are restricted in extent and confined to dunes and stabilized dunes consisting of acid mineral sand. They are usually freely drained and may contain buried profiles (the Links Association).

Major soil group 1.3 Alluvial soils

Alluvial soils are characterized throughout the region by their variability, particularly in texture, stoniness and drainage status.

Subgroup 1.3.1 Saline alluvial soils are restricted in this area to the saltings map unit. On the map legend they are referred to incorrectly as saline gleys. Soil profiles are characterized by high levels of sodium.

Subgroup 1.3.2 Mineral alluvial soils are closely confined to small levees along mountain rivers throughout most of the area and are often gravelly. Wider ribbons occur in some of the valleys of the north-east where textures are usually sandier. They are characterized by A-C profile sequences.

Subgroup 1.3.3 Peaty alluvial soils are more widespread than mineral alluvial soils but often found in close association with them. Both peaty topsoils (less than 50 centimetres of peat) and soils with extensive organic banding within the profile are classed here. The soils are wet.

Major soil group 1.4 Rankers

Rankers occur frequently in the shallow rocky landscapes of Western Scotland. The soils have a distinct mineral, humose or peaty topsoil overlying rock. They span a wide range of rock types from basic to acid, including limestones where the surface horizon is not calcareous.

Subgroup 1.4.1 Brown rankers are more commonly developed on basic igneous rocks and limestones than on acid rocks. They are always intimately associated with brown forest soils and may contain sufficient organic matter to be classed as humic.

Subgroup 1.4.2 Podzolic rankers occur associated with podzol map units and on the short steep sides of knolls in some wetter units. They are characterized by a bleached E horizon but have no B horizon and are rare in Western Scotland.

Subgroup 1.4.3 Gley rankers have wet topsoils and are found in depressional sites. Localized in extent, they are nearly always associated with brown rankers.

Subgroup 1.4.4 Peaty rankers are the most extensive of the ranker group of soils in the area. Any soil with less than 50 centimetres of peat over rock is included although the bulk of the soils have considerably less than this.

DIVISION 2. NON-LEACHED SOILS

Major soil group 2.1 Rendzinas

Subgroup 2.1.1 Brown rendzinas are confined to the Cambrian/Ordovician limestones (the Inchnadamph Association) and are, even within that association, restricted in extent due to the high rainfall. They are associated with brown rankers and brown forest soils.

Major soil group 2.2 Calcareous soils

Subgroup 2.2.1 Brown calcareous soils are restricted to the shell sands of the Fraserburgh Association. Topsoils are humose and B horizons are weakly developed. The limited number of analyses available indicate that some soils with B horizons over limestone (the Inchnadamph Association) may just qualify but that soils over calcareous schist (the Deecastle Association) do not.

DIVISION 3. LEACHED SOILS

Major soil group 3.2 Brown earths

The brown earths are close to their north-westerly limit and the profile is strongly influenced by the nature of the parent material and by the effects of climate and landscape position. They are rarely developed above 150 metres.

Subgroup 3.2.1 Brown forest soils *sensu stricto* are developed only on parent materials derived from basic rocks, particularly basalts (the Darleith Association). They exhibit the characteristic gradual horizon changes, A and B horizons being only marginally differentiated by colour, and mull humus form. Above 75 metres B horizon chromas increase and the soils intergrade to podzols. Soils developed from acid parent materials show this characteristic throughout and it has been suggested that they should be recognized as a podzolic brown forest soil subgroup (Ragg *et al.* 1978). A clear reduction in extent of brown forest soils is seen from south to north of the region and is accentuated on the very acidic Moine Schists, quartzites and granites (the Arkaig, the Durnhill and the Countesswells Associations). Soils over calcareous schists have been included in this subgroup due to their leached nature (the Deecastle Association). Soils developed from ultrabasic rocks (the Corriebreck Association) tend to be richer in exchangeable magnesium but not sufficiently so to qualify as brown magnesian soils and are also included here.

Subgroup 3.2.2 Brown forest soils with gleying are not widely developed except in the north-east and south-east of the region where some of the tills occur in slightly lower rainfall régimes.

Major soil group 3.3 Podzols

Podzols are soils with significant accumulation of organic matter at the surface and evidence of translocation of sesquioxides within the profile. In the west their distribution is related to steep slopes or to very coarse, deep parent materials.

Subgroup 3.3.2 Humus-iron podzols occur in well-drained situations. Their surface humus horizons have been formed under aerobic conditions (H horizon). Those occurring on lower slopes were attractive subjects for cultivation and settlement from early times and the distinction between cultivated humus-iron podzols and brown forest soils is difficult to make under field conditions. The expression of podzolization is weak in soils derived from basic rocks (the Darleith and Sourhope Associations) and some cultivated humus-iron podzols may be mapped as brown forest soils. Where the expression of podzolic characters is stronger, as on acid parent materials, the recognition of humus-iron podzol is easier.

Subgroup 3.3.4 Peaty podzols have peaty surface horizons characteristic of accumulation under anaerobic conditions. In the west of the region the subgroup is restricted to steep, short slopes on moraine or fluvioglacial gravels, but it becomes more extensive under the reduced rainfall of the east and where a deeper solum allows better subsoil drainage conditions. In some instances on lower slopes the O and Eg horizons are well developed and it is possible to dig to considerable depth before encountering an iron pan. The vegetation associated with these soils is often the same as that of the peaty gley and they are sometimes named peaty gleyed podzols.

Thin iron pans and freely draining B horizons are characteristic of peaty podzols on acid parent materials. Gleying above a thin iron pan is commonplace; some evidence of gleying below the thin iron pan is also quite usual in Western Scotland. Peaty podzols on basic parent materials have a peaty surface but an attenuated E horizon which is dark in colour and often only detected in the field by the presence of bleached grains under magnification or a slightly grey tinge to the horizon in dried-out profiles. Thin iron pans in such soils are sporadically developed. Induration may be present on lodgement till or on moraine but is usually absent on other drift types.

Subgroups 3.3.5 Subalpine podzols and 3.3.6 Alpine podzols have fairly weakly developed, heavily humus-stained profiles. The former has a clearly distinguishable surface organic horizon, often with a fine subangular blocky, or on occasion, crumb structure, while the latter has a surface horizon mixed by frost action with much mineral material. Stone pavements on the surface of the alpine podzol are common. Many of the subalpine podzols are developed on steep slopes and disturbance of the profile by mass movements is commonplace. Minor subalpine and alpine brown soils (Birse 1980) have been detected on the basalts of the western islands but for the purpose of this report are included with the podzols.

DIVISION 4. GLEYS

Major soil group 4.1 Surface-water gleys

Gley soils are the most extensive soil type of the region. Due to the cool, moist conditions a large proportion have high organic-matter contents. The distinc-

tion between surface-water gley soils and ground-water gley soils is often difficult to make. Apart from one or two special instances, most gley soils have been interpreted as surface-water gleys.

Subgroups 4.1.4 and 4.1.5 Noncalcareous and humic gleys are intimately intermingled and often indistinguishable in the field, the A horizons of both being dark coloured. They are mostly confined to glacial tills, principally developed in the south, south-east and north-east of the region. Fields under regular cultivation often have slightly less than 8 per cent organic matter (noncalcareous gleys) while those under long ley grassland or in neglected hill pastures have more (humic gleys). The drier areas (north-east and south-east) have more noncalcareous than humic gleys, but the converse is true for the lowland in the bulk of the region.

Subgroup 4.1.6 Peaty gleys are wide ranging, from sea level to mountain summit. They become prevalent above 150 metres and are a major constituent of many of the most widespread map units on all parent material types even basic rocks and gravels. As with all such widely distributed groups there is a great range of variants. The diagnostic characteristics are the presence of an O horizon less than 50 centimetres thick and subsoil horizons which are gleyed. Some drift types have well-developed Eg horizons (tills and acid parent materials) which are difficult to detect on others (basic parent materials). Humus staining is very widespread but on compacted and less-permeable materials is often confined to the upper horizons, while on colluvial drifts high humus contents are obvious throughout the profile. Very low values and chromas are characteristic.

Intergrade profiles from humic gleys are common, as are those to peaty podzols. It is sometimes difficult to allocate profiles with a moderately gleyed B horizon to either peaty podzol or peaty gley groups, but this is generally done on the presence or absence of a thin iron pan. An exception occurs when gleyed soil horizons directly overlie induration. Despite the presence of an iron pan at the surface of the induration in many instances, the view has been taken that these are dominantly wet soils and should therefore be included in the peaty gley subgroup, perhaps identified as peaty fragogleys, rather than in the peaty podzol group. B horizon development is typically restricted by the induration. The peaty gley subgroup is characterized by very weak structural development, except for those variants with a fragic horizon where coarse platy structure may be strongly developed.

Major soil group 4.2 Ground-water gleys

Subgroup 4.2.1 Calcareous gleys are restricted to a few basin sites on Tiree and Colonsay (the Fraserburgh Association).

Subgroups 4.2.5 Subalpine gleys and 4.2.6 Alpine gleys are characterized by the well-aerated, even 'fluffy' nature of the organic horizon and by wet subsoils. Water is often held up in rocky hollows at high levels on mountain summits, and the soils are associated with the much more prevalent subalpine and alpine podzols.

DIVISION 5. ORGANIC SOILS

Major soil group 5.1 Peats

Peats have surface organic horizons more than 50 centimetres thick. They are widely distributed throughout many of the map units of the soil associations as well as being mapped separately when the rigours of scale allowed. Where the latter units are shown they always contain substantial proportions of peat greater than 100 centimetres deep. Many stages of erosion are present but eroded phases have not been separated due to difficulties of definition. Organic soils in Western Scotland are predominantly amorphous and always wet.

Subgroup 5.1.1 Eutrophic flushed peat is confined to areas receiving water from base-rich igneous rocks or limestones.

Subgroup 5.1.2 Mesotrophic flushed peat is also confined to alluvial sites but is slightly more widely distributed, particularly in the southern and eastern parts of the region where it extends in channels from spring lines on the hills.

Subgroup 5.1.3 Dystrophic flushed peat is extensive throughout the area but better developed on base-rich rocks than elsewhere (the Darleith, the Torosay and the Insch Associations).

Subgroup 5.1.4 Dystrophic peat is extensive and particularly well developed on the major acid rocks (e.g. the Arkaig, the Countesswells and the Durnhill Associations).

VEGETATION

In the following account, the distribution of the plant communities and their relationships with the soils of the region are briefly discussed. The common names quoted for these communities are based on field vegetation units listed and described in Handbook 8. The classification of the plant communities in phyto-sociological terms is quoted in brackets after each community name and follows Birse and Robertson (1976) and Birse (1980, 1982). When a community is firmly established as an association it is put in the Latin form (-etum), but when there is some doubt as to the validity of the association, it is named by one or two plant species names followed by the term 'Association'. When there are insufficient records to establish an association, the vegetation is again named by one or two plant species, but followed by the term 'Community'. The individual species names for vascular plants follow Clapham, Tutin and Warburg (1962), as do the bulk of the common names. Terminology for the mosses is that of Smith (1978) and for lichens that of James (1965).

In Western Scotland, the keen botanist can explore such diverse environments as the dunes and machairs of the islands, the coastal raised beaches, the wooded lower hillslopes and the exposed mountain tops to reveal a wealth of interesting plants, some of which, Iceland purslane (*Koenigia islandica*) and Diapensia (*Diapensia lapponica*) for example, have their only stations in the British flora. Since three-quarters of the land surface has peaty soils, however, the vegetation is dominated by species tolerant of acid, waterlogged conditions, such as flying bent (*Molinia caerulea*), deer-grass (*Trichophorum cespitosum*), bog mosses (*Sphagnum* spp.), cotton-grass (*Eriophorum vaginatum*), bog heather (*Erica tetralix*) and heather (*Calluna vulgaris*).

The principal hill and mountain landscapes are dominated by peaty gleys and peat which support Atlantic and boreal heather moors and bog heather moor (Carici binervis-Ericetum cinereae, Vaccinio-Ericetum cinereae and Narthecio-Ericetum tetralicis) and blanket and flying bent bog (Erico-Sphagnetum papillosi). On the less severely waterlogged sites of the steep slopes where organic horizons are more decomposed, dry Atlantic and dry boreal heather moors (parts of Carici binervis-Ericetum cinereae and Caccinio-Ericetum cinereae) grow on peaty podzols and peaty rankers.

Most of the good quality permanent and semi-natural pastures are confined to areas of mineral soils at low altitudes. Where in-bye fields are not used for arable farming, rye-grass–crested dog's-tail pasture (Lolio-Cynosuretum) is the usual community on well-drained soils. Uncultivable steep slopes, often with brown forest soils, permit the growth of bent–fescue grassland (Achilleo-Festucetum tenuifoliae). Neglected wet meadows consist of rush pastures (Potentillo-Juncetum acutiflori and the *Ranunculus repens–Juncus effusus* Community), or under very poor drainage conditions on peaty gleys and peat soils, the vegetation may revert to yellow flag swamp (the *Iris pseudacorus* Community) and meadow-sweet meadow (Valeriano-Filipenduletum).

Distinctive pasture communities are generally associated with exceptional major soil subgroups; crested hair-grass grassland, for instance, is restricted to brown rendzinas of the Inchnadamph Association. On Tiree and Coll there are excellent semi-natural grasslands with species-rich eyebright–red fescue dune pasture (Euphrasio-Festucetum arenariae) on the calcareous regosols of the machairs. By contrast the neighbouring active dunes have only a sparse cover of northern marram grass dune (Elymo-Ammophiletum).

In addition to the lowland pastures, summer grazings are available on the higher hillslopes with subalpine podzols, where upland bent–fescue and white bent grasslands (parts of Achilleo-Festucetum tenuifoliae and Junco squarrosi-Festucetum tenuifoliae) largely replace the heather moors. At yet higher altitudes on exposed mountain tops (700 metres and above) communities such as stiff sedge grassland and viviparous fescue grassland (parts of the *Carex bigelowii–Festuca vivipara* Community) are vigorous on the alpine soils. Even under such extreme conditions the above pastures vie for prominence with mountain heath communities; on the subalpine slopes blaeberry heath (the *Rhytidiadelphus loreus–Vaccinium myrtillus* Community) and lichen-rich boreal heather moor (part of Vaccinio-Ericetum cinereae with *Cladonia arbuscula*) are frequent; on the high summits (above 700 metres) alpine azalea–lichen heath (Alectorio-Callunetum vulgaris) and the fescue–woolly fringe-moss heath (Festuco-Racomitrietum lanuginosi) occupy the wind-eroded crests while the more sheltered hollows with late snow-lie are colonized by dwarf cudweed and alpine clubmoss snow-bed (the *Gnaphalium supinum–Nardus stricta* Community and the *Lycopodium alpinum–Nardus stricta* Community).

Native woodland is rare and thus many of the remaining stands have been designated as National Nature Reserves and Sites of Special Scientific Interest by the Nature Conservancy. Woods consisting of broadleaved species (mainly Blechno-Quercetum) are commonest in inaccessible areas with steep rocky slopes which would be unsuitable for agriculture even after clear-felling. Humus-iron podzols and brown forest soils are the principal soils. Occasional stands of elmwood (Querco-Ulmetum glabrae) and other woodlands with exotic species (e.g. *Araucaria araucana, Sequoia wellingtonia*) are a result of estate planting to provide ornamental parks and gardens.

In the east of the region there are some remnants of native pinewood

(Pinetum scoticae). The best examples are in Glen Affric, Crannach Wood (south of Rannoch Moor) and in Glen Cononish near Tyndrum.

Commercial forestry is responsible for much the largest portion of wooded ground. The principal species are Sitka spruce (*Picea sitchensis*) on peaty podzols and peaty gleys with some lodgepole pine (*Pinus contorta*) on deep peat. In sheltered areas with mineral soils, larch (*Larix* spp.), Scots pine (*Pinus sylvestris*) and even some broadleaved species have been planted but on a much smaller scale.

So far the plant communities have been discussed in relation to the major soil subgroups. However other environmental elements, primarily climate, parent material, flushing and land use modify, and sometimes override, the influence of soil type. These additional factors are now appraised individually, though it will be appreciated that none of them operates in isolation.

There are three broad trends which follow climatic gradients from (a) west to east (b) north to south (c) sea level to mountain top.

(a) The peaty gleys of the wet humid lowlands and foothills of the west support communities with flying bent (parts of Carici binervis-Ericetum cinereae and Erico-Sphagnetum papillosi, dominated by *Molinia caerulea*), while on similar soils in the low-rainfall, less oceanic eastern lowlands and foothills, the dry heather moors (parts of Carici binervis-Ericetum cinereae and Vaccinio-Ericetum cinereae) flourish. The transformation from the grass-dominated to heather-dominated landscape is gradual, but a change in the preponderant species is discernible about a line between Loch Broom and Loch Lomond.

(b) With increasing latitude the northern forms of Atlantic heather moor (Carici binervis-Ericetum cinereae), bog heather moor (Narthecio-Ericetum tetralicis) and blanket bog (Erico-Sphagnetum papillosi), each with woolly fringe-moss (*Racomitrium lanuginosum*) and *Cladonia* spp., occur more commonly as a result of lower average temperatures and greater exposure. This phenomenon is particularly noticeable to the north of Loch Carron where another marked tendency is towards the dominance of bog heather moor, a feature thought to correlate with the underlying Torridonian strata.

(c) Further transitions can be observed with increasing altitude, besides the one already attributed to the alteration of soil type, the most obvious being the variation in the plant communities of peat. The blanket bog of the lowland peat is supplanted by upland blanket bog (part of Erico-Sphagnetum papillosi, with *Vaccinium myrtillus* and *Empetrum nigrum*) around the 300 metre contour, and is then itself progressively replaced by mountain blanket bog (Rhytidiadelpho-Sphagnetum fusci) at altitudes over 500 metres.

On peaty podzols, peaty gleys and peaty rankers with constantly waterlogged topsoils, the northern forms of Atlantic heather moor and bog heather moor start to appear above the 200 metre contour, while on drier unflushed sites with similar soils, boreal heather moor is the more usual replacement community. Higher still at altitudes over 500 metres the emergence of the lichen-rich form of the latter community may also coincide with the gradation in soil type from peaty podzol to subalpine podzol.

It should be emphasized that the quoted altitudes are approximate and that the overlapping ranges of the communities will vary with both local and regional climate (north- and south-facing slopes of the same hill often have different communities, and lowland communities are found at higher altitudes on the more continental eastern mountains than on the exposed western peaks).

In addition to the wide-ranging effects just described, variation of the microclimate is responsible for some sharp local contrasts in both the type and growth habit of the flora. Even at moderate altitudes (*c.*200 metres) for instance, morainic mounds sometimes have exposed crests with wind-cut fescue–woolly fringe-moss heath, a community usually associated with high summits, while sheltered hollows within a few metres may support tall heather moor, more in keeping with a lowland situation.

The mineral soils of associations with parent materials derived from basic rocks (e.g. the Darleith, Deecastle and Inchnadamph Associations) have communities richer in species than those derived from acid rocks (e.g. the Arkaig, Countesswells and Durnhill Associations). On brown forest soils for example, the woodland on soils derived from limestones (the Inchnadamph Association) is usually ash and hazel (Primulo-Quercetum) as at Rassal, Kishorn and at Tokavaig and Torrin on Skye. Similar soils over acid schists and gneiss (the Arkaig Association) normally carry birchwoods, but in some lower rainfall areas (at Beasdale, Arisaig for example) dry, acid woodland (part of Blechno-Quercetum) is also found. A similar contrast is evident on grassland; species-rich bent–fescue grassland (part of Achilleo-Festucetum tenuifoliae) forms the sward on soils of the basic group, while the more acid group supports the species-poor form of the same community. These variations are often, though not always, supported by analytical evidence. Unless there is eutrophic flushing however, the peaty soils of both basic and acid rocks support calcifuges typical of acid conditions, such as heather(*Calluna vulgaris*) and deer-grass (*Trichophorum cespitosum*).

Flushing has a regional effect in promoting the ascendancy of flying bent over heather throughout the west Highlands. It also exerts strong local influence since the base status of any flush clearly has a strong bearing on what species will grow there; bog moss water track (the *Juncus effusus—Sphagnum recurvum* Community) is typical of dystrophic flushes, while bog-rush mire (the *Schoenus nigricans* Community) is seen on the eutrophic flushed peaty gleys of basaltic drifts (Birse 1980).

In the montane environment calcicolous communities abound in flushes and on ledges, even on acid parent materials. Species such as the yellow mountain saxifrage (*Saxifraga aizoides*) and rose-root (*Sedum rosea*) are able to thrive because of the small but sustained contributions of nutrients from both runoff and newly weathered soil material.

The predominant species on heathlands and foothills is partly determined by the muirburn practice. In the wetter west the flushed peaty soils do not in any case form ideal substrata for heather; it is further suppressed by the haphazard muirburn carried out at irregular intervals, which removes the flying bent trash and enables sheep to browse on the young shoots. This may eventually lead to over-burning and a consequent lowering of the grazing quality. The severely waterlogged undulating moorlands with peat and peaty gleys are thus dominated by communities such as flying bent bog (part of Erico-Sphagnetum papillosi, with *Molinia caerulea*) and moist Atlantic heather moor (part of Carici binervis-Ericetum cinereae, with *Molinia caerulea*) and the less waterlogged steep slopes (such as those of the Monar and Affric Forests) with some peaty podzols carry heath rush-fescue grassland (Junco squarrosi-Festucetum tenuifoliae) which has heath rush (*Juncus squarrosus*), white bent (*Nardus stricta*) and flying bent (*Molinia caerulea*) as the dominant species. That the heathy element of the flora is at present subdued in the west Highlands is amply demonstrated by the rapid re-establishment of heather (*Calluna vulgaris*) and bog heather

(*Erica tetralix*) where grazing and burning have ceased, such as in fenced-off National Nature Reserves and forestry plantations.

The drier heathlands of the east have peaty podzols as the principal soils on which heather (*Calluna vulgaris*) flourishes and bell heather (*Erica cinerea*) is a prominent species. Here a controlled, small scale, rotational approach to muirburn has been adopted. As a result the heather never progresses to rank unpalatable maturity and stands of various ages for the sheep, grouse and deer are produced. Each animal is thus able to exploit the patches best suited to its needs.

Severe burning of heath on humus-iron podzols with thin organic horizons tends to encourage the spread of bracken (*Pteridium aquilinum*), which may then infest these soils. Muirburn over peat areas checks the growth of the bog mosses (*Sphagnum* spp.) and cotton-grass (*Eriophorum vaginatum*) and leads to the formation of deer-grass moor (the *Trichophorum germanicum–Calluna vulgaris* Association).

The reaction of any sward to grazing pressure will depend on the numbers and type of stock involved. Sheep are selective grazers, a fact borne out by their effect on a mosaic of moist Atlantic heather moor (part of Carici binervis-Ericetum cinereae) and bent–fescue grassland (Achilleo-Festucetum tenuifoliae); only rarely is the former community eaten and it therefore becomes tall and rank, while the latter forms a short turf and is gradually converted to meadow-grass–bent pasture (the *Galium saxatile–Poa pratensis* Community) under the régime of heavy grazing and dunging. Cattle, on the other hand, are much less exacting in their grazing habits and will take fibrous unpalatable species which the sheep reject. The normal effect of high stocking rates on rough grazings is to reduce the amount of heather in the sward and increase the proportion of grasses. The soil type dictates the nature of the replacement community; on brown forest soils and humus-iron podzols bent–fescue grassland (Achilleo-Festucetum tenuifoliae) develops; peaty podzols with thin organic horizons support common white bent grassland (part of Junco squarrosi-Festucetum tenuifoliae, with *Nardus stricta*), and the more waterlogged peaty podzols and peaty gleys progress to flying bent grassland (part of Junco squarrosi-Festucetum tenuifoliae, with *Molinia caerulea*).

A particular problem in the west Highlands is the invasion of the mineral soils by bracken due to a combination of cessation of cultivation, insufficient grazing pressure and over-burning of heather. Recent advances in herbicide production provide a solution, but spraying is expensive and more careful management may be sufficient to prevent further incursions by this troublesome fern.

The regeneration of natural woodland on well-drained soils occurs where grazing and burning have been discontinued. This is well illustrated at Ariundle, Strontian, where enclosed thickets of oakwood (part of Blechno-Quercetum) have a profusion of young trees in the shrub layer, a feature absent from neighbouring unfenced stands. It seems likely that the exclusion of grazing animals from native pinewood (Pinetum scoticae) could permit it to spread, a possibility hinted at by the proliferation of pine seedlings and saplings in the immediate vicinity of the West Highland railway at Crannach Wood, as the adjacent unfenced mature woodland has only a few younger trees.

Afforestation inflicts the most fundamental changes on the semi-natural vegetation. Initially forestry ploughing promotes the growth of grass species such as wavy hair-grass (*Deschampsia flexuosa*) and brown bent (*Agrostis canina*). If herbicide treatment has been insufficient, heather may recolonize the

plantations until the canopy closes. A mature forest floor has a carpet of needles and mosses and little else, but after thinning, grasses re-establish themselves along with shade-loving species such as blaeberry (*Vaccinium myrtillus*) and wood sorrel (*Oxalis acetosella*).

Though part of an evolving system, soils are generally regarded as relatively unchanging despite the short-term influences of man's activities. Vegetation, however, will always be prone to swift modification because of its sensitivity to land use and management practices.

2. The Soil Map Units

In Western Scotland the character of soil changes dramatically within short distances and is difficult to resolve except at very large map scales. Nevertheless it is possible to identify soil landscape patterns at a broad level, even though the detail is complex. The major soil landscape patterns have been resolved with the aid of aerial photograph interpretation and ground control and form the basis of the soil map units. The following criteria were used in their establishment: rock type and drift type (soil parent material), slope, amount of rock outcrop, climate zone, vegetation and the nature of the surface horizon (organic or mineral). The dominant major soil subgroup(s) was identified in the field, together with secondary major soil subgroups. On different parent material types, many units were found which differed in minor characteristics (analogues). Comparison of associations in the key will reveal the similarities; differences may be identified from the descriptions below.

In this section the map units are described in numerical order, starting with alluvial and organic soils and proceeding to the soil associations listed alphabetically. Within any association an attempt has been made to list the map units starting with those of the lowlands and proceeding through the foothills to hill and mountain units. The map unit legend is national and hence gaps in the map unit numbering represent those present elsewhere in Scotland but not encountered in this area.

THE ASSOCIATIONS AND MAP UNITS

THE ALLUVIAL SOILS

(Map units 1 and 2)

Alluvial soils are developed on recent, unconsolidated, water-laid sedimentary deposits and show little or no soil profile development; they may be encountered wherever there are water-courses. However, many of the alluvial fans and terraces along the length of small streams are too minor to be indicated on the map and are incorporated into other map units. Occasionally they are sufficiently frequent or form a significant portion of the pattern and are mentioned in the map unit definition. Only the larger alluvial deposits are shown separately on the map.

Most of the riverine alluvium in this area was deposited from fast-flowing streams and is predominantly sandy and gravelly. Occasionally, finer textures may be found in old lacustrine sites or saltings (periodically inundated estuarine alluvium) and these silts or fine sands may be interbedded with peat. The alluvium in the region is almost entirely mapped into one unit apart from an area of saltings on the Ardnamurchan peninsula.

Map unit 1 covers 95 square kilometres (0.6 per cent of Western Scotland). The most extensive areas are found in Strathglass, lower Strathconon and Glen Carron, with slightly smaller but important areas at Kinlochewe, Strath Bran, Applecross, Morvich, Kinlochmoidart, Glen Strae (Loch Awe), Loch Eck and Balquidder. The larger alluvial straths occur below 100 metres but smaller areas occur up to 200 metres and occasionally higher. Almost level land with small hollows and meander channels is the characteristic landform. Peat and peaty gleys develop in the hollows due to the influence of a ground-water table and are often extensive. Rock knolls occasionally protrude through the alluvial mantle, but rocky areas are generally insignificant. Alluvial flats provide striking contrasts to the steep, rocky valley sides and in many areas form the best, and sometimes the only, ploughable land.

Mineral and peaty alluvial soils have been grouped together, as have all textural and drainage categories, features which normally call for separate map units at larger scales. The mineral alluvial soils are extensive in the eastern straths, especially Strathglass and lower Strathconon, where some of the best farmland of the region is found. These freely and imperfectly drained soils become less prominent in the map unit in the wetter central mountains and western lowlands and foothills, being replaced by peaty alluvium. Poorly drained mineral alluvial soils occur throughout the area. Soil profile development in the mineral soils is largely restricted to humus accumulations in, or cultivation of, the surface horizons and the development of gley morphology (principally mottling where drainage is impeded or a fluctuating water-table occurs). As would be expected in a drift of such diverse provenance the soil chemistry is very variable and, in particular, trace element contents reflect those of the contributing rocks. Exchangeable cations are generally low and require frequent replenishment by liming and fertilizing, but in comparison with the sandier soils of the Corby Association, these soils are fertile.

Peaty alluvial soils are usually poorly or very poorly drained and are frequently encountered in glens in the central mountains, or in the western lowlands. Peat-alluvium consists of fluvially deposited peat, *in situ* peat formation over mineral alluvium, or interbedded organic and mineral fluviatile deposits.

There is a large variety of plant communities on this map unit, each closely associated with specific soils, or groups of soils, or climate areas. Arable and permanent pastures are seen on the freely and imperfectly drained alluvium of the eastern glens, giving way to permanent pastures and semi-natural grasslands on the same soils in areas of higher rainfall. Much of this land is either cultivated or provides good grazing. Rush pastures and sedge mires occupy the poorly drained mineral soils except where agricultural practice can eradicate them. Bog heather moors and occasional rush pastures are supported by the peaty gleys, with blanket bogs on the peat.

Map unit 2, saltings, is land periodically submerged by tides and extends downwards from the high-water mark of spring tides to the almost equivalent

point reached by neap tides. It occurs in many places on the west coast of Scotland, usually at the head of lochs or in estuaries or as fringes round alluvial fans which reach the sea. Unfortunately they are almost never extensive enough to qualify as individual map units. The only area of mappable size is at Kentra, near Acharacle where there is a large sandy estuary.

The soils of saltings are usually of a sandy or silty texture, often interbedded, and with few stones. Shell fragments are usually present in the sediments. The vegetation consists of halophytic species, but depending on the frequency and depth of inundation several different plant communities may be found. The ground surface is dissected by many channels of varying depths formed by tidal action and numerous very small pools dot the surface.

Without earthworks to keep out the sea there is little prospect of improving these soils. They provide healthy grazing for stock however.

THE ORGANIC SOILS

(Map units 3 and 4)

'Peatlands are amongst the more obvious of the great natural features of the Scottish landscape and their presence has profoundly modified the appearance of the land surface.' Thus Jowsey (1973) introduces an account of the peatlands of Scotland. He also observes that their distribution has severely affected both land use and communications patterns in the country. In Western Scotland peat is one of the most common and extensively occurring soil types but because of the mountainous nature of much of the terrain it is rarely developed in sufficiently extensive areas to show on a scale of 1:250 000. It is much more commonly developed as a component of soil complexes, where it occupies hollows and depressions at all elevations from sea level to over 700 metres. As a mappable deposit it occupies 706 square kilometres (4.2 per cent) of the area represented on Sheet 4.

For the purposes of survey, peat is defined as an organic deposit containing more than 60 per cent organic matter on a dry weight basis and more than 50 centimetres thick. Most if not all of the deposits mapped separately have depths in excess of 100 centimetres. In general terms, peat forms where the rate of formation of plant tissue exceeds the rate at which it is decomposed. This is most likely to occur when conditions are unsuitable for the activity of the soil micro-organisms responsible for breakdown. Waterlogging is the principal factor causing this and Western Scotland is abundantly endowed with rain. Although surface layers are occasionally fibrous, the bulk of the peat is amorphous and has a massive structure which renders it, to all practical purposes, impermeable.

The classification of peatland is not simple since the deposit is extensive and occupies a wide variety of topographic and climatic situations. For many years the classification of Fraser (1954), which divided peat into basin peat and climatic or hill peat, has been used by the Soil Survey of Scotland. Recently Hulme (1980) has suggested that a suitable classification for broad scale surveys should have three categories, which he describes as confined (basin), partly confined and unconfined (hill peat). Despite criticism of the climatic or zonal method of classing peat, it is clear from the examples in his paper that a zonal concept is incorporated however, for confined mires occupy lowland sites, partly confined occupy foothill sites (largely below 300 metres in the east of Scotland) and unconfined mires are on hills. For purposes of the current survey confined and partially confined peat have been included within one map unit

(*3*) which occurs principally on terraces or valley sites in the lowlands. Extensive flushing, particularly at the margins, is a characteristic of these sites. *Map unit 4*, blanket peat, is mapped under the ombrogenous conditions of the hill lands irrespective of its site characteristics. Peat within soil association mapping units is often in confined sites but it is more appropriately classed according to chemical and morphological criteria, e.g. dystrophic peat common on much of the acid hill land or mesotrophic peat, characteristically flushed by seepage from basic rocks. The pH values recorded from Western Scotland range from 3.1 to 5.0 but are commonly in the region of 4.3. Base saturation is often low but may occasionally be moderate.

Only a limited number of plant species are capable of thriving under the wet, acid conditions of the peat soils. These include the bog mosses (*Sphagnum* spp.), the cotton-grasses (*Eriophorum* spp), the flying bent (*Molinia caerulea*), the deer-grass (*Trichophorum cespitosum*), the bog heather (*Erica tetralix*) and heather (*Calluna vulgaris*). The principal plant communities are blanket bog and flying bent bog with, on occasion, bog heather moor and moist Atlantic heather moor.

Map unit 3 covers 100 square kilometres (0.6 per cent of Western Scotland) and is primarily developed in lowland situations under fairly warm and warm (more than 1100 day degrees C) and wet (potential moisture deficit less than 25 millimetres) conditions. It is widely distributed throughout the islands, the western coastal fringe and occasionally at the heads of major inland lochs. A concentration of small areas of the unit is found in the central part of the overlap to Sheet 5 (Eastern Scotland) from Rannoch Moor northwards. Many of these areas are uncharacteristically high; similar sites throughout the remainder of the hill land of West Scotland have been mapped as *unit 4*.

Apart from these upland valleys, two major site types have been grouped in *map unit 3:*

(i) Lowland peats in basin and valley floor sites below 100 metres. The chief areas are in northern Skye and Mull. Both alluvial peat and peat with discrete separate patches of alluvium frequently occur, particularly where the deposits flank a river

(ii) Lowland peats on level terrace sites such as those formed by outwash deposits and raised beaches below 50 metres. Good examples are found at Achnacree Moss near Oban, the Moine Mhor near Lochgilphead and the Mosses of Kentra and Claish on the Ardnamurchan peninsula. The latter three localities have tracts with dubh lochans, discrete but closely spaced pools dotting the surface of the peat. There are indications of flow patterns. A common attribute of all these bogs is that they are underlain by sand and gravel deposits, sediments normally associated with good drainage. The presence of indurated horizons (probably in this instance due to pedological causes), horizons cemented by iron and manganese compounds in circulating ground waters, the formation of thin iron pans and the presence of occasional silt bands have effectively prevented vertical drainage. There is clear evidence at Achnacree Moss that peat development started subsequently to cultivation by primitive man and this may have been a contributory factor to the waterlogging initiating peat development (Soulsby 1976). Many crofting communities are peripheral to these mosses and peat has traditionally been cut for fuel. Some of the surrounding arable ground has been reclaimed by the complete removal of the overlying peat.

The plant communities are principally blanket bog, bog heather moor and

occasionally flying bent bog. Although the two former occur with monotonous regularity, the edges of the bogs and channels within them may be flushed, with local occurrences of rush pastures, sedge mires, meadow-sweet meadow and yellow flag, reed-grass and bottle sedge swamps. The unit produces low-quality rough grazing land, though some flushed areas have slightly richer pastures. Due to the high rainfalls and low bulk density of the peat, reclamation for grassland is rarely attempted. Acreages devoted to forestry are increasing as modern techniques and better species selection develop. Neither stock nor forestry can make use of the dubh lochan peats though conservation agencies are usually interested in them.

Map unit 4, covering 606 square kilometres (3.6 per cent of the region) consists of blanket peat. On the islands it occurs in lowland zones and extends almost to sea level in the north and far west, probably as a response to lower temperatures. Except on slopes exceeding 15 degrees where it is rarely developed, it has subdued many topographic irregularities. Inland between 200 metres and 300 metres the blanket peat is rarely hagged. As it rises through the upper boreal zone, hagging develops. The distinction is not always clear-cut however and the eroded phase has not been separated as a unit on this map. Above 300 metres peat is extensive and hagging is common especially in subalpine units containing it. Above 600 metres peat is only found as occasional accumulations in hollows and cols and probably never constituted a full cover.

Peat units mapped on the islands are in lowland and foothill sites with a rather warm wet climate and a rainfall of 1800 millimetres. Mainland occurrences in the eastern uplands are usually in cold, wet zones (rainfalls about 2200 millimetres). Plant communities rarely diverge from the repetitious blanket bog and bog heather moor with flying bent bog in areas below 400 metres except for limited flushes with rush pastures and sedge mires. In subalpine zones (above 400 metres) the main vegetation types are upland and mountain blanket bogs. Intensive burning in some areas has created a deer-grass community.

The primary land use is rough grazing. Most bog plants are of low value but in spring grazing of cotton-grass or flying bent shoots may provide a subsistence diet when little else is available. It is notable that as soon as better grazings from communities in drier sites are available, these plants are virtually ungrazed. Until recently blanket bogs have remained unplanted. It is now clear that lodgepole pine will cope with the wet, acid conditions and afforestation is increasing below 400 metres.

THE ABERLOUR ASSOCIATION

(Map units 5, 6, 9–12 and 15)

Soils of the Aberlour Association are derived from a parent material of a type intermediate between that of the Arkaig and Countesswells Associations. The drift is derived either from a mixture of granite and schist or from granulites intruded by multiple granite veining. Also included in the associations are areas of granulites and granitic gneiss with intrusions of felsites. The granitic gneiss, schist and granulites are of the Moinian Assemblage. The texture of the drift is coarse sandy loam, locally varying to loam. The deposits are stony, frequently very stony.

The association has only been recognized in a 10 kilometre band on the

extreme east of the map, in the overlap with Eastern Scotland. Throughout the remainder of Western Scotland although mixed drifts of granites and gneisses occur, particularly where moraines pass from one formation to the other, the differences between the parent materials were considered insignificant. Soils in these areas were placed in either the Arkaig or the Countesswells Associations depending on the preponderance of Moine gneiss or granite debris in the drift.

The association therefore has a very limited extent (35 square kilometres; 0.2 per cent of Western Scotland) but is more extensive to the east. The largest areas are associated with the granitic mass of Rannoch Moor but it also occurs at Creag Meagaidh and at Whitebridge. The soils span an altitude range from 200–900 metres, with an annual rainfall of 1000 millimetres (Whitebridge) to over 2000 millimetres, and over 70 per cent of the association is mapped into units dominated by podzols.

Map unit 5 is composed of noncalcareous gleys and peaty gleys, with minor humic gleys, flushed peat and humus-iron podzols. It covers 3 square kilometres (10 per cent of the association). The unit is confined to the low, undulating Foyers valley between Whitebridge and Corriegarth and associated with concave sites or planar slopes with minor depressions. The slopes are gentle and strong and non-rocky. Agricultural operations are limited by the poor drainage and the unit usually supports permanent pasture, although minor cultivated areas are found. Rush pastures, sedge mires and bog heather moor also occur.

Map unit 6 is confined to a very small area (less than 1 square kilometre) north of Whitebridge. The soils are freely and imperfectly drained humus-iron podzols with minor areas of gley. It is associated with undulating lowland with non-rocky, gentle to strong slopes.

Map unit 9 is the most extensive of the association and dominated by peaty podzols with minor humus-iron podzols and, in the depressions, peaty gleys and peat. It occupies 22 square kilometres (65 per cent of the association) and is similar to *map unit 123* (the Countesswells Association) with which it is contiguous. The drift type is moraine and the landscape moundy with moderate to steep complex slopes. The map unit is non- to slightly rocky. The organic surface horizons, poor drainage and complex slopes provide serious obstacles to agricultural improvements although similar morainic areas have been planted satisfactorily. The plant communities are moist boreal heather moor, heath grass–white bent grassland and bog heather moor with blanket bog.

Map unit 10 occupies only two sites, one at Whitebridge almost entirely forested, and the other on the south shore of Loch Ossian (2 square kilometres; 5 per cent of the association). Soils are peaty podzols and humus-iron podzols with some peat, gleys and rankers. They support a vegetation of moist boreal heather moor and tussock grass–white bent grassland on moderately rocky, strongly sloping hillsides.

Map unit 11 is also very restricted and occupies a small area on the northern slopes of the Creag Meagaidh range. Its soils are peaty gleys and peat with some peaty podzols and local subalpine podzols and rankers. It occurs on a complex, moderately rocky hill slope at an altitude range of 500–800 metres and is of the same extent as *map unit 10*. The vegetation is moist boreal heather moor, blanket and upland blanket bog or bog heather moor.

Map unit 12 is even more restricted, occupying only 1 square kilometre on the eastern slope of Carn Dearg in Rannoch Forest. Subalpine podzols and rankers are associated with minor areas of peat, alpine and peaty podzols and some gleys. The vegetation is alpine azalea–lichen heath, lichen-rich boreal heather moor or mountain blanket bog.

Map unit 15 occupies 5 square kilometres on the summit of Carn Dearg, Rannoch Forest. Its soils comprise very stony rankers and lithosols together with rock. Alpine and subalpine podzols may also occur. The vegetation is alpine azalea–lichen heath, blaeberry and bog whortleberry heath and stiff sedge–fescue grassland.

THE ARKAIG ASSOCIATION

(Map units 19–36)

The Arkaig Association is the most extensive of the region accounting for more than a third (36.2 per cent; 6074 square kilometres) of the area. The soils are developed on drifts derived from the metamorphic rocks of the Moine Series, quartz-feldspar-granulite, quartz-mica-schist, granitic gneiss and quartzite. Although these and other lithological distinctions have been made by the Institute of Geological Sciences, all the soil parent materials examined are considered sufficiently similar to be classified within this association for the current survey. Further differentiation may be required in the future, possibly on geochemical grounds.

Parent materials are mainly colluvium and moraine with minor till deposits. Textures throughout these drifts are sandy and clay percentages are characteristically very low (often less than 3 per cent). Stony, cryic and aeolian drifts occur on the mountains above 400 metres.

The parent rocks are resistant to erosion and the terrain is either rugged, glacially scoured lowland and foothill with shallow drifts or mountainous, with extensive areas of bouldery, moundy moraines in valleys. Mountains rising to over 900 metres are common on the mainland north-west of the Great Glen where the association is most widespread and morainic drift is particularly well displayed in a broad belt stretching from Loch Eil to Loch Fannich. The lower-lying rugged aspect is clearly expressed in south-west Moidart and eastern Ardnamurchan. The mountains of the east have plateau-like summits, rising to 800 metres. The sharp arêtes and peaks so characteristic of the west are absent, though the terrain is still dissected by deep U-shaped valleys. Further extensive tracts of the association are encountered around Loch Treig and west of Bridge of Orchy.

Most of the Arkaig Association soils are peaty, 70 per cent of the map units having peaty gleys, peaty podzols and peat as major components, a feature due in large measure to the cool, wet climate and the acid nature of the parent materials. Well-drained mineral soils (brown forest soils and humus-iron podzols) are restricted to lowland steep slopes for the most part and map units dominated by these soils account for only 5 per cent of the association. Montane units, with subalpine and alpine podzols as major components, occupy 25 per cent, further emphasizing its upland nature.

Although other associations with acid parent materials have analogous map units with similar components, the internal balance of major soil subgroups in each unit is altered by minor parent material, climate and topographic

variations. In the same way disparities in the proportions of mineral and peaty soil dominated units in each association arise due to these influences. For example, within the Strichen Association, map units dominated by noncalcareous gleys, brown forest soils and humus-iron podzols occupy 18 per cent, while Arkaig Association has only 5 per cent of such units. This is probably due to the southerly distribution (and thus drier, warmer climate) and the slightly more base-rich parent materials of the former association.

The climate ranges from fairly warm and wet (rainfall *c.*1200 millimetres) in the lowlands and cool and wet (rainfall *c.*2000 millimetres) in the foothills of the southern and western areas to extremely wet (rainfall *c.*3600 millimetres) and cold in the mountains, and fairly warm and moist (rainfall *c.*800 millimetres) in the eastern lowlands and foothills. Owing to the widespread distribution of the association most of the comment on the climate for the whole of Sheet 4 applies, apart from that relating to the warm, wet lowland of the extreme south-east.

The land use is largely restricted to rough grazings for sheep and deer, but much of the less rugged, low-lying, peaty ground has been afforested. The drier heaths of the east provide grouse moors and there are occasional small farms and crofting townships on the mineral soils. The general rough mountainous landscape of the association is an obvious asset to the tourist industry if detrimental to farming and forestry interests.

Three broad regional trends in vegetation distribution are evident; flying bent grassland and moist Atlantic heather moor dominate the western tract from Knoydart to Morvern; northern Atlantic heather moor and white bent grasslands are common north of Loch Cluanie; and boreal heather moor is the major community in the eastern portion of the association. Montane communities are dominant above 400 metres in the west and 600 metres in the east.

These trends are modified locally by gradient, soil and parent material type, described under the map units below.

Map unit 19, very restricted in occurrence (6 square kilometres), is a non-rocky unit composed of noncalcareous, humic and peaty gleys with occasional humus-iron podzols. It is confined to lower slopes (below 300 metres) in Strath Bran and Strathconon.

The plant communities include rush pastures, sedge mires, bog heather moor, wet birchwood and limited permanent pasture and arable ground. The unit is suited to improvement for grassland.

Map unit 20 covering 55 square kilometres (less than 1 per cent of the association) is confined to the glens and straths of the north-east. It lies below 300 metres on drift-covered, non-rocky, strongly sloping but irregular valley sides. The dominant soils are humus-iron podzols, sometimes cultivated. The drainage is free and the texture of the parent material is loamy sand. Some noncalcareous, humic and peaty gleys are also present in depressions and receiving sites while occasional brown forest soils are found on the steepest slopes.

Of all the units within the Arkaig Association, this provides the best agricultural land. In Glen Urquhart the farms are concentrated on the south-facing slopes, where grass leys are the usual practice with occasional breaks of barley and oats. However, steepness, pattern of slopes and shallow stony soils pose considerable problems to mechanized agriculture. The north-facing slopes of the same glen have plantations of Sitka spruce and Douglas fir. In areas

retained as rough grazings, the chief communities are acid bent–fescue grassland and boreal heather moor.

Map unit 21 occupies an insignificant area to the south of Strathglass but develops more extensively farther east. Dominated by peaty podzols the area also contains some peat. There is no rock outcrop and the principal vegetation is dry and moist boreal heather moor.

Map unit 22 forms stretches of non-rocky, peaty ground in the hills and totals 6 square kilometres in extent.

Parent materials are thin colluvium on the hill summits with deeper tills in the hollows and lowlands. The altitudinal range is 100–500 metres.

Hill tops and steeper slopes carry peaty podzols with Atlantic and boreal heather moors, while peat and peaty gleys on the lower slopes are associated with blanket and upland bog and bog heather moor. Forestry and rough grazings are the major land uses.

Map unit 23 reflects the general decrease in rockiness in the foothill areas which takes place towards the north and east. The soils are peaty gleys and peat with subordinate peaty podzols. The landscape consists of gently undulating hillsides which are non-rocky but rock controlled. Parent materials are colluvium and shallow till (less than 1.5 metres), the latter often producing smooth topography in depressions surrounded by rocky units, as seen north of Glen Urquhart. In some areas, particularly towards the east, it intergrades to *map unit 22* except on the gentlest slopes at higher elevations.

The unit is extensively developed round Achnasheen and north of Ben Wyvis, the total area being 244 square kilometres (4 per cent of the association). Mostly, it is found between the 200- and 450-metre contours but occasionally extends as high as 600 metres.

The drier climate of the easterly parts of the region produces an increase in peaty podzols within the unit. Northern Atlantic and boreal heather moors replace the bog heather and northern bog heather moors and blanket bog typical of the unit further west.

Land use is as rough grazings and deer forest, though afforestation is increasing and some drier lowland patches of the map unit have improved pastures.

Map unit 24 has some similarities to *map unit 23* but occurs on non-rocky, steep and very steep slopes. It comprises peaty gleys, with some peaty podzols and deep peat, is concentrated on fairly long slopes on either side of Glen Carron and has an extent of 58 square kilometres (less than 1 per cent of the association). It ranges from 250 to 550 metres in altitude.

The peaty gleys support bog heather and northern bog heather moor with frequent flushed areas containing *Myrica gale* and *Molinia caerulea*. Atlantic heather moor is usual over peaty podzols and above 450 metres white bent and upland white bent grasslands occur.

The areas are traditionally used as deer forest since agricultural improvement is severely limited by gradient and wetness. The grazing values are usually low except on the white bent grassland of the higher slopes.

Map unit 25 occurs on that very distinctive landform, moundy moraine. The map unit is not extensive (34 square kilometres; less than 1 per cent of the

association) and usually at low elevations. It is principally found on the moundy deposits north of Fort William and around Loch Arkaig and on the steep slopes of Glen Elchaig, Gleann Chorainn and round Loch Lochy. Some small areas that could not be shown separately have been included within *map unit 26*.

Humus-iron podzols and brown forest soils are most frequent on the steep slopes and well-drained mounds, while noncalcareous, humic and peaty gleys and some peat occur in the hollows and flushes. The respective plant communities for these two assemblages of soils are bent–fescue grassland and dry Atlantic heather moor, and rush pastures and flying bent bog.

Rough grazings of good quality are available and some gently sloping areas have permanent and improved pastures.

Map unit 26 is the largest in Western Scotland (1553 square kilometres). It forms 9.3 per cent of the map area and 26 per cent of the Arkaig Association. Like *map unit 25* it is developed on moundy moraine, which, although characteristic and easily recognizable, takes a number of local forms (Fig. 4). In the wider valleys the moraine mounds are separated by extensive areas of peat, sometimes with a small alluvial strath; where the valleys are narrower the mounds are closer together (Plate 8). On the steeper valley flanks peat builds up in the hollows and the pattern becomes crudely terraced. Finally, on the very steep slopes, moraine banks up the slopes with no peat development and loses its moundiness. The latter areas are regularly recognized and sufficiently different in proportion of constituent soils to be mapped separately in larger scale surveys. Due to their mode of occurrence as narrow bands along valley sides it has not been possible to represent them on the 1:250 000 map. In some mountain valleys only the steep moraine variant is present (Plate 15) and is characterized by gullying and footslope debris-fan accumulations.

The moundy variant of the map unit is most commonly encountered, however, and consists of peat-filled hollows with peaty gleys and peaty podzols on the hummocks. Under the wet conditions of much of Western Scotland the peaty gley is more extensive, but as rainfall decreases the peaty podzol becomes dominant. On mounds in high valleys and corries (e.g. Glen Affric), subalpine podzols are found but are not sufficiently extensive to form a separate map unit.

The most obvious property of moraine is the presence of a very hard layer, known as an indurated horizon. There is some dispute about the origin of the horizon, which has been variously claimed to be of pedogenetic and geomorphic origins. Its close association with moundy moraine seems to favour the latter in this area. Induration prevents root penetration, impedes downward percolation of water and causes serious difficulties for ploughing, whether for forestry or agricultural purposes.

Where an indurated horizon lies close to the surface, frequently the case on the crest of mounds, peaty gleys or even peaty rankers on induration are formed. The surface of the indurated horizon becomes further sealed by the development of a thin iron pan in many instances. On the flanks of mounds, the solum above the induration is frequently deeper, drainage is better and iron pans may form, both higher in the profile and at the surface of the induration. Peaty podzols thus typically formed have an O horizon about 20 centimetres thick, a dark grey, humose loamy sand Eg horizon, iron pan and light yellowish brown loamy sand B horizon. The indurated horizon can sometimes be partially sorted and sometimes totally unsorted, with stones and boulders up to 50 centimetres or more in diameter. The stones carry a silt capping. Morainic

deposits form one of the most characteristic parent materials and map units developed on them occupy 19.5 per cent of the region.

The western moraines are dominated by flying bent grassland and moist Atlantic heather moor (on the mounds) and flying bent bog (in the hollows and on flats). Steep gullied moraines, particularly those of Affric and Monar Forests, commonly have a white bent grassland sward. Further east more heathy types are prevalent, such as Atlantic and boreal heather moors and bog heather moor and blanket bog. The subalpine moraines in the high valleys and corries have fescue–woolly fringe-moss heath and bog whortleberry heath on the exposed mound crests with mountain and upland blanket bog on the hagged peat of the hollows.

Although the soil and topographic patterns pose difficulties to forestry management, both in terms of efficient planting and uneven tree growth, the map unit represents a large portion of the planted ground, its principal merit being the scarcity of rock outcrops though boulders can be troublesome. Rough grazings are of variable quality, and some of the lower lying, less moundy and less wet tracts have been improved.

The landform of this map unit has analogues in many associations. However, the component proportions may vary considerably, e.g. the equivalent unit within the Strichen Association has more peaty podzols on subdued mounds.

Map unit 27 occupies 198 square kilometres (3 per cent of the association) and has a wide variation in the proportions of its component soils. Though fundamentally a rocky unit with brown forest soils and humus-iron podzols, some areas have significant amounts of humic gleys, peaty gleys and rankers, particularly where slopes are gentle with less rock. The main occurrences are on rocky, steep, wooded slopes below 200 metres throughout the Moinian area, but some gentler slopes also occur, as at Glenborrodale (Ardnamurchan) and at Arisaig.

Stony colluvium and stabilized screes form the main parent materials, though small pockets of raised beach sand and gravel, till and morainic drift are also included where they are too small to warrant separate delineation. The major components of the unit, podzolized brown forest soils, have A horizon textures of coarse sandy loam, usually becoming coarse loamy sand with depth, though rock is frequently encountered within 50 centimetres of the surface. Humus-enriched B horizons, due to lateral seepage of surface water within the profile along a rock or other impervious surface or sometimes within a layer of coarser texture, are frequently observed.

Woodland, chiefly birchwood and oakwood, is the main vegetation type, but some areas support bent–fescue grassland with bracken. A few less rocky patches with glacial drift have rye-grass–crested dog's-tail pasture as a result of improvement. Wetter soils carry bog myrtle scrub, flying bent grassland and rush pastures. Grazings are of very variable quality but the unit has the advantage of providing shelter for stock. There are a few coniferous plantations though large scale afforestation seems unlikely, due to the rugged topography.

Map unit 28, though generally similar in terms of landscape to *map unit 29*, has peaty podzols as the dominant components with subsidiary humus-iron podzols, peaty gleys and peat. Confined to the north-eastern portion of the sheet, it is 357 square kilometres in extent (6 per cent of the association). The plateau east of Strathglass between 200 metres and 450 metres is typical of the

map unit. A strongly undulating landscape with rock-cored knolls supports peaty podzols, humus-iron podzols and rankers, and the intervening channels, hollows and flats have peaty gleys and peat. On the other hand, some steep (greater than 20 degree) slopes (those of Glen Strathfarrar, for example) are dominated by humus-iron podzols with only limited wet flushes. The chief land uses are forestry, grouse moor and rough grazings, the main plant communities being heather moors with some acid bent–fescue grassland and blanket bog.

Map unit 29 is the third most extensive of the association (12 per cent) and the fourth most extensive of the sheet covering 746 square kilometres. The chief components are peaty gleys, peat, peaty podzols and peaty rankers.

Detailed investigations of part of this unit during the systematic survey of Ardnamurchan revealed the following components: peaty gleys, 38 per cent; peat (deeper than 50 centimetres) 27 per cent; peaty podzols, 17 per cent; rankers, 13 per cent; humus-iron podzols, 4 per cent; alluvium, 1 per cent. These figures do not, however, take account of the eastward extension of the unit, notably the increase in the peaty podzol component as it intergrades to *map unit 28*.

Analogous units within other associations have a comparable composition. *Map unit 127* of the Countesswells Association has 38 per cent peaty gleys, 39 per cent peat, 9 per cent peaty podzols, 10 per cent rankers, 2 per cent humus-iron podzols and 1 per cent alluvium in the Ardnamurchan area. The difference between the amounts of peat and podzols can be accounted for in terms of landform; *map unit 29* is strongly ridged with local steep slopes, whereas *map unit 127* has a gently undulating topography and thus more peat. Similarly *map unit 160* of the Darleith Association has a terraced landform with only occasional short slopes and a peat percentage of 40.

The pattern of soil type, parent material and vegetation distribution is closely related to the topography and can be divided into three facets.

(1) Ridges and knolls with rock outcrops. Soils are peaty rankers and peaty gleys on shallow stony colluvium of loamy sand texture. Bog heather and moist Atlantic heather moors and flying bent grassland are the main types of vegetation.

(2) Short, steep, generally non-rocky slopes, with peaty podzols on deeper colluvium or sometimes pockets of morainic drift and lodgement till of loamy sand to sandy loam texture. These better drained sites have a dry Atlantic heather moor or white bent grassland vegetation.

(3) Hollows, flats and very gentle slopes covered by more than 50 centimetres of peat and underlain by rock or drift. The plant communities are principally flying bent and blanket bogs.

The most commonly occurring profile is the peaty gley which typically has an O horizon 25 centimetres thick overlying a very humose dark brown loamy sand B horizon, and rock is generally encountered within 60 centimetres of the surface. The exchangeable cations are low, as is the percentage base saturation. In the surface the pH is about 4, rising to over 5 in the B horizon.

Local and regional variations in the percentages occupied by the component soils arise due to topographic and climatic changes. The increase of peaty podzols towards the east already remarked upon is chiefly as a result of the drier and warmer conditions.

Map unit 30 has an easterly distribution, the main areas being around Glen Moriston and to the east of Loch Ness. It covers 98 square kilometres. It is broadly similar to *map unit 28*, but is very rocky with a greater proportion of peaty rankers. Other soils are peaty podzols, humus-iron podzols and lithosols with minor peaty gleys and peat, the proportion of the latter two components increasing with altitude and rainfall.

Because of the rugged, rocky nature of the terrain any land use other than rough grazing is impracticable. Dry and moist boreal heather moors, bog heather moor and blaeberry heath are the main plant communities.

Map unit 31 occurs on steep slopes (greater than 15 degrees) with a wide range of rockiness. The soils are peaty gleys, peaty rankers and peaty podzols. Apart from the steeper slopes and lack of peat, it is similar to *map units 29* and *32* combined. Widespread throughout the area underlain by Moinian rocks, it occupies 692 square kilometres (11 per cent of the association).

Land use is mainly rough grazing but the area devoted to forestry is increasing. The vegetation is bog heather and Atlantic heather moors and flying bent grassland though white bent grassland is common north of the A87 road.

Map unit 32, like *map unit 29*, is composed of peaty gleys, peaty rankers, peaty podzols and peat and has similar landforms. It is considerably more rocky however and the peaty ranker content is higher. The unit covers 511 square kilometres below 400 metres in the west, particularly in Ardnamurchan and Moidart.

The usual land use is rough grazings as the ground is too rugged, rocky and wet for forestry. Grazings are generally poor on the moist Atlantic heather moor, flying bent grassland and bog, and bog heather moor.

Map unit 33, one of four units occurring above 400 metres, is by far the most subalpine podzols, which show a great deal of mixing of horizons particularly thaw and erosional processes. Also included within the unit are cliffs and screes and small areas closely resembling *map units 34*, *35* and *36*, too small to delineate separately.

Valuable summer grazings on upland bent–fescue grasslands are common, though more heathy variants such as Atlantic and boreal heather moors are also present.

Map unit 34 is associated with plateau areas between 400 metres and 600 metres. Subalpine podzols and gleys and hagged peat are the main components with alpine podzols on the most exposed eminences. Rockiness is extremely variable; the hills of Moidart and Ardgour are severely rocky while further east only a few rock outcrops are seen. Rough grazings constitute the main land use, the grazings on mountain heath communities and stiff sedge–fescue grassland providing seasonal pasture land. The unit extends to 238 square kilometres (4 per cent of the association).

Map unit 35 is confined to a few exposed plateaux at over 700 metres as on Ben Attow in Kintail, and Creag Meagaidh near Laggan. Soils are mainly alpine

podzols with a few alpine gleys and patches of hagged peat; the main vegetation is alpine azalea–lichen heath and fescue–woolly fringe-moss heath. In contrast to the following map unit, topography here is subdued and non-rocky with some bouldery patches.

Pastures of varying quality are grazed during the summer months. The unit occupies 41 square kilometres.

Map unit 36 embraces all the rocky and very rocky land in the oroarctic thermal subzone including minor crags and some areas too small to distinguish as *map unit 33*. The steep sides of Coire Ardair north of Loch Laggan and the mountain summits and slopes south of this loch to Ben Alder contain the major areas of the map unit which in total covers 49 square kilometres. Soils are lithosols and rankers with some alpine podzols. Plant communities are alpine azalea–lichen heath, blaeberry and bog whortleberry heath, and stiff-sedge–fescue grassland. A few patches of grazing are available during the summer.

THE BALROWNIE ASSOCIATION

(Map units 41–44 and 46)

The Balrownie Association covers 30 square kilometres in the south-east of the area. It forms the western extremity of a large tract developed in Eastern Scotland (1236 square kilometres). Its altitude range is from 15 metres on the shores of Loch Lomond, to 270 metres on the upland north-east of Balmaha. The lowlands and foothills are warm to fairly warm but wet with 1500–2000 millimetres of annual rainfall.

The parent rocks are sandstones of Lower Old Red Sandstone age. These rocks are usually soft and gritty but can be hard and fine-grained and often contain a considerable proportion of feldspar, mica and other minerals. Conglomerates of Lower Old Red Sandstone age are the parent rocks of drifts belonging to the Stonehaven Association, which are significantly more stony, with many rounded cobbles of quartzite. The drift derived from the sandstones is, by contrast, relatively stone-free, and in this area is usually a compact, loam to sandy clay loam till several metres deep. Sandstone ridges occasionally lie close to the surface, and here the drift is a colluvium of sandy loam texture. The till is water-modified in limited areas, producing a drift with sandy loam A and B horizons. The water-modification is restricted to altitudes below 180 metrres. The till is usually a bright reddish brown colour in its unmodified state.

The principal soils are noncalcareous gleys on the gentle sloping lowlands, with poor drainage where the sandy clay loam till is close to the surface. Brown forest soils, *sensu stricto*, and brown forest soils with gleying are found on colluvial slopes, where the drift has a low percentage of clay, or on water-modified till, and drainage is free or imperfect. At higher altitudes peaty gleys are common, with humus-iron podzols and peaty podzols covering limited areas on steeper ground.

Plant communities are mainly arable and permanent pastures, with subsidiary rush pastures and sedge mires, and, rarely, areas of broadleaved woodland. Dry and moist Atlantic heather moors and bent–fescue grassland occur on the podzols, and bog heather moor with rush pastures and sedge mires on peaty gleys.

Map unit 41, covering 5 square kilometres consists of brown forest soils with gleying, and is mainly developed on water-modified tills. These soils form the cultivated fringe to the wetter foothills and peaty uplands of *map unit 46.* The topsoil has a fine sandy loam texture which is liable to capping in heavy rain when the ground surface is bare, and to poaching during the winter. The water-modified tills provide a fairly deep solum however and cereals and forage crops are grown successfully with careful management.

Map unit 42 is found on sandy clay loam till and many of the soils are non-calcareous gleys, with some humic and peaty gleys in wetter hollows and occasional brown forest soils with gleying on steeper slopes. The problems of capping and poaching, mentioned in *map unit 41,* are exacerbated here by compact till occurring at shallower depth resulting in impeded drainage. Carefully designed, intensive drainage systems are necessary to achieve any worthwhile improvement in soil moisture and water-table levels. This unit covers 18 square kilometres and is mainly under permanent pasture with some rough grazing and forestry. Cobalt or copper deficiency may arise after reclamation.

Map unit 43 covers 4 square kilometres on gentle and strong slopes with occasional rock outcrops. The colluvial drifts have a stony sandy loam or loam texture and the natural permeability this imparts to the soil allows the development of brown forest soils with free and imperfect drainage. There are still capping and poaching problems with these soils, but they are generally less severe than on the noncalcareous and humic gleys in *map units 41* and *42.* Land use is mainly permanent pasture and rough grazing, but this land has the same potential trace element problems as *map unit 42.*

Map unit 44 is very restricted (1 square kilometre). The soils are dominantly humus-iron podzols with some brown forest soils and peaty podzols, and the land use is rough grazing.

Map unit 46 covers 2 square kilometres and occurs at altitudes higher than *map unit 44.* It consists of peaty gleys and peat with some peaty podzols. Bog heather moor and blanket bog provide rough grazings of low value.

THE BERRIEDALE ASSOCIATION

(Map unit 61)

The Berriedale Association consists of soils developed on drifts derived from sandstones and conglomerates of Middle Old Red Sandstone age. It covers 9 square kilometres (0.1 per cent of the area) but becomes very extensive in Northern Scotland. It occurs in only one area, between Strath Vaich and Strath Rannoch in the extreme north-east of the region, where it has been mapped by a single map unit.

The parent material is a reddish till, largely of sandy loam or loamy sand texture, but in some places with silty loam or even silty clay loam variants, presumably reflecting the incorporation of local mudstone into the till.

Map unit 61 has a hilly landform, ranging in altitude from 270 to 417 metres and is mainly non-rocky, with gentle and strong slopes, although a few small

rocky areas have been included. The climate ranges from cool to cold (550–1100 day°C) and is wet. The soils are dominantly peaty and comprise peaty podzols (poorly drained above a thin iron pan), peaty gleys, shallow and deep peat. Some noncalcareous gleys developed on the finer till occur, as do subalpine podzols on exposed sites above 350 metres.

The vegetation is dominated by moorland communities, moist Atlantic heather moor, bog heather and northern bog heather moors on the peaty podzols, peaty gleys and shallow peat and blanket and northern blanket bogs on the deep peat. Heath rush–fescue grassland is present on the noncalcareous gleys. The agricultural use of the map unit is limited to rough grazing. There is some potential for forestry on the lower sites.

THE BRAEMORE/KINSTEARY ASSOCIATIONS

(Map unit 71)

The Braemore/Kinsteary Associations consist of soils developed on drifts derived from red, purple and grey shales with calcareous bands. These rocks are believed to be of Lower Old Red Sandstone age. Accounting for only 6 square kilometres of the survey area, the association occurs in the Strathpeffer area and is represented by one map unit. The association also occurs in Northern and Eastern Scotland but is of limited extent even there.

Map unit 71 is dominated by brown forest soils. To the east and south of Strathpeffer on long, regular, gentle to strong slopes, the parent material has been derived mainly from red sandstones and shales. The drift is often shallow with soils developed in strongly weathered rock. Imperfect drainage is common; C horizons are reddish brown. To the south-east of the village grey shales containing calcareous bands outcrop sporadically in a rolling landscape. Here, freely drained brown forest soils on the hillocks are accompanied by gleys in the intervening hollows. It is likely that some of the gleys are calcareous. Textures throughout the unit range from sandy loam to silty loam. The soils are normally moderately stony but where the underlying rock is heavily weathered, may be stone-free. Most of the unit is cultivated. North of Marybank on south-facing slopes are some of the finest arable fields in the region.

THE CORBY/BOYNDIE/DINNET ASSOCIATIONS

(Map units 97–106)

These closely related associations, normally distinguished separately on larger scale maps, have been amalgamated for the purposes of this survey. The parent materials of the Dinnet Association do not occur in Western Scotland, but those of the Corby Association (soils developed on interbedded sands and gravels derived from acid rocks) and the Boyndie Association (soils developed on sands derived from acid rocks) are present. The Corby Association predominates. The associations cover 333 square kilometres or about 2 per cent of Western Scotland.

The lithologies of the parent materials are chiefly granulites, granitic gneisses, granites, quartz-mica-schists and quartzites and, locally, slates, phyllites and sandstones. They include rocks spanning a wide range of geological age.

Three types of deposit have been included; fluvioglacial ice-contact deposits, outwash terraces and raised beaches. Consequently the drift ranges from a bouldery unsorted and unstratified deposit with mainly subangular stones as in the former case, to sorted stratified sand and gravels with rounded stones as in the case of most outwash and beach parent materials. Though textures are always coarse, extreme variation from cobbles to sand is found.

The association experiences a wide range of climate depending on location: the coastal lowlands of the west are warm and moist with a mean annual rainfall of 1200 millimetres, mountain valleys are cool and wet with up to 2800 millimetres, and the eastern lowlands in the rain shadow are warm and dry with the rainfall as low as 800 millimetres.

In spite of the permeable nature of the parent materials, some 40 per cent of the map units have peaty soils, a phenomenon which is probably related to the formation of iron pans and cemented layers and the subsequent waterlogging of topsoils. Map units dominated by mineral soils provide much of the arable and permanent pasture land due to their free drainage but leaching of fertilizers is a problem. Constant inputs of lime and fertilizers are therefore essential to maintain productivity on these inherently infertile soils. The well-drained, non-rocky areas of the association are also in great demand for both building and recreational use and the deeper deposits of the parent material are quarried as a source of sand and gravel.

On uncultivated ground with mineral soils, the plant communities include bent–fescue grassland and rush pastures. Heather moors predominate on the peaty podzols and peaty gleys, and blanket and flying bent bogs swathe the peat areas. Thus rough grazings of variable quality are available on ground too wet or rugged for improvement, though afforestation in this kind of terrain is increasing.

Map unit 97 occupies 5 square kilometres (2 per cent of the association) and consists of humus-iron podzols, most of which are cultivated. Minor hollows have gley soils, and the tract at South Erradale, near Gairloch, has been reclaimed from peaty soils. Further portions providing good arable land occur west of Muir of Ord on the banks of the River Orrin (where the parent material is deprived partially from Old Red Sandstone conglomerate), south-west of Beauly and in Stratherrick.

Map unit 98 has a wide variety of topography and soils, and, with a larger scale of mapping, map units similar to *1*, *97* and *100* could be shown. The soils include undifferentiated alluvial soils on the river flood plains, humus-iron podzols and peaty podzols on the terraces and, in moundier areas, some peaty gleys and peat in the hollows.

The unit occupies 79 square kilometres (24 per cent of the association) and is found in many of the broader valleys, principally bordering east-flowing rivers such as the Spey, Moriston and Errick. There are additional areas south-west of Fort Augustus and in Glen Spean. Much of the map unit is cultivated, though the strongly hummocky stretches are only suitable for improved pastures. Where soils are severely waterlogged and the terrain very uneven, the land has either been afforested or remains as rough grazings. Bent–fescue grassland, heather moors, rush pastures and sedge mires are the chief communities of an extremely variable flora.

Map unit 99 is present on the gently undulating ground formed by raised beach and fluvioglacial outwash deposits. Though similar to *map unit 97* it has more variable soils, (humus-iron podzols, noncalcareous gleys, humic gleys and patchy undifferentiated alluvial soils) and occupies 46 square kilometres (14 per cent of the association). Some of the best arable ground of the west coast is found on this map unit, as in Glens Fyne and Shira and at Connel, Kilmichael, Taynuilt and Glenelg.

Map unit 100 resembles *map unit 98*, but has much less of an alluvial component and generally more irregular topography. It accounts for about 7 per cent of the association (23 square kilometres). The terrain varies from strongly moundy, as at Croulin (Knoydart) to gently undulating as at Kingairloch. Nontheless the soil pattern is similar, humus-iron podzols on elevated parts with gleys and occasional peat in the hollows and on flats.

The major occurrences are in Glen Spean, with smaller patches on Tiree and on Loch Shielside. At South Shian the uneven topography is due to a push moraine overlain by a variable depth of sands and gravels.

Away from the cultivated ground the main vegetation cover consists of bent–fescue grassland, rush pastures and sedge mires.

Map unit 101, occupying 84 square kilometres (25 per cent of the association) is, in landform terms, analogous to the previous unit but all the soils are peaty. Landscape extremes are well-illustrated by the very hummocky, fluvioglacial, ice-contact deposits south-east of Tyndrum, where there are steep-sided mounds with sharp crests and well-defined peat flats between, and the gently undulating terraced ground seen around the River Spey and upper reaches of the River Roy. It has a greater altitudinal range than *map unit 100* reaching over 300 metres in Ceannacroc Forest and Glen Tulla.

Soils are peaty podzols on the mounds with peat and peaty alluvial soils in the hollows. The wetness of the soils and the irregular topography usually exclude reclamation so the map unit remains largely as rough grazings. Vegetation is mainly moist Atlantic and boreal heather moors and blanket bog.

Map unit 102 is similar to the previous map unit but has in addition a large alluvial component in the soils. Only 6 square kilometres occur on Sheet 4 in the broad valleys of the north (Glen Carron and around Achnasheen). In both localities the soil pattern consists of mineral and peaty alluvial soils on the flood plains bordering the rivers, and peaty podzols and peat on the flanking fluvioglacial terraces. Blanket bog is found on the peat with Atlantic heather moor on the peaty podzols, which are usually strongly gleyed above an iron pan. Permanent and rush pastures are found on the alluvial soils, the dominant community depending on the drainage and management. Because of the flood risk no arable farming is possible on the alluvial flats while the peaty flats are limited to use as rough grazings.

Map unit 103 has the same soils and raised beach situation as *map unit 105*, but in addition has some rocky knolls with shallow soils which interfere with cultivations. The map unit is most extensive on Tiree where podzols and gleys, peat, peaty alluvial soils and alluvial soils occur in a very complex pattern. The total area is 24 square kilometres or about 7 per cent of the association, and the ground is used mainly for crofting and as common grazings.

Map unit 104 is similar to the previous map unit but the soils are mostly peaty gleys. Land use is restricted to rough grazings on the low raised beach areas of Coll and Tiree, where most of the 9 square kilometres (3 per cent of the association) are located. Plant communities include moist Atlantic heather moor, blanket bog and yellow flag swamp.

Map unit 105 has been formed by amalgamating areas of mineral and peaty soils which could be shown at the 1:50 000 scale but are too small to represent separately on the 1:250 000 map. It forms 16 per cent of the association (55 square kilometres). The soil types include cultivated podzols and gleys, humus-iron podzols, humic, noncalcareous and peaty gleys, peat, peaty alluvial soils and undifferentiated mineral alluvial soils. On some of the lower beaches and shingle bars, soil profile development is weak, notably around sheltered lochs (e.g. Loch Eil) where most of the profiles consist of a humose gravel. More mature soils occur on the upper beach and outwash terraces such as those of Corran and Ballachullish, where arable ground on mineral soils surrounds central areas of peat. Plant communities include permanent and rush pastures, heather moors, blanket bog and yellow flag swamp. Many crofting areas are situated on this map unit, and much of the ground probably had more peat in the past. This has been removed for fuel and the resulting 'skinned' land reclaimed for arable use. Some of the residual peat areas are used as common grazings and others have been afforested.

Map unit 106 is largely confined to one low-lying basin on Tiree, north-west of Loch a'Phuil. Only the lack of rock outcrops differentiates this map unit from *map unit 104*, since the soils are peaty gleys and peat. The wetness of the soils restricts the land use to grazing of the moist Atlantic heather moor and blanket bog vegetation.

THE CORRIEBRECK ASSOCIATION

(Map units 108–112)

The Corriebreck Association is found exclusively on the island of Rhum where it covers 34 square kilometres (0.2 per cent of Western Scotland). A preliminary account of the soils has been published (Ragg and Ball 1964). The soils are developed on drifts derived from ultrabasic rocks, mainly olivine and anorthite-rich allivalite, peridotite and harrisite. Small areas of eucrite and gabbro, which form drifts of the Insch Association, are mapped within the Corriebreck Association at this scale. The rocks are among the most basic found in Britain, with silica content as low as 39 per cent and low aluminium and calcium contents (Harker 1908). They have a very high magnesium content (30–40 per cent) contained in the olivine. Locally, where the feldspar content is higher, the proportions of silica, aluminium and calcium increase, while that of magnesium slightly decreases. The high total amounts of magnesium are not reflected in the extractable magnesium levels in the soils. These are generally low, with the exception of peaty podzols on colluvium, where increased weathering of the minerals is thought to account for higher levels of exchangeable magnesium. Because extractable magnesium is mostly low, the soils are not classed with the magnesian subgroups of brown soils and gleys.

Field examination reveals that the drifts derived from these rocks are principally colluvial or residual, with cryic deposits and morainic drift less extensive. The drift cover, except in areas of moraine, is shallow and

discontinuous. The terrain below about 400 metres is moderately to very rocky, forming gently undulating to rugged areas with steeper slopes flanking the mountains. The areas of hummocky moraines are bouldery.

The main soil types are peaty gleys and peaty podzols which are found on colluvium and moraines below approximately 400 metres. The peaty podzols lack the characteristic morphological podzol E horizon, as is normal on basic parent materials, and have unusually high exchangeable cations and percentage base saturation. They are classified as peaty podzols on the basis of their peaty surface horizons, occasional iron pans and brightly coloured podzol B horizons. Peat is widespread on the more gently sloping ground and in channels and hollows. On the local steep slopes around Papadil and Glen Harris, where deeper coarse-textured colluvial deposits are found, there are brown forest soils and brown rankers. On the cryic deposits subalpine and alpine soils become dominant, podzols occurring on steep slopes and gleys on more level sites, with some hagged peat restricted to cols.

The accumulated temperatures are categorized as fairly warm (1100–1375 day-degrees C) on the lower ground, but fall rapidly to cool and cold (550–1100 day-degrees C) on the mountains. Potential water deficit division is wet overall, except around Harris where it is slightly wet; the mean annual rainfall ranges from below 1600 millimetres around the south-west coast to over 3200 millimetres on the mountain tops.

The peaty soils are covered by Atlantic heather moor and bog heather moor, with bog-rush mires growing on shallow soils in the west of the island (Ferreira 1970). Flying bent grassland is found locally. Bog communities are widespread on the peat. The brown forest soils support bent–fescue grassland, locally herb-rich, which provide good grazings. Subalpine soils on steeper slopes give rise to upland bent–fescue grassland with good summer grazing value.

Map unit 108 is dominated by brown forest soils, brown rankers and humus-iron podzols on loamy colluvial drifts. The map unit is of restricted extent (1 square kilometre) and is found on steep slopes with a wide range of rockiness around Papadil and Harris. There are small areas of slightly rocky terrain on gentler slopes adjacent to the raised beach at Harris, forming the only reclaimable ground. The plant communities are principally herb-rich bent–fescue grassland, with some herb-rich Atlantic heather moor and woodlands, providing good grazings.

Map unit 109 consists of gently and strongly sloping, moderately rocky ground covering 3 square kilometres. The parent materials are colluvial with sandy loam textures, often shallow on rock. Peaty gleys and peaty podzols are the principal soils on the slopes and knolls, with small peat flats on gentler slopes and in rock basins. The peaty gleys support bog heather moor with some bog-rush mire and local flying bent grassland. Poorly drained peaty podzols have the same communities as the peaty gleys, but where drier moisture régimes prevail they support Atlantic heather moors and some heath grass–white bent grassland. Flying bent and blanket bogs cover the peat. Soil wetness for long periods of the year precludes pasture improvement and natural grazings are of low value, but some forestry potential exists.

Map unit 110 has similar slopes, parent materials, soils and vegetation to *map unit 109*; it is, however, extremely rocky with an associated reduction in peat and increase in peaty rankers. It is the most extensive map unit, covering 40 per

cent of the association (13 square kilometres). Rockiness restricts land use to rough grazings and the vegetation is the same as in *map unit 109*, providing low quality grazing.

Map unit 111 is developed on moundy valley moraines and covers 7 square kilometres. The boulder-strewn terrain has a low proportion of rock outcrops. The largest deposits are seen in Glen Dibidil and upper Glen Harris, the remaining areas being shallower and less extensive. Peaty podzols are prevalent on mounds and steeper ground while peaty gleys and peat take up the more gently sloping channels and hollows. Soil and slope patterns and boulderiness restrict land use to rough grazings, the heather moors and bog communities having low grazing value. The sheltered eastern glens will provide the best forestry potential.

Map unit 112 covers steep, rocky slopes and ridge crests in the mountains, occupying 10 square kilometres. The terrain is mainly rock and scree with soil development restricted to the more stable sites. The rocks are susceptible to frost-weathering which produces loose sandy debris. This material is transported to cols and ridge crests by strong winds, providing deep drifts of local extent with freely drained subalpine soils. Subalpine and alpine podzols occupy drier sites, with subalpine gleys and some hagged peat on gentler slopes and in cols. Plant communities are of restricted extent, with upland bent–fescue grassland on the slopes providing good summer grazings, and locally developed mountain blanket bog on the hagged peat.

THE COUNTESSWELLS/DALBEATTIE/PRIESTLAW ASSOCIATIONS

(Map units 119, 122, 123, 125–127, 129, 131, 132, 134–137)

The soils of the Countesswells Association (1311 square kilometres; 7.8 per cent of the region) are developed on drifts derived from granites and granitic rocks. Though granodiorites, granophyres and diorites are present locally, the main source of the parent materials is granite. The Dalbeattie and Priestlaw Associations which were mapped on granites in the Southern Uplands have not been recognized.

Intrusions vary in size from the huge batholiths of Etive, Rannoch and Strontian, to the smaller masses of Ben Nevis, Glenelg, the Red Cuillin, Glen Fyne and the Ross of Mull. Topography is generally mountainous with peaks rising to over 1100 metres, the chief exceptions being the bleak moraine-covered expanse of Rannoch Moor and the low-lying, rugged terrain of the Ross of Mull.

The most extensive drift type of the association is moraine (45 per cent), closely followed by colluvium on mountain slopes (40 per cent). Materials derived by comminution of granite by frost action and lying in the subalpine and alpine soil zones are the third group (15 per cent). Parent materials are characterized by gritty textures often as high as 90 per cent sand, much of it coarse, with approximately 7 per cent silt and only 3 per cent clay. Induration is common in the moraines and the association as a whole is bouldery.

Climatic conditions range from warm and wet (mean annual rainfall 1200 millimetres in the Ross of Mull, through the cool wet foothills of Morvern and

Rannoch Moor to the extremely cold wet mountains east of Loch Etive (rainfall 3600 millimetres).

As would be expected in an association with acid parent materials and a wet climate, map units dominated by peaty soils (peaty podzols, peaty gleys, peaty rankers and peat) account for a large percentage (82 per cent) of the area, with 3 per cent made up of map units dominated by mineral soils and 15 per cent subalpine and alpine soils.

The principal land use is rough grazings, but a few areas of lowland permanent pasture are present, and the acreage of ground devoted to forestry is increasing.

The dominance of wet peaty soils within the association is further reflected in the major plant communities present. These are flying bent grassland and bog, Atlantic and boreal heather moors and blanket bog.

Map unit 119, despite a lack of outcropping rock, usually has only a thin cover of till or colluvium and its landscape is rock-controlled. Peaty gleys and peat are the major soils together with some peaty podzols on steeper slopes. The unit is limited in extent (22 square kilometres) forming a few scattered tracts towards the eastern edge of the sheet from Inchbae to Rannoch. Bog heather moor, moist Atlantic heather moor, blanket bog and their northern forms constitute the bulk of the vegetation, giving poor rough grazings. A little forestry has also been undertaken.

Map unit 122 is very restricted in occurrence (10 square kilometres) at Ariundle (near Strontian), north of Ben Nevis, and near Bonawe (Loch Etive). It has the same hummocky and gullied slope moraine landforms as *map unit 123* but the soils of the mounds and slopes are brown forest soils and humus-iron podzols, while the hollows have humic gleys, peaty gleys and peat. Deciduous woodland, bent–fescue grassland and rush pastures constitute the main plant communities, which provide grazings of variable quality.

Map unit 123 accounts for almost half (574 square kilometres) of the area of the association. It has the classic hummocky moraine typical of the West Highlands and is very bouldery. A gullied steep slope phase, mapped separately at larger scales, is included in this unit due to difficulties of representation. It is, however, a much lower proportion of the unit than the analogous phase in *map unit 26* of the Arkaig Association.

Peaty gleys are frequent on the gentle slopes and mound crests; peaty podzols are commonest on the steeper slopes and peat blankets the intervening hollows and flats. B horizons are humose and an indurated horizon, a feature of many morainic soils, is often present.

There is a marked shift in both vegetation and soil components from west to east, well expressed at the extreme edges of Rannoch Moor. This phenomenon is probably due to a decrease in annual rainfall from 2400 millimetres in the west to 1200 millimetres in the east. The flying bent grassland and Atlantic heather moor communities are gradually replaced by boreal heather moor towards the east, blanket bog takes the place of flying bent bog and the peaty podzol component increases. Altitudinal variation too changes the nature of the unit. The higher valleys and corries (e.g. east of Loch Etive) have some subalpine podzols on the mounds with bog whortleberry heath, while the hagged peat hollows have upland blanket bog.

Except in a few favoured areas, where some pasture improvement has been attempted, land use is restricted to deer forest, sheep grazing, grouse moor and forestry.

Map unit 125 occurs locally on steep, moderately rocky slopes, principally around Strontian and Bonawe, and occupies 22 square kilometres (2 per cent of the association). Work carried out in Ardgour and Morvern on a 1:50 000 unit of similar composition showed it to have the following constituents: humus-iron podzols 24 per cent, brown podzolic soils 23 per cent, rankers 15 per cent, peaty gleys 14 per cent, peat (50–100 centimetres deep) 3 per cent, rock 6 per cent, peaty podzols 5 per cent. Shallow colluvium is the chief parent material and rock is often encountered within 60 centimetres of the surface. Occasional deeper patches of till and morainic drift are present. The topography is mostly steep slopes, though some irregularly knolly areas with surface boulders are also present.

Permanent pastures and bent–fescue grassland with bracken form the main vegetation cover, but the rockier, steep slopes carry oak and birchwood and flushed hollows support rush pastures and sedge mires.

Some improvement to grassland is possible and good quality grazings are available away from severe bracken infestation. Afforestation has taken place on a few less rocky slopes.

Map unit 126 is confined to the Red Cuillin of Skye (19 square kilometres) where it occurs on steep vegetated scree slopes, though some active screes and rock outcrops are present. Soils are poorly developed peaty podzols disturbed by colluvial movements. The vegetation is heath-dominated, boreal heather moor being the main community. It provides only poor rough grazings in contrast to similar steep slopes on the basalts nearby which support bent–fescue grasslands.

Map unit 127 forms 16 per cent of the association and covers 212 square kilometres. It consists of peat and peaty gleys, usually in an undulating landscape with rocky knolls and intervening flats, though the peat areas are not restricted to the flats nor the rocky outcrops to the prominent mounds.

The component soils of the map unit were investigated in Morvern and Ardgour during detailed mapping and comprise: peat 39 per cent, peaty gleys 38 per cent, rankers 10 per cent, peaty podzols 9 per cent, humus-iron podzols 2 per cent, alluvium 1 per cent. The peaty gleys are similar to those of *map unit 123* except that the indurated layer is absent. The peaty podzols are often poorly drained above the thin iron pan and freely drained below. Rock, sometimes weathered, is usually encountered within 60 centimetres of the surface. Heather moors and bogs, with a boreal influence in the east and northern forms in the north, are the main plant communities. Rough grazing is the principal land use, though many lower-lying areas with less rugged and less bouldery topography have been afforested.

Map unit 129 occupies only 6 square kilometres in the extreme east of the sheet. It is a very rocky rugged unit similar to *map unit 132* but with peaty podzols dominant. Other soils include peaty rankers, peaty gleys and peat. Boreal heather and bog heather moors usually form the bulk of the vegetation. Rough grazing is the only practical land use.

Map unit 131, 134 square kilometres in extent, is similar to *map units 127* and *132* but has a wide range of rockiness and occurs on steep (greater than 15 degrees) slopes with little or no peat. The main components are peaty gleys, peaty rankers, peaty podzols and rock. Parent materials are stony, gritty colluvium and stabilized scree. The morphology of the rock outcrops varies from craggy to slabby and rounded bosses are also seen. Vegetation is mainly heather moor, with some heath rush–fescue grassland on drier steeper areas.

Map unit 132, broadly a rockier equivalent of *map unit 127*, has peaty gleys and peaty rankers as major components with subsidiary peaty podzols and peat. Rugged, rocky and more subdued terrain with slabs are two varieties of topography. Good examples of the former may be seen in the Ross of Mull and of the latter in the hills east of Loch Etive. The unit covers 113 square kilometres. Vegetation ranges from flying bent grassland and moist Atlantic heather moor on drier sites to blanket and flying bent bogs in the wetter hollows.

Map unit 134 develops on steep slopes with a range of rockiness between 400 and 700 metres. It is dominated by subalpine podzols. However, it also includes some small areas of plateau, summits and rocky slope. Other soils represented are subalpine gleys, alpine podzols and gleys, and hagged peat. It extends to 79 square kilometres (6 per cent of the association). A striking feature of most of the subalpine podzol profiles on slopes is the layering caused by the downhill movement of successive waves of colluvial material containing different quantities of humus.

Lichen-rich boreal heather moor is common east of Loch Etive and upland bent–fescue grassland develops in the hills of eastern Morvern.

The map unit affords seasonal pastures of variable quality. The adverse climate rules out forestry.

Map unit 135 has an equivalent altitudinal range to the preceding unit but plateaux rather than slopes are the dominant landforms. It is usually rocky with subalpine podzols, subalpine gleys and hagged peat as the chief soil components (The eastern variant of this map unit is non-rocky with peat as the most important soil). Soils show signs of freeze-thaw sorting, for example stone pavements. The unit occupies 111 square kilometres (8 per cent of the association) and mountain blanket bog occurs in addition to the communities of the previous map units.

Map unit 136 is mapped where high plateaux and summits occur (over 700 metres) with alpine soils developed on mountain-top detritus. The unit covers 7 square kilometres, most of which has only limited boulder fields and rock outcrops. Though there are eroded patches with aeolian grits, alpine podzols are extensive. Vegetation is predominantly fescue–woolly fringe-moss heath, three-leaved rush heath and stiff sedge–fescue grassland. Snow-bed communities are also present.

Map unit 137 is the most rocky map unit of the alpine zone. The soils are alpine podzols, rankers and lithosols on mountain summits. Blaeberry and bog whortleberry heaths, alpine azalea–lichen heath and alpine clubmoss–snow-bed are the main plant communities. The unit occupies only 2 square kilometres.

THE DARLEITH/KIRKTONMOOR ASSOCIATIONS

(Map units 149, 155, 157–162)

The Darleith Association is the third most extensive (1486 square kilometres; 8.9 per cent) of the region and occurs principally in Skye, Mull, Canna, Eigg and Muck and parts of mainland Morvern and Ardnamurchan. It is developed on drifts derived from Tertiary basaltic rocks, which have been comprehensively described in several publications (Harker 1904; Bailey *et al.* 1924). Both the Darleith and the Kirktonmoor Associations were originally described on Carboniferous basalt in Ayrshire (Mitchell and Jarvis 1956) but the Kirktonmoor parent material was specifically moraine. At the current map scale this is no longer considered an appropriate criterion for the distinction of a separate association, but the name is included to provide a link with previous mapping. An abbreviated version of the title, the Darleith Association, will be used in the remainder of this account.

The composition and structure of the basalts have an important bearing on the distribution of soil types. The olivine-bearing plateau basalts form a distinctive landscape of strongly terraced hills and valley sides, the valley form and orientation principally determined by lines of structural weakness (e.g. fault-lines or dyke-swarms). Differentiation of individual lava flows during deposition into an upper scoriaceous and a lower massive layer and the subsequent response of each layer to erosion is responsible for the terracing. The high porosity of the slaggy layers allows water penetration, provides a large surface area for chemical weathering and, especially when the area was in a periglacial environment, provided a weakness that was exploited by accelerated mechanical weathering. The lower parts of the flows, by contrast, are massive and weather only slowly. The distribution of soil types follows the differences in rock type closely, and this is most marked at low altitudes. Where massive rock is near the surface the soils are shallow and often wet and peaty, in contrast to the deeper, more freely draining soils over the scoriaceous parts of the flows and their associated drifts. At higher altitudes where peaty surfaces develop the differences are marked by changes from peaty gleys or deep peat to peaty podzols.

Much of the area is occupied by colluvial drifts less than 80 centimetres deep. A thin, indurated, coarser drift with rare erratic pebbles is frequently found; it has been interpreted as lodgement till deposited by the major glaciation. On Skye some valleys have a deeper, moundy morainic drift, probably the only part of the association to have carried outlying corrie glaciers during the Loch Lomond Readvance glaciation. On the Trotternish and Waternish peninsulas, areas of more even topography are associated with a mixed drift derived from the basalt and the adjoining Mesozoic rocks. At larger scales of survey these areas could be differentiated as a separate association. The textures of the parent material are predominantly sandy loam or loam although drifts with higher clay contents are associated with Waternish. Colours are dark brown (7.5YR3/2) most commonly, of a distinct chocolate hue compared with a purple tinge in the related Sourhope Association (although the difference is hardly detectable on Munsell colour chips).

The basic composition of basalt and the ease with which some bands within it weather is reflected in the distribution of the major soil subgroups. The Darleith Association has higher percentages of map units dominated by brown forest soils (25 per cent) than associations derived from more siliceous parent materials in similar environments. Peaty podzols are also more extensive as

map units (10 per cent) but peat and peaty gley dominated units are still prevalent (60 per cent). Subalpine and alpine soils and their associated units are very restricted in extent (3 per cent).

The climate throughout the association is wet (average annual rainfall greater than 1600 millimetres). The southern region (Mull, Morvern and Ardnamurchan) is warmer than the north (more than 1375 day°C compared with 1100–1375 day°C) and this is a principal factor in the higher proportion of mineral soils found there (40 per cent to 21 per cent). Climate is obviously of the greatest relevance to current land use; despite the wetness, the weather over the areas of this association is, for the west coast, favourable. The areas have long been settled and in the late 1700s carried a substantial population at subsistence levels. Stock farming and forestry (soils of this association have been extensively planted in Mull and Morvern in recent years) are the principal industries. Severe financial burdens are imposed by the remote island and peninsula locations of the association.

Vegetation on the soils of the association is dominated by western elements, although in Skye there are tendencies for northern forms to appear. The relative richness of the basalts is reflected by a high proportion of rich bent–fescue grassland, herb-rich forms of Atlantic heather moor communities and widespread development of flying bent grassland and flying bent bog communities due to extensive surface flushing. There are, however, considerable areas dominated by communities which lack any indication of a basic influence. The flora of the Island of Mull (principally on the Darleith and the Torosay Associations) is described by Jermy and Crabbe (1978) and that of Skye by Birks (1973).

Map unit 149 is restricted to the north of Skye at Uig and on the Waternish peninsula. It occupies 30 square kilometres (2 per cent of the association) and although similar in many respects to *map unit 158* it has a deeper drift cover and is consequently less rocky. The drift is partially derived from Mesozoic rocks and has a high silt content, resulting in drainage impedance. Noncalcareous and humic gleys are present in addition to brown forest soils. The unit is entirely cultivated.

Map unit 155 has similar parent material to *map unit 149* and a greater extent (56 square kilometres; 4 per cent of the association). It occurs mainly on the west-facing hills of the Trotternish peninsula and carries peaty gleys and peat. The till cover either prevented the development of the strong terrace topography so characteristic of the bulk of the association, or effectively masks it. The vegetation is heath grass–white bent grassland, moist Atlantic heather moor and flying bent grassland. There is much flushing and rush communities are common; the land is largely used as rough grazing and forest land and has severe surface wetness problems.

Map unit 157 is the smallest in the association (7 square kilometres, less than 1 per cent). It comprises non-rocky, strongly hummocky valley moraine probably produced by outlying corrie glaciers during the Loch Lomond Readvance glaciation. It is confined to a few valleys in northern Skye and has been afforested. Its principal soils are peat and peaty gley hollows with peaty podzols (often with gleyed E horizons) on the mounds. Vegetation, when not afforested, is similar to that of *map unit 155*.

Map unit 158, although only the second most extensive (347 square kilometres; 23 per cent of the association), is much the most important economic unit. Dominated by mineral soils derived from the weathering of scoriaceous olivine-basalts, the soils of the unit are largely freely drained and consequently important agriculturally. Deeper soils are frequently cultivated, shallow soils are surface seeded and provide good grazing while sites not suitable for improvement carry herb-rich bent–fescue grassland and rye-grass–crested dog's tail pasture of high grazing value, often invaded by bracken. The pattern of soils in any area is dictated by the underlying rock structure. Where rock approaches the surface and intercepts sub-surface drainage, small wet patches occur, often characterized by an organic surface horizon. On knolls, although the organic content is high, the soils are usually well drained.

The map unit is essentially lowland in character, extending into hill areas along steep valley flanks. Over 85 per cent occurs at altitudes less than 150 metres. There is a wide range of slopes but over 60 per cent are less than 11 degrees. Rock exposures, although frequent, are usually small and low. Their pattern seriously interferes with ease of agricultural operations in many instances however.

The principal soil (60 per cent) is the freely drained brown forest soil which is predominantly shallow (70 per cent of site inspections encountered rock or large boulders at less than 75 centimetres in detailed investigations on the Island of Mull). The textures are sandy loam and loam. A high loss on ignition is frequent in A horizons, a feature unusual in the brown forest soils of the Darleith Association elsewhere in Scotland except at higher altitudes, and it is likely that the brown forest soils of Western Scotland represent variants, the high humus contents reflecting the climatic zone in which they have been formed.

Two groups of profiles have been recognized, one with moderate to high base status, the other with extremely low. The latter also have lower carbon:nitrogen ratios, lower colour values, a higher percentage carbon and occur at higher elevation (more than 75 metres) than the former. It is probable that such soils were, in their original form, humus-iron podzols and were reclaimed during the eighteenth century when the population in the area was much greater.

The second most extensive soils are the brown rankers, also of loam texture, occupying between 10 and 20 per cent of the map unit. Such soils are usually too shallow for cultivation but may be surface seeded. The remainder of the map unit comprises small areas of wet soils, both humic and peaty gleys, alluvial soils and occasional rock outcrops.

Map unit 159 is a variable unit covering 148 square kilometres (10 per cent of the association) and intergrading between *map units 158* and *160* both in character and topographic position. It contains a wide variety of soil types and drainage classes from brown forest soils to peaty gleys, but with a preponderance of peaty podzols. Mitchell and Jarvis (1956) noted that podzols on basaltic drifts commonly lack E horizons. The development of thin iron pans is also sporadic, although they may be exceptionally strong in some localities. Heavy staining by organic matter is common. The degree of wetness of the surface horizons of the peaty podzols is directly related to slope; at lower angles wetness increases and heavily gleyed variants develop which intergrade to peaty gleys. Steep slopes at elevations above 200 metres (lower in the north) frequently have many podzols, but they are rarely sufficiently extensive to show on maps of this

scale. During the compilation of the 1:250 000 soil map therefore, many amalgamations of this unit with *map unit 160* were made.

The major development of the unit occurs between 125 metres and 300 metres in southern areas; it occurs on steeper slopes than either *map unit 158* or *160* and the degree of rockiness can be very variable. Plant communities cover a broad range; dry and moist Atlantic heather moors develop over podzols and are sometimes herb-rich if light flushing occurs. The wetter sites with deeper, peaty surface horizons support bog heather moor, while a pattern of heather moor and bent–fescue grassland with bracken characterizes the lower part of the landscape, intergrading to *map unit 158.*

Map unit 160, extending over 828 square kilometres (56 per cent of the association) is characterized by the development of peat and peaty gley soils, with minor peaty podzols on steeper slopes. The map unit is extensive in the southern part of the association between 150 metres and 450 metres but occurs at lower altitudes in areas where drainage is impeded. It also extends to sea-level in the northern areas (Skye). Three variants of the unit are commonly found: a strongly terraced and craggy form associated with hill crests and exposed positions frequently heavily eroded, a variant with considerably less crag and more deep peat, sometimes hagged, and finally less extensive isolated occurrences at low elevations. The slopes are mainly gentle and strong.

The major soil is peat deeper than 50 centimetres (40 per cent) with peaty gleys (20 per cent), peaty rankers (20 per cent) and peaty podzols (10 per cent). The range of soil types represented is usually narrow and high organic-matter contents and pH levels below 5 characterize the surface horizons. In the peaty gleys, mottling is very subdued and associated with weathering of basaltic stones. Eg horizons beneath the peat are rare, but darker bands of organic accumulation above rock or induration are frequent. Organic-matter content remains high (12–15 per cent) throughout the subsoil. Base status is low and the soils are usually shallow.

Flying bent bog is associated with both peat and peaty gley soils, together with blanket bog in less-flushed areas. Moist Atlantic heather moor is associated with peaty podzols on sloping sites. Some cotton-grass, to which value as an early bite for sheep is attached, also occurs. Grazing values are low, however, and the severe surface wetness restricts the agricultural use of the land. Reclamation is usually not feasible and, where it has been attempted, rush infestation is found. For forestry the principal problems are wetness and surface acidity which restrict the choice of species and their yield. Sitka spruce and lodgepole pine will grow satisfactorily if the risk of windthrow is not too great and extensive areas have been planted on this type of land.

Map unit 161 is a small unit extending to 24 square kilometres (2 per cent) and closely related to the larger *map unit 158.* It contains similar soils but occupies steep slopes and usually occurs as a coastal fringe or on major inland escarpments surmounted by crags. Like *map unit 159* there are problems of representation at this scale and it has been included with other units in some cases. It is best described as loamy stabilized scree and is characterized by brown forest soils. It is often bouldery. While unsuitable for cultivation due to its slope (greater than 25°) and risk of erosion, its vegetation (bent–fescue and common white–bent grasslands with occasional herb-rich Atlantic heather moor) provides a valuable grazing resource for sheep and, occasionally, cattle.

Map unit 162 occurs above 400 metres and is consequently of restricted extent in the association (46 square kilometres; 3 per cent). Peat, often hagged, and subalpine brown soils and podzols are the principal soils. Tor-like landforms, the remnants of the more resistant lava bands, are associated with aeolian deposits which form deep freely-drained soils supporting stiff sedge–fescue grassland with moderate grazing value. Intermittent stone pavements, stone stripes and stone polygons, together with wind scoops, characterize the landscape. The land is unplantable.

THE DEECASTLE ASSOCIATION

(Map units 165–167)

The parent material upon which soils of the Deecastle Association are found is derived from thin bands of metamorphosed limestones (often in the form of calc-silicate rocks), interbedded with subordinate bands of slaty schist and, sometimes, igneous rocks. In Western Scotland this combination of rocks extends northwards from Lismore through the Appin district and Fort William to Glen Spean. In the latter area, however, they are covered by drifts derived from other rocks. Other limestone beds are associated with the epidiorites of mid-Argyll and in narrow bands eastwards to Perthshire, but their outcrop is restricted and few areas are large enough to provide map units. A glance at the maps published by the Institute of Geological Sciences will confirm the very broken distribution of rocks of this type. Even within areas mapped as the Deecastle Association, the presence of relatively small amounts of drift derived from adjoining acid rocks causes wide variation in the chemical properties and appearance of the soils. Although the limestones are frequently responsible for well-defined landscape features and provide a soil resource that was settled early in the history of the area, its soils show short-range fluctuation in their properties and frequently only reflect those of the limestones where the solum is thin.

The association occupies 62 square kilometres (0.4 per cent of Western Scotland). Lismore is the largest single limestone outcrop and its appearance is reflected by its local name, the 'Green Isle'. The proximity of the rock to the surface and differential erosion of its bedding gives the island a sharply ridged appearance and restricts severely the size of workable areas of soil, a factor less important in the days of hand labour and subsistence farming than in modern mechanized farming. In the mountains of the mainland to the north the limestones occur in valleys (where they may be obscured by other drifts) or as bands across steep slopes. Where they reach the surface they are always associated with better grazings and their presence may herald a change in sheep breed from the ubiquitous Blackface to Cheviot or Swaledale.

The mean annual rainfall in the area is high, ranging from 1600 millimetres to 2400 millimetres, but proximity to the sea prevents extremes of summer heat or winter cold. Despite the origins from calcareous materials, the soils are decalcified and are classed as brown forest soils rather than brown calcareous soils, but flushing in hollows indicates slight richness. The low altitude of the major areas accounts for the very high proportion of brown forest soils in the association, although peaty surfaces develop in the more northerly areas near Fort William. The vegetation is dominated by permanent pasture, but where not improved, herb-rich bent–fescue grassland, rock-rose–fescue grassland and richer moorland communities are found.

Map unit 165 is the dominant unit within the association (61 square kilometres; 95 per cent). Although composed predominantly of brown forest soils it also contains brown rankers, especially upon ridge crests, and noncalcareous gleys in hollows. The parent material is mainly colluvial in origin and the hollows contain soils deepened by material from the surrounding slopes. In some places small morainic or drumlin mounds, composed of indurated till from neighbouring rock types, often acidic, lie among the rock ridges. At larger scales of mapping such areas could be separated (e.g. north Lismore). The soils have silty loam textures, often humose (*c.*10 per cent organic matter) at the surface and are very dark grey in colour throughout the profile. The limestones underlying the Deecastle Association are low in magnesium (except for the Appin Limestone which has been included due to scale problems and more properly belongs with the Inchnadamph Association). No measurements on soil drainage are available and the uniform grey colour inherited from the parent material makes its assessment from morphological characters difficult. The soils are probably freely and imperfectly drained except in hollows where ponding in rock basins occurs. Soil structures are weakly developed. There is a strong resemblance to soils of the Foudland Association and the siltiness, high organic matter and high rainfall lead to similar problems of poaching.

The landscapes are very variable, ranging from ridged and hillocky on Lismore, through valley-forms (Appin) to the steep hill sides of lower Glencoe, but all are characterized by grassy plant communities with high grazing values.

Map unit 166 was recognized where a significant organic surface horizons developed, either as humus-iron or peaty podzols on ridge crests or as peaty gleys in hollows. The hill flanks in the unit usually remain as brown forest soils, although A horizons develop a higher humus content. The unit is very restricted in extent, occupying less than 1 square kilometre south of Fort William.

Map unit 167 is closely related to *map unit 165* but contains more rock. Lithosols are common, together with brown rankers and brown forest soils, and hollows contain humic gleys. The proximity of the rock, a slightly higher elevation and high rainfall combine to make the soils more humose and this is reflected in a higher proportion of herb-rich Atlantic heather moor. The map unit occurs only on the south of Lismore Island and is restricted in use to rough grazings. It is not plantable.

THE DURNHILL ASSOCIATION

(Map units 184–188, 190–193)

Soils developed on drifts derived from quartzites of both Dalradian and Cambrian age cover 293 square kilometres (1.8 per cent of Western Scotland) and comprise the Durnhill Association. The Cambrian quartzite series crops out in a narrow but obvious band between Loch Kishorn and Beinn a'Chlaidheimh in the north, with a small area at Ord on Skye. The series is composed of basal, false-bedded quartzites, overlain by a highly siliceous pipe-rock. Quartzites of the Dalradian assemblage are found in the districts of Lochaber and Appin and on the islands of Jura and Scarba. The quartzites of

the Crinan and Loch Awe areas are heavily interbedded with quartz-mica-schists and phyllites and their derived drifts have been included with the Strichen Association.

Quartzites are resistant to weathering, so typically form the summits and ridges of many mountains, especially in Lochaber and further north. In the Western Plateaux and Foothills region the quartzites have formed peat and rock-dominated gently sloping ground. The climate ranges from warm and wet in the lowlands, while the uplands and mountains are cool or cold and wet. The wet climate and silica-rich parent material ensures a low biotic activity, even in lowland areas, and map units in which brown forest soils and humus-iron podzols are dominant form only 3 per cent of the association. Map units dominated by peaty soils, mainly peaty gleys, peaty rankers and peaty podzols with peat, on the other hand, account for 62 per cent. The strong tendency for quartzites to form mountain summits and ridges is reflected by the high proportion (29 per cent) of subalpine and alpine soil units found in Durnhill Association.

Flying bent grassland and bog are widespread on the gently sloping ground on Jura, while on the mainland moist Atlantic heather moor and bog heather moor become more frequent: acid bent–fescue grassland with bracken is restricted to short dry slopes in one or two localities. A noteworthy element in the predominantly grassy western area is the development of dry Atlantic and boreal heather moors. Slopes around Loch Leven are covered by these communities and their formation is assisted by the permeable quartzite drift.

Map unit 184 has been mapped on drifts derived from Cambrian quartzites on the eastern slopes of Beinn Eighe (5 square kilometres) and from Dalradian quartzites on Jura (8 square kilometres). The drift is stony colluvium over rock in the former locality, but is a stony, sandy loam till on Jura, where there is a boulder pavement on its surface often covered by organic matter. The till is reddish in localized patches, where it can resemble the red drift of the Kintyre Association.

The landforms are regular gentle slopes (less than 15°) with occasional very subdued drumlins in the south-west and minor rock outcrops. Peaty gleys are the dominant soils, often over indurated till. Where these soils are found on colluvial drifts, they are similar to the peaty gleys described in *map unit 188*. Peat is widespread throughout this map unit because of the gently sloping topography, acidic nature of the drift and high rainfall. The relief is not limiting to mechanized improvement but the soil and climatic restraints are an obvious deterrent. The unit is suited to forestry, but nutrient problems may be encountered due to the impoverished parent materials.

Map unit 185 is mapped on morainic drifts around Loch Leven (Dalradian) and Beinn Eighe, Loch Clair and Beinn Liath Bheag (Cambrian). The map unit covers 25 square kilometres, and its main soils are peaty podzols and peaty gleys with widespread peat in channels. The soil distribution is characteristic of this type of map unit and has been described in the Arkaig Association (*map unit 26*). A prominent feature in peaty podzols on quartzite drifts is the E horizon which is thicker and more uniformly grey than in most other associations.

The combination of bedding and jointing planes found in quartzites produces small boulders readily, thus the surface of the moraines are not littered with the massive boulders typical of *map units 26*, *123* and *391* in the Arkaig, Countesswells and Lochinver Associations. These small boulders cause dif-

ficulty with forestry ploughing but there are no large surface obstacles to be avoided. Atlantic and boreal heather moors grow on peaty podzols, with bog heather moor and flying bent bog on the peaty gleys, and blanket and flying bent bogs on the peat.

Map unit 186 is developed on stony colluvium and extends to 9 square kilometres on steep, lower slopes in the foothill and mountain zones. The soils are mainly humus-iron podzols with some rankers on bouldery slopes. The rankers consist of a thin H horizon overlying angular quartzite boulders with interstitial organic matter, and their vegetation is dominated by bracken and moss with occasional grasses. Humus-iron podzols develop where the parent rock has formed a sandy drift and have prominent E horizons as in the peaty podzols of *map unit 185*. They support acid bent–fescue grassland, oakwood and birchwood. Peaty gleys also occur on wetter rock ledges.

Map unit 187 is found on steep slopes where the parent material is scree-dominated. It covers 8 square kilometres on Dalradian quartzites. The soils are peaty podzols and peaty rankers with better structured, drier O horizons than is usual in the west. These provide conditions suited to dry Atlantic and boreal heather moor communities, the heather-dominated appearance of which is quite striking in Western Scotland.

Map unit 188 is one of the most extensive units of the association (78 square kilometres) and is found on Cambrian and Dalradian quartzites. It is widespread on gently sloping ground on Jura, Scarba and the Garvellachs in the Firth of Lorn, and on gentle slopes below about 400 metres in the mountains of Lochaber and Torridon. The main characteristics of the map unit are slight to moderate rockiness and peaty soils. The peaty gleys, which form a high proportion of this unit, are acid soils with pH about 4.0 in the O horizon and 4.5 in the B horizon, which has a stony, loamy sand texture. The subsoil is severely stony and often shallow on rock; peaty rankers are found where B horizons are absent. Peat is widespread, possibly reaching 40 per cent of the unit in some areas. Bog heather moor and blanket bog, with northern variants in Torridon are replaced by flying bent grassland and bog on the islands. This vegetation provides rough grazing of low value, with little prospect for pasture improvement. The land is suitable for forestry.

Map unit 190 covers 32 square kilometres and is similar to *map unit 188*, except for an increase in rockiness. The soils of this rugged landscape are peaty gleys and peaty rankers, with the rankers possibly the most extensive in some areas. The amount of peat is very variable.

Map unit 191 is closely related to *map units 188* and *190* but has steeper slopes (greater than 15 degrees). The steep slopes improve drainage sufficiently to reduce peat formation so that peaty gleys, peaty rankers and peaty podzols are more widespread. Atlantic heather moor and bog heather moor are the dominant plant communities. The map unit covers 45 square kilometres and is found around the south-east end of Loch Maree and extensively (approximately 30 square kilometres) on mountain slopes below 400 metres near Loch Leven.

Map unit 192 is the most extensive (82 square kilometres) in the Durnhill Association and is found on steep mountain slopes with gently sloping ridge crests and plateaux. When the ridge crests or summits are extensive enough in the subalpine soil zone, they are mapped as *map unit 193*. Alpine soils on gentle and steep slopes have been mapped as *map units 194* and *195* elsewhere, but these soils are included with *map unit 192* in Western Scotland. The topography is very rocky, with numerous unvegetated scree patches. The main plant communities are lichen-rich boreal heather moor, blaeberry and bog whortle-berry heaths, which provide grazings of low value. The map unit is widespread on the Cambrian quartzite peaks and throughout Lochaber.

Map unit 193 is very localized, covering 1 square kilometre on the summit area of the island of Scarba. It is a gently sloping, very rocky unit with subalpine soils and peat, and is more extensive in South-West Scotland (Sheet 6).

THE FOUDLAND ASSOCIATION

(Map units 240–243, 246–255)

The association was first described in north-east Scotland (Glentworth 1954) on drifts derived from argillaceous schists of varying degrees of metamorphism. In Western Scotland it includes graphitic and other slates and phyllites, and some mica-schists in areas of low-grade metamorphism. The inclusion of the latter in the Foudland rather than the closely associated Strichen Association is debatable, but the soil textures appear to be sufficiently fine to warrant the distinction.

The Foudland Association covers 686 square kilometres (4.1 per cent of Western Scotland) and is the seventh largest. It does not extend north and west of the Great Glen but occupies a coastal strip from Craignish peninsula through the islands of Seil and Luing to Fort William. Soils of the association were also mapped to the north of Loch Fyne extending to Cladich on Loch Awe, and in the extreme south-east between Loch Long and Loch Lomond. The landforms in the northern coastal area, where the drifts are thin, are strongly controlled by rock structure and repeated sequences of ridges and hollows are common. Between Loch Fyne and Loch Awe the ridged topography is more subdued and the landscape, particularly in the lower parts of the valleys, has been influenced by till deposition. In the Loch Long–Loch Lomond area the ridged topography is not obvious and the hills rise steeply to over 700 metres. The general aspect of the land is more characteristic of the Southern Uplands than the Western Highlands with long, regular, steep slopes and rounded summits capped with hagging peat. A somewhat similar topography, also with hagging peat, develops on the slate outcrops south of Fort William.

The texture of the parent material is loam or silt loam with occasional sandy loam where some reworking of the tills or moraines has occurred. Silt contents of the soils are fairly high (35–50 per cent) compared with a mean of 35 per cent in this association throughout the rest of Scotland. The drifts are moderately stony and generally of greenish grey or olive colour.

The association is found in areas where the climate is warm or fairly warm and wet, but in the higher hills is also found under cool conditions. A few of the highest summits are orohemiarctic. The interaction between wet conditions and finer texture produces gley soils while the higher temperature régime induces more noncalcareous and humic gleys than usual (19 per cent). Peaty

gleys and peats still form the most extensive mapping units with 22 per cent over tills and 36 per cent developed on colluvial drifts over rock. Approximately 19 per cent of the association is dominated by brown forest soils and humus-iron podzols. Only 4 per cent has subalpine or alpine soils. The high proportion of areas with mineral surface horizons (38 per cent) causes the Foudland Association to be considered one of the most fertile and useful, despite the fact that high fine sand and silt contents can lead to structural instability under cultivation.

The vegetation of the moorlands is typically acid, Atlantic heather moor and various bog communities predominating, although a slightly higher proportion of flushing is apparent than in the Arkaig or the Strichen Associations. The grasslands of the lower hills are of both acid and basic types with more rush pastures and flushes reflecting the presence of gley soils. Much of the lower land of the association is under permanent and long ley pasture.

Map unit 240 extends from Eastern Scotland into this region at only one place near Loch Katrine. It is of insignificant extent and consists of brown forest soils on steep, moderately rocky slopes.

Map unit 241, approximately 2 square kilometres (less than 1 per cent of the association) in extent, is restricted to the Strath of Appin and Feorlin Farm, Crarae, Loch Fyneside. The unit encompasses noncalcareous and humic gleys developed on a silty, dark grey till and has no rock outcrops although some of the soils are shallow. The land is used as improved pasture although the soils could be cultivated.

Map unit 242 also contains noncalcareous and humic gleys but has a less-regular topography than *map unit 241* and occasional rock outcrops. Some small areas of podzolized brown forest soils and humus-iron podzols are found on rocky and shallow areas. The map unit is extensive on the western coastal fringe from the Craignish peninsula to Appin, along both shores of Loch Fyne and from the southern part of the sheet extending into South-West Scotland round Gare Loch (125 square kilometres; 18 per cent of the association). From the limited number of analyses available, organic-matter contents in the topsoils range from 8 to 10 per cent, base status is moderate to high and pH in the range 5 to 5.5, rising with depth. The grey or greyish brown fine sandy and silty loam subsoils have yellowish brown mottles and are poorly drained. Due to the combination of silty and fine sandy textures, proximity to rock, strong slope patterns and high rainfall, land of this type is often in long ley pasture. It provides valuable grazings. Shallowness and the exposed situation of much of the western seaboard produce a strong risk of windthrow if the land is used for forestry.

Map unit 243 has been mapped in a small area in the extreme south-east of the region (6 square kilometres; less than 1 per cent). It comprises humus-iron podzols with some peaty podzols, noncalcareous gleys and peat and has no rock outcrop. It is very extensive in Eastern Scotland.

Map unit 246 is a non-rocky unit of peaty gleys and peat with some minor podzols and peaty rankers. The soils are developed on a till parent material but are always shallow and there are occasional colluvial areas (usually podzolic). Slopes are less than 15 degrees and the unit occupies foothill sites between 100

metres and 300 metres. It occupies 18 square kilometres (3 per cent of the association) at two sites, a prominent upper hill slope between Strachur and St Catharines, Loch Fyneside, which is now largely forested and an area in the extreme east overlooking Flanders Moss.

Map unit 247 has a similar suite of soils to *map unit 246* but is broken by rock outcrops. It occupies 32 square kilometres (5per cent of the association) and also becomes more extensive in South-West Scotland. Due to excessive wetness, reclamation of this land for grass is difficult; it is extensively forested (Minard Forest, Loch Fyneside).

Map unit 248 is mapped on gently hummocky moraine derived from slates, phyllites and schists. The mounds develop the drier humus-iron podzols and the wetter soils (peat, peaty alluvium and humic gleys) occupy the hollows. The moraine landform is more subdued than analogous units in other associations on schists and gneisses, partly due to the high contents of fine sands and silts and partly to the nature of the rock which weathers easily. The soils are less stony and the morainic debris somewhat less bouldery. The podzolic soils usually have low base saturation and a lower pH than the gleyed soils, but the latter suffer from serious wetness defects and poach easily. The pattern of wet and dry soils, together with the irregular topography, precludes arable farming, but the land provides valuable grassland, especially when improved. In a semi-natural state the mounds support acid bent–fescue grassland, sometimes with bracken, and the hollows rush pasture. The map unit is also very suitable for forestry and extends to 46 square kilometres (7 per cent).

Map unit 249 is analogous to *map unit 248* in its drift type and general landscape but the mounds are occupied by peaty podzols, while the hollows contain peat and peaty gleys. The peaty podzols frequently show a weak iron pan and are frequently slightly gleyed below the pan. The unit has much wetter surface horizons than *map unit 248* and is rarely improved for grassland. Rush infestation of the hollows is common, but the mounds often carry common white bent grassland with a moderate grazing value. Stocking rates are often higher than analogous units in other associations. The deep valleys of the Luss Hills between Loch Long and Loch Lomond exhibit the best development of the unit which occupies 103 square kilometres (15 per cent of the association).

Map unit 250 is developed on slopes greater than 15 degrees with moderate rock outcrops and occupies 48 square kilometres (7 per cent of the association). The steep hill sides provide difficulties for reclamation and can be unstable if roads are cut into them, with considerable slumping of ditches and embankments. The brown forest soils and humus-iron podzols support bent–fescue grassland, often with bracken, of high grazing quality. The forestry potential of the land is also high with a wide choice of species.

Map unit 251 is closely related to *map unit 250* but has very low amounts of rock outcrop. It may attain altitudes as high as 600 metres, when the brown forest soils and humus-iron podzols gradually give way to peaty podzols supporting common white bent grassland of lower grazing value. The map unit occupies 28 square kilometres (4 per cent) of the association.

Map unit 252 is not extensive (4 square kilometres; less than 1 per cent) and is confined to the extreme south-east (Rowardennan). It consists of colluvial slopes with rock outcrops supporting peaty podzols and rankers. Peaty podzols can also be found west of Loch Lomond but are too small in area to be defined separately. It supports Atlantic heather moor.

Map unit 253 is the most extensive in the association in Western Scotland (162 square kilometres; 24 per cent of the association). It is developed on a shallow colluvium with rock close to the surface but only occasionally breaking through. In hollows and in the lee of hills, however, patches of till are found and the unit intergrades to *map unit 247*. The soils are peaty gleys and peat with peaty podzols on steeper slopes. It is closely analogous to *map unit 507* of the Strichen Association which may be slightly more rocky in places. Although few analyses are yet available, there is an indication that the average pH of the surface horizons is just above 4, rising to 5 in flushes. Strong gleying of the B horizons is apparent and the soils are wet for extended periods. Base status is moderate to low. The vegetation is dominated by moorland, in particular moist Atlantic heather moor and bog heather moor. There is subsidiary flying bent bog, flying bent grassland and common white bent grassland in many areas towards the west coast. The grazing value is usually low but may be moderate when the latter components are supplemented by flush communities. Wetness is a major drawback to agricultural use; some areas have been extensively forested although the species choice is usually restricted.

Map unit 254 is defined where *map unit 253* extends onto slopes steeper than 15 degrees. Above this angle the extensive peat component of *map unit 253* becomes very much reduced in amount and is replaced by peaty gleys, and peaty podzols with gleyed E horizons. Rock outcrop also increases as does the extent of flushing. The unit has considerable amounts of common white bent grassland which results in a moderate grazing value. Found on the coastal mountain slopes south of Fort William and in the Luss Hills of Loch Lomondside, the unit occupies 84 square kilometres (12 per cent of the association). In lower rainfall areas further east the soils become predominantly peaty podzols and so this and similar units in other associations are characteristically west coast types.

Map unit 255 occurs on the summits of some of the western mountains south of Fort William, south of Glen Shira (Bheinn Bhuidhe) and in the Luss Hills. It occupies 28 square kilometres (4 per cent of the association) and is composed principally of subalpine podzols and gleys and hagging peat. The summits are not usually as rocky as those in the Arkaig or the Strichen Associations, but their exposure causes wind-cutting of the vegetation which, coupled with the amounts of peat, reduces the grazing potential severely.

THE FRASERBURGH ASSOCIATION

(Map units 259–261 and 263)

The soils of this association are developed on wind-deposited and raised beach sands containing a high proportion of shelly material. They cover 45 square kilometres (0.3 per cent of the region), the largest tracts occurring on the islands of Tiree, Coll and Colonsay with smaller deposits at Calgary on Mull, Sanna in Ardnamurchan, on Iona and near Gairloch.

Strongly contrasting landscapes are included within the association, ranging from flat to extremely moundy, some of the mounds on Coll being 30 metres high. Since the parent material is of coarse sand texture, the soils are freely and excessively freely drained, except in a few low-lying receiving sites. Other striking features of the parent material are a very light colour, high pH (7–8) and 100 per cent base saturation. As comparatively little time has elapsed from the stabilization of these sands, most of the soils are immature and are classified as calcareous regosols. Brown calcareous soils and calcareous ground-water gleys are also seen.

The association is restricted to lowland sites with a warm moist climate and a rainfall of about 1200 millimetres per annum. These favourable conditions produce species-rich, semi-natural grasslands and give excellent grazings.

Map unit 259 occupies 15 square kilometres (35 per cent of the association) and contains humose calcareous regosols and brown calcareous soils on strikingly 'flat machairs. These soils have high organic matter in a surface horizon about 10 centimetres thick. Even though the organic matter is still high in succeeding horizons there is a sharp change in colour from dark reddish brown to very light brown or sometimes white. Dune pastures, herb-rich bent–fescue grassland and rye-grass–crested dog's tail pasture form the closely grazed sward. Thus the main agricultural use of the unit is as common grazing land, but some crofters have used more sheltered areas for arable cropping. Exposure, liability to erosion and drought restrict the area suitable for cultivation in spite of level terrain which is rare in the west Highlands.

Map unit 260, only 1 square kilometre in extent, is similar to the previous unit except for the presence of some rocky knolls of Lewisian gneiss with shallow soils.

Map unit 261 has strongly hummocky topography, in direct contrast to *map unit 259* but has, otherwise, similar soils. It is formed from stabilized sand dunes. Some hollows may be wetter and occasionally develop peaty surface horizons. The unit is the largest in the association occupying 26 square kilometres (60 per cent). There are additional plant communities such as the northern marram grass dune. As long as the unit is not eroded by the effects of strong winds and overstocking, excellent grazings are available. The moundiness and liability to drought exclude the possibility of arable farming, but the map unit has good scenic qualities and comes under recreational pressure.

Map unit 263, despite the calcareous nature of the parent material, has peaty gleys and peat soils on the largest dune slack north of the aerodrome on Tiree. Bottle sedge and marsh marigold swamps are the main plant communities, though some of the less-waterlogged peripheral areas near Balephetrish have been cultivated. It covers only 3 square kilometres.

THE GOURDIE/CALLANDER/STRATHFINELLA ASSOCIATIONS

(Map units 274–275)

The soils are developed on drifts derived from acid metamorphic rocks, Lower Old Red Sandstone sediments and igneous rocks. The main rock types are slaty and micaceous schists, grey and red sandstones and dyke rock of intermediate

composition. Some drifts are pinkish due to concentrations of red sandstone fragments, but the normal colour is yellowish grey. The only areas on Sheet 4, covering 6 square kilometres, are along the Highland Boundary Fault at Balmaha and near Aberfoyle, which have a mean annual rainfall ranging from 1500 to 1600 millimetres and lie in the warm wet lowland zone. Soils of the gentler footslopes are noncalcareous gleys, while steeper well-drained slopes have brown forest soils. Land use includes some arable farming but is mainly permanent pasture, rough grazing and forestry.

Map unit 274 has mainly brown forest soils, some with gleying, developed on a shallow stony till of fine sandy loam texture. Cobalt and copper deficiencies have been detected.

Map unit 275 has a till of sandy clay loam texture, deeper and less prone to trace element problems than that in the previous map unit. There are problems of poor drainage, low permeability and lack of structure in the principal soils, noncalcareous gleys.

THE GRULINE ASSOCIATION

(Map units 278–280)

The soils of the Gruline Association are developed upon raised beach or outwash sands and gravels derived from a range of igneous rocks but with a strong basic igneous component. They are closely related in their distribution to the outcrops of basalt, andesite and gabbros in the Western Highlands and to the complex vent areas of Skye and Mull. By virtue of its mode of formation the association occurs either in valley floors or close to the sea and is practically always below 40 metres. Very gentle slopes predominate, although differentiation into an upper and lower terrace is common. Rock is found in only one map unit. The soils of the Gruline Association have long been used for crofting, farming and as centres of settlement and although they are very restricted in extent they are important in this respect.

The parent material, having a significant proportion of basic igneous rock, is usually dark brown in colour although this may become lighter where acid rocks also occur. The association may intergrade to the Corby Association. The texture is dominantly gravel, sometimes very coarse as in part of the Gruline area of the Isle of Mull, but lenses and beds of sand are not uncommon. The material is sometimes indurated and a strong relationship between this characteristic and the upper terrace was observed on the Isle of Mull. In other areas, although induration was primarily associated with terraces above 15 metres, the relationship is not so strong and many non-indurated sites were found. The lower terraces are very rarely indurated. Compared with other associations developed in raised beach or outwash materials, the textures of the soils of the Gruline Association are usually more loamy.

The extent of the association is only 30 square kilometres, 0.2 per cent of Western Scotland, to which it is confined. Much is cultivated for pasture with occasional cereal or potato crops. It supports an acid bent–fescue grassland when uncultivated, but peaty areas, either over induration or in basin areas, are moist Atlantic heather moor, rush pastures, sedge mires or yellow flag swamp. The climate is warm or fairly warm and wet.

In mountainous country, gravel flats are not extensive and often contained

by steep slopes at the mouths of glens. Problems of scale and adequate representation have meant that some lines have been drawn round convenient groupings of units. *Map unit 279* is a mixture of *map unit 278* and some elements of *map unit 280* and is one of the few map units in Western Scotland that were designated for convenience of representation rather than as a natural soil landscape body.

Map units 278 and 279 differ only slightly, *map unit 278* (7 square kilometres; 25 per cent of the association) being composed of humus-iron podzols and brown forest soils with some small alluvial channels while *map unit 279* (18 square kilometres; 60 per cent of the association) contains, in addition, broader channels of peaty gley or small basins of peat. The peaty soils occur in quite distinct small areas rather than finely distributed throughout the map unit and have been differentiated on the 1:63 360 and 1:50 000 soil maps.

Due to the higher component of basic igneous rocks, the expression of podzolic characters in the profile is suppressed, in marked distinction to soils developed on gravels derived from acid rocks in the region. The soils are, however, strongly leached and many of the profiles are cultivated humus-iron podzols. The long history of use, varied management treatments over the years and the variable nature of the parent material itself render the soils difficult to categorize. Both *map units 278* and *279* have been extensively used for crofting and farming and little natural vegetation remains.

With *map unit 279* the wetter soils have been drained and reseeded with varying degrees of success. Almost all suffer from rush infestation and fairly rapid sward deterioration when compared with the freely drained sites.

Map unit 280 is almost exclusively wet soils, with peaty gleys and peaty podzols fairly extensive. It consists for the most part of a narrow coastal rock platform, probably preglacial in origin, which has been denuded of beach sediment except for a thin veneer. The presence of impermeable rock close to the surface in conjunction with the continual flushing of most sites by drainage from higher surrounding land has resulted in very wet soils and organic-matter accumulation. Rush pastures and sedge mires, yellow flag swamp and blanket bog account for much of the vegetation cover. Due to the degree of flushing, some areas will have a moderate grazing value but patterns of wetness and rock preclude much reclamation.

THE HATTON/TOMINTOUL/KESSOCK ASSOCIATIONS

(Map units 282, 285 and 286)

Prominent in the landscape of the inner Moray Firth region are a number of rounded and often rocky hills composed of conglomerate. These hills, isolated and of restricted extent, commonly abut Moinian rocks which formed the main source of their included pebbles. The conglomerates may be of Lower or Middle Old Red Sandstone age. The shallow stony soils developed on these rocks and drifts derived from them account for an area representing 29 square kilometres (0.2 per cent) in Western Scotland. On maps at 1:63 360 scale they have been placed into three associations which differ only in minor respects and are, for the purposes of this report, grouped as one association. The Stonehaven Association is also derived from conglomerates of Lower Old Red Sandstone

age but differs in containing a significant proportion of intermediate lava in its parent material and by the preponderance of cobbles in the soil which seriously affects farm operations.

The association occurs in areas with mean annual rainfall usually less than 1100 millimetres (potential water deficit division 0–50 millimetres) and with accumulated temperatures of 1100–1375 day-degrees C; the climate is therefore more favourable to man's activities than in much of Western Scotland. Dry and moist Atlantic heather moors blanket much of the association with some minor acid bent–fescue grassland on slopes and wetter communities in hollows. Undoubtedly heather is more vigorous under these conditions and the flying bent element of the western moorlands has almost disappeared. Much of the area of the association is devoted to forestry.

Map unit 282 is essentially a non-rocky unit with a wide range of slopes, but with a more subdued topography than *map units 285* and *286*. This reflects a deeper drift cover. Nevertheless, shallow soils and rock outcrops occur locally. The dominant soils are humus-iron podzols, cultivated in the more favourable areas. Stoniness is a persistent problem and much of the map unit has been forested. It occupies 6 square kilometres (20 per cent of the association).

Map unit 285 occurs in a number of small areas including two outliers of conglomerate north of Loch Luichart. It occupies 16 square kilometres in total (55 per cent of the association) and frequently forms a distinctive topography of knolls and hills with regular, steep, convex slopes and rounded summits. Although the map unit is only slightly rocky, individual exposures can be large and generally display the same convexity as the ground surface. Hard bed-rock underlies parts of the map unit at shallow depth and supports peaty and brown rankers. Peaty and humus-iron podzols however, are the prevalent soils in the map unit occurring where the solum is deeper. Associated with drift-filled cols and hollows between the hills are peat and peaty gleys. Dry and moist Atlantic heather moors on the rankers and podzols are the main plant communities. Some acid bent–fescue grassland occurs on the steepest slopes, while blanket bog and bog heather moor occupy depressions.

Map unit 286 is a rocky and very rocky unit. The main area is at Meall Fuarmhonaidh, a conglomerate hill rising to 700 metres approximately 10 kilometres south of Drumnadrochit. Rankers, together with some peaty and humus-iron podzols occur on the steep to very steep slopes, but the hill is capped by subalpine podzols. Some peat occurs, especially on the more gentle slopes on the north side of the hill. The plant communities are as *map unit 285* but include minor lichen-rich boreal heather moor and the unit occupies 7 square kilometres (25 per cent of the association).

THE INCHKENNETH ASSOCIATION

(Map units 307–309, 311–313)

The Inchkenneth Association is not extensive (99 square kilometres; 0.6 per cent of Western Scotland) but is an important soil resource in several of the West Highland crofting townships. It consists of deposits derived from the sandstones, limestones and shales of Triassic to Cretaceous age, but excludes the clay deposits (e.g. Kimmeridge and Oxford Clays) which form the parent

material of the Staffin Association. The association occurs in central Skye, on Eigg, Mull and Colonsay and on the mainland in Morvern, Ardnamurchan and Applecross. Of these the most extensive is from the isles of Pabay and Scalpay through the Broadford area to Loch Slapin, Strathaird and Elgol in Skye; remaining areas are all very small.

Three types of drift are found, colluvium, moraine and till, different mapping units being established upon each. The colluvium, which is most extensive, is often shallow and discontinuous. The sandy loam to loamy sand textures are permeable and of dark brown and dark reddish brown colour; little or no unaltered parent material is found, weathering often penetrating into the rock. The moraines, found only in one small area at Applecross, have sandy loam or loam textures. Tills occur in Colonsay, the Ross of Mull and in small areas on Rahoy Estate, Morvern, the two former associated with drift derived from subsea deposits by the action of a major ice-sheet, the latter from local sediments. The tills always have higher clay percentages but these vary between wide limits. The commonest textures are loam and clay loam. The three drift types have quite different landscapes, those on colluvium often terraced and showing the influence of underlying rock structures, the moraine hummocky and the till drumlins with gentle to strong slopes. An exception to the latter is the till on the higher hills of Morvern and on Raasay which lies in gently concave valley sites.

Of the major soil subgroups, those with mineral surface horizons are approximately equal in area to those with peaty surface layers, a feature which is unusual in the soil associations in Western Scotland. Areas dominated by brown forest soils and brown rankers total 36 per cent, those with humic and noncalcareous gleys 14 per cent and those with peaty gleys, peat and peaty podzols 50 per cent. All of the areas of mineral soil in the association have been cultivated at some stage, but most have been allowed to revert to grassland. The exception is the till of Colonsay and the Ross of Mull. Acid bent–fescue grassland and meadow-grass–bent pasture are dominant plant communities with rush pastures in flushes and on the gley soils. The peaty soils carry Atlantic heather moor, flying bent grassland, flying bent bog and blanket bog. Hollows are frequently flushed and where limestone contributes to seepage water the communities may be rich.

Map unit 307 extends to 34 square kilometres (35 per cent of the association) and is composed of terraced topography often steeply inclined. The soils are colluvial and shallow, with rock ridges breaking the slopes. Brown forest soils are dominant with humus-iron podzols developing where sandstones are prevalent and with many humic gleys as small flushes in channels and hollows. The map unit is found near Inchkenneth, Loch Don and Loch Spelve on Mull, near Swordle on Ardnamurchan and on Raasay and parts of Skye. Very few areas are now regularly cultivated, the soil pattern providing problems for modern machinery, but surface cultivations for improved grassland are very satisfactory.

Map unit 308 occupies a very small area on Colonsay (approximately 1 square kilometre) as drumlins overlying Torridonian sandstone. The till is composed mainly of fine material, probably derived from subsea Mesozoic rocks, with coarse material and stones derived from the local rocks. The noncalcareous gleys are fairly uniform in clay content (20–22 per cent), while sand and silt contents are a little more variable. The unit is utilized for both cereal and grass production.

Map unit 309 is similar in all respects to *map unit 308* except for the presence of rock outcrops. The unit occupies 12 square kilometres (10 per cent of the association) and is largely found in the Ross of Mull where the till overlies granite and schists, and on Ardnamurchan.

Map unit 311 is composed of peaty gleys with occasional humic gleys and shallow peat developed on a local till. It is very restricted in extent (2 square kilometres; less than 5 per cent of the association), being found in three valley situations, two on Morvern and one on Raasay. Rock outcrops occasionally break the surface. The unit was originally mapped with the Tarves Association, but due to its relationship with areas of Mesozoic rock outcrops is better included with the Inchkenneth. It is characterized by flying bent bog and moist Atlantic heather moor.

Map unit 312 is the most extensive in the association (48 square kilometres; 50 per cent of the association). The very wet climates under which it occurs, together with the predominance of peaty gleys and peat, render the land very difficult to manage. Some attempts at reclamation have been made, primarily where the unit is slightly drier and a higher proportion of podzols occurs, but deterioration of sown swards is rapid and rush-infestation common. The most extensive area occurs on the Elgol peninsula, Skye. Here the Kimmeridge and Oxford beds are sandstones rather than clays and although one or two areas of clayey soils are found, they are not sufficiently extensive to map as the Staffin Association. The pattern throughout *map unit 312* is strongly affected by underlying rock structure and outcrops are common. The vegetation of Atlantic heather moor and bog heather moor with blanket bog gives grazing of a low value.

Map unit 313 is not extensive (3 square kilometres; less than 5 per cent of the association). An extensive area of moraine derived from Torridonian rocks extends across Lias limestone and Triassic red marls, sandstones and conglomerates before reaching the sea at Applecross Bay. This small area contains brown forest soils on mounds and slopes and peaty gleys in hollows and provides areas of cultivable ground and ground suitable for reclamation for grass.

THE INCHNADAMPH ASSOCIATION

(Map units 314 and 315)

The Inchnadamph Association is one of the smallest in extent (21 square kilometres; 0.1 per cent of the area). It is found on the Isle of Skye between Torrin and Broadford and on the mainland in the valley of the River Kishorn. Its importance stems from the fact that it supports several farming and crofting settlements in areas where the surrounding soil resources are extremely poor. The parent material of the association is largely colluvial in origin (although as in the Deecastle Association there are many areas of shallow drift) and derived from limestones of Cambro-Ordovician age. These 'Durness limestones' vary from dolomite to almost completely non-magnesian limestones, but the former are prevalent and soil analyses from the association reflect this feature.

The landscapes of the association are very similar to those developed on the Dalradian limestones (the Deecastle Association) and are usually found below 250 metres in valley sites. Shallow soils with much rock outcrop on strongly

undulating ground are prevalent. Some of the higher areas develop a peaty surface, but even this unit appears dry as the peat is structured. There are often small swallow holes and limited areas of clint and grike topography.

The principal soils are shallow, brown rendzinas on rock and brown forest soils (the latter developed on a shallow, mixed drift of quartzite, schist and limestone), with peaty gleys and peat at higher elevations. The proportion of brown mineral soils to peaty soils is almost exactly reversed between Western Scotland (70 : 30) and Northern Scotland (25 : 75). The change from south to north is gradual. It probably reflects a difference in topography, the landscapes of the south having a higher proportion of sloping land than those of the north, combined with the south to north temperature gradient and slight variation in drift cover.

Climatic characteristics in Western Scotland are cool and wet which is reflected in the predominantly pastoral land use. The vegetation is sharply contrasted between the two soil units, but the richer variants of the limestone are well-expressed throughout.

Map unit 314 is the most extensive (15 square kilometres; 70 per cent of the association). It occurs below 200 metres and consists of brown rendzinas and brown forest soils developed on gently to strongly sloping limestone ridges and knolls. The landscape is often rocky, sometimes extremely so, and the soils dominantly shallow. The soils are dark yellowish brown to brownish yellow in colour in contrast to the sombre greys of analogous soils in the Deecastle Association although some grey horizons occur. Textures are usually silty loam (50–70 per cent silt in this association) and moderately stony. Base saturation figures are higher than in comparable soils on the calc-silicate rocks, magnesium figures higher but the organic-matter content is similar at 8–10 per cent.

Vegetation is dominated by herb-rich bent–fescue grassland and permanent and long ley pastures. There is little arable land, except small pockets among the rocks utilized for forage crops or potatoes by the crofting community. The land is predominantly grazing land but of a high quality and often heavily stocked. The white faces of the Cheviot breed replace Blackface sheep here. The shallowness of the soil, the exposed situation of the Western Highlands and higher pH of the subsoil horizons provide difficulties for forestry on soils of this type.

Map unit 315 occupies higher land on Skye (ridge-crests) and a narrow band on the eastern side of the valley north of Kishorn. It is a mixed soil unit, brown mineral soils on steeper slopes contrasting with peaty hollows. At higher elevations peaty podzols occupy the slopes and peaty gleys the hollows. The rock often remains close to the surface and thin peaty horizons resting directly on rock are not uncommon. In such situations the organic soil is often much drier, coarsely structured into a series of prisms and supports dry Atlantic heather moor. In flushed hollows the effects of the limestone can also be seen, and acid bent–fescue grassland occupies the brown forest soil sites. Grazings of this map unit are usually of moderate quality.

THE INSCH ASSOCIATION

(Map units 321–323, 325 and 327)

Soils developed on drifts derived from gabbros and associated rocks are grouped into the Insch Association (Glentworth 1944, 1954). In Western Scotland the rocks involved are of two ages, those intruded into Moinian rocks during the Caledonian orogeny and the Tertiary volcanic vents of the west coast. In the older group, occurring in Glen Loy, Glen Dessary and Ratagan, the rocks are hornblende-gabbros, mafic metasyenites and basic syenites. In the younger group on Skye and Ardnamurchan, olivine-gabbros, quartz-gabbros and eucrite are found. Gabbros occur in two other Tertiary volcanic centres, Rhum and Mull; in the former they are a minor component with ultrabasic rocks and placed in the Corriebreck Association, in the latter, although locally prominent, they are part of the very complex igneous assemblage mapped into the Torosay Association. The Insch Association occupies 86 square kilometres (0.5 per cent of the region).

The basic rocks of Glen Loy, Glen Dessary and Ratagan have been deeply excavated. The valley floors are mainly moraine-filled and at Ratagan and Glen Loy there is such a high schist and gneiss content that they have been mapped into the Arkaig Association. At Glen Dessary the moraines contain a high proportion of basic material. On Skye the gabbros form the Cuillin mountain mass and have been mapped as rock and scree except for a fringe of very bouldery rocky moraines in the corries. On the Ardnamurchan peninsula the biotite-eucrite forms a high, rocky ring enclosing a core of lower quartz-gabbro and fluxion gabbro, the quartz- and hypersthene-gabbros also forming lower ground outside the eucrite ring. There are few moraines in evidence although some deposits which may be morainic occur on lee slopes. The principal drift-type is, however, colluvium. The coarse-grained gabbroic rocks weather to form a gritty, brown, sandy loam. Since the rock structures are usually very coarse, the colluvium forms only a thin skin over broad boss-like landforms, except in hollows where accumulation takes place. The wide variety of scenery in the gabbros is simplified on the soil map into five map units; over 90 per cent of the soils in the association have peaty surface horizons, the remaining 10 per cent (principally brown forest soils and brown rankers) having a proportion of steep land which prevents intensive agricultural use in marked contrast to the till landscapes and good farmland on the association in Eastern Scotland. The percentage of peat soils also contrasts with the usual trend for basic rocks in Western Scotland to develop a high proportion of soils with mineral surface horizons.

Despite the wide distribution of the association, the climate is wet or very wet (potential water deficits less than 25 millimetres and mean annual rainfall always greater than 1600 millimetres and often above 2000 millimetres) and cool, with accumulated temperatures falling below 825 day°C to cold and very cold in most of the mountains. The vegetation follows the climatic pattern and shows little influence of the parent material except in the restricted areas of mineral soils where richer variations may occur. Hence herb-rich bent–fescue grassland and herb-rich Atlantic heather moor may be found among the acid bent–fescue grassland and heath rush–fescue grassland on the brown forest soils and humus-iron podzols, but the uplands are dominated by flying bent bog, bog heather moor, moist Atlantic heather moor and blanket bog. The only indication of the chemical richness of the parent rock is found in the light flushing which encourages the development of flying bent (*Molinia caerulea*) and the more intensive rush flushes. Some northern forms also occur.

Map unit 321 is the smallest of the association (3 square kilometres; less than 5 per cent of the association) and is confined to south-facing slopes in Glen Dessary and Glen Pean. Some of the landscape is hummocky with brown forest soils on the mounds and humic gleys, peaty gleys and occasional peat in the hollows; the most extensive occurrence in Glen Pean, however, consists of a steep gullied slope with brown forest soils on shedding sites and gleys in the flushes between. The well-drained soils support bent–fescue grassland which is often infested with bracken; rush pastures occur in the flushed areas and the peat carries flying bent bog. Much of the map unit has been forested but some land remains as rough grazings of good quality.

Map unit 322 occupies 9 square kilometres (10 per cent of the association) and occurs on the valley floors of Glen Dessary and Glen Pean. In this locality it is less bouldery than the high corries around the Cuillin mass, its other principal occurrence. The mounds of peaty gley and peaty podzol contrast sharply with the deep peat hollows. Grazing on the bog heather moor, and the moist and northern Atlantic heather moors is poor, though occasional flushes may provide a slight improvement in places.

Map unit 323, although comprising only 5 square kilometres (5 per cent of the association) is the most valuable land. The shallow, brown, freely draining, rather gritty sandy loam soils, broken up by rock outcrops, provide good grazing on acid and herb-rich bent–fescue grasslands. In some areas the sward has been improved by rotavation and reseeding but is unsuited to arable use. The unit was examined in detail during systematic mapping on the Ardnamurchan peninsula where it was discovered to contain 45 per cent brown forest soils and 22 per cent brown rankers, both freely drained, and a wide range of soil types including 6 per cent of both peaty ranker and alluvium. Some podzols are associated with the unit on steeper slopes which have not been cultivated. The brown forest soils are low in clay and silt and contain over 80 per cent sand; base saturation is low and surface pH about 5.0. Organic matter is high throughout the profile (often 10 per cent at 40–50 centimetres depth). Soil colours are correspondingly dull. The map unit is found principally on the gabbros of Ardnamurchan where it forms the heart of a farming and crofting community. Elsewhere an extensive area on steeper slopes above Glen Loy is forested. Except in sheltered areas, shallowness may lead to windthrow.

Map unit 325 is one of the most extensive units of the association (34 square kilometres; 40 per cent of the association) and is essentially peaty. A detailed investigation of part of the map unit during the systematic mapping of Ardnamurchan revealed 42 per cent peaty gleys, 17 per cent rankers and 13 per cent peaty podzols. Despite the prominence of rock outcrops in the landscape they occupy only 2 per cent of the five sample areas investigated. The profile of the peaty gley soils is similar to other associations which are found on basic or intermediate igneous rocks (e.g. the Darleith, Sourhope and Torosay) in that very low values and chromas prevail and mottling is subdued by large amounts of translocated humus. Profile colours are usually dark brown or dark greyish brown. The high proportion of peaty rankers in the unit is an indication of the shallow depth to rock. In 62 out of 100 profiles examined in the sample areas, rock was encountered at less than 60 centimetres from the surface.

Apart from a very small area on the tip of Ardnamurchan, the average annual rainfall is over 1600 millimetres; the peaty surfaces would therefore be

very difficult to reclaim and manage for grassland without serious risk of damage by poaching. A small area near Kilchoan has been reclaimed, otherwise most of the map unit is used for rough grazings of low value.

Map unit 327 is almost identical to *map unit* 325 even in area. It occupies 35 square kilometres (40 per cent of the association). Rock however is prevalent and there is a corresponding increase in peaty rankers and a slight decline in the amount of peat in the unit. The map unit is clearly unsuitable for reclamation and yields grazings of low value. It is only partially suited to forestry and even then severe windblow would be likely.

THE KINTYRE ASSOCIATION

(Map unit 335)

Soils of the Kintyre Association are developed on till comprising a mixture of Dalradian schists and red sandstones (either Old or New Red Sandstone) which impart the characteristic reddish brown to red colour to the drift. These rocks are thought to be sandstones from the Clyde basin which have been dragged up by ice during the main glaciation and mixed with the local rocks. The parent material has a fine sandy loam to loam texture and sometimes has a platy structure. The association covers 2 square kilometres on the southern edge of the area, in two localities, near Loch Fyne and Loch Eck, and forms the northern extremity of 486 square kilometres found in South-West Scotland. The landscape is one of lodgement till, with some rock outcrops and rock-controlled ground. Slopes are gentle and strong.

Map unit 335 is the only map unit in this association in the region. The soils are mainly noncalcareous and humic gleys, with some brown forest soils and peaty gleys. The high proportion of fine sand in the drift gives capping problems in the cultivated portion of the map unit and poaching is also a problem associated with the gleys. Some colluvial drift is found close to the rock outcrops, and has soils of the Strichen Association developed on it, principally brown forest soils and humus-iron podzols. Larger areas of non-rocky ground may be cultivated, but most of the unit is in permanent pastures, with rush pastures and sedge mires found on flushed noncalcareous and humic gleys. Grazing value of the semi-natural plant communities is usually high.

THE KNOCKSKAE ASSOCIATION

(Map units 357 and 358)

This association is found near Inverary on the north-west shores of Loch Fyne and between Loch Eishort and Broadford on Skye, covering 45 square kilometres. The landscape is one of moderately to very rocky ridges and plateaux.

The parent rocks are felsites, fine-grained acid to intermediate igneous rocks of Tertiary age. These also occur in the igneous complexes of Glencoe, Mull and Skye where they are incorporated in the Torosay Association. The parent material is a stony colluvium with a low fine earth fraction and interstitial material consisting of organic matter. The soils are peaty gleys and peaty rankers, and peat is widespread in the map units. The climate is fairly warm to

cool and wet. Moorland species dominate the plant communities which are bog heather moor, with some Atlantic heather moor on steeper slopes and dry knolls. Boreal heather moor is seen at higher elevations and the peat is covered by bog communities. The main land use is rough grazing.

Map unit 357 is the most extensive map unit of the association (38 square kilometres) and is found on slightly to moderately rocky, strongly undulating hills. Altitude ranges from sea level to just over 400 metres and there are some subalpine soils at the upper limit. Peaty gleys are the most important soils and have B horizons which consist of interlocking shattered rock with interstitial sandy organic matter passing gradually into bedrock. Peaty rankers are also present. Atlantic and boreal heather moors and bog heather moor are the main plant communities of the peaty gleys and peaty rankers, while there is some flying bent grassland.

Map unit 358 is mainly found on Skye and covers 7 square kilometres. The land is very rocky and irregular but slopes are generally less than 15 degrees. The soils are peaty gleys, peaty rankers and peat.

THE LAURENCEKIRK ASSOCIATION

(Map unit 368)

The soils of the Laurencekirk Association are developed on drift derived from marls and mudstones of Lower Old Red Sandstone age. Although extensive farther east, the only occurrence in Western Scotland is between Loch Ard Forest and Gartmore where two hog's-back ridges amount to approximately 1 square kilometre.

Map unit 368 has been mapped on these ridges. The major soil type is a brown forest soil with gleying in the B and C horizons, though some noncalcareous gleys are present in depressions. The topsoils are silty and give considerable problems of wetness and workability under the 1750 millimetres rainfall of the district. Despite this, some arable cropping is possible.

THE LINKS ASSOCIATION

(Map units 381 and 384)

Although of very limited extent, only 2 square kilometres, the Links Association is important since it forms cultivable land in a wilderness of peat and rock. The soils are developed on undulating and moundy deposits of windblown sand and found on the west coast between Gortenfern (Ardnamurchan) and Mallaig, and also on Coll. Most of the sandy parent material is siliceous but occasional pockets of shelly sand (the Fraserburgh Association), too small to show on the map, are found, mainly near Traigh. Mineral soils of the more recently stabilized dunes close to sea level are immature and show few profile features apart from humus staining and buried surface horizons. Slightly further inland and a few metres higher the older dunes display well-developed humus-iron podzols. The topography is rarely severely moundy and the association provides good croft land and permanent grazings, but the excessive drainage

and low water-retention capacities of the soils leads to drought problems in a dry spring.

Increasing recreational use is being made of these areas. There are many camp sites, caravan parks and a golf course. Eroded areas due to both overgrazing and intensive recreational use are occasionally evident.

Map unit 381 accounts for most of the area occupied by the association. The soils are noncalcareous regosols and humus-iron podzols which in their natural state have northern marram grass dune and acid bent–fescue grassland as the main plant communities. A few wetter hollows with gley soils have rush pastures and sedge mires.

Map unit 384 is seen only on the coast between Gortenfern and Ardtoe where it occupies less than 1 square kilometre. Soils are generally weakly developed peaty gleys. In addition, peat is present on flats and in hollows. Vegetation is Atlantic heather moor and blanket bog. Some eroded areas and active dunes are present but the ground is used for forestry and rough grazings.

THE LOCHINVER ASSOCIATION

(Map units 386, 387, 389, 391–398)

The soils of this association cover 729 square kilometres (4.4 per cent of the region) and are developed on drifts derived from rocks of Lewisian age. They are found at many localities, principally on the Hebridean islands of North Uist, Rona, Raasay, Skye, Coll, Tiree and Iona, on the mainland around Loch Maree and between Loch Torridon and Loch Hourn and near Scardroy, with some smaller parcels in Fannich Forest and near Sgurr na Lapaich. The landscapes range from very rocky, peaty moorland, for example on Coll, to slightly rocky crofting and farming land seen on the Sleat peninsula of Skye. Steep, slightly rocky slopes with good grazings round Loch Duich and Loch Long provide a pleasant contrast to the surrounding Moinian landforms whose slopes are more rugged.

The drifts are formed from a variety of rocks, broadly divided into gneisses and schists. The gneisses are of acid, intermediate and basic composition and are resistant to weathering. Consequently, the terrain is usually rocky and drift cover thin except in areas of valley moraine. The gneiss drift is of a stony, coarse sandy texture with low silt content (10 per cent). There are some large areas of basic gneiss (amphibolites and hornblende-gneiss) near Scardroy which produce drifts with higher proportions of brown forest soils and humus-iron podzols.

The schists, providing mellower landscapes, are chloritic and found in fairly close proximity to the Moine Thrust, being extensive on the Sleat peninsula and around Glenelg and Loch Duich. Chlorite-schist is more easily weathered to form a drift which, although ubiquitously thin, obscures the rock over large areas. This drift is less stony, has a higher proportion of silt (30 per cent in the B horizon) and is often slightly deeper than that from the gneisses. There are also significantly more brown forest soils and humus-iron podzols on the schists than on the gneisses.

Map units dominated by brown forest soils and humus-iron podzols cover 14 per cent, but peaty gley, peaty podzol and peat units are the most extensive, accounting for 78 per cent. Subalpine and alpine soil units cover 8 per cent and

are especially extensive in the north on the mainland. The mineral soils are mostly in crofting tenure but there is some farming (e.g. the area north of Armadale on the Sleat peninsula) and the steeper slopes around Morvich provide rough grazing of good value and some good forestry land. Most of the peaty and montane soils provide rough grazings of poor to moderate value.

The association is located in the north of the region, in fairly warm and cool temperature régimes. The cooler climate, combined with high rainfall, allows the growth of northern elements in the bog heather moor, Atlantic heather moor and blanket bog communities. Acid bent–fescue grassland grows on the mineral soils and is bracken-infested on steeper ground where control by spraying is difficult. Upland bent–fescue grassland with some alpine azalea–lichen heath and mountain blanket bog occur on upper mountain slopes, ridge crests and summits.

Map unit 386 is of very restricted extent (2 square kilometres) and only found on the north-west shore of Loch Carron between Strome Castle and Lochcarron village. The land is in crofting tenure and the soils have been cultivated so that mixing of organic and mineral horizons, iron pan disruption and higher pH and base status are all common features. Some morainic drifts are included in the unit which may, in parts, be very similar to *map unit 388* (in the Outer Hebrides) which has humus-iron podzols and cultivated soils on moraines. Arable crops and permanent pastures occupy the well-drained soils, while rush pastures and sedge mires cover the flushed, peaty or poorly drained soils.

Map unit 387 is located on drifts derived from chlorite-schists and is mostly found in close proximity to, and east of, the Moine Thrust. The unit covers 22 square kilometres and about 75 per cent of this is on the Sleat peninsula of Skye, with small areas on the mainland at Balmacara, Sandaig and Achmore. Landforms are slightly to moderately rocky, but the soils are always shallow on weathered rock. The drifts are usually locally derived colluvium which provides a thin, relatively stone-free mantle, but there is one small area north-west of Armadale where drift derived from these rocks has been carried approximately 1 kilometre and deposited over Torridonian strata. Podzolic brown forest soils and brown rankers are the main soil types in this predominantly freely drained unit. Some brown forest soils are also found on steeper uncultivated slopes with deeper drift. Textures are silty loams and sandy loams, with clay content rarely above 7 per cent. B horizon colours are strong brown to brown, with brighter colours probably indicating more podzolic soils, although organic-matter content is higher in the browner B horizons, and could be masking the colour. The pH is about 5 and the organic-matter content of the topsoil can be as high as 10 per cent. The brown rankers consist of a silty loam A horizon over weathered rock. The soils carry acid bent–fescue grassland, locally herb-rich and there are some areas of permanent pastures and arable, where slope and rock outcrops permit. There are some peaty gleys in the map unit that support rush pastures and sedge mires. Crofting and farming are the main land uses.

Map unit 389 is essentially a steeply sloping, moderately to very rocky variant of *map unit 387* and covers 36 square kilometres. The slopes are irregular and mostly wooded. An extensive area occurs along the north-east shores of Loch Maree. The unit is found either side of the Moine Thrust on drifts derived from gneisses and is dominated by brown forest soils and humus-iron podzols with

some peaty gleys on rocky ledges. The bent–fescue grassland provides valuable rough grazings.

Map unit 391 covers 51 square kilometres in this area, 21 square kilometres of which occurs on North Uist. The main area on the mainland lies in upper Strathconon, near Scardroy, consisting of moraines and some colluvium derived from the more basic gneisses. It also occurs in glens to the north-west of Loch Maree. Hummocky valley moraines form most of the unit with a few steeper, smoother slopes. Peaty podzols are found on the mounds and steep slopes, peaty gleys on the more subdued mounds and in flushes on steep slopes. The channels and hollows are usually filled with peat. Around Scardroy Lodge there is an area of mounds with brown forest soils and humus-iron podzols. The vegetation is bog heather and northern bog heather moors on the peaty podzols and gleys with some Atlantic heather moor on peaty podzols on steeper ground. Bent–fescue grassland is found on the mineral soils and provides better grazing.

Map unit 392 is found around Fionn Loch in the north of the area and in the same locality as *map unit 391* at Scardroy. It is a peaty, non-rocky unit covering 35 square kilometres and has a higher proportion of peat than *map unit 394*, from which it also differs in rockiness. Some isolated patches of till are also present. The main soil types are peat and peaty gleys, with peaty podzols on steeper slopes. Blanket and northern blanket bog occupies the peat, with bog heather or Atlantic heather moors on the peaty gleys and peaty podzols. These plant communities provide herbage of low grazing value.

Map unit 393 is confined to drifts derived from rocks east of the Moine Thrust and its principal locations are above the northern shores of Loch Alsh, Loch Long and Loch Duich, near Lochs Fannich and Luichart and around Scardroy. The unit covers 40 square kilometres, with 75 per cent in the first mentioned coastal localities. The steep slopes are slightly to moderately rocky and are frequently regular with minor gently undulating areas. The colluvial drifts are derived from basic Lewisian rocks, chlorite-schist, hornblende-schists and gneisses, and have an olive brown colour and a sandy loam texture. The dominant soils are brown forest soils at lower elevations and humus-iron podzols at higher elevations. The brown forest soils are often podzolic. These steep, well-drained slopes have a southerly aspect, support bent–fescue grassland and are well known locally for their grazing value.

Map unit 394 is one of the most extensive (203 square kilometres) in Lochinver Association and occurs throughout the area covered by the association. Moderate rockiness, slopes less than 15 degrees and peaty soils characterize this map unit, which is very similar in landform to *map unit 29* (the Arkaig Association), except on drifts derived from the chlorite-schist where it can be less rocky. Gently undulating to irregular, hillocky country typifies much of *map unit 394*. Colluvial drifts derived from both schistose and gneissic rocks form the parent materials. The main soil types are peaty gleys; on the acid gneisses their B horizons are characterized by a dark grey colour and stony sandy loam to loamy sand textures. On the schists, B horizons are yellowish brown and textures silty loam. The darker colours in the soils derived from gneiss are due to a higher organic-matter content (8 per cent) compared to the schistose rocks (1 per cent). Peaty rankers are also found in the map unit and peat is widespread. Bog heather moor and northern bog heather moor are extensive on the peaty gleys and rankers and blanket bog occupies the peat. Grazing values are low.

Map unit 395 is the most extensive (237 square kilometres) and differs from the previous map unit by being very rocky and having slightly higher proportions of peaty rankers. It covers 33 per cent of the association and has a rugged irregular landscape which can consist of rock outcrops and peat flats, or rock with peaty rankers and gleys. Plant communities have low nutritional value and forestry potential is lower than in *map units 395* and *392* due to the presence of rock. Land uses are mainly deer forest and sheep grazings.

Map unit 396 is essentially a steep-slope variant of *map units 394* and *395*, and is slightly to very rocky with slopes steeper than 15 degrees. There is little peat and a corresponding increase in peaty podzol, but peaty gleys on colluvium again dominate this unit. Bog heather moor, with some Atlantic heather moor, impart a low grazing value. The unit covers 47 square kilometres.

Map unit 397 consists of subalpine podzols and peat and occurs on upland plateaux with gentle and strong slopes. It is usually moderately rocky, but there can be considerable variation. It extends to 15 square kilometres and the two main areas are to the east of Beinn a'Chaisgein Mor in the extreme north of Sheet 4 and to the north of Loch Carron. Because of the topography, altitude and climate of these areas, subalpine podzols and peat are both developed. There is a sharp contrast between the knolls, which may be bouldery, and the hagged peat flats.

Alpine azalea–lichen heath occurs on the podzols and northern, upland and mountain blanket bogs on the peat, while the terminal phase of blanket bog is often found on the edges of the peat hags. Largely because of the severe climates at these altitudes, the land use is restricted to poor rough grazing.

Map unit 398 consists of subalpine and alpine soils, lithosols, regosols and rankers on slightly to very rocky mountains with gentle to very steep slopes. The extent is 41 square kilometres and is concentrated in the Letterewe Forest to the north of Loch Maree. Smaller areas occur to the north of Loch Carron and on the Scardroy inlier, further east. Two types of parent material occur, colluvial and cryic, and they correlate with steep slopes and plateaux respectively.

Many of the steep and very steep slopes in this map unit are crag and scree, and the most widespread soil types are lithosols, rankers and regosols. Vegetation cover is very sparse. Some less-rocky slopes of colluvium with weakly developed subalpine podzols occur and support stiff sedge–fescue grassland.

The more common landform is an undulating plateau with strong slopes where the dominant soils are subalpine and alpine podzols, with occasional gleys in hollows. Much of the alpine zone has only patchy vegetation and is very bouldery. Solifluction terraces and lobes are common micro-relief features. Subalpine podzols usually support alpine azalea–lichen heath, but fescue–woolly fringe-moss heath also occurs. Gleys are much less common and support white bent communities. On the more base-rich hornblende-schists, particularly on Beinn Lair, subalpine and alpine brown soils occur and support mountain white bent grassland. Much of the land has little or no agricultural significance, because of the extremely severe climate which results in a very short grazing season. Below the full oroarctic climate zone the land use is generally restricted to poor rough grazing, although some of the grassier slopes provide moderate grazing.

THE NIGG/PRESTON ASSOCIATIONS

(Map unit 420)

Soils of the Nigg/Preston Associations are developed on raised beach deposits which, although usually fine-textured, may be gravelly. These deposits, a feature of the Moray Firth coastal fringe, penetrate the valley of the River Peffery, just east of Strathpeffer. Although they occupy a mere 1 square kilometre they nevertheless are probably the best soils represented on Sheet 4 and all are cultivated. The unit extends to 62 square kilometres in the adjoining sheet, Eastern Scotland.

Map unit 420 is developed on the high raised beach which falls from 35 metres at the head of the strath of the River Peffery to 25 metres on the eastern edge of Sheet 4, a distance of 1.5 kilometres.

The carse-like soils are mostly imperfectly drained brown forest soils formed in deep, fine sandy loam or silty loam drift containing very few stones. In places the drainage may be poor. On the south side of the A834 road there is a gravel bank in the raised beach with cultivated podzols, indicative of the variability in the unit. There are some areas of riverine alluvium.

The area has one of the lowest rainfalls of any represented on Sheet 4; nevertheless, there are still some limitations to agriculture when compared with the still drier and warmer areas which are found further east along the Moray Firth coast.

THE NORTH MORMOND/ORTON ASSOCIATIONS

(Map units 424 and 425)

Soils of the North Mormond/Orton Associations have been mapped in the north-east of the Western Scotland region, mainly on the slopes and foothills that border the Moray Firth. Of the associations containing rocks of Old Red Sandstone age this combined association is the most extensive (38 square kilometres; 0.2 per cent of the region).

The parent material is a till derived from schists and granulites of the Moine Series, together with Old Red Sandstone sediments, mainly conglomerates and sandstones. The drift is usually below 300 metres and exhibits considerable variation, even over relatively short distances. Where the influence of sandstone is strong, the parent material is red at depth and the texture as fine as sandy clay loam. More commonly, however, the sandstone influence is not so apparent and the drift is a pale brown, stony sandy loam or loamy sand. The stones are frequently subrounded and it is probable that many of them were originally derived from the conglomerates although boulders of conglomerate are rarely encountered in the drift. Induration is a consistent feature of the subsoils. The tills are banked against the western hill masses giving regular, strong slopes rising steadily from the alluvial flats in the lower reaches of Strathconon and Strathglass to 250–300 metres over distances ranging from 2 to 4 kilometres.

The soils are predominantly humus-iron podzols with only minor peaty or wet elements. This reflects the drier climatic conditions of the east. Mean annual rainfall is about 900 millimetres and accumulated temperatures are between 1100–1375 day°C. If such parent materials had occurred farther west they would undoubtedly have been extensively gleyed. A large proportion of

the soils is cultivated or forested but in a few areas dry Atlantic heather moor overlies unimproved podzols. Although in much of the area the soils are used for pasture with occasional arable cropping, at Marybank near Strathconon is some of the best arable land of the Western Scotland region.

Map unit 424 is of minor extent, being confined to a small area of hill land about 3 kilometres north of Glen Urquhart. It occupies receiving sites and embayments in the foothills. Peaty and humic gleys, with subsidiary noncalcareous gleys are vegetated by bog heather moor and rush pastures. Due to the drier climate the soils are capable of improvement.

Map unit 425 is by far the largest in the association and occupies foothills and lower hill slopes for about 20 kilometres south of Strathconon. The slopes are mostly regular and strong and the unit is non-rocky.

Humus-iron podzols are the dominant soils and a large proportion is cultivated, especially at lower altitudes and on gentler slopes. Some peaty podzols develop near the upper limit of the unit where the gradient is less. Noncalcareous, humic and peaty gleys are minor components occupying hollows. In some areas drainage is impeded by the indurated horizon, but this is not a serious limitation to their use. At higher elevations, slope is a serious obstacle to agricultural development, especially when combined with shallow stony soils and peaty surface horizons.

Current land use probably reflects potential in these areas with a range of uses from arable land on the lower slopes to improved grazings on the upper. Much of this area is afforested. Induration may cause shallow rooting but the area is not exposed and windthrow rarely a problem.

THE ROY ASSOCIATION

(Map units 452 and 453)

The glacial lake systems of Glen Roy and Glen Gloy are internationally known to students of geomorphology and illustrations of the 'parallel roads' or shorelines of the lakes have appeared in many textbooks. The sediments which were deposited beneath the surface of the glacial lakes present an extremely variable soil parent material, ranging in texture from coarse gravels to silt over distances of a few metres. In some places the deposits are totally unsorted and probably represent the original morainic infill of the valley. The Roy Association was designated to meet the special circumstances of the Glen Roy–Glen Gloy area, for although the parent materials are related to those of other recognized associations (e.g. the Corby, Stirling and Strichen Associations), they show a higher degree of variability than any and are geographically associated in a recognizable pattern. Two other areas were subsequently recognized near Loch Tulla, Bridge of Orchy and in Knoydart.

The extent of the association is small (36 square kilometres; 0.2 per cent of the area). It is located on the lower slopes and floors of strongly glaciated valleys in areas of high rainfall (1800–2000 millimetres). Current-bedding of the parent materials results in highly permeable gravel beds in proximity to slowly permeable silts. On steep slopes this produces spring lines and surface flushing with, on occasion, structural incompetence and the formation of landslips. Well-developed gullying is common.

The soils developed on this diverse parent material themselves vary greatly, principally in drainage characteristics. In freely drained sites strong leaching produces humus-iron podzols or at higher elevations, peaty podzols. On the silts the soils are humic gleys, noncalcareous gleys and peaty gleys. Many intergrades between these types are found.

The plant communities reflect spring lines and the flushing of surface water down slopes. Rush pastures and sedge mires are interspersed with small areas of acid bent–fescue grassland at lower elevations while Atlantic heather moor and bog heather moor, heath rush–fescue grassland and rush pastures are found on the peatier soils at higher elevations.

Map unit 452 occupies 12 square kilometres (35 per cent of the association) and occurs in Glen Gloy and in small areas in Glen Roy. It comprises humic and noncalcareous gleys developed on silts, and humus-iron podzols on sands. The soils support swards with good grazing values but the site characteristics, particularly slope, are unfavourable to grassland operations and the soils are considered only marginally reclaimable.

Map unit 453 comprises peaty soils and occupies the largest part of Glen Roy and its tributary glens. The soils are dominantly peaty gleys but peaty podzols occur on steeper slopes or where a deeper solum has accumulated due to colluvial processes. Flatter sites have areas of shallow peat. The unit occupies 24 square kilometres (65 per cent of the association) and is largely unsuited to reclamation but is of moderate grazing value due to the presence of rush communities in frequent flushes. Glen Glas Dhoire is now forested and since the valley flushes are well-sheltered, windthrow problems associated with high water-tables over silty subsoils should be greatly reduced.

THE SABHAIL/MOUNTEAGLE ASSOCIATIONS

(Map unit 457)

Soils belonging to the Sabhail/Mounteagle Associations occupy 11 square kilometres on the west side of Loch Ness south of Drumnadrochit. The parent material in this area is drift derived from red sandstone which is believed to be of Lower Old Red Sandstone age. Locally there are thin pebbly bands. Low rock-controlled ridges, aligned north-east to south-west, are apparent in several localities of the single unit.

Map unit 457 is in the form of an undulating plateau lying at 200 metres above Drumnadrochit and rising gently to 350 metres to the south-west. Slopes in general are gentle or strong and the unit is non-rocky to slightly rocky. At the southern end of the plateau peaty soils predominate, the peaty podzols on the mounds and ridges and the peaty gleys in hollows and on gentle slopes. Toward the north, patchy cultivation has occurred and soils include cultivated podzols, cultivated peaty gleys and noncalcareous gleys. Soils tend to be shallow with induration often acting as an impediment to drainage. Subsoil textures are sandy loam or loamy sand. The main plant communities are Atlantic heather moor and bog heather moor.

The narrow, but prominent, very steep plateau edge has been retained within this unit and here humus-iron podzols with some brown forest soils are developed on the colluvium. Bent–fescue grassland with bracken and natural oakwood occupy these slopes.

THE SOURHOPE ASSOCIATION

(Map units 479 and 480)

In Scotland, lavas of andesitic composition occur either associated with sediments of Old Red Sandstone age, as in the Midland Valley, or with granitic masses as at Cheviot, and Ben Cruachan, Argyll. The latter is in the Western Scotland area where the Lorne Volcanic Plateau extends south-west from Cruachan to the coast (342 square kilometres; 2 per cent of the area). Its soils are grouped into the Sourhope Association (Muir 1956). Two smaller outcrops of andesite occur in Glencoe and on the summit plateau of Ben Nevis; the former has been included in the Torosay Association because of its complex relationships with other rock types, the latter is mapped as scree and rock. Andesites of the Loch Don anticline, Mull, are below the minimum size for mapping.

The Lorne Volcanic Plateau is composed of rocks ranging in composition from basic andesites (closely resembling basalts) through pyroxene- and hornblende-andesites to tuffs and sediments. The sediments occur chiefly near Oban and on the Island of Kerrera and were produced by the erosion of an earlier suite of andesitic rocks. Their soils are similar in field appearance to those of the Sourhope Association with which they are included.

The drifts forming the soil parent materials are of two types, a brown loam or sandy loam colluvium, shallow and moderately stony for the most part, and a more stony morainic drift. The moraines are often indurated and slightly coarser in texture. The colluvial deposit is prevalent on hill summits and slopes, the moraine deposits being restricted to valley floors and lower slopes. The latter are thin and patchy and rarely have the strong topographic expression so characteristic of the moraines in other soil associations.

Kynaston and Hill (1908) described the scenic features as 'a monotonous succession of scarped and terraced hills and peat covered moors with numerous rounded knobs and bosses of rock unrelieved by any conspicuous peak or lofty eminence'. Although distinct areas can be recognized among the 'scarped and terraced hills' which may be dominated by one soil or another, they are rarely extensive enough to provide separate units for mapping. Even the scarps and terraces are more subdued than those of the Tertiary basalts (the Darleith Association) and since the plateau rarely rises above 400 metres subalpine soils are not often developed. Only two mapping units have been used therefore, one dominated by brown forest soils (29 per cent), the other equally by peaty gleys, peats and peaty podzols (71 per cent). The percentage dominated by the brown forest soil unit is similar to that in the Darleith Association (25 per cent).

The climate in the valleys is warm (greater than 1375 day°C) and that of the main part of the plateau fairly warm to cool (greater than 875 day°C). The whole area is wet with summer rainfall exceeding evapo-transpiration by more than 500 millimetres over a large part of the hill land. Vegetation types are similar to those of the Darleith Association with bent–fescue grassland, often severely invaded by bracken on the brown forest soil unit, rush pasture and yellow flag swamp in flushes and on alluvium in valley floors. Oakwoods are common. The hills are typically moist Atlantic heather moor with a high proportion of flying bent, sometimes developing into flying bent grassland and flying bent bog. Dry Atlantic heather moor characterizes some of the steep slopes underlain by peaty podzols and there are often grassy patches on deeper scree slopes. Peat is prevalent on the higher hills and blanket bog communities

predominate. Only on the highest summits do the communities show signs of becoming oroarctic.

Map unit 479 is found at low elevations (usually below 100 metres) on a wide range of slopes and spans both colluvial and shallow moraine deposits. Like *map unit 158* of the Darleith Association it is dominated by brown forest soils. Substantial amounts of brown rankers are found, reflecting the shallowness of the solum and humic gleys are common in hollows in the irregular topography. Although the number of analyses yet available is limited, there seems to be a similar trend to brown forest soils developed on basalt in that sites above 30 metres have higher organic-matter contents, especially in the surface horizons, higher carbon/nitrogen ratios and lower base status. These properties probably reflect former humus-iron podzols that were cultivated when populations were higher during the nineteenth century.

The map unit is slightly rocky but the prevalence of rock close to the surface renders few areas suitable for regular arable use, though many are very suitable for reclamation for grassland. On sites which are not developed, soft rush pastures occupy the wetter hollows, and bent–fescue grassland the drier sites, which are often heavily infested with bracken. The unit occupies 99 square kilometres (29 per cent of the association).

Map unit 480 is extensive above 100 metres (243 square kilometres; 71 per cent of the association). Climatic conditions and shallowness lead to a high proportion of peaty gleys and peat. Peaty podzols develop on steep slopes or where slope and a deeper solum combine to provide better overall site drainage. Both peaty gleys and peaty podzols have organic horizons, usually less than 30 centimetres thick, which at elevations less than 150 metres have been important in allowing reclamation for sheep grazing. In podzolic soils the development of an E horizon is weak and it is particularly difficult to detect in freshly dug profiles due to the lack of quartz in the parent rock and the presence of heavy humus staining. Iron pans are usually discontinuous and weak except in soils on morainic parent material when the pan forms at the top of the indurated horizon. In the peaty gleys the humus staining results in low values and chromas in all horizons and the obscuring of mottling except in weathering stones.

Several farms have reclaimed portions of the complex, which then gives earlier and better quality grazing for sheep and lambs. The management of the sward is more difficult than that on soils in *map unit 479*, but it obviously provides a valuable addition to farm resources. The reasons why reclamation should be successful in this unit and not in analogous units in other associations (e.g. *map units 160* or *247*) is not clear but may be partially explained by the ground configuration. The most successful reclamation schemes are usually on land with little or no peat, shallow soils and strong slopes which assists run-off at times of heavy rainfall.

The vegetation of unimproved sites in the unit is Atlantic heather moor, bog heather moor or boreal heather moor on the higher summits. Minor hagging of all soils with organic horizons is also widespread at high elevations.

THE STAFFIN ASSOCIATION

(Map units 483–486)

The association which occupies 60 square kilometres (0.4 per cent of the area) is restricted to northern Skye, Raasay, Tiree and Coll. The soils are developed

upon a silty or clayey till derived from calcareous shales, clays and some limestones of Jurassic age (Kimmeridge and Oxford clays) on Skye. On Tiree and Coll there are no terrestrial outcrops of these rocks but off-shore basins containing them are known (Institute of Geological Sciences 1979). The correlation with the Skye parent materials is rather tentative. Stones in the till have several sources; basalt, dolerite and sandstones occur in Skye, while Lewisian gneiss is found in the drifts of Tiree. The texture of the C horizon varies from loam to silty clay, the coarser textures probably reflecting local contamination by weathered sandstones on Skye. The colour of the parent material is dark greenish grey. In the Scottish context parent materials of this type derived from Mesozoic rocks are unusual, the only other recorded area being on Shempston Farm, near Duffus in Morayshire (6 hectares, Grant 1960).

The landscape consists of gently undulating, subdued drumlins separated by wet hollows and flats and is always below 100 metres (Plate 7). The areas are dominantly non-rocky. The Staffin Association is one of the few soil associations in Western Scotland with high base saturation and significant amounts of exchangeable calcium and magnesium (the others being the Fraserburgh, the Inchnadamph and some soils of the Inchkenneth Associations). Sodium too is unusually high, probably a result of the island situation and salt contamination from sea spray. The saltiness gives rise to some maritime pasture in Tiree, although the vegetation generally is not halophytic. In common with other associations of soils developed on basic rocks, high proportions of mineral soils are recorded (the extent of units dominated by mineral and peaty soils is approximately equal). The principal soils are calcareous, noncalcareous and humic gleys with peaty alluvium, peaty gleys and peat occurring in hollows.

Warm, moist conditions prevail in Tiree with a mean annual rainfall of approximately 1200 millimetres, while Skye has a fairly warm rather wet climate with rainfall of 2000 millimetres. The land is used mainly as grazings, both rough and improved, although some arable crops are grown on areas of lighter land as in Tiree where windblown shell sand has been incorporated into the plough layer. Very careful management of the soils is necessary to avoid excessive poaching by stock and compaction by tractor operations. The soils usually occur in very exposed areas which would give problems for forestry as would the calcareous nature of some of the subsoils.

Map unit 483 accounts for nearly half the area of the association (28 square kilometres) and most of this occurs in northern Skye. The principal components are gleys, mainly noncalcareous, calcareous and humic gleys but some peaty gleys and peaty-alluvial soils are present in hollows. The gleys have a shallow plough layer (18 centimetres) often mottled, underlain by a brown Bg horizon with strong brown mottles, coarse prismatic structure and clay or clay loam texture about 40 centimetres in depth, followed by a massive C horizon. Fields with marginally better drainage or lighter textures are used for arable crops but permanent pastures, often invaded by rushes, are more usual. Rush pastures and yellow flag swamp are found on the wetter sites.

Map unit 484 is equivalent to *map unit 483* but is slightly rocky. It is confined to Coll and Tiree and occupies only 4 square kilometres. The soils are gleys on till with limited rankers associated with the rock knolls. Grazing is the main land use on improved and rush pastures.

Map unit 485 is composed of soils with organic surface horizons. On Skye both peaty gleys and peat have developed, but under the lower rainfalls of Tiree only a peaty gley with shallow organic horizons (15 centimetres) and sometimes high pH (greater than 7) is found. Some reclamation has been attempted on Tiree but on Skye the additional rainfall has restricted the use of these soils to rough grazing. Plant communities include moist Atlantic heather moor, bog heather moor, blanket bog and yellow flag swamp. The unit occupies 19 square kilometres (30 per cent of the association).

Map unit 486 occupies 9 square kilometres chiefly on Tiree. It is similar in most respects to the previous map unit, but rankers occur on knolls of Lewisian gneiss, in addition to the peaty gleys, humic gleys and peat present on the till.

THE STIRLING/DUFFUS/POW/CARBROOK ASSOCIATIONS

(Map unit 488)

This group of soil associations is one of the smallest and least significant in Western Scotland (3 square kilometres; less than 0.1 per cent of the area), although it is extensive in the east of Scotland. Its soils are formed from deposits of raised beach silts, always estuarine in occurrence and found below 15 metres. The silts are derived by local deposition from fine-grained rocks, calcareous schists and interbedded slates (Lismore Island), graphitic slates (South Shian, Benderloch) and Ardrishaig phyllites (the Moine Mhor, Lochgilphead). At South Shian, materials of this type have been involved in the push moraine of the Glen Creran glacier and folded into an arcuate ridge from which an arctic marine fauna has been recovered.

Under the high rainfalls of the west coast the low permeability of the silts causes the soils to remain wet throughout the year. With practically no fall for drainage they are extremely difficult to improve. Porous backfill for the drains is necessary, but due to the low-lying nature of the sites even this is not sufficient in some cases, as drain outlets may be covered by the sea at high tide. The soils have attracted attempts at reclamation but swards are easily damaged and reversion to rushes is rapid. This is in marked distinction to similar soils in the east of Scotland in lower rainfall régimes which provide noted farmland.

Map unit 488 comprises a range of noncalcareous, humic and peaty gleys. In addition to the mapped areas, isolated examples of these soils have been included with other mapping units, for example at North Shian and Strath of Appin.

THE STONEHAVEN ASSOCIATION

(Map units 490, 493, 495 and 496)

The parent material of the Stonehaven Association is derived from conglomerates and lavas of Lower Old Red Sandstone age. It is usually a compact, reddish brown sandy loam till with a significant number of cobbles (2–10 centimetres diameter) of quartz-mica-schist, quartzite and lava. On steep hill sides the till gives way to colluvium derived directly from the conglomerates. It is very restricted in extent in Western Scotland (8 square kilometres; 0.1 per cent of the area), extending in a north-easterly direction along a pronounced

ridge from Balmaha on Loch Lomondside towards Aberfeldy, just outside the map boundary. Near Balmaha conglomerates of Upper Old Red Sandstone age are found; these are largely obscured by peat and their outcrop above Balmaha is so restricted that they have been incorporated with the Stonehaven Association. It also occurs on islands in Loch Lomond. The ridge is 1 to 2 kilometres wide and rises from 30 metres on Loch Lomondside to 460 metres on Gualann, the highest point, before falling steadily through the Loch Ard forest. The average annual rainfall varies from 1600 millimetres to 2200 millimetres over the same distance; the climate is categorized as warm and wet in the lowland to cool and wet on the hills.

Four soil complexes have been designated which are dominated by two major soils, brown forest soils and humus-iron podzols. Noncalcareous gleys, brown rankers, peaty podzols and peaty gleys also occur. Brown forest soils occupy the lowest slopes, humus-iron podzols the middle slopes and peaty podzols and peat with rock outcrops the gentler slopes at high altitudes.

The land use throughout the association is rough grazing and forestry.

Map unit 490 is dominated by brown forest soils with some flushed noncalcareous gleys. The soils are developed on tills and are usually free draining, but in some areas where the till is thin (e.g. the islands of Loch Lomond) small patches similar to *map unit 495* may be included. The map unit occupies 3 square kilometres (40 per cent of the association). The principal plant community is acid bent–fescue grassland.

Map unit 493 is mapped where humus-iron podzols with subsidiary gleys and peaty podzols are found. The map unit occurs on the middle slopes of rolling foothills where the tills are thin and stony, and has occasional rock outcrops. It is devoted to rough grazing and both deciduous and coniferous woodland are found. It occupies 3 square kilometres (40 per cent of the association). Plant communities include dry Atlantic heather moor and acid bent–fescue grassland.

Map unit 495 is very restricted in extent (less than 1 square kilometre) and occurs on steep, rounded slopes with low rock outcrops at their heads. The fairly deep, loamy, colluvium thins occasionally to give rankers. Plant communities include acid bent–fescue grassland, rush pasture and sedge mires.

Map unit 496 is very similar in landform to *map unit 495* but is found at higher altitudes where humus-iron podzols, peaty podzols and rankers are the predominant soil groups. Minor peat and flushed peaty gleys also occur. The parent material is a thin stony till or patchy colluvium and the soils support dry Atlantic heather moor, acid bent–fescue grassland and common white bent grassland.

THE STRICHEN ASSOCIATION

(Map units 497–515)

The rocks contributing to the Strichen Association were originally described (Glentworth 1954) as slates, phyllites, schists, gneisses, granulites and marbles of the Keith Division of the Highland Schists. Until 1980 soils formed on drifts derived from both the Moinian and the Dalradian Assemblages were included within the association by the Soil Survey. Recent work has shown significant

differences between the two groups in textural, morphological, chemical and soil landscape properties. The soils developed on drifts derived from Moinian rocks are now included in the Arkaig Association and this change should be noted in referring to the two larger scale maps so far published in Western Scotland (Bibby 1974; Bibby, Hudson and Henderson 1980).

The Strichen Association is defined as soils developed on drifts derived from schistose grits and mica-schists, principally of the Dalradian Assemblage. It intergrades to several other associations, for example the Arkaig Association which is coarser, shallower and more rocky, the Foudland Association which is finer with higher silt contents and less rocky and the Durnhill Association which is mapped where massive quartzites provide very stony, coarse soils. Intergrades to the Tarves Association are also found where the schists contain hornblende or high concentrations of chlorite affecting soil development, or where local igneous intrusions add basic igneous material to schistose drifts. Textures of the parent materials of the Strichen Association have high proportions of fine sand and silt which cause structural instability and problems with capping, poaching and collapse of drainage ditches. There is an element of coarse sand too however, which distinguishes it from the finer textures of the Foudland Association. The drifts have much stone and are fairly shallow through most of the region.

Moraine, tills and colluvium have all been identified. Map units developed on moraines occupy 599 square kilometres (30 per cent of the association). The deposits have the typical hummocky landforms in valley bottoms. Moraine-covered valley sides and mountain slopes are frequently gullied but there are some smoother slopes. Induration is almost always present in the olive grey moraines, frequently displaying platy structure, but the boulderiness of the surfaces is not as severe as in the Arkaig Association. The mounds appear to be more stable than those of the Foudland Association however, which are very gentle, probably due to the instability of slopes with high silt and fine sand content. Tills occupy only 4 per cent of the association in the wider valleys and the south-east of the region and often have slightly heavier textures. They become considerably more extensive outside the limits of the Loch Lomond Readvance glaciation to the east of the region. Colluvial drifts occupy 50 per cent of the association on hill slopes and valley sides. They are frequently shallow with soil horizon formation penetrating to shattered rock and no clear indication of a C horizon. The colluvium, rarely indurated, has a sandy loam or loam texture. The upper hill slopes and summits are covered with shallow, stony, frost-comminuted materials (16 per cent) often *in situ* or very close to their place of origin.

The association is the second most extensive (1965 square kilometres; 11.7 per cent of the region) and is confined to the area south-east of the Great Glen fault. The landscapes are mountainous but often with a more even outline and more regular slopes than the northern and western mountains. It achieves its highest elevations at Ben More and Stob Binnein near Crianlarich, and Aonach Beag near Ben Nevis. A large portion of the terrain is upland lying between 100 metres and 500 metres and has a characteristic strong north-east to south-west grain which is very apparent both on Ordnance Survey maps and aerial photographs. The percentages of map units in the very rocky class is 11, 5 and 0 respectively in the Arkaig, the Strichen and the Foudland Associations, further illustrating the intermediate nature of the Strichen Association. The association is found in the Western Plateau and Foothill region and the Dissected Central Mountain region (Fig. 2).

The large number of map units in the association can be grouped according to their dominant soils to indicate approximately the amount of each major soil subgroup. Map units dominated by peaty gleys and peaty podzols cover 34 per cent and 32 per cent respectively, humus-iron podzol and brown forest soil units cover 16 per cent, alpine and subalpine soil units 16 per cent and noncalcareous gley units are least extensive with only 2 per cent. The most extensive soils of the Strichen Association are peaty gleys and peaty podzols and ten map units are devoted to describing their distribution. The warmer climates of the south-east of the region have resulted in the development of a relatively high proportion of humus-iron podzols (compared to other associations on acid rocks to the north). The noncalcareous gleys are the western outliers of an extensive area of till in the Strichen Association in Eastern Scotland, the soils of which become progressively drier under the lower rainfalls of the east.

The climate of areas occupied by the Strichen Association is warm at low elevations in the west; a large area of fairly warm and cool conditions in the Western Plateaux and Foothills is followed by a rapid change to cold and very cold in the higher altitudes of the Dissected Central Mountain region. Rainfall is high everywhere and potential water deficit is zero.

The plant communities are dominantly heathy or grassy, and bog heather moor and Atlantic heather moor in the extreme south-west are gradually replaced by common white bent and bent–fescue grassland on the mountains and in the east. Flying bent grassland is extensive throughout the area, particularly in the west.

The land use is inevitably extensive sheep grazings and forestry. Compared to the Arkaig Association there are larger areas of grazings with moderate value and trees also fare better. Some of the small units mapped in the extreme south-east, especially non-rocky areas with mineral soils, are particularly important.

The first four map units (497–500) are extensive in Eastern Scotland, and in the handbook for that area fuller descriptions including more comprehensive soil information will be found.

Map unit 497 is dominated by noncalcareous gleys with lesser areas of humic and peaty gleys, humus-iron podzols and minor patches of peat. It is found in the south-east corner of the area, east of Loch Lomond, where it covers 30 square kilometres (2 per cent of the association). The parent materials are predominantly sandy loam or loam colluvium with some till on the lower slopes. The tills are of low permeability with poorly drained soils and some surface flushing. The colluvial noncalcareous and humic gleys have C horizons of a light yellowish brown colour, strong brown mottles and a sandy loam or loam texture. Organic-matter content of the topsoil is usually greater than 5 per cent and often higher than 8–10 per cent. Much of the unit occurs on hill slopes in this area and is extensively forested.

Map unit 498 is mainly humus-iron podzols with some brown forest soils and minor noncalcareous and peaty gleys. Occurring in the same general locality as *map unit 497* its parent material is a compact stony sandy loam till or shallow drift. The freely drained soils are found on strong slopes and poorly drained or peaty soils on gentler slopes or in receiving sites. The land is non-rocky with long, straight slopes of less than 15 degrees. It occupies 18 square kilometres (less than 1 per cent of the association) and is extensively forested.

Map unit 499 is not extensive (1 square kilometre), has similar landform and parent material to *map unit 498* but occurs at higher altitude where cooler and wetter climate prevails. The soils found are peaty podzols and some peat. Rough grazings of low value and coniferous woodland dominate land use.

Map unit 500 is developed on shallow, stony, parent material and its soils are peaty podzols and peat with some peaty gleys. The peaty gleys usually have an iron pan which impedes drainage further. Peat is confined to depressions receiving surface run-off. Land use is rough grazing of low value. The unit covers 11 square kilometres.

Map unit 501 has similar landforms to *map unit 500*; the dominant soils are peaty gleys, with peaty podzols confined to the steeper ground. The topography is either gently undulating or long straight slopes (less than 15 degrees) and the parent material occurs as till in embayments in valleys and on hill sides. There is a wide altitude range and some of the soils at lower elevations have been cultivated. Peat-filled basins are more extensive than in *map unit 500*. The map unit covers 32 square kilometres and provides rough grazing of low relative value.

Map unit 502 contains a similar suite of soils to *map unit 501*, but differs from it in occurring on steep slopes (greater than 15 degrees). The proportion of peat is therefore much lower and there is an increase in the amount of peaty podzol. The unit remains dominated by peaty gleys on fairly regular and often convex slopes. Occupying 29 square kilometres, it occurs close to the southern and eastern boundaries of the sheet, but there is a small area on the north-facing slopes above Leanachan Forest. Altitude ranges up to 900 metres, where the upper edge is marked by a change to subalpine and alpine soil types.

Map unit 503 extends to 145 square kilometres (7 per cent of the association) and is the less common (and drier) form of two map units developed upon moundy moraine. Humus-iron podzols and, occasionally, brown forest soils occupy the mounds, while intervening hollows develop humic gleys or, in wetter or higher situations, peaty gleys and peat. The mounds vary in their degree of development; sometimes strong as in valleys near Tyndrum and Crianlarich, sometimes more subdued as near Strachur. Occasionally the moraine has been carried over more basic rock types, as on the southern shores of Loch Etive between Oban and Taynuilt where andesites have been overrun, or near Strachur and Cairndow where Green Beds are invaded. Where this happens soils of *map unit 503* develop more readily and the unit is more extensive. The drifts do not, however, appear to be sufficiently distinctive to form a different parent material and new association. Intergrade situations are found between *map units 503* and *504* on occasion.

The freely drained acid brown forest soils and humus-iron podzols carry acid bent–fescue grassland. Bracken is locally dominant. The humic gleys are usually flushed and develop rush pasture with occasional sedge mires. In intergrade situations heathy elements develop more widely.

The map unit provides opportunities for reclamation for grassland but the soil and topographic variations rarely encourage arable cropping. Because of its sheltered situations in valley bottoms it is often good forest land despite the presence of induration and thin iron pans which prevent root penetration.

Map unit 504 covers 454 square kilometres (23 per cent of the association) and is the most extensive in the association. Moraine forms the parent material. On valley floors it has a hummocky form comprising mounds aligned up and down gentle slopes, whereas on steeper slopes it consists of gullied sheet moraine.

The landscape is less boulder-strewn than in the Arkaig or Countesswells Associations, and the drift has a finer texture. Peaty podzols are found on the mounds and steep slopes, while peaty gleys and peats occupy the channels, hollows and gentler slopes. The peaty podzols have a strong thin iron pan and, because this is impermeable, the mineral horizons above it are strongly gleyed. Organic-matter content is high in E horizons, but is very low below the iron pan in the B and C horizons. A thin zone of translocated iron is developed in the top of the indurated C horizon material and the soils intergrade to peaty fragogleys.

Bog heather moor is found on the peaty gleys and podzols, with some Atlantic heather moor in drier sites. Blanket bog communities are developed on the peat. The steeper, drier slopes are extensive and carry common white bent grassland, providing grazings of higher value. This map unit has quite good forestry potential which is now being utilized in many areas.

Map unit 505 consists of steep, slightly to moderately rocky slopes in lowland to mid-hill areas. It is found on many valley and hill sides throughout the Strichen Association, except where that topographic situation is taken up by moraines (*map units 503* and *504*) and extends to 114 square kilometres. Most of the map unit is moderately rocky, has irregular slopes steeper than 15 degrees and is best seen east of Loch Long. The map unit is sometimes found on smooth, almost planar slopes with very few rock outcrops, particularly well developed between Loch Lochy and Glen Roy. Parent material is colluvial with slightly higher silt contents than in the moraines, but still with low clay percentages. Humus-iron podzols and brown forest soils are extensive, especially on the planar slopes with their associated deeper drifts. Humic and peaty gleys are found on rocky ledges, where the proximity of rock causes drainage impedance. The humus-iron podzol profiles have not been mixed by cultivation and exhibit their natural horizon sequence of L, F and H horizons overlying the E horizon. Brown forest soils are often podzolic on this silty, acid parent material, though evidence for podzolization is chemical.

Acid bent–fescue grassland with bracken is widespread on the freely drained areas. Bracken is expensive to eradicate on steep slopes, requiring spraying from helicopters. Oakwood and birchwood cover a substantial portion of the map unit, and sedge mires with rush pastures are found on wetter sites. Grazings are of good to moderate quality, and the land provides good wintering areas for stock.

Map unit 506 has similar landforms to *map unit 505*; some steep, smooth slopes with slight rockiness are present but most of its 145 square kilometres is moderately rocky, with slopes less than 15 degrees. The smooth, sloping variant of the map unit is well developed in Glen Roy and Glen Gloy. Drifts are largely colluvial with some till pockets. Peaty podzols and peaty rankers are dominant soils, with peat appearing on slopes less than 15 degrees. In the south-east corner of the area, where most of this map unit is found, humus-iron podzols become more prominent and there are some subalpine podzols at higher elevations. Boreal and Atlantic heather moors dominate the plant communities and provide grazing of low value.

Map unit 507 is widespread, covering 325 square kilometres of peaty moorland. A north-east to south-west trend of parallel rock ridges with intervening hollows forms the landscape, and more detailed mapping at Lephinmore Farm, Loch Fyneside, has shown that the major soil groups follow this alignment. The unit is found mainly in the Western Foothill region, but is also seen on slopes of less than 15 degrees in the mountains. In the eastern, drier, part of the area it is partly replaced by the moderately rocky *map unit 506*, dominated by peaty podzols.

Peaty gleys and peat with some peaty rankers are found in *map unit 507* and the drifts are usually shallow and colluvial, but some patchy thin till occurs, especially along Loch Fyneside. The peaty gleys are less stony than those of the Arkaig Association. Textures are sandy loams, with occasional loam and silty loam. B horizon colours are brown or grey-brown, with olive colours typical of the parent material prominent below.

Atlantic heather moor or bog heather moor is found on the peaty gleys, with some boreal heather moor at higher elevations. Heath rush–fescue grasslands are found on both flushed (flying bent grassland) and sloping, drier ground (white bent grassland). These communities provide pastures with low to moderate grazing value. Pasture improvements can be made if areas free from peat are chosen but grass species do not survive well in the waterlogged conditions.

Map unit 508 is very rocky but otherwise similar to *map unit 505*, and covers 38 square kilometres. The soils are usually shallow humus-iron podzols and the unit has a high proportion of rankers. Because of high slope angle and rockiness, areas of this type are only used for rough grazing, primarily of the acid bent–fescue grassland in the clearings between oakwoods and birchwoods. The grazing is of moderate to high value, depending on the amount of shading.

Map unit 509 is a very rocky unit, covering 18 square kilometres on the hills east of Loch Lomond. The slopes are rugged, but seldom exceed 15 degrees and the unit is rockier than *map unit 506*. The main soil types are peaty podzols and peaty rankers, with some humus-iron podzols on steeper slopes with more permeable drifts. Peat is occasionally found in basins or depressions. Rockiness restricts land use to rough grazings and the predominant Atlantic or boreal heather moors have low grazing value.

Map unit 510 occurs on steep slopes (greater than 15 degrees) and ranges from slightly to very rocky. It is the third most extensive unit (251 square kilometres) in the association and is seen on the mid-slopes of mountains between the valley moraines and the lower edge of the subalpine and alpine units (*map units 512–515*). Because of this landscape position, the unit is more extensively developed in the south of the area where moraines are less extensive and the lower limit of subalpine soils rises.

The main soil types are peaty gleys, peaty rankers and some peaty podzols. In areas with very steep slopes the peat horizon is substantially reduced and many humic gleys and peaty gleys have very thin surface O horizons. The peaty gleys are similar to those of the low slope map unit (*507*) but, apart from thinner O horizons, can have more prominent E horizons and slightly brighter values and chromas in B horizons. These soils are considered to be intergrades with peaty podzols. The true peaty podzols in this map unit are developed on colluvial drifts which are not indurated, a significant difference from those described in

map unit 504. B horizons are thicker and more uniformly coloured, their development helped by more permeable drift.

Common white bent grassland covers many of the slopes in the south and east corner of Sheet 4, but they are gradually replaced by flying bent grasslands and heather moors in the north and west where the climate is cooler and wetter. The grassland communities provide moderate value grazings. Afforestation is successful on the less-rocky slopes in parts of the unit.

Map unit 511 is a very rocky, gently and moderately sloping equivalent of *map unit 507*, and covers 39 square kilometres. The analogous map units in the more rugged associations, the Arkaig and Countesswells, cover 8 and 9 per cent of those associations, while *map unit 511* amounts to only 2 per cent of the Strichen Association. The landscape and soils are similar to those of *map unit 507*, but there may be a slight increase in the proportion of peaty rankers close to rock outcrops. Rockiness restricts land use to rough grazings and the plant communities of heather moors and bogs provide low grazing value. Some afforestation may be possible.

Map unit 512 is the most extensive (239 square kilometres) of the mountain soil units, occupying steep and very steep upper mountain slopes above 500 metres. There are also ridge crests and summit plateaux smaller than 40 hectares which are similar to those of *map units 513* and *514*. Subalpine podzols are extensive on the steep slopes and their profiles exhibit well-developed podzolic B horizons with high value and chroma, but cryoturbation causes mixing of the upper horizons and the O and E horizons are intermixed to form an A horizon. There is a wide range of rockiness, with scree in some areas.

Upland white bent grassland covers much of the ground, providing moderate grazing value for the summer months in most years, and in spring and autumn when the weather is milder. The map unit is not plantable.

Map unit 513 is mapped on plateaux and ridge crests and is mainly confined to the orohemiarctic thermal subzone where subalpine soils are most common. Peat is also found in hollows and channels between rocky knolls and is frequently hagged. Slopes are generally less than 15 degrees and there is a wide range of rockiness. Subalpine podzols occur on the hummocks, with subalpine gleys and peaty gleys in the wetter hollows. The unit occupies 66 square kilometres.

Plant communities are mountain blanket bog and mountain heaths, with occasional white bent grassland. Land use is rough grazing which is of lower value than in *map unit 512*.

Map unit 514 is restricted to the oroarctic thermal subzone where alpine soils develop. It is a non- and slightly rocky unit with many boulders in the surface of the soil although the mountain summits appear smooth. It covers 8 square kilometres. Grazing value of the vegetation is low and there is a very short growing season.

Map unit 515 covers 2 square kilometres and consists of very rocky mountain summits and upper slopes with alpine soils. Alpine azalea–lichen heath, dwarf shrub communities and occasional white bent grassland are found, providing grazing of low value.

THE TARVES ASSOCIATION

(Map units 519, 525, 526, 528, 531 and 533)

The soils of the Tarves Association are developed on drifts derived from rocks of intermediate composition (both igneous and metamorphic) or from drifts containing a mixture of acid and basic rocks. In Western Scotland the major rock types contributing to the association are (i) epidiorites, originally largely extrusive and intrusive basic igneous rocks now metamorphosed, and (ii) a series of calcareous and pelitic sediments also metamorphosed to chlorite-, epidote- and hornblende-schists and collectively known as 'the Green Beds'. The texture of the parent material is dominantly fine sandy loam, with some sandy loams where the shallow tills and colluvium show evidence of water-modification. The deposits are frequently stony, particularly those developed from the epidiorites. Parent material colours in the epidiorites are reddish brown, those on the Green Beds yellowish brown. Both groups of rocks were involved in the Caledonian mountain-building movements and the distribution of this association reflects the strong north-east to south-west orientation imposed at this time. The epidiorites occur principally in Mid-Argyll to the east and west of Loch Awe and the Green Beds in north Cowal.

The association occupies 270 square kilometres (1.6 per cent of Western Scotland), ranging in altitude from sea level to 450 metres, the hill land being strongly ridged. Hills formed from epidiorites are frequently rocky and bouldery, contrasting with the longer, more even slopes derived from the Green Beds.

Climatically, accumulated temperatures are mostly in the warm and fairly warm categories (greater than 1100 day°C) and the mean annual rainfall ranges from 1600 millimetres to over 2000 millimetres. Only in the extremely hilly areas at the head of Loch Fyne does this association penetrate the extremely wet division where summer rainfall exceeds evapo-transpiration by over 500 millimetres (Birse and Dry 1970).

A feature of the association is the high percentage of map units containing brown forest soils, noncalcareous gleys and humus-iron podzols (38 per cent). This compares favourably with similar map units in the Darleith Association on Mull (37 per cent), although the figure for the Darleith Association throughout Sheet 4 is lower due to the influence of the more northerly latitude of the Island of Skye. The Sourhope Association is also comparable at 29 per cent, the slight reduction occurring because of the amount of upland in the volcanic plateau. Soils on acid parent materials in the same climate area have a much lower proportion of brown forest soils. Only 2 per cent of the soils are subalpine. The vegetation of the association is typically western, acid bent–fescue grassland, Atlantic heather moor and bog heather moor and blanket bog. Occasional bands of rich bent–fescue grassland occur over included limestones.

Map unit 519 consists of humic gleys and brown forest soils, the latter often showing signs of strong leaching. The humic gleys are almost always found in lowland and lower hill slope sites and are developed on fine sandy loam or loam tills. The high silt and fine sand content and degree of packing (slight induration is often found) result in low permeability and the organic-matter content of the topsoils may reach 15 per cent. In hollows peaty gleys may develop. The freely drained brown forest soils, in contrast, are associated with strong slopes and ridge crests, and in higher areas podzols are found as a regular although minor component. The landforms of the unit are not severe; slopes are

usually less than 15 degrees and altitude below 250 metres. The map unit is slightly to moderately rocky, but in parts may be very bouldery. It accounts for 23 per cent of the association (62 square kilometres).

In agricultural terms the pattern of the soils is sometimes complex but reclamation for grassland is often possible, and some areas are suitable for arable use. When the land is not reseeded, soft rush pastures occupy the wetter sites and acid bent–fescue grassland with bracken the drier. Where limestones occur with epidiorite, rich bent–fescue grassland may develop. Some of the land, particularly the steeper shores of Loch Awe, is forested and a wide choice of species is available.

Map unit 525 is closely related to *map unit 519* but occurs on steeper land (greater than 15 degrees) and is associated with the Green Bed outcrops of Cowal. It has less till and consequently less humic gleys but some of the brown forest soils are imperfectly drained and flush channels are usual on the steep slopes. Although rarely reclaimable, it provides valuable grazings. It is of restricted extent (7 square kilometres; 3 per cent of the association).

Map unit 526, like the last unit, is closely related to *map unit 519*. It is composed of similar soil types (humic gleys and brown forest soils) but the amount of rock in the complex increases as do the brown ranker soils. It has an acid bent–fescue grassland vegetation. Reclamation is not possible but the 32 square kilometres (12 per cent of the association) provide good grazing.

Map unit 528 is the most extensive within the association in Western Scotland (55 per cent; 149 square kilometres). Peaty gleys and peat are the principal soils with some peaty podzols on the crests and flanks of the steeper ridges. Textures are loamy but often stony. The parent materials are of colluvial origin but on the lower ridge flanks areas of lodgement till are present in which induration is found. Peat occupies the majority of hollows.

Although the landforms within the unit are not severe, the higher altitudes (200–450 metres) and the wetness of the soils preclude extensive reclamation. Occasional improvement on a mosaic pattern to encourage sheep to range and assist better utilization of the unimproved areas is occasionally practised. The grazing resource is poor however. Moist Atlantic heather moor is found on peaty podzols and peaty gleys but bog heather moor is restricted to peaty gleys and peats. Some blanket bog occurs on peat and flushes support sharp-flowered rush pasture or soft rush pasture.

Much of the unit is under forest, where the principal species are Sitka spruce and lodgepole pine.

Map unit 531 is almost identical to *map unit 528* except that the proportion of rock increases, that of peat decreases and more peaty rankers occur. The unit has similar grazing potential but its forestry potential is more restricted due to risk of windthrow. It has an extent of only 14 square kilometres (5 per cent of the association).

Map unit 533 occurs only on the exposed summits to the west of Glen Aray and near Hells Glen, to the north and south-east of Loch Fyne respectively. It consists of subalpine podzols with strongly hagged peat. It provides some summer grazings but is unplantable for forestry. The extent is 6 square kilometres (2 per cent of the association).

THE TOROSAY ASSOCIATION

(Map units 546–551)

The centres of igneous activity in the Western Highlands and Islands are well known and geologists have documented their composition and histories in some detail. They contain a wide variety of rock types ranging from acid to basic in composition and are broken by complex structures, for example cone-sheets and ring-dykes. When a rock occurs in a well-defined mass, its weathering products characterize the drifts and soils developed from them and they are allocated to the appropriate association. However, when a granite mass is invaded by immense numbers of basic cone-sheets, as in Mull, mixed drifts are produced. The mixed drifts of the vent areas of the Highlands have been grouped as the Torosay Association; they include a wide range of rock types from acid to basic in composition, both intrusive and extrusive in character, and also include, in some areas, members of the basement complexes through which the vents burst. The association is therefore heterogeneous and has many local variants. It is, however, recognizable as a distinct soil-landform relationship.

The Torosay Association has been mapped on the Island of Mull, Ardnamurchan and Skye in the Tertiary volcanic districts. The older vents at Glencoe and at Ben Cruachan have also been included. The landscapes are mountainous and include several well-known rock climbing areas. Two major types of parent material are found, a solifluction or colluvial deposit which thinly covers the mountain summits and upper slopes, and a deeper hummocky moraine occupying the valley floors and sides. The latter was mapped separately as the Lussa Association on the Island of Mull (Bibby 1974). Colluvial materials in the association are shallow, very stony, and heavily humus-stained from water percolating laterally down steep slopes. Dark brown colours of low value and chroma are common. The morainic materials often have higher values (4 or 5) but low chroma. They are frequently strongly indurated and stony and were mainly produced during the Loch Lomond Readvance glaciation 10000–11000 years ago.

The Torosay Association occupies 518 square kilometres (3.1 per cent). It is found under wet climates with temperature régimes ranging from warm to cool, and the wetness is reflected in soil distribution. Over 68 per cent of the units are dominated by peaty gleys or peat, 15 per cent peaty podzols, 13 per cent subalpine podzols and peat and only 4 per cent brown forest soils. The peaty gley and peat soils are dominated by moist Atlantic heather moor, often flushed, and by bog heather moor and blanket bog communities. The podzols are confined to steep slopes and are associated with common white bent grassland and boreal heather moor. The subalpine mountain summits and ridges support upland bent–fescue grassland, upland blanket bog and fescue–woolly fringe-moss heath. The very restricted brown forest soils have both acid and herb-rich bent–fescue grassland. The vegetation of the principal area of the Torosay Association on the Island of Mull has been described by Jermy and Crabbe (1978).

Map unit 546 contains podzolized brown forest soils and brown rankers with humic and peaty gleys in hollows or where the rock is very close to the surface. The soil textures range from loamy sand to sandy loam but organic-matter contents of the surface horizons are always high (19 per cent) which give a finer feel to the soils. Even at depth organic-matter contents can remain fairly high

(*c.*7 per cent). Base status of the soils is always low, attesting to a high degree of leaching and pH is usually 5.

Due to the rather irregular nature of the underlying rocks there is a wide variation in soil depth, which, combined with climate, often restricts this land to grass production. There is a wide range of slope in the unit and rock outcrops are common. The map unit carries a bent–fescue grassland or oak–birch woodland, but where site conditions allow is responsive to improvement and often carries long ley grassland. It is unfortunately of very limited extent (23 square kilometres; 4 per cent of the association).

Map unit 547 has a very characteristic topography of mounds and hollows. Soils on the mounds are peaty gleys, or occasionally peaty podzols on the edges where a greater depth of solum assists subsoil drainage. The peaty gley soils have a peat horizon, below which is a shallow, eluviated and gleyed horizon heavily stained by humic acids. B horizons, too, have heavy staining which often obscures gley morphology except around weathered stones. A root mat and sometimes a thin iron pan directly overlie the greyish brown to olive grey, indurated, moraine. Soil textures are gravelly sandy loams but significant variation from sand to silt occurs in bands within the deposit.

The moraine frequently extends on to the steeper hill footslopes. Above angles of 15 degrees peat is practically absent and the map unit assumes a fluted form with erosion gullies and ridges. The soils remain dominantly peaty gleys until the indurated moraine ceases, when a more open soil structure of loamy scree allows better drainage and the development of the soils of *map unit 549*. Some small areas of freely drained soils can occur in the unit.

The moraines provide very little scope for reclamation for agricultural use. They support flying bent bog and bog heather moor of low grazing value. Considerable forest planting has taken place. The unit is the most extensive in Torosay Association (177 square kilometres; 34 per cent).

Map unit 548 develops extensively on areas of pneumatolysed basalts affected by both cone-sheets and other intrusions associated with the adjoining volcanic centres. Such basalts would normally be part of the Darleith Association but do not produce any fine material upon weathering and are clearly part of the main vent landscapes. The soils in the map unit are peaty gleys and peaty rankers, often very shallow and stony. Detailed work in Mull and Ardnamurchan showed that these soils accounted for 56 per cent of the unit, a further 20 per cent being peat. Peaty podzols occupied 9 per cent, while 5 per cent was brown forest soils and brown rankers.

The vegetation is almost entirely moist Atlantic heather moor and bog heather moor. The shallow, peaty soils have been improved in some areas but only for use by sheep. Invasion by rushes is common. The shallowness is a disadvantage for forestry, particularly since the major areas of the unit are found in exposed situations. The unit occupies 151 square kilometres, 29 per cent of the association.

Map unit 549 is not extensive (77 square kilometres; 15 per cent of the association) but supports bent–fescue grassland, white bent and flying bent grasslands and rush pastures, all of which are important communities to the grazing animal. It is developed on the steeper upper slopes of the hills, usually between *map unit 547* and the ridge crests comprising *map unit 551* and has a wide range of soil types in which podzols are dominant. Many of the soil profiles are

disturbed by soil-creep and wash-outs, and bi-sequel profiles are common. There is strong, short-range variation both in the depth and type of solum and the soil type. The unit presents little scope for mechanized improvement and is on the upper edge of the planting zone for forestry. It often extends into the orohemiarctic thermal subzone.

Map unit 550 is similar in most respects to *map unit 548* except that it is more rocky. It is relatively unimportant, occupying 25 square kilometres, 5 per cent of the association.

Map unit 551 is found at altitudes greater than 350–400 metres on ridge crests and mountain summits in the orohemiarctic thermal subzone. Short range variation in the unit is strong, from hagged amorphous peat to stony frost-shattered debris or sandy aeolian accumulations within distances of a few metres. Soils of the mountain summits on the more basic parent materials in the association have little evidence of podzolization in the profile morphology. On more acid parent materials bleached grains and leached horizons can be seen. Some grazing is available, particularly on the steeper slopes. The map unit is unplantable. It occupies 65 square kilometres, 13 per cent of the association.

THE TORRIDON ASSOCIATION

(Map units 553–561)

The soils of the Torridon Association are developed on drifts derived from the sedimentary pre-Cambrian rocks of the Torridonian formation. Within this formation are two major groups of varying lithology: the Applecross Group, which accounts for most of the area, occurs in Torridon and Applecross and consists of red arkoses, brown shales, conglomerates and grits; and the Diabaig Group found mainly on Skye and in Colonsay, consisting of grey shales and phyllites. Insufficient information has been collected at present to determine if the soils developed on the two groups are significantly different. It does appear, however, that the Applecross Group has redder colours and coarser textures, particularly in residual and till parent materials. The association occupies 1050 square kilometres, (6.3 per cent of the region).

Parent materials are mainly colluvial and morainic drifts, with smaller areas of deep till. Textures are generally coarse loamy sand though tills are sometimes loam when derived from phyllite. The climate ranges from warm and moist on Colonsay (mean annual rainfall 1300 millimetres) to extremely cold and wet on the mountains of Torridon (rainfall over 3600 millimetres), but for the most part it is either rather warm and wet or cool and wet with a rainfall in the region of 1700 millimetres. The vegetation is dominated by heather moor and blanket bog, providing rough grazings of poor quality.

The effects of the acid parent materials and poor climate are amply demonstrated by the proportions of map units dominated by peaty soils, over 80 per cent. Map units with mountain soils account for about 16 per cent, while the remaining 4 per cent are map units with mainly mineral soils. There is a strong contrast within the association between the high, rugged, terraced mountains and the boggy foothills and lowlands.

Map unit 553 has peaty podzols and peaty gleys, many of which have been cultivated. It forms much of the non-rocky coastal croft land at Gairloch and Diabaig and sometimes includes a fringe of raised beach sands and gravels, though the chief parent material is till.

Map unit 554, occupying 143 square kilometres (14 per cent of the association), has the characteristic hummocky topography of Loch Lomond Readvance moraines as well as some gullied slope moraines. There are peaty podzols and peaty gleys on the slopes and peat infills the hollows and flats. The surface of the valley deposits is often strewn with boulders, frequently over 3 metres across. Moundiness is very pronounced, particularly in Glen Torridon where steep-sided mounds are tightly packed with only small hollows lying between them. However, another more open variant with large widely spaced, gently sloping mounds and broad peat flats is seen south of Loch Damh. The amount of peat encountered within the unit is thus very variable. Above 350 metres subalpine podzols occur on the mounds due to the greater exposure and funnelling effects of wind through the valleys.

Moist Atlantic heather moor and bog heather moor and their northern forms grow on the mounds, while the peaty flats have blanket bog. Soil wetness and topographic patterns confine the land use to poor rough grazings and forestry.

Map unit 555 is the only map unit of the Torridon Association possessing significant amounts of brown forest soils and humus-iron podzols. Flushed areas have noncalcareous and humic gleys, though some patchy peaty topsoils are seen. Steep slopes with severe rockiness are common and most of the parent material is stony colluvium. Some morainic drift is also present, however. An example of this drift under a brown forest soil has an olive grey sandy loam C horizon. The main areas are around Loch Torridon and in south Skye where the vegetation is broadleaved woodland and bent–fescue grassland with rush pastures in the wetter flushes. There are 36 square kilometres of the unit (3 per cent of the association) which provides sheltered rough grazings of mainly good quality.

Map unit 556, 105 square kilometres, 10 per cent of the association, is essentially a non-rocky version of the extensive *map unit 557* though the drift here tends to be shallow till rather than colluvium. Soils are peaty gleys and peat with subsidiary peaty podzols in undulating lowlands and on lower hillslopes. The reddish and pinkish tills are generally stony and of loamy sand to sandy loam texture, but can be finer locally when underlain by slates. Vegetation is predominantly bog heather moor with some Atlantic heather moor on drier sites. The land is so wet that at present land use is restricted to rough grazings, though some small areas could be reclaimed and forestry should be possible. The largest tract is that between Loch Gairloch and Loch Torridon, probably outside the area covered by the Loch Lomond Readvance glaciation.

Map unit 557 is an extensive map unit covering 402 square kilometres and accounting for about 38 per cent of the association. The principal soils are peaty gleys and peat with subordinate peaty podzols and peaty rankers. Various landscape types are seen, terraced, stepped, ridged and knolly, generally with gentle slopes, though local steep slopes are common as on terrace risers and flanks of ridges. Peat forms distinct flats and also blankets undulating terrain.

Most of the soils are developed on a shallow, stony colluvium of loamy sand texture. Soil distribution is determined partly by topography; peat occurs in hollows and on flats, peaty gleys are present on gentle slopes, peaty rankers are associated with the rock-cored knolls and peaty podzols are confined to steep slopes.

Peaty gleys are encountered most frequently and an example from Kinloch, Skye has an O horizon 7 centimetres thick overlying a brownish grey Eg horizon 23 centimetres thick. Underlying this is a brown Bg horizon with strong brown mottles, with hard rock at 56 centimetres; textures below the O horizon are sandy loam.

Plant communities are mainly heather moors, chiefly the northern forms of Atlantic heather moor and bog heather moor. The deep peat has blanket and northern blanket bog. The wetness and uneven topography mean that the map unit is used mainly as rough grazings with some forestry.

Map unit 558 is an extensive unit (117 square kilometres) very similar to *map unit 557* but is more rugged and rocky with a greater proportion of peaty rankers. Other soils include peaty gleys, peat and peaty podzols.

Map unit 559 has the same soils as *map unit 557* except that the peat component is absent due to the steep (greater than 15 degrees) slopes. The peaty gleys, peaty podzols and peaty rankers vary in their proportions according to the gradient and rockiness. The rock outcrops are in the form of both minor crags and steep slabs. It occupies 75 square kilometres. Vegetation is mainly heather moor, the most prominent plant communities being the northern forms of bog heather moor and Atlantic heather moor. Common white bent grassland also occurs locally on Skye. The land use is exclusively rough grazings.

Map unit 560 represents the few areas of subalpine plateaux large enough to distinguish separately. Exposed non-rocky to very rocky knolls have subalpine podzols and gleys, while the sheltered hollows have hagged peat, the plant communities being alpine azalea–lichen heath and mountain blanket bog respectively.

Map unit 561 is an extensive (164 square kilometres, about 16 per cent of the association) mountain map unit, which includes subalpine and alpine slopes, summits and plateaux, with the subalpine slope facet predominating. Parent materials are aeolian and frost-shattered detritus on summits and solifluction debris and scree on the slopes. Subalpine podzols are most abundant, but locally, on higher and more exposed peaks, alpine podzols dominate and on lower, more sheltered plateaux, hagged peat is common. Terraced rocky topography is widespread, though not strongly expressed in south Skye. Fescue–woolly fringe-moss heath and stiff sedge–fescue grassland form an incomplete vegetation cover on the summits, while stable areas on the slopes have patchy common white bent grassland and heather moors.

This map unit provides only scant rough grazings, and its chief merits lie in its scenic qualities and suitability as a remote climbing and walking area.

Table B Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
ALLUVIAL SOILS (95 sq. km., 0.6%)	1	95	0.6	100
	2	<1	<0.1	<5
ORGANIC SOILS (706 sq. km., 4.2%)	3	100	0.6	14
	4	606	3.6	86
ABERLOUR (35 sq. km., 0.2%)	5	3	<0.1	10
	6	<1	<0.1	<5
	9	22	0.1	65
	10	2	<0.1	5
	11	2	<0.1	5
	12	1	<0.1	<5
	15	5	<0.1	15
ARKAIG (6074 sq. km., 36.2%)	19	6	<0.1	<1
	20	55	0.3	<1
	21	<1	<0.1	<1
	22	6	<0.1	<1
	23	244	1.5	4
	24	58	0.4	<1
	25	34	0.2	<1
	26	1553	9.3	26
	27	198	1.2	3
	28	357	2.1	6
	29	746	4.5	12
	30	98	0.6	2
	31	692	4.1	11
	32	511	3.1	8
	33	1188	7.1	20
	34	238	1.4	4
	35	41	0.2	<1
	36	49	0.3	<1
BALROWNIE (30 sq. km., 0.2%)	41	5	<0.1	15
	42	18	0.1	60
	43	4	<0.1	15
	44	1	<0.1	<5
	46	2	<0.1	5
BERRIEDALE	61	9	0.1	100
BRAEMORE/ KINSTEARY	71	6	<0.1	100

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA(sq. km)	% Land Area	% Association
CORBY/ BOYNDIE/ DINNET (333 sq. km., 2.0%)	97	5	<0.1	2
	98	79	0.5	24
	99	46	0.3	14
	100	23	0.1	7
	101	84	0.5	25
	102	6	<0.1	2
	103	24	0.1	7
	104	9	0.1	3
	105	55	0.3	16
	106	2	<0.1	<1
CORRIEBRECK (34 sq. km., 0.2%)	108	1	<0.1	<5
	109	3	<0.1	10
	110	13	0.1	40
	111	7	<0.1	20
	112	10	0.1	30
COUNTESSWELLS/ DALBEATTIE/ PRIESTLAW (1311 sq. km., 7.8%)	119	22	0.1	2
	122	10	0.1	<1
	123	574	3.4	44
	125	22	0.1	2
	126	19	0.1	1
	127	212	1.3	16
	129	6	<0.1	<1
	131	134	0.8	10
	132	113	0.7	9
	134	79	0.5	6
	135	111	0.7	8
	136	7	<0.1	<1
	137	2	<0.1	<1
DARLEITH/ KIRKTONMOOR (1486 sq. km., 8.9%)	149	30	0.2	2
	155	56	0.3	4
	157	7	<0.1	<1
	158	347	2.1	23
	159	148	0.9	10
	160	828	4.9	56
	161	24	0.1	2
	162	46	0.3	3
DEECASTLE (62 sq. km., 0.4%)	165	61	0.4	95
	166	<1	<0.1	<5
	167	1	<0.1	<5

Table B Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
DURNHILL (293 sq. km., 1.8%)	184	13	0.1	4
	185	25	0.2	9
	186	9	0.1	3
	187	8	0.1	3
	188	78	0.5	27
	190	32	0.2	11
	191	45	0.3	15
	192	82	0.5	28
	193	1	<0.1	<1
FOUDLAND (686 sq. km., 4.1%)	240	<1	<0.1	<1
	241	2	<0.1	<1
	242	125	0.8	18
	243	6	<0.1	<1
	246	18	0.1	3
	247	32	0.2	5
	248	46	0.3	7
	249	103	0.6	15
	250	48	0.3	7
	251	28	0.2	4
	252	4	<0.1	<1
	253	162	1.0	24
	254	84	0.5	12
	255	28	0.2	4
FRASERBURGH (45 sq. km., 0.3%)	259	15	0.1	35
	260	1	<0.1	<5
	261	26	0.2	60
	263	3	<0.1	5
GOURDIE/CALLANDER/ STRATHFINELLA (6 sq. km., <0.1%)	274	1	<0.1	15
	275	5	<0.1	85
GRULINE (30 sq. km., 0.2%)	278	7	<0.1	25
	279	18	0.1	60
	280	5	<0.1	15
HATTON/TOMINTOUL/ KESSOCK (29 sq. km., 0.2%)	282	6	<0.1	20
	285	16	0.1	55
	286	7	<0.1	25
INCHKENNETH (99 sq. km., 0.6%)	307	34	0.2	35
	308	<1	<0.1	<5
	309	12	0.1	10
	311	2	<0.1	<5
	312	48	0.3	50
	313	3	<0.1	<5
INCHNADAMPH (21 sq. km., 0.1%)	314	15	0.1	70
	315	6	<0.1	30

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA(sq. km)	% Land Area	% Association
INSCH (86 sq. km., 0.5%)	321	3	<0.1	<5
	322	9	0.1	10
	323	5	<0.1	5
	325	34	0.2	40
	327	35	0.2	40
KINTYRE	335	2	<0.1	100
KNOCKSKAE (45 sq. km., 0.3%)	357	38	0.2	85
	358	7	<0.1	15
LAURENCEKIRK	368	<1	<0.1	100
LINKS (2 sq. km., <0.1%)	381	2	<0.1	100
	384	<1	<0.1	<5
LOCHINVER (729 sq. km., 4.4%)	386	2	<0.1	<1
	387	22	0.1	3
	389	36	0.2	5
	391	51	0.3	7
	392	35	0.2	5
	393	40	0.2	5
	394	203	1.2	28
	395	237	1.4	33
	396	47	0.3	6
	397	15	0.1	2
	398	41	0.2	6
NIGG/PRESTON	420	1	<0.1	100
NORTH MORMOND/ ORTON (38 sq. km., 0.2%)	424	<1	<0.1	<5
	425	38	0.2	100
ROY (36 sq. km., 0.2%)	452	12	0.1	35
	453	24	0.1	65
SABHAIL/ MOUNTEAGLE	457	11	0.1	100
SOURHOPE (342 sq. km., 2.0%)	479	99	0.6	29
	480	243	1.5	71
STAFFIN (60 sq. km., 0.4%)	483	28	0.2	45
	484	4	<0.1	5
	485	19	0.1	30
	486	9	0.1	15

Table B Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
STIRLING/DUFFUS/ POW/CARBROOK	488	3	<0.1	100
STONEHAVEN (8 sq. km., 0.1%)	490	3	<0.1	40
	493	3	<0.1	40
	495	<1	<0.1	<5
	496	2	<0.1	25
STRICHEN (1965 sq. km., 11.7%)	497	30	0.2	2
	498	18	0.1	<1
	499	1	<0.1	<1
	500	11	0.1	<1
	501	32	0.2	2
	502	29	0.2	1
	503	145	0.9	7
	504	454	2.7	23
	505	114	0.7	6
	506	145	0.9	7
	507	325	1.9	17
	508	38	0.2	2
	509	18	0.1	<1
	510	251	1.5	13
	511	39	0.2	2
	512	239	1.4	12
	513	66	0.4	3
	514	8	0.1	<1
	515	2	<0.1	<1
TARVES (270 sq. km., 1.6%)	519	62	0.4	23
	525	7	<0.1	3
	526	32	0.2	12
	528	149	0.9	55
	531	14	0.1	5
	533	6	<0.1	2
TOROSAY (518 sq. km., 3.1%)	546	23	0.1	4
	547	177	1.1	34
	548	151	0.9	29
	549	77	0.5	15
	550	25	0.2	5
	551	65	0.4	13
TORRIDON (1050 sq. km., 6.3%)	553	2	<0.1	<1
	554	143	0.9	14
	555	36	0.2	3
	556	105	0.6	10
	557	402	2.4	38
	558	117	0.7	11
	559	75	0.5	7
	560	6	<0.1	<1
	561	164	1.0	16
ROCK		187	1.1	
BUILT-UP AREAS		22	0.1	

1 sq km 100 hectares

Areas in this table have been estimated by print-count methods. Discussion of method and estimation of error is contained in Handbook 8

MISCELLANEOUS LAND UNITS

Bare rock, scree and cliffs In an area dominated by mountain masses the presence or absence of rock frequently plays a leading rôle in dictating the ease with which land can be used for various purposes. It has often, therefore, been used to discriminate between otherwise similar soil groupings to give different map units (soil landscape units). Occasionally rock occurs in unbroken areas which can be represented at the 1:250 000 scale (e.g. the Cuillins of Skye). Such areas amount to 187 square kilometres (1.1 per cent of the Western Scotland region). Although rock dominates such units, they are internally variable and often include lithosols, rankers and minor amounts of other soil subgroups.

Built-up areas As indicated in the introduction, Western Scotland is sparsely populated. The total built-up area is only 22 square kilometres (0.1 per

cent of the region), smaller than that of any other map area except the Outer Hebrides.

Freshwater lochs The total area of freshwater lochs in Western Scotland is 521 square kilometres.

A GUIDE TO THE SOIL LANDSCAPES OF WESTERN SCOTLAND

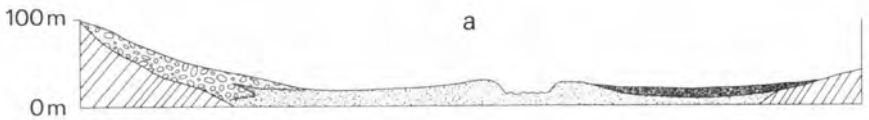
Landforms can be divided, for convenience, into those generated by depositional processes resulting in ground gain, such as accumulations of windblown sand or moraine, and those generated by erosional processes resulting in ground loss. In the following section an attempt has been made to illustrate the main landforms of Western Scotland used as a basis for most of the soil map units. The depositional landforms are given first, followed by those dominated geomorphologically by removal of material whose form is dictated by underlying rock types and structure.

Similar landforms can differ quite markedly in appearance, however, according to environmental characteristics which affect the development of soils. The combination of landform and associated soil types is here termed a 'soil landscape'. Some of the most significant and extensive soil landscapes are illustrated in the plates; others, which it has not been possible to illustrate are listed, together with their associated map unit numbers. A generalized cross-section provides further information aimed at defining the variations recognized and giving an indication of major soil subgroup distribution. The scale at the left hand edge of the diagrams should be interpreted very loosely; it in no way implies the altitudinal range of any unit.

This section can be used in conjunction with the soil map or with the handbook to provide a visual impression of the different types of map unit recognized in the survey and to supplement handbook descriptions.

Plate 1. *Alluvial soils (map unit 1) at the mouth of the River Aray, Inveraray, Argyll. Areas of mineral alluvium are rare in Western Scotland, most are peaty.* Aerofilms.

Landform description: Level areas with minor undulations, small terraces, abandoned channels and pools. The mottled area (left of castle in Plate 1) indicates a combination of well-drained and poorly drained soils. Saltings rarely form areas large enough to map but are often present at the head of sea lochs and on the periphery of river deltas (Plate 8). In mountain areas alluvial debris cones form a significant component (Plate 15).

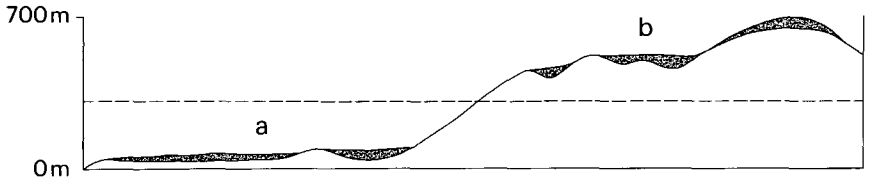


Soils	Map units
a. Mineral soils (debris cones and alluvial flats) and peaty alluvial soils.	1
b. Saltings (not illustrated).	2

Plate 2. *Terrace peat (map unit 3) Achnacree Moss, North Connel, Argyll. Old peat cuttings, now flooded, occupy the foreground. An abandoned stream channel with alluvial soils is also prominent.*

Plate 3. *Eroded hill peat (map unit 4) Druim Ghlaoidh above Loch Lochy (map unit 505, Strichen Association in foreground). The rounded hill forms are typical of mountains composed of Dalradian rocks.* Aerofilms.

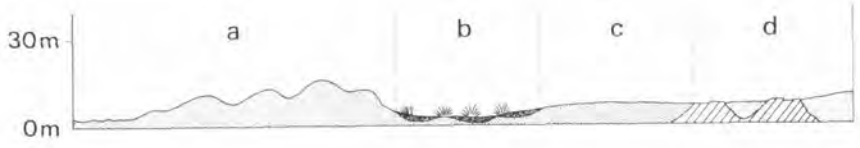
Landform description: Organic deposits occur on terraces (Plate 2) and in valley sites (map unit 3) and also on gently sloping hillsides and ridge crests (map unit 4, Plate 3). In more rugged topography, hill peat may form from a series of coalescing basins. At low altitude it is not usually eroded but hagging may be severe in exposed situations above 300 metres.



Soils	Map units
a. Basin, terrace and valley peat.	3
b. Hill peat (extends to sea level in the west, lower limit circa 300 m in the east).	4

Plate 4. *Dunes and machair (map unit 261, Fraserburgh Association), Sanna, Ardnamurchan. Wind-blown sands form active, stable and eroding dunes and stabilized undulating flats.*

Landform description: Mainly restricted to exposed coastal areas below 30 metres where the landform varies from extremely moundy dunes to flat or gently undulating machairs.



Soils	Map units
a. Regosols and calcareous regosols on dunes.	261
b. Flushed peat and peaty gleys in depressions.	263
c. Brown calcareous soils and regosols on undulating machairs, non-rocky.	259
d. Brown calcareous soils and regosols on undulating machairs with some rock.	260
Types a-d are recognized but are not separated at the 1:250,000 scale in	381, 384

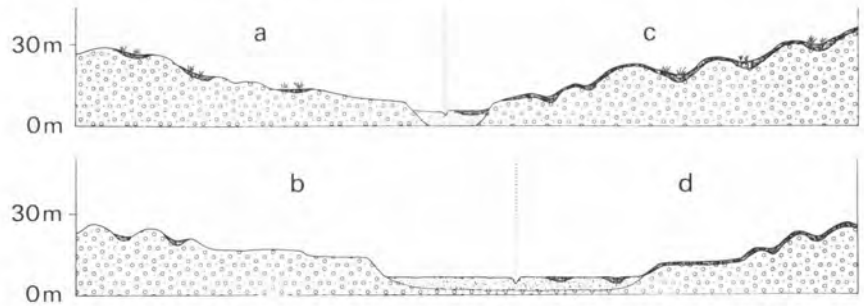
Plate 5. *Raised beach terraces, Gruinard Bay, Wester Ross. Although outwith Sheet 4 this plate exemplifies the landforms.*

Landform description: Raised beaches occur below 30 metres and are level or gently sloping, with some steep slopes on terrace risers and areas with rocky knolls.

Soils	Map units
a. Brown forest soils and cultivated podzols, freely drained.	97, 278, 420
b. Cultivated podzols, humic gleys	99
c. Peaty podzols, peaty gleys and peat	106
d. Peaty podzols, peaty gleys and peat with rock knolls	104, 280
Types a-c are recognized but not mapped separately, within	105, 279
Types a-d are recognized, but not mapped separately, within	103
A small area of gleyed, estuarine silt is also recognized	488

Plate 6. *Moundy and terraced fluvioglacial sand and gravel with alluvial soils, Ford, Argyll (map unit 98, Corby Association). Depressions, mainly kettleholes may be filled by lochans or peat.* Aerofilms.

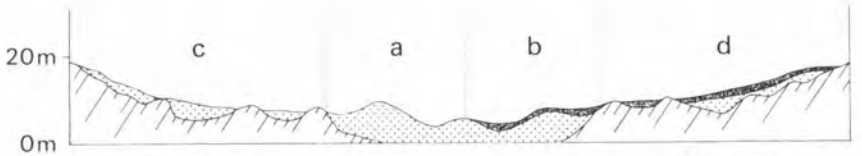
Landform description: Fluvioglacial deposits range from level to strongly hummocky land. Broad alluvial straths often occur within the units, especially in the east.



Soils	Map units
a. Humus-iron and cultivated podzols on mounds and terraces	100, 452
b. Cultivated podzols, gleys and alluvial soils on mounds, terraces and flood-plains	98
c. Peaty podzols, peaty gleys and peat on mounds and terraces	101, 453
d. Peaty podzols, peaty gleys, peat and alluvial soils on mounds, terraces and flood-plains	102

Plate 7. *Non-rocky, undulating topography with subdued drumlins, Kilmuir Skye (map unit 483, with map unit 485 in peaty areas, often in depressional sites, Staffin Association).* Aerofilms

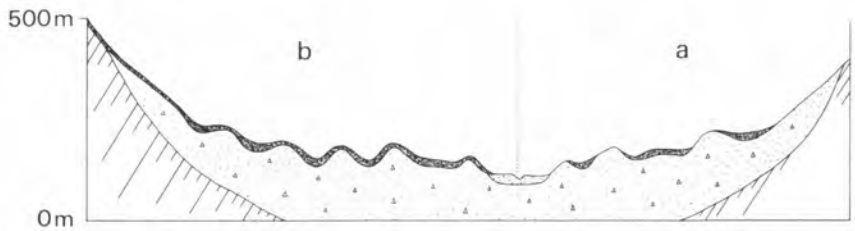
Landform description: Till landforms are depositional and obscure underlying rock structure. Deep drifts in the form of drumlins and ridges are common but occasional outcrops sometimes occur where the till is thin.



Soils	Map units
a. Noncalcareous gleys, brown forest soils with gleying, brown forest soils and humus-iron podzols on non-rocky undulating terrain	5, 6, 19, 20, 41, 42, 44, 71, 241, 243, 274, 275, 282, 308, 368, 425, 483, 490, 493, 497, 498
b. Peaty gleys, peat and peaty podzols on non-rocky undulating terrain	46, 61, 119, 184, 246, 424, 485, 499
c. Soils as a, but with rock outcropping	43, 242, 309, 335, 484, 519, 553
d. Soils as b, but with rock outcropping	247, 311, 486

Plate 8: *Moundy moraines in the valley of the Garvan River, Loch Eil-side (map unit 26, Arkaig Association). The croft land in the foreground is included in map unit 105 (Corby Association).* Aerofilms.

Landform description: Moundy moraines form deep deposits on valley floors. On steep slopes, however, the moundiness is replaced by gullied moraines (Plate 15). Plate 8 illustrates soil landscape b.



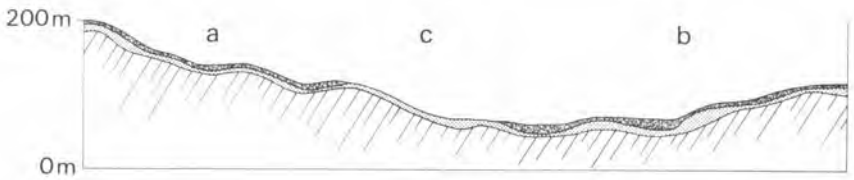
Soils	Map units
a. Humus-iron podzols, noncalcareous and peaty gleys	25, 122, 248, 313, 321, 503
b. Peaty podzols, peaty gleys and peat	9, 26, 111, 123, 157, 185, 249, 322, 391, 504, 547, 554

SOIL LANDSCAPES DEVELOPED ON ROCK-CONTROLLED LANDFORMS

NON-ROCKY SOIL LANDSCAPES

Plate 9. *Gentle and strongly sloping non-rocky land, Badluarach, Little Loch Broom (map unit 556, Torridon Association, with map unit 553 close to the loch shores).*

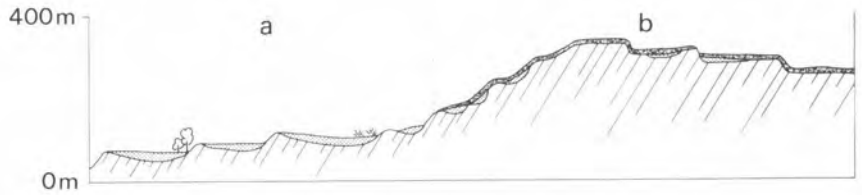
Landform description: The form of the land is controlled by rock, only obscured by a shallow veneer of colluvium or till. Intergrades to till landforms occasionally occur.



Soils	Map units
a. Peaty podzols, peat	21, 22, 500
b. Peaty gleys, peat	23, 155, 392, 501, 556
c. Noncalcareous gleys, humic gleys, brown forest soils	149

Plate 10. *Gently and strongly sloping, slightly rocky, terraced land on basic extrusive igneous rocks, Mingary, North-west Mull (map unit 158, Darleith Association).*

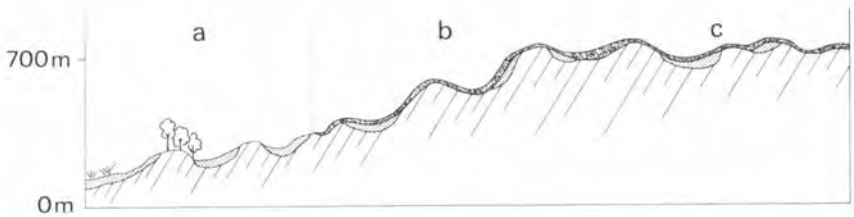
Landform description: The landform is dominated by the tabular forms conferred by the underlying geology, although some variation in the strength of this expression is found. Plate 10 illustrates soil landscape a in the section below.



Soils	Map units
a. Brown forest soils, humus-iron podzols and brown rankers	158, 307, 479, 546
b. Peat, peaty gleys, peaty podzols and peaty rankers	160, 480

Plate 11. *Gently and strongly sloping moderately rocky land on metamorphic, sedimentary and acid igneous rocks, Loch a' Ghille Ghobaich, Morar (map unit 29, Arkaig Association).* Aerofilms

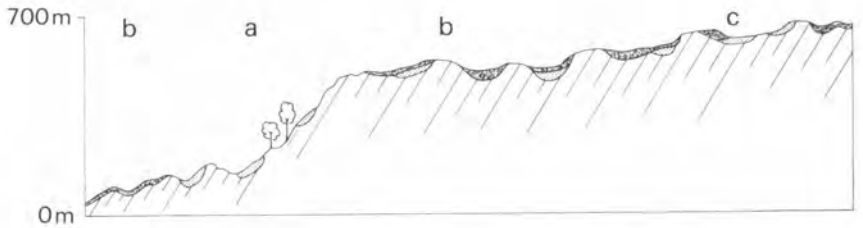
Landform description: The structure of the underlying rock dictates the morphology of the terrain. Ridged landforms are often found on foliated metamorphic rocks, while more massive rocks, for example granite, produce an irregular hillocky topography. Plate 11 illustrates soil landscape c.



Soils	Map units
a. Brown forest soils, humus-iron podzols, noncalcareous gleys and brown rankers	165, 314, 323, 386, 387, 457, 495, 496
b. Peaty podzols, humus-iron podzols, peaty gleys, peat and peaty rankers	28, 166, 312, 315
c. Peaty gleys, peat, peaty podzols and peaty rankers	11, 29, 109, 127, 188, 253, 325, 357, 394, 507, 528, 548, 557

Plate 12. *Gently and strongly sloping very rocky land, Eilean Shona, Loch Moidart (map unit 32, Arkaig Association).* Aerofilms.

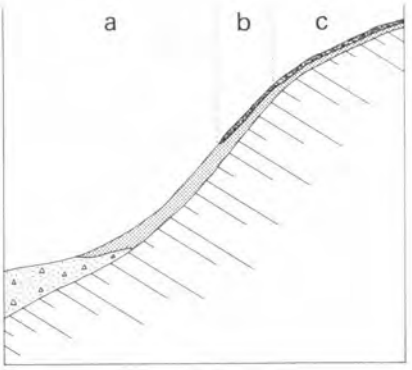
Landform description: Intense glacial scouring has produced this very rocky landform, almost totally controlled by geological structure and differential erosion. It occurs between sea level and 400 metres. Plate 12 illustrates soil landscape c.



Soils	Map units
a. Brown rankers, brown forest soils	167, 526
b. Peaty podzols, peaty rankers, some peaty gleys and peat (eastern distribution)	30, 129, 509
c. Peaty gleys, peaty rankers, peat; some peaty podzols (western distribution)	32, 110, 132, 190, 327, 358, 395, 511, 531, 558

Plate 13. *Steeply sloping non- and slightly rocky land in Glen Luss (map unit 251, Foudland Association). The gently sloping land in the foreground is map unit 249.*

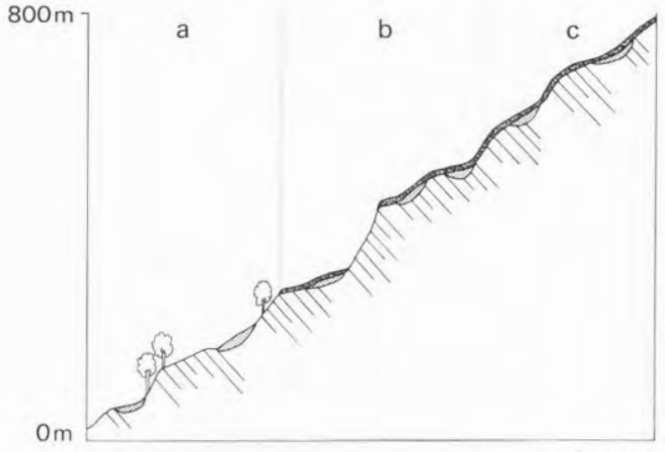
Landform description: Steep slopes, usually in excess of 15 degrees, with very little or no rock outcrop. The drifts are usually shallow and associated with rocks which are susceptible to frost weathering. They vary from angular scree to loamy colluvium and often intergrade to moraine or till on their lower slopes.



Soils	Map units
a. Brown forest soils, humus-iron podzols (0-700 metres)	251, 525
b. Peaty podzols, humus-iron podzols, rankers (100-400 metres)	126, 187
c. Peaty gleys, peaty podzols (200-800 metres)	24, 502

Plate 14. *Steeply sloping land - moderately and very rocky in Glenmore near Glenelg (map unit 393, Lochinver Association, on the left, map unit 31, Arkaig Association on the right).*

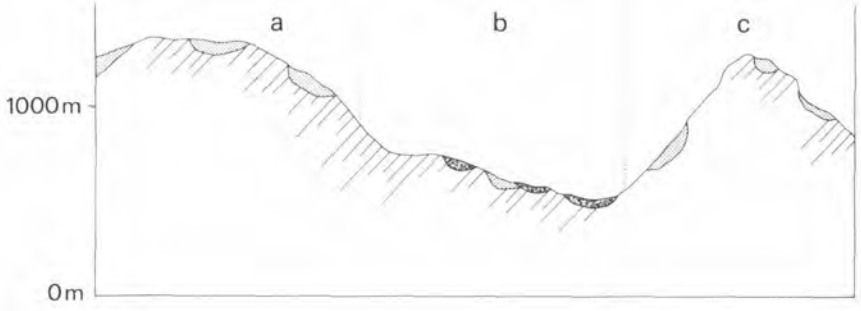
Landform description: Steep usually irregular slopes, greater than 15 degrees with the amount of rock outcrop ranging from occasional to frequent. The drifts are shallow and stony, most often of colluvium or stabilized scree, though morainic drift has been incorporated within the unit on some footslopes.



Soils	Map units
a. Brown forest soils, humus-iron podzols, humic and noncalcareous gleys	27, 108, 125, 161, 186, 240, 250, 389, 393, 505, 508, 555
b. Peaty and humus-iron podzols	10, 159, 252, 285, 286, 506, 549
c. Peaty gleys and peaty podzols	31, 131, 191, 254, 396, 510, 550, 559

Plate 15. *Aonach Beag and Carn Dearg Mheadonach, Ben Nevis Range. Frost-patterned ground is present on the summits and low-angle slopes while steep slopes have a wide range of rockiness with some shallow colluvial drift (map unit 134, Countesswells Association). Gullied moraine is present in the valley.* Aerofilms.

Landform description: The arctic climate zone of the mountains extends upwards from 400 metres in the west and 600 metres in the east. It includes a wide range of slopes and rockiness classes. Evidence of active movement of slope debris is common and the main landforms are erosional in origin.



Soils	Map units
a. Alpine podzols, some alpine gleys on high summits, slopes usually ‹15°	15, 35, 36, 136, 137, 514, 515
b. Subalpine soils and peat on broad ridge crests and lower summits, slopes usually ‹15°	34, 135, 193, 397, 513, 533, 560
c. Subalpine podzols, some alpine podzols, slopes usually ›15°	12, 33, 112, 134, 162, 192, 255, 398, 512, 551, 561

3. Land Evaluation

Earlier chapters of this book have described the main natural resource attributes of Western Scotland (climate, geology, landform, soil and vegetation) and classified them into a number of units. The characteristics of each of these units influence man's use of the land contained within it. Land evaluation is the assessment of the potential of land for a range of possible uses, for example for agriculture, forestry, recreation or engineering. It incorporates not only the physical attributes of the land but also man's resources of technology, finance and labour. Since the latter are variable through time in a manner not accurately predictable, systems of assessing the capability of land for any specific purpose usually attempt to standardize them. The potential use of the land may then be assessed under the standard conditions and expressed as capability classes. Land evaluation is not something which is static, but must be reviewed periodically and repeated when significant changes take place in any of the human resources.

It is worth stressing that land capability classifications are not recommendations for the particular use of a piece of land. They seek to identify areas where that use may be carried out most easily. Only by carefully comparing all the alternatives and incorporating economic and political judgements in particular cases can recommendations for actual land use be arrived at. For this reason no one map indicating 'best land use' is likely to be achieved.

In Scotland, a system of land capability classification for general agricultural purposes has been constructed (Bibby, Douglas, Thomasson and Robertson 1982). An explanation of its broad principles and the parameters used in its application in Western Scotland form the bulk of this chapter. A final section provides some comments on the effects of natural resources on other uses, for which fuller classification systems have not yet been constructed.

LAND CAPABILITY CLASSIFICATION FOR AGRICULTURE

The Land Capability Classification for Agriculture has as its objective the integration of detailed information on soil, climate and relief in a form which will be of value to land-use planners, agricultural advisers, farmers and others involved in optimizing the use of land resources.

Its applications include the following:

1 Contributing to an inventory of the national land resource
2 Providing a means of assessing the value to agriculture of land on a uniform basis as an input to planning decisions
3 Defining major limitations to land use
4 Assisting in environmental and amenity planning
5 Contributing to farm and estate planning and to technical advisory work.

PHYSICAL FACTORS AND THEIR EFFECT UPON AGRICULTURE IN WESTERN SCOTLAND

Climate There is no doubt that the principal feature of climate affecting land use in Western Scotland is high rainfall, but the lower temperatures of the main hill masses and the exposure of the extreme west, despite lower rainfall levels, are also significant. Only in the areas immediately to the west of the inner Cromarty and Beauly Firths and in the extreme north-east of the Great Glen are conditions sufficiently dry to encourage regular arable cropping. Over the rest of the region, agricultural enterprises based on grass production are the only option. Even then conditions are not good; dry, cold springs may hold back the onset of the growing season, while hay-making is fraught with difficulty from wet weather. Stock suffer more easily from exposure when wet, but parasites such as ticks and fluke appear to thrive, not to mention the Highland midge from which, on occasion, even the hardy locals must flee. Moulds, mildews and fungal attacks occur under the humid conditions and commonly reduce crop yields.

Gradient Slope is frequently a serious obstacle to reclamation of land for grass, not only from difficulty in initial operations but also in maintenance. While in theory 25 degrees is the limit of operation of four-wheeled drive tractors, in practice little ground over 15 degrees is reclaimed. Grassy, wet and peaty surfaces encourage tractor instability, the slope pattern severely affects operations, and finally four-wheel drive tractors are more expensive and marginal agriculture with low profit margins can rarely sustain expensive equipment. The conventional two-wheel drive tractor is limited to land below 15 degrees and even then considerable care is necessary. Forage harvesters are only used on fairly low-angled slopes.

Soil The soils are inherently poor. They are often sufficiently shallow to prevent ploughing, have restricted root-room, can rapidly become waterlogged during periods of heavy rain, yet dry out to give burning if there is any prolonged period without rain. Soils are often stony, sometimes exceptionally so. Those with loamy or clayey textures are always wet and become difficult to manage, while soil structures, despite high organic-matter contents, are weak due to the lack of any pronounced regular wetting and drying cycles. Organic-matter contents over 8 per cent increase susceptibility of soils to damage from trampling by stock. In the south of the region the better soils have high fine sand and silt contents and slaking of the sides of ditches is a common problem requiring increased maintenance. Capping of seed beds, produced by a tendency to rapid drying in April or May after a wet March, is frequent. The low clay contents of most of the soils produce inherent poor fertility and 'little-but-often' fertilizer régimes are probably the most economic. Some inextensive

exceptions (e.g. the Braemore/Kinsteary and Nigg/Preston Associations where some of the parent materials are slightly calcareous) only serve to highlight regional deficiencies.

Wetness High rainfall levels combined with trends to high organic-matter production and low breakdown rates, soil shallowness and the presence of indurated soil horizons produce soil wetness. If any site in the region has even the slightest obstruction to drainage it becomes severely wet. This accounts for the paucity of soils classed as imperfectly drained. Probably the only exceptions lie under the lower rainfalls of the extreme north-east. Even soils with free drainage can remain at field capacity for considerable periods during wet weather and suffer damage from stock or harvesting operations. Fortunately, they seem to recover fairly rapidly in subsequent seasons, due to higher organic-matter levels, combined with low-intensity farming systems. Soils with organic surface horizons remain wet for substantial portions of the year and, even when reclaimed, are suitable only for light use and fairly low stocking rates. Workability and trafficability are low and poaching risk high.

Flooding is a major winter risk in many of the valleys whose water courses have to cope not only with seepage flows, but with large amounts of surface run-off produced in storm conditions. Frequent warm fronts causing rapid melt of high-lying snow exacerbates the problem.

Erosion Erosion in hill lands is a fundamental geomorphic process and evidence of it can be seen throughout the region. After every winter new scars appear in the landscape but these seldom exist for long before being re-vegetated. The chief concern is to avoid systems of land use which enhance the natural tendencies to erosion. In general, the low levels of stocking throughout the region assist this aim, although the steepest slopes often have the driest soils, the richest plant communities and the highest stocking rates. Should techniques ever be evolved which would allow extensive reclamation in the area, it is likely that erosion would be a serious problem. Under present and foreseeable systems however, erosion is not a serious problem to agriculture in the hills.

In the outlying islands, especially Tiree but also locally elsewhere, wind erosion of the machair lands occurs. Spring gales across bare surfaces result in serious topsoil losses. Three or four such gales are not unusual in any 50 year period and the long-term result must be depletion of the soil resource. Any increase in agricultural operations involving soil disruption should be accompanied by planting of wind-breaks to minimize this risk.

Pattern Short-range variation in the properties of land is a serious limitation to the use of resources in Western Scotland. In past times, labour-intensive practices and the use of light farm machinery drawn by horses allowed many small patches to be worked and the land was intensively used. Recent times have seen trends to a smaller labour force and increased mechanization, coupled with higher standards of agricultural produce and increased yields to which the land of the west of Scotland is by and large unsuited. Short-range variability in soil characters (shallowness or stoniness), slopes and wetness has meant that the necessary long tractor runs and uniform seed beds are not obtainable. The unreliability of weather conditions militates against close quality control and thus land which was once cultivated for arable crops has been put under pasture. Even then high levels of grassland management such as are practised in areas to the south with less rainfall (e.g. Bute, Kintyre,

Ayrshire) encounter limitations and only the less intense soil management systems are now really practicable. In the face of these difficulties the West of Scotland Agricultural College and the Hill Farming Research Organisation have recently shown that careful attention to stock management systems coupled with sympathetic use of land resources can dramatically increase sheep-meat production.

On the till soils in the extreme north-east of the region, problems of pattern are less severe and soil management systems operate with fewer constraints.

THE CLASSIFICATION

The classification comprises three main categories, the class, the division and the unit, of which only the first two are utilized on the 1:250 000 map presented with this report. Land placed in any *class* or in any *division* has a similar *overall degree* of limitation; within any class or division there are therefore different management requirements. Comments on the principal *types* of limitation and the management problems which occur will be found in the descriptions of the classes and divisions.

Land in Classes 1 to 4 is suited to arable use and that in Classes 5–7 unsuited to arable use. There are no divisions within Class 1, 2 and 7; two divisions in each of Classes 3 and 4; and three divisions in Classes 5 and 6. A full description of the classification system and national guidelines is available as a Soil Survey Monograph (Bibby, Douglas, Thomasson and Robertson 1982). The following is a condensed description of the classes and divisions.

Land suited to arable cropping

Class 1 *Land capable of producing a very wide range of crops*

Cropping is highly flexible and includes the more exacting crops such as winter harvested vegetables. The level of yield is consistently high.

Class 2 *Land capable of producing a wide range of crops*

Cropping is very flexible and a wide range of crops may be grown but difficulties with winter vegetables may be encountered in some years. The level of yield is high but less consistently obtained than in Class 1.

Class 3 *Land capable of producing a moderate range of crops*

Division 1 The land is capable of producing consistently high yields of a narrow range of crops (cereals and grass) or moderate yields of a wider range (potatoes, field beans and other vegetables and root crops). Grass leys of short duration are common.

Division 2 The land is capable of average production but high yields of grass, barley and oats are often obtained. Grass leys are common and longer than in division 1.

Class 4 *Land capable of producing a narrow range of crops*

Division 1 Long ley grassland is commonly encountered but the land is capable of producing forage crops and cereals for stock.

Division 2 The land is primarily grassland with some limited potential for other crops.

Land suited only to improved grassland and rough grazings

Class 5 *Land capable of use as improved grassland*

Division 1 Land well suited to reclamation and to use as improved grassland.

Division 2 Land moderately suited to reclamation and to use as improved grassland.

Division 3 Land marginally suited to reclamation and to use as improved grassland.

Class 6 *Land capable only of use as rough grazing*

Division 1 Land with high grazing value.

Division 2 Land with moderate grazing value.

Division 3 Land with low grazing value.

Class 7 *Land of very limited agricultural value.*

Assumptions

The following assumptions must be taken into account in using the classification:

1 The classification is designed to assess the value of land for agriculture.

2 Land is classified according to the degree to which its physical characteristics affect the flexibility of cropping and its ability to produce certain crops consistently.

3 The classification does not group land according to its most profitable use.

4 The standard of management adopted is the level of input and intensity of soil, crop and grassland management applied successfully by the reasonable and practical farmer within the relevant sector of the farming industry. Such management will maintain or improve the land resource.

5 Land which has limitations which may be removed or reduced at economic cost by the farmer or his contractors is classed on the severity of the remaining limitations.

6 Land with more severe limitations is classified accordingly except where there is clear evidence that a major improvement project (e.g. arterial drainage) will be completed within the next 10 years. In such cases the land is classed as if the improvements had occurred.

7 Location, farm structure, standard of fixed equipment and access to markets do not influence the grading. They may, however, affect land-use decisions.

8 The interpretations are an expression of current knowledge and revision may be necessary with new experience or technological innovations.

CLASS 3

(Land capable of producing a moderate range of crops)

No land of higher quality than Class 3 occurs within the confines of Sheet 4 due to constraints of climate, principally high rainfall. Class 3 land occupies 26 square kilometres (0.2 per cent of the area) and is confined to Strathpeffer, Strathconon and Strathglass in the extreme north-east. A very small area in the extreme south-east, north of Drymen, has also been included in Class 3, but with an average annual rainfall of 1400–1500 millimetres is becoming marginal for the class.

Division 1 Situated in an area with slightly less than 1000 millimetres of rainfall, land in this division occurs to the east of Strathpeffer and extends southwards to the south-facing slopes of Conon valley above Wester Moy. It has been recognized on the north-facing slopes of the same valley, south of Marybank and a very small area some 9 kilometres to the south, is also included. In extent this division totals 12 square kilometres (46 per cent of Class 3) and is a westward extension of a larger area of good quality agricultural land round the shores of the Beauly Firth.

The soils included in the division are freely or imperfectly drained brown forest soils and freely drained humus-iron podzols, sometimes with shallow areas over either soft sandstone or indurated till. They become dry enough for cultivation early in spring and are frequently accessible even during late winter. The strongly sloping topography and, in the case of the area between Strathpeffer and Wester Moy, southerly aspect, also assist in the removal of excess winter rainfall. Although dominated by cereal and grass production the soils offer scope for the production of a range of arable crops. The small area of land (approximately 1 square kilometre) on the south bank of the River Beauly at Beaufort Castle, near Kiltarlity, is situated on mineral alluvium and contains numerous wetter areas in old channels. Although marginal for the division, it is part of a larger area of good class land extending into the Eastern Scotland region.

Division 2 The occurrence of land in this division is, as may be expected, closely associated with that of division 1. In the north-east four separate areas occur, two of alluvial soils in Strathconon and one of alluvial soils and one of strongly sloping humus-iron podzols in Strathglass. The alluvial soil areas are sandy and stony with, occasionally, an irregular pattern of wet hollows occupying old meander channels. Nevertheless, they are fairly level and provide few limitations to agricultural production except that of a marginal climate as the hill lands to the west are approached. In lower Strathglass the Fanellan area, south of Kilmorack, is composed of humus-iron podzols, sometimes stony, on strong slopes and is marginal to the division. Also marginal, but for climatic reasons, are the till slopes in the south-east round Milton. Here the soils are imperfectly drained brown forest soils on a sandy loam till, sometimes indurated, but more often water-modified. The water-modified horizon provides a sufficiently deep solum for drainage and the soil surface dries out earlier on these soils than where till forms the immediate

subsoil, allowing crops of spring cereals, usually barley or oats. Grass leys are a common feature of rotations.

Land in division 2 occupies 14 square kilometres (54 per cent of the class).

CLASS 4

(Land capable of producing a narrow range of crops)

The class comprises land marginal for the economic production of crops, usually confined to types suitable for winter feeding to livestock. Farming enterprises are based primarily on grass. Year-to-year variability in yield of crops other than grass is large and there is a serious risk of crop failure or poor weather interfering with harvests. Such marginal arable land is distributed throughout the whole of Western Scotland, for the most part as isolated areas surrounded by mountain and moorland. The limited extent of many occurrences of the class has given serious difficulties in representation at the 1:250 000 scale. In some instances, therefore, the areas have been slightly exaggerated. In other cases several small areas of arable land broken by land of lower quality occur. Where the arable areas formed the predominant class, the land was mapped into Class 4. Despite this attempt to give preference to what are, in the context of hill land utilization, key areas, some small pockets of arable land could not be shown. Parts of Mull, Morvern and Skye were particularly difficult in this respect.

The most extensive areas of Class 4 land are associated with the periphery of the Class 3 lands of Strathpeffer, Strathconnon and Strathglass, with Glen Urquhart and Glen Moriston also contributing to this north-eastern sector. Others, rather more broken, occur in the Great Glen, southern Loch Lomondside, coastal Argyll at Kilmartin, Connel and Appin, and on Tiree. Apart from this the occurrence of the class is sporadic. Class 4 land occupies 215 square kilometres (1.3 per cent of Western Scotland).

Division 1 Land in this division (47 square kilometres, 22 per cent of Class 4) is most extensive in the north-east of the region and is also found near Gartmore and Kilmartin, on the extreme south-eastern and south central edges of the area respectively.

Long ley grassland is commonly encountered but the land is also capable of producing forage and cereal crops and cropped fields are always an element in the vista over land in the division. Cereals are usually produced for stock feed within an individual farm enterprise rather than as a cash crop, due to the variable yields and quality obtained.

Land in this division in the north-east occurs under a cooler, but drier, climate than the more southerly parts. Around Strathpeffer and south of Culburnie in lower Strathglass, brown forest soils of the Braemore/Kinsteary Associations and humus-iron podzols of the North Mormond/Orton Associations are restricted to this division, primarily because patterns of slopes and soils provide problems for regular cultivation. Strongly undulating land with shallower soils on steep slopes and hollows containing soils with impeded drainage are found. Pattern is also a problem on alluvial soils in lower Strathglass. In the valley of the Black Water near Contin and in upper Strathglass around Cannich, the alluvium is less strongly patterned but very gravelly. Climate, however, is becoming the principal factor limiting the range of cropping. Similar limitations apply to moderately stony but freely drained

land at Whitebridge, at Fort Augustus and at Kilmartin in Argyll, these areas containing soils of the Corby/Boyndie/Dinnet Associations. Under the heavier rainfalls, the coarser soils with low water-retention capacities are advantaged, although the leaching rates of fertilizers are notoriously rapid.

Two small drumlin ridges to the west of Gartmore in the extreme south-east of the region are also included and complete the description of this division. Imperfectly drained brown forest soils of the Laurencekirk Association, extensive in Eastern Scotland, underlie this land. The coarse textures and strong slopes allow sufficient drainage to support cropping despite an average annual rainfall of some 1600 millimetres.

Division 2 The land in this division is primarily grassland with some limited potential for other crops. Grass yields can be high but difficulties of conservation and utilization are severe. Forage cropping and an occasional cereal crop, when the extra risks can be accepted, is possible. Throughout most of Western Scotland climate limits arable cropping, either through its direct effects, such as rain or wind damage, or by its effects on farm operations (cultivation, harvesting etc.). Where rainfall exceeds 1600 millimetres per annum only freely drained soils provide any possibility of cropping and even then their usefulness is limited. Such soils must be of coarse texture and the sands and gravels of the Corby/Boyndie/Dinnet Associations (Plate 16), with some limited extents of alluvium, form the major areas. On soils with

Plate 16. *Cultivated gravels of Corby Association (map unit 99), land capability class 4.2, near to Glenelg, Lochaber District. Because of high rainfall these soils do not suffer from severe drought limitations, but leaching of nutrients is rapid. After ploughing, fine soil particles are washed downwards and stony surfaces hinder seedling emergence and result in uneven growth.*

appreciable amounts of clay, silt or fine sand, lesser rainfalls (as low as 1200 millimetres) cause wetness and lead to problems of workability. Even so, tills derived predominantly from Mesozoic rocks (the Inchkenneth and Staffin Associations) would probably qualify for a higher division on Colonsay, the Ross of Mull, Tiree and northern Skye were it not for the fact that these areas are also severely exposed. Their utility is also limited by the intricate pattern which they often make with peat.

Nevertheless, there are some areas within the map boundaries whose potential is limited by factors other than climate. A tract along Glen Urquhart is limited partially by slope and, at the western end of the glen, by soil pattern. South of Contin, gravelly alluvium is crossed by old meander channels producing a pattern of wet and dry soils. Throughout most of the region Class 4.2 land is the best agricultural land available. It provides the heartland for the production of fodder crops and conserved grass for winter maintenance of stock. Without it, stock farming over much of the region would be impossible. Although it occupies only 168 square kilometres (78 per cent of the class), it has an importance to the agricultural economy out of all proportion to its extent. Like better land in other regions, development for housing and commerce puts pressure on this resource. It is, however, scarce and considerable care should be taken in its utilization.

CLASS 5

(Land capable of use as improved grassland)

The agricultural use of land in Class 5 is restricted to grass production but such land frequently plays an important rôle in the economy of British hill farms. Land qualifies for this class if mechanized treatments to improve or reclaim it are possible. The mechanized treatments can range through ploughing to rotavation to surface seeding and other improvements by non-disruptive techniques, but they must be within a realistic economic framework. Although occasional pioneer forage crops may be grown, the land is generally unsuited to the introduction of an arable rotation of any kind. Grass yields within the class can be variable and difficulties in production, and particularly utilization, are common. It is worth stressing that the allocation of land to this class only indicates that it is suited to improvement; it does not mean that it should be improved. The latter can only be determined with regard to farm structure, farm management and capitalization. In some cases it may not be either necessary or desirable to improve all the land that can be improved on a holding.

The important factors to be considered in improvement are (a) the ease or otherwise of establishment of the sward, (b) the persistence of the sown species, (c) the ease of maintenance and (d) whether the resultant sward can be used for grass conservation or whether it can be grazed. In Western Scotland grass conservation is primarily carried out on land in Classes 3 and 4. Improved grass is almost entirely used as additional grazing. The ease of establishment and maintenance is strongly related to soil drainage and site characteristics (particularly overall slope and patterns with rock) and the persistence of sown species is also strongly related to good soil drainage. In broad terms, areas with large amounts of freely draining soils have the best potential; those on intermediate or basic rocks are noteworthy in this respect, with the addition of shell sands (the Fraserburgh Association) which are susceptible to erosion if

cultivated. Very wet soils, in particular those with peat surface horizons, are unsuitable subjects for reclamation due to very low bearing strengths and anaerobic conditions which cause the more palatable grasses to die out rapidly. Soils of this type unfortunately cover very large areas of the region. The class comprises 1534 square kilometres (9.2 per cent of Western Scotland).

Division 1 Principally found in the western coastal areas overlying basalts, calc-silicate schists and shell sands, this division occupies 271 square kilometres (17.7 per cent of Class 5). Northern Mull, Morvern, parts of northern Skye and the islands of Lismore and Tiree are particularly notable but the andesites of the Lorn plateau and the Lewisian rocks of the southern Sleat peninsula also contribute.

In northern Mull, Morvern and northern Skye the terraced landscapes of the lowland and lower hill slopes carry freely draining brown forest soils, brown rankers and humus-iron podzols. The landscapes are, however, dissected and irregular and the soil depths very variable (Plate 17). Small pockets of land suited to arable agriculture occur, sometimes one or two small fields together, but in general the land is unsuitable for cultivation. It can be readily improved by bracken control, followed by surface seeding for grass production. With standard management the swards establish easily in the moist climate and the persistence of sown species is remarkably good. The high humus content of the topsoils is a slight disadvantage, as the soils suffer from poaching from stock in autumn and winter unless carefully managed. These conditions also apply in

Plate 17. *Strong soil and landscape patterns on the Island of Mull. The peaty gleys and peat of map unit 160 (Class 6.3) of the foreground contrast sharply with the improved grazings on the humose brown forest soils of map unit 158 (Class 5.1) of the centre ground. Some improvement of peaty soils in the gully on the extreme right has been attempted.*

the Sleat peninsula and the island of Lismore, where shallow freely draining brown forest soils in a hillocky landscape overlie Lewisian chlorite-schists and Dalradian limestones respectively. Considerable areas of the division are already reclaimed and under productive grassland.

In the island of Tiree most of the land in the division has been mapped overlying excessively freely drained shell sand machair and stabilized dunes which, due to the high wind speeds, has a severe erosion risk under cultivation. Some areas of gravelly raised beach with rock outcrops and sometimes small flushes are also included. Indeed, areas of gravels and alluvium with wet channels and hollows, or broken ground, have been mapped into the division throughout the region, for example in Glen Spean, at Laggan in the Great Glen and in Strathglass. Throughout much of the mountainous land, however, this division is entirely absent.

Division 2 Land in division 2 is moderately suited to reclamation and to use as improved grassland. Usually sward establishment can be achieved but increasing problems with steep slopes or strongly pattern land, including soil variability, leads to difficulties of maintenance. On wetter sites, problems of poaching contribute to a more rapid deterioration of the sward, rush infestation and a general decline in productivity. Nevertheless, with careful management the problems can be overcome and satisfactory stocking levels achieved.

In Western Scotland, the division occupies 651 square kilometres (42.4 per cent of the class) and is of greatest extent in the western islands and southern Argyll. In areas with similar freely drained soils to division 1 sites, but with steeper slopes or a more severe pattern of shallow soils and/or rocky mounds, the restraints to management increase and division 2 is recognized. The freely drained soils of the Sourhope Association in the Oban area, those of the Tarves Association near Kilmartin and the humus-iron and peaty podzols of the North Mormond/Orton Associations in the north-east of the region are typical. On soils of the Foudland Association division 2 land occupies parts of Seil and Luing Islands. Here very strong topographic irregularities are found and the areas are very marginal for the division.

Even wetter soils occur on parts of Tiree, Skye and north of Drymen, the noncalcareous, humic and peaty gley soils developed on the tills of the Staffin and Balrownie Associations. These sites often attract attention because of their more uniform appearance and gentle slopes in a region where such characteristics are in short supply. On occasion attempts have been made to use the soils for arable agriculture. On one or two favourable sites in Tiree this has been achieved, but generally soil moisture relationships are too severe and the susceptibility to poaching and risk of damage to soil structure ensures that they are placed in this division.

Finally, some of the humus-iron and peaty podzols and peaty gleys developed over sands and gravels of the Corby/Boyndie/Dinnet Associations and occupying valley floor sites in central and northern parts of the region have been included, as have one or two areas of alluvium. Pattern problems with very wet hollows (which sometimes flood) and the exceptionally high rainfall of the area cause severe management difficulties.

Division 3 Land in this division may be described as marginally improvable land. It has very serious physical defects which, without sustained maintenance, lead quickly to sward deterioration with the subsequent high costs that that entails. The defects may be severe pattern limitations or steep slopes (e.g.

Glen Lochay) but by far the bulk of the division suffers from wetness problems associated with peaty surface horizons (Plate 18). Land in this division is usually only suitable for improved grazings for sheep, as the low bulk densities and high moisture content of the surface horizons will not sustain the weight of other stock without very serious sward damage at almost any period of the year except high summer. Improvement of land of this type for sheep, coupled with paddock management systems, has led to vast improvements in lambing

Plate 18. *Severe poaching of peaty or humose surface horizons can occur at almost any period of the year and sward deterioration is rapid. Improved peaty gleys of map unit 160 (Class 5.3).*

percentages and stocking rates (for example at Melfort Estate, Kilmelford, and Barguillean Farm, Taynuilt). If the farm units also have land of higher quality to allow integrated use, so much the better.

Land in this division is extensive on the shallow, stony, peaty drifts of the lower hills to the east of Oban (the Sourhope Association). Here a particular combination of hill slopes and shallower soils seems to provide conditions suited to improvements. Similar conditions are present north-east and south-west of Strachur on Loch Fyneside and in the extreme north-west near Gairloch. The tabular hills of Mull to the west, although superficially similar, have lower slopes and greater thicknesses of peat which render them unsuited to reclamation.

Through much of the region long narrow tracts of land in this division occupy the floors of valleys. The soils are frequently a strongly patterned mixture of peaty gleys and peaty podzols or humus-iron podzols on moraine mounds, or wet, peaty alluvial soils prone to flooding. The division occupies 612 square kilometres (39.9 per cent of Class 5).

CLASS 6

(Land capable of use only as rough grazings)

Although land in Class 6 is defined as unsuited to improvement by mechanized means but with some sustained grazing value, its value to the grazier varies widely. At one end of the class, land with a high natural or semi-natural sward could be a more valuable asset than land in Class 5 which is marginally improvable but carries a financial penalty in recurrent maintenance costs, while land at the other end of the class may have extremely low stocking rates. In order to provide guidance on such matters within the class, which is the largest in Western Scotland (14271 square kilometres, 85.1 per cent of the region), three divisions are mapped. Their basis is the array of plant communities present in an area and an interpretation of their grazing values. An abbreviated explanation of the methods used will be found in Handbook 8 of this series and a fuller description in the monograph on Land Capability Classification for Agriculture. In the broad sense, there is a relationship between plant communities and the underlying soil type and both are related to climatic zones in mountainous areas.

Division 1 Land with high grazing value, in which the dominant plant communities contain high proportions of nutritious herbage, principally the better grasses (e.g. bent–fescue or meadow-grass–bent grasslands) is directly linked to brown forest soils, brown calcareous soils and humus-iron podzols. Those soil associations with high proportions of such soils are therefore important. The Darleith, Sourhope and Fraserburgh Associations are noteworthy in the west, while in the south the Dalradian rocks (the Strichen, Tarves and Foudland Associations) are also important. In the coastal areas round Loch Crinan for example, there are some extensive areas of very shallow rocky ground in the Tarves and Strichen Associations that qualify for the division. Although brown forest soils and humus-iron podzols are found on the Torridonian and Moinian rocks (the Torridon and Arkaig Associations), they occur in units with peatier and wetter soils and rarely qualify. Exceptions are some small coastal areas and a steep south-easterly facing slope in Strathglass. However, the slopes of the Great Glen, north of Spean Bridge, in which the age of the rocks is in some doubt (Moinian or Dalradian), have such strong affinities to the southern areas that they have been mapped with the Strichen Association (Dalradian). To the north, the only significant land in this division is associated with steep slopes on parts of the Lochinver Association (in particular the Lewisian rocks occurring to the east of the Moine Thrust).

Bracken is an invading fern on freely drained brown forest soils or occasionally on humus-iron podzols. It can also grow on deep, well-drained, humose soils on hill land but this soil is never extensive. If the bracken is very dense, little else can exist due to heavy shading, but overall, although the values of the grazings are reduced they seldom fail to qualify for the division. Aerial spraying to remove the weed is occasionally practised but is not economic unless follow-up treatments with fertilizers and grass-seed can be applied. By definition, this is rarely the case in Class 6 land. Occasionally small areas of land within the class can be subjected to reseeding or application of fertilizers which may be allowed to 'weep' down steep slopes in the hope that less accessible land will benefit. Such techniques are considered as patch reclamation unless they are sufficiently extensive to qualify the land as Class 5.

Some small areas of vegetated dunes have been included in the division on Tiree, Coll, Iona, Colonsay and western Ardnamurchan. Saltings almost always qualify for inclusion despite periodic unavailability due to inundation, but are rarely of sufficient extent to separate at this map scale.

Land in the division is fairly restricted in Western Scotland (653 square kilometres, 4.6 per cent of Class 6) but is an important farming resource.

Division 2 Land with moderate grazing value, with plant communities such as common white bent grassland, flying bent grassland, rush pastures and herb-rich moorlands, or with a mosaic of high and low grazing values characterizes the division. It covers 2382 square kilometres (16.7 per cent of Class 6).

Several types of land can be recognized. Around Loch Long extensive steep slopes of peaty podzols and peaty gleys of the Strichen and Foudland Associations carry heath rush–fescue grasslands (in particular common white bent grassland). This community develops more widely in the Southern Uplands and although white bent is not particularly palatable, other accompanying species in the community are. Extensive flushing is also found in the higher rainfall areas. The soil map units dominated by podzols in the Darleith Association of the Inner Hebrides carry a mixture of moorland communities and bent–fescue grassland.

In the north, most of the limited extent of the brown forest soil and humus-iron podzol units found in the Arkaig Association are included. These units show a very wide variety of soil types with acid flushes, peaty gley and peat-alluvium hollows. In addition, many carry birch and oak woodlands which reduce the value of the underlying sward by shading.

Plate 19. *The northern slopes of Meall nan Caora near Glen Falloch exemplify the sharp change in plant communities from the Atlantic, bog and boreal heather moors (Class 6.3) to the stiff sedge-fescue grassland and mountain heaths (Class 6.2) of the oroarctic climate zone round the summit. The high mountain pastures are extensively grazed by sheep during spring, summer and early autumn.*

The greatest extent of the division throughout the central parts of the region is on steeply sloping map units containing subalpine soils, starting as low as 400 metres in the extreme west but not until some 600 metres in the east. The vegetation of the map units is characterized by upland bent–fescue grassland, stiff sedge–fescue grassland and mountain heath communities, which often contrast sharply in the landscape with the heather moor communities of the mid-hill (Plate 19). The mountain slopes are preferred by sheep to the mid-hill; in spring sheep can often be seen foraging through the heather moors but for most of the summer they occupy the lower ground or the upper slopes constantly. The grazing season in the uplands extends from late April to late October.

The mountain land in the division exhibits an interesting distribution. It is most extensive on the steep, upper slopes of the Dissected Central Mountain region (Fig. 2). The Western Plateaux and Foothills rarely achieve sufficient altitude; the Eastern Mountain Plateaux not only have restricted steep slopes at the correct altitude due to their configuration, but also develop a more heathy vegetation due to climatic influences. The disappearance of the division northwards, caused by the tabular form of the Torridonian sandstones in the Dissected Central Mountain region almost meeting the westwards extension of the Eastern Mountain Plateau region in the vicinity of Strathconon and Loch Monar is a marked feature. To the north the outline of the Moinian hills is more rounded and the division is of very limited extent in Northern Scotland.

Regrettably for the utilization of much of the upper mountain grazing, the mid and lower hills have a paucity of land on which to base farm units. North of a line from the Moor of Rannoch and Glencoe throughout western Inverness-shire, only the narrow valleys adjoining the Great Glen, a few coastal flats and the major break at Strathconon provide a footing for the agriculturalist. Throughout this wild and remote region the hills seem destined to remain lightly stocked, a haunt of eagle and deer rather than sheep.

Division 3 This land type, the most extensive in Western Scotland, occupies 11236 square kilometres (78.7 per cent of the class). The vegetation is dominated by plant communities with low grazing value, particularly a wide variety of heather moors and bogs. The soils are acid, peaty and predominantly wet and they cover a wide variety of landforms and site types, ranging from sea level to mountain top.

Although generally unsuitable for reclamation, for a variety of reasons, occasional attempts are made to reclaim small areas, either in a mosaic or far out on the hill to encourage stock to range and to relieve grazing pressure on other, perhaps scarce, plant communities. Such management as is attempted consists of burning rank or old vegetation, periodically in the case of heather dominated swards or almost annually in the case of bogs with a high proportion of flying bent.

CLASS 7

(Land of very limited agricultural use)

This land has extremely severe limitations which cannot be removed or rectified. In Western Scotland it consists primarily of the alpine soils under the

Table C Areas of land capability for agriculture map units

CLASS and DIVISION	SHEET 4		SCOTLAND	
	SQ. KM.	% LAND AREA	SQ. KM.	% LAND AREA
1	0	0	41	0.1
2	0	0	1723	2.2
3	26	0.2	11724	15.2
3.1	12	0.1	4586	5.9
3.2	14	0.1	7138	9.3
4	215	1.3	8219	10.7
4.1	47	0.3	3690	4.8
4.2	168	1.0	4529	5.9
5	1534	9.2	14270	18.5
5.1	271	1.6	1810	2.4
5.2	651	3.9	5899	7.6
5.3	612	3.7	6561	8.5
6	14271	85.1	37329	48.4
6.1	653	3.9	1556	2.0
6.2	2382	14.2	5463	7.1
6.3	11236	67.0	30310	39.3
7	697	4.2	2548	3.3
BUILT-UP AREAS	22	0.1	1233	1.6
TOTAL	16765		77087	

1 sq. km. = 100 hectares

Areas in this table have been estimated by point-count methods. Discussion of method and estimation of error is contained in Handbook 8.

arctic climate régimes of the mountain summits, extremely rocky areas such as the Cuillin Hills of Skye, or dubh-lochan bogs, for example Claish and Kentra Mosses, Ardnamurchan. Throughout the vast majority of the peatland of the region, hagging is not sufficient to downgrade land below Class 6.3 but in Eastern Scotland some extremely hagged land is found and this finds its way into the west in the Corrieyairack and Glendee Forest areas. On mountain tops some poor grazing may be available for limited periods of the year.

LAND CAPABILITY FOR NON-AGRICULTURAL USES

The range of uses to which land is put in Western Scotland is wide, including building, industry, ports and harbours and transport. There is little doubt, however, that forestry uses the most extensive tracts after agriculture and that recreation activities also make wide demands on the land resource. No formal classification schemes have yet been finalized for these activities in Britain, although there are examples from Canada and the United States, but it is possible to comment on the advantages and limitations of the major map units identified in the soil survey for these purposes. The remainder of this section constitutes a short discussion of the properties of land for forestry and for recreation in Western Scotland.

FORESTRY

Although in world terms the British climate is without severe extremes and is generally favourable to tree growth, Western Scotland shows a wide range of conditions from sheltered, warm, moist glens, ideal for growth, to cold, exposed mountain summits with an arctic climate where trees will not survive. The hills and mountains of the region lead to a strong expression of the vertical zonation of climate which is as marked for forestry as it is for agriculture. Perhaps more so, for while stock can find shelter during the worst storms, the trees remain exposed. The general exposure of the western islands, for example, Colonsay,

Plate 20. *Windthrow on a peaty gley in a gully in Inverleiver Forest, Lochaweside, Argyll. The standing trees in the background are on deeper, better drained soils.*

Coll, Tiree and western Mull, is a serious limitation to growth and little commercial forestry is possible. Immediately some shelter is available, however, as in northern and central Mull and the mainland glens, a range of tree species will thrive, particularly at low altitudes. Nevertheless, during the fifty or sixty years needed for the maturation of a forest crop, at least two extremely severe gales can be expected and all but the most sheltered sites are at risk from windthrow (Plate 20).

Windthrow severely affects forest crop management, determining thinning régimes and the length of time that the crop can be expected to stand. The risk is greatest where restricted rooting depths coincide with exposure. The height of the tree crop is also critical. Rooting depths are determined by shallowness to rock or other impenetrable horizon, such as induration, or to a waterlogged horizon. Shallow and wet soils are features of large parts of the region and it is no coincidence that areas of windthrow can be seen in all the older major forestry blocks.

Apart from shallowness or wetness, soils also influence forestry management through their natural fertility, especially when the costs of purchase and application of fertilizers are rising steeply. On mineral soils nutrient availability is related to the volume of soil available for rooting and the chemical composition of the parent material. Those derived from quartzites, quartzose sandstones and gneisses (e.g. the Durnhill, Torridon or Arkaig Associations) are poorest. Basic igneous rocks give problems of poor phosphorus availability (the Darleith Association). On organic soils, nutrient availability has been related to the total content of nitrogen, phosphorus and potassium. Soils with shallow organic horizons require phosphate at planting, those with greater depths, both phosphate and potash. Peats characterized by the absence of *Molinia* usually need further applications and on the poorest peats, nitrogen may also be needed. The presence of nutrients is often indicated by the occurrence of plant indicator species. the generalized plant community descriptions accompanying the soil descriptions are of some value in this respect.

Throughout the area soil wetness, particularly in peat, is a problem in establishment, and the ploughing of a turf in which to plant seedlings and to suppress competition is important. Occasionally minor topographic patterns are strictly limiting, for example boulders, but slope is the most important element affecting mechanization. Only limited areas less than 5 degrees (the limit of two-way ploughing at deep draught) are found but apart from this one-way ploughing presents few difficulties throughout the area up to a limit of 30 degrees on non-rocky slopes. The difficulty of ploughing steep slopes increases in proportion to the amount of rock. Road design and construction are also affected by the amount of rock present and ultimately so is the cost of harvesting.

From the above description it is quite clear that the most favourable areas for tree growth and those making available the widest choice of species are in the south of the region (south of an east–west line from Glen Dochart to Loch Etive) and on the north-eastern fringe. The best sites are in the lower, sheltered glens where soils are deepest and exposure least (the tallest tree in Britain is currently claimed to be growing in the arboretum at Cairndow at the head of Loch Fyne). Both soil and climatic restrictions quickly assert themselves with altitude however, and in most of the hill land choice is restricted to Scots and lodgepole pine and Sitka spruce. Nevertheless the soils of the Strichen, Foudland and Tarves Associations (the Dalradian province) and of the Sourhope Association

have been extensively forested. In the west, although exposure is a problem on many of the islands, sheltered parts of Mull provide suitable conditions. On Skye, however, forestry is largely restricted to the peaty podzols and peaty gleys, since the areas of brown forest soils are less extensive and subject to more competition from agriculture.

The choice of species on the soils of the Arkaig, Torridon, Durnhill and Countesswells Association, forming most of the central and western parts of the region, is confined almost entirely to Sitka spruce and lodgepole pine. There is some evidence that yields are less and rotations longer in these areas. Only in the far north-east, as climatic conditions ameliorate and soils become less peaty and wet, does the species range on Moinian rocks approach that of the Dalradian of the south.

RECREATION

Both agriculture and forestry generate tangible products. They differ from recreation whose products are ethereal or aesthetic, and, in this sense, the requirements of and limitations on recreation are considerably more difficult to assess. The provision of recreational facilities, such as camping and caravan sites, chalet and hotel developments does make a demand upon the physical environment however, and some sites are obviously more suitable than others. Some recreation requires a specific physical feature, for example, climbing and skiing, and the impact of such popular sports on the surrounding land resources can be assessed.

The ruggedness and remoteness of many parts of Western Scotland and the vistas of mountain and sea draw large numbers of people each year. The best conditions for the provision of accommodation are found where coarse textured soils with good drainage occur on low slopes. Land of this type is confined to raised beaches (map units containing brown forest soils and humus-iron podzols in the Corby/Boyndie/Dinnet and Gruline Associations). Camping usually requires the presence of turf and free drainage. It is necessary however that surface horizons have at least a moderate capacity to retain moisture, otherwise surfaces dry out, vegetation fails and continued use produces erosion. For this reason sites on the sand dunes and machair (e.g. Fraserburgh Association) are not good for sustained use as depletion of the soil resource quickly results. Roading and hard standings allow more flexibility in the provision for caravan sites (although at increased cost) but even so, areas with free drainage are almost essential. Building sites for chalet or hotel development are cheaper if expensive extra foundation work (such as is occasioned by rock or steep slopes) is avoided and this again concentrates attention upon a relatively small amount of land.

Since most of the settlements in the region are small, main drainage by sewers is of restricted extent. Many rural areas rely on the disposal of effluent by means of septic tanks and soakaways. Deep soils with good drainage are important; the presence of shallowness to either indurated horizons or rock is undesirable. Also undesirable are soils of very low permeability, for example, peat or fine sand. Through Western Scotland therefore, areas available for development are restricted, and the density of development on them must be carefully controlled unless mains sewers are available.

Certain areas of the region attract a high proportion of use. Hence the Ben Nevis range of hills, Glencoe and the Cuillins are heavily trafficked by walkers and by climbers. When approaches to the mountains cross wet, peaty areas, the vegetation is unable to withstand continuous use and dies leaving the underlying peat unprotected. Erosion of both the peat and its subsoil is already very obvious in some areas. Where access is across freely drained mineral soils, podzols, or very stony areas damage is minimal. Without extensive works to protect the most heavily trafficked approach routes, or control on the number of people using the routes, this process will continue. It is currently localized but as the tracks widen by walkers circumventing the worst places, it will certainly spread. Apart from these three areas, the concentration of walkers is relatively light; the growing popularity of the sport and the increasing search for less crowded areas raises some concern for the future however, especially on the susceptible peaty gley, peat and mountain summit soils.

Only one centre for skiing, the north-facing corries of Meall a' Bhuiridh, has so far been developed. Surveys are also being made to determine areas of longest snow-lie which will almost certainly identify other northern corries and one proposal has already been made. Building works for ski-lifts at high altitudes always leaves erosional scars which persist for many years due to the inability of vegetation to colonize the bare areas under severe climates. Extreme care is necessary in the management of such areas to minimize erosion and assistance to natural species to recolonize is often necessary. In similar ways to walking routes, heavy trafficking around huts or major ski runs, particularly just after snowmelt in spring, causes damage to turf. The damage, although severe, is very localized at Meall a' Bhuiridh and careful planning and management should be able to contain this problem in the future due to the limited areas involved.

Erosion, particularly on unprotected embankments and cuttings, is also a problem for hill roads constructed for stalking purposes. These are few and far between in Western Scotland since the wet moorlands are in general unsuitable for grouse and the primary target for hunters is the red deer, an animal which must be stalked rather than 'beaten up'.

The soil map is an important adjunct to the identification of a wide range of habitats for environmental studies. Probably the most important areas are those underlain by limestones (the Deecastle, Inchnadamph and part of the Inchkenneth Associations), the basic igneous rocks of the western islands and mainland (the Darleith, Torosay, Insch, Corriebreck and Sourhope Associations) and the specialized environmental conditions of the machairs (the Fraserburgh Association), other coastal areas and the arctic mountain summits (a wide range of soil associations). The Dalradian rocks also provide richer flora occasionally, but the bulk of the area is composed of acid gneiss, schist and granite with a very restricted flora and fauna. Perhaps the best known examples of flow-bog in Scotland occur at Claish and Kentra Mosses, but for the most part the peats are acid and restricted in their floral range.

The preceding brief comments on the potential of the soils of Western Scotland have drawn attention to the great importance that attaches to the brown forest soils and humus-iron podzols of the raised beaches and to those areas underlain by the richer rocks. Perusal of the areas of the map units containing such soils (Table B) reveals that they are of very restricted extent. Competition for such scarce resources for agriculture, forestry and urban and industrial developments is already apparent; pressures of recreation and nature conservation are increasingly making demands. The best land use

pattern to adopt for any area at any given time is a matter of balancing the physical properties and potentials of the land against the economic and social requirements of the populations. Reserving some flexibility for future changes is also an important consideration. In these matters the careful assessment of the nature of land, its properties and the limits that those properties impose on man's activities, will always be essential. The survey reported upon in this handbook is a contribution to these studies.

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