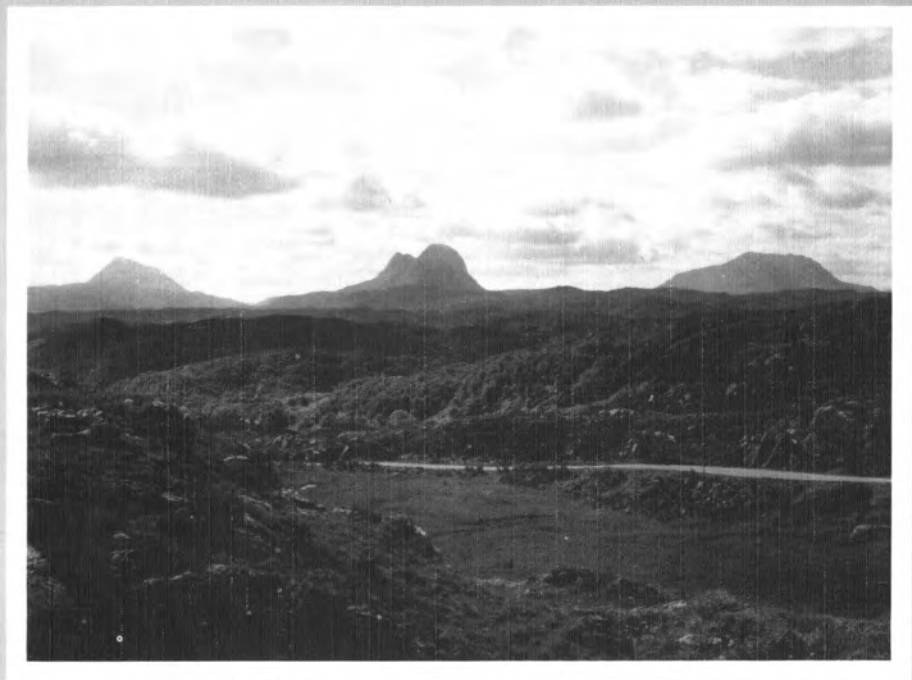


Soil Survey of Scotland

NORTHERN SCOTLAND



1:250 000 SHEET 3

The Macaulay Institute for Soil Research
Aberdeen 1982

SOIL SURVEY OF SCOTLAND

Soil and Land Capability for Agriculture

NORTHERN SCOTLAND

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The Macaulay Institute for Soil Research
Aberdeen 1982

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Front cover. *Canisp, Suilven and Cul Mor from north of Lochinver, Sutherland. Hills of Torridonian sandstone rise above a strongly undulating plateau of Lewisian gneiss.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

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Preface

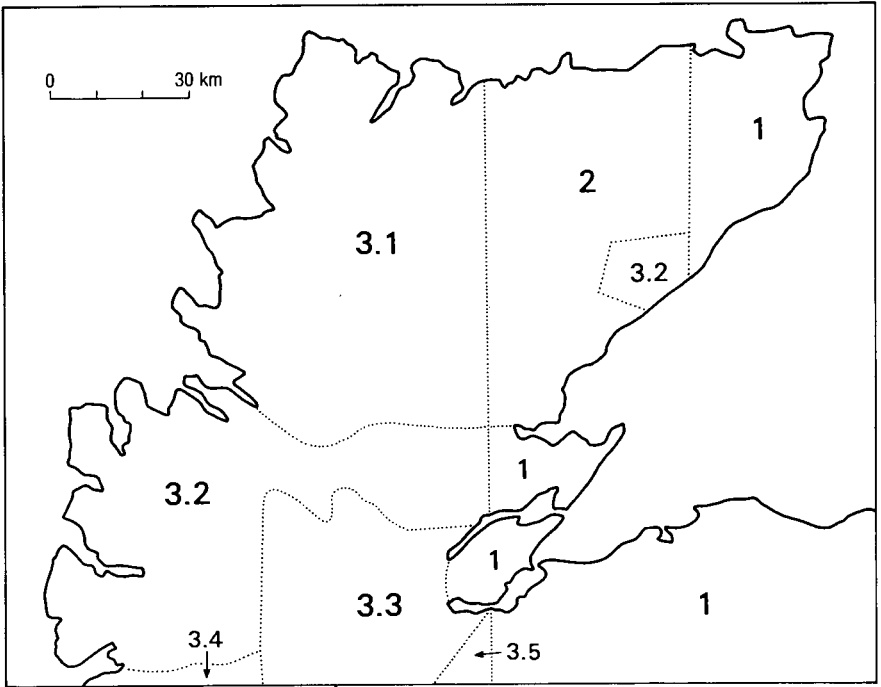
Prior to 1978, soil and land capability surveys in Northern Scotland were concentrated in the eastern areas. Published soil maps were available for most of the area east of Inverness and for much of Caithness and Easter Ross, together with a number of land capability maps. In 1978 the proposal to survey the remaining areas of the Highlands at a scale of 1:250 000 was formerly approved by the Department of Agriculture and Fisheries for Scotland.

Field-work was carried out in 1978-80, and the responsibilities for the mapping are shown in the diagram below.

The compilation of the soil map was based on the National Soil Map Legend compiled by B. M. Shipley. The vegetation assessments were carried out by field staff according to a system designed by E. L. Birse and J. S. Robertson; the latter also correlated the vegetation descriptions on the soil map. 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 was drawn at Ordnance Survey and the land capability for agriculture map was drawn by W. S. Shirreffs and Miss P. R. Carnegie.

The handbook was written principally by D. W. Futty and W. Towers, with contributions from R. E. F. Heslop, C. G. B. Campbell, A. D. Walker, G. G. Wright, J. H. Gauld, D. Laing, D. J. Henderson, F. T. Dry and G. Hudson; J. S. Robertson wrote the account of the vegetation in Chapter 1 and checked the vegetation descriptions in Chapter 2; and J. S. Bibby read and commented on the chapter on Land Evaluation. The figures were prepared for publication by A. D. Moir and Mrs. R. M. J. Fulton. The handbook was edited by D. W. Futty and R. E. F. Heslop.

Assessments of land capability for agriculture were made using the guidelines devised by Bibby, Douglas, Thomasson and Robertson (1982). Advisory groups, one for the area north and west of Inverness and the other for the area to the east, were established to assist the soil survey staff in this task. They comprised representatives of the Department of Agriculture and Fisheries for Scotland, the North of Scotland College of Agriculture 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 map. The responsibility for the map remains entirely with the Soil Survey Department however.



1 PUBLISHED 1:63 360 SOIL MAPS

2 UNPUBLISHED 1:63 360 SOIL SURVEY

by D. W. Fuddy, W. Towers, F. T. Dry and J. Mackay

3 1:250 000 SURVEY

3.1 D. W. Fuddy and W. Towers

3.2 D. W. Fuddy, W. Towers and A. J. Nolan

3.3 R.E.F. Heslop and C.G.B. Campbell

3.4 J. S. Bibby, G. Hudson and D. J. Henderson

3.5 A. D. Walker and G. G. Wright

Figure 1. Survey teams' map areas

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

ROBERT GRANT
Head of the Soil Survey of Scotland

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The Soil Survey Department wishes to thank the many land owners and farmers who willingly co-operated in the survey by allowing access to their land. The assistance of other agricultural organizations in the land capability assessments has already been acknowledged, but the Department would like to thank in particular, the following (listed in alphabetical order) for their valuable assistance and contributions to the two committees which advised on the north-western and south-eastern areas:

G. Buchanan, W. J. Calder, C. G. Davidson, J. Davidson, F. M. B. Houston, A. MacDonald, I. Mathieson, J. G. Rennie, W. C. Robbie, E. Stewart and J. Valentine (Department of Agriculture and Fisheries for Scotland);

G. D. Findlay, J. W. Grant, A. Howie, W. J. S. Merchant, J. R. Seton and J. Vallance (North of Scotland College of Agriculture); and

P. E. Durham, K. J. Gill, D. L. Girvan, M. Martin and G. M. Murray (National Farmers' Union of Scotland).

Photographs by the Institute of Geological Sciences and by Aerofilms Limited are acknowledged on the captions; other photographs are by the staff of the Soil Survey Department of the Macaulay Institute.

I Description of the Area

This handbook describes the area covered by the 1:250 000 Sheet 3 (Northern Scotland) soil and land capability for agriculture maps.

The area includes the former counties of Caithness and Sutherland, most of Ross and Cromarty, the northern part of Inverness-shire, practically all of Nairnshire, most of Morayshire, much of Banffshire, and a small bit of Aberdeenshire. The total land area (i.e. excluding inland lochs) is 16,442 square kilometres.

Parts of the area have been dealt with in previous publications: Glentworth (1954) includes the narrow eastern edge to the south of Portknockie, Grant (1960) describes the Elgin district, and Fuddy and Dry (1977) the part of Caithness which lies to the east of a line between Thurso and the Ord of Caithness. A list of published soil and land use capability maps is included in the References section.

PHYSIOGRAPHIC REGIONS—GEOLOGY, LANDFORMS AND PARENT MATERIALS

There are four main physiographic regions:

- 1 The Northern Highlands
- 2 The Grampian Highlands
- 3 The Caithness Plain
- 4 The Moray Firth Lowlands

The descriptions of the geology of each region are based on Phemister (1960), Craig (1965) and Johnstone (1966). The dominant rock types and their distribution are shown in Fig. 2.

THE NORTHERN HIGHLANDS

This extremely extensive region includes most of the land to the north and west of Loch Ness (which lies in Glen Mor, colloquially the Great Glen), and Inverness. It excludes only the Caithness Plain and the lowlands of the Moray Firth, while to the east of the Great Glen lie the Grampian Highlands.

In the west, the Moine Thrust, extending approximately from Loch Carron in the south to Loch Eriboll in the north, divides the region into an area of largely

NORTHERN SCOTLAND

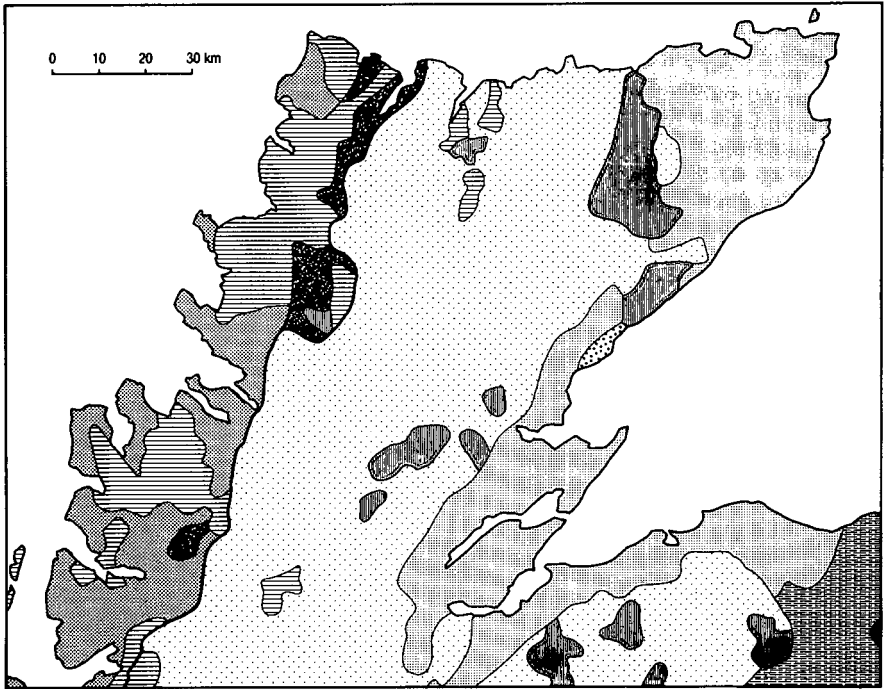











Figure 2. *Geology*

DESCRIPTION OF THE AREA

| | | | | |
|--|--|---------------------|---|-------------------|
|  | Sandstones, shales and limestones | Jurassic | } | Sedimentary rocks |
|  | Sandstones, conglomerates, shales and flagstones | Old Red Sandstone | | |
|  | Quartzites and limestones | Cambrian/Ordovician | | |
|  | Sandstones and grits | Torridonian | | |
|  | Granites and allied rocks | | } | Igneous rocks |
|  | Gabbro and allied rocks | | | |
|  | Schists, slates, phyllites and quartzites | Dalradian | } | Metamorphic rocks |
|  | Granulites and schists | Moine | | |
|  | Gneisses | Lewisian | | |
| — | Moine Thrust | | | |

Lewisian and Torridonian rocks to the west and one of mainly Moinian rocks to the east. The two subregions are described separately.

West of the Moine Thrust To the west of the Moine Thrust lies some of the most rugged land in Northern Scotland. Lewisian rocks dominate the area to the north of Enard Bay. Between Enard Bay and Laxford Bridge they are largely pyroxene-gneisses with concordant bands and lenticles of basic and ultrabasic rocks and intruded by basic dykes which have a north-west or west-north-west trend. Further north, biotite- and hornblende-gneisses with veins and sheets of granitic material are present. Lewisian rocks are also extensive in the district between Loch Gairloch, Loch Maree and Gruinard Bay, and comprise hornblende- and biotite-gneisses intruded by basic dykes and by granite and pegmatite veins; areas of metasediments and hornblende-schists occur on the north-west side of Loch Maree and to the east of Gairloch.

Torridonian rocks are particularly extensive in Wester Ross and dominate most of the area between Loch Kishorn and Loch Gairloch, but their distribution in Sutherland is much more patchy. The rocks comprise red, current-bedded feldspathic sandstones and grits, together with some conglomerates and shales.

Cambrian and lower Ordovician rocks occur in a narrow band lying immediately to the west of the Moine Thrust and extending from Eriboll in the north to Kishorn in the south. The succession comprises a lower sequence of arenaceous rocks—predominantly quartzites—and an upper one of limestones; these limestones (the Durness limestones) consist of a series of fossiliferous dolomitic limestones with occasional bands of chert, the main outcrops being at Durness, Eriboll, Inchnadamph, Knockan and Kishorn.

Other rocks in this subregion include the syenites at Loch Borralan and Loch Ailsh, and the few small outcrops of Triassic and Jurassic sediments present at the coast—as, for example, at Applecross.

The subregion is made up of two physiographic divisions, the western lowlands and the mountains. The western lowlands, lying mainly below 200 metres but locally rising higher, have a predominantly very rugged and rocky landscape with a highly indented coastline containing many deep and narrow sea lochs. The land is strongly undulating and ice-scoured. The Lewisian gneiss forms large areas of 'knob and lochan' topography, particularly in Sutherland, comprising rock knolls with lochans and deep peat in hollows or channels between them. The landscape is strongly controlled by the structure, the channels indicating lines of faults or intrusions of dykes. The lowland landscape of the Torridonian rocks reflects the underlying strata; local 'scarp and dip' features are common, with low crags on short steep slopes and rock pavements and slabs exposed on the more gently sloping dip slopes. The Cambrian quartzites generally present a similar landscape pattern. The areas of limestone outcrops are rocky; the largest one, at Inchnadamph, forms a plateau with a steep escarpment. Much of this western lowland area is drift-free or has a patchy cover of stony shallow drift, although till occurs locally in some of the less-rocky coastal areas.

The mountains lie mainly in the south, particularly between Loch Carron and Little Loch Broom, but there is also a narrow band of mountainous country further north to the immediate west of the Moine Thrust. In the south the mountains are mainly of Torridonian sandstone with some of Lewisian gneiss, but those to the north often have a more complex geological structure. Steep rocky slopes with crags, scree and stony colluvium are widespread. Some mountains have stony cryogenic material on a gently or strongly sloping plateau

surface, with patterned-ground features such as terraces common. Moraine is generally present in the valleys of the mountain areas.

East of the Moine Thrust To the east of the Moine Thrust the greater part of the land is much less rugged. It comprises a dissected plateau, highest in the south and sloping northwards to the coast, underlain by Moinian rocks with some granites and allied rocks, and some Old Red Sandstone sediments. The Moinian rocks are predominantly roughly foliated quartz-feldspar-biotite-granulites, with mica-schists, hornblende-schists, quartz-schists and quartzites occurring locally. The granites and allied rocks occur in a number of localities and in a number of forms. The Carn Chuinneag-Inchbae intrusion is a foliated biotite-granite or augen-gneiss. Injection complexes, comprising migmatites with discrete granitic masses, veins and pegmatites, occur at Loch Choire and Strath Halladale. Intrusions belonging to the Newer Granites of late Silurian or early Old Red Sandstone age include the biotite-granite of Helmsdale and the zoned igneous complex, largely of granodiorite and biotite-granite, at Rogart and Lairg as well as a few small other masses. Alkaline intrusions of syenite occur at Loch Loyal. Lower and Middle Old Red Sandstone rocks—mainly sandstones and conglomerates, but also some shales, fringe much of the east of this subregion and also occur as a few outliers. Of minor extent are a few inliers of Lewisian rocks.

To the north of Strath Oykel much of the land lies between 50 and 250 metres with local areas of higher ground. The land is predominantly non-rocky with gentle and strong slopes. The areas of higher ground in the north-west and in central Sutherland around Loch Choire are partly mountainous. South of Strath Oykel the land has a much greater altitude range—from 100 to over 1000 metres—and is rockier and much more strongly dissected; it is an area of hills and glens, with strong east-west lineation, and is partly mountainous. Slope ranges are consequently much greater. Most of the subregion is drained by rivers flowing either northwards to the north coast (the Naver and the Halladale) or eastwards to the Moray Firth (the Helmsdale, the Oykel and the Conon). The soil parent materials are mainly stony drifts of loamy sand and sandy loam textures. Till is extensive in the northern part of the subregion but less common in the south, hummocky moraine is common in the valleys, colluvium occurs on the steeper slopes, and cryogenic drift is present on the mountain tops. Peat has developed extensively in the northern part of the subregion.

THE GRAMPIAN HIGHLANDS

This region lies to the east of the Great Glen and to the south of the Moray Firth Lowlands. All of the land lies above 60 metres. Moinian and Dalradian rocks are dominant with intrusive igneous rocks and sedimentary rocks only locally extensive. The area of Moinian rocks is characterized by its uniformity and has a close similarity to the Moinian rocks of the Northern Highlands. Quartz-feldspar-biotite-granulites are dominant, particularly between the Dorback Burn and Strathspey, although mica-schists and quartz-mica-schists occur locally further west.

In contrast, the Dalradian group of rocks to the east has a much greater range of rock types. Most common are mica-schists, quartz-mica-schists, black graphitic schists and slates, with quartzites, quartz-schists, hornblende-schists and epidiorites more restricted. The Dalradian rocks are thought to be essentially conformable on the Moinian rocks although the stratigraphical relationships are not known precisely.

Granitic intrusions occur at Moy, Ardclach, Ben Rinnes and Craig Liath and are found almost entirely within the area of Moinian rocks; biotite-granite is most common although muscovite-biotite-granite is also present in the Moy and Ardclach intrusions. Both rock types generally have a pinkish hue and grain size is variable. A small basic intrusion with gabbro, serpentinite and picrite occurs in the east; this area is on the western edge of the Huntly mass which is present in Eastern Scotland (Sheet 5).

Middle Old Red Sandstone strata are present on Drum Mossie Muir, but also occur locally further east, particularly around the Spey valley. Sandstones are dominant, with some conglomerates, shales and flagstones; the sandstones are often coarse and pebbly to the north of Rothies.

Much of the area lies between 120 and 600 metres although the altitude rises to 840 metres on Ben Rinnes. West of the River Spey, the area consists of a peneplain in the north, gently undulating between 200 and 400 metres, and a higher 600-metre dissected plateau in the south. To the east the general altitude is lower, apart from the southern edge which includes Ben Rinnes; this area merges with the North-East Lowlands of Eastern Scotland (Sheet 5). The high ground in the south is broken by the deep valleys of the Rivers Spey, Findhorn and Nairn. This whole region is drained by rivers flowing north-east into the Moray Firth.

The land is predominantly non-rocky with gentle and strong slopes. Only small areas are exceptions to this, for example around Farr and Loch Moy. To the west of the River Spey, thick till, often exceeding 30 metres, covers parts of the peneplain, in marked contrast to the shallow drift of the lower slopes of the dissected plateau. The bulk of the dissected plateau is covered by deep dystrophic peat, much of which is very strongly hagged. Cryogenic deposits, formed by freeze-thaw processes, occur on the more exposed sites where the peat has been completely removed. Till in the valleys and on the lower slopes, with shallow drift on the upper hill slopes is the dominant pattern to the east of Strathspey. Fluvio-glacial sands and gravels are locally extensive, particularly in the lower Findhorn valley and to the south of Nairn, but these deposits also occur in most of the other river valleys; landforms include terraces, mounds and ridges. Related to, and often adjacent to these well-sorted and bedded deposits, are deposits of rudely stratified gravelly loamy sands; they are also a product of a meltwater process and are occasionally overlain by well-sorted sands and gravels. These partially sorted deposits are most extensive in the Findhorn valley where they form an area of gently undulating ground with long low mounds.

THE CAITHNESS PLAIN

The Caithness Plain, lying in the north-east corner of Northern Scotland, is a gently undulating lowland area underlain by Old Red Sandstone strata. Barren Group rocks, largely of Lower Old Red Sandstone age, form a narrow band along the western boundary; the rocks comprise unfossiliferous and predominantly red-coloured sandstones, conglomerates and breccias, with some mudstones. Most of the region, however, is formed of the Middle Old Red Sandstone Caithness Flagstones, a succession of greyish and brownish rocks comprising finely laminated limestones and calcareous flags, fine-grained sandstones and mudstones, the limestones and flags being well known for their fossil fish remains. In the north-east corner of Caithness, friable yellow and red calcareous sandstones of the Middle Old Red Sandstone John o' Groats Sandstones are present, while at Dunnet Head there is a small area of Upper Old

Red Sandstone, the Dunnet Sandstones, made up of pink and yellow, false-bedded, unfossiliferous sandstones with some shales and mudstones.

The northern part of the Caithness Plain lies mainly below 60 metres but has isolated hills rising from it to about 120 metres. Much of the land is covered with till and there are some extensive areas of deep peat. Windblown shelly sand deposits occur around some of the more open shallow bays, notably at Dunnet and at Keiss. The central part of the plain, lying between 75 and 150 metres, is mainly level or gently sloping and covered in deep peat. In the southern part of the plain the land is somewhat higher (between 180 and 240 metres), more rolling and dissected, and there is much shallow drift and drift-free ground. The topography is in some places ridged or stepped, a north-south grain being common, and slightly or moderately rocky.

THE MORAY FIRTH LOWLANDS

This region comprises the lowland area that extends around the Moray Firth from the east coast of Sutherland through Easter Ross, Nairn and Moray to Buckie. Almost all of it is underlain by Old Red Sandstone strata. The Middle Old Red Sandstone rocks, consisting of red and yellow sandstones, conglomerates, and some shales, mudstones and flagstones, occur mainly in the western part of the region (particularly in the Black Isle and between Inverness and Nairn) but also around Fochabers in the east. The Upper Old Red Sandstone strata, which are present between Nairn and Elgin, between Invergordon and Tain, and around Dornoch, are largely false-bedded yellow and red sandstones. In addition, Permo-Triassic sandstones, together with some Jurassic rocks, crop out near Elgin, and Mesozoic rocks, comprising Triassic sandstones and Jurassic sandstones, shales and limestones, underlie the whole of the narrow coastal lowlands to the north of Golspie.

The land lies mainly below 60 metres, although the whole of the Black Isle, rising to over 250 metres on the central ridge, has been included in this region. Slopes are predominantly gentle or strong. The mainly smooth coastline with shallow firths contrasts with that of the west coast. The region is almost entirely covered with superficial deposits, the notable exceptions being the cliffs and ridges between Burghead and Lossiemouth and at Kessock and Ethie. Fluvio-glacial and raised beach deposits, mainly sands and gravels but with some locally finer material, are extensive. Steps between various raised beach levels are distinctive features in parts of the region. Massive storm beach shingle ridges are present on the lowest of the raised beach levels. Windblown sand occurs on much of the coastline, being particularly extensive at Culbin where some of the dunes are up to 25 metres high. Till of moderately coarse texture occurs on the higher parts of the region, sometimes as 'islands' surrounded by fluvio-glacial materials. Alluvium is common east of Inverness and in the lower reaches of the River Conon and the River Beaully.

CLIMATE

The main elements of the climate which affect soil formation are rainfall and temperature, upon which depend the water for leaching and gleying and the energy available for weathering and biological activity. In Northern Scotland, the most important factors affecting climate are altitude and the degree of influence Atlantic depressions have on the climate. Decreasing temperature and increasing

NORTHERN SCOTLAND

rainfall are usually directly related to an increase in altitude; a lapse rate of 6°C per 1000 metres is adopted by the Meteorological Office. Rainfall and temperature also greatly influence land use although exposure to, and the frequency of, high winds are also significant.

RAINFALL AND POTENTIAL WATER DEFICIT

Much of the rainfall in Northern Scotland originates from depressions which develop over the Atlantic Ocean and move eastwards. The average annual rainfall (Fig. 3) is linked to the relief of the area, but modified by the rain-shadow effect caused by the mountains in the west. Rainfall seldom exceeds 1200 millimetres east of a line from Bettyhill to Cannich. Totals vary from 600 to 800 millimetres in the Moray Firth Lowlands, 800 to 1000 millimetres on the Caithness

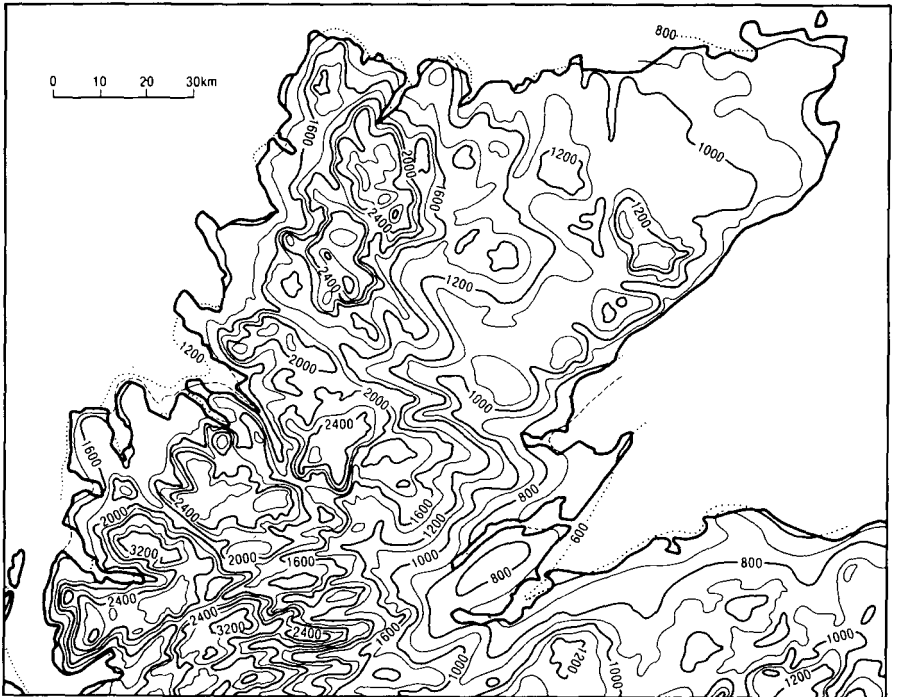


Figure 3. *Rainfall (average annual, mm)*

Plain and much of the ground east of the Great Glen, and 1000 to 1200 millimetres in east Sutherland and the extreme south. Rainfall to the west of this line generally exceeds 1600 millimetres, except on the coastal strip north of Loch Broom, and increases to 2400–3200 millimetres on the mountains. In common with most of Scotland, April to June is the driest part of the year.

Potential water deficit (PWD) is measured to indicate the effective wetness of the climate and is defined as the excess of potential evapo-transpiration over rainfall in one year. Moderately dry areas have a PWD of greater than 25 millimetres; wet areas have a PWD of less. The distribution of these two categories (after Birse and Dry, 1970), is shown in Fig. 4. Most of Northern Scotland is wet, the moderately dry areas being mainly restricted to the Moray Firth Lowlands and the Caithness Plain. Despite having fairly low rainfall (900 to 1200 millimetres), large areas in the rain-shadow are wet; low summer temperatures resulting in slow evapo-transpiration are largely the cause of high humidity levels in this region. Large areas in the western mountains, and occasionally almost to sea level, are very wet; summer rainfall exceeds summer evapo-transpiration by at least 500 millimetres.

ACCUMULATED TEMPERATURE

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). For all biotic activity, especially plant growth, 0°C and 5.6°C are usually considered important limits. Birse and Robertson (1970) have used accumulated frost (day-degrees below 0°C) as an indicator of severity of winter. The lowest totals (less than 20 day-degrees) occur on the west and north coasts, indicating the strong maritime influence in these areas. In contrast, 20 to 50 day-degrees of frost are accumulated on the Moray Firth coasts. Totals in the west and north are mainly 50 to 110 day-degrees of frost, whereas in the higher and less oceanic centre and south-east, 110 to 230 day-degrees are more common. Mountain summits are coldest, generally accumulating between 230 and 470 day-degrees of frost.

Values of accumulated temperature above 5.6°C have been calculated by Birse and Dry (1970) and their results are shown in a simplified form in Fig. 4. This threshold is generally accepted as the point above which plant growth becomes significant, but many wild plants, particularly mountain species, can have a lower growth threshold. The warm category (greater than 1375 day °C) occurs only in part of the Moray Firth Lowlands, whilst the rest of the Moray Firth Lowlands and the remaining coastline are fairly warm (1100 to 1375 day °C). Much of the area lying to the north of a line between Loch Broom and the Dornoch Firth, and to the east of Strathglass is cool (825 to 1100 day °C), whereas the higher ground to the south of this line is cold (550 to 825 day °C). On the mountain summits, the climate is very cold (0 to 550 day °C). These values illustrate the small annual range in temperature, with the absence of hard winters offset in most areas by the low accumulated temperatures of the summer months.

EXPOSURE

Windiness is a very significant element of the climate, particularly in the hilly areas, the west and north coasts, and to a lesser extent on the Caithness Plain. The least exposed ground is in the east and in valleys; this ground is assessed as sheltered (average wind speed less than 2.6 metres per second) or more commonly moderately exposed (2.6 to 4.4 metres per second) (Birse and Robertson, 1970). Although much of Caithness and east and central Sutherland is fairly low lying, the ground is exposed (4.4 to 6.2 metres per second). This category is also widespread on the higher ground east of Strathglass and on much of the low

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ground in the west. The hilly ground in the west and south and much of the western and northern coastlines are very exposed (6.2 to 8 metres per second), whilst the mountain summits are extremely exposed (greater than 8 metres per second).

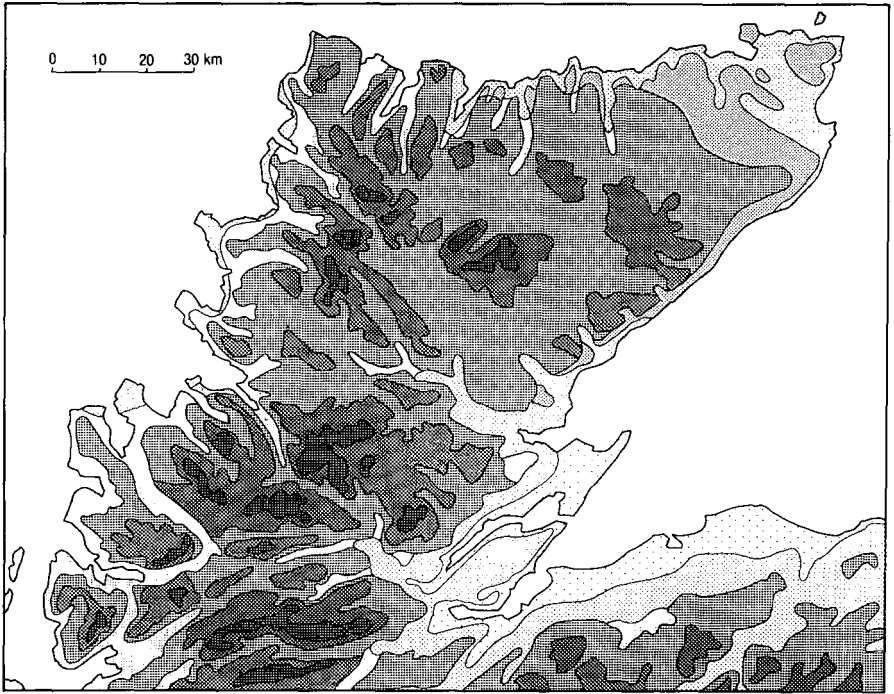


Figure 4. *Climate regions*

SOILS

GENERAL ASPECTS

Soil textures

Soil texture is a property inherited largely from the parent material; soils developed on coarse-textured parent materials have coarse textures, and those on fine materials have fine textures. Most of the soils in Northern Scotland are stony and have textures of sandy loam or loamy sand, reflecting the extensive cover of superficial deposits of similar nature. Soils with finer textures are developed where parent materials are derived, in whole or in part, from fine-grained rocks such as mudstones, shales, flagstones and some schists. These occur only locally,

DESCRIPTION OF THE AREA



warm and moderately dry



fairly warm and moderately dry



fairly warm and wet



cool and moderately dry



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 | moderately dry |
| <25 | wet |

The moderately dry division incorporates the 'dry', 'rather dry' and 'moist' divisions of Birse and Dry; the wet division incorporates the 'rather wet' and 'wet'.

Modified from Birse and Dry (1970)

perhaps the most extensive being the till of sandy clay loam texture in Caithness, derived from the Caithness Flagstones strata. Soils with fine textures include those developed on the fluvio-glacial, lacustrine and raised beach silts and clays which occur locally in the Moray Firth Lowlands.

Induration

An indurated horizon is a common feature in many of the soils developed on the tills and stony drifts. Although mainly a feature of freely and imperfectly drained soils it can occur in poorly drained soils too. Its characteristic features are that it is compact, brittle, and often has a coarse platy structure, sometimes with reddish staining or, less commonly, black manganese mottling on the faces of the plates. Fine pores are present, and fine sand or silt is found to line stone cavities or form cappings on stones. The degree of induration is typically greatest at the top and decreases in intensity with depth. The horizon is generally encountered at less than 40 centimetres from the top of the mineral material (that is, excluding any

organic surface accumulation) and is mostly between 20 and 50 centimetres thick, although it can be more. Induration can cause gleying to occur in the horizons above.

Drainage classes

Throughout much of the Northern Highlands and Caithness the soils are poorly or very poorly drained. Almost all have an organic surface horizon and peat development is widespread. Poorly drained mineral soils are common only in Caithness. Freely and imperfectly drained soils are found in the Moray Firth Lowlands, on the foothills of the Grampian Highlands, and in parts of lowland Caithness. In the Northern Highlands they are common in the drier south-eastern part, but elsewhere are found only on stony mountains and locally on steep valley sides.

Chemical aspects

Most soils are developed on parent materials derived from acid rocks and consequently are inherently acid and low in bases. Leaching rapidly depletes what bases there are to make these soils even more acid. The pH values in uncultivated soils are commonly between 4.0 and 4.5 at the surface, increasing down the profile to 5.0 or 5.5. Soils with medium textures—loams and sandy clay loams—generally have a moderate base saturation. Calcareous parent materials are not common, but include the Cambrian and Ordovician limestones, the windblown shelly sand and some of the raised beach silts and clays. Soils developed on these materials have a moderate or high pH at the surface and a high pH in the horizons below. More locally, soils with high amounts of magnesium are developed on parent materials derived from ultrabasic rocks, and high amounts of sodium are found in the soils strongly affected by salt-spray.

CLASSIFICATION AND DISTRIBUTION

The system of soil classification used in this handbook is similar to the one used by the Soil Survey of Scotland in published memoirs. Some additions have been made to accommodate those soils which have not been previously described. The classification is described in Handbook 8. In the following section the major soil groups and subgroups which appear on the soil map legend or are mentioned in the text are commented on; they are arranged in the same order as in the full classification.

Lithosols are listed in the soil map legend only as component soils of *map units* 36 (the Arkaig Association), 66 (the Berriedale Association), 398 (the Lochinver Association) and 561 (the Torridon Association). To some extent, however, lithosols can be found in all map units on rocky landscapes.

Regosols

Calcareous regosols are found only on the shelly sand parent materials of the Fraserburgh Association.

Noncalcareous regosols are present on the non-shelly windblown sand of the Links Association, and as component soils, developed on sandy colluvium, in map units with subalpine and alpine soils.

Alluvial soils

Saline alluvial soils are present on marine alluvium (saltings), the largest area of which lies between Nairn and Findhorn (*map unit 2*).

Mineral alluvial soils are found on mineral alluvium. They are the principal soils in most areas of *map unit 1* (the Alluvial Soils Association) and are one of the component soils in *map units 98, 99, 102 and 103* (the Corby/Boyndie/Dinnet Associations) and *381* (the Links Association). Also, they can be present locally along streams and rivers throughout the whole area.

Peaty alluvial soils occur on peaty alluvium, that is, alluvium which contains a high amount of organic matter or which is a layered deposit of mineral and organic-rich material. These soils dominate a few areas of *map unit 1*, but overall are not so common as the mineral alluvial soils. They are also a component soil of *map unit 106* (the Corby/Boyndie/Dinnet Associations).

Rankers

Brown rankers are closely associated with brown forest soils on rocky land, or on non-rocky land where the rock lies very close to the surface.

Podzolic rankers are found mainly associated with humus-iron podzols on rocky land.

Peaty rankers are common components of map units of peaty soils on rocky landscapes. They are much more widespread than the previous two subgroups.

Rendzinas

Brown rendzinas are found only on the outcrops of Cambrian and Ordovician limestones (*map units 314 and 315*, the Inchnadamph Association).

Calcareous soils

Brown calcareous soils are developed on the windblown shelly sand deposits of the Fraserburgh Association.

Magnesian soils

Brown magnesian soils are found only on the parent materials derived from the ultrabasic igneous rocks (*map units 369 and 370*, the Leslie Association). Their extent is consequently very small.

Brown earths

Brown forest soils occur in a number of map units but are not common. In the west they are restricted mainly to steep rocky slopes at low altitudes. The brown forest soils in Caithness were probably peaty podzols which have lost their original morphology by cultivation and consequent mixing of the upper horizons over a long period.

Brown forest soils with gleying are the principal component soils of *map units 487* (the Stirling/Duffus/Pow/Carbrook Associations) and *545* (the Tippetty/Carden Associations), and in both units the soils are developed on parent materials of silty clay or clay texture. Soils of this subgroup are also present in *map unit 518* (the Tarves Association). In all, however, these soils cover only a small area.

Podzols

Humus podzols are found in some of the map units of the Corby/Boyndie/Dinnet

Associations in the Moray Firth Lowlands, but are not common enough to be listed on the soil map legend. Most soils are cultivated and have an Ap horizon replacing the L, F, H and E horizons of the original soil profile.

Humus-iron podzols occur in a large number of map units and in many are the principal soils. They are particularly common in the drier eastern areas where, associated with non-rocky land with gentle or strong slopes, they form the main arable soils. As in the previous subgroup, the cultivated soils have an Ap horizon. Some cultivated soils included in this subgroup may have previously been peaty podzols. Humus-iron podzols are much more local elsewhere and tend to be restricted to steeper, often rocky, slopes, although some occur on raised beach materials.

Iron podzols occur locally in some of the map units of the Brightmony, the Corby/Boyndie/Dinnet, and the Hatton/Tomintoul/Kessock Associations, but are not common and have not been mentioned on the soil map legend.

Peaty podzols are widespread and occur as component soils, generally together with peat, in a large number of map units. In the wetter areas, particularly in the north and west, they are generally strongly gleyed and humus-stained above the thin iron pan, but in the drier eastern areas they commonly have little or no gleying and an iron pan is not always present.

Subalpine podzols are present on the higher ground, above the upper limit of the peaty podzol zone which in the northern and western areas is at approximately 400 metres, although lower on more exposed land, but in the south and east is about 500 metres or more. These soils are generally the dominant soils in all map units described on the soil map legend as having subalpine soils as component soils.

Alpine podzols are present only on the highest land above the zone of subalpine podzols. They are often associated with areas of patterned ground.

Surface-water gleys

Saline gleys occur in *map unit 83* (the Canisbay Association), present only on Stroma and Muckle Skerry off the Caithness coast, but can be locally present in narrow coastal zones exposed to salt-spray. (The saline gleys of *map unit 2*, found on saltings, are now classified as saline alluvial soils).

Calcareous gleys are found only on the calcareous lacustrine clays and silty clays of the Duffus Association near Elgin (*map units 487* and *488*, grouped in the Stirling/Duffus/Pow/Carbrook Associations).

Magnesian gleys occur only on parent materials derived from the ultrabasic igneous rocks (*map units 369* and *370*, the Leslie Association). Their extent is very small.

Noncalcareous gleys are extensive in Caithness, where they form the main arable soils (*map unit 537*, the Thurso Association). These soils occur locally, in a number of map units, in the foothills of the Grampian Highlands and in the Moray Firth Lowlands, but are absent or rare elsewhere.

Humic gleys occur in a number of map units but mostly as minor components. They are found mainly in flushed sites, but also on land which has been reclaimed from peaty gleys.

Peaty gleys are extremely extensive soils, particularly in northern and western

districts, and they are listed among the principal soils, generally together with peat, in a large number of map units. Strong organic staining in the Eg horizon is common, and induration in the B horizon is often a feature of peaty gleys developed on parent materials with loamy sand or sandy loam textures.

Ground-water gleys

Calcareous gleys are developed only on the shelly sands of the Fraserburgh Association, where they form one of the principal soils in *map unit 261* and minor components of *map units 259* and *260*.

Noncalcareous gleys and *humic gleys* are found only on the non-shelly sands of the Links Association. Their extent is small.

Subalpine gleys and *alpine gleys* are, respectively, closely associated with subalpine and alpine podzols, but are much less common. They are restricted to channels and hollows which are often the sites of snow-beds. Such soils are found as minor components in most map units described on the soil map legend as having subalpine or alpine soils, or both, as component soils.

Peat

Dystrophic flushed peat is found locally in most of the map units in which peat is a component soil. It is weakly flushed and is present in channels, hollows or basins.

Dystrophic peat is unflushed and extensive, and most of the peat in Northern Scotland belongs to this subgroup. Much of it is more than 1 metre thick and comprises a surface layer of fibrous peat overlying very wet pseudofibrous peat.

VEGETATION

In the following account, the distribution of the plant communities and their relationship with the soils of Northern Scotland are briefly discussed. The common names quoted for these communities in the text, both here and in Chapters 2 and 3, are based on the vegetation field units used in the 1:250 000 survey. These units are listed and described in Handbook 8. Individual species names follow those of Clapham, Tutin and Warburg (1962) for vascular plants as do the bulk of the common names, those of Smith (1978) for mosses and those of James (1965) for lichens.

The classification of the plant communities in phytosociological terms is quoted in brackets after each community name and follows that of 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 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 with the term 'Community' following.

Several environmental parameters exist that can affect the presence or absence of particular plant communities within the area. The dominating influence is that of climate, expressed through rainfall, thermal zonation and oceanicity, and the overall effect is that northern forms of the vegetation occur mainly in the north and west, flushed forms in the west and boreal forms in the highlands in the south. The nature of the rocks and their derived parent materials also influences

the degree of richness and diversity expressed in the vegetation. Soil type, too, is important. The brown forest soils and freely drained podzols of the steep slopes and river terraces in the straths and valleys carry the richer forms of grassland and moorland, and are the sites of most of the fragmentary woodland communities within the region, while the vast peat-covered tracts support blanket bog of little grazing value. Within the strictures of the natural environment, land management also influences the form of vegetation that is present, but on a limited scale in this area. Arable agriculture is largely confined to the lowlands around the Moray Firth and on the northern part of the Caithness Plain. Control of burning and grazing, together with some surface treatment on the more moderate hill slopes, has created rough grassland in place of moorland across the foothills of the farming areas. The environmental parameters described above are all closely interrelated and ultimately no one factor is totally responsible for the presence of a particular vegetation type.

MOORLAND

The dominant form of vegetation present throughout Northern Scotland is that of moorland. Typical or lowland blanket bog vegetation covers most of the peat of the Caithness Plain and the Northern Highlands, with the northern form, characterized by the presence of the woolly fringe-moss (*Racomitrium lanuginosum*) and the lichens *Cladonia arbuscula* and *C. uncialis*, predominating in the north-west, and the upland form containing crowberry (*Empetrum nigrum*) and hooked moss (*Rhytidiadelphus loreus*) on the higher ground to the south. (All forms are included in *Erico-Sphagnetum papillosum*). The peat-covered flats and gentle slopes round most of the high hills and mountain tops carry mountain blanket bog (*Rhytidiadelpho-Sphagnetum fuscum*) with cloudberry (*Rubus chamaemorus*), and extensive areas of this association can be seen on the deep, eroding peat of Knockfin Heights. A form of mountain blanket bog with dwarf birch (*Betula nana*) occurs on the slopes of Ben Armine. In the higher rainfall areas of the west and north-west, heather (*Calluna vulgaris*) loses its dominance on the peat and peaty gleys, except on unflushed sites and on the acid rocks of the Torridonian where it continues to dominate, and its place is taken by flying bent (*Molinia caerulea*) and bog myrtle (*Myrica gale*). The overall effect is a green as opposed to a brown landscape. Flying bent bog (part of *Erico-Sphagnetum papillosum*) is found also in the south and east but is confined to channels and basins on flushed dystrophic peat. In certain crofting areas of the north, especially round Tongue, the practice of widespread flash burning of the flying bent trash is carried out in the spring to encourage new growth for grazing by the Cheviot sheep. This practice leads to the creation of a replacement bog community in which the tussocks of cotton-grass (*Eriophorum vaginatum*) and cushions of bog mosses (*Sphagnum* spp.)—characteristic elements of blanket bog—are suppressed and the vegetation is dominated by a mixture of heather (*Calluna vulgaris*), flying bent (*Molinia caerulea*), bog heather (*Erica tetralix*) and deer-grass (*Trichophorum cespitosum*). This deer-grass moor (the *Trichophorum germanicum*–*Calluna vulgaris* Association) can also be derived from bog heather moor (*Narthecio-Ericetum tetralicis*) by the same management practice of intense burning and grazing.

Bog heather moor is itself a common community of the north and west—usually in its northern form—and it spreads out over the peaty gleys and shallow peat of the lower hill slopes. Here it lends a 'stippled' appearance to the landscape as its form is that of small waterlogged 'steps' with little else other than bog

asphodel (*Narthecium ossifragum*) and mosses, and densely vegetated 'risers' with the rest of the community species. Like flying bent bog, it is confined to channels and basins associated with blanket peat in the east and south.

On the more freely drained peaty soils of mounds and steeper hill slopes, blanket bogs and bog heather moors are replaced by dry and moist heather moors. Atlantic heather moors (*Carici binervis*-*Ericetum cinereae*) are by far the most widespread of these associations, occupying all but the south-eastern part of the region. The herb-rich form occurs locally where brown forest soils and humus-iron podzols are developed on morainic mounds and on steep bouldery slopes of straths in the north and east. Dry Atlantic heather moor is found on brown forest soils, humus-iron podzols and peaty podzols in the same area, while the moist form—on peaty podzols and peaty gleys—has a much more widespread distribution. As exposure increases, the northern form of the moor may be found locally throughout the region on mounds, headlands and hills, generally on the wetter podzols. A maritime form of Atlantic heather moor characterized by the presence of birdsfoot-trefoil (*Lotus corniculatus*) and sand sedge (*Carex arenaria*) was recorded on the immature sandy soils of the links at Dunnet in Caithness, Coul in east Sutherland, Delnies in Nairnshire and Findhorn in Morayshire.

In the south-east on the high hills of the Grampian Highlands, Atlantic heather moors are replaced by boreal equivalents (*Vaccinio*-*Ericetum cinereae*) in which broadleaved ericaceous shrubs such as cowberry (*Vaccinium vitis-idaea*), blaeberry (*V. myrtillus*) and bearberry (*Arctostaphylos uva-ursi*) become important elements. Boreal heather moors also occur locally on exposed northern and western sites. The various forms of the association—herb-rich, dry and moist—occupy much the same habitats as those of the Atlantic heather moors but at higher altitudes or subjected to greater exposure. The lichen-rich form—equivalent to northern Atlantic heather moor—occurs very locally on subalpine and alpine podzols on some mountains as a transition to full alpine heath (for example, on Ben More Assynt).

OROARCTIC COMMUNITIES

As exposure or altitude increases, so there is a transition from Atlantic heather moor through boreal to true oroarctic communities on subalpine and alpine podzols. The most widespread of these, the alpine azalea-lichen heath (*Alectorio*-*Callunetum vulgaris*), is found on mountain tops throughout the region but it also occurs on very exposed valley moraines in the west where the steep valley walls rise to over 300 metres and cause a wind-funnelling effect. It was recorded also on an isolated knoll at 120 metres on Dunnet Head. Fescue-woolly fringe-moss heath (*Festuco*-*Racomitrietum lanuginosi*) is another of the oroarctic communities; heather (*Calluna vulgaris*) is no longer dominant and the most abundant species are usually grasses and woolly fringe-moss (*Racomitrium lanuginosum*). The upper slopes of the mountains and high ridges are the sites of late snow-lie and the alpine soils here tend to be gleyed and seasonally flushed. These sites support oroarctic grassland communities of which stiff sedge-fescue grassland (the *Carex bigelowii*-*Festuca vivipara* Association) is the one most commonly found. Bog whortleberry heath (the *Racomitrium lanuginosum*-*Vaccinium uliginosum* Association) and alpine clubmoss snow-bed (the *Lycopodium alpinum*-*Nardus stricta* Community) occur on similar sites but to a much lesser extent. In the south on the steep upper slopes and corrie walls of both the upland and mountain zones, especially on stabilized scree, blaeberry heath (the *Rhytidiadelphus loreus*-*Vaccinium myrtillus* Community) can be the

dominant vegetation on a wide range of soil types including brown forest soils, podzols, peaty podzols and redistributed peat.

GRASSLAND

The most extensive areas of cultivation lie within the climatically favourable Moray Firth Lowlands. The only other important area of cultivated land is to the north-east on the northern part of the Caithness Plain where the moderately fine-textured till soils are best suited to permanent and rotational pastures (*Lolio-Cynosuretum*). Elsewhere the landscape is primarily managed as rough grazings for sheep and cattle and as grouse-moors, deer-forest and forestry plantations, and the natural plant communities are altered to a greater or lesser degree depending on their proximity to the crofting and farming areas. Local conditions may allow some pasture improvement by reseeding (Class 5 land) and often such pastures, through neglect or overgrazing, have become altered to a meadow-grass-bent pasture (the *Galium saxatile-Poa pratensis* Community) from which rye-grass (*Lolium* spp.) and crested dog's-tail (*Cynosurus cristatus*) have been excluded and in which the cover of white clover (*Trifolium repens*) is greatly reduced. This last community can also evolve from semi-natural rough grassland under a régime of heavy grazing and dunging and it is often found as the principal grazing on sheltered river terraces which might otherwise carry bent-fescue grassland (*Achilleo-Festucetum tenuifoliae*) or common white bent grassland (part of *Junco squarrosi-Festucetum tenuifoliae*).

Acid bent-fescue grassland is commonly found on the brown forest soils and humus-iron podzols of the mounds, terraces and slopes of the valleys. Where the sites are rocky and uneven the community can be dominated by bracken (*Pteridium aquilinum*) and the productivity of the underlying grasses significantly reduced. The herb-rich form is very local and confined to brown magnesian soils of the ultrabasic rocks and the brown rendzinas of limestone outcrops while the upland form occasionally occurs on steep flushed slopes in the upland and mountain regions of the south. Common white bent grassland is found locally on peaty podzols, peaty gleys, noncalcareous gleys and peat on some flushed hill slopes and river terraces, and the wetter form of the same association — flying bent grassland — is even less abundant and occurs on the peaty gleys and peat of flushed slopes and channels, one such site being on the slopes of Strath Mulzie. White bent-tussock-grass grassland (the *Cirsium palustre-Nardus stricta* Community) is rare within the region and is confined to flushed slopes in the uplands of the south on noncalcareous gleys. Soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) colonizes the noncalcareous gleys and flushed peat of wet alluvial flats, flushed slopes and channels both in the hills and within the arable areas where the drainage system has been allowed to deteriorate.

Throughout the landscape, flush communities usually dominated by sedges colonize channels, slopes and depressions on a range of wet soils from noncalcareous and humic gleys to peaty gleys and peat. The presence of a particular community is dependent on the degree of base saturation of the flush water, the nutrient status of the habitat and the position of the community within the drainage feature. Three sedge communities occur commonly, though locally, in association with each other but each occupying a slightly different habitat within the flush system. Few-flowered spike-rush mire (*Carici dioici-Eleocharitetum quinqueflorae*) is found at the bottom of the flush channels on waterlogged noncalcareous gleys, humic gleys and peat, and flea-sedge mire (*Caricetum hostiano-pulicaris*) occurs on similar soils but higher up the sides of the channels. Both

communities are on soils of moderate to high base status. Furthest from the base of the drainage channels and spilling out onto flushed slopes and depressions on more dystrophic peaty gleys and peat is star sedge mire (*Caricetum echinato-paniceae*). At the dystrophic end of the flush system, bog moss water track (the *Juncus effusus-Sphagnum recurvum* Community) is found on peaty gleys and peat associated with the drainage water from peat mosses. Bog-rush mire (the *Schoenus nigricans* Community) occurs on noncalcareous gleys, peaty gleys and flushed peat of more eutrophic sites. Although mainly a western community, it does extend down the eastern side of the country as far as the Moray Firth and was recorded from sites on Holborn Head in Caithness, at The Alders near Golspie and at Ballycherry in the Black Isle.

FORESHORE AND DUNES

Windblown coastal sand deposits are well represented in the north and east of Northern Scotland and several of these sites have well-developed dune systems, such as those on Dunnet and Keiss Links and at Dornoch and Culbin Sands. Immediately above the high-water mark on the beaches is the pioneer community, orache strand-line (the *Salsola kali-Atriplex glabriuscula* Association), in which the rare oyster plant (*Mertensia maritima*) is sometimes found. The foredune or northern sea couch-grass dune community (*Elymo-Agrophyretum boreo-atlanticum*) and the yellow or northern marram grass dune community (*Elymo-Ammophiletum*) usually give way to dune pasture on the dry, more stable grey dunes and flats to the rear of the dune system. On northern and western coasts, this community is the eyebright-red fescue dune pasture (*Euphrasio-Festucetum arenariae*) and it is also found down the east coast as far as Keiss Links. On Dunnet Links, it is the site of the Scottish primrose (*Primula scotica*). From Keiss southwards, the community is replaced by the milk-vetch-red fescue dune pasture (*Astragalo-Festucetum arenariae*), good examples of which can be seen on Embo and Dornoch Links and on the sandy flats of the Carse of Delnies and Findhorn. Wet dune slacks and depressions to the rear of the dune systems support silverweed pasture (the *Potentilla anserina-Carex nigra* Community) on salt-water-influenced noncalcareous and humic gleys.

SALTINGS AND SPLASH ZONE

The two common communities on the saline alluvial soils of the saltings are the sea poa salt-marsh (*Puccinellietum maritimae*), which colonizes the lowest level around the high-water mark, and the mud rush salt-marsh (*Juncetum gerardii*) which succeeds it at higher levels. On some of the most exposed headlands of the north coast such as Dunnet Head and Holborn Head, saturation by sea-spray has caused the formation of a narrow band of vernal squill maritime pasture (the *Scilla verna-Festuca rubra* Community) and sea plantain-crowberry heath (the *Plantago maritima-Empetrum nigrum* Community) on soils which are, in essence saline gleys (some of which are humic) and saline peats.

SCRUB AND WOODLAND

By far the greatest area of woodland in the region is that of coniferous plantations. These are mainly concentrated in the lowlands, foothills and straths around the Moray Firth, but occur locally elsewhere. Small remnants of true native pinewood (*Pinetum scoticae*) do still exist, the northernmost record being

a fragmentary stand on the flank of Ben Hope in Sutherland (Birse, 1982). A number of sites, however, especially in the south-east, carry Scots pine plantations which have been established for many years (up to 200 years) and the vegetation beneath the canopy is effectively that of a native pinewood, containing species such as lady's tresses (*Goodyera repens*) and lesser twayblade (*Listera cordata*) in a thick carpet of mosses. These pinewoods on humus-iron podzols have been classed as bell-heather-Scots pine plantations (*Erica cinerea*-*Pinus sylvestris* plantations). Most oakwoods in the eastern part of the region owe their existence to planting and they can be grouped into two main associations. Southern oakwood (*Galio saxatilis*-*Quercetum*) on brown forest soils is a fragmentary community within the region, being largely confined to the area bounding the Moray Firth and, as its name implies, only gains in importance further south. The best examples may be seen in the woodlands of Cawdor and Darnaway where the grassy field layer contains bluebell (*Endymion non-scriptus*) and honeysuckle (*Lonicera periclymenum*). Eastern highland oakwood and birchwood (*Trientali-Betuletum pendulae*) extend throughout the valleys of the eastern foothills on brown forest soils and humus-iron podzols. The oakwood at Spinningdale is part of this association and contains both grassy and heathy forms. In the west, oak and birch wood (*Blechno-Quercetum*) are far more likely to be remnants of the natural vegetation and clothe the steep valley sides on brown forest soils and humus-iron podzols. Flushed brown forest soils of the same area carry western ash-oak wood (*Primulo-Quercetum*) which is characterized by the presence of a shrub layer of hazel (*Corylus avellana*) and a herb-rich carpet containing species such as primrose (*Primula vulgaris*), bluebell (*Endymion non-scriptus*) and common violet (*Viola riviniana*). The larger tree species are often absent and a shrub layer dominated by hazel makes up the canopy. The hazel-dominated woodland of the east is classed as part of the elmwood (*Querco-Ulmetum glabrae*), the broadleaved woodland of steep-sided gullies and mixed bottom land with brown forest soils. Examples can be seen at Golspie Burn in Sutherland and at Rosemarkie in the Black Isle. Flush alderwood (the *Crepis paludosa*-*Alnus glutinosa* Association) is found locally on poorly and very poorly drained alluvial soils. One outstanding site is at The Alders, near Golspie, where alder and willow have colonized the wide alluvial flat round the mouth of the River Fleet. Many fragmentary scrub communities occur locally within the region, but their distribution is very limited. These include wet birchwood (the *Sphagnum palustre*-*Betula pubescens* Community), bog myrtle scrub (*Myricetum galis*) and common sallow scrub (the *Salix atrocinerea* Community) on gleys, peaty gleys and peat, and broom and gorse scrub (*Sarothamnion*), blackthorn scrub (the *Primula vulgaris*-*Prunus spinosa* Association) and boreal juniper scrub (*Trientali-Juniperetum communis*) on brown forest soils.

2 The Soil Map Units

This chapter describes the soil associations and map units that are shown on the 1:250 000 soil map of Northern Scotland (Sheet 3). The Alluvial Soils are described first, followed by the Organic Soils, and then the 36 soil associations (or association groupings), arranged in alphabetical order. The 173 map units are numbered according to the national 1:250 000 map legend; they have been arranged in each association so that, in general, lowland units are described first, then upland units, and finally the units of the mountains.

Each association description covers parent material, extent, relief, climate, soils and vegetation; for each map unit there is a brief description of the soils and topography, a comment, where appropriate, on variation, and finally a note of current land use together with a mention of the factors which affect the agricultural capability of the land. The extent of each association and soil map unit is shown in Table A.

Soil map units with similar soils and topography, but occurring either in different soil associations or, more rarely, in the same association but on slightly different types of parent material, are grouped in Table B. Figure 5 summarizes topography in terms used to describe the landforms of many of the soil map units in the Northern Highlands and the Grampian Highlands.

THE ALLUVIAL SOILS

(Map units 1 and 2)

This association comprises soils developed on recent riverine, lacustrine and marine alluvial deposits. Riverine deposits are most common; textures range from sand to silty loam, but sand, loamy sand and sandy loam occur most often. Locally, more stony gravel-rich deposits are found, the stones present reflecting the lithology of the surrounding rocks and drifts. Lacustrine deposits are more restricted, and also have a wide range of texture class. Thin peaty layers are often found interstratified with the mineral material, and drainage is usually poor or very poor. Marine alluvial deposits are even more restricted and although the only mapped area is composed of marine sand, other less extensive deposits have sandy or silty textures.

The largest areas of alluvial soils occur along the courses of the major rivers and are thus most common in the east of the area. The Alluvial Soils Association

NORTHERN SCOTLAND

Table A Areas of soil map units

| ASSOCIATION (sq. km., % Land Area) | MAP UNIT | AREA (sq. km) | % Land Area | % Association | ASSOCIATION (sq. km., % Land Area) | MAP UNIT | AREA (sq. km) | % Land Area | % Association | |
|---|---|---------------|-------------|---------------|---------------------------------------|----------|---------------|-------------|---------------|--|
| ALLUVIAL SOILS (248 sq. km., 1.5%) | 1 | 245 | 1.5 | 99 | | | | | | |
| | 2 | 3 | <0.1 | 1 | | | | | | |
| ORGANIC SOILS (2525 sq. km., 15.4%) | 3 | 43 | 0.3 | 2 | | | | | | |
| | 4 | 673 | 4.1 | 27 | | | | | | |
| | 4d | 1337 | 8.1 | 53 | | | | | | |
| | 4e | 472 | 2.9 | 19 | | | | | | |
| ABERLOUR (103 sq. km., 0.6%) | 5 | 34 | 0.2 | 35 | | | | | | |
| | 6 | 46 | 0.3 | 45 | | | | | | |
| | 7 | 5 | <0.1 | <5 | | | | | | |
| | 10 | 14 | <0.1 | 15 | | | | | | |
| ARDVANIE | 11 | 4 | <0.1 | <5 | | | | | | |
| | 17 | 38 | 0.2 | 100 | | | | | | |
| ARKAIG (6130 sq. km., 37.3%) | 18 | 29 | 0.2 | <1 | | | | | | |
| | 19 | 45 | 0.3 | <1 | | | | | | |
| | 20 | 281 | 1.7 | 5 | | | | | | |
| | 21 | 51 | 0.3 | <1 | | | | | | |
| | 22 | 194 | 1.2 | 3 | | | | | | |
| | 23 | 2121 | 12.9 | 35 | | | | | | |
| | 24 | 119 | 0.7 | 2 | | | | | | |
| | 25 | 26 | 0.2 | <1 | | | | | | |
| | 26 | 855 | 5.2 | 14 | | | | | | |
| | 27 | 129 | 0.8 | 2 | | | | | | |
| | 28 | 305 | 1.9 | 5 | | | | | | |
| | 29 | 916 | 5.6 | 15 | | | | | | |
| | 30 | 71 | 0.4 | 1 | | | | | | |
| | 31 | 136 | 0.8 | 2 | | | | | | |
| | 32 | 106 | 0.7 | 2 | | | | | | |
| | 33 | 574 | 3.5 | 9 | | | | | | |
| BERRIEDALE (304 sq. km., 1.9%) | 34 | 127 | 0.8 | 2 | | | | | | |
| | 35 | 40 | 0.2 | <1 | | | | | | |
| | 36 | 5 | <0.1 | <1 | | | | | | |
| | 59 | 66 | 0.4 | 22 | | | | | | |
| | 60 | 2 | <0.1 | <1 | | | | | | |
| | 61 | 176 | 1.1 | 58 | | | | | | |
| | 62 | 6 | <0.1 | 2 | | | | | | |
| | 63 | 2 | <0.1 | <1 | | | | | | |
| | 64 | 19 | 0.1 | 6 | | | | | | |
| | 65 | 22 | 0.1 | 7 | | | | | | |
| 66 | 6 | <0.1 | 2 | | | | | | | |
| 67 | 5 | <0.1 | 2 | | | | | | | |
| BRAEMORE/ KINSTEARY (44 sq. km., 0.3%) | 71 | 7 | <0.1 | 15 | | | | | | |
| | 72 | 1 | <0.1 | <5 | | | | | | |
| | 73 | 8 | <0.1 | 20 | | | | | | |
| | 74 | 16 | <0.1 | 35 | | | | | | |
| | 75 | 12 | <0.1 | 25 | | | | | | |
| | BRIGHTMONY | 76 | 21 | 0.1 | 100 | | | | | |
| | CANISBAY (29 sq. km., 0.2%) | 79 | 27 | 0.2 | 95 | | | | | |
| | | 83 | 2 | <0.1 | 5 | | | | | |
| | CORBY/BOYNDIE/ DINNET (725 sq. km., 4.4%) | 97 | 483 | 2.9 | 67 | | | | | |
| | | 98 | 126 | 0.8 | 17 | | | | | |
| 99 | | 1 | <0.1 | <1 | | | | | | |
| 100 | | 45 | 0.3 | 6 | | | | | | |
| 101 | | 58 | 0.4 | 8 | | | | | | |
| 102 | | 10 | <0.1 | 1 | | | | | | |
| 103 | | 2 | <0.1 | <1 | | | | | | |
| 105 | | <1 | <0.1 | <1 | | | | | | |
| 106 | | <1 | <0.1 | <1 | | | | | | |
| COUNTESSWELLS/ DALBEATTIE/ PRIESTLAW (478 sq. km., 2.9%) | | 115 | 10 | <0.1 | 2 | | | | | |
| | 116 | 1 | <0.1 | <1 | | | | | | |
| | 117 | 19 | 0.1 | 4 | | | | | | |
| | 118 | 231 | 1.4 | 48 | | | | | | |
| | 119 | 36 | 0.2 | 8 | | | | | | |
| | 121 | 38 | 0.2 | 8 | | | | | | |
| | 122 | <1 | <0.1 | <1 | | | | | | |
| | 123 | 22 | 0.1 | 5 | | | | | | |
| | 125 | 19 | 0.1 | 4 | | | | | | |
| | 126 | 11 | <0.1 | 2 | | | | | | |
| CRAIGELLACHIE | 127 | 56 | 0.3 | 12 | | | | | | |
| | 128 | 3 | <0.1 | <1 | | | | | | |
| | 129 | 2 | <0.1 | <1 | | | | | | |
| | 130 | 2 | <0.1 | <1 | | | | | | |
| | 131 | 7 | <0.1 | 1 | | | | | | |
| | 134 | 17 | 0.1 | 4 | | | | | | |
| | 135 | 1 | <0.1 | <1 | | | | | | |
| | 136 | 3 | <0.1 | <1 | | | | | | |
| | 140 | 12 | <0.1 | 100 | | | | | | |
| | CROMARTY/KINDEACE (242 sq. km., 1.5%) | 144 | 63 | 0.4 | 26 | | | | | |
| 145 | | 158 | 1.0 | 65 | | | | | | |
| 146 | | 21 | 0.1 | 9 | | | | | | |

Table A Areas of soil map units

| ASSOCIATION (sq. km., % Land Area) | MAP UNIT | AREA (sq. km) | % Land Area | % Association |
|---|----------|---------------|-------------|---------------|
| DULSIE (96 sq. km., 0.6%) | 172 | 27 | 0.2 | 30 |
| | 173 | 3 | <0.1 | <5 |
| | 174 | 3 | <0.1 | <5 |
| | 175 | 63 | 0.4 | 65 |
| DUNNET | 176 | 13 | <0.1 | 100 |
| | 181 | 6 | <0.1 | 1 |
| DURNHILL (464 sq. km., 2.8%) | 182 | 81 | 0.5 | 17 |
| | 184 | 6 | 0.1 | 1 |
| | 185 | 51 | 0.3 | 11 |
| | 186 | 2 | <0.1 | <1 |
| | 188 | 123 | 0.8 | 27 |
| | 190 | 10 | <0.1 | 2 |
| | 191 | 31 | 0.2 | 7 |
| | 192 | 144 | 0.9 | 31 |
| | 193 | 5 | <0.1 | 1 |
| | 194 | 5 | <0.1 | 1 |
| ELGIN (61 sq. km., 0.4%) | 201 | 4 | <0.1 | 5 |
| | 202 | 56 | 0.3 | 90 |
| | 203 | 1 | <0.1 | <5 |
| ETHIE | 204 | 16 | <0.1 | 100 |
| FOUDLAND (156 sq. km., 0.9%) | 241 | 12 | <0.1 | 10 |
| | 243 | 101 | 0.6 | 65 |
| | 244 | 3 | <0.1 | <5 |
| | 245 | 39 | 0.2 | 25 |
| | 257 | 1 | <0.1 | <5 |
| FRASERBURGH (23 sq. km., 0.1%) | 259 | 2 | <0.1 | 10 |
| | 260 | 2 | <0.1 | 10 |
| | 261 | 19 | 0.1 | 80 |
| HATTON/ TOMINTOUL/ KESSOCK (106 sq. km., 0.6%) | 281 | 1 | <0.1 | <5 |
| | 282 | 50 | 0.3 | 45 |
| | 284 | 24 | 0.2 | 25 |
| | 285 | 26 | 0.2 | 25 |
| | 286 | 5 | <0.1 | <5 |
| INCHKENNETH | 313 | 3 | <0.1 | 100 |
| INCHNADAMPH (53 sq. km., 0.3%) | 314 | 13 | <0.1 | 25 |
| | 315 | 40 | 0.2 | 75 |

| ASSOCIATION (sq. km., % Land Area) | MAP UNIT | AREA(sq. km) | % Land Area | % Association |
|--|----------|--------------|-------------|---------------|
| INSCH (12 sq. km., <0.1%) | 316 | 7 | <0.1 | 60 |
| | 317 | 4 | <0.1 | 30 |
| | 318 | 1 | <0.1 | 10 |
| LESLIE (6 sq. km., <0.1%) | 369 | 2 | <0.1 | 35 |
| | 370 | 4 | <0.1 | 65 |
| LINKS (57 sq. km., 0.3%) | 380 | 45 | 0.3 | 80 |
| | 381 | 4 | <0.1 | 5 |
| | 382 | 5 | <0.1 | 10 |
| | 383 | 3 | <0.1 | 5 |
| LOCHINVER (1321 sq. km., 8.0%) | 386 | 2 | <0.1 | <1 |
| | 387 | 1 | <0.1 | <1 |
| | 389 | 55 | 0.3 | 4 |
| | 391 | 51 | 0.3 | 4 |
| | 392 | 57 | 0.3 | 4 |
| | 393 | 10 | <0.1 | <1 |
| | 394 | 229 | 1.4 | 17 |
| | 395 | 702 | 4.3 | 53 |
| | 396 | 115 | 0.7 | 9 |
| | 397 | 28 | 0.2 | 2 |
| 398 | 71 | 0.4 | 5 | |
| MILLBUIE (199 sq. km., 1.2%) | 405 | 12 | <0.1 | 5 |
| | 406 | 187 | 1.1 | 95 |
| NIGG/PRESTON (165 sq. km., 1.0%) | 420 | 121 | 0.7 | 75 |
| | 421 | 44 | 0.3 | 25 |
| NORTH MORMOND/ ORTON (209 sq. km., 1.3%) | 424 | 29 | 0.2 | 14 |
| | 425 | 175 | 1.1 | 84 |
| | 426 | 5 | <0.1 | 2 |
| SABHAIL/MOUNT EAGLE (188 sq. km., 1.1%) | 454 | 119 | 0.7 | 65 |
| | 455 | 51 | 0.3 | 25 |
| | 456 | 18 | 0.1 | 10 |
| STIRLING/DUFFUS/ POW/CARBROOK (5 sq. km., <0.1%) | 487 | 1 | <0.1 | 20 |
| | 488 | 4 | <0.1 | 80 |
| STRICHEN (240 sq. km., 1.5%) | 497 | 58 | 0.4 | 24 |
| | 498 | 134 | 0.8 | 56 |
| STRICHEN (240 sq. km., 1.5%) | 499 | 15 | <0.1 | 6 |
| | 500 | 32 | 0.2 | 13 |
| | 514 | 1 | <0.1 | <1 |

NORTHERN SCOTLAND

Table A Areas of soil map units

| ASSOCIATION (sq. km., % Land Area) | MAP UNIT | AREA (sq. km) | % Land Area | % Association | ASSOCIATION (sq. km., % Land Area) | MAP UNIT | AREA (sq. km) | % Land Area | % Association |
|---------------------------------------|----------|---------------|-------------|---------------|---------------------------------------|-----------------------------|---------------|-------------|---------------|
| TARVES (36 sq. km., 0.2%) | 517 | 27 | 0.2 | 75 | TORRIDON (1384 sq. km., 8.4%) | 553 | 21 | 0.1 | 2 |
| | 518 | 9 | <0.1 | 25 | | 554 | 142 | 0.9 | 10 |
| THURSO (626 sq. km., 3.8%) | 535 | 96 | 0.6 | 15 | | 555 | 19 | 0.1 | 1 |
| | 536 | 5 | <0.1 | <1 | | 556 | 324 | 2.0 | 23 |
| | 537 | 383 | 2.3 | 61 | | 557 | 456 | 2.8 | 33 |
| | 539 | 8 | <0.1 | 1 | | 558 | 113 | 0.7 | 8 |
| | 540 | 1 | <0.1 | <1 | | 559 | 65 | 0.4 | 5 |
| TIPPERTY/CARDEN | 541 | 1 | <0.1 | <1 | | 560 | 8 | <0.1 | <1 |
| | 543 | 63 | 0.4 | 10 | | 561 | 236 | 1.4 | 17 |
| | 544 | 69 | 0.4 | 11 | | TYNET (44 sq. km., 0.3%) | 565 | 2 | <0.1 |
| TIPPERTY/CARDEN | 545 | 6 | <0.1 | 100 | | | 566 | 30 | 0.2 |
| | | | | | 567 | | 12 | <0.1 | 25 |
| | | | | | | BUILT-UP AREAS | 54 | 0.3 | |

Areas in this table have been estimated by point-count methods. Care should be exercised in calculations involving units of less than 10 square kilometres. Discussion of method and estimation of error is contained in Handbook 8.

covers 248 square kilometres (1.5 per cent of the land area). There are, however, many areas of alluvium which are too small to show on the 1:250 000 soil map, and areas of alluvium are also present in a number of other map units, particularly map units 98 and 102 of the Corby/ Boyndie/Dinnet Associations.

The landforms are most commonly very gently sloping flood plains and terraces; alluvial fans also occur, but are much less common. Marine deposits are restricted to the lowest raised beach around the high-water mark of ordinary spring tides.

Average annual rainfall is mainly between 600 and 1000 millimetres except in the more westerly areas where totals are 1600 to 1800 millimetres. The climate in the eastern areas is mostly warm or fairly warm and moderately dry, whereas in the smaller more scattered occurrences farther west it is fairly warm and wet. The exposure categories are mainly sheltered or moderately exposed with exposed areas near the coast.

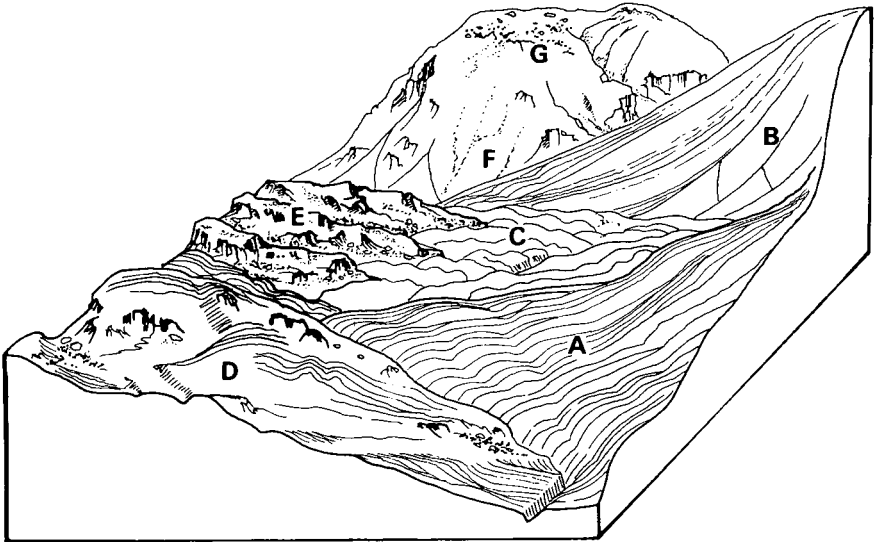
Most of the soils are mineral alluvial soils, particularly on the flood plains, but soils on the slightly higher older terraces can have better profile development. Drainage classes range from free to very poor, with freely and imperfectly drained soils being most common. In the poorly and very poorly drained soils, gleying, due to impeded drainage or a fluctuating water-table, results in grey and greenish grey colours. Manganese mottles are also often found where there is a fluctuating water-table. In very wet sites, peaty alluvial soils are common and consist of mineral material interstratified with organic matter, or mineral material with a high organic-matter content, or mineral alluvium with an

Table B Soil map units grouped according to dominant soils and topography

| Dominant soils | Topography | | |
|--|----------------------|----------------------------------|--|
| | Dominant slopes | Dominant rock class | Soil map units |
| Brown forest soils | hummocky moraines | non-bouldery | 313, 539 |
| | gentle and strong | non-rocky | 71, 517, 535 |
| | steep and very steep | moderately rocky | 393, 555 |
| Brown forest soils, humus-iron podzols | hummocky moraines | often bouldery | 25, 122 |
| | gentle and strong | slightly and moderately rocky | 18, 121, 386 |
| | steep and very steep | moderately and very rocky | 27, 125, 186, 389 |
| Humus-iron podzols | gentle and/or strong | non-rocky | 6, 20, 59, 74, 76, 97, 140, 144, 145, 172, 202, 204, 406, 425, 566 |
| | | non- and slightly rocky | 115, 454, 553 |
| | strong and steep | non-rocky | 17, 243, 282, 318, 498 |
| Peaty podzols, humus- iron podzols | strong and steep | non-rocky | 426, 499 |
| | | moderately rocky | 10, 28, 126, 285 |
| Peaty podzols | gentle and strong | non-rocky | 21, 182, 455, 541 |
| | gentle to steep | | 117, 203, 244, 567 |
| Peaty podzols, peat | hummocky moraines | often bouldery | 26, 62, 123, 185, 391, 540, 554 |
| | gentle to steep | non-rocky | 7, 22, 61, 118, 173, 176, 245, 284, 456, 500 |
| Noncalcareous gleys | gentle | non-rocky | 60, 73, 405, 424, 536, 537 241, 497 |
| | gentle and strong | | |
| Noncalcareous gleys, peaty gleys | gentle | non-rocky | 79, 201, 317, 518 5, 19, 116, 146, 181, 281 |
| | gentle and strong | | |
| Peaty gleys, peat | gentle and strong | non-rocky | 23, 75, 119, 174, 184, 392, 543, 556 |
| | | moderately rocky | 11, 29, 127, 188, 394, 557 |
| Peaty gleys, peat, peaty rankers | gentle and strong | very rocky | 32, 190, 395, 558 |
| Peaty gleys, peaty podzols, peaty rankers | steep and very steep | moderately and very rocky | 31, 131, 191, 396, 559 |
| Subalpine soils | gentle to very steep | non- to very rocky | 66, 134 |
| Subalpine soils, peat | gentle and strong | non- to moderately rocky | 34, 67, 135, 193, 397, 560 |
| Subalpine and alpine soils | gentle to very steep | non- to very rocky | 33, 192, 398, 561 |
| Alpine soils | gentle and strong | non- and slightly rocky | 35, 136, 194, 257, 514 |
| Rankers, peaty podzols | strong and steep | very rocky | 30, 129, 286 |

Some soil map units do not have counterparts in other associations and have not been included in the table.

organic surface horizon. Saline alluvial soils are poorly and very poorly drained; below about 40 centimetres the horizons are permanently waterlogged and greenish grey colours predominate.



- A Non-rocky, gentle and strong slopes
- B Non-rocky, steep and very steep slopes
- C Hummocky valley moraine
- D Moderately rocky, gentle and strong slopes
- E Very rocky, gentle and strong slopes
- F Moderately and very rocky, steep and very steep slopes
- G Mountains, wide range of rockiness and slopes

Figure 5. Summary diagram of Highland landforms

The freely and imperfectly drained alluvial soils are usually cultivated and are under either arable crops or permanent and ley pastures (*Lolio-Cynosuretum*). Soft rush pasture (the *Ranunculus repens*-*Juncus effusus* Community), sedge mires and swamp communities occur on the poorly and very poorly drained mineral and peaty alluvial soils. Common white bent grassland (part of *Junco squarrosi*-*Festucetum tenuifoliae*) and bent-fescue grassland (*Achilleo*-*Festucetum tenuifoliae*) occur in small areas, particularly in the higher localities. Some common sallow scrub (the *Salix atrocinerea* Community) and flush alderwood (the *Crepis paludosa*-*Alnus glutinosa* Association) are found locally flanking the river systems, a notable example occurring at The Alders near Golspie.

Sea poa salt-marsh (*Puccinellietum maritimae*) and mud rush salt-marsh (*Juncetum gerardii*) are dominant on the very poorly drained saline alluvial soils.

There are two map units in the Alluvial Soils: one, comprising soils developed on riverine and lacustrine alluvium, accounts for almost the entire area; the other, of saline alluvial soils, is very restricted.

Map unit 1 consists of alluvial soils developed on riverine and lacustrine alluvial deposits. Landforms are mainly very gently sloping flood plains and river terraces; most lie below 100 metres, but towards the west their altitude increases

as the rivers near their sources. Alluvial fans are much less common and are restricted to a few localities. Riverine mineral alluvial soils are most extensive in the east, for example along the valleys of the Rivers Spey, Lossie, Findhorn, Glass (Plate 1), Beauly and Oykel. The largest areas in the west are in Strath Carron and at Kinlochewe. Lacustrine alluvium is more restricted, but is present at Loch Spynie near Elgin, Loth on the east Sutherland coast, and on the Caithness Plain. The unit covers a total of 245 square kilometres (99 per cent of the association).



Plate 1. *Strathglass, Inverness-shire. Alluvial soils (map unit 1) occupy the valley floor with soils of the Arkaig Association on either side. Map unit 27, brown forest soils and humus-iron podzols, occurs on the wooded slope, and map unit 28, peaty podzols and humus-iron podzols, is present on the far slope.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Although mineral alluvial soils vary considerably in drainage and texture class, there are usually one or two dominant types within each valley; this is evident where more detailed survey has been done. In the Spey valley and the straths of north and east Sutherland, freely and imperfectly drained soils with mainly sandy loam to sand textures are most common. Around Elgin and on the Caithness Plain, imperfectly and poorly drained soils with loamy and sandy textures are dominant. Freely and imperfectly drained soils with loam textures occur in the Findhorn and Nairn valleys. Poorly and very poorly drained soils are present in the lower part of Strath Fleet, particularly at The Alders where the soils have a very high water-table. In a few localities such as Strath Bran and at Tornapress near Loch Kishorn, peaty alluvial soils are found.

Because of the great variability in soil texture and drainage, land use can vary from good quality arable ground to land which is too wet for animals to graze on. The best areas are on the alluvium of the Rivers Findhorn and Nairn, the deep freely and imperfectly drained loamy soils providing high-quality land. In the Spey valley, the alluvium is also mostly cultivated. Flood risk is the greatest hazard in many areas and despite favourable climate, soils and topography, land use is often restricted to pasture improvement, for example in Strath Brora and the Strath of Kildonan. In some straths, particularly Strathglass, Strath Fleet and

Strath Oykel, land use varies within the strath largely because of flood risk. In the west and centre of the area, strips of alluvium are important for providing high- or moderate-value natural grazing in otherwise poor land dominated by peaty soils with moorland plant communities.

Map unit 2 consists of saline alluvial soils developed on marine sand of salt-marshes (saltings). It covers only 3 square kilometres (1 per cent of the association) and has been mapped in two areas between Nairn and Findhorn. Areas of saltings, too small to be identified individually on the 1:250 000 soil map, occur in this locality and also in Easter Ross (for example, around Nigg Bay and at Morrich More); they are included in *map units 382* (the Links Association) and *421* (the Nigg/Preston Associations). The unit is non-rocky and found at sites which are periodically submerged by the sea, particularly at spring tides. Land use is restricted to rough grazing, the salt-marsh plant communities providing grazing of high value.

THE ORGANIC SOILS

(Map units 3, 4, 4d and 4e)

The organic soils are considered here only as an association of map units in which peat is almost exclusively the component soil. Peat is, however, a major component of a large number of map units and a minor component of many others. In general, areas of peat greater than 1 square kilometre have been delineated separately as one of the Organic Soils map units, smaller areas being included as components of other map units.

There are two types of peat deposit. The first type, basin and valley peat, comprises those peat deposits which have formed under the influence of ground-water in confined or partially confined sites such as basins or river terraces. The peat usually shows some stratification in composition which reflects the changes in vegetation due to changes in hydrological conditions during the formation of the deposit. This type of peat has a very restricted distribution. The second type is blanket peat, developed on unconfined sites and forming, as its name suggests, a blanket covering the landscape. It shows little variation in composition with depth and is very extensive.

The Organic Soils Association covers 2525 square kilometres (15.4 per cent of the land area) and is the second largest soil association in Northern Scotland. Its main distribution is in the Northern Highlands east of the Moine Thrust and in the Caithness Plain, but it also occurs in the Grampian Highlands to the south of Nairn and Elgin and, less commonly, in the area to the west of the Moine Thrust, and extremely locally in the Moray Firth Lowlands.

The association ranges from sea level to 650 metres although most lies between 100 and 500 metres. Landforms are level or have gentle or occasionally strong slopes. The climate is mainly exposed or very exposed cool wet and cold wet, although some of the peat in Caithness lies in the cool moderately dry region. The average annual rainfall is between 800 and 2400 millimetres.

Some of the peat is shallow (50–100 centimetres) but most is deep (more than 1 metre thick). Dystrophic unflushed peat predominates, with dystrophic flushed peat locally present.

The vegetation on the deep peat is dominantly that of the various blanket bog communities (*Erico-Sphagnetum papilloso*). On the unflushed sites, lowland and northern blanket bogs are extensive, some upland blanket bog occurs at higher

altitudes and mountain blanket bog (*Rhytidiadelpho-Sphagnetum fuscii*) is found on most of the high hills and mountains. The terminal phase of blanket bog is present on the edges of eroded peat hags. In some areas of frequent muirburn, deer-grass moor (the *Trichophorum germanicum-Calluna vulgaris* Association) has developed locally. Flying bent bog (part of *Erico-Sphagnetum papillosum*) occurs on weakly flushed peat, especially in the wetter western areas, and communities such as bog moss water track (the *Juncus effusus-Sphagnum recurvum* Community), sedge mires, soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and swamp communities may be found on flush sites throughout the landscape. Bog heather moor and its northern form (*Narthecio-Ericetum tetralicis*) occur on shallow peat, principally in the north and west, although in the drier east its place may be taken by moist Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*).

There are four map units: one is a unit of basin and valley peat, one of undifferentiated blanket peat, the third a unit of deep blanket peat and the fourth of hagged blanket peat.

Map unit 3 comprises basin and valley peat developed in basins and on river terraces, either level or with gentle slopes. The unit covers 43 square kilometres (2 per cent of the association) and it occurs below an altitude of 50 metres in small patches, each generally less than 2 square kilometres, mainly in the Moray Firth Lowlands, on the Caithness Plain and in north-west Sutherland. Dystrophic flushed peat is usually more common in this unit than in the other peat units.

Land use is restricted by wetness limitation mainly to rough grazing of either moderate or low value depending on the type of vegetation present. Some in the drier Moray Firth Lowlands is marginally suited to improvement for use as grassland. Some areas of this unit have been partially cut over for fuel.

Map unit 4 consists of undifferentiated blanket peat, the associated landforms including undulating land and hill sides with gentle and strong slopes (Plate 5). It covers 673 square kilometres (27 per cent of the association) and is widespread, ranging in altitude from sea level to 300 metres.

The map unit comprises shallow peat and deep peat in varying proportions. In some places there is a strong relationship with the landform, the deep peat occurring on the level and more gently sloping ground and the shallow peat on the steeper slopes. This sort of pattern can occur on undulating land and on irregular or stepped hill sides. Some areas of this unit in Caithness are dominantly shallow peat.

Land use is largely rough grazing, the dominantly moorland plant communities providing grazing of only low value. Near crofting areas it is common to find that some of the peat has been cut over for fuel.

Map unit 4d consists of deep blanket peat on level, gently sloping and gently undulating land. It covers 1337 square kilometres (53 per cent of the association, 8.1 per cent of the land area). The map unit is very extensive in Caithness and widespread in Sutherland, mostly occurring below 300 metres but ranging overall from sea level to 500 metres. In Caithness and Sutherland there are numerous small areas of dubh lochans (Plate 2), closely packed pools which occur well away from the natural drainage channels.

Land use is restricted by wetness limitations to rough grazing, the moorland plant communities providing grazing of low value. Some fringes of the deep blanket peat have been cut over for fuel.

Map unit 4e identifies areas of strongly eroded peat (Plate 3) and it covers 472 square kilometres (19 per cent of the association). The unit occurs mainly in central Sutherland, along the Caithness–Sutherland boundary in the region of the Knockfin Heights, and to the south of Nairn.



Plate 2. *Dubh lochans on deep blanket peat, Caithness.*



Plate 3. *Hagged peat near Melvaig, Wester Ross.*

The peat is mainly deep peat and almost entirely dystrophic unflushed. The associated landforms are mainly undulating plateaux, hill tops and hill sides with gentle and strong slopes, and the unit is generally found at higher altitudes than those of the other Organic Soils map units, ranging from 250 to 650 metres. Erosion in channels or gullies has in some places revealed the underlying rock or drift, the surface of which is often bouldery. The pattern of erosion on the gentle slopes of the plateaux and hill tops is generally a network of channels, although on the Knockfin Heights and near Loch Choire in central Sutherland it appears to be the result of the natural degradation and drainage of dubh lochan complexes. On the steeper sides of the plateaux and hills, the erosion pattern consists largely of a number of deep parallel channels running down the slopes. The unit can include small patches of map units with peaty soils, or small areas of non-eroded peat can be present which form a mosaic with the eroded peat.

Climate, topography and wetness limitations restrict land use to rough grazing, although the eroded peat to the south of Nairn has extremely severe topographic limitations which give the land little or no agricultural value.

THE ABERLOUR ASSOCIATION

(Map units 5-7, 10 and 11)

In Northern Scotland the soils of the Aberlour Association are for the most part developed on parent materials intermediate between those of the Arkaig and the Countesswells Associations, the drifts being composed either of a mixture of granite and Moinian rocks or else being derived from Moinian granulites which have been intruded by multiple granite veining. Also included in this association are drifts derived from granulites and granitic gneiss with variable intrusions of felsites; in the Aberlour district, the parent materials may be partly derived from Dalradian rocks. The drifts have a gritty sandy loam, locally loam, texture and are stony, frequently very stony.

The association covers 103 square kilometres (0.6 per cent of the land area) and it occurs patchily between Drummoissie Muir and Keith at altitudes of 200 to 500 metres. The average annual rainfall is between 800 and 1000 millimetres and the association lies in the fairly warm moderately dry and the cool wet climate regions; the exposure categories are mainly moderate.

The soils are mainly peaty gleys, humus-iron podzols, peaty podzols and peat; minor soils include noncalcareous gleys, humic gleys, brown forest soils and rankers.

The vegetation on the uncultivated soils consists largely of moorland plant communities. Bog heather moors (*Narthecio-Ericetum tetralicis*) occur on the peaty gleys, dry and moist boreal heather moors (parts of *Vaccinio-Ericetum cinereae*) on humus-iron podzols and peaty podzols respectively, and lowland and upland blanket bog communities (parts of *Erico-Sphagnetum papilloso*) on the peat. Arable and permanent pastures (*Lolio-Cynosuretum*) are present on the noncalcareous gleys, brown forest soils, and on the cultivated humus-iron podzols; soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires occur on the humic gleys and on some of the noncalcareous gleys.

The association comprises five map units, of which the two most extensive ones are one dominated by humus-iron podzols (45 per cent of the association) and one by noncalcareous and peaty gleys (35 per cent).

Map unit 5 comprises noncalcareous gleys and peaty gleys with some humic gleys, flushed peat and humus-iron podzols; the landforms are non-rocky, gentle and strong, concave or regular slopes with minor depressions. The unit covers 34 square kilometres (35 per cent of the association) and it occurs in the Findhorn valley and around Dufftown, Craigellachie and Rothes. The land use is mainly marginal arable land, the main factors affecting the agricultural capability being climate and the poor natural drainage of the soils. Some land is limited to poor rough grazing.

Map unit 6 is a unit of freely and imperfectly drained humus-iron podzols with minor noncalcareous gleys and peaty gleys, and it is found on non-rocky gentle and strong slopes. It covers 46 square kilometres (45 per cent of the association), large areas of it being present in the triangle formed by Rothes, Dufftown and Ballindalloch in Speyside. The land is mainly cultivated or in permanent pasture. The unimproved land under dry boreal heather moor is moderately suitable for use as improved grassland.

Map unit 7 consists of peaty podzols and peat with minor areas of peaty gleys and humus-iron podzols; the associated landforms comprise non-rocky or slightly rocky hills and valley sides with strong and steep slopes. The unit covers only 5 square kilometres (less than 5 per cent of the association) and it occurs in two areas to the south of Nairn and lying close to the southern margin of the map. Wetness limitation, caused by the organic surface horizons, restricts potential land use to pasture improvement, although there are areas which are drier and suitable for marginal arable land, and areas too wet to be improvable.

Map unit 10 comprises peaty podzols and humus-iron podzols with some peat, gleys and rankers, and the unit is found on slightly and moderately rocky hill and valley sides with strong or steep slopes. The unit covers 14 square kilometres (15 per cent of the association) in the upland areas of Morayshire and Nairnshire.

The agricultural capability of the land is limited by rock outcrops, organic surface horizons and soil pattern to rough grazing, the moorland plant communities providing only grazing of low value. Some small areas of humus-iron podzols may be improvable if rock outcrops are sufficiently far enough apart. Many areas of this map unit have been afforested and good yields of timber obtained.

Map unit 11 is a unit of peaty gleys and peat with some peaty podzols and rankers, and it is present on slightly and moderately rocky, gentle and strong, complex slopes. The unit is only found in one locality, Carr Mor north-west of Grantown-on-Spey, where it covers 4 square kilometres (less than 5 per cent of the association).

Land use is restricted mainly to rough grazing by topography and wetness, the moorland plant communities giving only low grazing values. Locally, some land is marginally suited for use as improved grassland.

THE ARDVANIE ASSOCIATION

(Map unit 17)

The soils of the Ardvanie Association are developed on morainic drifts derived from Middle Old Red Sandstone strata and Moinian schists. There is only one map unit and its description is included with that of the association. It covers 38

square kilometres (0.2 per cent of the land area) and it occurs between Evanton and Tain in Easter Ross, and between Inverness and Forres.

The parent material is brown or reddish brown, stony, sometimes stone-dominated, and varies from a gravelly loamy sand to a loamy sandy gravel. Minor bands of sand or, more rarely, of silt occasionally show traces of bedding. Though closely related to the morainic drifts of the Millbuie Association, it is distinguished by the schist content. Locally it may have close affinities with the fluvioglacial gravels of the Corby Association.

The landform consists of undulating lowlands and foothills with occasional areas of mounds. Slopes are normally gentle but may be locally steep especially in the mounded areas. Rock outcrops are rare. In Easter Ross, the altitude ranges from 20 metres near Balintore to around 100 metres in The Wilderness. South of the Moray Firth, where the unit flanks Drummosie Muir, the altitude ranges up to 224 metres. The average annual rainfall is between 600 and 800 millimetres in the lowlands, rising to 1000 millimetres in Strathnairn. Climatically the unit lies mainly in the warm and fairly warm moderately dry regions. The exposure categories are mostly moderately exposed, locally sheltered.

Freely drained humus-iron podzols are the dominant soils on the straight or slightly convex slopes on the southern side of the Moray Firth, whereas in the more mounded areas in Easter Ross, freely and imperfectly drained humus-iron podzols are co-dominant. Minor areas of noncalcareous gleys and peaty gleys are associated with sporadic depressional sites, especially within the mounded variant. As with most of the soils that are developed on coarse-textured morainic and fluvioglacial sands and gravels, the cation-exchange capacity is low. Exchangeable calcium, magnesium and potassium values are much lower in the B horizon than in the horizons above, and this decrease continues into the C horizon.

Land use is almost evenly divided between agriculture and forestry. On the cultivated land arable crops and ley pastures (*Lolium-Cynosuretum*) are found. Where the gleys are not afforested with Sitka or Norway spruce they are characterized by the presence of soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires. The uncultivated humus-iron podzols support dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*).

THE ARKAIG ASSOCIATION

(Map units 18-36)

The soils of the Arkaig Association are developed on drifts derived from Moinian granulites, schists and gneisses. The drifts are almost all very stony, of loamy sand or sandy loam texture and usually have pale colours. Various types of drift occur in different parts of the landscape: moraines mainly in the valleys, till on the lower ground and on lower hill slopes, colluvium and some scree on hill and valley sides and cryogenic material on the mountains.

The association is by far the most extensive in Northern Scotland, covering 6130 square kilometres or 37.3 per cent of the land area. It extends from the north coast to the southern boundary of the area, but only reaches the east and west coasts at a few localities; to the west it is bounded by the Moine Thrust and to the east by Old Red Sandstone strata, granite and Dalradian rocks. The Arkaig Association is also the most extensive association in the Highlands of Scotland.

The land covered by the association forms the bulk of a dissected plateau which increases in altitude from 250 metres in the north to 450 metres around Loch Shin and Strath Oykel and to 1000 metres in the south. There is a sharp rise from 450 to 800 metres along a line from Loch Broom to the Dornoch Firth. To the north of this line, with the exception of the Reay Forest and the Ben Klibreck–Ben Armine area, the landscape is mainly non-rocky with gentle and strong slopes, whereas to the south it is more hilly and rocky, with many more steep and very steep slopes. East of the Great Glen, the altitude decreases again and the landscape is mainly non-rocky with gentle and strong slopes. This area is also part of a dissected plateau with an altitude between 500 and 600 metres.

Around the Moray Firth, east of Strathglass and in north and east Sutherland, the average annual rainfall is mainly between 800 and 1200 millimetres. The mountains to the west mainly have rainfall totals of 1200 to 2400 millimetres, but up to 3200 millimetres in the extreme south-west. The climate also becomes cooler and more exposed towards the south-west, largely as a result of the general increase in altitude. The lowest ground, around the Moray Firth, has a fairly warm moderately dry climate. Most of the area north of the Loch Broom–Dornoch Firth line and east of Strathglass is cool and wet, whereas the more mountainous south and north-west is very cold and wet. Exposure categories range from moderately exposed and sheltered in parts of the low-lying east to exposed over much of the northern area and very and extremely exposed in the southern and western mountains.

The soils of the Arkaig Association are stony, with sandy loam or loamy sand textures; structures are generally weak. Peaty soils and peat are dominant, with peaty gleys probably most common and increasing in abundance towards the west. Moderate organic-matter content in the upper mineral horizons leads to dark greyish brown and greyish brown colours being most common. Peat is present throughout the area, but is more common in the north and to the east of the Great Glen where the landscape is more gently undulating. The peat is almost always the unflushed dystrophic type, except locally on steep slopes and in channels and basins on more gently sloping ground where it is flushed. Above approximately 400 metres, the surface of the peat is usually strongly hagged. Two types of peaty podzol occur; the first, although present throughout the area, occurs mainly in the north and east, whereas the other is entirely restricted to the east. The more widespread type occurs on gentle slopes and has a strongly gleyed E horizon above a well-defined iron pan. A very stony, strongly indurated B or C horizon is usually found beneath the iron pan. The second type is restricted to mainly strong slopes in the extreme east, these soils being much drier and the E horizon only weakly gleyed. The peaty surface horizon has frequent root mats in cracks which have formed by periodic partial drying of the peat, in contrast to the wetter, more plastic, peaty horizon of the other type. Peaty rankers are most common in close proximity to rock outcrops, but also occur on scree on very steep slopes. In very rocky areas, there is much drift-free ground with peat lying directly on rock. Mineral material, where present, is usually strongly gleyed.

Subalpine and alpine podzols are the most common soils on the mountains. They are usually developed on cryogenic deposits, but occasionally on colluvium. These soils are characteristically loose with abundant small stones although medium and large angular stones are also present. Alpine and subalpine gleys are less common and are present in basin and channel sites. They usually have humose topsoils and, like the podzols, are very stony and loose.

Humus-iron podzols are the most extensive soils in the lowland areas and significantly they occur in the warmest, driest region in which the association occurs.

Where cultivation has taken place, a dark greyish brown Ap horizon, usually 20 to 30 centimetres thick, overlies a stony Bs or Bsx horizon, and in some profiles, traces of an iron pan occur at the top of the B horizon. Brown forest soils are less common and are generally restricted to steep colluvial slopes. These soils are less stony and have slightly finer textures, particularly in the A horizon, than the other soils in the association. Noncalcareous and humic gleys occur only in basin and channel sites and do not cover large areas.

The range of plant communities strongly reflects the dominance of peaty soils with moorland communities widespread and oroarctic communities, grasslands and woodlands much less common. Deep peat normally occurs under lowland or northern blanket bog communities (parts of *Erico-Sphagnetum papillosum*), but occasionally these have been replaced by deer-grass moor (the *Trichophorum germanicum-Calluna vulgaris* Association) as a result of intense burning and grazing. At higher altitudes, on hagged peat, terminal phase and upland blanket bog communities (parts of *Erico-Sphagnetum papillosum*) and mountain blanket bog (*Rhytidiadelpho-Sphagnetum fuscum*) also occur, and become increasingly abundant with increasing altitude. Bog heather moors (*Narthecio-Ericetum tetralicis*) are found on peaty gleys, shallow peat and peaty podzols with strong gleying above the iron pan, and are probably the most widespread communities of the whole association. The drier type of peaty podzol usually supports northern, moist and, less frequently, dry Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*). Moist and very occasionally dry boreal heather moors (parts of *Vaccinio-Ericetum cinereae*) are present in some southern areas, particularly east of the Great Glen. This is largely a consequence of the increased altitude of the habitats and the decreasing effect of oceanicity. Peaty rankers usually support the northern forms of bog heather moor and Atlantic heather moor because they tend to occur in the more exposed sites.

Mountain heath communities are most common on the higher ground, although the vegetation cover is very patchy, particularly at the higher altitudes. The subalpine and alpine podzols are most often found under alpine azalea-lichen heath (*Alectorio-Callunetum vulgaris*), although the alpine podzols can also support fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosum*) or less commonly bog whortleberry heath (the *Racomitrium lanuginosum-Vaccinium uliginosum* Association). Stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association) is locally extensive, particularly on steep colluvial slopes. Blaeberry heath (the *Rhytidiadelphus loreus-Vaccinium myrtillus* Community) is also found on these slopes, as well as on steep corrie walls. Snow-bed communities are also present, the dwarf cudweed snow-bed (the *Gnaphalium supinum-Nardus stricta* Community) on subalpine and alpine gleys and the alpine clubmoss snow-bed (the *Lycopodium alpinum-Nardus stricta* Community) on alpine podzols with gleyed E horizons.

The uncultivated humus-iron podzols usually support dry and less often moist or occasionally herb-rich Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*), although bent-fescue grasslands (*Achilleo-Festucetum tenuifoliae*) and heath rush-fescue grasslands (*Junco squarrosi-Festucetum tenuifoliae*) do occur, probably partly as a result of heavy grazing pressure and repeated muirburn. Cultivated podzols are mainly under permanent or long-ley pastures (*Lolio-Cynosuretum*) with rather limited rotation with root crops and cereals. Brown forest soils most often support bent-fescue grasslands, oak and birchwood (*Trientali-Betuletum pendulae*) and herb-rich Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*). The noncalcareous and humic gleys are often strongly flushed as indicated by the presence of soft rush pasture (the

Ranunculus repens-*Juncus effusus* Community), sedge mires and less commonly flying bent bog (part of *Erico-Sphagnetum papilloso*), often with bog myrtle (*Myrica gale*).

There are nineteen soil map units in the Arkaig Association: ten are dominated by peaty soils and peat and account for almost 80 per cent of the association, another four are mainly subalpine and alpine soils and extend over approximately 13 per cent of the association, and the remaining five are mainly mineral soils and cover less than 10 per cent.

Map unit 18 consists of brown forest soils and humus-iron podzols, with some brown rankers and noncalcareous gleys; these soils are developed on a shallow stony till. Landforms are slightly and moderately rocky with gentle, strong and occasionally steep slopes. The unit covers 29 square kilometres (less than 1 per cent of the association), the largest areas occurring at Croick in Strathcarron, on the lower slopes of the valley, and on undulating lowlands along the north coast, particularly at Skerray and Bettyhill. The freely drained soils are usually more extensive except at Bettyhill where the proportions of freely and poorly drained soils are approximately equal. Soils with deep man-made topsoils occur locally in the Bettyhill area. Permanent pasture is the most common land use owing to the limitations imposed by rockiness and soil pattern.

Map unit 19 consists predominantly of noncalcareous, peaty and humic gleys, with some humus-iron podzols and peaty podzols present on low mounds. In lowland sites, the unit is usually confined to spring lines and depressions, whereas in the foothills the unit occurs on non-rocky, long, straight or concave, gentle and strong slopes. The soils are developed on till which becomes progressively shallower with increasing altitude. The unit covers 45 square kilometres (less than 1 per cent of the association) and it is found in the foothills of the Grampian Highlands and in the Spey valley.

In some lowland sites, cultivation has improved the soils, but the overriding climatic limitation increasingly restricts the range of crops grown as altitude increases. Isolated abandoned areas of arable soils and areas where peaty gleys are dominant are suitable for use as improved grassland.

Map unit 20 consists of humus-iron podzols with some brown forest soils and noncalcareous gleys, and it occurs on non-rocky undulating lowlands and valley sides with mainly gentle but also some strong slopes. The soils are developed on a stony coarse-textured till. The map unit covers 281 square kilometres (5 per cent of the association) and, like the other podzol-dominated map units, occurs mainly in the drier east of the area. The largest areas are around Lairg and Bonar Bridge, Strathspey and in Glen Urquhart. It is usually found below 200 metres west of the Great Glen, but up to 400 metres in the east.

The dominant humus-iron podzols are frequently cultivated. Gleys occur occasionally in depressions throughout the unit, but are less frequent than in the more strongly undulating *map unit 18*. Locally, small areas similar to *map units 18* and *25* have been included and in these instances a higher proportion of gleys occurs and topographic limitations are more severe. In the area lying between Lairg and Shinness, the soils have probably been reclaimed from peaty soils; very dark humose topsoils are common and gleys are more frequent.

The land is often cultivated, particularly to the west of the Great Glen, but although the climate can be favourable, soil limitations, including coarse textures, stoniness, induration and acid parent materials, largely restrict farming

practice to long-leys pastures with only limited arable cropping. In Strathspey, the map unit has a greater altitude range and climatic factors greatly influence land use particularly on the upper slopes; these upper slopes have extensive forestry plantations although large areas are also suitable for pasture improvement. Natural grazing is mainly of low value.

Map unit 21 is dominated by peaty podzols with some peaty gleys and peat, and it occurs on till-covered, non-rocky hills and valley sides with mainly strong, but some gentle slopes. It is found in east Sutherland, mainly in the Strath of Kildonan, and in Strathspey, and it covers 51 square kilometres (less than 1 per cent of the association).

Both types of peaty podzol are present along with small patches of flushed peat and peaty gleys on the steeper slopes. The *Juncus* and *Sphagnum* species in the flushes are very conspicuous and contrast with the *Calluna*-dominant hill sides.

Above approximately 200 to 250 metres, the climate limits land use to rough grazing, whereas below this altitude the land is marginally suited to pasture improvement. Grazing values are low. Trafficability is low although wetness limitations are not quite so severe as on much of the lower hill ground in Northern Scotland.

Map unit 22 is dominated by peaty podzols and peat with minor areas of peaty gleys and humus-iron podzols, and it occurs on non- and slightly rocky hills and valley sides with strong and steep slopes. The parent material is usually a shallow drift, although on some of the lower valley slopes, deeper till deposits occur. The unit covers 194 square kilometres (3 per cent of the association) and although some small areas occur to the west of Loch Ness, it is more extensive further east, particularly on the foothill slopes of the Grampian Highlands. Like the other podzol-dominated units of the Arkaig Association (*map units 20, 21, 28 and 30*), it is almost entirely restricted to the drier less-oceanic eastern part of the area.

Where the peaty podzols are dominant, the unit is moderately or marginally suitable for pasture improvement, but where the peat is more common, land use is restricted to rough grazing by the very low trafficability. Grazing values are low due to the dominance of moorland plant communities. At the higher altitudes, climate is the overriding limitation, whatever the proportion of the component soils may be.

Map unit 23 consists mainly of peat and peaty gleys with some peaty podzols, and it occurs on non-rocky undulating lowlands and uplands with gentle and strong slopes (Plate 7 and Fig. 6). The soils are developed on a stony till. It is the most extensive unit in Northern Scotland, covering 2121 square kilometres (12.9 per cent of the land area, 35 per cent of the association). It is most extensive in Sutherland, but more restricted further south where the landscape is more rugged and hilly.

Two types of landform are present and although the range of soils in both is similar, the proportions vary. The first type is more common in the north and east and is usually associated with large peat flats. It can be considered as an expanse of deep peat broken up by areas of peaty gleys, peaty podzols and shallow peat. Despite the dominance of gentle slopes, peaty podzols, usually with strong gleying above an iron pan, are more common towards the north and east. The second type occurs on more strongly undulating hilly land, with the individual soil types in the unit less well demarcated. Many of the hill slopes are very smooth, with shallow peat and peaty gleys co-dominant and closely associated. Deep peat

is much less common on these slopes and is restricted to local very gently sloping areas. Peaty podzols are also restricted, largely as a result of the wetter climate. Bouldery patches occur occasionally but are insignificant. Bog heather moors dominate the vegetation although in some areas where peaty gleys are dominant, such as Glen Cassley, flying bent grassland is also important.

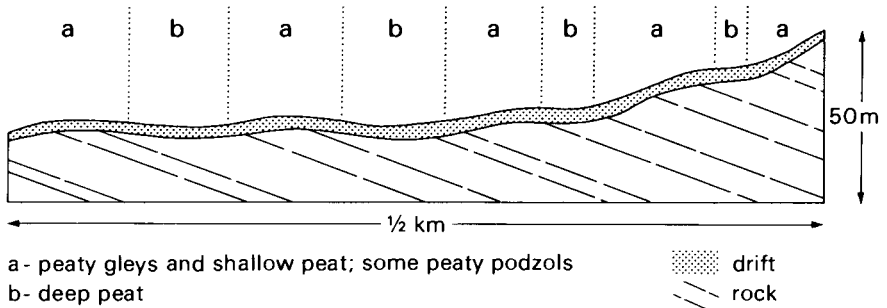


Figure 6. Generalized section of non-rocky gently and strongly sloping land with peaty gleys and peat. (Map units 23, 75, 119, 184, 392, 543 and 556).

The unit can locally include small patches similar to *map unit 26*, particularly between Loch Glass and the Strath of Kildonan, and small patches similar to *map unit 29*. Occasionally the landscape strongly displays the underlying rock pattern, usually in the form of parallel ridges. Moorland communities almost always dominate, but in Strath Mulzie, heath grass-white bent grassland, common white bent grassland and flying bent grassland have replaced the moorland communities, probably because of grazing pressure. Occasional mineral soils under bent-fescue grassland also occur in this area.

Land use is primarily deer-forest, rough grazing and, to a lesser extent, forestry. Grazing values are almost entirely low. Over much of the area, climate is the overriding limitation, except in the north and east where ground below approximately 250 metres is marginally suitable for reclamation. Deep peat should be avoided in any reclamation scheme because of its very low trafficability.

Map unit 24 comprises peaty gleys and peaty podzols with some shallow peat and peaty rankers, and it occurs on steep and very steep non-rocky hill and valley sides. The associated parent material is colluvium. The unit extends to 119 square kilometres (2 per cent of the association) and is more common in the hilly south, particularly around Glen Carron and the Diebidale Forest. In the north the only significant occurrences are in the Ben Klibreck area.

The unit commonly occurs on the long lower slopes of mountains, with *map unit 33*, subalpine and alpine soils, above. The peaty gleys are usually weakly flushed and found on concave slopes, whilst the peaty podzols occur on straight or convex slopes, although their distribution is also influenced by the climate. Peaty rankers are developed on scree. Slightly and moderately bouldery patches are present on some slopes, but are not extensive. At higher altitudes, mountain white bent grassland occurs.

Land use is restricted to deer-forest and rough grazing by climate, slope and wetness limitations. Grazing values are generally low except on some of the higher southern slopes where upland grasslands provide moderate grazing.

Map unit 25 is a unit of brown forest soils and humus-iron podzols with some gleys and peat, and it is developed on hummocky valley and occasionally slope moraine. The mounds usually have a slightly or moderately bouldery surface. Overall slopes are mainly gentle and strong, except in Gleann Chorainn in southern Ross-shire where the moraines occur on steep and very steep valley slopes. Individual mounds can have short steep slopes. The unit covers 26 square kilometres (less than 1 per cent of the association) and occurs mainly as small areas in some of the northern and eastern straths.

Brown forest soils and humus-iron podzols are present on the mounds, and flushed humic gleys, peaty gleys and peat occur in the channels and hollows between them. Soil pattern and boulderiness limit the agricultural potential to pasture improvement, but in some areas, severe boulderiness or wetness limitations or both restrict land use mainly to rough grazing. Grazing values are moderate.

Map unit 26 consists of peaty podzols and deep peat with some peaty gleys and shallow peat. Like *map unit 25* it is developed on hummocky valley and slope moraine (Fig. 7), but is much more extensive, covering 855 square kilometres (5.2 per cent of the land area, 14 per cent of the association). Its distribution is strongly influenced by the valley network, the unit being found mainly in central Ross-shire, and central and north Sutherland. The unit is almost absent east of Strathglass.

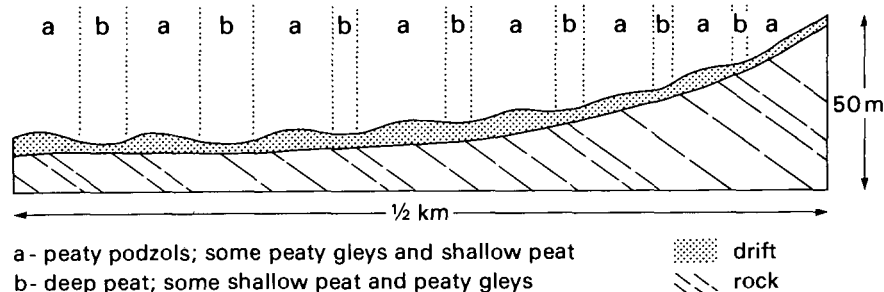


Figure 7. Generalized section of moraine with peaty podzols, peaty gleys and peat. (Map units 26, 62, 123, 185, 391, 540 and 554).

The local geomorphology, altitude and exposure of the valleys play a large part in determining the proportion of the major soil types. Most of the valleys are fairly broad and open, except in the hilly west and south where some are much more confined. In broad valleys, the deep peat element is much more extensive than in narrow valleys and the moraine mounds on which the peaty podzols occur are usually widely spaced. If the moundiness is subdued and gentle slopes predominate, peaty gleys and shallow peat also occur. Flats of deep peat are common on the valley floors. In narrower, more confined valleys, often with steep-sided walls, the mounds are frequently contiguous and deep peat is a subsidiary component. Weak flushing is common on the peaty gleys and shallow peat which occur between the mounds. The mounds usually have a slightly to very bouldery surface. The unit also occurs on some steep valley slopes and the mounded terrain is replaced by steep gullied ground. Subalpine podzols occur locally on the tops and windward sides of exposed mounds, usually above 350 metres, but occasionally lower if the valley is orientated parallel to the direction

of the prevailing wind. These soils are also found in more open situations and in these areas, the deep peat is often hagged.

The unit mainly occurs in large deer-forests given over to sporting interests, with only rough grazing of low value. Only in the north and east does any marginally reclaimable land occur, the climate and boulderiness being the main limitations over much of the southern and western areas.

Map unit 27 is a unit of brown forest soils and humus-iron podzols with some gleys and rankers, and it occurs on steep and very steep, mainly moderately rocky but occasionally very rocky, hill and valley sides (Plate 1). The associated parent material is colluvium. The unit covers 129 square kilometres (2 per cent of the association) and is more common in the southern half of the association where the valleys are more deeply incised and slopes generally are steeper and longer.

Brown forest soils and humus-iron podzols are most abundant, with flushed humic and peaty gleys occurring in channels. The rankers occur both on rock and on very stony colluvium. Towards the top of some of the higher slopes, peaty rankers on rock and scree can occur. Some slopes, particularly the lower parts, are only non- or slightly rocky but are almost invariably bouldery to some extent. Often the two valley sides have been mapped together and in these instances, the unit includes a narrow valley bottom with features such as alluvium, river terraces and gravel mounds.

Only the land in the valley bottoms is readily improvable although there may be a flood risk. The less steep slopes are marginally suitable for improvement, but as they already provide natural grazing of high or moderate value they may be more profitably left as they are.

Map unit 28 consists mainly of peaty podzols and humus-iron podzols with some peat, peaty gleys and rankers, and it occurs on undulating moderately rocky hills and lowlands with gentle to steep slopes (Plate 1). The soils are developed on a shallow stony till and on colluvium. The unit covers 305 square kilometres (5 per cent of the association) and is most extensive between Loch Garve and Glen Urquhart. Significantly, like the other podzol-dominated units, *map units 20, 21, 22 and 30*, it is more common in the east of the area covered by the association.

The diagnostic feature of the unit is the combination of dominantly podzolic soils in a moderately rocky landscape. The largest area occurs between Strathglass and Glen Urquhart, on a strongly undulating plateau. Peaty podzols, humus-iron podzols and rankers occur on the rocky areas which are separated by channels, hollows and flats of peat and peaty gleys. The plateaux to the north of Strathglass and to the north of Drumnadrochit are similar, but have a more subdued landform. The lower-lying areas to the south of Kirkhill are mainly humus-iron podzols and contain little peat. To the west, the wetter *map unit 29* becomes more common, and *map unit 28* becomes restricted to steep valley sides. Humus-iron podzols are the major soils on these steep irregular slopes, with gleys being restricted to narrow channels and flushes. Peaty podzols are present on the upper slopes and on more gently sloping areas.

Rough grazing of low value is the dominant land use with only the low-lying grasslands providing good grazing. Some small areas of dominantly humus-iron podzols are very suitable for improvement. Many of the steep valley sides have been afforested.

Map unit 29 comprises peaty gleys and peat with some peaty podzols and peaty rankers, and it occurs on moderately rocky undulating lowlands and hills with

gentle and strong slopes (Plate 7 and Fig. 8). The soils are developed on a stony till. The unit extends over 916 square kilometres (5.6 per cent of the land area, 15 per cent of the association) and has a scattered distribution. It is most extensive in the north and around Loch Broom, and is less common east of Strathglass and between the Strath of Kildonan and Strathcarron.

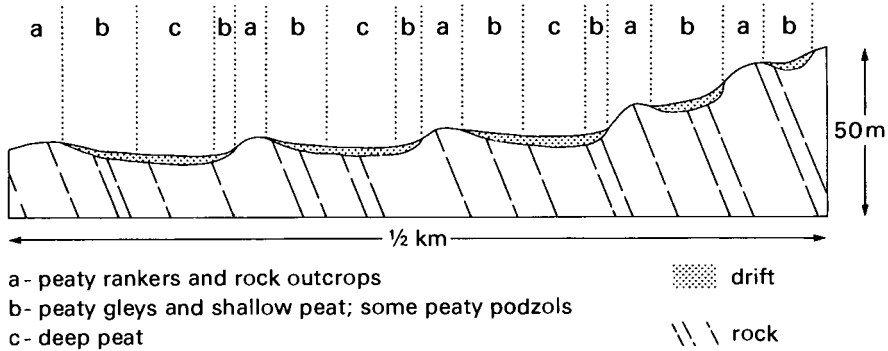


Figure 8. Generalized section of moderately rocky gently and strongly sloping land with peaty gleys and peat. (Map units 29, 127, 188, 394 and 557).

The presence of rock outcrops and peaty rankers is the main difference between this unit and *map unit 23*. Deep peat is often most extensive and occurs as flats and channels between moderately rocky areas which consist mainly of peaty gleys with some peaty rankers and shallow peat. Peaty podzols with strong gleying above an iron pan are usually restricted to strong slopes, except in the low-rainfall area east of Strathnaver. There is a strong lineation to the rock outcrops in some areas, particularly to the immediate east of the Moine Thrust, where quartz-schist is the bed-rock, and in Strath Bran.

At higher altitudes severely eroded deep peat is a common component. Rocky knolls have been revealed and subalpine podzols have developed on some of the more exposed ones. Peaty gleys and peaty rankers also occur, but hagged peat is generally the dominant soil of this variant. Another less common variant is one which contains little peat and occurs on drier, moderately and very bouldery slopes with few rock outcrops.

Land use is restricted to rough grazing and deer-forest because of wetness and topographic limitations. The grazing is of low value due to the dominance of moorland plant communities.

Map unit 30 consists of peaty rankers, podzolic rankers and peaty podzols with some humus-iron podzols, peaty gleys and peat, and it occurs on very rocky rugged hills with strong and steep slopes. The soils are developed on shallow semi-residual drift and colluvium, with small patches of scree. The unit covers 71 square kilometres (1 per cent of the association) and has a similar distribution to *map unit 28*, occurring mainly between Glen Urquhart and Loch Luichart, but also around Lochindorb.

The unit generally occurs within areas of *map unit 28*, the rock being exposed as crags, pavements and knolls. Rankers are most common, and the podzols, mainly peaty podzols, are developed on the thicker drift between the outcrops. Peaty gleys and peat are restricted, but become more common towards the west.

Severe rockiness and slope limitations restrict land use to rough grazing, the moorland communities providing grazing of only low value.

Map unit 31 is a unit of peaty gleys, peaty rankers and peaty podzols with some shallow peat, and it occurs on moderately and very rocky, steep and very steep hill and valley sides. The soils are developed on colluvium. The unit covers 136 square kilometres (2 per cent of the association) and, like *map unit 24*, which is similar but non-rocky, is most common in the hilly parts of the association. It is most extensive in the extreme north-west and south-west of the area.

The main difference from *map units 29* and *32* is the much smaller proportion of peat due to the steeper slopes. Peaty gleys are the dominant soils with peaty podzols generally restricted to convex or straight unflushed slopes. Peaty rankers on scree are locally extensive and are the most common soils in some areas, for example in Glen Alladale to the west of Croick.

Climate, slope and wetness limitations restrict land use to rough grazing; the moorland plant communities have low grazing values.

Map unit 32 consists of peaty gleys, peaty rankers and peat with some peaty podzols, developed on a patchy stony drift. The landscape is very rocky and strongly undulating and although most of the slopes are gentle and strong, there are frequent short very steep crags (Fig. 9). The unit covers 106 square kilometres (2 per cent of the association) and occurs mainly to the immediate east of the Moine Thrust.

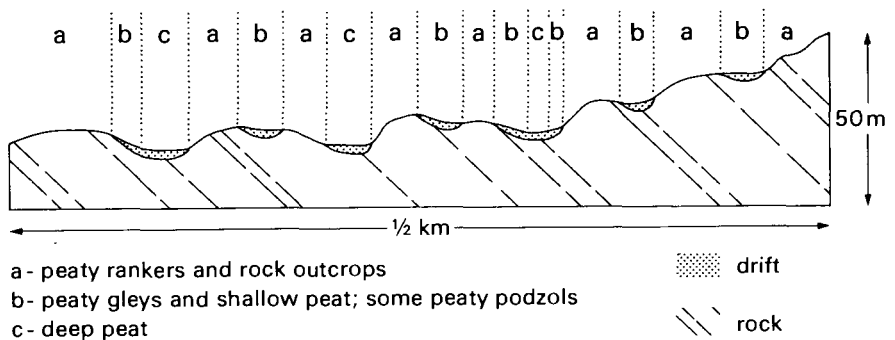


Figure 9. Generalized section of very rocky gently and strongly sloping land with peaty gleys, peaty rankers and peat. (*Map units 32, 190, 395 and 558*).

The unit often occurs on slightly higher hills within a large plateau-type landscape of *map unit 29*. Large parts of the rocky knolls are drift-free or have a very thin veneer of material. Shallow peaty gleys and peaty rankers are most common on these knolls, with peaty podzols and peat much more restricted. The peaty surface horizon is often eroding, particularly above approximately 300 metres. Above 450 metres, subalpine podzols occur locally on exposed sites. Peat, often slightly hagged, is present in channels and on flats between the knolls. The lineation of the rock outcrops described in *map unit 29* also occurs in this unit.

Land use is restricted to deer-forest and rough grazing by the strongly undulating, very rocky terrain which imposes very severe limitations; the grazing is of low value.

Map unit 33 comprises mainly subalpine and alpine podzols with some rankers,

lithosols, noncalcareous regosols and gleys, and it occurs on mountains with a wide range of rockiness and slope classes. The parent materials are cryogenic deposits and colluvium. The unit covers 574 square kilometres (9 per cent of the association) with the largest areas found south of a line from the Dornoch Firth to Loch Broom.

A number of different landscape elements are present including steep and very steep slopes, rounded summits, plateaux and ridges. The steep and very steep slopes are often dominated by unvegetated crag and scree, with lithosols, noncalcareous regosols and rankers most common. Particularly towards the south, weakly podzolized soils are developed on non- and slightly rocky colluvial slopes. Subalpine and alpine podzols occur on the summits, plateaux and ridges, with gleys generally restricted to small local hollows and basins. The land is often extremely stony and bouldery, with patterned ground common (Plate 4). Very locally, hagged peat occurs below 650 metres. On mountains with high non-rocky plateau tops, for example Moruisg and Maoile Lunndaith, parts of the unit are similar to *map unit 35* with alpine podzols dominant.



Plate 4. Solifluction terraces in the Fannich Forest, central Ross-shire (part of map unit 33, *Arhaig Association*). Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

The severe climate is the main limitation affecting land use. Below approximately 650 metres the land is only suitable for use as rough grazing, mainly of low value, although some moderate rough grazing is available on grassy colluvial slopes. Above this altitude the land has little or no agricultural use.

Map unit 34 consists of deep peat and subalpine podzols, and it occurs on non- to moderately rocky upland plateaux with gentle and strong slopes. The podzols are developed on cryogenic material. The unit has a scattered distribution and

extends to 127 square kilometres (2 per cent of the association); the largest area is at the north-west end of Loch Shin.

The podzols are found on the non- to moderately rocky knolls, with deep peat, which is often strongly hagged, between them. Although the boundary between the two soil types is usually sharp, a very narrow zone of peaty podzols and peaty gleys is sometimes present. The knolls are often moderately or very bouldery. In some areas the unit has previously been covered by peat, now severely eroded, and rocky knolls are exposed on which subalpine podzols have developed.

The overriding climatic limitation restricts land use to rough grazing, the mountain heath and moorland communities having only low grazing values.

Map unit 35 is dominated by alpine soils and it occurs on the mainly non- and slightly rocky summits and upper convex slopes of the highest mountains. Slopes are mainly gentle and strong. The soils are mostly weakly podzolic and are developed on cryogenic material. The unit covers 40 square kilometres (less than 1 per cent of the association) and occurs on the Beinn Dearg and Ben Wyvis masses.

This unit is found in close association with *map unit 33* and it occurs on the higher plateaux of the mountains; the lower limit, approximately 750 metres, is dependent on local topography, aspect and exposure. The plateaux are gently undulating. Most areas are non- or slightly rocky, and micro-relief features due to cryoturbation are common. The area directly north of Beinn Dearg is very rocky, whilst Beinn Dearg itself is largely boulder-strewn, with lithosols dominant. Although alpine podzols are most common, alpine gleys occur in the more restricted receiving sites.

Because of the limitations imposed by the extremely severe climate, this unit has little agricultural value, although local occurrences of mountain white bent grassland provide moderate grazing for a few months in summer.

Map unit 36 consists primarily of rankers and lithosols, and it occurs on the steep and very steep rock and scree slope of the Findhorn valley near Moy. The parent material is mainly colluvium with a little shallow drift on ledges and summits. The unit covers only 5 square kilometres (less than 1 per cent of the association).

It is, however, much more extensive in other parts of the Highlands of Scotland where, in addition to the steep element described above, there is usually a gently sloping element consisting of ridges and mountain summits with areas of extensive rock pavements. Land use is restricted to rough grazings of low value, but where rock is dominant the ground has little agricultural value.

THE BERRIEDALE ASSOCIATION

(Map units 59–67)

The Berriedale Association consists of soils developed on drifts derived from sandstones and conglomerates of the Middle Old Red Sandstone Barren Group.* There are four main types of drift – till, the most extensive, moraine, colluvium and cryogenic material. All are reddish and have textures of sandy loam or loamy sand; some of the till has a sandy clay loam texture. The drifts are stony and include stones of schist, granulite and granite which have been derived from the conglomerates, and stones of sandstone composition derived from the sandstones.

*Some of this Middle Old Red Sandstone has now been reclassified as Lower Old Red Sandstone (Institute of Geological Sciences, 1979).

Drifts derived largely from the conglomerates tend to be browner, stonier and have a slightly coarser texture.

The association occurs mainly in the east of Sutherland and in the Berriedale and Reay districts of Caithness, but there are also a few small patches of it in central and north Sutherland and in central Ross-shire. It covers 304 square kilometres (1.9 per cent of the land area).

The association extends from sea level to 700 metres. Much of the land is non-rocky with gentle and strong slopes although a number of other landforms are also present. The average annual rainfall is 700–1200 millimetres. Most of the association lies in the moderately exposed or exposed cool wet climate region, some is in the fairly warm moderately dry, and some is in the cool moderately dry region; the higher hills lie in the very exposed cold wet climate region.

The association includes a wide range of soils of which peaty podzols and peaty gleys, together with shallow and deep dystrophic peat, are the most extensive. The peaty podzols are poorly drained above an iron pan which frequently has formed directly on the top of a reddish indurated B horizon. Indurated horizons are found in some of the peaty gleys too, particularly in the district around Reay, but are browner or greyer. Peaty rankers are associated with peaty soils on rocky landscapes.

Freely and imperfectly drained humus-iron podzols are the dominant cultivated soils of the association, typical profiles having a reddish or brownish indurated B horizon either immediately below the surface horizon or below an intervening friable B horizon. Uncultivated humus-iron podzols, and brown forest soils, are much less common. Noncalcareous gleys occur locally and have mottled B horizons.

The soils of the higher ground are largely freely drained subalpine podzols developed on cryogenic drift, noncalcareous regosols developed on colluvium, and lithosols on rock.

The vegetation consists predominantly of moorland communities with some grassland, woodland and oroarctic communities. The peaty podzols, peaty gleys, peaty rankers and shallow peat support moist and northern Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*) and bog heather moors (*Narthecio-Ericetum tetralicis*). Lowland blanket bog, northern blanket bog, and at higher altitudes, upland blanket bog communities (parts of *Erico-Sphagnetum papilloso*) and mountain blanket bog (*Rhytidiadelpho-Sphagnetum fuscum*) all occur on the deep peat. The subalpine soils and the noncalcareous regosols on the higher hills carry a vegetation cover of alpine azalea-lichen heath (*Alectorio-Callunetum vulgaris*), lichen-rich boreal heather moor (part of *Vaccinio-Ericetum cinereae*), fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosum*) and stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association). The cultivated humus-iron podzols support arable or permanent pastures (*Lolio-Cynosuretum*). So do some of the noncalcareous gleys, while others are colonized by soft rush pasture (the *Ranunculus repens-fucus effusus* Community) and sedge mires. The uncultivated brown forest soils and humus-iron podzols support acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*), dry and herb-rich Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*) and some eastern highland oakwood and birchwood (*Trientali-Betuletum pendulae*).

There are nine soil map units. Four of them consist mainly of peaty soils and peat, making up over 70 per cent of the association, three units are of mineral soils (23 per cent of the association) and two are of subalpine soils (4 per cent of the association), one of them with peat, the other without.

Map unit 59 consists of humus-iron podzols with some brown forest soils, and it occurs on non-rocky undulating lowland with gentle and strong slopes. The soils are developed on till of mainly sandy loam, sometimes sandy clay loam, texture. The unit covers 66 square kilometres (22 per cent of the association) and is present mainly between Spinningdale and Brora in east Sutherland, less extensively in the Berriedale and Reay districts of Caithness, and in a small area near Tongue on the north coast of Sutherland.

The soils are mostly cultivated freely and imperfectly drained humus-iron podzols although uncultivated humus-iron podzols occur near Loch Brora and some peaty gleys with indurated subsoils are present near Embo.

The land use is mainly arable. The chief factors which affect the agricultural capability of this land are soil shallowness due to the presence of an indurated horizon, and climate.

Map unit 60 is a small unit of poorly drained noncalcareous gleys developed on till and occurring on gentle slopes. It covers 2 square kilometres (less than 1 per cent of the association) and is found at Dunbeath and at Reay. The land is either cultivated or under permanent pasture, the factors which limit the agricultural capability being climate and soil wetness.

Map unit 61 comprises peaty podzols, peaty gleys, shallow peat and deep peat. The soils are developed on till and are associated with non-rocky, gently undulating to hilly land with gentle, strong and occasionally steep slopes. The unit covers 176 square kilometres (58 per cent of the association) and it occurs mainly in east Sutherland and in south and west Caithness, with a few small areas of it elsewhere in Sutherland and in central Ross-shire.

The pattern of soils is not the same in each area. In the Reay and Dunbeath districts it accords with the modal concept of the unit as described above, whereas in the Berriedale district it consists largely of peaty podzols and shallow peat, and in east Sutherland mainly peaty podzols and shallow peat with patches of deep peat, some subalpine podzols occurring on the higher ground (above about 400 metres).

Land use is mainly rough grazing of low value, grouse-moor and deer-forest. In general, the land below 200 metres in Caithness and below 300 metres further south is marginally suited to reclamation. Climate and soil wetness are the main limitations affecting the agricultural capability.

Map unit 62 comprises peaty podzols, shallow peat and deep peat developed on hummocky moraine (Fig. 7). It covers only 6 square kilometres (2 per cent of the association) and occurs in two localities in Caithness, one to the west of Shurrery and the other to the west of Reay.

The soil pattern consists of peaty podzols on the moraine mounds and shallow and deep peat between the mounds. In the Reay area the unit includes patches of deep peat large enough to have been cut over for fuel, and in the Shurrery area some small patches of noncalcareous gleys are present between the mounds and some cultivated humus-iron podzols occur on the mounds.

The land is used for rough grazing. Much of it is marginally suitable for improvement, the major limitation being wetness due to the peaty surface. However, the larger patches of deep peat are probably too wet, or their surface is too irregular, for improvement, and some of the mounds may be too steep.

Map unit 63 is a small unit of brown forest soils and humus-iron podzols

developed on colluvium on steep non-rocky hill and valley sides. It covers 2 square kilometres (less than 1 per cent of the association) and is found only near Brora. Land use is rough grazing; slope is the principal limitation, although not too great to preclude the land from being marginally improvable.

Map unit 64 comprises peaty podzols, peaty gleys, shallow and deep peat and peaty rankers. The soils are developed on till, which is often shallow, and on colluvium. The unit is found on slightly and moderately rocky irregular hill sides with gentle, strong and locally steep slopes; the hill sides can be stepped, often with low crags present, and the steeper slopes can be bouldery. The unit covers 19 square kilometres (6 per cent of the association) and occurs as a few small patches scattered throughout east, central and north Sutherland.

The peaty podzols occur on the steeper parts of the unit, the peaty gleys and shallow peat are present on the gentler slopes, the deep peat has formed on the flatter areas and the peaty rankers are associated with rock outcrops and patches of scree.

The land is used for rough grazing and deer-forest. The chief limitations of topography and soil wetness render it unsuitable for improvement and the moorland plant communities provide grazing of only low quality.

Map unit 65 is a unit of peaty podzols and peaty rankers with some shallow peat. It is associated with moderately and very rocky hill sides and hills with steep and very steep slopes; in some places the unit occurs on the lower slopes of a hill and in others it forms the whole hill. The map unit covers 22 square kilometres (7 per cent of the association) and it is present mainly in Glen Sletdale and Glen Loth in east Sutherland and on Ben Griam Beg.

The soils are developed on colluvium. On Ben Griam Beg the higher part of the unit includes a narrow patch, too small to show on the 1:250 000 soil map, of subalpine podzols and deep hagged peat similar to *map unit 66*. The slope and wetness limitations and the dominance of moorland plant communities restrict land use to rough grazing of low quality.

Map unit 66, consisting of subalpine soils, lithosols and noncalcareous regosols, occurs as small patches on the tops of the higher Old Red Sandstone hills in east and central Sutherland and in south-west Caithness. It covers a total of 6 square kilometres (2 per cent of the association).

The soils are developed on cryogenic, and colluvial drifts associated with moderately and very rocky, stony and bouldery hill tops and slopes. The subalpine soils, largely subalpine podzols developed on cryogenic drift, are present on the gentle and strong slopes of the hill tops. On the steeper hill sides, noncalcareous regosols occur on the colluvium and scree, and lithosols are associated with rock outcrops. A few small patches of shallow peat are also present on the summit plateau of Beinn Dhorain.

Climate and slope limit land use to rough grazing, the mountain heaths and the moorland plant communities providing grazing of only low quality.

Map unit 67 is a unit of subalpine podzols and deep peat on non- to moderately rocky, undulating or moundy topography. It covers only 5 square kilometres (2 per cent of the association) and is found in two areas, one to the north of Lairg and the other to the north of Brora.

The subalpine podzols are developed on cryogenic drift and occur on the mounds, and the deep peat, hagged in the area to the north of Lairg but less so in

the area north of Brora, is present on the flats and in the hollows and depressions between the mounds.

Climate is the overriding factor which limits the land use to rough grazing, the vegetation providing grazing of only low values.

THE BRAEMORE/KINSTEARY ASSOCIATIONS

(Map units 71–75)

The Braemore and Kinsteary Associations, both comprising soils developed on drifts derived from mudstones and shales of mainly Lower Old Red Sandstone age, the latter association with fine sandstones also present, have been grouped on the 1:250 000 soil map.

In the Braemore area of southern Caithness, and in Glen Loth in east Sutherland, the parent materials are derived from mudstones. A reddish till of clay loam or silty clay loam texture occurs on the gently sloping lower ground, and a thinner reddish drift of loam or silty loam texture is more common on the steeper, higher land. In Easter Ross the parent materials are derived from mudstones, shales and fine sandstones. Colours range from red to grey and textures from sandy loam to silty clay loam. The drift is often shallow and weathered rock can lie close to the surface.

The associations together cover 44 square kilometres or 0.3 per cent of the land area. The landscape is dominantly non-rocky and gently undulating with a general altitude range of 150 to 300 metres. Average annual rainfall is between 800 and 1200 millimetres and the associations lie in the fairly warm moderately dry and the cool wet climate regions. Exposure is moderate in the south, but increases in the more open landscape around Braemore.

Compared to the soils derived from the surrounding sandstone, conglomerate and schist, most in the Braemore/Kinsteary Associations have much finer textures. Most common are silty clay loam and clay loam, with silty loam and sandy loam in the sandstone soils. Most stones are small. Humus-iron podzols are most common, although brown forest soils, noncalcareous gleys, peaty podzols, peaty gleys and unflushed dystrophic peat also occur.

The humus-iron podzols are generally imperfectly drained with mottled B horizons, due largely to the moderately fine texture and the frequent proximity of bed-rock to the surface. The brown forest soils are also usually shallow and both freely and imperfectly drained soils occur. Reddish brown colours predominate, the redness becoming stronger with depth. To the south-west of Strathpeffer these soils are developed on till derived from grey shales with calcareous bands. The humus-iron podzols and brown forest soils, along with peaty podzols, are usually developed on the shallower drift type. The peaty podzols are strongly gleyed above a well-defined strong iron pan. In contrast the noncalcareous and peaty gleys are present on the deeper clay loam and silty clay loam tills of the gently sloping lower ground; the moderately fine textures and gentle slopes induce strong gleying processes. Humic gleys often occur in close association with the noncalcareous gleys.

On the cultivated mineral soils, permanent and ley pastures (*Lolio-Cynosuretum*) and arable crops are found, but soft rush pasture (the *Ranunculus repens*-*Juncus effusus* Community) and sedge mires also occur on some non-calcareous gleys which are too wet to cultivate. The uncultivated humus-iron podzols support dry Atlantic heather moor (part of *Carici binervis*-*Ericetum cineræe*) and less commonly acid bent-fescue grassland (part of *Achilleo-*

Festucetum tenuifoliae). Boreal heather moors (*Vaccinio-Ericetum cinereae*) are also found and reflect the less oceanic climate in the lee of Ben Wyvis. A large proportion of this land is afforested, mainly by Sitka and Norway spruce (*Picea* plantations). The peaty podzols support moist Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) and the shallow peat mainly bog heather moor (part of *Narthecio-Ericetum tetralicis*). The peaty gleys support either of these communities, depending largely on local site conditions. The deep peat and areas of shallow peat adjacent to it are found under lowland blanket bog vegetation (part of *Erico-Sphagnetum papillosum*).

There are five soil map units in the Braemore/Kinstearry Associations: four are dominated by mineral soils and account for 75 per cent of the combined associations, and the fifth is a unit of peaty soils and peat.

Map unit 71 consists of brown forest soils and it occurs on non-rocky valley sides with gentle and strong slopes. The soils are developed on shallow drift and, in some cases, on strongly weathered rock. The unit is present around Strathpeffer and in Glen Loth and covers 7 square kilometres (15 per cent of the combined associations).

Most of the unit consists of freely and imperfectly drained brown forest soils on long regular slopes, but to the south-west of Strathpeffer the landscape is more rolling. Brown forest soils are dominant and found on the hillocks, with gleys, and locally peat, in the intervening hollows.

Land use is varied throughout the unit. Arable agriculture is practised on the lower ground and afforestation on the higher ground. In Glen Loth, the area was formerly crofting land but now supports acid bent-fescue grassland.

Map unit 72 is a unit of humus-iron podzols, podzolic rankers, humic gleys and some noncalcareous gleys, and it occurs on moderately rocky undulating hill sides with gentle and strong slopes. The soils are developed on till and on shallow stony drift. The unit covers only 1 square kilometre (less than 5 per cent of the combined associations) in the Clach Liath Forest north of Dingwall. Freely and imperfectly drained podzols and rankers occur on parallel rock ridges and the flushed gleys in the channels and hollows between them. The land is suitable only for pasture improvement because of pattern limitations imposed by rockiness and wetness.

Map unit 73 comprises noncalcareous gleys developed on till and it occurs on non-rocky valley sides with gentle slopes. The only occurrence is in Strath Sgitheach where the unit covers 8 square kilometres (20 per cent of the combined associations). The unit is present on the lower concave slopes of the valley and although it is non-rocky, shale is occasionally found within 50 centimetres of the surface. Flushing is common on parts of the slopes.

In the lower parts of the strath, wetness limitations restrict land use mainly to permanent pastures with limited arable rotation. At higher altitudes, climatic limitations restrict agricultural use and much of the ground has been afforested.

Map unit 74 is dominated by humus-iron podzols, developed mainly on a shallow drift, and occurring on non-rocky hills and undulating lowlands with gentle and strong slopes. The unit covers 16 square kilometres (35 per cent of the combined associations) and is most extensive just north of Dingwall. A smaller area occurs near Ardross.

In the larger area, the unit occurs on a broad ridge which falls away towards

the north-east. Apart from the lower southern slopes, most of the ground is under forestry or is uncultivated. Slope limitations on the ridge slopes and climatic limitations on the gently sloping summit restrict land potential mainly to pasture improvement. In contrast, in the Ardross area the till is much thicker and accompanied by a more favourable climate; the soils are cultivated, with the emphasis on grassland.

Map unit 75 is a unit of peaty gleys, peaty podzols and peat, with some non-calcareous gleys. These soils occur on non-rocky hill and valley sides with gentle and strong slopes (Plate 5 and Fig. 6). Two types of parent material are present; peaty podzols are developed on the shallow drift, the gleys on the deeper, finer-textured till. The unit covers 12 square kilometres (25 per cent of the combined associations) and occurs in two areas, the larger at Braemore and the other in Glen Loth.



Plate 5. Braemore and Scaraben, Caithness. Map unit 75 (Braemore/Kinsteary Associations), consisting of peaty gleys, peaty podzols and peat, occurs on the lower slopes, with map unit 4 (Organic Soils) above. Map unit 191 (Durnhill Association) is present on the steep, partly vegetated, scree slopes of Scaraben. Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Peaty gleys, peaty podzols and shallow peat occur in approximately equal amounts, with deep peat more restricted, being confined to the most gently sloping areas. Noncalcareous gleys under soft rush pasture and heath rush-fescue grassland occur around the numerous abandoned crofts present in the Braemore area.

Below about 200 metres, the unit is marginally suitable for improvement because of low trafficability caused by wetness limitations. Above this altitude, climate limits land use to mainly rough grazing, which is of low value. The more restricted rush pastures and grasslands have mainly moderate grazing values.

THE BRIGHTMONY ASSOCIATION

(Map unit 76)

The Brightmony Association is one of the smaller associations in Northern Scotland and is found only on the southern side of the Moray Firth between Inverness and Forres. It occupies 21 square kilometres or 0.1 per cent of the land area. Because there is only one map unit its description has been included with that of the association.

Interbedded sands and gravels form the parent material, with textures ranging from slightly gravelly loamy fine sands to sandy gravels, the former being dominant. The stones vary widely in their lithology but are mainly sandstones with common schists and granites, usually rounded or subrounded and less than 5 centimetres in diameter. A pinkish or reddish cast is normally associated with the sand bands. Reddish brown sandy loam till derived from Upper or Middle Old Red Sandstone strata underlies the interbedded drift at depths of 120 to 200 centimetres. Characteristic polygonal frost cracks mark the upper surface of the till.

The non-rocky landscape consists mainly of long broad ridges with gentle slopes within an altitudinal range of 10 to 76 metres. A minor element comprises a deeply dissected slope to the east of Cawdor which rises to approximately 140 metres; short strong slopes lead to misfit streams in narrow alluvial channels. The average annual rainfall is 600–800 millimetres and the climate is warm and moderately dry; the exposure category is moderate.

Freely drained humus-iron podzols are the dominant soils, and iron podzols occur less commonly. Induration and an associated well-developed platy structure are characteristic of the B horizon. Minor areas of gleys occur to the south of Auldearn.

Apart from small areas of mixed deciduous and coniferous woodland at Darnaway and Ordhill, the association is devoted to arable agriculture. Much of the area is concerned with barley production.

THE CANISBAY ASSOCIATION

(Map units 79 and 83)

The Canisbay Association comprises soils developed on reddish brown drifts derived from sandstones and flagstones of Middle Old Red Sandstone age. The parent material, predominantly a till containing a mixture of stones from the John o' Groats Sandstones and the Caithness Flagstones strata, mainly has a sandy clay loam texture, although sandy loam, clay loam and silty loam textures can also occur locally. The reddish colour of the till comes from the red strata of the John o' Groats Sandstones. The clay loam till, which has a redder hue than the sandy clay loam till, is probably derived largely from the finer-textured rocks which occur locally in the John o' Groats Sandstones.

The association covers 29 square kilometres (0.2 per cent of the land area) and is found in the north-east corner of Caithness and on the islands of Stroma and Muckle Skerry. It is also extensive in Orkney (Sheet 1).

The association extends in altitude from sea level up to 60 metres and occurs on non-rocky land with mainly gentle slopes. The average annual rainfall is around 800 millimetres and the association lies in the exposed and very exposed categories of the fairly warm moderately dry climate region.

The soils are predominantly gleys. Most common are the poorly drained peaty

gleys in which the organic surface horizon has been disturbed by cultivation which in some cases has included the addition of shell sand; a black or very dark greyish brown sandy loam A horizon, often with a high organic content, overlies a strongly gleyed, organic-stained sandy loam or sandy clay loam B horizon. The reddish colour of the parent material is usually absent in the upper part of the soil profile. Some shallower soils, with rock at less than 1 metre, are present on slopes. A few small patches of uncultivated peaty gleys occur locally. Noncalcareous gleys are less common and are characterized by reddish brown mottled B horizons lying immediately below the plough layer. Saline gleys are extremely local and have very coarse prismatic or columnar structure in the subsoil, with very high amounts of exchangeable sodium and magnesium throughout the profile.

The plant communities are largely those of grassland. The noncalcareous and cultivated peaty gleys support permanent pastures (*Lolio-Cynosuretum*), soft rush pasture (the *Ranunculus repens*-*Juncus effusus* Community) and sedge mires, and the saline gleys carry sea plantain-crowberry heath (the *Plantago maritima*-*Empetrum nigrum* Community) and vernal squill maritime pasture (the *Scilla verna*-*Festuca rubra* Community).

There are two map units in the Canisbay Association, one, by far the more extensive, of peaty and noncalcareous gleys, the other a unit of saline gleys.

Map unit 79 is a unit of peaty and noncalcareous gleys on non-rocky, gently undulating or level and gently sloping lowland. It covers 27 square kilometres and accounts for 95 per cent of the association.

The dominant soils are poorly drained peaty gleys with surface horizons disturbed by cultivation, although some normal peaty gleys occur locally. Noncalcareous gleys are present mainly in the Auckingill area. The unit includes some small patches (less than 0.5 of a square kilometre) of shallow and deep peat, alluvial soils, peaty podzols of the Canisbay Association, and soils of the Fraserburgh Association.

Land use is largely crofting, with one or two larger farms present. The principal limitations on agriculture are climate, particularly the exposure factor, and wetness.

Map unit 83 comprises saline gleys developed on a clay loam or silty loam till, and it occurs on gently sloping land which is often strongly eroded and bouldery. The unit covers 2 square kilometres (5 per cent of the association) and is only found on Stroma and on Muckle Skerry. Land use is restricted to rough grazings of moderate value, the principal limiting factors being climate (particularly exposure) and soil.

THE CORBY/BOYNDIE/DINET ASSOCIATIONS

(Map units 97-103, 105 and 106)

The soils of the Corby, Boyndie and Dinnet Associations are developed on sands and gravels and have been grouped together on the 1:250 000 soil map.

The fluvioglacial and raised beach sands and gravels of the Corby Association are derived mainly from the acid Moinian granulites and schists. Other rocks, particularly strata of the Old Red Sandstone and granite, are incorporated locally. On the raised beaches of the west coast, the gravel is mostly composed of Lewisian gneiss and Torridonian sandstone. The deposits are often stratified, with lenses and seams of sand, and can be up to tens of metres thick. Texture is

most commonly coarse sand and stone content is very high; the stones are very variable in size and are usually rounded or subrounded. The sand of the Boyndie Association is mainly fluvioglacial in origin and has few or no stones. The parent material of the Dinnet Association is a drift, thought to be a reworked sand and gravel deposit, and it occurs only in Eastern Scotland (Sheet 5).

The associations together cover 725 square kilometres or 4.4 per cent of the land area. The Corby Association is the more extensive, occurring mainly on the Moray Firth Lowlands from Helmsdale to Buckie and also in most of the principal river valleys. The Boyndie Association is extensive only between the River Spey and Nairn.

The associations occur on coastal lowlands and in river valleys; on the coastal lowlands the landform is usually an undulating mounded outwash plain, or less often high raised beaches. Fluvioglacial terraces are most common in river valleys although undulating mounded ground is also found; both these landforms are commonly associated with alluvial deposits in these situations. Steep-sided kames and eskers occur locally on the outwash plains and less frequently in valleys.

The area has a favourable climate—warm or fairly warm and moderately dry with average annual rainfall mainly between 600 and 800 millimetres. In contrast, the much more restricted central and western areas have rainfall totals up to 1800 millimetres and a fairly warm or cool wet climate. Exposure is mainly moderate, but the eastern straths are sheltered and the west coast is exposed.

Strongly leached freely drained soils are most common, with humus-iron podzols most extensive, although peaty podzols, iron podzols and humus podzols are also found. The humus-iron podzols are usually cultivated, except where slope and soil patterns are restricting. A dark grey-brown topsoil (the Ap horizon) of generally 25 to 40 centimetres has resulted from the long history of disturbance of the H, A, E and Bh horizons. Deeper man-made topsoils, over 60 centimetres thick, also occasionally occur. Textures range from loamy sand to fine sandy loam. These Ap horizons have had most of the larger cobbles removed from them and the stony nature of these soils only becomes apparent in the Bs horizon. In some Boyndie soils, the 'Moray Pan'—a dark brown, humus-iron-cemented B horizon—acts as a physical impediment to root development.

The peaty podzols are most common to the east of the Great Glen where they are often freely drained below a weakly laminated fibrous organic horizon which seldom exceeds 15 centimetres in thickness. An iron pan may or may not be present. These soils are generally only found below 300 metres in the east and only occasionally at low altitudes in the north. To the west and north of the Great Glen and on concave sites in the east, the peaty podzols generally have strongly gleyed E horizons because of the presence of a well-developed iron pan. The organic horizon is usually thicker and more decomposed than in the freely drained soils.

Gleys are not common and are confined to basins and channels between mounds. Peat occupies similar sites, but is usually associated with mounds of peaty podzols; the peat is dystrophic with occasional weak flushing.

As a large proportion of the ground is cultivated, permanent and ley pastures (*Lolium-Cynosuretum*) in rotation with arable and root crops are most common, whilst the uncultivated podzols usually support dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) and occasionally dry boreal heather moor (part of *Vaccinio-Ericetum cinereae*). Bent-fescue grassland (*Achilleo-Festucetum tenuifoliae*) frequently occurs in small areas because of burning and grazing pressure. The flushed nature of the uncultivated gleys is reflected in the presence of soft rush pasture (the *Ranunculus repens-Juncus effusus* Community)

and sedge mires. The peaty podzols generally support moist Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) although locally the dry form is present. Lowland and northern blanket bog communities are most common on the peat, although some areas are weakly flushed and support flying bent bog (parts of *Erico-Sphagnetum papilloso*).

There are nine soil map units in the combined Corby/Boyndie/Dinnet Associations: seven, accounting for approximately 90 per cent of the area, are dominated by humus-iron podzols with variable types and amounts of minor soils, and the remaining two are mainly peaty soils and peat.

Map unit 97 is dominated by humus-iron podzols, with some noncalcareous and peaty gleys, and it occurs on non-rocky undulating lowlands, mounds and terraces with mainly gentle slopes. The most common parent material is fluvio-glacial sands and gravels, but raised beach material is present at coastal sites. Fluvio-glacial sand of the Boyndie Association is extensive between Nairn and the River Spey. The unit covers 483 square kilometres (67 per cent of the combined associations). Its greatest extent is in the Moray Firth Lowlands from Inverness to Buckie, with smaller areas, occurring mainly on raised beaches, scattered up the east coast as far as Helmsdale. A few small areas are also present on raised beaches on the west coast; some are too small to show on the 1:250 000 soil map (Plate 6).



Plate 6. *Gruinard Bay, Wester Ross. The raised beach, too small to show on the 1:250 000 soil map, has humus-iron podzols typical of map unit 97 (Corby/Boyndie/Dinnet Associations) on the west coast. In the middle distance, brown forest soils and humus-iron podzols occur on the steep, very rocky slopes (map unit 389, Lochmver Association).*

The unit is predominantly agricultural with free draining cultivated podzols extensive and noncalcareous and peaty gleys restricted to small localized hollows and depressions. Where the gleys have been drained and cultivated they support arable crops, otherwise their vegetation is dominated by soft rush pasture.

Uncultivated soils occur on steep-sided ridges and mounds, but form only small individual areas.

Much of this unit is cultivated or under forestry. The sandy textures give good drainage conditions and general ease of cultivation, but this tends to be offset by the low capacity of the soils to retain moisture and nutrients. In dry years, the sandy soils of the Boyndie Association in particular can suffer from summer drought. Wind erosion is a most serious hazard in spring, before the ground cover of arable crops is established, and re-sowing may be necessary. The problem has increased because of continuous cereal cropping which tends to lessen the organic-matter content of the topsoil and seriously affects soil stability. Where deeper and man-made topsoils exist, such problems are less severe and these areas form the best ground in the unit.

Map unit 98 consists of humus-iron podzols and alluvial soils, and it occurs on fluvioglacial terraces and mounds, and valley floors. Slopes are mainly gentle and strong, but short steep slopes occur at terrace edges. The podzols are developed on fluvioglacial sands and gravels, whereas the alluvial soils occur on the undifferentiated valley floor alluvium. The unit covers 126 square kilometres (17 per cent of the combined associations) and occurs in many of the principal valleys of the area, in particular those of the Spey, Nairn, Lossie, Findhorn, Naver and Halladale. The unit is a complex of *map unit 97* and alluvial soils; valley floor alluvium is flanked by fluvioglacial terraces and mounds. The proportion of the unit which either element occupies is very variable, both from valley to valley and within each valley.

Alluvial soils are described under *map unit 1*. Liability to flooding is the chief limitation on the alluvium; where there is a risk of summer floods, land use is restricted to pasture improvement, but elsewhere, areas with free or imperfect drainage can support arable cultivation. In some areas, the alluvium is very poorly drained and provides only rough grazing of good or moderate value.

The fluvioglacial terraces and mounds are dominantly freely drained and although they are largely cultivated they have the same soil limitations due to coarse texture as *map unit 97*. Some parts are uncultivated, particularly where the ground is strongly undulating and moundy, but these areas are often under coniferous plantations or birchwood.

Map unit 99 consists of humus-iron podzols with some humic gleys, noncalcareous gleys and alluvial soils, and it occurs on raised beach platforms with predominantly gentle slopes. The unit covers only 1 square kilometre (less than 1 per cent of the combined associations) and it is present at Attadale and Achmore on the south side of Loch Carron. This unit is much more extensive further south in Western Scotland (Sheet 4). The unit is similar to *map unit 97* but has a greater proportion of gleys. The podzols are mainly under permanent grassland, with very limited arable and root cropping mainly for use as fodder; the gleys are usually uncultivated, but provide rough grazing of high and moderate value.

Map unit 100 is a unit of humus-iron podzols with some peaty gleys, humic gleys, basin peat and alluvial soils, and it occurs in areas of fluvioglacial mounds including kame and esker complexes; slopes are mainly strong and steep, locally gentle. The unit covers 45 square kilometres (6 per cent of the combined associations) and is present between Loch Ness and the River Findhorn, both on fluvioglacial outwash plains and in river valleys.

The pattern of soils and topography is distinctive; mainly uncultivated humus-iron podzols occur on the mounds and ridges, with the subsidiary gleys, peat and alluvial soils in the weakly flushed basins and channels between. Iron podzols and cultivated podzols are also found, but to a very limited extent.

The gradient, pattern and frequency of slopes all exert a considerable influence on the land use of the unit. On subdued mounds there is some potential for mechanized improvement, but otherwise the steepness and the strongly undulating nature of the terrain limits land use to rough grazing. Apart from isolated areas where Man's influence has improved the moorland vegetation to acid bent-fescue grassland, the grazing is of low value.



Plate 7. *Fluvioglacial terraces at Achnasheen, central Ross-shire. Alluvial soils on the partly afforested lower ground, flanked by older terraces of fluvioglacial sands and gravels with peaty podzols and peat, comprise map unit 102 (Corby/Boyndie/Dinnet Associations). Two map units of the Arkaig Association, both dominated by peaty gleys and peat, occur on the slopes above: map unit 23 on the non-rocky lower slopes and map unit 29 on the higher, moderately rocky ground.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Map unit 101 is dominated by peaty podzols with some humus-iron podzols and peat. It occurs in areas of fluvioglacial mounds, ridges and terraces with gentle to steep slopes. The unit covers 58 square kilometres (8 per cent of the combined associations) and has a scattered distribution, but is most extensive around Lochindorb.

Peaty podzols occur on the strongly and steeply sloping mounds and ridges, with peat in the basins and channels between them. Terrace landforms are less common. Both types of peaty podzol are normally present, but the slope range of the mounds in individual areas determines which type is the more common. Locally peaty gleys and alluvial soils are present. Small areas of this unit occasion-

ally occur within larger areas of *map unit 26*, but are too restricted to display on the soil map.

Topographic and wetness limitations restrict land use to rough grazing, although small, less steep areas are marginally improvable. Grazing values are low.

Map unit 102 consists of flood-plain alluvium flanked by older fluvioglacial terraces and mounds with peat and peaty podzols. The landform is similar to *map unit 98*, with mainly gentle slopes, except on the more mounded ground. The unit covers 10 square kilometres (1 per cent of the combined associations) and only occurs at Balnacra and Achnasheen (Plate 7) in Ross-shire and at Strathy on the north coast of Sutherland.

The alluvial soils can be peaty or mineral. Flood risk limits land use to marginal pasture improvement, soft rush pastures providing moderate rough grazing where wetness limitations preclude improvement. The fluvioglacial terraces are largely peat-covered, and peaty podzols occur on the mounds. Wetness limitations restrict land use to rough grazing; the moorland vegetation provides grazing of only low value.

Map unit 103 is a very varied unit with humus-iron podzols, peaty podzols and noncalcareous, humic and peaty gleys. Basin peat is found in hollows. This unit occurs on slightly rocky raised beach and fluvioglacial platforms, with mainly gentle, but a few strong and steep slopes. The unit covers only 2 square kilometres (less than 1 per cent of the combined associations) but is more extensive further south in Western Scotland (Sheet 4). It is present only at Duirinish and Plockton where it forms the crofting ground. Much of it is cultivated, although permanent and rush pastures are most common because of soil pattern limitations.

Map unit 105 is similar to *map unit 103* in respect of both soils and landform, but is non-rocky and also contains some mineral and peaty alluvial soils. The unit only occurs at Killilan at the head of Loch Long (less than 1 square kilometre, less than 1 per cent of the combined associations), but is much more extensive further south in Western Scotland. The mineral soils are cultivated although mainly under permanent pasture, and the peaty soils provide rough grazing of variable quality.

Map unit 106 resembles *map unit 102*, but is developed on raised beach sands and gravels. The soils are peaty podzols, peaty gleys, peat and peaty alluvial soils, and they occur on a small gently sloping raised beach platform at the head of Loch Long (less than 1 square kilometre, less than 1 per cent of the combined associations). Saline alluvial soils are also present. The ground is generally too wet for extensive pasture improvement and apart from rush pastures and sedge mires, the rough grazing is mostly of low value.

THE COUNTESSWELLS/DALBEATTIE/PRIESTLAW ASSOCIATIONS

(Map units 115–119, 121–123, 125–131, 134–136)

These associations, all comprising soils developed on drifts derived from granite and granitic rocks, have been grouped together on the 1:250 000 soil map. In Northern Scotland, the soils developed on drifts derived from granitic rocks belong to the Countesswells Association.

The drifts are all stony, gritty and have sandy loam to sand textures. Various types of drift occur including till, which is by far the most widespread, on the gently sloping lower ground, moraines in some of the valleys, colluvium on the steep hill and valley sides, and cryogenic material on the mountains.

The association covers 478 square kilometres (2.9 per cent of the land area) and is widely distributed. The most extensive areas occur around Helmsdale and between Rogart and Lairg. Large parts of the Strath Halladale, Carn Chuinneag, Moy and Findhorn intrusions are covered by extensive areas of blanket peat. The association is most extensive in Eastern Scotland (Sheet 5), whilst the Dalbeattie and Priestlaw Associations occur only in the south of Scotland.

The landscape is dominantly non-rocky undulating land between 150 and 450 metres high, and includes Ben Loy, Carn Chuinneag and Ben Rinnes. Average annual rainfall is mainly between 1000 and 1200 millimetres, but rises to 1600 millimetres in the more westerly Carn Chuinneag and Ben Loy areas. A large part of the area is exposed, cool and moderately dry or wet, whilst on the higher ground, very and extremely exposed, cold and very cold, wet climates occur. A small part of the lower ground is moderately exposed, fairly warm and moderately dry.

The soils of the Countesswells Association are very stony, gritty and have sandy loam or loamy sand textures. Peaty soils are most common, with peaty podzols dominant, reflecting the relatively drier climate. Two types of peaty podzol occur: one, on gentle slopes, with a thick strongly gleyed E horizon above a strong iron pan, and the other, on strong slopes, with much less gleying and an incipient iron pan. Induration is usually present in these soils. Peaty gleys are more extensive in the higher rainfall areas. Peat often occurs associated with peaty podzols and peaty gleys and is found mainly on gentle slopes. Above approximately 400 metres, the peat is strongly hagged. Peaty rankers are present in rocky areas. The lowland mineral soils are mainly freely and imperfectly drained brown forest soils and humus-iron podzols; they are often shallow, and some brown rankers and podzolic rankers are found near rock outcrops. On the higher ground the soils are mainly subalpine and alpine podzols, with gleys being confined to channels and depressions. Lithosols are common in rocky areas.

The range of plant communities strongly reflects the dominance of peaty soils, with moorland communities widespread, whereas oroarctic, grassland and woodland communities are very much restricted. Deep peat supports lowland and less often northern blanket bog communities (parts of *Erico-Sphagnetum papillosum*), whilst at higher altitudes, hagged peat is found under terminal phase, northern and upland blanket bog communities (parts of *Erico-Sphagnetum papillosum*) and occasionally mountain blanket bog (*Rhytidadelpho-Sphagnetum fuscum*). On the peaty podzols, moist Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) is most common, although moist boreal heather moor (part of *Vaccinio-Ericetum cinereae*) occurs locally on steep slopes east of the Great Glen. Peaty podzols with strong gleying above an iron pan are generally present under bog heather moor (part of *Narthecio-Ericetum tetralicis*) and this community, along with northern bog heather moor, is dominant on the peaty gleys and shallow peat. Flying bent grassland (part of *Junco squarrosi-Festucetum tenuifoliae*) occurs in local flushed sites. Because of their greater degree of exposure, the peaty rankers usually support the northern forms of bog heather moor and Atlantic heather moor.

The brown forest soils support the richest semi-natural vegetation, which includes bent-fescue grassland (*Achilleo-Festucetum tenuifoliae*), eastern high-

land oakwood and birchwood (*Trientali-Betuletum pendulae*), and herb-rich Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*). Acid bent-fescue grassland occurs also on the uncultivated podzols, although dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) is most common. Occasionally they support dry boreal heather moor (part of *Vaccinio-Ericetum cinereae*) inland and at higher altitudes. Some areas are cultivated and carry pasture communities (*Lolio-Cynosuretum*) with limited arable cropping. The humic and noncalcareous gleys usually occur under soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) or sedge mires.

Alpine azalea-lichen heath (*Alectorio-Callunetum vulgaris*) and fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosi*) are most widespread on the subalpine and alpine podzols, but stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association) is also common, particularly on steep colluvial slopes. The dwarf cudweed snow-bed community (the *Gnaphalium supinum-Nardus stricta* Community) is found on the subalpine and alpine gleys whereas the alpine clubmoss snow-bed (the *Lycopodium alpinum-Nardus stricta* Community) occurs mainly on alpine podzols with gleyed E horizons. The vegetation cover is patchy and very sparse in some areas, particularly at the higher altitudes.

There are eighteen soil map units in the Countesswells Association: ten are dominated by mainly peaty soils and account for 80 per cent of the association, five are mainly mineral soils and cover 15 per cent of the association, whilst units dominated by subalpine and alpine soils account for the remaining 5 per cent.

Map unit 115 is dominated by humus-iron podzols, with some gleys and brown forest soils, developed on till. The ground is gently and strongly sloping. The unit covers 10 square kilometres (2 per cent of the association), the larger areas occurring at Achentoul and Helmsdale, with smaller areas at Lairg and near Dufftown. Most of the unit is non-rocky, although slightly rocky areas do occur, particularly at Lairg. Bouldery areas are also occasionally present. This is a very extensive unit in Eastern Scotland (Sheet 5), particularly in Aberdeenshire.

Many of the podzols have been reclaimed from peaty podzols, particularly in the Achentoul area, the very dark humose topsoils and the frequent occurrences of chips of iron pan being evidence of this. Brown forest soils are comparatively unimportant, except in the Lairg area where the parent material is more base-rich and derived from granodiorites.

The current land use in the different areas is largely determined by differing climatic conditions. At Achentoul, the climate limits agricultural practice to pasture improvement, whereas at Helmsdale the lower altitude and rainfall enables a rather restricted rotational ley system of farming to be carried out.

Map unit 116 consists mainly of peaty gleys and it occurs on non-rocky undulating lowlands and foothills with straight or concave, gentle and strong slopes. The soils are developed on till, which can be shallow at higher altitudes. The unit covers only 1 square kilometre (less than 1 per cent of the association) and occurs to the south of Darnaway Forest. Like *map unit 115* it is much more extensive in Eastern Scotland (Sheet 5). Owing to wetness limitations causing severe trafficability problems, the unit is only marginally suitable for pasture improvement. At present, much of the land is under forestry.

Map unit 117 comprises peaty podzols with some peaty gleys and peat, and is developed on till. It occurs on non-rocky hill and valley sides with gentle to steep

slopes. The unit covers 19 square kilometres (4 per cent of the association), the largest areas occurring at Achentoul and Lothmore (Plate 8). Like the previous two map units, this unit is much more extensive in Eastern Scotland.

The altitude range is mainly 150 to 400 metres. The two types of peaty podzol are present and dominate the unit, with peaty gleys, humic gleys and peat found in occasional flushes. These are very conspicuous, as the *Juncus* and *Sphagnum* species stand out in sharp contrast to the dark *Calluna*-dominant hill sides. Peat also occurs in small patches on gently sloping ridge tops.

The present land use is primarily grouse-moor and rough grazing. Pasture improvement is marginally feasible up to an altitude of approximately 250 metres, the main limitation being soil wetness; above this, the climate limits land use to rough grazing, with low grazing values because of the predominance of moorland plant communities.



Plate 8. Hills south of Helmsdale, east Sutherland, illustrating two map units of the Countesswells/Dalbeattie/Priestlaw Associations. On the higher ground is map unit 117, dominantly peaty podzols, supporting Atlantic heather moor. Map unit 125, humus-iron podzols with some brown forest soils, occurs on the lower ground under bent-fescue grassland, broom and gorse scrub and woodland. Aerofilms.

Map unit 118 consists of peaty podzols and peat with some peaty gleys, developed on till, and it occurs on non-rocky undulating hills and hill sides with gentle and strong slopes. It is the most extensive unit in the association, covering 231 square kilometres (48 per cent of the association). The largest occurrences are in the Strath of Kildonan and the Rogart area, but numerous smaller areas are found in western Caithness and on the lower slopes of Ben Rinnes.

The landscape is gently undulating, although the unit does occasionally occur

on distinct hill slopes. Deep peat generally occupies level or very gently sloping sites, whilst peaty podzols are present mainly on strong slopes. In most areas, the deep peat occurs on flats between peaty podzol slopes, but to the north of the Strath of Kildonan, the peat also occurs on higher ground above areas of peaty podzols. Northern blanket bog becomes more widespread in these situations. Although the unit is non-rocky, the topography is strongly rock-controlled. This is particularly evident in the area north of Strath Fleet where small areas similar to *map unit 127* are quite common.

The land use is mainly poor rough grazing, or given over to sporting interests. However, below 200 to 250 metres, the peaty podzol element of the unit is marginally suitable for reclamation; above this altitude, climatic factors limit land use to rough grazing, which is of low value owing to the dominance of moorland vegetation.

Map unit 119 comprises peaty gleys and shallow peat with some deep peat and peaty podzols, and it occurs on gently undulating, non-rocky hill sides and hills with gentle and strong slopes (Fig. 6). The soils are developed on till. The unit covers 36 square kilometres (8 per cent of the association) and is most extensive in the Carn Chuinneag and Inchbae areas. Peaty gleys and shallow peat are co-dominant, and only where there are short steeper slopes or more gently sloping areas, do peaty podzols and deep peat respectively become locally important. The two principal soils are usually intimately associated. Some humic gleys under soft rush pasture occur on flushed slopes to the south-west of Inchbae Lodge.

Because of climatic limitations, most of the unit is utilized as rough grazing and only at lower elevations, particularly at Loch Loyal, does any marginally reclaimable land occur. Some of the Inchbae area has been afforested. Grazing values are generally low.

Map unit 121 consists of brown forest soils, humus-iron podzols and rankers with some gleys and basin peat, and it occurs on slightly and moderately rocky valley sides and undulating lowlands. The soils are developed on till and shallow drift. Slopes are mainly gentle and strong, but some short steep and very steep slopes also occur. The unit covers 38 square kilometres (8 per cent of the association) and almost all of it occurs in the Rogart area.

Significantly, brown forest soils are widespread in this unit and are directly related to the more basic rocks which occur in the Rogart area. These rocks, comprising granodiorite and diorite, are richer in ferromagnesian minerals, particularly hornblende, than most other granitic rocks, and their derived drifts are correspondingly more base-rich.

This is a very varied unit, but the basic pattern is one of freely drained brown forest soils and brown rankers on the strong, often bouldery, lower slopes, and freely and imperfectly drained humus-iron podzols and podzolic rankers on the higher gentle slopes. Associated particularly with the podzols are frequent channels of flushed peaty gleys, humic gleys and peat. Larger basins of peat and very poorly drained lacustrine alluvial deposits also occur on the lower ground. Short, steep, craggy slopes similar to those of *map unit 125* are scattered throughout the unit, whilst on the lower ground small areas similar to *map unit 122* are found.

Although there are numerous small non-rocky areas, usually of brown forest soils where arable cropping is possible, most of the unit is too rocky and bouldery and agricultural practice is generally restricted to grassland improvement. Some

areas are too rough even for this and provide rough grazing of high value on the grassy slopes and low value on the moorland plant communities.

Map unit 122 is a unit of freely drained humus-iron podzols and brown forest soils with some peaty gleys and peat, developed on hummocky valley moraine, the surface of which is often bouldery. The freely drained soils occur on the moraine mounds, with the gleys and peat in the flushed channels between them. It is a very restricted unit (less than 1 square kilometre, less than 1 per cent of the association) and it occurs only in Glen Diebidale, to the immediate west of Carn Chuinneag. It occupies the valley bottom and lower valley sides with gentle and strong overall slopes, but with some short steep slopes on individual mounds. The overriding climatic limitation restricts land use to rough grazing. A mosaic of good grazing on the grassland and poor grazing on the moorland plant communities gives an overall moderate grazing value.

Map unit 123 consists of peaty podzols and deep peat, with some peaty gleys and shallow peat, and is developed on valley moraine (Fig. 7). Slopes are mainly gentle and strong. The unit covers 22 square kilometres (5 per cent of the association) and has a scattered distribution; the largest area occurs at Inchbae in Easter Ross. This unit is very extensive in Western Scotland (Sheet 4).

Peaty podzols with strong gleying above an iron pan occur on the moraine mounds, with deep peat between. The proportion of each is variable, but the moraines are rarely contiguous as in some other associations, and deep peat is always an important element. Except where the moundiness is subdued, shallow peat and peaty gleys are much less common. In the Inchbae area, the mounds have a very bouldery surface and occasionally are rock-cored.

This boulderiness excludes the possibility of pasture improvement, but the other areas, to the south of the Dornoch Firth and at Achentoul, are non-bouldery and are marginally suited for improvement.

Map unit 125 is a unit of humus-iron podzols with some brown forest soils, gleys and rankers occurring on non- to moderately rocky hill and valley sides with strong to very steep slopes. The parent material is colluvium. Extending to 19 square kilometres (4 per cent of the association), the unit is widely scattered, although the two largest areas are found near Helmsdale.

The humus-iron podzols dominate, with gleys occurring in flush sites. Although most slopes are moderately rocky, some are non-rocky (Plate 8) or slightly rocky; they are usually bouldery to some extent however. In the lower part of the Strath of Kildonan, small areas of alluvium and river terraces are included in the unit.

Although slopes up to 25 degrees can be marginally suitable for pasture improvement, rockiness and boulderiness are limiting and these slopes may be better utilized as rough grazing with moderate and high grazing values.

Map unit 126 is dominated by peaty podzols and humus-iron podzols with minor areas of peat, gleys and rankers, and it occurs on slightly and moderately rocky hills and valley sides with strong and steep slopes. The soils are developed on a shallow drift. The unit covers 11 square kilometres (2 per cent of the association) and occurs only in the low rainfall area east of the Great Glen, particularly around Loch Moy; the dominance of podzols and boreal heather moor is a reflection of the dry, less oceanic climate of the area.

Rockiness, wetness limitations and the complex pattern of slopes limits land

use to rough grazing of low value, although limited reclamation may be possible locally where rock outcrops are few. However, the unit has proved to be successful for timber production, particularly where humus-iron podzols are more abundant and organic horizons are not too deep.

Map unit 127 consists of peaty gleys and peat with some peaty podzols and peaty rankers, and it occurs on moderately rocky, hilly and undulating land with gentle and strong slopes (Fig. 8). The soils are developed on till and shallow drift. The unit covers 56 square kilometres (12 per cent of the association) and is most common around Carn Chuinneag (Plate 9) and in the Loch Borrallan–Loch Ailsh area.



Plate 9. Moderately rocky land near Carn Chuinneag, central Ross-shire. The soils belong to map unit 127 of the Countesswells/Dalbeattie/Priestlaw Associations and comprise peaty gleys and peat with some peaty rankers and peaty podzols. Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

The unit occurs in similar positions in the landscape to *map units 117–119*, the presence and abundance of outcropping rock being the essential difference. Deep peat occurs on the gently sloping ground and is often extensive, whilst the peaty gleys, shallow peat and peaty rankers occur in the more undulating rocky areas. Peaty podzols are rare in the larger areas, but in more easterly localities such as Helmsdale and Forsinard they become locally dominant. Above 450 metres in the Carn Chuinneag area, subalpine podzols occur on exposed rocky knolls. The slopes to the north-west of Loch Morie are very bouldery and there is considerably less peat on them. Small very rocky areas are scattered throughout the unit.

Land use is restricted to rough grazing because of wetness and topographic limitations; the moorland plant communities have low grazing values.

Map unit 128 comprises mainly brown rankers and brown forest soils with some

humus-iron podzols on the upper slopes and occasionally on gently sloping ledges. Some of the brown forest soils are also weakly podzolized. Slopes are mainly strong and steep and the associated parent material is a stony colluvium. Scree is found on some parts of the slope. The unit covers 3 square kilometres (less than 1 per cent of the association) and only occurs on a very rocky slope at the northern end of Loch Ness. Limitations imposed by slope and rockiness restrict land use to rough grazing, the plant communities having moderate grazing values.

Map unit 129 is similar to *map unit 126* but because of the moderately and very rocky nature of the terrain, lithosols and rankers, in addition to the peaty podzols and humus-iron podzols, are also important components. Minor soils include peaty gleys and peat and, at higher altitudes, subalpine podzols. The landform consists of hills and valley sides with mainly strong and steep slopes; scree is present in minor amounts on parts of the slopes. The parent material is a shallow drift, often overlain by shallow colluvium. The unit covers 2 square kilometres (less than 1 per cent of the association) and occurs in only one locality, to the west of Loch Moy.

Rockiness, soil shallowness and stoniness, the complex pattern of slopes and the wet organic surface horizons limit land use to rough grazing. Grazing is mainly poor although small patches of heath rush-fescue grassland provide restricted moderate grazing. Small, extremely rocky areas have little agricultural value. Although forestry is feasible, considerable problems involved with establishment and extraction rule it out as an economic viability.

Map unit 130 consists of peaty podzols, peaty gleys and some shallow peat, and it is found only on a non-rocky hill side on the south side of the Strath of Kildonan, where it covers 2 square kilometres (less than 1 per cent of the association). Slopes are steep and very steep, and the parent material is colluvium. Both types of peaty podzol are common, with peaty gleys and occasionally shallow peat on concave slopes. Slope and wetness limitations restrict land use to rough grazing and the moorland plant communities have low grazing values.

Map unit 131 is similar to *map unit 130*, but is rocky, and consists of peaty gleys, peaty rankers and peaty podzols developed on colluvium. The unit occurs on moderately and very rocky hill sides with steep and very steep slopes, and covers 7 square kilometres (1 per cent of the association). It is found only in the Loch Loyal area of Sutherland. The gleys are most common and occur on weakly flushed, concave slopes, whilst the podzols are found on unflushed, straight or convex slopes. Land use is restricted to rough grazing of low value by slope and wetness limitations and by the predominance of moorland plant communities.

Map unit 134 consists of subalpine podzols, with some noncalcareous regosols, alpine soils, rankers, lithosols and gleys. It occurs on non- to very rocky mountain summits and slopes and has a wide slope range. The soils are developed on cryogenic material on the gentle and strong slopes, and on colluvium on the steep and very steep slopes. The unit covers 17 square kilometres (4 per cent of the association) and it occurs on Ben Loyal and Carn Chuinneag.

Most of the ground lies above 500 metres, although on Ben Loyal the northern crags below this level have been included. Apart from these precipitous very rocky slopes, where lithosols are dominant, much of the ground is strongly or steeply sloping with subalpine podzols most common. Very bouldery ground dominated by regosols and lithosols is extensive on Carn Chuinneag. The rockiness is very

variable—on the summit of Ben Loyal, there are frequent, large, non-rocky, non-bouldery areas separated by tors.

Most of the unit has little or no agricultural value because of the overriding extremely severe climate, and even below approximately 600 metres, land use is restricted by the plant communities present to low-quality rough grazing.

Map unit 135 is a unit of deep peat and subalpine podzols, and it occurs on the non-rocky, slightly bouldery, gently sloping summit of Beinn Mhealaich, west of Helmsdale. The podzols are developed on cryogenic material. This unit covers only 1 square kilometre (less than 1 per cent of the association), but is much more extensive in the Highlands further south. This area differs from most units of deep peat and subalpine podzols in other associations, as it is non-rocky and the peat is only occasionally hagged. Land use is restricted to rough grazing of low value by limitations imposed by climate, wetness and soil.

Map unit 136 is dominated by alpine podzols with minor areas of rankers, peat, gleys and subalpine podzols. The unit covers only 3 square kilometres (less than 1 per cent of the association), and it occurs on the non- and slightly rocky summit plateau and upper slopes of Ben Rinnes. Slopes are mainly gentle and strong and the soils are developed on shallow cryogenic material.

The unit has an altitude range of 500 to 850 metres and the extreme climate at these levels is the overriding physical limitation to agriculture. Above about 650 metres, the unit has little agricultural value because of the extremely short growing season and the very patchy nature of the vegetation cover. Below this altitude, which is variable due to local aspect and exposure, rough grazing of low value is the dominant land use although the upland grasslands do provide valuable moderate grazing for a few months in summer.

THE CRAIGELLACHIE/POLFADEN ASSOCIATIONS

(Map unit 140)

The Craigellachie and Polfaden Associations both include soils developed on fluvioglacial silts and clays, and have been grouped together on the 1:250 000 soil map. There is only one map unit and its description is included with that of the associations.

The parent material of the Craigellachie Association comprises compact fluvioglacial silt with some silty clay and clay, and the deposits also include a few thin bands and lenses of sandy or gravelly material. That of the Polfaden Association consists of lacustrine silts and clays. Both associations contain small patches of fluvioglacial gravels and sands (the Corby and Boyndie Associations) and the Craigellachie Association includes, in addition, some patches of till (of the Aberlour Association).

The two associations, which together cover 12 square kilometres (less than 0.1 per cent of the land area) are geographically distinct. The Craigellachie Association occurs mainly between Charlestown of Aberlour and Craigellachie on a non-rocky, gently sloping terrace above the River Spey at an altitude of 100 to 200 metres, and there is also a small area of it a few kilometres to the south of Elgin. This association has an average annual rainfall of less than 900 millimetres and a sheltered fairly warm, moderately dry climate.

The Polfaden Association is present in one small area to the east of Inverness on non-rocky, gently undulating land at an altitude of below 50 metres. It lies in

the sheltered, warm, moderately dry climate region and the average annual rainfall is below 700 millimetres.

The dominant soils of both associations are humus-iron podzols, mostly cultivated, with some mainly noncalcareous gleys. The podzols in the Craigellachie Association are mostly imperfectly drained, whereas both freely and imperfectly drained podzols are present in the Polfaden Association, the freely drained soils often having deep man-made topsoils of 40 centimetres or more.

Most of the land is cultivated. Arable and permanent pastures (*Lolium-Cynosuretum*) are the main plant communities, with soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires locally present in wet hollows.

THE CROMARTY/KINDEACE ASSOCIATIONS

(Map units 144–146)

The Cromarty and the Kindeace Associations, both comprising soils developed on drifts derived from Middle and Upper Old Red Sandstone strata, have been grouped together on the 1:250 000 soil map.

The parent material in the Cromarty Association is a compact reddish brown till with a sandy loam, loam or sandy clay loam texture, sometimes overlain by a thin veneer, up to 30 or 40 centimetres thick, of coarser-textured material which is mostly incorporated with the Ap horizon where the soil has been ploughed. That of the Kindeace Association comprises a thicker layer, often 1 metre or more, of coarser-textured morainic or partially water-sorted material overlying till of the Cromarty type. Some colluvium occurs locally.

The associations together cover 242 square kilometres or 1.5 per cent of the land area and their distribution is restricted to the Moray Firth Lowlands and the foothills of the Grampian Highlands, from Easter Ross to the River Spey. The altitude ranges from sea level to 220 metres and slopes are gentle and strong. The average annual rainfall is between 600 and 900 millimetres and the climate is moderately exposed, warm, moderately dry and fairly warm, moderately dry.

The soils of the Cromarty/Kindeace Associations are mostly cultivated and predominantly freely and imperfectly drained humus-iron podzols with some noncalcareous, humic and peaty gleys and some peaty podzols and dystrophic peat occurring locally. The podzols developed on the Cromarty-type till have sandy loam, loam or sandy clay loam textures, the clay contents being within the range of 10 to 25 per cent and increasing only slightly with depth. The soils are moderately stony, the stones largely being composed of sandstone. A compact or indurated B horizon is present at less than 20 centimetres from the surface in the higher parts of the Black Isle, although elsewhere within the association such horizons usually occur at greater depths, often below 50 centimetres. The podzols on the Kindeace-type parent material have sandy loam or loam Ap horizons, but the B horizons are usually loamy sand or sandy loam, and the underlying C horizons normally sandy loam. These soils tend to be stonier than the podzols developed on the compact till, many of the stones being derived from the acid Moine schists.

Most of the land is cultivated, and arable and permanent pastures (*Lolium-Cynosuretum*) are widespread. Soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires occur on some of the gleys on the lower ground, with bog heather moor and northern bog heather moor (*Narthecio-*

Ericetum tetralicis) on the peaty gleys of the higher ground, and lowland blanket bog (part of *Erico-Sphagnetum papilloso*) present on the peat.

There are three map units: two are dominated by humus-iron podzols and account for 91 per cent of the combined associations, and the third is a unit of gleys.

Map unit 144 comprises humus-iron podzols with some gleys, and it occurs on undulating lowlands and foothills with mainly gentle but locally strong slopes. The parent material is mostly the compact reddish brown till of the Cromarty Association, although on some of the low hills the shallow Kindeace-type drift occurs, overlying soft red sandstone. The map unit occupies 63 square kilometres (26 per cent of the combined associations) and it occurs mainly in the eastern part of Easter Ross.

Imperfectly drained podzols are the most common soils, with freely drained podzols present on shedding sites and on steeper slopes. Noncalcareous gleys have a very limited extent. Some of the podzols have deep topsoils and form the best agricultural soils in Easter Ross.

Apart from a few areas of higher ground the land in this map unit is mostly cultivated. Soil shallowness due to the presence of a compact or an indurated horizon, together with climate, are the two main factors affecting the agricultural capability of the land.

Map unit 145 consists of humus-iron podzols with some gleys, and it is found on undulating lowlands and foothills with gentle and strong slopes. The parent material comprises the water-sorted or morainic drift of the Kindeace Association which overlies till of the Cromarty type. The map unit covers 158 square kilometres (65 per cent of the combined associations) and it occurs in Easter Ross and to the south of the Moray Firth, its main expression being on the slopes of the foothills of the Grampian Highlands.

The humus-iron podzols are mostly imperfectly drained and have mottled horizons overlying either a compact or an indurated horizon. Freely drained podzols are restricted to shedding sites, often on ridges. Locally, peaty and non-calcareous gleys occur in hollows and receiving sites, and peaty podzols can be present on the higher ground.

Much of the land in this unit is cultivated, but there are substantial areas under forestry, and some uncultivated land is present in Easter Ross and on Drummoisie Muir near Inverness. The main limitations affecting the agricultural capability of the land are stoniness and shallowness, the latter being due mainly to the presence of an underlying indurated horizon.

Map unit 146 comprises noncalcareous gleys and peaty gleys with some humic gleys and peat, and it is found in hollows and receiving sites in undulating lowlands and foothills. Slopes are mainly gentle, rarely strong. The parent materials include the reddish brown compact till, the coarser-textured drift, and colluvium.

The map unit covers 21 square kilometres (9 per cent of the combined associations). In Easter Ross it occupies three small, mostly cultivated, areas of noncalcareous gleys, whereas to the south of the Moray Firth it occurs in three larger, mainly uncultivated, areas dominated by peaty gleys. The large area to the south-west of Forres is mostly afforested.

Wetness and climate are the main limiting factors affecting the use of the land for agriculture.

THE DULSIE ASSOCIATION

(Map units 172-175)

The Dulsie Association consists of soils developed on rudely stratified gravelly loamy sands and sandy loams derived mainly from acid schists of the Moinian, but occasionally with a minor content derived from granite.

Though the Dulsie Association is obviously related to associations developed on fluvioglacial materials, for example, the Corby Association, its degree of sorting and bedding is not as clearly defined. This poor grading is reflected by a consistently higher content, 20 to 25 per cent, of silt (2 to 50 μm) throughout the profile, compared with the combined silt and clay fractions in fluvioglacial sands and gravels where 2 to 5 per cent is normal. Usually the parent material of the Dulsie Association forms a veneer, 1 to 4 metres thick, overlying the local till or rock. Over much of the peneplain to the south of Nairn and covered by blanket peat, this parent material is frequently sandwiched between a schist-derived till (the Arkaig Association) and an overlying mantle, 1 to 2 metres thick, of fluvioglacial sands and gravels belonging to the Corby Association. It is probable that the Dulsie parent material has resulted from the penultimate stage of deglaciation and that the deposition was englacial.

Covering 96 square kilometres (0.6 per cent of the land area) the association occurs mainly in the Grampian Highlands between Lochindorb and Drummosie Muir and less frequently on the Moray Firth Lowlands to the north. Only one small area, to the south of Beauly, is present to the west of the Great Glen. The altitude ranges from 30 metres above sea level to approximately 450 metres. Below about 250 metres, the landform is mainly non-rocky, undulating lowlands and hills with gentle and strong slopes. On the higher ground the landform is more commonly a hummocky moraine though not necessarily confined to the valleys. Average annual rainfall varies from 800 millimetres in the warm moderately dry lowlands to over 1100 millimetres in the cold wet foothills and uplands of the Grampian Highlands. The lower ground is mainly moderately exposed and the higher ground exposed.

The soils are dominated by humus-iron podzols and peaty podzols, frequently with an iron pan; they are mainly freely drained. A strongly indurated B horizon, displaying a well-developed platy structure is characteristic. Usually the horizon is about 50 centimetres thick. Small rounded bluish grey stones, generally less than 5 centimetres, constitute a large proportion of the stone content. Prominent silty or fine sandy caps on the stones, together with a well-developed fine pore system, are common in the C horizon. The colour of the parent material is typically a pale brown. Peaty surface-water and ground-water gleys are less common, and minor areas of humic gleys are associated with flushed sites.

Arable and permanent pastures (*Lolio-Cynosuretum*) are widespread in the cultivated areas of the lowlands and fringing foothills. Soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires occur on some of the gleys on the low ground. The greater part of the association, however, is dominated by dry and moist boreal heather moors (parts of *Vaccinio-Ericetum cinereae*) on the humus-iron podzols and peaty podzols with bog heather moor (part of *Narthecio-Ericetum tetralicis*) on the peaty gleys and peaty podzols of the higher slopes and summits. Blanket bog communities (*Erico-Sphagnetum papilloso*) accompany the peat deposits. Many dry slopes on the foothills are afforested by Scots pine, with Sitka and Norway spruce on the restricted wetter ground.

There are four map units. One (30 per cent of the association) is dominated by humus-iron podzols, the other three by peaty soils and peat.

Map unit 172 is a unit of mainly humus-iron podzols. Minor soil components include some gleys and peaty podzols. The unit covers 27 square kilometres (30 per cent of the association) and is developed in a highly water-worked drift.

With a scattered distribution, areas are found mainly at the junction of the undulating lowlands with the foothills of the adjacent '300-metre peneplain', for example near Cawdor, the Divie and Dorback confluence and west of The Aird. Slopes are usually gentle and strong.

On the lower slopes, land use is mainly long-ley grassland with a limited arable rotation. With increasing altitude, climatic limitations become more significant and arable rotations normally cease around 250 metres. Above this altitude rough grazing, grouse-moor and forestry are the dominant land uses.

Map unit 173, consisting of peaty podzols with some peaty gleys and humus-iron podzols, occurs on hill and valley sides with gentle and strong slopes. It is a minor unit which covers only 3 square kilometres (less than 5 per cent of the association) and is found in the Findhorn catchment area near Ferness. Larger areas exist to the south in Eastern Scotland (Sheet 5) within the Spey and Dulnain valleys.

Occurring mainly on convex or straight slopes, the unit is developed on a highly water-worked drift which is normally 2 or 3 metres thick and overlies either the local schist-derived till or bed-rock. An iron pan and induration are widespread.

Most of the area is planted to Scots pine, with much natural regeneration on the surrounding grouse-moors in the south where burning has been restricted in recent years. Grassland reclamation would be possible on much of the land, especially if the iron pan were disrupted by tine-ploughing

Map unit 174 consists of peaty gleys and shallow peat, and it occurs near Daviot on a hill side with gentle and steep slopes. It covers only 3 square kilometres (less than 5 per cent of the association) although other areas, too small to map at the 1:250 000 scale, are distributed sporadically across the junction of the lowlands and the adjacent foothills.

The peaty gleys are developed on a highly water-worked drift although they are often underlain by a schist-derived till at a depth of 2 metres or more. Situated on northern and north-western slopes, below a series of spring lines, the soils are subjected to surface-water gleying induced by the impermeable and strongly indurated B horizon. Additional problems are associated with the fluctuating ground-water table when the subsoils are disturbed; thixotropic conditions are created readily in a waterlogged subsoil due to the high content of uniformly sized silt particles.

Grassland improvement is feasible, but rough grazing is the primary agricultural land use. Deep organic surface horizons, induration and surface wetness are the main limitations. Much of the area is planted with lodgepole pine and Sitka spruce.

Map unit 175 consists of peaty podzols and occurs mainly as hummocky moraine, but also as a veneer of highly water-worked drift overlying the local till or bed-rock. The podzols include those with a strongly gleyed horizon above an iron pan and those which are imperfectly drained throughout the profile.

Covering 63 square kilometres (65 per cent of the association), it is situated on

the foothills and uplands to the south of Nairn. The unit occurs usually on the valley floors and the lower slopes, but also on gentle, convex, upper slopes and summits.

On the lower flanks, there is substantial afforestation, namely Scots pine and lodgepole pine, as well as a few limited areas of permanent pasture. Much of the lower ground is only marginally suited to grassland reclamation because of the thickness of the organic horizons, especially in the hollows. The remainder of the area is devoted to grouse-moors and rough grazing. Climate, complex local topography and thickness of organic horizons are the primary limiting factors.

THE DUNNET ASSOCIATION

(Map unit 176)

The soils of the Dunnet Association are developed on parent materials derived from the Upper Old Red Sandstone Dunnet Sandstones. The predominant type of parent material is friable weathered yellowish sandstone which breaks down readily into material of sand texture, although in some places hard rock is present at or near the surface. Drift is thin or absent.

The association occurs only at Dunnet Head in Caithness, where it covers 13 square kilometres (less than 0.1 per cent of the land area). It is, however, extensive on the island of Hoy in Orkney. As there is only one map unit in this association its description has been combined with that of the association.

Dunnet Head is a headland with steep cliffs mainly 50 to 70 metres high but in some places up to 120 metres. The landscape is undulating, partly stepped, and consists of mainly non-rocky, level or gently sloping land with some strong or occasionally steep slopes which are often slightly rocky and form narrow escarpments. The average annual rainfall is 700–800 millimetres and the headland lies in the very exposed category of the cool, moderately dry climate region.

The soils of the Dunnet Association consist of peaty podzols and dystrophic peat, with some peaty rankers. The peaty podzols are strongly gleyed above a well-defined iron pan, and dark organic staining is often present immediately above the pan. They are developed on the friable sandstones, have sand and loamy sand textures, and occur on the strong and steep slopes. The peaty rankers are present on outcrops of harder rock. Shallow peat, often with well-developed coarse vertical cracks, is found associated with the peaty podzols. The most extensive soil is deep peat which occurs on the level and gently sloping land; where it has been cut for fuel peaty gleys and shallow peat can be present.

The plant communities are dominantly those of moorland. The peaty podzols, peaty rankers and shallow peat support northern Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) and the extensive areas of deep peat carry lowland and northern blanket bog communities (parts of *Erico-Sphagnetum papillosum*). Some alpine azalea-lichen heath (*Alectorio-Callunetum vulgare*) occurs on peaty rankers on the exposed tops of the higher ground such as Dunnet Hill.

The agricultural capability of this map unit is restricted to rough grazings mainly by the severe wetness limitations of the extensive areas of deep peat. The moorland plant communities provide only low-quality grazings.

THE DURNHILL ASSOCIATION

(Map units 181, 182, 184–186, 188, 190–194)

The Durnhill Association consists of soils developed on drifts derived from quartzites and quartzose grits. These drifts comprise till, moraine, colluvium and cryogenic material; all are stony, pale-coloured and have loamy sand or sandy loam textures although some of the till in the Keith district has a texture of sandy clay loam.

The association covers 464 square kilometres (2.8 per cent of the land area) and it occurs in three main areas. The most extensive area is associated with the narrow belt of Cambrian quartzites lying immediately to the west of the Moine Thrust and extending from Loch Eriboll in the north to Loch Kishorn in the south. It ranges from sea level to over 1000 metres and includes a number of distinctive landforms, most of which are rocky. The average annual rainfall is 1600–3200 millimetres and most of this area lies in the exposed and very exposed categories of the cool and wet climate region, with some in the cold and very cold regions.

A much smaller area lies mainly in south-west Caithness, associated with the Moinian quartzites. The altitude ranges from 220 to 626 metres, the rainfall is about 1200 millimetres and the area lies mainly in the very exposed cold and very cold, wet climate regions.

The third area is in the district around Keith on the Dalradian quartzites. It lies between sea level and 720 metres, has a lower rainfall (700–1200 millimetres) than that of the other two areas, and a range of climate regions from warm and moderately dry at the coast to cold and wet on the highest hills, most of the area lying in the moderately exposed category.

The soils of the Durnhill Association have loamy sand or sandy loam textures and an inherently low fertility. Peaty podzols and peaty gleys are the most extensive soils. The peaty podzols have a strongly gleyed E horizon above an iron pan and an indurated B horizon is present in some of the peaty podzols and peaty gleys. Peaty rankers occur in the rockier areas, and shallow and deep dystrophic peat are widespread. Subalpine and alpine soils—mainly podzols with some gleys—together with noncalcareous regosols and lithosols occur extensively on the higher ground, above about 400 metres. Brown forest soils, humus-iron podzols, noncalcareous gleys and humic gleys occur on the lower ground but are not extensive.

The vegetation consists mainly of moorland communities. In the western area and in Caithness, bog heather moor and northern bog heather moor (*Narthecio-Ericetum tetralicis*) are extensive, occurring on the peaty podzols, peaty gleys, peaty rankers and shallow peat, and lowland and northern blanket bogs, and at higher levels, upland blanket bog (parts of *Erico-Sphagnetum papillosum*) and mountain blanket bog (*Rhytidiadelpho-Sphagnetum fuscum*) are the communities present on the deep peat. Some moist and northern Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*) can also occur on the peaty podzols and peaty rankers. In the drier eastern area of the association, dry and moist boreal heather moors (parts of *Vaccinio-Ericetum cinereae*) form the dominant communities on the peaty podzols and humus-iron podzols.

The subalpine and alpine soils of the higher ground largely carry mountain heaths such as alpine azalea-lichen heath (*Alectorio-Callunetum vulgaris*) and fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosum*) although the plant cover is usually very patchy and there is much bare ground. Other communities which can be present include stiff sedge-fescue grassland (the *Carex*

bigelowii-*Festuca vivipara* Association) and lichen-rich boreal heather moor (part of *Vaccinio-Ericetum cinereae*).

Grassland communities are much less common than the moorlands and comprise acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) on the brown forest soils, soft rush pasture (the *Ranunculus repens-juncus effusus* Community) and sedge mires on noncalcareous gleys and very locally on peaty gleys, and arable and permanent pastures (*Lolio-Cynosuretum*) on cultivated soils. Some woodland, comprising oak and birchwood, is also present.

The association contains eleven map units: six of them (65 per cent of the association), are dominated by peaty soils and peat, two (32 per cent of the association) comprise subalpine and alpine soils, and one (less than 1 per cent of the association) is a unit of mineral soils. The remaining map units comprise one of mineral and peaty soils and another of peat and subalpine soils.

Map unit 181 consists of noncalcareous gleys with some peaty gleys, humic gleys and peat. It occurs in the lowlands and foothills on non-rocky, mainly concave gentle and strong slopes in receiving sites, often around the headwaters of streams. The main parent material is a stony grey loamy sand to sandy clay loam till.

The map unit covers 6 square kilometres (1 per cent of the association) and it occurs mainly on The Balloch and on Millstone Hill near Keith, and in a small area on the eastern slopes of Ben Aigan near Rothes. The soils are weakly structured and the topsoils of the noncalcareous gleys have a dark colour.

The land is used for permanent pasture and rough grazing, the limitations affecting the agricultural capability being soil wetness and climate.

Map unit 182 comprises peaty podzols with some freely and imperfectly drained humus-iron podzols and some gleys. It occurs on hills, undulating lowlands and valley sides, the slopes being gentle to steep and mainly non-rocky. The soils are developed on very stony thin drifts of loamy sand or sandy loam texture, and on thicker stony sandy loam or loamy sand till. Near Findochty the till has a pinkish colour, probably due to the inclusion of Old Red Sandstone material, and a coarse-textured, water-sorted upper layer containing many rounded quartzite stones. The map unit covers 81 square kilometres (17 per cent of the association) and it occurs mainly in the Portknockie-Millstone Hill-The Balloch area and on Ben Aigan.

Many of the soils in the Findochty area and on the southern side of Millstone Hill are cultivated, but often have very dark topsoils. The gleys are restricted to receiving sites on concave slopes. Subalpine soils occur on the top of Ben Aigan.

The land is used for rough grazing, forestry and arable agriculture, and spans a wide range of capability classes. The main limiting factors are stoniness, slope and climate, together with an inherently low soil fertility due to the very low nutrient content of the parent materials.

Map unit 184 comprises peaty gleys, shallow peat and deep peat on non-rocky hill sides with gentle and strong slopes (Fig. 6). The soils are developed on till. The map unit covers 6 square kilometres (1 per cent of the association) and it occurs near Loch Eriboll on the north coast of Sutherland and on the lower slopes of Beinn Eighe near Kinlochewe.

Land use is rough grazing, the main limitation being wetness. Where climate is not too severe the land is marginally suitable for reclamation, but elsewhere—on

Beinn Eighe, for example—climate limits the land use to rough grazing, the moorland vegetation having only low grazing values.

Map unit 185 comprises peaty podzols, shallow peat, deep peat and peaty gleys developed on hummocky valley moraine (Fig. 7). The map unit covers 51 square kilometres (11 per cent of the association) and it occurs in three districts—west and south of Loch Eriboll, near Ben More Assynt, and in the Coulin Forest near Kinlochewe.

The surface of the moraine mounds is bouldery. The soil pattern is dominantly one of peaty podzols with some shallow peat and peaty gleys occurring on the mounds and deep peat in the hollows or on the flats between the mounds. The proportions of the soils vary according to whether the mounds are closely packed or widely spaced.

Land use is rough grazing and deer-forest, the topographic and wetness limitations precluding improvement. The moorland plant communities provide grazing of low value.

Map unit 186 comprises brown forest soils and humus-iron podzols with some peaty gleys and rankers. It occurs on non- to moderately rocky, steep and very steep valley sides and the soils are developed on colluvium. The map unit covers only 2 square kilometres (less than 1 per cent of the association) and is present in two areas, one near Kinlochewe, the other near Achnashellach. Land use is rough grazing. Improvement is precluded by slope limitations, but the vegetation provides grazing of moderate value.

Map unit 188 consists of peaty gleys, shallow peat and deep peat with some peaty rankers and peaty podzols. The associated landforms are moderately rocky and include undulating land, hills and hill sides. Slopes are mainly gentle and strong with some short, steep and very steep slopes including low crags (Fig. 8). The soils are developed on till and colluvium. The map unit covers 123 square kilometres (27 per cent of the association) and it is widespread throughout the western area of the association.

Peaty gleys, shallow peat and deep peat occur on the more gently sloping parts of the unit, together with rock outcrops in the form of pavements, whereas on the steeper parts, peaty rankers are present on the drift-free upper part of the slope and peaty podzols on the lower part where drift is usually present. A pattern of scarp and dip slopes, though on a small scale, is common. Locally this map unit includes some small patches similar to *map units 185 and 192*. Near Inchnadamph it occurs on a small area of porphyry.

Topography and wetness limit the use of the land to rough grazing and deer-forest, the moorland plant communities providing grazing of only low value.

Map unit 190 consists of peaty gleys and peaty rankers with some shallow peat, deep peat and peaty podzols; the associated topography comprises very rocky land with gentle, strong and locally steep and very steep slopes (Fig. 9). The soils are developed on a patchy drift cover of shallow till and colluvium. This unit has similarities with *map unit 188* but the associated topography is rockier, peaty rankers are more extensive and there is less peat. The map unit covers 10 square kilometres (2 per cent of the association) and it occurs near Inchnadamph and at Achfary in Sutherland.

The land use is rough grazing and deer-forest, the main limitation being the topography. The moorland plant communities have only low grazing values.

Map unit 191 is a unit of peaty podzols, peaty gleys and peaty rankers, with some shallow peat, and it is found on moderately and very rocky steep and very steep hills, hill sides and valley sides. The soils are developed on colluvium. It is similar to *map units 188 and 190* but slopes are steeper, peaty podzols are more common, and there is little or no deep peat. The map unit covers 31 square kilometres (7 per cent of the association) and it occurs on both the Moinian and the Cambrian quartzites. It is the only unit on the Moinian quartzites (Plate 5), where it usually includes a small patch of subalpine soils similar to *map unit 192* on the tops of the hills; these patches are, however, too small to show on the 1:250 000 soil map. Land use is restricted by slope to rough grazing and deer-forest, the grazing values being low.

Map unit 192 comprises subalpine and alpine soils, lithosols and noncalcareous regosols (Plate 14). It occurs on mountains and has a wide range of slope and rockiness classes. The soils are developed on cryogenic and colluvial materials. It is the most extensive unit in the Durnhill Association, covering 144 square kilometres (31 per cent of the association).

It occurs at altitudes of generally more than 400 metres throughout the area of the Cambrian quartzite outcrop in the west. Some areas are extensive, the largest one, lying on a broad ridge to the east of Inchnadamph, being about 15 kilometres in length. It also occurs near Dufftown.

The mountain sides have mainly steep and very steep slopes with crags and scree (Plate 12); the soils are largely noncalcareous regosols on stony colluvium. The mountain tops include plateaux and ridge crests, and have gentle and strong slopes (Plate 16). They are extremely stony and bouldery, and there is much patterned ground in the form of terraces and lobes. Vegetation cover is very patchy. The soils are subalpine and alpine soils, largely podzols, developed on cryogenic drift. Peaty rankers, together with small patches of peat, usually in hollows or channels, are present in the lower part of the unit. A very rocky dip slope of quartzites forms the eastern slopes of some hills, such as Canisp in Sutherland, and map unit 192 can reach quite low altitudes.

Above about 650 metres the land has little or no agricultural value because of the overriding extremely severe climate limitations. Below this altitude, climate, topography and soil factors limit land use to rough grazing; the mountain heaths have low grazing values and the small patches of stiff sedge-fescue grassland which occur locally have moderate values.

Map unit 193 consists of deep peat and subalpine podzols on slightly and moderately rocky hummocky terrain on exposed hills. It covers 5 square kilometres (1 per cent of the association) and it occurs only in two areas, one near Inchnadamph and the other near Whiten Head on the north coast. The subalpine podzols are developed on stony drift on the rocky and bouldery mounds, and the deep peat, generally hagged, is present between the mounds. Land use is restricted to rough grazing by climate, wetness and topography. The mountain heaths on the mounds and the blanket bog communities on the peat have low grazing values.

Map unit 194 is a unit of alpine and subalpine soils with some peat, noncalcareous regosols and lithosols. It occurs on the non- or slightly rocky upper slopes of mountain summits and ridges, the slopes, mainly convex, ranging from gentle to steep. The soils are developed on very stony shallow drift of loamy sand or sandy loam texture. The map unit covers 5 square kilometres (1 per cent of the

association) and is found to the south of Dufftown on the hills above Glen Fiddich.

The alpine soils occur mainly on the summits and ridges, with the subalpine soils on the lower slopes. The steep slopes are often covered with scree, noncalcareous regosols occurring where the scree has been stabilized by vegetation.

Land use is largely deer stalking, grouse shooting and rough grazing. Most of the land has extremely severe limitations and is of very limited agricultural value.

THE ELGIN ASSOCIATION

(Map units 201-203)

The soils of the Elgin Association are developed mainly on drifts derived from sandstones of Upper Old Red Sandstone age. The sandstones are grey, yellow and red, and often coarse and pebbly. The drift is mainly a till which can be up to 6 metres thick although thicknesses of 1.5-2 metres are more common. The upper part of the till has a pale reddish brown colour and a sandy loam texture, but with increasing depth the colour becomes darker and redder and there is an increase in the clay content. The stones in the till are mainly sandstones but towards the south, as the boundary between the Old Red Sandstone and the Moinian rocks is approached, there is an increase in the number of stones of acid metamorphic composition. In the vicinity of the Middle Old Red Sandstone and the Permo-Triassic outcrops the drift contains material derived from these sandstones.

The association covers 61 square kilometres (0.4 per cent of the land area) and is restricted to the south of the Moray Firth between Buckie and Kinloss. In general it occurs on the higher ground of the plain, standing above a mantle of fluvioglacial sands and gravels. The largest areas are on the broad ridges which lie to the west of Elgin, and between Lossiemouth and Burghead; these areas lie below 150 metres. Another large area occurs to the south-east of Elgin on ground up to 340 metres.

The landforms in the Elgin Association include undulating lowlands with gentle and strong slopes, and hills and valley sides with gentle to steep slopes. Rock outcrops are rare. The average annual rainfall ranges from 630 to 900 millimetres and the association lies mainly in the warm moderately dry climate region, with some in the fairly warm moderately dry region. Exposure category is mainly moderate.

By far the most extensive soils in the Elgin Association are the freely and imperfectly drained humus-iron podzols in which an indurated B horizon is generally present. Other soils in the association include peaty podzols, noncalcareous gleys, peaty gleys and humic gleys. The peaty podzols are freely or imperfectly drained above an iron pan.

The humus-iron podzols are largely dominated by arable and permanent pastures (*Lolio-Cynosuretum*) on the lower ground and by forestry plantations on the higher ground; locally, some eastern highland oakwood and birchwood (*Triantali-Betuletum pendulae*) is present, and some boreal heather moor (*Vaccinio-Ericetum cinereae*) occurs on the higher ground. Arable and permanent pastures also occur on most of the noncalcareous gleys; soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires are present on other noncalcareous gleys and on the humic gleys. The peaty podzols support boreal heather moors (*Vaccinio-Ericetum cinereae*) and Atlantic heather moors (*Carici binervis-Ericetum cinereae*), the peaty gleys carry bog heather

moors (*Narthecio-Ericetum tetralicis*) and the local areas of peat have blanket bog vegetation (*Erico-Sphagnetum papillosum*).

The Elgin Association comprises three map units: the most extensive one, accounting for 90 per cent of the association, is dominated by humus-iron podzols, and the other two units comprise one unit of noncalcareous and peaty gleys, and one in which peaty podzols are the principal soils.

Map unit 201 consists of noncalcareous gleys and peaty gleys with some humic gleys, and it occurs in depressions and receiving sites with gentle slopes in lowland areas. It covers 4 square kilometres (5 per cent of the association) and is present in two localities, the larger one at Teindland to the south-east of Elgin and the other, in which the soils are all noncalcareous gleys, lies to the south of Alves.

Some of the land is cultivated and some is in permanent pasture and rough grazings. Wetness is the main factor affecting the agricultural capability although the uncultivated land is moderately suitable for use as improved grassland.

Map unit 202 comprises humus-iron podzols with some gleys and peaty podzols. It occurs on undulating lowlands and hills with predominantly gentle and strong slopes although locally, as in Glen of Rothes, some steep slopes are present. The landscape is mainly non-rocky, but some rock outcrops occur along the ridge between Alves and Elgin. The map unit covers 56 square kilometres and accounts for 90 per cent of the association.

The humus-iron podzols are largely freely drained and cultivated. On the higher ground, imperfectly drained podzols become common and afforestation, mainly coniferous plantations, is widespread. Climate is the main factor which affects the land use and it becomes progressively more limiting with altitude so that on the higher ground the agricultural use is restricted to improved grassland.

Map unit 203 consists predominantly of peaty podzols, in places transitional to humus-iron podzols, with peat and gleys occurring locally in depressional sites. The topography comprises non-rocky, mainly gently sloping hill and valley sides. This unit only occurs in one area, namely on the higher ground to the north of Rothes, where it covers 1 square kilometre (less than 5 per cent of the association).

Land use is rough grazing. The principal limiting factors are climate and wetness, but they are not too severe and the land overall is moderately suitable for use as improved grassland.

THE ETHIE ASSOCIATION

(Map unit 204)

The soils of the Ethie Association are developed on drifts derived from sandstones of Middle Old Red Sandstone age together with acid gneisses of the Moine; the distribution corresponds with that of the coastal band of Moine gneiss in Easter Ross which extends discontinuously from Rosemarkie to the Hill of Nigg and includes the Sutors of Cromarty. The parent material is mainly a brownish stony drift, often less than 50 centimetres thick, with a texture generally of sandy loam but ranging overall from loamy sand to loam. It is largely derived from the sandstones, but also includes some acid gneisses, the amount of which often increases with depth and can be high where a rubbly bed-rock of gneiss lies close

to the surface. Colluvial material, which in some places overlies till of the Cromarty Association, often infills local depressions but is not extensive.

The association covers 16 square kilometres (less than 0.1 per cent of the land area). There is only one map unit, the description of which is combined with that of the association.

The associated landform comprises low hills, often in the form of long ridges; slopes are normally strong but locally steep or very steep, especially the seaward slopes. The hills rise to 203 metres on Hill of Nigg and 220 metres at Callachy Hill north of Rosemarkie. There are sporadic rock outcrops.

The average annual rainfall is between 630 and 750 millimetres, and the association lies in the warm and fairly warm, moderately dry, moderately exposed and exposed climate regions.

The soils are predominantly humus-iron podzols. Freely drained podzols are the most extensive and occupy the hill tops and the convex slopes. The B horizons of the podzols developed on the shallow drift are usually dark reddish brown, but yellowish brown on the deeper drift. Indurated B horizons are occasionally present. Imperfectly drained podzols occur on the hill slopes; drainage becomes increasingly poorer towards the bottom of the slope. Minor patches of poorly drained noncalcareous gleys, and occasionally calcareous gleys, occur in valley bottoms. Some peaty gleys are also present.

The main plant communities on the humus-iron podzols are arable and permanent pastures (*Lolium-Cynosuretum*) and dry Atlantic heather moor (part of *Carici binervis-Ericetum cineraceae*), with soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires on the gleys.

Land use is mainly mixed farming or forestry, the steep slopes and the shallow and stony soils restricting much of the agricultural capability of the land to grass production, although some land is suitable for arable cropping.

THE FODLAND ASSOCIATION

(Map units 241, 243–245 and 257)

In Northern Scotland the soils of the Foudland Association are developed on drifts derived mainly from black graphitic schists and slates of the Dalradian. The most common drift is a yellowish brown to olive-brown fine sandy loam or loamy fine sand containing many platy stones mainly less than 20 centimetres in size. Less extensive is a grey till of fine sandy loam or loam texture in which the silt fraction (2–50 μ m) is 20–50 per cent. The high fine sand and silt content in the parent materials of the Foudland Association has imparted a characteristic smooth feel to the soils. The underlying rock is often shattered and locally strongly weathered.

The association covers 156 square kilometres (0.9 per cent of the land area) and it occurs in the south-east of the area, around Keith and Dufftown. It is, however, a much more extensive association in Eastern Scotland (Sheet 5), particularly in the Huntly and Turriff district.

The altitude range is 50–550 metres and the landforms include undulating lowlands, hills and valley sides with slopes ranging from gentle to steep. Most areas are non-rocky, partly as a consequence of the nature of the rock which weathers fairly readily to produce smooth landforms.

The average annual rainfall ranges from 800 millimetres near the coast to 1200 millimetres on the highest ground south-west of Dufftown. Most of the land lies in the cool and wet climate region although on the lower ground the climate is fairly

warm and moderately dry and on the highest ground it is cold and wet. The exposure categories are moderately exposed or exposed.

Humus-iron podzols are the predominant soils. Some are cultivated. The uncultivated humus-iron podzols developed on drifts derived from black schists have characteristic bluish grey E horizons and the B horizons tend to be more olive-coloured than those of the Strichen Association soils (developed on drifts derived from Dalradian schists). Other soils include peaty podzols (also characterized by a bluish grey E horizon when developed on drifts derived from black schists), together with noncalcareous, peaty and humic gleys, peat, and some small areas of freely drained subalpine soils.

Although the argillaceous rocks from which the parent materials are derived have adequate amounts of cobalt and copper, the application of lime on improved grazings on hill land can induce deficiencies of these elements.

The most extensive plant communities are boreal heather moors (*Vaccinio-Ericetum cinereae*), associated with the humus-iron podzols, peaty podzols and subalpine soils. The humus-iron podzols also support Atlantic heather moors (*Carici binervis-Ericetum cinereae*) on lower ground near the coast, and some acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*). Arable and permanent pastures (*Lolio-Cynosuretum*) occur on cultivated humus-iron podzols and on some noncalcareous gleys. Other noncalcareous gleys support soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires, and the peaty gleys carry bog heather moors (*Narthecio-Ericetum tetralicis*). On the peat the dominant communities are lowland and upland blanket bogs (parts of *Erico-Sphagnetum papilloso*).

Of the five units in the association, one, the most extensive, is dominated by humus-iron podzols (65 per cent of the association), one by peaty podzols and peat (25 per cent) and one by gleys (10 per cent). The other two units are one of peaty podzols and one of subalpine soils.

Map unit 241 consists of noncalcareous gleys and peaty gleys with some humic gleys, peat and humus-iron podzols. It occurs on gently or strongly sloping lower slopes of non-rocky lowlands and foothills. The unit covers 12 square kilometres (10 per cent of the association) and it occurs patchily throughout the area of the association.

The gleys, predominantly noncalcareous gleys, are developed on the grey till of fine sandy loam or loam texture in hollows, basins and on concave slopes. There are also a few patches of peat associated with the receiving sites. The humus-iron podzols are developed on the yellowish brown to olive-brown drift and are mainly imperfectly drained.

Most of the land is cultivated. Soil wetness and climate are the main limitations which affect the agricultural capability. The highest ground is only suitable for use as improved grassland.

Map unit 243 comprises humus-iron podzols with some noncalcareous and peaty gleys, peaty podzols and peat. The associated landforms are non-rocky undulating lowlands, rounded hills and valley sides; slopes are gentle and strong, locally steep. The soils are developed on the yellowish brown to olive-brown drift. This is the most extensive unit in the association and it covers 101 square kilometres (65 per cent of the association). It is widespread throughout the association, the largest area being in the Clashindarroch Forest.

Most of the humus-iron podzols are freely drained and have a friable Bs horizon which tends to be less stony than the underlying weakly indurated B

horizon. The gleys and peat are found in receiving sites, mainly in hollows and basins.

The land is used for rough grazing, forestry and arable agriculture, the limitations affecting the agricultural capability being climate, stoniness and, locally, slope.

Map unit 244 is a unit of peaty podzols with some humus-iron podzols, subalpine soils, peaty gleys and peat, and it occurs on non-rocky rounded hills with gentle to steep slopes. It covers only 3 square kilometres (less than 5 per cent of the association) and is found to the south-east of Dufftown. This map unit includes about 40 per cent of soils of the Strichen Association.

Some peaty podzols, especially those on convex slopes, are freely drained and either do not possess an iron pan or have only a weakly developed one. Other peaty podzols are gleyed above a well-developed iron pan.

The land is used for rough grazing. The limitations which affect the agricultural capability of the land are climate, the peaty surface of the ground and, locally, slope. The unit is moderately suited to use as improved grassland.

Map unit 245 consists of peaty podzols and peat with some humus-iron podzols, peaty gleys and subalpine soils. It occurs on non-rocky rounded hills with gentle, strong and locally steep slopes, and on plateaux; slopes tend to be gentler than those of *map unit 244*, a unit which it slightly resembles. The unit covers 39 square kilometres (25 per cent of the association) and it occurs to the south of Dufftown.

The peat is most common on the gentle slopes and plateaux. The subsidiary humus-iron podzols are restricted to the lowest elevations and the subalpine soils to the highest; those soils, and the peaty podzols, are developed on the yellowish brown to olive-brown drift. The peaty gleys, developed on the grey till, occur on concave lower slopes and in basins and hollows.

Land use is rough grazing and forestry. The limitations affecting the agricultural capability are climate and soil wetness; at lower altitudes this unit is moderately suited for use as improved grassland, but the higher ground and the areas where peat is extensive are limited to rough grazing, the moorland plant communities providing grazing of only low values.

Map unit 257 is a unit of mainly subalpine soils on hill summits and on upper, mainly convex, gentle to steep slopes. The soils are freely drained. The unit covers only 1 square kilometre (less than 5 per cent of the association) and it occurs in two small patches to the south-west of Dufftown. The land use is limited by climate to rough grazing, the grazing values of the moorland plant communities being only low.

THE FRASERBURGH ASSOCIATION

(Map units 259–261)

The soils of the Fraserburgh Association are developed on shelly sand. In this area, the deposits are of windblown origin and there are three main types:

- (1) Active dunes which form mainly high, steep-sided mounds; in Caithness they occur as a narrow fringe above the shoreline.
- (2) Stable dunes, forming either a low mounded topography or a partial cover on

undulating moderately rocky land. Slopes are mainly gentle and strong, sometimes steep.

(3) Stable sand flats, often overlying till or peat at depths of about 1 metre. The shell fragments in this type are generally coarser and more abundant than in the previous types. In some areas a pattern is formed of sand flats partly overlain by small low stable dunes.

The association covers 23 square kilometres (0.1 per cent of the land area). There is a large area of it at Dunnet in Caithness and a number of fairly small patches scattered along the coast between Gairloch in the west and Keiss in the east. (The windblown sand deposits of the Moray Firth coastline, from east Sutherland to Buckie, are largely non-shelly and give rise to soils of the Links Association).

The Fraserburgh Association occurs mainly from sea level up to 30 metres, although near Bettyhill it extends up to 100 metres. The average annual rainfall is about 800 millimetres on the east coast, about 1000 millimetres on the north coast and about 1500 millimetres on the west coast. Most of the association lies in the exposed and very exposed categories of the fairly warm moderately dry climate region, with some in the exposed and very exposed, fairly warm, wet region.

The soils comprise calcareous regosols, brown calcareous soils and calcareous gleys, all characterized by a high sand content, the presence of shell fragments, and high pH values generally throughout the soil profile; pH values at the surface are, however, variable, depending on the balance between loss of calcium through leaching and gain through further addition of windblown shelly sand. The calcareous regosols are excessively and freely drained immature soils developed on the active dunes. The brown calcareous soils are freely drained and occur on the low stable dunes; soil profiles are generally weakly developed, comprising an A horizon of organic matter and sand, a B horizon of brown sand and a C horizon of paler sand. Thin buried A horizons are sometimes present and represent brief periods of stability during the accumulation of the deposit when a vegetation cover formed at the surface. Calcareous ground-water gleys with poor and very poor drainage occur on sand flats and in hollows between dunes (dune slacks); the upper part of the profile is pale brown and mottled, and the lower part grey, unmottled and wet.

The vegetation consists largely of dune and grassland communities. The calcareous regosols support northern sea couch-grass dune (*Elymo-Agropyretum boreo-atlanticum*), northern marram grass dune (*Elymo-Ammophiletum*) and eyebright-red fescue dune pasture (*Euphrasio-Festucetum arenariae*); the brown calcareous soils carry permanent pastures (*Lolio-Cynosuretum*) in addition to the three communities above; and the calcareous gleys support permanent pastures, silverweed pasture (the *Potentilla anserina-Carex nigra* Community) and sedge mires.

There are three map units in the association. Two of them, one on rocky and the other on non-rocky land, are dominated by calcareous regosols and brown calcareous soils, and the third, and by far the most extensive (80 per cent of the association), is a unit of calcareous regosols, brown calcareous soils and calcareous gleys.

Map unit 259 is a unit of brown calcareous soils and calcareous regosols on undulating stable and active dunes with gentle to steep slopes; the topography is

non-rocky. It covers 2 square kilometres (10 per cent of the association), occurring near Reay in Caithness and near Gairloch in Ross-shire.

Land use is rough grazing in addition to a golf course at Reay and a caravan and camp site at Gairloch. The main factor affecting the agricultural capability of the land is that the soils are liable to be eroded by the wind if the protecting vegetation cover is destroyed. This type of land is, however, very suitable for use as improved grassland.

Map unit 260 has a similar range of soils to the previous unit – brown calcareous soils and calcareous regosols – but it occurs on moderately rocky undulating land with gentle to steep slopes. It covers 2 square kilometres (10 per cent of the association) and is present at Torrisdale and Strathy Bays on the north coast and near Kinlochbervie on the west coast. Some shallow soils occur near rock outcrops. Land use is rough grazing, the principal limitation being the susceptibility of the soils to wind erosion. Grazing values are high. Areas where slope and rockiness are not further limiting are very suitable for improvement.

Map unit 261 consists of calcareous regosols, brown calcareous soils and calcareous ground-water gleys, and it occurs on active dunes, stable dunes and sand flats. There is a wide range of slopes, from level to steep, and the topography is non-rocky.



Plate 10. *Windblown sand landscape at Links of Greenland, Castletown, Caithness, illustrating map unit 261 (Fraserburgh Association). Calcareous regosols and brown calcareous soils occur on the low mounds, and calcareous gleys are present on the flatter land in the middle distance. Class 5.1 land.*

The unit covers 19 square kilometres (80 per cent of the association), and it occurs at Dunnet Bay (Plate 10) and Sinclair's Bay in Caithness, and at Balnakeil Bay and Sandwood Bay in north-west Sutherland.

The land is used predominantly for grazing, the principal limitation being that

the drier soils are liable to be eroded by wind. Grazing values are high. Where the slope and pattern are not limiting the land is very suitable for improvement; some areas already have been improved and now carry permanent pasture. The Forestry Commission have a plantation near Dunnet.

THE HATTON/TOMINTOUL/KESSOCK ASSOCIATIONS

(Map units 281, 282, 284–286)

These associations, all comprising soils developed on drifts derived from Middle and Lower Old Red Sandstone conglomerates, have been grouped together on the 1:250 000 soil map.

Brown, greyish brown and reddish brown conglomerates are dominant. The pebbles in the conglomerate are derived from Moine schists and granulites and locally from granite. In the Evanton area, brown and reddish brown sandstones contribute to the parent materials. The drifts have a yellowish to reddish brown colour and a loamy sand or sandy loam texture. They are usually very shallow (less than 50 centimetres) and stony on convex slopes, summits and ridges; rock sometimes crops out in these situations. Thicker colluvial drifts mantle some of the steep and lower slopes. Finer-textured sandy loam or sandy clay loam drifts occur on some lower slopes, as for example to the north of Evanton where they are underlain at depths of 1 to 2 metres by water-sorted material ranging from gravel to loamy fine sands.

The combined associations cover 106 square kilometres or 0.6 per cent of the land area. They are most extensive to the north of Evanton, but numerous smaller areas are scattered throughout the foothills and occasionally the lowlands around the Moray Firth, from Struie-Hill to Strathnairn.

The landforms include hills and valley sides with gentle to very steep slopes and undulating lowlands with gentle and strong slopes. Although much of the ground is non-rocky, all classes of rockiness do occur. The general altitude range is 100 to 500 metres, although the associations are found near sea level in some areas. Average annual rainfall ranges from 700 millimetres on the Black Isle to 1200 millimetres on the highest ground in the Evanton area. Most of the combined associations occur in the fairly warm moderately dry and cool wet climate regions; the lowest ground is in the warm moderately dry region. Exposure categories range from sheltered and moderately exposed over the larger part of the area to very exposed on the highest ground.

Humus-iron podzols and peaty podzols are the most extensive soils, but a wide range of other soils is present including iron podzols, noncalcareous, humic and peaty gleys, dystrophic peat, brown forest soils, rankers and subalpine podzols. Freely drained humus-iron podzols are most common, but imperfectly drained soils are found where drainage is impeded by bed-rock. Indurated B horizons do occur, but are infrequent. The peaty podzols generally have an iron pan and, on concave slopes, a strongly gleyed E horizon below a thick peaty surface horizon.

The range of plant communities strongly reflects the dominance of podzolic soils and the relative dryness and decreasing influence of oceanicity of the climate. Dry and moist Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*) are most common on the humus-iron podzols although boreal heather moors (*Vaccinio-Ericetum cinereae*) also occur. Arable and permanent pastures (*Lolio-Cynosuretum*) are present on the rather restricted arable areas and acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) is found on some of the steeper slopes. Peaty podzols generally support moist Atlantic heather

moor. These two most extensive soils are largely under forestry. Atlantic heather moors occur on the rankers, whilst boreal heather moors, often wind-cut, are found on the exposed subalpine soils. The small areas of poorly drained soils support a variety of communities: arable and permanent pastures, soft rush pasture (the *Ranunculus repens*-*Juncus effusus* Community) and sedge mires on the noncalcareous gleys, bog heather moor (part of *Narthecio-Ericetum tetralicis*) on the peaty gleys, and lowland blanket bog (part of *Erico-Sphagnetum papillosum*) on the peat.

There are five map units. Four, accounting for almost all the combined associations, are units in which podzols are the dominant or co-dominant soils; the fifth is a unit dominated by gleys.

Map unit 281 consists of noncalcareous and peaty gleys, with some humic gleys, peaty podzols and freely or imperfectly drained humus-iron podzols. The unit covers 1 square kilometre (less than 5 per cent of the combined associations) and is found only on an undulating, gently sloping, non-rocky hill terrace to the north of Evanton. Wetness and climate limits land use mainly to permanent pasture, with very limited arable cropping.

Map unit 282 is a unit of humus-iron podzols with some iron podzols, noncalcareous and peaty gleys, brown forest soils, peaty podzols and rankers. It occurs on lowlands and foothills with gentle to steep, often convex, slopes, although to the south of Loch Ussie the relief is moundy. Rock crops out locally and the drift cover is usually shallow. The unit covers 50 square kilometres (45 per cent of the combined associations) and has a scattered distribution fringing the Moray Firth Lowlands to the west of Inverness.

Freely drained humus-iron podzols are most common, although iron podzols also occur in the Evanton area. In this area imperfectly drained humus-iron podzols are also found on the lower slopes; these soils also occur elsewhere on ridge tops where drainage is impeded by the underlying conglomerate. Non-calcareous and peaty gleys are found in receiving sites, mainly on lower concave slopes, whereas the brown forest soils are restricted to the steep lower slopes. Rankers occur on some of the ridge tops.

Much of the ground is under forestry, the wooded slopes above Novar House, north of Evanton, being notable for the prolific natural regeneration of a number of species, especially western hemlock. Some areas are cultivated, soil limitations restricting agricultural practice to a limited rotational system with pasture improvement often the most common form of land use.

Map unit 284 consists of peaty podzols and peat with some peaty gleys, humus-iron podzols and, above 500 metres, subalpine soils. The unit occurs on rounded hills with gentle to steep slopes, but with a number of cols and valleys where the peat and peaty gleys occur. Although most of the unit is non-rocky, rock, mainly conglomerate, is usually close to the surface, particularly on convex slopes, and crops out locally. The unit occupies 24 square kilometres (25 per cent of the combined associations) and occurs to the west of Alness.

Land use is rough grazing, sporting interests and forestry. The moorland plant communities have low grazing values. Some of the more gentle, drier, convex slopes are very suitable for pasture improvement, but most of the limited area of reclaimable land is on lower concave slopes with soils of low trafficability only marginally suitable for improvement.

Map unit 285 is a unit of peaty podzols and humus-iron podzols with some rankers and peaty gleys, and it occurs on moderately rocky hills and valley sides with strong and steep slopes. It covers 26 square kilometres (25 per cent of the combined associations) and has a scattered distribution, the largest area occurring near Boblainy Forest. The unit frequently forms a distinctive topography of knolls and hills with smooth steep convex slopes and rounded summits. Individual rock outcrops are sometimes large and often display the same general convexity as the landscape.

Peaty and humus-iron podzols are dominant and occur in close association with peaty and podzolic rankers on the knolls and hills. Peat and peaty gleys lie in the drift-infilled cols and hollows between the rocky hills.

Land use is primarily rough grazing, mainly of low value with limited areas of moderate grazing. The limitations which affect the agricultural use of the land are largely soil and topography, but where these are not too severe, such as in an area to the north of Drumnadrochit, the land is very suitable for reclamation.

Map unit 286 is a unit of rankers, peaty podzols and humus-iron podzols with some subalpine podzols and peat. The associated topography comprises moderately and very rocky hills with strong to very steep slopes, the rock outcrops occurring as rock pavements or as crags. The unit lies below 400 metres and covers only 5 square kilometres (less than 5 per cent of the combined associations). It occurs to the east of Loch Ness (where it forms the small northernmost part of a much larger area), and near Contin. Slope and rockiness limitations restrict agricultural land use to rough grazing; the moorland plant communities have low grazing values. On the steep slopes to the east of Loch Ness, there is some afforestation.

THE INCHKENNETH ASSOCIATION

(Map unit 313)

The Inchkenneth Association comprises soils developed on drift derived from Mesozoic sandstones, shales and limestones. The parent material is moraine of sandy loam or loam texture and it includes an admixture of Torridonian rocks which gives it a reddish tinge. The unit occurs in only one area, near Applecross, where it covers 3 square kilometres (less than 0.1 per cent of the land area). There is only one map unit and its description is combined with that of the association.

The association extends from sea level to 150 metres. The landform is hummocky, the pattern of mounds and hollows being more strongly developed at the higher altitudes. The average annual rainfall is between 1400 and 1600 millimetres and the climate is exposed, fairly warm and wet.

Brown forest soils are the dominant soils; they are largely freely drained with an indurated B horizon, and are developed on the mounds. Peaty gleys and dystrophic shallow and deep peat are present in the channels and hollows and on the flats between the mounds.

Much of the unit is uncultivated and used as rough grazing. The vegetation is a mosaic of grassland and moorland communities. The brown forest soils support acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) and herb-rich Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*), and the peaty gleys and peat carry soft rush pasture (the *Ranunculus repens-Juncus effusus* Community), sedge mires and some lowland blanket bog and flying bent

bog (parts of *Erico-Sphagnetum papillosum*). On some of the lower ground the brown forest soils have arable and permanent pastures (*Lolio-Cynosuretum*).

The climate and the pattern of mounds and hollows restrict the agricultural capability of the higher ground to use as improved grassland, but on the lower ground, where limitations are less severe, cultivation is possible.

THE INCHNADAMPH ASSOCIATION

(Map units 314 and 315)

The Inchnadamph Association consists of soils developed on parent materials derived from limestones of Cambrian and Lower Ordovician age. These materials are of three kinds:

- (1) Shallow material on rock. This kind is patchily distributed on rock knolls and ridges, has a loam texture and is stoneless in some places but stony, containing fragments of limestone, in others. It is generally less than 30 centimetres thick.
- (2) Stony colluvium with a loam texture, occurring on the steeper slopes.
- (3) Till, brownish or reddish in colour, stony, and with a sandy loam or loam texture. It is derived from the limestones but contains an admixture of other rocks such as Cambrian quartzites and Lewisian gneisses.

The association covers 53 square kilometres (0.3 per cent of the land area). It occurs in three main areas—at Durness and Eriboll at altitudes of below 100 metres; at Inchnadamph and Elphin between 100 and 300 metres; and at Kishorn, where it extends from sea level to 450 metres. All the landforms are rocky and slopes are gentle and strong with some steep.

The average annual rainfall ranges from between 1200 and 1400 millimetres in the north to about 2400 millimetres in the south. Near the coast the climate is fairly warm and wet, but further inland and at higher altitudes, it is cool and wet; all the association lies in the exposed and very exposed categories.

The dominant soils of the association are brown rendzinas, brown forest soils, peaty podzols and peat. The brown rendzinas are developed on the shallow material associated with the limestone outcrops, the profiles comprising a dark brown A horizon of loam texture overlying either a C horizon of shattered limestone with interstitial A horizon material, or hard rock; the pH values in the ten or so profiles analysed to date are between 5.0 and 7.5 in the A horizon and between 6.8 and 7.9 in the C horizon. The brown forest soils, developed on colluvium or till, have loam or sandy loam textures, are stony and generally freely drained. The peaty podzols are developed on till and range from those which are freely drained throughout the profile to those which are strongly gleyed above the iron pan. The peat is largely deep peat with some shallow peat, and is mostly dystrophic.

The vegetation comprises mainly grassland communities on the mineral soils and moorland communities on the peaty podzols and peat. Herb-rich bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) occurs on the brown rendzinas and acid bent-fescue grassland (also part of *Achilleo-Festucetum tenuifoliae*) is present on the brown forest soils. Dry boreal heather moor (part of *Vaccinio-Ericetum cinereae*) and dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) are found on the drier of the peaty podzols, while moist *Atlantic heather moor* occurs on those peaty podzols in which there is

strong gleying above an iron pan. Bog heather moor (part of *Narthecio-Ericetum tetralicis*) is present on the shallow peat, and lowland blanket bog (part of *Erico-Sphagnetum papilloso*) on the deep peat. Some western ash-oak wood (*Primulo-Quercetum*) is present on the mineral soils near Kishorn.

The association includes only two map units: one is dominated by mineral soils, and the other, the more extensive, is a unit of mineral and peaty soils.

Map unit 314 consists of brown rendzinas and brown forest soils, and it occurs on moderately or very rocky valley sides and undulating lowland. Slopes are mainly gentle and strong but some short steep slopes are also present. All three types of parent material—shallow material on rock, colluvium and till—are present. The unit covers 13 square kilometres (25 per cent of the association) and is found in all three areas of the association.

The brown rendzinas occur on limestone knolls and ridges and have a patchy distribution. The brown forest soils are present on the lower and generally less-rocky slopes of the knolls and ridges, and on the flats and in the hollows between the rock outcrops. In the Durness area, there are some cultivated mineral soils developed on till on gentle slopes; these soils have probably been derived from the cultivation of peaty podzols.

The land is mainly used for rough grazing, although at Durness some is cultivated, particularly where there are slightly larger areas of non-rocky gently sloping land with soils developed on till. The rock outcrops and the numerous short steep slopes can be major limitations to agriculture in some areas, limiting land use to rough grazing, but where these limitations are less severe the land is suitable for improvement. The bent-fescue grasslands have high grazing values.

Map unit 315 comprises brown rendzinas, peaty podzols, shallow peat and deep peat. It is present on slightly and moderately rocky, occasionally very rocky, undulating lowland and hill sides; slopes are mainly gentle and strong with some short and steep, and the unit includes the limestone escarpments at Inchnadamph and Knockan. As in *map unit 314*, all three types of parent material are present. The map unit is more extensive than the previous one and covers 40 square kilometres (75 per cent of the association). It is present in all the three main areas of the association although near Kishorn the area covered is only small.

The brown rendzinas occur on the limestone knolls and ridges and have a patchy distribution. The peaty podzols, sometimes with shallow peat, are present on the gently to steeply sloping parts of the unit. The deep peat occurs in channels, hollows and on flats between the rock outcrops; some of the deep peat flats are quite extensive, although at Durness deep peat forms only a small proportion of the unit.

Land use is mainly restricted to rough grazing by the strong pattern of topography and wetness limitations. A mosaic of vegetation—herb-rich bent-fescue grassland on the limestone outcrops and moorland communities on the peaty soils and peat—gives this unit overall a moderate grazing class. Limitations are less severe at Durness and the unit is suitable for improvement.

THE INSCH ASSOCIATION

(Map units 316–318)

The soils of the Inch Association are developed on drifts derived from gabbros and allied igneous rocks, but locally can contain hornblende-schist and epidiorite. The drift on concave slopes and in basins is commonly a grey sandy

loam to clay loam till with ochreous mottling; elsewhere, but mainly on upper slopes, the drift is stonier, yellowish brown and has a sandy loam or loamy sand texture. The drifts are sometimes underlain by weathered basic igneous rocks.

The association covers 12 square kilometres (less than 0.1 per cent of the land area) and it occurs mainly in the Deveron valley east of Dufftown. It does, however, occur more extensively to the east and south of the Northern Scotland area.

The altitude range is 170–480 metres and landforms include undulating lowlands and foothills, hills and valley sides. Slopes range from gentle to steep and most areas are non-rocky. The average annual rainfall ranges from 1000 to 1100 millimetres and the association lies in the cool wet and cold wet climate regions. Most of the area is exposed, though the floor of the Deveron valley is only moderately exposed.

The dominant soils are brown forest soils both freely and imperfectly drained, noncalcareous gleys and peaty gleys, with some humus-iron podzols. The brown forest soils and the humus-iron podzols are developed on the stony, yellowish brown drift of sandy loam or loamy sand texture, whereas the gleys occur on the grey sandy loam to clay loam till. Because of the higher base status of the parent materials, the brown forest soils reach higher elevations than do those of the more acid neighbouring associations and still predominate at the upper altitudinal limit of the association. The humus-iron podzols differ from those developed on the more acid parent materials in lacking a clear ash-coloured E horizon below the organic surface layers. Most brown forest soils and humus-iron podzols have a weakly indurated B horizon, in contrast to the strong induration found in similar soils of many other associations. The imperfectly and poorly drained soils usually have prominent ochreous mottles in the subsoil due to the high content of iron derived from the ferromagnesian minerals. Because of the predominance of these minerals, adequate amounts of copper and cobalt are usually present. Amounts of total phosphorus are high, but nevertheless trees often respond to applications of phosphorus suggesting that this element must be non-available.

The vegetation includes arable and permanent pastures (*Lolio-Cynosuretum*) on the brown forest soils and noncalcareous gleys, acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) and boreal heather moors (*Vaccinio-Ericetum cinerae*) on the brown forest soils and humus-iron podzols, and soft rush pasture (the *Ranunculus repens-Juncus effusus* Community), sedge mires, and white bent-tussock-grass grassland (the *Cirsium palustre-Nardus stricta* Community) on the gleys.

The association comprises three map units: one (60 per cent of the association) is dominated by brown forest soils, another (30 per cent) by gleys, and the third (10 per cent) by humus-iron podzols.

Map unit 316 consists of brown forest soils with some noncalcareous gleys, and it occurs on undulating lowlands and rounded foothills with gentle, strong and, locally, steep slopes. Most areas are non-rocky, the main exception being on the more southerly Brown Hill where there are outcrops of ultrabasic rocks. The unit covers 7 square kilometres (60 per cent of the association) in the Deveron valley, the main area of the association.

Both freely and imperfectly drained brown forest soils are present. The Ap horizons usually have a well-developed crumb structure and a dark brown colour. The noncalcareous gleys are limited to receiving sites and are not extensive.

The land is used for rough grazing, forestry and arable agriculture, the main

limitations affecting the agricultural capability being climate, slope and, in some parts, rockiness.

Map unit 317 is a unit of noncalcareous and peaty gleys with some brown forest soils, and it occurs on the lower, concave, gentle slopes and in basins and hollows. It is non-rocky. The unit covers 4 square kilometres (30 per cent of the association) in the main area of the association, the Deveron valley. The non-calcareous gleys are more extensive than the peaty gleys, which occur mainly at higher elevations. The land is used for rough grazing, arable agriculture and forestry, the main limiting factors which affect the agricultural capability being soil wetness and climate.

Map unit 318 consists of humus-iron podzols on a gently and strongly sloping, non-rocky hill side on the south-west slopes of Black Hill in the Cabrach area south-east of Dufftown. The map unit covers 1 square kilometre (10 per cent of the association). Some humus-iron podzols of the Tarves Association, formed on drifts derived from acid and basic rocks, have also been included in this unit. The land is used for rough grazing but is suitable for use as improved grassland; the limiting factor is climate.

THE LESLIE ASSOCIATION

(Map units 369 and 370)

The Leslie Association comprises soils formed on parent materials derived from ultrabasic rocks. In this area, these rocks mainly comprise serpentinite and picrite, and the parent materials can, in addition, contain some basic igneous rocks such as troctolite and olivine-gabbro. The drifts are grey and brown, stony and have a sandy loam or loam texture; they usually contain erratics of acid schist, hornblende-schist and quartzite. Where the underlying rock is close to the surface the drift is very stony, with abundant angular ultrabasic stones present.

The association covers only 6 square kilometres (less than 0.1 per cent of the land area), the main area being in the Deveron valley to the south-east of Keith, with a smaller area further up the valley to the south-east of Dufftown.

Elevations range from 150 to 400 metres, and the landforms include lowlands, foothills and valley sides; slopes are mainly gentle and strong, locally steep, and most of the land is non-rocky. The average annual rainfall ranges from about 950 millimetres to just over 1000 millimetres and the association lies in the fairly warm moderately dry and the cool wet climate regions. The lower ground is moderately exposed and the higher ground exposed.

The soils are magnesian gleys and brown magnesian soils. The magnesian gleys are dominant and developed on greyish drift; the B horizons are grey with ochreous mottling and a prismatic structure, and the C horizon is massive. The brown magnesian soils, mainly freely drained, occur on the brownish drift, and occasional rankers are present around rock outcrops.

The soils of the Leslie Association contain high amounts of exchangeable magnesium, the content usually being greater than that of exchangeable calcium with the ratios sometimes exceeding 10 to 1 in the lower B and in the C horizons, where the base saturation is usually more than 80 per cent. Tree growth is often poor on these soils for a number of reasons including phosphorus deficiency, high pH, high magnesium to calcium ratios, and toxicities due to high levels of nickel and other trace elements.

THE SOIL MAP UNITS

The plant communities on the magnesian gleys include coniferous plantations, arable and permanent pastures (*Lolio-Cynosuretum*), soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires; on the brown magnesian soils, herb-rich bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) and arable and permanent pastures are present.

The association comprises two map units, one dominated by magnesian gleys (65 per cent of the association) and the other by brown magnesian soils (35 per cent).

Map unit 369 consists of brown magnesian soils with some magnesian gleys. It occurs on foothills and valley sides with gentle to steep slopes; most of the unit is non-rocky, but some areas are bouldery and rock outcrops occur locally, particularly on the Craigs of Succoth. The unit covers 2 square kilometres (35 per cent of the association) in the Deveron valley. Freely drained brown magnesian soils are the most common, with imperfectly drained soils being limited to the lower slopes. The magnesian gleys are restricted to the lower, mainly concave slopes. Land use is mainly rough grazing and arable agriculture, limitations affecting the agricultural capability of the land being climate, stoniness and slope.

Map unit 370 consists of magnesian gleys and some brown magnesian soils. It occurs on lowlands and foothills with gentle, strong and, locally, steep slopes; the unit is non-rocky, but some areas are bouldery. The unit covers 4 square kilometres (65 per cent of the association) south-east of Keith. The land is used mainly for coniferous plantations with some arable agriculture. The main limitation affecting agriculture is soil wetness, but locally slope and stoniness limitations can be dominant.

THE LINKS ASSOCIATION

(Map units 380–383)

Links soils are developed on windblown quartzose sand which usually overlies coastal raised beach deposits. Shelly sand, the parent material of the Fraserburgh Association, may be incorporated locally. Most of the sand is stabilized, but active dunes are present, usually as a narrow fringe next to the sea, but occasionally in fairly large areas which extend further inland.

The association extends to 57 square kilometres (0.3 per cent of the land area) and is most extensive between Culbin Forest and Lossiemouth, but it also occurs to the east of Tain, in east Sutherland and near Durness.

The stabilized areas of sand have a wide variety of landform and slope range, from a strongly undulating dune and slack topography near Embo, to a nearly level low raised beach to the south and west of Dornoch. Unstable dunes are more strongly undulating with many steep slopes. All these areas lie mainly below 20 metres, but at Durness the association extends up to 50 metres.

Average annual rainfall is around 600 to 700 millimetres and most of the area lies in the warm or fairly warm and moderately dry climate regions. However, at Durness the rainfall is 1200 millimetres and the climate is fairly warm and wet. Because of the coastal situation, most of the ground is exposed, but only moderately so in the Dornoch Firth area.

Freely and excessively drained noncalcareous regosols are the dominant soils. The excessively drained soils are generally restricted to unstable dunes. There is

no or very little accumulation of organic matter at the surface and vegetation cover is sparse; marram grass is the dominant species and helps to stabilize the sand to a certain extent. Some areas have been planted with conifers to prevent or lessen the sand from being blown onto the rich agricultural ground further inland. The freely drained noncalcareous regosols usually occur on the more gently sloping areas of windblown sand, commonly known as links. These areas are stabilized and generally have a continuous vegetation cover. The typical profile consists of a dark greyish brown A horizon, usually less than 10 centimetres thick, with moderate organic matter, underlain by light yellowish brown sand. Thin buried A horizons are common in the upper part of the profile. Occasionally, profiles with the characteristics of a very weakly developed podzol occur. Noncalcareous ground-water gleys are much less common and occur in very low-lying sites with a high water-table; grey and greenish grey colours produced by very strong gleying are found in the B and C horizons, which are waterlogged for long periods of the year.

Northern sea couch-grass dune (*Elymo-Agropyretum boreo-atlanticum*), northern marram grass dune (*Elymo-Ammophiletum*) and milk-vetch-red fescue dune pasture (*Astragalo-Festucetum arenariae*) are most common on the noncalcareous regosols, although a maritime form of Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) and acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) also occur. Dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) is found on the more mature humus-iron podzols developed on the shingle ridges between Golspie and Loch Fleet. The more restricted gleys support silverweed pasture (the *Potentilla anserina-Carex nigra* Community), soft rush pasture (the *Ranunculus repens-Juncus effusus* Community), sedge mires and some small areas of permanent pastures (*Lolio-Cynosuretum*) where the water-table is low enough to allow cultivation.

Links soils have been mapped in four soil map units: three are dominated by freely drained soils and account for 90 per cent of the association, the other is dominated by gleys and covers 10 per cent of the association.

Map unit 380 is dominated by freely and excessively drained noncalcareous regosols with some noncalcareous ground-water gleys. Excessively drained regosols occur mainly on unstable mounded dunes with gentle to steep slopes, whilst the freely drained regosols are found on mainly gently sloping stabilized beaches and dunes. The unstabilized dunes usually occur next to the foreshore; the more gently sloping links are found immediately to the landward side of them. The unit covers 45 square kilometres (80 per cent of the association) and is extensive from Culbin Forest to Lossiemouth. It is also common in the Dornoch Firth area.

In the Culbin Forest, the whole area is almost entirely unstable dunes with excessively drained soils, whereas around Dornoch most of the ground consists of gently sloping stabilized sand with freely drained soils. The area to the north of Embo consists of mounded stabilized dunes with approximately equal proportions of regosols and gleys. Most areas, however, have more than one type of landform.

Unstable dunes with a sparse vegetation cover have little or no agricultural value. Even on the stabilized areas, land use is generally restricted to pasture improvement by the coarse texture of the soils and their susceptibility to wind erosion, particularly after ploughing. On the Culbin sands, where the blowing of sand onto adjacent farmland can cause severe damage, the establishment of coniferous plantations has greatly reduced this risk.

Map unit 381 is found only between Littleferry and Golspie, where it covers 4 square kilometres (5 per cent of the association) and consists of humus-iron podzols and noncalcareous regosols with some gleys and alluvial soils. In the southern half of the area, the sand cover is patchy, exposing areas of shingle bars, on which the more mature humus-iron podzols are developed. A large part of the unit is under forestry, whilst the remainder of the ground is highly suited to pasture improvement.

Map unit 382 is dominated by noncalcareous ground-water gleys, and it occurs on very gently sloping raised beaches and links. Some freely drained noncalcareous regosols are present on strongly sloping stabilized dunes. Saltings, with saline alluvial soils, fringe much of the coast. The unit covers 5 square kilometres (10 per cent of the association) and is found only on Morrish More, east of Tain.

Erosion is not such a problem as it is on the drier soils and the very high water-table is the main limitation to agriculture. The vegetation provides rough grazing of high or moderate value.

Map unit 383 is a unit of freely drained noncalcareous regosols on slightly and moderately rocky, gently sloping lowlands. It covers only 3 square kilometres (5 per cent of the association) and is found at the Kyle of Durness. The underlying rock is the Durness limestone. Land use is restricted to permanent pasture by the risk of wind erosion.

THE LOCHINVER ASSOCIATION

(Map units 386, 387, 389, 391–398)

The soils of the Lochinver Association are developed on drifts derived from Lewisian gneisses. These drifts are mainly brown or dark brown, stony, and have loamy sand or sandy loam textures. In areas where granitic material has intruded the gneiss, the drift has a pinkish hue. A shallow, stony, undifferentiated drift is the most common type of parent material, but others include colluvium on steep slopes, till on the less rocky lower ground, moraine in valleys, and cryogenic materials, together with scree, on the mountains. Much of the area, however, is very rocky with only a patchy cover of drift. Also included in this association are soils developed on drifts derived from the Lewisian metasediments and hornblende-schists of the Gairloch and Loch Maree district.

The association covers 1321 square kilometres (8.0 per cent of the land area) and is the fourth most extensive association in Northern Scotland. Most of it lies to the west of the Moine Thrust and it is particularly extensive in Sutherland, but there are one or two patches to the east of the thrust, associated with the inliers of Lewisian gneiss in the Moinian rocks. The Lochinver Association is also extensive in the Outer Hebrides (Sheet 2).

Much of the land lies at altitudes of less than 300 metres, with higher ground present towards the south. Landforms are predominantly rocky. The average annual rainfall is about 1200 millimetres in the Assynt area, 1800 millimetres at Loch Carron, and over 2400 millimetres on the mountains. The climate regions range from exposed, fairly warm and wet on the lower ground through cool and wet to extremely exposed very cold and wet on the mountain summits.

Most of the soils have a peaty surface horizon. Peaty gleys are extensive and largely have shallow profiles overlying rock, but some are developed on deeper

indurated drift. Peaty rankers are common; in most cases the organic horizon lies directly on rock, but in others a thin horizon, generally strongly gleyed, is present between the organic material and the rock. Peaty podzols are mainly restricted to deeper drifts on the more freely draining sites such as the moraine mounds or on steeper slopes; they usually have a strongly gleyed E horizon above a well-developed iron pan. Peat is extensive throughout much of the association; much of it is deep and dystrophic unflushed, although dystrophic flushed peat is common in partially confined sites in rocky areas. Subalpine and alpine soils, largely podzols, are found on the mountains. Brown forest soils and humus-iron podzols occur locally on steep colluvial slopes at low altitudes. Other soils present in the Lochinver Association include brown rankers and flushed humic and noncalcareous gleys.

Reflecting the distribution of soil types, moorland plant communities are most common, whereas oroarctic, grassland and woodland communities are much more scattered. Peaty gleys, shallow peat and peaty podzols support bog heather moor (part of *Narthecio-Ericetum tetralicis*), whereas lowland blanket bog (part of *Erico-Sphagnetum papilloso*) occurs on the unconfined deep dystrophic peat. The northern forms of both communities are also common. Flying bent bog (part of *Erico-Sphagnetum papilloso*) is found on the dystrophic flushed peat. On hagged peat, at higher altitudes, northern, terminal phase, upland (parts of *Erico-Sphagnetum papilloso*) and mountain blanket bogs (*Rhytidadelpho-Sphagnetum fuscii*) occur. Some of the peaty podzols are found under moist Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*). This community and bog heather moor occur on the peaty rankers.

Alpine azalea-lichen heath (*Alectorio-Callunetum vulgaris*) is most common on the subalpine and alpine podzols, but stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association) also occurs, particularly on the soils developed on hornblende-schist on Beinn Lair. Fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosi*) is much less common, as are the *Nardus* snow-beds (the *Gnaphalium supinum-Nardus stricta* and *Lycopodium alpinum-Nardus stricta* Communities).

Brown forest soils support the richest semi-natural vegetation which includes bent-fescue grassland (*Achilleo-Festucetum tenuifoliae*), herb-rich Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) and birchwood (*Blechno-Quercetum*). Dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) is most common on the uncultivated humus-iron podzols although the richer communities mentioned above do occur locally. Permanent pastures (*Lolio-Cynosuretum*) occur on the more gently sloping areas of cultivated podzols. The flushing in the noncalcareous and humic gleys is indicated by the presence of soft rush pasture (the *Ranunculus repens-Juncus effusus* Community).

There are eleven soil map units in the association: five are dominated by peaty soils and peat and account for over 85 per cent of the association, two are mainly of subalpine and alpine soils (7 per cent of the association) and four are mainly of mineral soils (5 per cent).

Map unit 386 consists of brown forest soils and humus-iron podzols with some gleys and rankers, developed on shallow till. It occurs on slightly rocky lowlands at Scourie and Faraid Head, and on lower valley sides in Strath Carron. Slopes are predominantly gentle and strong. The map unit covers only 2 square kilometres (less than 1 per cent of the association). Many of the podzols have probably been reclaimed from peaty soils, the very dark humose topsoils being

indicative of this. In Strath Carron, the ground is no longer worked and bent-fescue grassland and bog heather moor form the dominant vegetation. Because of pattern limitations, land use is restricted mainly to permanent pasture with some small areas of arable cropping.

Map unit 387 consists of brown forest soils and brown rankers with some humus-iron podzols and peaty gleys, and it occurs on slightly rocky, hilly lowlands with gentle and strong slopes. It covers only 1 square kilometre (less than 1 per cent of the association), occurring at Achmore near Loch Carron. Rockiness and pattern limit land use to pasture improvement, although the natural vegetation provides grazing of high value.

Map unit 389 is a unit of brown forest soils and humus-iron podzols with some rankers and gleys, and it occurs on moderately and very rocky valley and lower hill sides with steep and very steep slopes. The soils are developed on colluvium. The unit covers 55 square kilometres (4 per cent of the association) and is mainly associated with the hornblende-schist of the Loch Maree and Gairloch areas and the numerous basic dykes of the Assynt district.

The unit is commonly found on steep slopes by the sea (Plate 6) or above a loch. The brown forest soils and humus-iron podzols are extensive, the gleys being confined to flushed channels between the rock outcrops. Very small patches of this unit can occur at low altitudes throughout the association, particularly in *map unit 395*.

The steep and very steep slopes and their rocky nature restrict land use to rough grazing; grazing values are moderate or high depending on the relative proportion of grassland and moorland communities present.

Map unit 391 consists of peaty podzols and deep peat with some peaty gleys and shallow peat, and it is developed on hummocky valley moraine (Fig. 7). The unit has a very scattered distribution and covers 51 square kilometres (4 per cent of the association).

The pattern of soils is essentially one of peaty podzols on the mounds, and peat and peaty gleys in the flats and channels between them, with variation in the proportion of soils present according to the local topography of each valley. In Strath Dionard in north-west Sutherland, this is well illustrated. The valley towards its head is very enclosed and the moraines are closely packed and often contiguous. As the valley widens northwards the mounds become much more widely spaced; consequently, peaty podzols become less common and the proportion of deep peat increases. A conspicuous decrease in the boulderiness of the unit accompanies the increase in deep peat. In the higher localities above 400 metres, subalpine podzols are found on some of the mounds. Locally around Scardroy Lodge in Ross-shire, brown forest soils under bent-fescue grassland are present, possibly as a result of the richer rocks of the area.

The present land use is restricted to deer-forest and poor rough grazing because of limitations imposed by boulderiness and wetness, except for limited areas at Scardroy where common white bent grassland on steep gullied ground provides grazing of moderate value. The brown forest soils in the same area are moderately suited for reclamation.

Map unit 392 comprises shallow and deep peat and peaty gleys. It is non-rocky and occurs mainly on gently undulating land and occasionally on hill sides; slopes are gentle and strong (Fig. 6). The soils are developed on a stony till. The unit

covers 57 square kilometres (4 per cent of the association) and is most widespread to the south of Little Loch Broom and in the Cape Wrath area.

Deep peat is most common, with shallow peat and peaty gleys occurring on the gently and strongly sloping undulations which rise above the general level of the peat flats. Peaty podzols are generally restricted to strong and short steep slopes. Where the unit occurs on smooth hill slopes the deep peat loses its dominance, and shallow peat and peaty gleys are found in close association.

Below about 150 metres in the north and 200 metres in the south, this unit is marginally suited to pasture improvement, but at higher altitudes the climate and moorland vegetation limits land use to rough grazing of low value.

Map unit 393 consists mainly of brown forest soils and humic gleys with some noncalcareous gleys and brown rankers, and it occurs on slightly and moderately rocky hill sides with steep and very steep slopes. It is similar to *map unit 389*, but has a greater proportion of gleys and is less rocky. The soils are developed on colluvium. The unit covers only 10 square kilometres (less than 1 per cent of the association) and occurs mainly on the Lewisian inliers present to the east of the Moine Thrust. The presence of brown forest soils and brown rankers is probably directly related to the more base-rich amphibolites and hornblende-gneisses of these inliers.

The slopes are generally too steep for mechanized improvement, but the grassland and rush communities provide natural grazings of high and moderate values. One area near Loch Luichart has gentler slopes and is highly suited for reclamation.

Map unit 394 is a unit of peaty gleys and peat with some peaty rankers and peaty podzols, and it occurs on moderately rocky lowlands and hills with gentle and strong slopes (Plate 12 and Fig. 8). The soils are developed on a shallow stony till. The unit has a very scattered distribution and covers 229 square kilometres (17 per cent of the association).

Although the unit does occur on individual hills and hill sides it is more common on gently undulating land. The peaty gleys, shallow peat and peaty rankers are associated with the gently and strongly sloping rocky areas, whereas the deep peat, which is occasionally dominant, is found on flats between rock outcrops. The peaty podzols are restricted mainly to locally steeper slopes. Where the unit occurs on hill sides, deep peat, although less common, is still a major component and is present on terraces. The proportion of peaty podzols can be slightly greater in this variant. Map unit 394 includes a few patches of very rocky land similar to *map unit 395* but too small to delineate on the 1:250 000 soil map.

Land use is restricted to rough grazing because of wetness and topographic limitations, the moorland plant communities providing grazing only of low value.

Map unit 395 consists of peaty gleys, peat and peaty rankers with some peaty podzols, and it occurs on very rocky, rugged, strongly undulating lowlands and hills (Plate 11). Slopes are mainly gentle and strong, but short, very steep, craggy slopes are common (Fig. 9). The drift is very shallow and patchy. The unit is extensive and covers 702 square kilometres (53 per cent of the association); most of it occurs in a large, nearly continuous mass between Loch Inchard and Loch Sionascaig, with numerous smaller areas to the south.

Peaty gleys and peaty rankers are most common on the knolls, but shallow peat does occur occasionally on small shelves. Peaty podzols are found at the base of

knolls where the drift is thickest and slopes are steepest. Short steep slopes with brown forest soils and humus-iron podzols are occasionally present, particularly in the Assynt and Gairloch areas. Deep and shallow peat occur in the hollows and channels between the rocky knolls; in partially confined sites, the peat is weakly flushed but mainly unflushed on the larger areas elsewhere. Deep peat is most common, but if the channel is strongly sloping, shallow peat usually occurs. A variation of the unit is present at several localities near the coastline where there are fewer peat flats and channels.

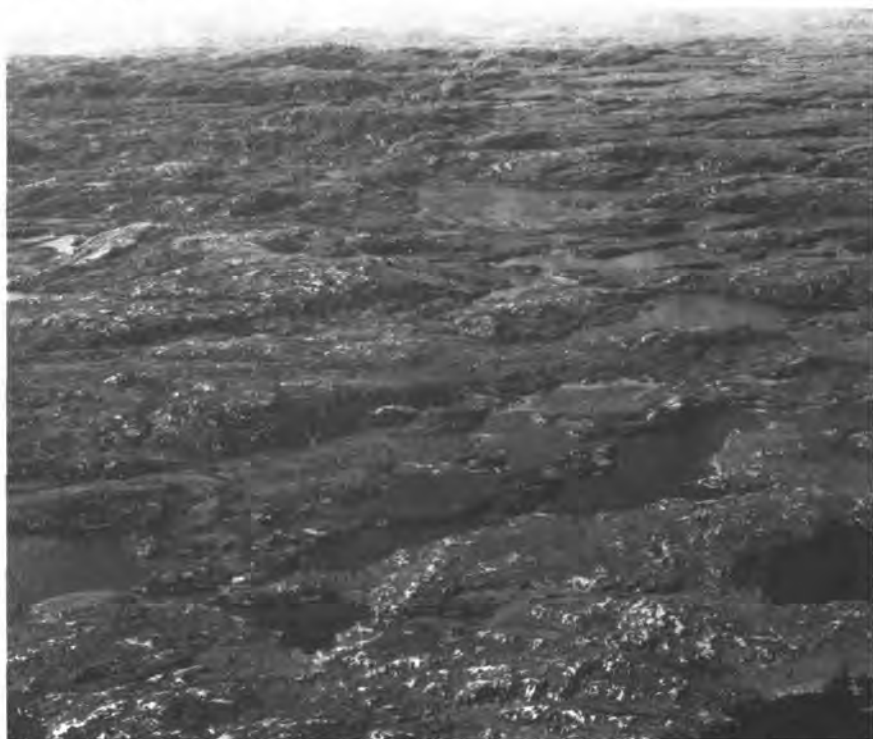


Plate 11. Assynt, Sutherland, showing the distinctive landscape of map unit 395 (Lochinver Association). Peaty rankers, peaty gleys and some peaty podzols occur on the rocky knolls with weakly flushed deep peat in the channels and basins between. Aerofilms.

Land use is restricted to rough grazing, the limiting factors being rockiness, the strongly undulating topography and wetness. The moorland plant communities provide grazing of only low value.

Map unit 396 comprises peaty gleys, peaty rankers, peaty podzols and some shallow peat, and it occurs on slightly to very rocky, steep and very steep hill sides. The soils are developed on colluvium. The map unit covers 115 square kilometres (9 per cent of the association) and has a very scattered distribution. The unit occurs mainly on the lower slopes of mountains (Plate 12), but near Loch Glencoul and Loch Glendhu, and in the Fisherfield Forest, it can extend over the entire hills.

The range of soils is similar to that of *map units 394 and 395* except that deep peat is generally absent. Peaty gleys, often weakly flushed, are most common,

whereas peaty podzols are generally restricted to convex slopes. Some slopes are very bouldery, with boulders up to 3 or 4 metres across.

Limitations imposed by slope, wetness and rockiness restrict land use to rough grazing, the moorland vegetation providing grazing of low value.



Plate 12. *Arkle, Sutherland. Map unit 396 (Lochmver Association), consisting of peaty gleys, peaty podzols and peaty rankers, occurs on the steep, lower slopes of the hill, below the line of screes. Above it is map unit 192 (Durnhill Association) comprising crags and scree on the steep slopes, and subalpine and alpine soils on the sloping plateau. Map unit 394 (Lochmver Association) occurs to the right of the loch.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Map unit 397 is a unit of subalpine podzols and deep peat, occurring on slightly and moderately rocky upland plateaux with gentle and strong slopes. It covers 28 square kilometres (2 per cent of the association) and occurs mainly to the south of Little Loch Broom.

The podzols are developed on cryogenic material on rocky and bouldery knolls, with hagged deep peat between them. A small transition zone of peaty gleys and peaty podzols often exists between the podzols and the peat, although much of the peaty surface horizon has been eroded, leaving bare stony patches.

Climate, soil and wetness limitations all restrict land use to rough grazings; the moorland plant communities have low grazing values.

Map unit 398 consists of subalpine and alpine podzols with some lithosols, noncalcareous regosols, rankers and gleys. It occurs on slightly to very rocky mountains with gentle to very steep slopes. The soils are developed on cryogenic material and colluvium. The unit covers 71 square kilometres (5 per cent of the association) and is most common between Little Loch Broom and Loch Maree. It is also extensive on Ben More Assynt.

The steep and very steep slopes are largely unvegetated crag and scree with lithosols, rankers and noncalcareous regosols. Subalpine and alpine podzols, de-

veloped on cryogenic material on strongly sloping plateaux, are more common and although these areas are rarely very rocky, they are almost invariably moderately or very bouldery. On Beinn Lair, the base-rich hornblende-schists have given rise to soils with more uniform brown colours throughout the profile.

Much of this unit lies in an extremely severe climate and has little or no agricultural value. Below about 650 metres, however, the land is suitable for rough grazing of low value with some grasslands locally providing grazing of moderate value.

THE MILLBUIE ASSOCIATION

(Map units 405 and 406)

The soils of the Millbuie Association are developed on morainic drifts derived from sandstones, with occasional shales, of Middle Old Red sandstone age. The sandstones are mostly brown or yellowish brown; the shales are sometimes calcareous. The drift is stony and has a sandy loam or, less commonly, a loamy sand texture. The colour, largely brown or yellowish brown, reflects the colour of the sandstones from which the drift has been derived. In the area bounded by Avoch, Kessock and Tore, a reddish brown drift overlies red sandstones and conglomerates. North-east of Muir of Ord the drift contains an abundance of schist stones. In general the morainic drift is thickest in the west and becomes thinner towards the central and eastern parts of the Black Isle where underlying compact reddish brown till, the parent material of the Cromarty Association, can form the C horizon of the soils. Thus there is a transitional zone between the two associations.

The Millbuie Association covers 199 square kilometres (1.2 per cent of the land area) and it occurs only in the Black Isle. The associated landforms comprise non-rocky undulating lowland with gentle and strong slopes. Throughout much of the area the slopes are long but gently moundy, and in places the land rises gently from sea level to almost 200 metres on the ridge which forms the backbone of the Black Isle.

The average annual rainfall ranges from about 700 millimetres around the coast to over 800 millimetres on the higher ground. Most of the association lies in the fairly warm, moderately dry climate region, but there is a narrow fringe of warm and moderately dry land around the coast. Exposure categories are mainly moderately exposed, with sheltered land along the Beaully Firth.

The dominant soils of this association are humus-iron podzols, mainly imperfectly drained but some are freely drained. Most are cultivated and have an indurated B horizon within 25 to 40 centimetres of the surface, although soils with deep Ap horizons—up to 45 centimetres thick—occur locally, probably indicating the selective improvement of infield land. Freely drained podzols are developed mainly where the morainic drift is thickest or the slopes are steepest, whereas podzols with imperfect drainage are generally present on gently sloping ground where the drift is shallower and underlain by compact till at less than 1 metre. Other soils in the Millbuie Association are very local in extent and include noncalcareous gleys, peaty gleys and dystrophic peat.

The humus-iron podzols are mainly under arable agriculture on the lower ground, carrying arable and permanent pastures (*Lolium-Cynosuretum*), whereas on the higher ground they are mostly afforested, with some supporting dry and moist Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*). The noncalcareous gleys have either arable and permanent pastures or, where

uncultivated, soft rush pasture (the *Ranunculus repens*-*Juncus effusus* Community) and sedge mires. Bog heather moor (part of *Narthecio-Ericetum tetralicis*) is present on the peaty gleys, and the peat carries a blanket bog vegetation (*Erico-Sphagnetum papillosum*). The Millbuie Association comprises two map units: one is a small unit of mainly noncalcareous gleys, and the other, accounting for 95 per cent of the association, a unit of humus-iron podzols.

Map unit 405, although variable, is primarily one of noncalcareous gleys, in some places with humus-iron podzols. It occurs as a few mainly small patches scattered throughout the association, and covers an area of 12 square kilometres (5 per cent of the association).

The area to the south-west of Mount Eagle is one of poorly drained soils with indurated horizons, occurring on the broad, level or gently sloping central part of the ridge of the Black Isle. The other patches of this map unit comprise poorly drained noncalcareous gleys on gentle slopes in hollows and receiving sites which are often elongated south-west to north-east and associated with drainage channels. Many of these hollows include poorly drained soils developed on alluvial and solifluction deposits. The most westerly patch is a variant of the map unit and comprises an area of mounded kettlehole topography. Noncalcareous gleys, together with some peaty gleys and a patch of peat, occur between the mounds, and humus-iron podzols, in some places tending towards peaty podzols with iron pan, are developed on the mounds.

Much of the area of kettlehole topography is afforested. The other areas of this map unit are mostly cultivated, soil wetness being the principal factor affecting the agricultural capability of the land.

Map unit 406 consists of humus-iron podzols on gently and strongly sloping ground, with a few small patches of noncalcareous gleys restricted to localized hollows; its extent is virtually the same as that of the association. It covers 187 square kilometres and accounts for 95 per cent of the association.

Imperfectly drained podzols are the most extensive soils. Freely drained humus-iron podzols occur mainly at the western end of the Black Isle peninsula, where they are developed on deeper morainic drift, but to the east, where the drift is shallower, they occur patchily on shedding sites and on steeper slopes. Towards the top of the central ridge, to the east of Mount Eagle, some of the podzols have developed an iron pan although a peaty surface horizon is not present, perhaps having been removed by turf-stripping in the past.

Most of the land below 150 metres is cultivated and under rotational arable agriculture. Above, there is some semi-permanent pasture and much of the central ridge is afforested, although there are a few local areas of moorland. With increasing altitude the climate becomes progressively more limiting and the soils become shallower and stonier.

THE NIGG/PRESTON ASSOCIATIONS

(Map units 420 and 421)

The soils of the Nigg and Preston Associations are developed on undifferentiated raised beach deposits. They have been grouped together on the 1:250 000 soil map, but only the Nigg Association is present in Northern Scotland.

The parent materials have textures ranging from shingle, gravelly sand and sand to silt; landforms are mainly raised beach terraces, together with shingle

storm beaches and estuarine and marine alluvium (saltings). The raised beach and alluvial terraces are level or gently sloping, but there can be very short, steep slopes between different terrace levels. Some windblown sand is present.

The association covers 165 square kilometres (1 per cent of the land area); it extends patchily from Golspie round the coast of the Moray Firth almost to Buckie, the largest areas lying to the north of Nigg Bay in Easter Ross and along the coasts of Moray and Nairn.

The average annual rainfall is about 700 millimetres or below; the climate is warm and moderately dry except in the northernmost part of the association where it is fairly warm. Exposure categories range from sheltered at the inner part of the Beaully Firth, moderately exposed in Easter Ross and Sutherland, and exposed along the Moray and Nairn coast.

On the lower raised beach terraces many of the soils are immature, whereas on the higher terraces humus-iron podzols are extensive, together with some humus podzols and iron podzols. Poorly drained soils are mainly noncalcareous ground-water gleys with some calcareous ground-water gleys present where the parent material is shelly; some peaty gleys occur locally. The soils on the areas of wind-blown sand are noncalcareous regosols.

The freely and imperfectly drained soils support either arable and permanent pastures (*Lolium-Cynosuretum*) or they are afforested; some dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) occurs on the gravelly areas of the low raised beaches. On the gleys the plant communities are mainly arable and permanent pastures, together with some soft rush pasture (the *Ranunculus repens-juncus effusus* Community) and sedge mires.

The association contains two map units, one dominated by freely and imperfectly drained soils (75 per cent of the association) and the other by poorly drained soils (25 per cent).

Map unit 420 consists mainly of freely and imperfectly drained soils ranging from those with immature profiles to humus-iron podzols. Gleys occur only locally, and noncalcareous regosols are present in areas of windblown sand. Soil textures are variable according to the type of beach deposit. In general the associated topography is flat or gently undulating. The unit covers 121 square kilometres (75 per cent of the association) and it occurs throughout the area of the association.

In Easter Ross, much of this unit is arable land, some of it highly productive. Artificial drainage has been necessary to lower what under natural conditions would be a high water-table in the imperfectly drained soils of the lower beach. At Findhorn, Maviston and Lossiemouth the land has been afforested.

Map unit 421 is a unit of ground-water gleys, generally noncalcareous but with some calcareous and peaty gleys, and locally some saltings with saline alluvial soils. Largely it occupies extensive depressions and low-lying coastal margins. The parent materials are mainly sandy, occasionally silty. The unit covers 44 square kilometres (25 per cent of the association) and it has a patchy distribution throughout the area of the association. Most of it in Easter Ross and around Beaully is cultivated although the successful management has required artificial drainage to control the water-table level.

THE NORTH MORMOND/ORTON ASSOCIATIONS

(Map units 424–426)

The North Mormond and Orton Associations both comprise soils developed on drifts composed of a mixture of Old Red Sandstone sedimentary rocks and Moinian or Dalradian acid metamorphic rocks. The two associations have been grouped together on the 1:250 000 soil map, but in Northern Scotland only the Orton Association is present. The parent materials are derived from Old Red Sandstone conglomerates and sandstones, with Dalradian schists and quartzites present in the association east of the River Spey, and Moinian schists and granulites occurring to the west. Locally, granite is found in the drift. The acid metamorphic stones are often subrounded and it is possible that many were originally pebbles in the conglomerates. Fragments of sandstone or conglomerate are less common in the drift.

Between Keith and the River Nairn the parent material is a reddish brown, often compact, till of sandy loam texture. Further west, however, it is more varied; most commonly it is a stony pale brown sandy loam or loamy sand, but where there are underlying sandstones and shales a red sandy clay loam can be present at depth. In some areas this finer-textured till may be part of a bisequel drift deposit.

The association occupies 209 square kilometres (1.3 per cent of the land area) and it occurs below an altitude of 300 metres on the slopes and foothills around the Moray Firth between Evanton and Keith, the main area lying on the hill slopes between Marybank and Inverness. Slopes are mainly strong. The average annual rainfall is 750–1150 millimetres and the climate regions range from sheltered warm and moderately dry to moderately exposed cool and wet.

Well-drained soils, mostly humus-iron podzols, are the dominant soils; other soils include noncalcareous gleys, peaty podzols, peaty gleys, humic gleys and dystrophic peat.

Most of the association is under arable or rotational grassland, the rest being under forestry or moorland. The noncalcareous gleys and the cultivated humus-iron podzols support arable and permanent pastures (*Lolio-Cynosuretum*). The uncultivated humus-iron podzols and the peaty podzols carry either boreal heather moors (*Vaccinio-Ericetum cinereae*) or Atlantic heather moors (*Caricibinervis-Ericetum cinereae*), and the peaty gleys bog heather moors (*Narthecio-Ericetum tetralicis*); the humic gleys and the peat support soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires.

The association comprises three map units, the most extensive one (84 per cent of the association) being dominated by humus-iron podzols; another (14 per cent) is largely of noncalcareous gleys and the third (2 per cent) is a unit of mainly peaty podzols.

Map unit 424 consists of noncalcareous gleys with some peaty gleys and humic gleys; it occupies gently sloping receiving sites and hollows. The unit is scattered throughout the area of the association, covering a total of 29 square kilometres (14 per cent of the association). Generally the noncalcareous gleys predominate, but west of the Great Glen, peaty gleys and humic gleys, sometimes with peat, are more common.

Some of the unit forms marginal arable land best suited for long leys, and the rest is under moorland and forestry. Soil wetness, and the presence of a peaty surface horizon on some of the soils, are the main limitations affecting the agricultural use of the land.

Map unit 425 comprises humus-iron podzols with minor peaty podzols and gleys, and the associated landform consists of non-rocky undulating lowlands and foothills with mainly strong slopes. The parent material is most commonly a brown sandy loam, generally indurated, which occasionally overlies reddish brown till at depth. The unit covers 175 square kilometres (84 per cent of the association) and its distribution is similar to that of the association as a whole. The main area lies between Inverness and Marybank on the foothill slopes which are mostly strong and regular, rising to about 250 to 300 metres over a distance of 2 to 4 kilometres.

Most of the humus-iron podzols are cultivated, especially at lower altitudes on the gentler slopes. The peaty podzols occur locally at higher elevations where the slope often lessens. The gleys, mostly noncalcareous, are confined to wet channels and hollows.

The best agricultural land in this map unit lies near Kirkhill and Marybank. On the lower and middle slopes of the foothills the gradient is a limiting factor; here are small farms and crofts with most fields in long ley and only minor cropping taking place. The upper slopes of the unit are either afforested or remain as moorland, with some local areas of improved grazing, the limitations to agriculture being stoniness, soil pattern and, locally, the peaty surface horizon.

Map unit 426 consists of peaty podzols with some humus-iron podzols, gleys and peat; the associated landform comprises hills with gentle, locally strong, slopes. The unit covers 5 square kilometres (2 per cent of the association) and it occurs as one single area on the hills to the north of Rothes.

The peaty podzols cover the gently sloping hill tops which rise to 260 metres, peaty gleys occupy receiving sites and peat infills streamhead channels. Imperfectly drained podzols and associated noncalcareous gleys are found on the lower steeper slopes. Almost all the unit is planted with coniferous trees.

THE SABHAIL/MOUNT EAGLE ASSOCIATIONS

(Map units 454–456)

The soils of these associations are developed on drifts derived from yellow and brown sandstones of mainly Middle Old Red Sandstone age, with flagstones and shales occasionally present; in Easter Ross Lower Old Red Sandstone rocks contribute to the parent materials in the western parts of the association. The soils of the Mount Eagle Association are developed on a shallow stony semi-residual drift with less than 1 metre of material on top of weathered shattered sandstone. In contrast, the parent material of the Sabhail Association is a brown compact till. Both these materials have textures mainly of sandy loam but occasionally of loamy sand. The two associations have been grouped together on the 1:250 000 soil map.

The extent of the combined associations is 188 square kilometres or 1.1 per cent of the land area. They are most extensive in Easter Ross and at the south-west end of Drummossie Muir.

The landscape is predominantly non-rocky, with mainly gentle and strong slopes, although some steep slopes do occur. Altitude is from sea level to almost 400 metres. The average annual rainfall is low, varying from 600 millimetres on the coast to 1000 millimetres inland. The climate of the lower ground is fairly warm and moderately dry, and the highest ground cool and wet. Shelter from the

prevailing westerly winds is reflected in the sheltered and moderately exposed exposure categories.

Reflecting this drier eastern climate is the dominance of humus-iron and peaty podzols; gleys and peat occur only in subsidiary amounts. Humus-iron podzols are developed on both parent materials; they are generally uncultivated on the shallow stony drift of the Mount Eagle Association, whereas those of the Sabhail Association are almost always cultivated. Peaty podzols are the most common soils at higher altitudes. Two types of profile are found. The first occurs on gentle slopes and has a strongly gleyed E horizon above a well-developed iron pan, and the second type occurs more often on strong slopes, has a much weaker iron pan and a less gleyed E horizon. This latter soil is transitional to a humus-iron podzol. The strongly gleyed type has a wetter, more decomposed, peaty horizon compared with the fibrous, blocky, peaty humus of the drier soil. An indurated B horizon also commonly accentuates the gleying. Peat and peaty gleys occur on small, level and gently sloping sites, generally on hill and ridge tops, but are very restricted. Noncalcareous gleys are even more limited in extent and are confined to flushed channels and basins at lower levels.

Arable and root crops in rotation with ley pastures (*Lolio-Cynosuretum*) are found on the cultivated podzols, whilst dry Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) is most common on the uncultivated podzols. The few restricted areas of mineral gleys support soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires. The peaty podzols usually support dry and moist Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*), and bog heather moor (part of *Narthecio-Ericetum tetralicis*) is occasionally found on the wetter, more gently sloping sites. This community also occurs on the unflushed peaty gleys; the flushed type is usually found on strong, locally steep, slopes under soft rush pasture and bog moss water track (the *Juncus effusus-Sphagnum recurvum* Community). Lowland blanket bog and less commonly upland blanket bog (parts of *Erico-Sphagnetum papilloso*) are found on the mainly dystrophic peat.

There are three soil map units in the Sabhail/Mount Eagle Associations; one dominated by humus-iron podzols accounts for 65 per cent of the combined associations, one dominated by peaty podzols covers 25 per cent, and the third, a unit of peat and peaty podzols, covers the remaining 10 per cent.

Map unit 454 is dominated by humus-iron podzols with gleys, peat and peaty podzols of more limited extent; the gleys and peat are generally restricted to minor hollows and peaty podzols limited to gentle slopes above 200 metres. The landforms are non-rocky or slightly rocky undulating lowlands and foothills with gentle and strong slopes. The unit covers 119 square kilometres (65 per cent of the combined associations) and is extensive in the Cromarty Firth area and on Drummosie Muir.

In the former area the deeper soils of the Sabhail Association are found on the lower slopes and are usually cultivated. Above approximately 150 metres, the shallower, stonier soils of the Mount Eagle Association remain under moorland vegetation or are afforested. Drummosie Muir forms a plateau-type landscape between 200 and 250 metres. Although the overall slopes are gentle, west of the A9 road there is a complex topography of parallel low ridges aligned south-west to north-east; the ridges are of varied composition with till, moraine or shattered rock all forming the parent material. Humus-iron podzols and some peaty podzols, often imperfectly drained, occupy the raised sites, whereas peat and peaty gleys are found in the intervening hollows.

In Easter Ross, land use varies from intensive cultivation on the low ground to forestry and rough grazing on the upper slopes; soil limitations and climatic factors largely determine the different land uses. Because of the overriding climatic limitation Drummoissie Muir is marginal for agriculture and land use is largely poor rough grazing, grouse-moor and forestry.

Map unit 455 is a unit of peaty podzols, with some gleys and humus-iron podzols, and it occurs on non-rocky hills and valley sides with gentle and strong slopes. The soils are developed on the till of the Sabhail Association. The unit occurs in the Morangie Forest, west of Tain, where it covers 51 square kilometres (25 per cent of the combined associations).

Both types of peaty podzol are present and they usually occupy distinct parts of the convex hill slopes; the wetter gleyed type usually occurs on the more gently sloping upper slopes and the drier type is present on the strongly sloping lower slopes. Humic and peaty gleys are fairly common in flushes on the steep slopes, although they also occur along with peat near the gently sloping summits. Humus-iron podzols occur on some of the steeper slopes on the hill sides.

Much of the ground is afforested, or utilized as grouse-moor and rough grazing. Climate and the moorland plant communities limit land use to rough grazing of low value on the upper slopes; the lower slopes are only marginally suitable for improvement because of low trafficability.

Map unit 456 consists mainly of peaty podzols and peat, with some peaty gleys, and it occurs on non-rocky hills and valley sides with gentle to steep slopes; the soils are developed on till. The unit covers 18 square kilometres (10 per cent of the combined associations) and occurs to the north of Alness and at Loch Duntelchaig.

The peat occupies the level and gently sloping areas of the unit, whilst the peaty podzols occur on the less gentle, strong and steep slopes; the distribution of the two types of peaty podzol is very similar to that in *map unit 455*. Peaty gleys occur in local flushes on strong slopes or as intergrades between peat and the gleyed type of peaty podzol.

The ground is marginally suited for reclamation although areas of deep peat have very low trafficability which restricts land use to rough grazing, the bog communities having only low grazing values. At present, forestry blocks are being established on the area in Easter Ross.

THE STIRLING/DUFFUS/POW/CARBROOK ASSOCIATIONS

(Map units 487 and 488)

These associations, all comprising soils developed on estuarine and lacustrine raised beach silts and clays, have been grouped together on the 1:250 000 soil map. However, only the Duffus Association occurs in Northern Scotland. The parent material of the Duffus Association is a lacustrine calcareous clay or silty clay containing 40–50 per cent clay (less than $2\mu\text{m}$) with some interbedded sand and silt.

The association, which covers only 5 square kilometres (less than 0.1 per cent of the land area), occurs on a gently sloping raised beach terrace to the north-west of Elgin under an average annual rainfall of 650–700 millimetres and in the moderately exposed, warm and moderately dry climate region. The two main soil types are calcareous gleys and brown forest soils with gleying. Both have clay

textures and coarse prismatic structures in the B and C horizons. The calcareous gleys, poorly drained, are often calcareous throughout the profile. In the brown forest soils with gleying the base status is high either throughout the soil profile or below the Ap horizon, the Ap horizon often having a coarser texture—generally loam—than the underlying horizons due to the addition and incorporation of windblown sand.

The soils of the Duffus Association are highly productive. They are, however, liable to dry out in some years although generally the rainfall is sufficiently well distributed throughout the year to prevent serious restrictions to land use.

Arable and permanent pastures (*Lolium-Cynosuretum*) are the dominant plant communities, with some soft rush pasture (the *Ranunculus repens*-*Juncus effusus* Community) and sedge mires.

Of the two map units, one, accounting for 80 per cent of the association, is dominated by calcareous gleys, and the other is a unit of mainly brown forest soils with gleying.

Map unit 487 comprises brown forest soils with gleying, together with some calcareous gleys. It covers only 1 square kilometre (20 per cent of the association), occurring on ground which, at altitudes of about 9 metres, is slightly higher than that of the remainder of the association. Most of the land is cultivated and capable of producing a wide range of crops, the limitations affecting the agricultural capability being only slight.

Map unit 488 consists of calcareous gleys together with some brown forest soils with gleying. The unit covers 4 square kilometres (80 per cent of the association) and it occurs on the lower ground of the association. Only minor to moderate limitations affect the agricultural capability of the land.

THE STRICHEN ASSOCIATION

(Map units 497-500 and 514)

The soils of the Strichen Association are developed on drifts derived from Dalradian schists. In valley bottoms and foothills the parent material is mainly a yellowish brown till of sandy loam or sandy clay loam texture containing subrounded and subangular stones largely of schist composition; locally the till is water-sorted. On hill tops and upper convex slopes a shallow stony drift overlying shattered rock at less than 1 metre is widespread; it has a loamy sand or sandy loam texture and contains mainly angular stones. Other soil parent materials include cryogenic drift on the highest hill tops, deeply weathered rock and colluvial material.

The association covers 240 square kilometres or 1.5 per cent of the land area and it occurs mainly around Dufftown and near Keith. This is only the northern part of a large area of the Strichen Association which extends from the Buchan Plain to the south-west Highlands.

The altitude ranges from about 70 to 550 metres. The landforms are predominantly non-rocky and include lowlands, hills and valley sides. The average annual rainfall is 900-1400 millimetres and the association lies mainly in the fairly warm moderately dry and the cool moderately dry climate regions; on the highest ground the climate is cold and wet. The exposure categories range from moderately exposed on the lower ground through exposed to very exposed on the very highest land.

The soils are largely podzols and gleys. Humus-iron podzols developed on till and on shallow stony drift are extensive. They have free or imperfect drainage, many are cultivated, and an indurated horizon is a normal feature of the profile. Brown forest soils are much less common and occur on steep colluvial slopes. Peaty podzols, mainly on shallow stony drift, include soils with free drainage throughout the profile and those with gleying above an iron pan. The gleys are mainly noncalcareous and peaty gleys with humic gleys less common. Induration also occurs in the gleys. Subalpine and alpine podzols, developed on cryogenic materials, are stony and loose, humus-stained soils with pronounced Bh horizons.

The plant communities on the humus-iron podzols are arable and permanent pastures (*Lolio-Cynosuretum*), boreal heather moors (*Vaccinio-Ericetum cinereae*), Atlantic heather moors (*Carici binervis-Ericetum cinereae*) and acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*). The brown forest soils support either birch woodland or forestry plantations. The vegetation on the peaty podzols is boreal or Atlantic heather moor. The cultivated gleys have arable and permanent pastures, and the uncultivated noncalcareous and humic gleys support soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires; the peaty gleys carry bog heather moors (*Narthecio-Ericetum tetralicis*). On the peat, the vegetation is lowland and upland blanket bogs (parts of *Erico-Sphagnetum papilloso*). The subalpine and alpine podzols of the higher hill tops are characterized by alpine azalea-lichen heath (*Alectorio-Callunetum vulgaris*), stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association) and alpine clubmoss snow-bed (the *Lycopodium alpinum-Nardus stricta* Community).

The association comprises five map units: of the two most extensive, one is dominated by gleys (24 per cent of the association) and one by humus-iron podzols (56 per cent of the association).

Map unit 497 is a unit of gleys with some humus-iron podzols; it is associated with depressions in lowland areas and with concave slopes below spring lines on valley sides. The unit is non-rocky and the soils are mostly developed on till. The unit covers 58 square kilometres (24 per cent of the association) and it occurs throughout the area of the association.

Many of the noncalcareous gleys are artificially drained and are cultivated. The peaty gleys and humic gleys, the latter often flushed, occur in wetter depressions and are mainly uncultivated, and the humus-iron podzols are present on mounds.

The main factors affecting the agricultural capability of the soil are wetness, and shallowness due to the presence of an indurated horizon.

Map unit 498 comprises humus-iron podzols with some brown forest soils and gleys, and it occurs on non-rocky undulating lowlands and foothills with strong and steep slopes. Most of the soils are developed on till but some are developed on shallow drifts. The unit covers 134 square kilometres (56 per cent of the association) and it is present throughout the area of the association.

The humus-iron podzols are freely and imperfectly drained, and are cultivated or were formerly so. The brown forest soils are present on steep colluvial slopes and the gleys occur in depressions. Extensive areas, including former arable land, are under forestry. Shallowness caused by the presence of an indurated horizon, and stoniness, are the main limiting factors affecting the agricultural capability of the land.

Map unit 499 is a unit of peaty podzols and humus-iron podzols with some gleys, and it occurs on non-rocky hills and valley sides with mainly strong but some steep slopes. Shallow drift forms a large proportion of the soil parent materials. The unit covers 15 square kilometres (6 per cent of the association) and it occurs in a few patches between Dufftown and Keith.

The peaty podzols are mainly freely drained but some have poor drainage above the iron pan. The humus-iron podzols occur in the lower parts of the unit. All soils can be shallow.

Some parts of the unit are afforested. Elsewhere, with the exception of the steep slopes, the unit is moderately suited to use as improved grassland.

Map unit 500 comprises peaty podzols and peat with some peaty gleys, and it occurs on non-rocky hill and valley sides with gentle and steep slopes. The soils are mainly developed on a shallow drift. The unit covers 32 square kilometres (13 per cent of the association) and it is found to the south of Dufftown.

Compared with the previous unit, this one has considerable amounts of peat, mainly deep, while the peaty podzols generally have a thicker O horizon and a higher proportion of them are gleyed above the iron pan.

Climate and wetness are the main limitations, restricting the land use mainly to rough grazing; some of the unit, however, is moderately suited to use as improved grassland.

Map unit 514 consists of subalpine and alpine podzols on a mainly non-rocky, locally rocky, mountain summit with gentle and strong slopes. The soils are developed on loose, stony, cryogenic material. This unit covers only 1 square kilometre (less than 1 per cent of the association) and is confined to one small patch to the south of Dufftown. The subalpine podzols occur on the slopes and the alpine podzols on the exposed top. The land is limited to rough grazing by climate and soil factors. The grazing is mostly of low value.

THE TARVES ASSOCIATION

(Map units 517 and 518)

The soils of the Tarves Association are developed on parent materials of intermediate basicity composed either of a mixture of acid schist and basic igneous rocks, or derived from hornblende-schist. A yellowish brown till of sandy loam or sandy clay loam texture is common on freely drained valley sides and in lowland sites; in poorly drained sites the till is grey and the textures are finer. A drift, stonier and coarser in texture than the till, is present on the hill tops. Locally, weathered rock forms a soil parent material.

The association covers 36 square kilometres or 0.2 per cent of the land area and it occurs to the south of Keith, mainly around the headwaters of the River Deveron and the Black Water. The altitude ranges from about 250 to 400 metres and the topography consists of non-rocky undulating lowlands, hills and valley sides with gentle and strong slopes.

The average annual rainfall is 900–1000 millimetres. Most of the association has a cool and wet climate, but on the lower ground the climate is fairly warm and moderately dry. Exposure categories include moderately exposed and exposed land.

Brown forest soils are extensive, mostly freely drained with some imperfectly drained, and often cultivated; an Ap horizon overlies a Bs horizon on an

indurated or compact horizon. Humus-iron podzols, less common, have free or imperfect drainage and an indurated horizon; those that are uncultivated have a distinct E horizon but cultivated soils have an Ap horizon containing abundant bleached sand grains. Brown forest soils with gleying occur locally. Gleys are mainly noncalcareous gleys, with some peaty gleys in the wetter hollows and on the higher ground.

The vegetation on the cultivated brown forest soils, humus-iron podzols and noncalcareous gleys is mainly arable and permanent pastures (*Lolio-Cynosuretum*). Acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) also occurs on brown forest soils, and dry boreal heather moor (part of *Vaccinio-Ericetum cinereae*) is present on the uncultivated humus-iron podzols. Soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires occur on uncultivated gleys, together with white bent-tussock-grass grassland (the *Cirsium palustre-Nardus stricta* Community) and common white bent grassland (part of *Junco squarrosi-Festucetum tenuifoliae*).

The association comprises two map units, one dominated by brown forest soils (75 per cent of the association) and the other by gleys (25 per cent).

Map unit 517 consists of brown forest soils with some humus-iron podzols, noncalcareous gleys and peaty gleys, and the landforms are non-rocky undulating lowlands and hills with gentle and strong slopes. The soils are mainly developed on till but there is some stony drift on the hill tops. The unit covers 27 square kilometres or 75 per cent of the association and it occurs throughout the association area.

The brown forest soils are mostly freely drained and generally cultivated. The humus-iron podzols are mainly confined to hill tops and are uncultivated, and the gleys occur mainly in depressions; most are surface-water gleys, but some are ground-water gleys.

Land use is predominantly arable, but careful management is required to overcome the climate limitation and the limitation of soil shallowness caused by an indurated horizon.

Map unit 518 is a unit of noncalcareous and peaty gleys with some brown forest soils with gleying, and it occurs on non-rocky undulating land with gentle slopes. The soils are mainly developed on indurated till.

The unit covers 9 square kilometres (25 per cent of the association) and it is present throughout the area of the association. The peaty gleys generally occur in the wetter hollows, and the brown forest soils with gleying, mainly cultivated, are developed on low mounds. Most of the land is cultivated, with wetness and climate the main limitations.

THE THURSO ASSOCIATION

(Map units 535–537, 539–541, 543 and 544)*

The Thurso Association consists of soils developed on drifts derived from strata of the Middle Old Red Sandstone Caithness Flagstones. The drifts are of four types:

(1) A greyish brown, compact till of sandy clay loam texture. The till is widespread and has a general thickness of about 1 metre but is locally thinner,

**Map unit 538* is not present in Northern Scotland. The areas shown as this unit—the two islands off the north-east coast of Caithness—should be *map unit 83*, the Canisbay Association.

particularly on higher ground, and much thicker where it occurs as the partial infillings of valleys and bays; this thicker till is calcareous below depths of about 1.2 to 2 metres.

(2) A brownish shallow stony till of sandy loam, loam or sometimes sandy clay loam texture. Also widespread, this till is generally 50–100 centimetres thick, the upper part of it usually being indurated and the lower part friable.

(3) Hummocky moraine of loamy sand or sandy loam texture. This type is similar to the shallow stony till in colour and stoniness, but it generally has a coarser texture and is thicker. It is much less common than the previous two types.

(4) Partially sorted material of loamy sand or sandy loam texture. This type often overlies the compact till of sandy clay loam texture, but is very local in extent.

The association covers an area of 626 square kilometres (3.8 per cent of the land area) and almost all of it lies in the north-eastern part of Caithness. It extends from sea level to 280 metres, although most of it occurs below 100 metres. The landforms are predominantly non-rocky lowlands with gentle or occasionally strong slopes. Some rocky land occurs mainly in the southern and western areas of the association, and there are some mainly small areas of hummocky moraine landforms.

The average annual rainfall ranges from less than 750 millimetres in the drier eastern parts around Wick to over 900 millimetres in the Dounreay area. Most of the lower ground—below about 60 metres—has an exposed, fairly warm and moderately dry climate, with some very exposed areas around the coast and some moderately exposed land in the valleys of the Wick and Thurso rivers. Between 60 and 120 metres the climate is exposed, cool and moderately dry, and above 120 metres it is exposed, cool and wet.

The Thurso Association covers much of the farming land in Caithness and most of the soils are cultivated. Mineral soils, comprising brown forest soils, brown rankers and noncalcareous gleys, are widespread. The brown forest soils are developed on the shallow stony till and on the moraine. They are freely and imperfectly drained. A dark brown Ap horizon overlies a yellowish brown strongly indurated B horizon; soils developed on the shallow drift overlie rock at about 75 centimetres, but those on the moraine have deeper profiles. The indurated horizon has a coarse platy structure, commonly with reddish iron staining or black manganese mottles on the faces of the plates, fine pores, and fine sand or silt linings to stone cavities. Sometimes an iron pan, or the trace of one, is present on the upper surface of the indurated horizon. It seems likely that most of these brown forest soils have been developed from peaty podzols by cultivation over a long period.

In the brown rankers a dark brown Ap horizon overlies rock at 20 to 30 centimetres, or sometimes more. There is usually a sharp boundary with the rock, where a root mat is present.

The noncalcareous gleys are mainly poorly drained surface-water gleys developed on the compact till of sandy clay loam texture. Below a dark brown or dark greyish brown Ap horizon the soils have sandy clay loam textures and grey colours with mottles of high and medium chroma. The structure in the upper part of the Bg horizon is commonly coarse prismatic, with grey sandy coatings on the prism faces and strong ochreous mottling within the peds. Rock is often present at around 100 centimetres, but deeper profiles, often calcareous below about 120 centimetres, occur in areas where the till is thicker. Noncalcareous

gleys are also developed on the partially sorted drift. Profile morphology is varied, depending on the thickness of the material overlying the compact till.

Along the exposed coastal cliff-tops a narrow band of saline gleys is often present, formed as a result of the constant exposure to sea-spray.

The peaty soils comprise peaty gleys, peaty podzols and peaty rankers. The peaty gleys are developed on the compact till and on the shallow stony till; typical profiles have organic staining in the upper part of the Eg horizon. In some, a greyish brown indurated B horizon is present. The peaty podzols are developed on the shallow stony till and on the moraine; the Eg horizon is usually much thinner than those of other peaty podzols in Northern Scotland, and a Bs horizon is usually present over a paler, indurated horizon. The peaty rankers usually have O and Eg horizons similar to those of the peaty podzols. The peat is dystrophic, mainly deep and unflushed.

Much of the land covered by the mineral soils of the Thurso Association comprises arable and permanent pastures (*Lolio-Cynosuretum*), with, in addition, some soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge communities such as star sedge mire (*Caricetum echinato-paniceae*) on the noncalcareous gleys, and acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*) and herb-rich Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) on the brown forest soils and brown rankers. The peaty podzols carry moist Atlantic heather moor (part of *Carici binervis-Ericetum cinereae*) as do some of the peaty gleys and shallow peat, the rest supporting bog heather moors (*Narthecio-Ericetum tetralicis*). Lowland and northern blanket bogs (parts of *Erico-Sphagnetum papilloso*) are present on the deep peat. The saline gleys are colonized by a mosaic of vernal squill maritime pasture (the *Scilla verna-Festuca rubra* Community) and sea plantain-crowberry heath (the *Plantago maritima-Empetrum nigrum* Community).

There are eight map units in the Thurso Association: four are dominated by mineral soils and account for nearly 80 per cent of the association and the other four (20 per cent) are dominated by peaty soils and peat.

Map unit 535 comprises brown forest soils and brown rankers with some noncalcareous gleys. The associated landscape is mainly non-rocky undulating lowland with gentle and strong slopes, although in the Ulbster district to the south of Wick the unit is found on slightly rocky, ridged topography. The map unit covers 96 square kilometres, (15 per cent of the association) and is a common unit throughout the arable land in Caithness. Almost all of it is found below 100 metres.

The brown forest soils, developed on the shallow stony till, are usually more extensive than the brown rankers, although in one or two areas, notably north of Halkirk and in the Ulbster district, the brown rankers are dominant. The noncalcareous gleys, developed on the sandy clay loam till, form only a minor component of the unit and in some areas may be absent. Other soils which can be present locally as small patches include mineral alluvial soils and peat; in general, the more extensive areas of the unit are the ones more likely to have these minor inclusions.

Most of the land is cultivated. In addition to climate, which has an overall limiting effect on agriculture in Caithness, there is the additional limitation of shallowness of rooting depth caused by the proximity of an indurated horizon or rock in the brown forest soils and brown rankers. Soil wetness, requiring artificial drainage, affects the agricultural capability of the small patches of noncalcareous gleys.

Map unit 536, a small unit of only 5 square kilometres (less than 1 per cent of the association), comprises noncalcareous gleys developed on partially sorted material of loamy sand or sandy loam texture overlying compact till of sandy clay loam texture. It occurs on gentle slopes in the district around Wick. Land use is mainly arable.

Map unit 537 consists of noncalcareous gleys with some peaty gleys, brown forest soils and brown rankers, and it is associated with gently undulating lowlands with gentle slopes (Plate 13). The unit occurs mainly below 100 metres. It covers 383 square kilometres (61 per cent of the association) and is particularly extensive between Dounreay and Wick.



Plate 13. *Arable land near Lyth, Caithness, with dominantly noncalcareous gleys (map unit 537, Thurso Association). Class 3.2 land.*

The noncalcareous gleys and some of the peaty gleys are developed on the compact till of sandy clay loam texture; the other peaty gleys and the brown forest soils occur on the shallow stony till. A number of small patches (less than 1 square kilometre) of mineral alluvial soils and peat, including a few basin peat deposits, occur locally throughout the unit.

Land use is mostly arable. Climate and wetness are the main limitations affecting the agricultural capability. Artificial drainage schemes are required, and the use of permeable fill up to the base of the Ap horizon is desirable to ensure that surface water flows more readily into the drain-pipes. The limitations affecting the small patches of brown forest soils and brown rankers in the unit are as described for *map unit 535*.

Map unit 539 is a unit of brown forest soils with some noncalcareous gleys, and it occurs on hummocky moraine. The unit covers 8 square kilometres (1 per cent of

the association) and is present near Halkirk and Watten. The brown forest soils are on the mounds and the noncalcareous gleys, generally developed on colluvial material, in the hollows between the mounds. Some of the hollows are peaty.

Land use is mainly arable. Limitations which affect the agricultural capability are soil shallowness in the brown forest soils due to an underlying indurated horizon, soil wetness in the noncalcareous gleys, and the overall one of climate.

Map unit 540 consists of peaty podzols and peat developed on hummocky moraine (Fig. 7). It covers only 1 square kilometre (less than 1 per cent of the association) and it occurs only in one area, lying to the west of Loch Calder. The peaty podzols are developed on the mounds and the peat is present in hollows and on flats between the mounds. Land use is rough grazing. The land is marginally improvable for use as grassland, the wetness of the peaty surface being limiting.

Map unit 541, comprising peaty podzols, is another very small unit of the Thurso Association. It occupies 1 square kilometre (less than 1 per cent of the association) and it occurs in only one area — near West Dunnet. The associated topography is gently and strongly sloping. The soils are developed on sandy clay loam till and are slightly different from the normal peaty podzols of the Thurso Association, having ochreous and grey mottling in the B and C horizons. The land is used for rough grazing but is marginally improvable, soil wetness being the limiting factor.

Map unit 543 is one of dominantly peaty gleys. It covers 63 square kilometres (10 per cent of the association) and it occurs mainly in the higher parts of lowland Caithness between 50 and 120 metres and on fringes of areas of peat. The associated landform is undulating with gentle and strong slopes (Fig. 6).

The peaty gleys are developed on till of sandy loam, loam and sandy clay loam textures. Some of the peaty gleys have indurated subsoils. Locally, the map unit includes noncalcareous gleys, brown forest soils and peat as minor components.

The land is used mainly for rough grazing but some has been reclaimed. All the areas of this unit are marginally suitable for use as grassland, since climate limitations are not too severe, but soil wetness, particularly the presence of a peaty surface horizon, is a major limiting factor affecting the agricultural capability of this type of land.

Map unit 544 is a unit of peaty podzols and peat with some peaty gleys and peaty rankers. It occurs on slightly or moderately rocky undulating lowland and stepped hill sides, and the landscape often has a strong pattern of ridges, knolls and hollows or flats. A wide range of slopes is present. The unit covers 69 square kilometres (11 per cent of the association), occurring near Dunbeath, Achavanich, Camster and Thrumster in south-east Caithness, in the Ben Dorrery district of west Caithness, and at Holborn Head near Thurso.

The drift cover is thin over much of the unit and soil profiles are generally shallow. Peaty podzols occur on the steeper parts of the unit and peaty rankers on the tops of rock knolls, ridges or steps; peaty gleys and peat are present on the gentle slopes. At Camster the pattern is one of rock knolls with peaty podzols and peaty rankers separated by flat areas of deep blanket peat; at Holborn Head the soils are somewhat less peaty and comprise peaty gleys or noncalcareous gleys on the more level ground between the rock ridges, and peaty rankers and shallow peaty gleys on the rock ridges.

Land use is limited to rough grazing, mainly by the strong pattern of shallow

soils, rock outcrops, short steep slopes, and wet hollows and flats. The moorland plant communities provide grazings of only low value. Some land marginally suitable for use as improved grassland is present where the pattern is less intense, for example in the Dorrery area.

THE TIPHERTY/CARDEN ASSOCIATIONS

(Map unit 545)

These two associations, both comprising soils developed on fluvioglacial or lacustrine silts and clays derived from Old Red Sandstone sediments, have been grouped together on the 1:250 000 soil map. Only the Carden Association occurs in Northern Scotland. The parent material is a reddish glaciolacustrine silty clay, well bedded, with occasional thin layers of coarser material. There is only one map unit and its description is combined with that of the association.

The association covers 6 square kilometres (less than 0.1 per cent of the land area) and it occurs in four small areas to the west of Elgin at altitudes of up to 45 metres on undulating lowland with gentle slopes. The average annual rainfall is around 650 millimetres and the climate is warm, moderately dry and moderately exposed.

The soils are predominantly brown forest soils with gleying. The Ap horizons often have a loam texture, the relatively high sand content compared with the silty clay or clay B and C horizons being due to the incorporation of windblown sand. The reddish brown B and C horizons have a coarse prismatic structure although it is only weakly developed in the C horizon. A high base status is common. Small patches of poorly drained gleys occur locally.

All the soils are cultivated and limitations affecting agriculture are only minor.

THE TORRIDON ASSOCIATION

(Map units 553–561)

The Torridon Association comprises soils developed on drifts derived from Torridonian strata. These rocks are mostly reddish feldspathic sandstones and grits and they give rise to drifts that are characteristically reddish or pinkish, stony and with predominantly loamy sand textures. The drifts are of four main types:

- (1) Till, common on the lower ground. Locally, where shales have contributed to the composition of the till, the texture is a sandy clay loam. In rocky areas the till has a patchy distribution and some of it is shallow.
- (2) Hummocky moraine, extensive in valleys.
- (3) Colluvium, present on the hill and valley sides.
- (4) Cryogenic material, found on the mountain tops; in some places it is overlain by patches of windblown sand up to 1 metre thick.

The association covers 1384 square kilometres (8.4 per cent of the land area) and is the third largest association in Northern Scotland. It occurs extensively in the west between Applecross and Cape Wrath, the largest area being in Wester Ross. The overall altitude range is from sea level to over 1000 metres, and much of the land is rocky and bouldery.

The average annual rainfall ranges from 1200 millimetres at the coast to 3200 millimetres on the highest ground. The climate regions range from fairly warm moderately dry or wet at the coast through cool and wet to cold and wet on the

higher ground. Most of the association lies in the exposed and very exposed categories, with some moderately exposed land in the more sheltered lowland valleys, and some extremely exposed land on the high mountain tops.

The soils of the Torridon Association have textures mainly of loamy sand or sandy loam and a large proportion have a peaty surface horizon overlying a gleyed horizon. The dominant soils are peaty gleys, peaty podzols, peaty rankers and dystrophic peat. The peaty gleys are strongly gleyed and the reddish colour of the parent material is not always evident in the upper part of the soil profile. The peaty podzols are usually strongly gleyed above an iron pan and have either a friable or an indurated B horizon immediately below the pan. Shallow and deep peat are both present.

Subalpine and alpine soils—mainly podzols but with some gleys—together with noncalcareous regosols and lithosols are the dominant soils on the mountains above about 400 metres. Brown forest soils, humus-iron podzols and humic gleys are of minor extent and occur mainly on the lower ground below 200 metres.

The vegetation consists predominantly of extensive areas of moorland communities, particularly bog heather moors (*Narthecio-Ericetum tetralicis*) and blanket bog communities (*Erico-Sphagnetum papillosum*) associated with the peaty soils and peat. The peaty gleys and shallow peat, together with some of the peaty podzols and peaty rankers, support bog heather moor and its northern form, while the rest of the peaty podzols and peaty rankers carry moist or northern Atlantic heather moors (parts of *Carici binervis-Ericetum cinereae*). The deep peat mainly carries lowland or northern blanket bog, with some terminal phase of blanket bog where the peat is hagged. Upland blanket bog (part of *Erico-Sphagnetum papillosum*) and mountain blanket bog (*Rhytidadelpho-Sphagnetum fuscum*) occur at the higher altitudes.

On the subalpine and alpine soils the vegetation includes alpine azalea-lichen heath (*Alectorio-Callunetum vulgare*) and fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosum*), together with some stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association) and some lichen-rich boreal heather moor (part of *Vaccinio-Ericetum cinereae*). The vegetation cover is patchy and there is much bare ground.

The cultivated humus-iron podzols and gleys have arable or permanent pastures (*Lolio-Cynosuretum*), the brown forest soils and brown rankers support acid bent-fescue grassland (part of *Achilleo-Festucetum tenuifoliae*), and the humic gleys carry soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires. Some steeper areas with brown forest soils and humus-iron podzols carry hazel scrub (part of *Primulo-Quercetum*) and oak or birch woodland (*Blechno-Quercetum*).

There are nine soil map units in the association. Five of them have peaty soils and peat, and together account for 79 per cent of the association, two map units have subalpine and alpine soils, amounting to about 18 per cent, and two, in which mineral soils predominate, account for only 3 per cent.

Map unit 553 consists of humus-iron podzols and humic gleys on non-rocky, occasionally slightly rocky, lowland with gentle and strong slopes. It covers 21 square kilometres (2 per cent of the association) and it occurs in small patches on the west coast between Gairloch and Stoer, mostly lying between sea level and 50 metres.

The soils are developed on till. The humus-iron podzols are freely and imperfectly drained and their profiles have been disturbed by cultivation; many may formerly have been peaty podzols. Similarly the poorly drained humic gleys

may have been developed from peaty gleys. Some coastal areas between Gairloch and Ullapool include a narrow fringe of raised beach sands and gravels, too small to indicate on the soil map; the soils are similar to those of *map unit 97* of the Corby Association. Land use is crofting, those soils which are no longer cultivated supporting pasture communities. The main factors affecting the agricultural capability of the land are climate, particularly exposure, and soil pattern.

Map unit 554 comprises peaty podzols, peat and peaty gleys developed on hummocky valley moraine (Fig. 7). It covers 142 square kilometres (10 per cent of the association) and occurs mainly between Loch Carron and Loch Maree in Wester Ross.

The surface of the valley moraine is usually strewn with boulders and blocks of Torridonian sandstones and grits, some of which can be more than 3 metres across. The topography is varied. The moundiness is generally highly pronounced, particularly in Glen Torridon (Plate 14), with the mounds tightly packed and only small hollows lying between them. In some areas, notably at Coudoran near Kishorn, the mounds are more widely spaced, separated by channels and flats.



Plate 14. *Very bouldery, hummocky valley moraine in Glen Torridon, Wester Ross (map unit 554, Torridon Association). The unit consists of peaty podzols on the mounds and peaty gleys and peat in the channels and basins. Map unit 192 (Durnhill Association) occurs on the hills in the background. Institute of Geological Sciences photograph published by permission of the Director: NERC copyright.*

Peaty podzols, together with some peaty gleys and shallow peat, are developed on the mounds, with peaty gleys, shallow peat and deep peat in the hollows and channels, and deep peat on the flats between the mounds. Above about 350 metres subalpine podzols are often present on the tops and sometimes on the sides of the mounds, a consequence of the greater degree of exposure at those levels due to the funnelling effect of the wind through the valleys.

Land use is almost entirely rough grazing and deer-forest. The land is not

suitable for improvement, limiting factors being the steep slopes of the mounds, the amount of boulders littering the surface, and the wetness of the hollows, channels and flats; above about 200 metres, climate limitations are overriding. The moorland plant communities provide grazing of only low value.

Map unit 555 comprises brown forest soils and brown rankers with some humic gleys and peaty podzols. It occurs on moderately rocky valley sides with strong to very steep slopes. Most areas lie between sea level and 200 metres but at Loch Coulin the map unit occurs at up to 500 metres. The soils are developed on stony colluvium. The unit covers 19 square kilometres (1 per cent of the association) and it forms a few small patches mainly around Loch Torridon. The land use is dominantly rough grazing, and the grassland communities have high grazing values. Much of the land is too steep to be improved.

Map unit 556, comprising peaty gleys and peat with some peaty podzols, occurs on non-rocky undulating lowland and hill sides with gentle and strong slopes (Fig. 6). The soils are developed on till. It is an extensive unit, covering 324 square kilometres (23 per cent of the association) and is widespread throughout the area of the association.

The dominant soils are peaty gleys, shallow peat and deep peat, the deep peat often forming large discrete areas of up to 1 square kilometre. The peaty podzols tend to occur on the steeper parts of the landscape. Some small patches similar to *map unit 553* but too small to show on the 1:250 000 soil map are present along the west coast between Gairloch and Ullapool, and some small rocky areas, similar to *map unit 557*, can occur locally elsewhere.

Land use is primarily rough grazing. The main limiting factors are soil wetness due to the predominance of peaty soils and peat, and climate. Below about 200 metres much of the land is marginally suitable for use as improved grassland although the patches of deep peat are too wet to be improvable. Above this altitude, the climate limitation overrides all other factors and makes the land unsuitable for improvement. The moorland plant communities provide rough grazing of only low value.

Map unit 557 consists of peaty gleys and peat with some peaty podzols and peaty rankers; it occurs on moderately rocky, strongly undulating and hilly land with mainly gentle and strong slopes, but also including many short steep slopes (Plate 15 and Fig. 8). The soils are developed on till and colluvium, the drift cover often being shallow. The unit covers 456 square kilometres (33 per cent of the association) and is the most extensive unit in the association. It is widespread in the Applecross peninsula.

Differential erosion of the Torridonian strata, and of the many joints which cut across them, has produced a complex topography of rock ridges, knolls, channels, and terraced or stepped hill sides. The peaty gleys, shallow peat and deep peat occur on the more gently sloping parts of the unit, the deep peat being particularly associated with channels and flats between rock outcrops. The peaty rankers are associated with the rock outcrops, and the peaty podzols are present on the lower sections of the short steeper slopes where the drift is generally thicker. Some areas of this unit include small patches (less than 1 square kilometre) similar to the *map units 556* (non-rocky land), *558* (very rocky land) and *559* (steep rocky land).

Land use is rough grazing and deer-forest. The factors which preclude

improvement are topography and wetness. The small included patches of non-rocky land referred to above are marginally improvable where they occur at altitudes of less than about 200 metres (above this height the climate is limiting) provided they do not contain more than about 50 per cent of deep peat. The moorland plant communities provide grazing of low value.



Plate 15. *Torridon Association landscape, Quinag, Sutherland* Peaty gleys, peaty rankers and peat occur on moderately rocky (map unit 557) and very rocky (map unit 558) land. Lithosols, rankers and noncalcareous regosols, together with crags and scree, are found on the very steep slopes of Quinag (map unit 561). Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Map unit 558 is a unit of peaty gleys, peaty rankers, peat and some peaty podzols. It occurs on very rocky or extremely bouldery land, largely rugged hills and hill sides with mainly gentle and strong slopes but it includes some steep and very steep slopes (Plate 15 and Fig. 9). The main differences between this unit and the previous one (*map unit 557*) are that the associated landform is more rocky, the drift cover is thinner and more patchy, and the proportions of soils are different, there being less deep peat and more peaty rankers.

The map unit covers 113 square kilometres (8 per cent of the association) and the main areas lie in Coigach, around An Teallach, near Loch Maree and to the south of Loch Torridon.

The peaty gleys, peaty rankers and peaty podzols are developed on the patchy cover of shallow drift, and the peat, mainly deep hagged peat, occurs in channels and as small patches on the horizontal or gently dipping sandstone slabs.

Land use is restricted largely by topography to rough grazing and deer-forest, the moorland plant communities providing grazing of low value.

Map unit 559 consists of peaty gleys and peaty podzols with some peaty rankers; it is found on moderately and very rocky hill sides with steep and very steep slopes.

The rock outcrops are usually in the form of rock bands or crags, and scree is sometimes present. The soils are developed on colluvium.

Compared with *map units* 557 and 558, the slopes are much steeper, peaty podzols are more common and there is little or no peat present. The map unit covers 65 square kilometres (5 per cent of the association) and is present mainly in the Applecross–Torridon area and in the Inverpolly Forest.

The steep rocky slopes restrict the land use to rough grazing and the moorland plant communities have low grazing values.

Map unit 560 comprises subalpine podzols and deep peat occurring on non- to very rocky undulating or mounded land in upland areas, with slopes gentle and strong. The unit covers 8 square kilometres (less than 1 per cent of the association) and it occurs in a few small patches mainly on the hills to the south of Loch Torridon.

The subalpine podzols are developed on cryogenic drift on mounds whose form is controlled by the underlying rock; deep peat, usually hagged, is present between the mounds. Some noncalcareous regosols, developed on windblown sand, occur locally.

Land use is restricted to rough grazing by the overriding climate limitation, and grazing values are low.



Plate 16. Summit plateau of Beinn Liath Bheag, Wester Ross. Map unit 561 (Torridon Association), in the foreground, has a patchy vegetation cover of oroarctic plant communities on subalpine and alpine podzols with bare rocky and bouldery areas between. The typically very bouldery map unit 192 (Durnhill Association) occurs at the far end of the plateau. Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Map unit 561 consists of subalpine soils, alpine soils, noncalcareous regosols and lithosols. It occurs in mountain areas and has a wide range of slope and rock class. The soils are developed on cryogenic and colluvial material, with some windblown sand. The map unit covers 236 square kilometres (17 per cent of the association) and is found mostly in Wester Ross. It occurs mainly above about 400

metres, although on some hills, such as Liathach, it extends considerably below this level to include the crags and scree.

The associated landform comprises mountain sides, summits, ridges and plateaux. The mountain sides have steep and very steep slopes, often with crags and scree (Plate 15). The soils are developed on stony colluvium and are mainly noncalcareous regosols, although peaty gleys, peaty podzols and peaty rankers may be present on the lower parts of the slopes. The summits, ridges and plateaux are undulating, with gentle and strong slopes (Plate 16). The surface is usually extremely stony and bouldery with patterned-ground features such as solifluction lobes and terraces. Subalpine and alpine podzols, with some gleys, are developed on cryogenic drift. Patches of windblown sand on which noncalcareous regosols are developed occur on some of the mountains such as An Teallach and Ben Mor Coigach. This unit is found in a number of different forms, ranging from the one in which steep rocky slopes with crags and scree predominate (such as on Suilven and Liathach) to the one of smooth rounded hills in the far north-west of Sutherland, where steep craggy slopes are generally absent.

The land above about 650 metres has little agricultural value and below is restricted to rough grazings. Climate is the overriding limiting factor although topography and soil would also be limiting. The mountain heaths provide grazing of low value although small patches of stiff sedge-fescue grassland, which have moderate grazing values, can be locally present.

THE TYNET ASSOCIATION

(Map units 565-567)

The soils of the Tynet Association are developed on drifts derived from sandstones and conglomerates of Middle Old Red Sandstone age. The drifts are normally red or reddish brown and the texture a sandy loam or loam in the upper part, becoming finer with depth. Rounded pebbles of quartzite, quartz-schist and granite, all derived from the conglomerates, are common in the drift together with angular fragments of sandstone and fine conglomerate.

The association covers 44 square kilometres (0.3 per cent of the land area) and stretches from Buckie south-westwards to the Spey valley. Most of it lies in the foothills which border the coastal lowlands; slopes are gentle and strong, locally steep. A common feature of the landscape is the deep gullying of the soft rocks, although rock outcrops are rare. Overall the association ranges in altitude from 30 to 270 metres.

The average annual rainfall is between 700 and 900 millimetres and the association lies in the fairly warm, moderately dry climate region. The exposure categories are mainly moderate, with some exposed on the higher ground.

The soils of the Tynet Association are stony, have a sandy loam or loam texture, and are very largely podzols. Humus-iron podzols, mostly freely drained but locally imperfectly drained, are extensive; peaty podzols, freely to imperfectly drained above an iron pan, are less common and largely confined to the higher ground. An indurated B horizon is a common feature in all these podzols. Noncalcareous, humic and peaty gleys occur locally.

The two main forms of land use are forestry and arable agriculture, forestry covering the greater part of the association. Excluding the afforested land, the vegetation on the humus-iron podzols consists of arable and permanent pastures (*Lolio-Cynosuretum*) on the lower ground with some boreal heather moors (*Vaccinio-Ericetum cinereae*) on the higher land. Those peaty podzols which

have not been afforested carry boreal heather moors and Atlantic heather moors (*Carici binervis-Ericetum cinereae*). The vegetation on the gleys includes permanent pastures (*Lolio-Cynosuretum*) on the noncalcareous gleys, soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) and sedge mires on the noncalcareous and humic gleys, and bog heather moors (*Narthecio-Ericetum tetralicis*) on the peaty gleys.

The Tynet Association comprises three map units: the first is a unit of gleys, the second, and the most extensive unit in the association, is dominated by humus-iron podzols, and the third consists mainly of peaty podzols.

Map unit 565 consists of noncalcareous gleys with patches of humic gleys, peaty gleys and peat, and it occurs on undulating lowlands, mainly in receiving sites, with gentle slopes. Four small areas lying to the north-west of Keith together cover 2 square kilometres (less than 5 per cent of the association). Most of the unit is afforested. Wetness, and to a lesser extent climate, are the main factors affecting the agricultural capability of the land.

Map unit 566 comprises humus-iron podzols with some gleys and peaty podzols, and it occurs on undulating lowlands and hills with gentle and strong slopes. It covers 30 square kilometres and makes up 70 per cent of the association.

Humus-iron podzols, the dominant soils, are mostly freely drained, with imperfectly drained soils occupying some of the gentle slopes. The gleys are locally present in receiving sites, and the peaty podzols are restricted to the higher ground.

Land use is almost evenly divided between arable farming on the lower ground and coniferous plantations on the higher ground. Climate is the major limiting factor and at the higher altitudes restricts the agricultural capability of the land to the production of grass.

Map unit 567 consists of peaty podzols with some freely and imperfectly drained humus-iron podzols, and the associated topography comprises non-rocky hill and valley sides with gentle to steep slopes. The unit mostly occurs above 150 metres on the higher ground to the south of Fochabers, where it covers 12 square kilometres (25 per cent of the association).

Almost all of the map unit is afforested. Climate, and to a lesser extent soil wetness, are the factors which restrict the agricultural potential of this land to use as improved grassland.

BUILT-UP AREAS

Built-up areas occupy 54 square kilometres (0.3 per cent of the land area) and occur mainly in the Moray Firth Lowlands.

3 Land Evaluation

Earlier chapters of this book have described the main natural resource attributes of Northern Scotland (climate, 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 a range of possible uses of the land units, 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 static, but must be reviewed periodically and repeated when significant changes take place in any of the human resources.

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 *et al.*, 1982). An explanation of its broad principles and the parameters used in its application in Northern 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 presentation 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 NORTHERN SCOTLAND

Climate

The climate of Northern Scotland has been described in Chapter 1 in terms of rainfall, potential water deficit, accumulated temperature and exposure, and the climate regions of the area shown in Fig. 4. The most favourable climate is found in the Moray Firth Lowlands, wherein lies most of the arable land; the climate is warm or fairly warm, moderately dry, and moderately exposed with some sheltered land around the heads of the firths and in the straths. Cereal production forms an important part of the agriculture. Arable land is extensive on the lower ground of the northern part of Caithness. The climate is cooler and slightly wetter than that of the Moray Firth Lowlands, although the area lies in the fairly warm, moderately dry region; the land is however, more exposed, and overall the climate is more limiting on agricultural capability. The pattern of farming is basically one of small stock-rearing units.

The foothills of the Grampian Highlands have a fairly warm, moderately dry, moderately exposed climate; the land is used for forestry, stock-rearing and grouse-moor. Small areas of crofting lands are to be found along the north and west coasts of the Northern Highlands; the climate is mainly fairly warm and moderately dry or wet, but the land is exposed or very exposed. Upland areas with exposed cool and wet climates are either uncultivated or have agricultural enterprises based on grass production, whereas the areas which lie in the cold or very cold, wet, exposed and very exposed regions are largely restricted to rough grazing, deer-forest or grouse-moor.

Gradient

Gradient affects the use of agricultural machinery on land. Although general limits of operation are recognized — up to 11 degrees for a combine-harvester, 15 degrees for a 2-wheeled drive tractor with fully mounted equipment, and 25 degrees for a 4-wheeled drive tractor with trailed equipment — the nature of the slope has to be taken into account; wet slopes, for example, provide less traction than dry slopes, and on steep peaty slopes there is the danger of tractors 'rafting' downslope.

The main arable areas have slopes of generally less than 11 degrees; in the Moray Firth Lowlands, level or gently sloping raised beaches are common on the lower ground, and in Caithness much of the land is also level or gently sloping. Some of the crofting land on the west coast is situated on gently sloping raised beach terraces. Throughout much of the uncultivated land in the northern areas, slopes are only gentle and strong, but climate and wetness preclude cultivation.

Steep and very steep slopes are a dominant feature of the landscape in the western and southern parts of the Northern Highlands. Although in theory, slopes up to 25 degrees can be suitable for use as improved grassland, particularly where brown forest soils or humus-iron podzols are present, in practice a much lower figure is the upper limit of improvement.

Soil

Soil factors which can affect the agricultural capability of the land are numerous and include shallowness, stoniness, texture, structure, droughtiness and inherent fertility.

Soil shallowness relates to the thickness of material available to the plant roots, and is a common limitation in the arable soils of Northern Scotland. In Caithness, a shallowness limitation occurs in freely and imperfectly drained soils and can be due either to an indurated horizon or to rock close to the surface, whereas in the Moray Firth Lowlands, shallowness due to induration is a feature of soils developed on till.

Stoniness, coarse textures and weak structures can also be important factors affecting particularly the agricultural capability of much of the land in the Moray Firth Lowlands. Soil droughtiness affects many of the soils in the low rainfall area of the Moray Firth Lowlands, particularly those developed on coarse-textured fluvioglacial and raised beach sands and gravels.

Many of the soils in Northern Scotland have an inherently low fertility, particularly those developed on fluvioglacial or raised beach sands and gravels derived from acid rocks. Such soils are low in trace elements, particularly copper and cobalt, as well as being low in plant nutrients. Manganese deficiency is associated with the soils developed on the shelly sands of the Fraserburgh Association.

Wetness

Soil wetness affects land management in terms of workability, trafficability and poaching risk—wet soils have low workability and trafficability, but high poaching risk. Many of the cultivated soils in the Moray Firth Lowlands are freely or imperfectly drained and have no wetness limitations, but in Caithness most of the cultivated land has poorly drained surface-water gleys. Poorly drained soils under regular cultivation need artificial drainage, those developed on parent materials of moderately fine or fine texture requiring permeable infill for optimum effect.

Soils with a peaty surface horizon, extensive throughout the Northern Highlands, are marginally suitable for use as improved grassland provided other factors such as climate or topography are not restricting, but there can be high poaching risks particularly in high rainfall areas. Peat is generally too wet for use other than rough grazing. In Caithness, however, many small patches have been reseeded or even cultivated where they adjoin large areas of deep peat, although this is generally done to 'square-off' arable fields rather than as a direct attempt to reclaim the peat. In the Moray Firth Lowlands, basin peats have been successfully reclaimed.

Alluvial land can be subject to flooding. Where there is a high risk of damage to crops by flash-flooding, cultivation is precluded.

Erosion

Wind erosion is a major hazard in areas of windblown sand, where there is rarely a complete cover of vegetation. Such areas are not, therefore, suitable for regular cultivation. It is also a problem, occasionally a severe one, on the sandy soils of the low rainfall area in the Moray Firth Lowlands east of Inverness if harrowing, discing or rolling activities in spring should coincide with a period of strong south-west winds. Re-sowing of crops is sometimes necessary.

Liability to erosion by water is not a factor likely to affect the agricultural capability of the land, but it is an important consideration in the designing of drainage schemes involving open ditches on hill land, where open drains in deep drift constructed at too steep a gradient can lead to too rapid a rate of run-off and consequent gullyng of the land.

Pattern

Rapid lateral variation in soil or land makes land management more difficult; wet hollows can be awkward to drain and may have to be left uncultivated, and rock outcrops or steep slopes can provide obstacles to the operation of machinery. Pattern restricts agricultural practice on rocky land, particularly where brown forest soils or humus-iron podzols which could be cultivated occur between rock outcrops. An extensive area of this kind of land occurs in the Rogart district of east Sutherland. Under an intensive crofting system of management, which can make use of small areas of soil, such areas can be cultivated. Under modern farming systems (which is the management level assumed for the purpose of this capability classification), requiring large areas of more uniform land, this type of ground is more likely to be used for improved grassland.

Throughout the major arable regions of the Moray Firth Lowlands and Caithness, pattern is not generally a limitation except in some areas of the moundier fluvioglacial gravels, where wet hollows, steep slopes, and droughtiness and loss of topsoil at the top of the mounds can all occur within a short distance.

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 Classes 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 *et al.*, 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 levels of yield are consistently high.

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

Cropping is very flexible and a wide range of crops can 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 use as improved grassland.

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

Division 3 Land marginally suited to reclamation and 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.*

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 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.

THE CLASSES AND DIVISIONS IN NORTHERN SCOTLAND

The areas of each land capability class and division are given in Table C. The soil map units are grouped according to land capability class and division in Table D; many units occur in more than one class or division.

There is no Class 1 land in the area, but all the other classes and divisions are present.

Class 2

Class 2 land is capable of producing a wide range of crops. It covers 151 square kilometres (0.9 per cent of the land area) and is restricted to the Moray Firth Lowlands from Easter Ross to Elgin. All the land is non-rocky, and the limitations, which are only minor, include soil and wetness.

Land with minor soil limitations includes some with mineral alluvial soils, and some with humus-iron podzols developed on raised beach sands and gravels, till and water-sorted material overlying till. The limitations include stoniness, coarse texture and slight droughtiness. Those soils developed on raised beach materials generally have a deep, man-made surface horizon.

Class 2 land with minor wetness limitations includes some with mineral alluvial soils, and some with brown forest soils with gleying and calcareous and noncalcareous gleys developed on raised beach, estuarine and lacustrine silts and clays. The gleys are inherently poorly drained, but by means of artificial drainage the water-table has been lowered. This type of Class 2 land occurs in the Spynie basin near Elgin and at the head of the Beaully Firth.

Class 3

Class 3 land is capable of producing a moderate range of crops. It covers 1498 square kilometres (9.1 per cent of the land area) and its overall distribution is restricted by climate to Caithness, the Moray Firth Lowlands, and the foothills and valleys of the Grampian Highlands. The limitations are moderate and include wetness, soil, slope and climate. There are two divisions according to the degree of the limitations.

Division 1 land covers 463 square kilometres (2.8 per cent of the land area). It does not occur in Caithness, where the climate restricts the best possible land to

NORTHERN SCOTLAND

Table C Areas of land capability for agriculture map units

| CLASS and DIVISION | SHEET 3 | | SCOTLAND | |
|-----------------------|---------|----------------|----------|----------------|
| | SQ. KM. | % LAND AREA | SQ. KM. | % LAND AREA |
| 1 | 0 | 0 | 41 | 0.1 |
| 2 | 151 | 0.9 | 1723 | 2.2 |
| 3 | 1498 | 9.1 | 11724 | 15.2 |
| 3.1 | 463 | 2.8 | 4586 | 5.9 |
| 3.2 | 1035 | 6.3 | 7138 | 9.3 |
| 4 | 1400 | 8.5 | 8219 | 10.7 |
| 4.1 | 568 | 3.4 | 3690 | 4.8 |
| 4.2 | 832 | 5.1 | 4529 | 5.9 |
| 5 | 3255 | 19.8 | 14270 | 18.5 |
| 5.1 | 140 | 0.9 | 1810 | 2.4 |
| 5.2 | 755 | 4.6 | 5899 | 7.6 |
| 5.3 | 2360 | 14.3 | 6561 | 8.5 |
| 6 | 9553 | 58.1 | 37329 | 48.4 |
| 6.1 | 79 | 0.5 | 1556 | 2.0 |
| 6.2 | 356 | 2.2 | 5463 | 7.1 |
| 6.3 | 9118 | 55.4 | 30310 | 39.3 |
| 7 | 531 | 3.2 | 2548 | 3.3 |
| BUILT-UP AREAS | 54 | 0.3 | 1233 | 1.6 |
| TOTAL | 16442 | | 77087 | |

1 sq. km. = 100 hectares

Areas in this table have been estimated by point-count methods. Care should be exercised in calculations involving units of less than 10 square kilometres. Discussion of method and estimation of error is contained in Handbook 8.

Class 3.2, but it is distributed throughout the area of Class 3 land as far north as Dornoch in east Sutherland. The land is non-rocky and slopes are predominantly gentle. Limitations are mainly soil factors. A common type of land comprises cultivated humus-iron podzols developed on drifts—mainly tills of sandy loam texture—with shallowness (due to induration) and stoniness the main limitations.

Some of the fluvio-glacial and raised beach sands and gravels are included in Class 3.1 land. The soils are mainly freely drained cultivated humus-iron podzols, and the limitations are a combination of a number of soil factors including coarse textures, weak structures, stoniness, shallowness due to cementation (the 'Moray Pan'), droughtiness, and the hazard of wind erosion.

The Class 3.1 land also includes mineral alluvial soils such as in the Spey and Isla valleys, and a few small areas of gleys which have been improved by artificial drainage.

Division 2 land covers 1035 square kilometres (6.3 per cent of the land area). The land is non-rocky, and limitations include soil, wetness, climate and slope. Some of the land is very similar to that of Class 3.1 land, but the limitations are greater. In the Moray Firth Lowlands, Class 3.2 land mainly includes areas of fluvio-glacial and raised beach sands and gravels, similar to that described in Class 3.1 but with soil factors more limiting. It also includes mounded areas of fluvio-glacial materials where wet hollows, steep slopes on the sides of mounds, and droughtiness and loss of topsoil on the tops of the mounds all combine to give an overall pattern limitation. Class 3.2 land in the Moray Firth Lowlands and the foothills

Table D Soil map units grouped according to land capability classes and divisions

| Class | Division | Soil map units |
|-------|----------|--|
| 2 | | 1, 71, 97, 98, 140, 144, 145, 172, 406, 420, 421, 454, 487, 488, 545 |
| 3 | 1 | 1, 6, 17, 20, 59, 71, 76, 97, 98, 140, 144, 145, 172, 201, 202, 243, 282, 406, 420, 421, 425, 454, 498, 566 |
| | 2 | 1, 6, 17, 19, 20, 59, 60, 74, 76, 97, 98, 100, 144, 145, 146, 172, 182, 202, 204, 241, 243, 316, 370, 405, 406, 420, 421, 424, 425, 454, 497, 498, 517, 518, 535, 536, 537, 539 |
| 4 | 1 | 1, 17, 20, 59, 71, 74, 97, 98, 115, 121, 145, 172, 173, 182, 201, 202, 243, 282, 405, 406, 420, 424, 425, 426, 454, 455, 497, 498, 535, 539, 566 |
| | 2 | 1, 5, 6, 7, 17, 19, 20, 59, 60, 73, 74, 76, 79, 97, 98, 100, 115, 144, 145, 146, 172, 181, 182, 201, 202, 204, 241, 243, 281, 282, 313, 316, 317, 369, 370, 405, 406, 424, 425, 454, 455, 497, 498, 517, 518, 535, 536, 537, 553, 565, 566 |

NORTHERN SCOTLAND

Table D Soil map units grouped according to land capability classes and divisions

| Class | Division | Soil map units |
|-------|----------|---|
| | 1 | 1, 18, 20, 28, 72, 74, 97, 99, 105, 115, 121, 204, 259, 260, 261, 282, 285, 314, 380, 381, 383, 386, 393, 406, 425, 454, 553 |
| 5 | 2 | 1, 5, 6, 7, 18, 19, 20, 21, 22, 23, 25, 26, 28, 59, 71, 76, 97, 100, 101, 103, 106, 115, 117, 121, 172, 174, 175, 182, 201, 202, 203, 204, 241, 243, 244, 245, 260, 282, 313, 314, 315, 318, 370, 380, 386, 387, 391, 393, 420, 421, 424, 425, 426, 454, 497, 498, 499, 500, 555, 566, 567 |
| | 3 | 1, 3, 5, 11, 19, 20, 21, 22, 23, 25, 26, 27, 28, 61, 62, 63, 75, 100, 101, 102, 115, 116, 117, 118, 119, 123, 125, 126, 146, 172, 173, 175, 182, 184, 284, 285, 380, 389, 392, 405, 420, 421, 424, 455, 456, 537, 540, 541, 543, 544, 555, 556 |
| | 1 | 1, 2, 27, 125, 260, 261, 314, 389, 555 |
| 6 | 2 | 1, 3, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33, 83, 101, 122, 125, 128, 186, 204, 282, 285, 315, 380, 382, 389, 391, 393, 420, 421, 454, 555 |
| | 3 | 1, 3, 4, 4d, 4e, 5, 7, 10, 11, 21, 22, 23, 24, 26, 28, 29, 30, 31, 32, 33, 34, 36, 61, 64, 65, 66, 67, 75, 101, 102, 106, 117, 118, 119, 123, 126, 127, 129, 130, 131, 134, 135, 136, 173, 175, 176, 182, 184, 185, 188, 190, 191, 192, 193, 194, 245, 257, 282, 284, 285, 286, 380, 391, 392, 394, 395, 396, 397, 398, 420, 455, 456, 500, 514, 544, 554, 556, 557, 558, 559, 560, 561 |
| 7 | | 4e, 33, 34, 35, 36, 134, 136, 192, 194, 398, 421, 561 |

and valleys of the Grampian Highlands also includes land where limitations are principally shallowness due to an indurated horizon close to the surface, or stoniness, or both, although at higher altitudes, climate can be an overriding limitation. To the south and east of Keith, Class 3.2 land includes some with wetness limitations, the soils comprising noncalcareous and humic gleys.

All the Class 3 land in Caithness is restricted to division 2 by climate. It includes a number of land types. The most extensive comprises areas of noncalcareous gleys, with some cultivated peaty gleys, developed on till of moderately fine texture; this type of land has additional wetness limitations and requires artificial drainage with permeable infill. Another land type has freely and imperfectly drained brown forest soils, where shallowness of rooting material, caused by an indurated horizon or bed-rock close to the surface, is a limitation

additional to the overriding one of climate. Some mineral alluvial soils are included in Class 3.2 and have additional wetness or soil limitations. The extensive area of Class 3.2 land in Caithness includes some patches of wetter land, Classes 5.3 and 6.3, too small to show on the 1:250 000 land capability for agriculture map.

Class 4

Class 4 land is capable of producing a narrow range of crops. It covers 1400 square kilometres (8.5 per cent of the land area) and occurs mainly in the Moray Firth Lowlands and in the Grampian Highlands at altitudes of up to 380 metres, as well as in Caithness, in some of the straths of the Northern Highlands, and in a few places on the west coast. Limitations are moderately severe and include climate, wetness, soil and slope. There are two divisions according to the severity of the limitations. Although the national guidelines indicate that land in this class is suitable for enterprises based primarily on grassland with short arable breaks, much of the Class 4 land in the drier parts of the Moray Firth Lowlands is used for growing barley, rather than grass, as an animal feed.

Division 1 land covers 568 square kilometres (3.4 per cent of the land area). It does not occur on the west coast, where the climate is too severe, but is present throughout the rest of the general area of Class 4 land. The Class 4.1 land is mainly non-rocky with freely and imperfectly drained soils. To the north and west of Inverness, climate is the primary limitation, although shallowness of available rooting depth, due either to an indurated horizon or rock close to the surface, can be an additional factor; the soils are mainly humus-iron podzols with some brown forest soils and locally some mineral alluvial soils.

To the south of the Moray Firth and east of Inverness, the Class 4.1 land is more varied. It includes some of the soils on fluvio-glacial and raised beach materials, where coarse texture, droughtiness, wind erosion and, in some mounded areas, pattern, are all interrelated in their limiting effect. Other Class 4.1 land is limited by soil shallowness due to an indurated horizon or, less commonly, rock lying close to the surface, and only locally is climate an overriding limitation.

Division 2 land covers 832 square kilometres (5.1 per cent of the land area). There are two main types of land and both are non-rocky. One type comprises land with freely and imperfectly drained soils restricted to Class 4.2 by climate. The soils are mainly humus-iron podzols, with a few areas of brown forest soils and brown magnesian soils. This type of land occurs mainly on the fringes of the Grampian Highlands and on the crofting land of the west coast.

The Class 4.2 land also includes areas of gleys restricted to Class 4 land by climate and to division 2 by wetness limitations. Such land is common in Caithness above altitudes of about 60 metres.

Class 5

Class 5 land is capable of use as improved grassland. It covers 3255 square kilometres (19.8 per cent of the land area). With the exception of the higher ground where climate limitations are very severe, this class is found throughout the whole of the area. Limitations are severe and include wetness, slope, soil, pattern, erosion and climate. There are three divisions according to the severity of the wetness, slope and pattern limitations.

Division 1 land covers 140 square kilometres (0.9 per cent of the land area) and it has a scattered distribution.

Rocky land with freely and imperfectly drained soils, and slopes mainly less than 11 degrees is included in Class 5.1 land. The amount of rock precludes regular cropping but is not too great to prevent the land from being used as improved grassland, although in crofting areas some cultivation may take place. The soils are mainly brown forest soils, humus-iron podzols and, occasionally, peaty podzols; some brown rendzinas are present at Durness. Small patches of noncalcareous or humic gleys may be included in some areas.

Some non-rocky, gently or strongly sloping land with humus-iron podzols is restricted to Class 5.1 by climate.

Class 5.1 land also includes areas of windblown sand — most of the Fraserburgh and some of the Links Association — where the main limitation is that wind erosion will occur if the vegetation cover is damaged. In such areas, only surface treatments are suitable. Other factors include the coarse texture, weak structure, poor development of a surface horizon, and, in the Fraserburgh Association, a high pH value which commonly induces trace element problems, especially manganese deficiency. This type of land often includes a narrow coastal fringe of dunes, land which is not suitable for improvement but is too small to delineate on the map.

Some narrow areas of freely and imperfectly drained mineral alluvial soils are included in Class 5.1 land because of flooding risks; examples are found in Strath Brora, in the Strath of Kildonan, and in Strathglass.

Division 2 land covers 755 square kilometres (4.6 per cent of the land area). To the south of the Moray Firth and east of Inverness, much of Class 5.2 land is on non-rocky slopes with humus-iron podzols or peaty podzols. North and west of Inverness, Class 5.2 land is less common. It includes rocky land with brown forest soils, humus-iron podzols, and some gleys; the land is generally undulating or hilly, and slopes can be up to 15 degrees. Pattern is the main limitation. Some areas of this type of land include small patches of Class 4 land where rockiness is not limiting, and small wet or very steep patches of Class 6 land, but these are too small to indicate on the 1:250 000 map. Areas of hummocky moraine with humus-iron podzols or brown forest soils on the mounds and gleys or peat in the hollows are mainly Class 5.2 land; pattern of drainage classes, together with the strongly sloping sides of the mounds, are the main limiting factors. Such land is found in Strath Brora.

Division 3 land covers 2360 square kilometres (14.3 per cent of the land area) and it occurs extensively in central and east Sutherland, but less commonly throughout the rest of the area. There are two main types of land, one with wetness limitations and the other with slope limitations.

Extensive areas of Class 5.3 land are non-rocky with gentle or strong slopes and peaty gleys, peaty podzols (with strongly gleyed E horizons) and peat. In the area to the north and west of the Great Glen, this type of land is found below about 250–300 metres in the east, but 200 metres in the west; above these altitudes climate restricts the land to Class 6. To the south and east, however, Class 5.3 land can extend up to 450 metres. Wetness is the main limitation, the peaty surface horizons having low trafficability and high poaching risk. Some of the land is limited to Class 5 by climate. Up to 60 per cent of deep peat, too wet to be improved, can be present in this type of land, particularly in north Sutherland. Such areas with high amounts of peat are borderline between Class 5.3 and Class 6.3 land.

Another type of Class 5.3 land occurs on steep valley sides with slopes up to 25 degrees and brown forest soils and humus-iron podzols; slope is the main limitation. These areas tend to be small and scattered, and examples are found in Glen Carron and to the south of Ullapool. In practice, however, this type of land is rarely, if ever, improved.

Other types of Class 5.3 land include some poorly drained mineral alluvial soils which are liable to flooding, some noncalcareous gleys where climate precludes regular cultivation, and some Links Association and raised beach soils.

Class 6

Class 6 land is capable only of use as rough grazing. It covers 9553 square kilometres (58.1 per cent of the land area) and its main occurrence is throughout the Northern Highlands, where much of it is given over to deer-forests, but it is also found in the Grampian Highlands, on the Caithness Plain, and very locally on the Moray Firth Lowlands. Limitations are very severe and include climate, slope, soil, wetness and pattern; land use is often restricted by more than one limitation. Locally, some improvement may be possible, but such areas are too small to delineate on the 1:250 000 map. There are three divisions, based on the relative grazing values of the plant communities present (Bibby *et al.*, 1982).

Division 1 land has a high grazing value. The dominant plant communities contain high proportions of palatable herbage, principally the better grasses; an example of such a community is bent-fescue grassland. Class 6.1 land covers 79 square kilometres (0.5 per cent of the land area).

Most of the land is too steep or rocky or both to be improved by mechanized means. Such land includes soil map units of brown forest soils and humus-iron podzols under acid bent-fescue grassland on steep rocky slopes, and brown rendzinas and brown forest soils with herb-rich and acid bent-fescue grasslands on rocky land with a range of slope classes. It is found mainly in the western part of Northern Scotland in small and scattered areas between Loch Carron and Assynt.

Other Class 6.1 land includes those areas of windblown sand which have steeply sloping dunes such as occur in north-west Sutherland at Balnakeil and Sandwood Bay; the plant communities are largely dune pastures. Slope and risk of wind erosion preclude improvement of this type of land.

Also included in Class 6.1 is a large strip of the Strath Oykel alluvium, very wet and liable to flooding.

Division 2 land has a moderate grazing value. The vegetation either comprises plant communities with moderate grazing values, such as common white bent grassland and herb-rich Atlantic heather moor, or it consists of a mosaic of communities with high and low values. The Class 6.2 land covers 356 square kilometres (2.2 per cent of the land area) and it includes land of several types.

A major type comprises brown forest soils and humus-iron podzols on steep, mainly rocky, colluvial slopes with either a mosaic of grassland and moorland (generally bent-fescue grassland and Atlantic heather moor) or herb-rich moorland. Slope is the main limitation. This land occurs mainly in the Kinlochewe district, in Glen Carron, and in Gleann Mor to the west of Bonar Bridge.

Peaty soils and peat under a heath rush-fescue grassland (often common white bent grassland) in areas where climate precludes improvement comprise a second

type of Class 6.2 land. Slopes are usually strong or steep and can be non-rocky or rocky. This type of land is found mainly to the south of Glen Carron.

A third type consists of subalpine soils with stiff sedge-fescue grassland. Climate is an overall limitation and this land also is found mainly to the south of Glen Carron.

Another type comprises a well-defined pattern of brown rendzinas on rock knolls and ridges with patches of peaty podzols and deep blanket peat between; the vegetation is a mosaic of bent-fescue grassland of high grazing value on the brown rendzinas, and moorland communities of low value on the peaty podzols and peat.

Other types of land in Class 6.2, but of minor extent, include alluvial soils (limited by wetness), some basin peat, some Links Association soils, some mineral soils on hummocky moraine, and some soils on undifferentiated raised beach deposits.

Division 3 land is dominated by plant communities with low grazing values such as moist Atlantic heather moor, bog heather moor and lowland blanket bog. It is extensive (9118 square kilometres, 55.4 per cent of the land area) and covers large tracts of land. Class 6.3 land includes land with wetness, topographic and climate limitations.

An extensive type of land comprises rocky land, of all slope classes, with peaty soils and peat. There is generally more than one limitation which precludes improvement; climate or slope can be overriding although in some places a pattern of rock knolls and deep peat is the main factor. This type of land is very common, particularly in the west of Sutherland and in Wester Ross. It can, however, include small patches, usually less than 1 square kilometre, of Class 5.3 land.

Another type of Class 6.3 land is non-rocky, with peaty soils and peat on gentle and strong slopes, but limited by very severe climate. In the Northern Highlands such land occurs above around 200 metres in the west and 300 metres in the east; at lower altitudes where climate is less severe, this type of land is Class 5.3. Non-rocky steeply sloping land with peaty soils and peat is limited to Class 6.3 by slope.

Class 6.3 also includes land in which wetness is the dominant factor that precludes improvement; this land comprises blanket peat, and also peaty alluvial soils. Some areas of peat are also limited by climate. Small areas of Class 7 land can be included in Class 6.3 in areas of peat where haggling is severe or where dubh lochans are present.

Hummocky moraine with peaty soils and peat is included in Class 6.3 land if the surface is too bouldery to allow the use of machinery on the land, such land being common in the glens of the western part of Northern Scotland. In some places, however, climate is also limiting.

Class 6.3 land also includes higher ground — up to about 650 metres — largely with subalpine soils. Above this limit the extremely severe climate limits the land to Class 7. The vegetation consists mainly of alpine azalea-lichen heath and fescue-woolly fringe-moss heath, although some small patches of stiff sedge-fescue grassland can be locally present and provide grazing of moderate value. In this type of land, climate is the overall limitation.

Class 7

Class 7 land is of very limited agricultural value. It covers 531 square kilometres (3.2 per cent of the land area). Limitations are extremely severe. In the Northern

Highlands, mainly in west and central Ross-shire and in west Sutherland, Class 7 land lies on the higher hills, above about 650 metres, where the harsh climate—very cold and wet, and extremely exposed—is the overriding limiting factor. The soils are mainly alpine soils, noncalcareous regosols and lithosols, with some areas of subalpine soils. There is much stony, bouldery and rocky land, including crags and scree. The vegetation cover, often patchy, can provide some grazing during the summer months. The plateau of Ben Wyvis is, however, less bouldery and has a more complete vegetation cover than most of the other mountain tops.

In the Grampian Highlands the Class 7 land consists mainly of the strongly eroded peat which lies on the hills to the south of Nairn and is included in this class because of the high degree of dissection of the peat. Snow lies late in the channels and gullies. Class 7 land on Ben Rinnes is similar to that described above for the Northern Highlands.

A further type of Class 7 land, but very local in extent, is associated with the undifferentiated raised beach deposits of the Nigg/Preston Associations and includes the off-shore shingle bars near Culbin, and the shingle bar and saltings at Whiteness (some of which is now the site of the Ardersier oil-platform-construction yard).

LAND CAPABILITY FOR NON-AGRICULTURAL USES

Many other forms of land use can be evaluated from the information presented on soil maps and in accompanying reports. In the rest of this chapter, some of the soil and site factors which affect the capability of the land for forestry and for recreation are briefly examined.

FORESTRY

Afforestation in Northern Scotland is concentrated mainly in the lowlands, foothills and straths around the Moray Firth, particularly in Strathnairn, the lower Findhorn valley and Strathspey. Elsewhere it has a more scattered distribution, the main areas being centred on Lairg and including the forests of Strath Oykel, Strath Tirry and Strathnaver. Most of the afforested land lies below 250–300 metres, although some in the Grampian Highlands region is up to 400 metres or more.

Four principal factors affect the relative suitability of land for forestry (Bibby and Heslop, in preparation). These are climate, windthrow, nutrients and topography.

The main elements of climate affecting forestry capability are accumulated temperature and exposure. Since accumulated temperature divisions are used to define the climate regions of the area, Fig. 4 provides a general picture of the climatic constraints on the suitability for forestry of land in Northern Scotland. In general, climate limitations are least in warm and sheltered climates but become greater with decreasing temperature and increasing exposure. Cold and very cold climates are not suitable unless the configuration of the land provides some shelter, and neither is very exposed land unless it is only marginally so and is fairly warm.

Windthrow, a feature which particularly affects the forestry capability of upland and coastal areas, is likely to occur where there is the combination of a

shallow rooting system and high wind speeds. Shallow rooting systems develop where waterlogging occurs in the upper part of the soil profile due to the presence of an impermeable horizon such as an indurated layer, an iron pan, or a fine-textured subsoil, and also in peat and in soils with a very high water-table.

The nutrient availability is related to the volume of soil available for rooting and the chemical composition of the soil. Organic surface horizons are low in nutrients and trees require the addition of phosphorus at the time of planting; potassium and nitrogen may also be required in the thicker organic surface horizons and in peat. Tree growth on soils derived from ultrabasic rocks (the Leslie Association) is often slower than on soils derived from more acidic parent materials. Water, considered here as a nutrient, can restrict choice of species in droughty soils such as are present in parts of the Moray Firth Lowlands on coarse-textured parent materials.

Topography limitations mainly affect the use of machinery in the preparation of the ground. Slope is the principal factor. In general, tractors with mounted forest ploughs can operate on dry slopes of up to 35 degrees, but considerably less on wet peaty slopes where there is the danger of the peat surface breaking up and the machinery 'rafting' downhill out of control. The presence of rock outcrops can locally preclude the use of machinery. Hagged blanket peat is usually not plantable.

Bibby and Heslop (*op cit.*) describe seven capability classes which are ordered by the degree of limitation imposed by the factors discussed above. In the Moray Firth Lowlands, there is land, for example near Inverness, which has a potential, allowed by the climate, of Class F1, but because of the scarcity of deep fertile mineral soils the extent of such land is small. Land in the lowlands, foothills and straths around the Moray Firth ranges mainly from Class F2 to F5, suitable for many conifers and, except for the areas of Class F5, some broadleaved trees. Elsewhere, the plantable land is in Classes F4, F5 and, for much of the extensive areas of dystrophic peat and land with climates no better than cool and exposed, Class F6. Land in the last-named class is marginal for forestry and produces only low yields of a restricted number of species, lodgepole pine and Sitka spruce.

RECREATION

Red deer stalking takes place on many estates throughout the Northern Highlands and in south and west Caithness. The deer-forests are largely situated away from coastal areas. The land has an agricultural capability mainly of Class 6.3, but there is some Class 5.3 land particularly in central and east Sutherland. Much of the vegetation comprises bog heather moors and blanket bog communities, with some Atlantic heather moors and oroarctic communities; grassland communities are not extensive, but are advantageous. In the Grampian Highlands, the only area of red deer lies on the land immediately to the east of Strathnairn, where the deer winter.

Grouse shooting is, in general, restricted to the drier eastern and southern parts, in areas where *Calluna* is denser and more extensive. The best grouse-moors are in the Grampian Highlands on boreal heather moors with some Atlantic heather moors and bog heather moors. Grouse shooting in the eastern parts of the Northern Highlands and in south and west Caithness is over mainly Atlantic heather moors and bog heather moors; grouse populations are, however, lower than in the Grampian Highlands.

Soil and site factors considered in evaluating land for various other forms of

recreation are described in Montgomery and Edminster (1966), Jarvis and Mackney (1979), and McRae and Burnham (1981). The best land for camp sites is gently sloping, well drained, and the soils should not be too stony, nor too shallow, to make the pitching of tents difficult. Slopes can be levelled or terraced for caravan and tent pitches provided the underlying rock is not too close to the surface, but this increases the cost of site preparation. An overriding consideration, however, is that the soil and site conditions must allow for an efficient means of disposal of sewage to be installed. Many of the camp sites in Northern Scotland are situated around the coast on soils developed on windblown sand and raised beach sands and gravels.

Playing fields also require land which drains quickly, or can be drained readily, but unlike most camp sites this requirement may be for the whole year rather than for seasonal use. The land should be level, or nearly so, and there should be sufficient depth of soil material to enable a smooth flat surface to be constructed. If a serviceable grass sward is to be established and maintained throughout the year it is preferable that the soils are non-droughty.

The requirements for golf courses are less exacting than those of camp sites and playing fields. Well-drained land is preferable for the fairways, but a variety of slope is perhaps more acceptable than level or uniformly sloping land. Golf courses in Northern Scotland are commonly sited on windblown sand and raised beach sands and gravels.

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Handbooks of the Soil Survey of Scotland

- 1 Orkney and Shetland
- 2 The Outer Hebrides
- 3 Northern Scotland
- 4 Western Scotland
- 5 Eastern Scotland
- 6 South West Scotland
- 7 South East Scotland
- 8 Organization & Methods of the 1:250 000 Soil Survey

