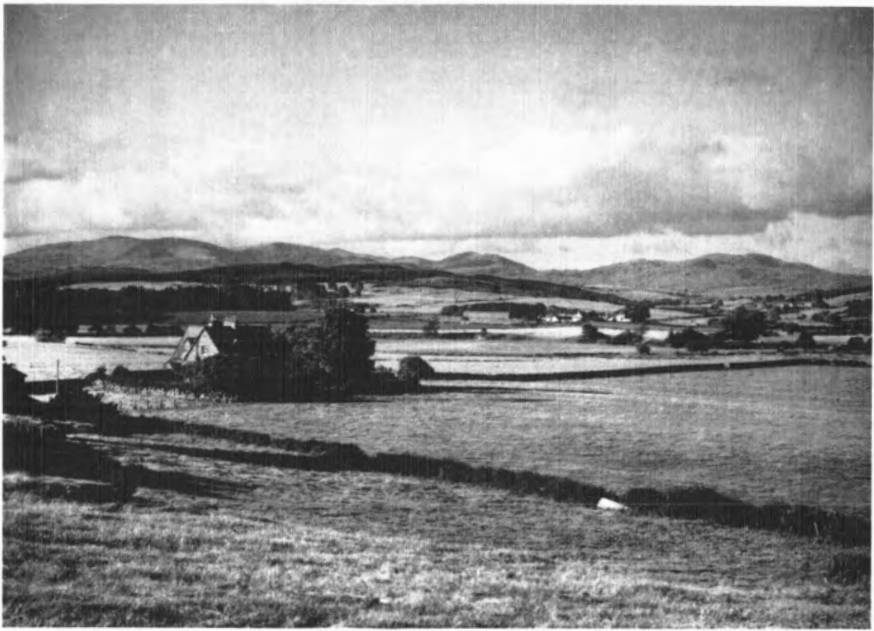


Soil Survey of Scotland

# SOUTH WEST SCOTLAND



1:250 000 SHEET 6

The Macaulay Institute for Soil Research  
Aberdeen 1982

SOIL SURVEY OF SCOTLAND

Soil and Land Capability for Agriculture

**SOUTH-WEST SCOTLAND**

By C. J. Bown, BSc, B. M. Shipley, BSc and  
J. S. Bibby, BSc

with contributions by G. Hudson, BSc, D. J. Henderson BSc and  
J. S. Robertson, BSc

The Macaulay Institute for Soil Research  
Aberdeen 1982

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*Front cover: Nether Barr Farm, Newton Stewart. The foreground is occupied by noncalcareous gleys of the Stirling Association (map unit 488) developed on stone-free silty clays of the Post Glacial raised-beach. The Lamachan Hills in the background carry soils of the Eltrick Association.*

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# Contents

<i>Chapter</i>	<i>Page</i>
PREFACE	vii
ACKNOWLEDGEMENTS	ix
1 DESCRIPTION OF THE AREA	1
Location and extent	1
Geology, physical features, landforms and parent materials	1
The Highlands and Islands	4
The Midland Valley	5
The Southern Uplands	6
Climate	7
Soils	10
The Highlands and Islands	11
The Midland Valley	15
The Southern Uplands	16
Vegetation	18
Grassland	19
Moorland	20
Oroarctic communities	21
Woodland	21
Foreshore and dunes	22
Saltings and splash zone	22
Land use	22
2 THE SOIL MAP UNITS	24
The Alluvial Soils	24
The Organic Soils	25
The Arran Association	31
The Ashgrove Association	32
The Balrownie Association	33
The Bargour Association	35
The Barncorkrie Association	36
The Benan Association	36
The Blair Association	38
The Carpow/Panbride Associations	39

The Carter Association	39
The Corby/Boyndie/Dinnet Associations	40
The Countesswells/Dalbeattie/Priestlaw Associations	42
The Craigdale Association	47
The Creetown Association	47
The Darleith/Kirktonmoor Associations	48
The Darvel Association	52
The Deecastle Association	53
The Doune Association	54
The Dreghorn Association	54
The Drongan Association	55
The Durisdeer Association	56
The Durnhill Association	57
The Eckford/Innerwick Associations	59
The Ettrick Association	59
The Foudland Association	69
The Fraserburgh Association	73
The Glenalmond/Maybole Associations	74
The Gleneagles/Auchenblae/Collieston/Darnaway Associations	76
The Gourdie/Callander/Strathfinella Associations	88
The Hayfield Association	89
The Hindsward Association	90
The Holywood Association	91
The Inchkenneth Association	91
The Kilmarnock Association	93
The Kintyre Association	93
The Kippen/Largs Associations	95
The Kirkcolm Association	98
The Knockskae Association	98
The Lanfine Association	100
The Laurencekirk Association	101
The Lethans Association	102
The Linfern Association	103
The Links Association	103
The Lochinver Association	104
The Mauchline/Auchinleck Associations	105
The Reppoch Association	106
The Rhins Association	108
The Rowanhill/Giffnock/Winton Associations	110
The Shawhill Association	112
The Sorn/Humbie/Biel Associations	113
The Sourhope Association	115
The Stirling/Duffus/Pow/Carbrook Associations	116
The Stonehaven Association	117
The Strichen Association	118
The Tarves Association	123
The Torosay Association	125
The Torridon Association	126
The Yarrow/Fleet Associations	128
Miscellaneous land units	129
Bare rock, scree and cliffs	129

Built-up areas	129
Fresh water lochs	129
<b>3 LAND EVALUATION</b>	<b>130</b>
Land capability classification for agriculture	130
Physical factors and their effect upon agriculture in South-West Scotland	131
The classification	133
The classes and divisions in South-West Scotland	135
Class 1	135
Class 2	135
Class 3	135
Class 4	139
Class 5	142
Class 6	145
Class 7	147
Land capability for non-agricultural uses	147
Forestry	148
Recreation	149
<b>REFERENCES</b>	<b>151</b>
<b>LIST OF PLATES</b>	
Front cover Nether Barr Farm and the Cree Valley	
1 Eastern Islay	77
2 Near Bridgend, Islay	78
3 Knapdale, Argyll	79
4 Kintyre Peninsula	79
5 Glendaruel, Argyll	80
6 Island of Bute	80
7 The Campsie Fells	81
8 The Carse of Stirling	81
9 The Clyde Valley, Lanarkshire	82
10 The Darvel Valley, Ayrshire	83
11 The Nith Valley at Kirkconnel	84
12 The Mennock Valley and the Lowther Hills	84
13 The Ken Valley, Kirkcudbrightshire	85
14 The Knock of Luce and the Moors of Wigtownshire	86
15 Haugh of Urr, Kirkcudbrightshire	87
16 Landscape near Borgue, Kirkcudbrightshire	87
<b>LIST OF FIGURES</b>	
1 Survey teams' map areas	viii
2 Geology	2-3
3 Climate	8-9
4 Rainfall	10
5 Landforms on the Machars and Rhins of Wigtownshire	12
6 Landforms of the Galloway Hills	12
7 Landforms in the Highlands and Islands subregion	13
8 Landforms in the Midland Valley	13
<b>LIST OF TABLES</b>	
A Areas of soil map units	26
B Areas of land capability for agriculture map units	136

## Preface

Prior to 1978 soil maps within the South-West Scotland region had been published for the following areas: Kilmarnock, Ayr, Girvan and Carrick, Stranraer and Wigtown, Stirling, and Airdrie. Upon approval of the proposal for the soil survey of the upland areas of Scotland at a scale of 1:250,000, mapping was commenced in 1978 and continued in 1979 and 1980. The Hebridean Islands, Arran and the Highland area west of Loch Lomond were surveyed by J. S. Bibby, G. Hudson, D. J. Henderson and J. A. Hipkin from the Soil Survey Regional Office in Oban. Mapping in the Midland Valley and the Highland area east of Loch Lomond was carried out by B. M. Shipley, J. S. Bell and T. W. M. Brown who were assisted during part of 1980 by F. T. Dry and A. J. Nolan. The Southern Uplands were surveyed by C. J. Bown, assisted in 1979 by J. Corbett, from the Soil Survey Regional Office in Dumfries. The responsibility for mapping is shown in Fig. 1. Field survey of all areas was completed by the end of 1980. Compilation of the maps and handbooks was carried out during 1981, based on a National Soil Map Legend compiled by B. M. Shipley. The senior authors of the South-West Scotland Handbook were C. J. Bown, B. M. Shipley and J. S. Bibby with major contributions from D. J. Henderson and G. Hudson. Analytical results quoted in the text were produced at the Macaulay Institute for Soil Research, Aberdeen, mostly in the Department of Mineral Soils. The vegetation assessments were carried out by field staff according to a system designed by E. L. Birse and J. S. Robertson; correlation was the responsibility of the latter who also wrote the account of the plant communities. The handbook has been edited by R. E. F. Heslop and D. W. Fitty.

Concurrently with the soil mapping the staff of the Survey Department carried out assessments of land capability for agriculture, using guidelines devised by J. S. Bibby, H. A. Douglas, A. J. Thomasson and J. S. Robertson (Bibby *et al.*, 1982). Advisory groups were established to assist the surveyors in this task. They consisted of representatives of the Department of Agriculture and Fisheries for Scotland, the Scottish Agricultural Colleges and the National Farmers' Union of Scotland. In addition, consultation with the local offices of the various organizations was maintained. The committees proved lively forums for discussion and made valuable contributions to the interpretative maps. The responsibility for the maps, however, remains entirely with the Soil Survey of Scotland.

The base map was compiled and drawn by the Soil Survey cartographic section using modified components from Ordnance Survey 1:250,000 scale topographic

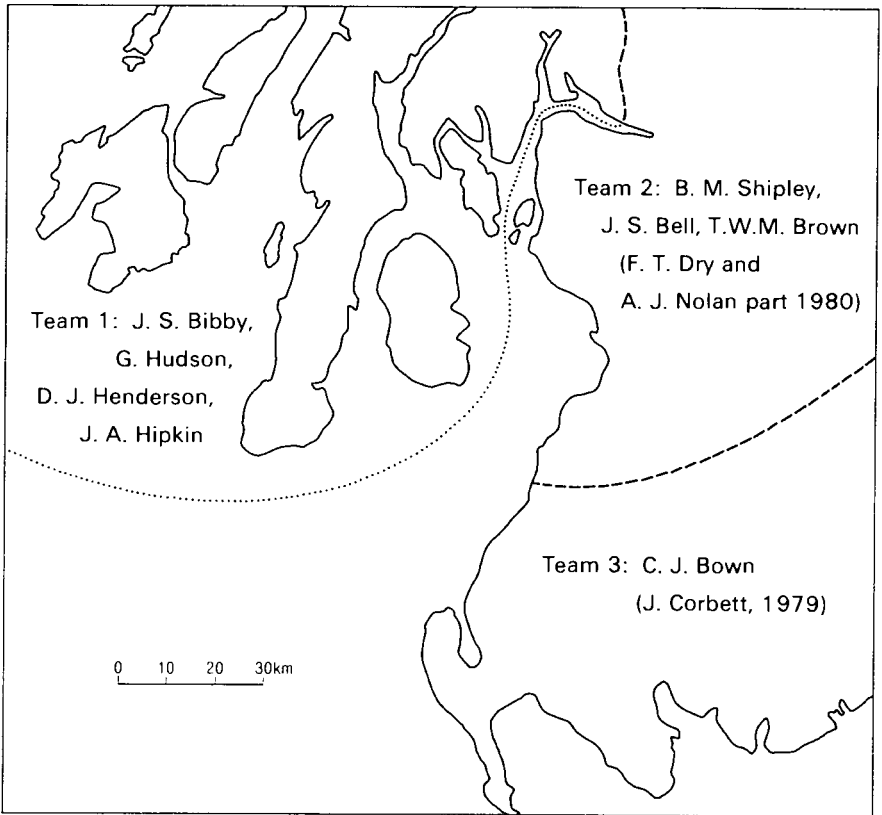


Figure 1. *Survey teams' map areas*

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 diagrams in this book were drawn by A. D. Moir and Mrs. R. M. J. Fulton.

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

ROBERT GRANT  
*Head of the Soil Survey of Scotland*



## Acknowledgements

The Soil Survey Department wish to thank the many landowners and farmers who willingly co-operated in the survey by allowing access to their land. The assistance of various other agricultural organizations in the land capability assessments has already been acknowledged, but valuable contributions to the two committees who advised on the northern and southern areas of the sheet were made by H. H. Donald, F. M. B. Houston, A. T. Glegg, D. G. MacLachlan and J. Valentine (DAFS), A. Campbell, A. MacLeod and G. E. D. Tiley (WOSAC) and G. Brechin, C. W. Campbell, the late J. Leitch, J. Johnstone, A. MacIntyre and I. D. Wilson (NFU (Scot.)).

Photographs in the text are by members of the Soil Survey Department, Aerofilms Ltd, the Institute of Geological Sciences, the Scottish Development Department and A. D. S. Macpherson.

# 1 Description of the Area

## LOCATION AND EXTENT

The area described in this handbook lies in south-western Scotland and encompasses such a rich and varied tapestry of landscape that it may well be regarded as Scotland in microcosm. In the north and west the Inner Hebridean islands of Islay, Jura and Colonsay flank the mountains of the southern Grampians. Traditional industries of fishing, sheep farming and whisky production have been supplemented in the past half century by increasing tourism and forestry and, latterly, by fish farming in lochs and rivers.

In the north-east the farming lands of the Carse of Stirling contrast sharply with the heavy industrial belt around Glasgow and the lower Clyde valley where the availability of coal encouraged the development of steel, shipbuilding and engineering industries. Textile industries too were formerly extensive. The Renfrew Hills separate these regions from the Ayrshire plain, traditionally associated with the dairy industry, but whose coastlands are also noted for seaside tourist resorts, golf courses and early potatoes.

The hills of the western Southern Uplands resemble in many features, although on a reduced scale, the mountains of the north. During recent decades forests, with Sitka spruce as the principal species, have been established widely on tracts of remote land. The Solway coast is strongly indented and varied; in parts mountains rise steeply from the sea but elsewhere lowlands share with Ayrshire a reputation for excellence in dairying.

## GEOLOGY, PHYSICAL FEATURES, LANDFORMS AND PARENT MATERIALS

The south-west of Scotland, in common with the rest of northern Britain, has a wide variety of rocks and physical features resulting from a long and complicated geological history. The superficial deposits and some landforms arise, however, from glacial and other agencies active during relatively recent times.

The geomorphic contrasts within the area have complex causes amongst which tectonic movements and differential erosion of hard and soft strata played major parts. Their effects have been long-term and preserved probably through periodic burial and subsequent erosion and emergence. Two of the principal geologic faults of Scotland, the Highland Boundary Fault and the Southern

SOUTH-WEST SCOTLAND

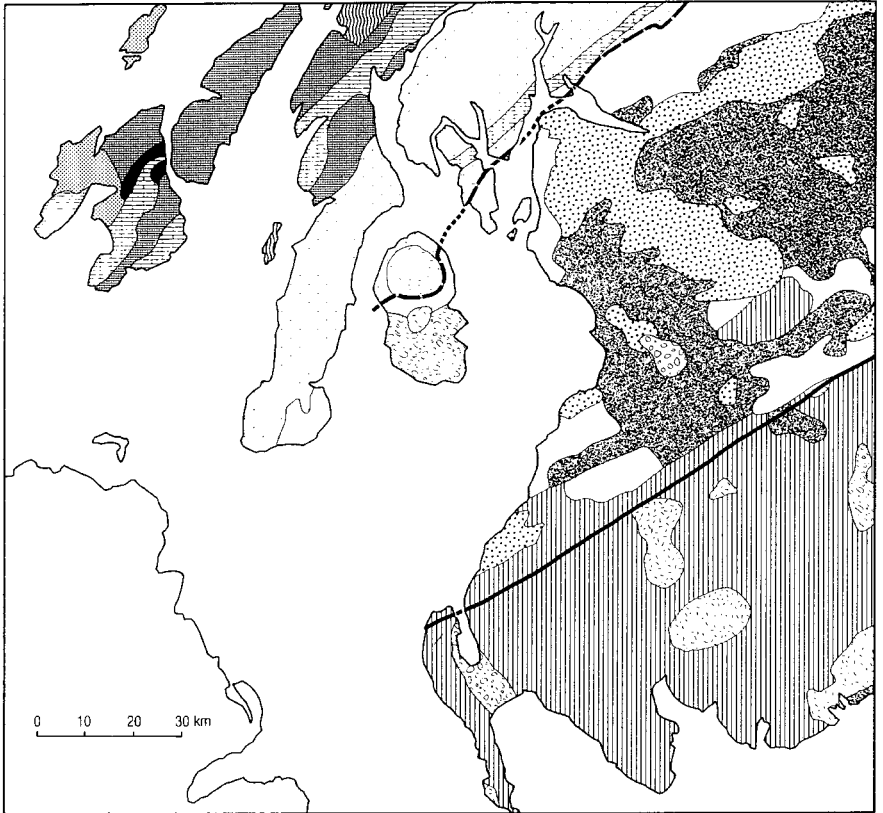

















Figure 2. *Geology*

DESCRIPTION OF THE AREA

	Breccias and sandstones	Permian/Triassic	} Sedimentary rocks
	Sandstones, shales grits and limestones	Carboniferous	
	Sandstones and conglomerates	Upper and Lower Old Red Sandstone	
	Greywackes and shales	Ordovician/Silurian	
	Sandstones and grits	Torridonian	
	Basalts and andesites	Extrusive (with some intrusive)	} Igneous rocks
	Granites	Intrusive	
	Metamorphosed igneous rocks (epidiorites and hornblende schists)	Moine/Dalradian	} Metamorphic rocks
	Islay limestone	} Dalradian	
	Slates phyllites and mica-schists		
	Quartzites		
	Quartz-mica schists		
	Gneisses	Lewisian	
	Highland Boundary Fault		
	Southern Uplands Fault		

Uplands Fault, traverse the area dividing it into three main physiographic and tectonic divisions, the Highlands and Islands, the Midland Valley and the Southern Uplands.

### THE HIGHLANDS AND ISLANDS

The oldest rocks, gneisses of Lewisian age, are found in the extreme west of the subregion on the Rinns of Islay. Farther north on the same peninsula and round Bowmore, a Torridonian age has been ascribed to a series of grey grits and arkoses. These rocks also occur on the island of Colonsay, together with phyllites which produce a less rocky landform although still hilly. A major dislocation of the earth's crust, the Iltay boundary slide (Johnstone, 1966), separates these rocks from the Dalradian strata to the east.

The Dalradian Assemblage consists of a wider range of rock types from metamorphosed igneous rocks (epidiorites) and thin limestones, mainly occurring to the north of Lochgilphead, on Gigha Island and near Ardmore Point on southern Islay, to quartz-mica-schists, which occupy central Kintyre and spread north-eastwards through Cowal to beyond Loch Lomond. A ring of metamorphosed schists occurs around the Tertiary granite intrusion of northern Arran. Quartzites make up much of Jura and northern Islay and are also found in northern Kintyre. In Kintyre they are much broken by schistose grits and quartz-mica-schists and give a substantially different soil parent material. Slates and phyllites occur on Islay and on the mainland from Loch Caolisport to northern Loch Fyne. They give a rounded hilly landform, locally rocky where bands of epidiorite break through, and their generally shallow drifts have high silt and fine sand contents. Bute, southern Cowal, the Rosneath peninsula and part of Glen Fruin north of Helensburgh contain similar rocks. Limestones occur as thin bands in Cowal and Kintyre where they have only local impact on the soils, but on Islay from Bowmore to Ballygrant and Port Askaig they are more extensive and underlie farmland.

Old Red Sandstone sandstones and a range of Carboniferous rocks are found on southern Kintyre, in central and northern Arran, Bute and southern Loch Lomond. Although the first-named rocks have a considerable impact on the textures and colours of the soils in these areas, the Carboniferous rocks are either hidden by thick drift (near Machrihanish) or occur in steep coastal cliffs (Arran).

The area was subjected to strong erosion during glaciation as the strongly dissected, fjord-type coastline testifies. Many other features of the landscape (Fig. 7) result from the action of ice. The principal influence was exerted during the main glaciation when ice flowed from the Midland Valley at first in a south-westerly direction, but later west over Kintyre and then north-westwards over Islay, the southern end of Jura and Colonsay. Its path may be traced by a thick reddish brown or red deposit of sandy till which penetrates up the glens of Cowal and into the Loch Fyne basin as far as Lochgilphead. The till is also found as isolated drumlins in Colonsay. There is much evidence to indicate that sediments from sub-sea basins are incorporated in this till and some suggestion that along the shores of northern Islay and Jura a fluctuating ice-shed formed a barrier against Highland ice entering the area from Loch Linnhe and the Firth of Lorne.

Later during the Loch Lomond Readvance only the valleys of Jura, Arran, Cowal and Loch Lomond itself were glaciated, the remainder of the area being subjected to intense periglacial conditions resulting in the removal of some of the tills and the production and solifluction of frost-shattered debris on the steep hill sides. A close relationship between the drift types and the rock types from which they were produced still exists, both texturally and in stoniness. The phyllites and

mica-schists were intensely split and produced fine-textured drifts with fairly small, often tabular, stones, while the blocky structures of the granites, epidiorites and quartzites led to coarse bouldery drifts with few fines.

The final episode which produced a significant drift type was the Post Glacial uplift and the development of an extensive fringe of sandy and gravelly raised beach. These areas form the heart of the farmland and have influenced the settlement patterns throughout history. On the outer fringes of Colonsay and Islay the beaches are sandy, locally shelly, and have been sculpted by the wind into dunes.

In many parts of the area, particularly in the cool and wet north-west and on the hills of the south-east, organic materials have accumulated, generally as the peaty horizon of peaty podzols and peaty gleys, but often also of sufficient thickness to form peat.

### THE MIDLAND VALLEY

The Midland Valley is a graben of broadly synclinal structure between the Highlands to the north and the Southern Uplands to the south. Palaeozoic rocks accumulated to a great thickness in the graben and along the edges of the adjoining massifs, and in age intermittently span Cambrian to Permian times. Their accumulation was periodically interrupted by earth movements, sometimes intense, which resulted in folding and unconformity and in an interrupted stratigraphical succession.

Within this subregion there is a close relationship between type of rock, structural pattern and landform. In general, the igneous rocks are harder and more resistant to erosion than the surrounding sediments, and the hill areas within the graben are almost always underlain by rocks of igneous origin.

Some of the oldest strata occupy a small area near Lesmahagow where Upper Silurian sediments form an inlier of Silurian rocks. The Old Red Sandstone sediments are principally sandstones with some conglomerates, and are red in colour and have gentle dip slopes. Lower Old Red Sandstone strata occupy southern Strathallan, extend south-west to Loch Lomond and occur between Maybole and Girvan in Ayrshire with smaller areas near Lanark. Sandstones of the Upper Old Red Sandstone extend from Kippen to Dumbarton, occur along the Clyde coast at Largs and on south Bute and, together with conglomerates, form a small area of high ground at Cairn Table near Muirkirk.

Igneous activity in the Old Red Sandstone period gave rise to the andesitic lavas of the Ochil Hills, the southern margin of which lies within the region, but which are more extensive to the north. The basalts of the Heads of Ayr have a similar origin and the small granite outcrop near Darvel also dates from this period.

The most extensive rocks, however, are those of the Carboniferous system, both sedimentary and igneous. The sediments are mainly shales and sandstones with some coals and occasional limestones and calciferous sandstones. They range in age from the earliest Carboniferous rocks in the Calciferous Sandstone Measures, through the Limestone Group and Millstone Grit to the Coal Measures, which are among the youngest rocks of the system. The predominant igneous rocks are basaltic lavas forming the high ground of the Gargunnoch, Kilsyth, Kilpatrick and Renfrew Hills on which some slopes have prominent step features. Further igneous activity between the end of the Carboniferous period and the beginning of the succeeding Permian period resulted in the formation of basaltic sills around Stirling, in Ayrshire and in West Lothian. Desert sandstones of Permian age occupy a small area at Mauchline and underlie much of southern Arran.

The Midland Valley was not an area of ice accumulation and valley glaciers do not appear to have been active. The area was, however, engulfed by ice-sheets moving south off the Highlands and north from the Southern Uplands. The principal effects have been the deposition of thick lodgement tills which mantle the underlying rocks and smooth much of the lowlands into gentle and strong rolling slopes and drumlin ridges (Fig. 8). As the climate grew warmer and the ice-sheet melted, glacial meltwaters deposited in many valleys gravel mounds and terraces, later dissected by river erosion.

During and subsequent to the disappearance of the ice, changes in the relative levels of land and sea have led to the formation of raised beaches on the coast and in the estuaries, such as the expanses of sand at Ayr and the level silty clays of the Carse of Stirling. Landform features attributable to the erosive effects of glaciation are relatively few, although the removal of the pre-existing regolith and subsequent formation of thin drifts and solifluction materials on high ground are pedologically important.

### THE SOUTHERN UPLANDS

The Southern Upland Fault, crossing south Scotland from south-west to north-east, is prominent in the landscape throughout its length, marked either by deep narrow valleys cut by streams excavating the shatter belt, or by steeply rising ground where the relatively soft, gently dipping sediments of the Midland Valley give way to the weakly metamorphosed, strongly folded and harder greywackes and shales of the Ordovician and Silurian systems. These rocks form the smooth rounded hills and steep-sided, narrow valleys typical of the Southern Uplands and are well exemplified by the Lowther Hills north of Thornhill, Dumfriesshire. At the western end of the Uplands, spilitic lavas and ultrabasic rocks of Arenig age and Lower Ordovician conglomerates with a high proportion of basic igneous-derived material are distinctive rocks.

Under the influence of glacial and other erosive agencies the Galloway granites, intruded into the greywackes during Old Red Sandstone times, have developed mountainous landscapes similar in many respects to the Highlands rather than south Scotland. Interior basins within the greywacke uplands are occupied at Sanquhar by sandstones and shales of the Productive Coal Measures and at Thornhill mainly by sandstones and breccias of Permian age. Similar rocks underlie the country south of Stranraer but are largely buried by sands and gravels.

As in the Highlands, the Southern Uplands nourished powerful glaciers which were active in moulding the landscape, and have been the predominant agency to have affected the nature and distribution of the superficial deposits from which the soils have developed. In Carrick and Galloway well-formed corries with crescent-shaped rock walls above steep stable, or partially stabilized, slopes of scree, have been etched at the heads of valleys into hills such as Merrick and Corserine, which are, however, smooth and rounded on their summits. Hummocky terrain in valley floors and adjacent low-lying ground is formed by coarse-textured stony and bouldery deposits of moraine left by shrinking valley glaciers in Late Glacial times (Fig. 6). The erosion of extensive areas of hill and upland at the western end of the Uplands has left rugged, rocky or rock-controlled landscapes, such as the country between Loch Doon and Loch Dee or around Cairnmore of Fleet, in which patterns of soil and vegetation are complex. Farther east and north the hills, from which the ice retreated earlier than from the rugged western areas, were subjected to prolonged cold conditions during which vigorous splitting and physical breakdown of the rocks occurred.

The Lowther Hills, which exemplify such areas, are smooth in outline and carry surficial materials thinner and more stony than the lodgement tills of lowland areas and which in their fabric and stone orientation show the effects of solifluction.

In the Galloway lowlands striking examples of landform features, typical of glacial deposition and erosion, occur in juxtaposition and form terrain in which drumlins of thick lodgement till are scattered across fields of ice-scoured rock knolls (Fig. 5). On the Rhins of Galloway the till is red-brown and, as on Kintyre, probably contains material dredged by ice from sedimentary strata beneath the Firth of Clyde.

As the climate became warmer at the end of the glaciation, large amounts of water from the melting ice left many deposits of sand and gravel as terraces or hummocky ground with kettlehole hollows, often in river valleys but also more extensively as between Stranraer and Luce Bay and on Galdenoch Moor. Changes in the relative levels of sea and land in Post Glacial time led to the exposure of extensive level terraces of silts and clays in the estuaries of the Solway, similar to the carse lands at Stirling, and elsewhere round the coast to the formation of tracts of shingle and sands. Dune sands are prominent at the head of Luce Bay.

## CLIMATE

The south-west of Scotland has a predominantly mild windy oceanic climate, affected by the Gulf Stream drift, with rather warmer and drier conditions in the lowlands of Wigtownshire, Ayrshire, the Clyde valley and Strathallan than in the Highlands and Islands or Southern Uplands. The wind regime is governed by the passage of North Atlantic depressions, although an opposing synoptic pattern with high pressure centred in northern latitudes can recur during the first half of the year. The predominance of westerly winds is marked, with a frequency of nearly 60 per cent, although winds from an easterly quarter are fairly common in spring.

The interaction of these winds with the main landforms governs the climatic range within the area. Orographic uplift over the hills of Argyll and the Southern Uplands increases the intensity and duration of rainfall, which in both areas reaches 2500 millimetres per annum. Average annual precipitation less than 1000 millimetres is restricted to a small coastal area around Ayr and parts of the Clyde and Forth valleys, with 1000–1500 millimetres per annum general elsewhere in the lowlands.

Autumn and early winter are the wet seasons of the year, about 45 per cent of the annual total precipitation falling during the months October to January. February usually initiates a marked change in the rainfall pattern with successive monthly reductions associated with the increased frequency of easterly winds in spring. Thunderstorms on high ground are in part responsible for the summer increase in rainfall, which continues to rise to the autumn and winter maximum.

Temperature is closely related to altitude and the Meteorological Office adopts a standard lapse rate of daily mean temperature with increasing height of 6°C for 1000 metres. The lapse rate in South-West Scotland is probably rather steeper, largely as a result of the prevalence of polar maritime air masses in the region. Mean annual temperature at the Mull of Galloway is 9.5°C with 8–9°C at a number of other lowland sites; at about 400 metres at Leadhills it is 6.7°C and at 700 metres on Lowther Hill it is 4°C. These mean temperatures decrease



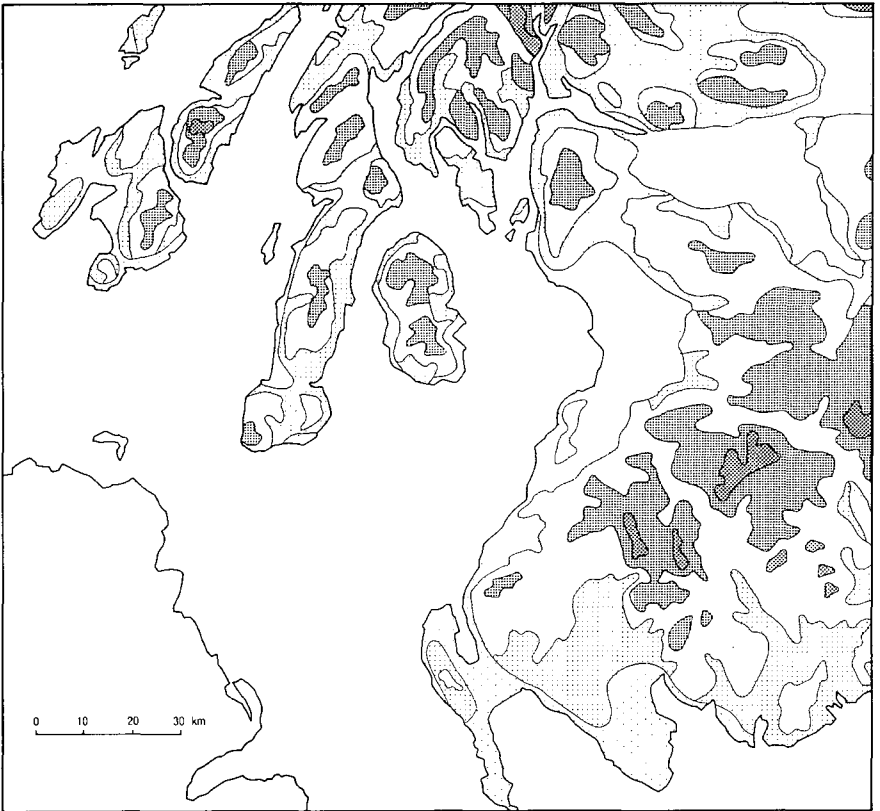








Figure 3. *Climate*

with increasing latitude. The growing season, defined conventionally as the period when the daily mean temperature is  $5.6^{\circ}\text{C}$  or above, at the Mull of Galloway is about 300 days; other coastal lowlands have about 270 days declining at 200 metres altitude to 240 days, and on the mountains to about 150 days. Warmth, promoting plant growth, has been assessed in terms of day-degrees Celsius of accumulated temperature during the growing season (Birse and Dry, 1970), the 'warm' lowlands having more than 1375 day  $^{\circ}\text{C}$ , the 'cool' uplands 825–1100 day  $^{\circ}\text{C}$ , with even more severe conditions, 275–550 day  $^{\circ}\text{C}$ , on the mountain tops. The area in the 'warm' category shows a marked reduction from south to north, partly due to increased hilliness and partly to a more northerly latitude.

Average values for potential evapo-transpiration range from 547 millimetres in coastal areas of Wigtownshire to 391 millimetres at 365 metres altitude in Kirkcudbrightshire. Humidity is at a sustained high level throughout the year in south-western Scotland and contributes to reduced evapo-transpiration. The coastal lowlands are relatively sunny, within the context of Scotland, with 1400 hours per annum at West Freugh, Wigtownshire and 1300 hours, general in most lowlands, declining to 757 hours at 723 metres altitude on Lowther Hill.

Exposure is a further element of the climate important in South-West Scotland lying on the western seaboard in the path of the prevailing winds. A map of exposure produced by Birse and Robertson (1970) shows some western coastal

DESCRIPTION OF THE AREA

	warm and moderately dry
	warm and wet
	fairly warm and moderately dry
	fairly warm and wet
	cool and wet
	cold and wet

Accumulated Temperature Divisions		Potential Water Deficit Divisions	
RANGE (day °C)	DESCRIPTION	RANGE (mm)	DESCRIPTION
>1375	warm	>25	moderately dry
1100-1375	fairly warm	<25	wet*
825-1100	cool	* The wet division incorporates the 'rather wet' and 'wet' divisions of Birse and Dry	
550-825	cold		

After Birse and Dry (1970)

areas on Colonsay, Islay, the Mull of Kintyre and Mull of Galloway to be very exposed (average wind speeds in the range of 6.2-8.0 metres per second), but more generally coastal areas are exposed (4.4-6.2 metres per second). Exposure is moderate (2.6-4.4 metres per second) in the inland lowland areas of the Clyde valley, parts of Ayrshire and Galloway and in a few valleys such as the Nith, Ken and Ayr the land is sheltered (less than 2.6 metres per second). Like the western coastal areas, most of the hills are very exposed with extremely exposed land on the high mountains. An important result of exposure is the effect of wind-chill on livestock, especially in wet weather in upland areas.

The incidence of frost is generally low in coastal areas because of the maritime influence on the climate. Accumulated frost is used by Birse and Robertson (1970) to indicate the severity of winters, which in coastal lowlands are extremely mild (<20 day °C). The freedom from late frosts of these areas is particularly important in Ayrshire and Wigtownshire where the successful cultivation of early potato crops is possible. In general, the severity of frost increases away from the coast and with rising altitude but is strongly affected by the local configuration of the land.

Temperature and rainfall are the principal climatic influences on soil formation, with wind important in modifying the effect of temperature. These factors affect the distribution of soils and, in general, mineral soils, mainly brown forest soils, brown forest soils with gleying and noncalcareous gleys, are predominant in the warm and fairly warm zones of accumulated temperature, peaty soils, mainly peaty podzols, peaty gleys and organic soils, in the cool and cold

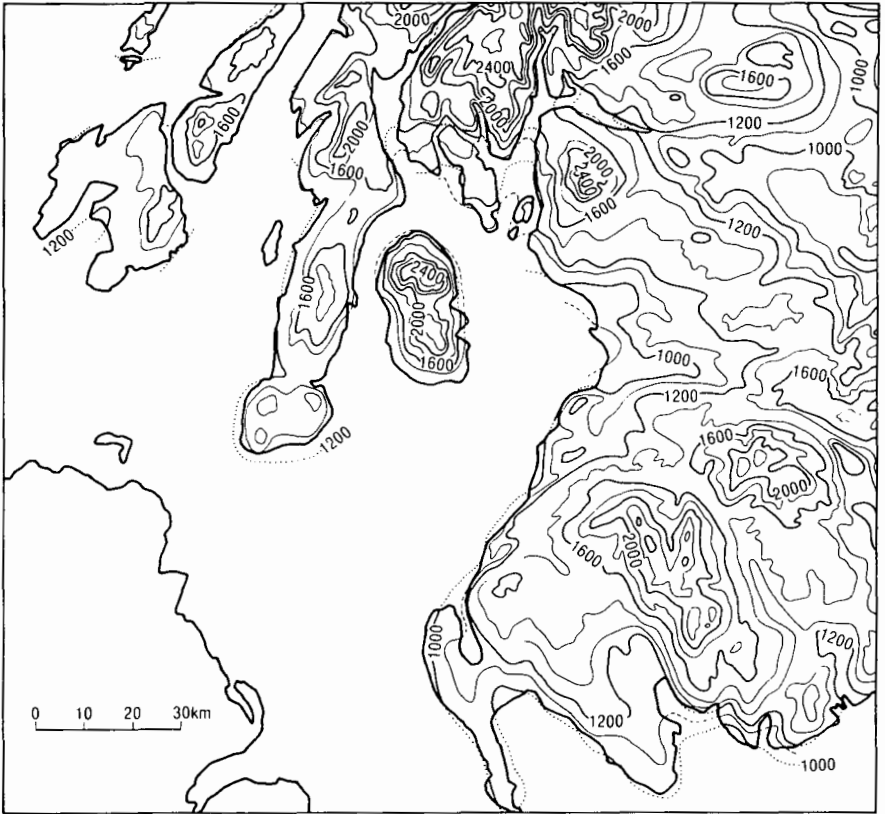


Figure 4. *Rainfall (average annual, mm)*

zones, and subalpine and alpine soils in the cold and very cold zones. Soil temperatures tend to be high in areas of low rainfall within South-West Scotland, as in the Midland Valley lowlands and around the coasts, and in comparison with areas of high rainfall the breakdown of organic matter is relatively rapid.

## SOILS

Soil is formed by complex interactions between geology, landforms, parent materials, climate and, of course, time, with the concomitant range of biological influences that this implies. In an area such as south-western Scotland, which spans the three major landform divisions of the country, Southern Uplands, Midland Valley and Highlands, there is a very wide range of individual soils. The Soil Survey identifies individual soils from a two-part array, the first of which is the soil classification and the second the type of parent material.

The soil classification, described in greater detail in Handbook 8 of this series, is based on the recognition of sequences of horizons described in terms of their morphology and supplemented by subsequent laboratory analyses. It comprises three tiers, the division, the major soil group and the major soil subgroup, the last of which is most commonly used. It is this level which is usually (but not exclu-

sively) quoted in the soil column of the map legend. In Scotland most of the soils date from the end of the glacial period and are thus, at most, only 13,000 years old although some, in the Highlands and Islands, may only be 10,000 years old. It is not surprising that with such young soils the relationships with geology and drift-types are still marked. This is expressed in the second part of the array, which is a grouping of all soils developed on one recognizable parent material and is called the soil association.

When surveys at large scales are designed to delineate individual soils, for example brown forest soils on basaltic parent material, the resultant map unit is termed a soil series. With increasing topographic complexity separation of such units is not possible and groups of soils, related to landscape (and thus to geology and drift-type), are recognized and termed soil complexes. Both these terms (soil series and soil complexes) will be found on previously published maps of parts of the area. A similar effect is produced by reducing map scale, however, and thus the map units of the accompanying 1:250,000 scale map are groups of soil individuals that are related to one another through common parent material, landform and geographical proximity. Often an ecological relationship can also be detected and the list of plant communities associated with the soils reflects this.

In all, fifty-nine associations (in a few instances groupings of associations) have been recognized in South-West Scotland and two hundred and eighty-six map units described. In much of the area south of the Highland Boundary Fault, systematic surveys at 1:63,360 scale have been published and these have been simplified and reduced to the 1:250,000 scale. The remaining areas were surveyed in the relatively brief period of two years by field observation combined with the interpretation of aerial photographs. In the following account a description of the principal soil features is given.

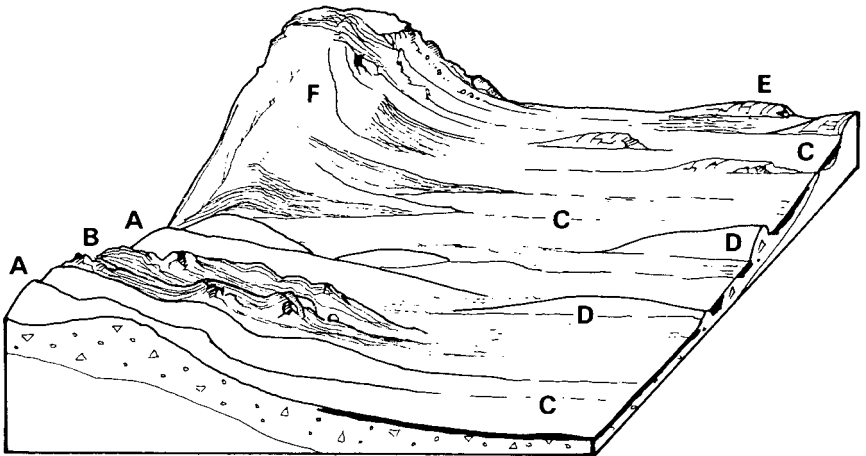
### THE HIGHLANDS AND ISLANDS

The principal characteristics of the soils of this subregion are: (1) a strong trend to the formation of major soil subgroups with organic surface horizons and, in particular, to peaty gleys and organic soils, (2) a predominance of shallow soils which become more marked in a northerly direction, (3) marked short-range variation in soil properties.

Reference to Fig. 3 readily reveals that most of the subregion is described as warm or fairly warm and wet. The subregion is noticeably wetter (Fig. 4) than other subregions with the whole area having more than 1200 millimetres annual rainfall. These conditions are ideal for rapid vegetative growth at a rate which far exceeds the processes of breakdown. The result is accumulation of organic matter, both on the surface of the soils and within the soil profile. In the warm moderately dry lowlands, peat is found only in basin sites, particularly if the surrounding soils are coarse textured and freely draining, but in the wetter and often cooler conditions of the foothills peat occupies every hollow and spreads across the intervening ridges and mounds. Here peaty gleys are the usual soil type, with peaty podzols (often intergrading to peaty gleys) only found on steeper slopes or where the solum permits a degree of drainage. Soil type is not exclusively related either to altitude or to rainfall; soil texture also plays a part. Where drainage is impeded by fine texture, peaty surface horizons develop at lower altitudes and under lower rainfalls than where texture is coarse.

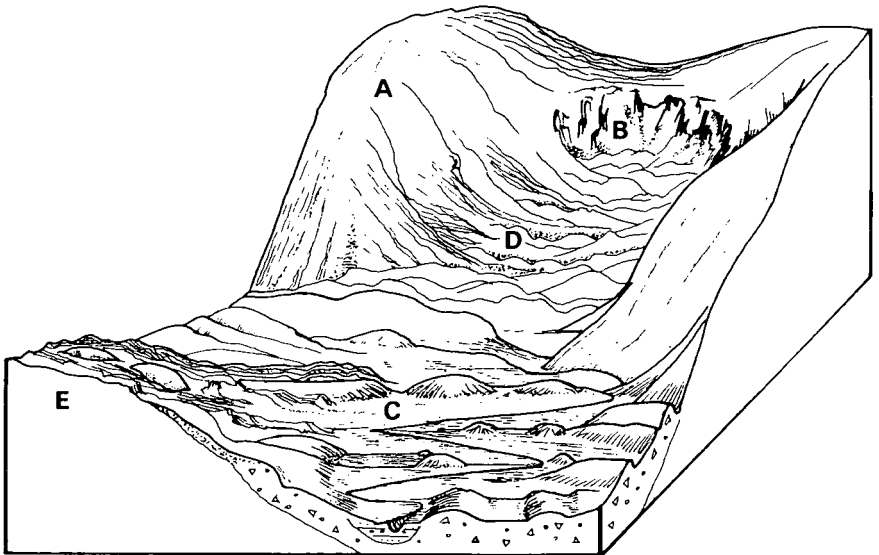
The high organic content of surface layers is frequently reflected throughout the soil profile where drainage waters can percolate, but in closely packed, more compact subsoils, organic-matter contents fall away rapidly with depth. Very dull

SOUTH-WEST SCOTLAND



- |                                  |  |
|----------------------------------|--|
| A Drumlins and till ridges       | D Isolated drumlins                                      |
| B Rock outcrops amongst drumlins | E Roche moutonnée  |
| C Peat                           | F Isolated hill with rock outcrops and thin stony drifts |

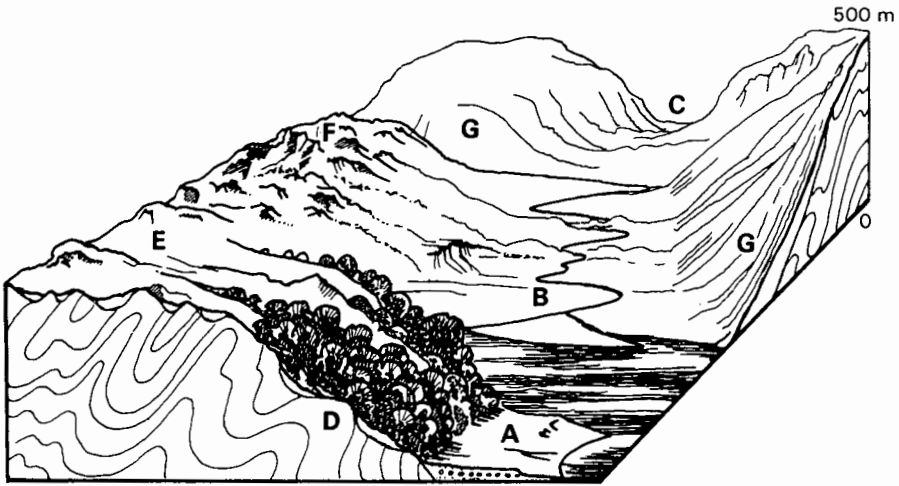
Figure 5. Landforms on the Machars and Rhins of Wigtownshire



- |                           |   |
|---------------------------|---|
| A Rounded hill crests     | D Piedmont moraine                              |
| B Corrie feature          | E Irregular hill with occasional moraine mounds |
| C Hummocky valley moraine |   |

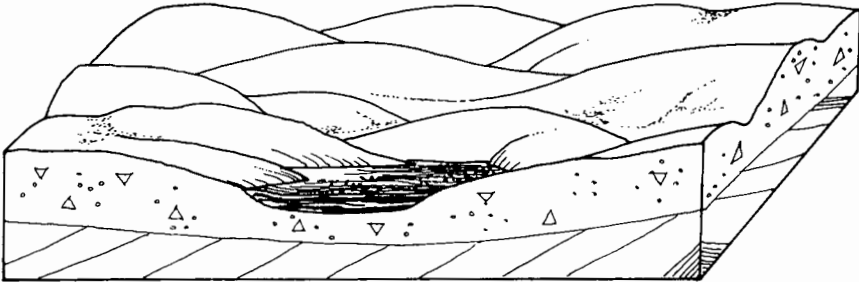
Figure 6. Landforms of the Galloway Hills

DESCRIPTION OF THE AREA



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

Figure 7. Landforms in the Highlands and Islands subregion



**TILL PLAIN TYPE:** Broad low-slope drumlins generally, with occasional steeper variants; occasional peat mosses in larger hollows.

Figure 8. Landforms in the Midland Valley

colours (low values and chromas) characterize many of the soils of the Highlands and Islands, reflecting the high humus contents, a feature common to soils throughout north-west and north Scotland.

The colouring of the soil map reflects the prominence of wet, peaty soils, green being used for map units dominated by peaty gleys and purple for peat. However, even the peaty podzol, which occurs in significant, though minor, amounts, is often very wet and has gley processes occurring in the E horizon and frequently also has a mottled B horizon.

Shallow soils are predominant north and west of a line from the south end of Gigha Island through West Loch Tarbert and along Loch Fyne. The topography of this area is strongly ridged, particularly around Loch Sween and in Knapdale. South of this line the Dalradian quartz-mica-schists produce long even slopes although some very irregular and rocky areas occur in places. Throughout practically the whole of Kintyre south of West Loch Tarbert extensive areas of till occur which form deeper soil parent materials and smoother landscapes. Tills are also found south-west of a line from Gigha Island to the south of Jura and northwards to Colonsay but they become progressively restricted to isolated drumlins in these northern and western areas. Colonsay is indeed very rugged, as are parts of Islay.

Related to the increasingly irregular topography is the third prominent characteristic, marked short-range variation in both soil types and soil properties. The intricate pattern of ridge and hollow (Plate 3) with, invariably, deep wet peat or peaty alluvial soils in hollows and peaty gleys and peaty podzols occurring in close proximity to extremely shallow soils on both slopes and crests makes the representation of map units dominated by even two soil types impossible. It is noticeable that even at the large scale (1:10,000) used by the Site Survey Section of the Forestry Commission, complex map units including three or four soil types are often necessary. This is, of course, significant for any proposed soil treatments during management as any procedures inevitably will not be optimal for several of the soils in a map unit.

Although peat, peaty gleys and peaty podzols dominate the landscape of the western and northern hills, there are some notable exceptions. The coarse-textured parent materials of the raised beach fringe allow excess rainfall to drain away quickly. Subject to leaching, the soils maintain a high organic matter level (usually greater than 8 per cent) which persists in some cases deep into the profile. They are readily cultivated. Brown forest soils and noncalcareous gleys occupy considerable areas at the lower elevations; many of the lower steep slopes of the glens between Loch Fyne and Loch Lomond carry brown forest soils, while noncalcareous gleys are found on the till-covered gentle slopes and valley floors. On Colonsay and parts of Islay shell-sand provides highly calcareous subsoils, although topsoils have the usual humus contents and may even have indications of leaching.

A few isolated summits on Jura, Arran and part of the northern mainland have such a severe climate that their profiles are characterized by an intensely black, often crumbly, humus in intimate association with mineral soil constituents. These soils are intensely leached and impoverished of plant nutrients, and their degree of chemical weathering is relatively low. They are subject to intense frost action during autumn and spring and are frequently frozen throughout the winter months so that they resemble soils found under arctic conditions in other parts of the world.

## THE MIDLAND VALLEY

The marked contrast of climate, geology and physiography between the Highlands and Islands and the Midland Valley is reflected in the predominant pedological processes and the soils to which they give rise. The principal trends in soil development in the Midland Valley are: (1) the widespread occurrence of slow internal drainage, prominent gley features and soils of the noncalcareous gley and brown forest soil with gleying major soil subgroups, (2) the prevalence of topsoils having mull humus which are periodically worked and fertilized, and of sufficient depth for most crops, (3) soil uniformity and consistency over broad areas and only gradual changes of soil types. These trends contrast with those described for the Highlands and Islands and although in both subregions the effects of gleying are prominent, the soils differ markedly in their morphology and agricultural potential.

The character of the Midland Valley lowlands derives in large part from the thick mantle of lodgement tills forming the smooth undulating landscapes. Differences of appearance and colour associated with the lithology of the parent rocks typify individual tills, but in the main, all are of fine texture, sandy clay loam to clay, and very slowly permeable to moisture. Although the climate is less wet than in the hill ranges lying to the north and south, rainfall in west central Scotland is, nevertheless, high, 1000–1250 millimetres per annum over much of the area, and considerably exceeds the loss of moisture from the land by evapotranspiration. High moisture levels prevail, therefore, in the soils and upper till layers for much of the year and under natural conditions waterlogging persists for considerable periods in the winter months. The resulting exclusion of air and oxygen from the soil pores and spaces leads to anaerobic conditions and the reduction of elements such as iron and manganese able to exist in oxidized and reduced forms, and gleying becomes the predominant feature of the soil profile. Slow permeability of the parent tills leads to waterlogging being most severe in the upper soil layers and it is in the Eg and Bg horizons that gleying is most intense. Anaerobic effects tend to be greatest where organic matter from Ah horizons promotes microbiological activity and oxygen levels fall rapidly. Grey and pale colours, of low value and chroma, and ochreous mottles predominate and mask the colours of the parent tills. As gleying decreases with depth, the colours of the unweathered, little-altered tills become more apparent. Although there is slow water movement mainly down the temporary channels of worms or other animals or, more generally, down cracks between coarse prismatic structural peds in the Bg horizons, movement of moisture within peds is even less; leaching is moderate with base saturation generally more than 50 per cent in the Bg horizons and greater in the Cg horizons. The noncalcareous gleys with poor natural drainage developed on the grey and grey-brown till derived from the Carboniferous shales are amongst the most extensive in the region.

Frequently developed on red-brown sandy clay loam tills derived from Old Red Sandstone strata and associated with noncalcareous gleys are brown forest soils with gleying, which are also characterized by slow moisture permeability. Gley features, however, are developed less intensely than in the gley soils, partly on account of the resistance to alteration of materials with strong haematitic coatings.

The moderate leaching, pH levels and base saturation of the soils in the lowlands of Ayrshire, Lanarkshire, Stirlingshire and Renfrewshire are allied with warm and generally moist, but occasionally wet, climatic conditions (Fig. 4)



favouring abundant and rapid vegetative growth but also allowing high levels of activity by earthworms and other biotic agencies able physically to break down plant litter and incorporate it into the upper soil horizons where micro-organisms attack and further degrade it chemically. Turnover of organic matter is relatively rapid therefore, and humus of the mull type develops in intimate association with the mineral soil to form thick Ah surface horizons. Following improvement of water relationships by drainage these soils under the prevailing climate are well suited to agriculture, and throughout much of the subregion cultivation has disrupted and mixed the surface horizons to greater depths thus creating plough layers (Ap horizons), which favour the proliferation and deeper penetration of roots and more ready percolation of moisture. Although in comparison with hill areas, acidity and leaching are moderate in these soils, modern farming has greatly increased their lime and nutrient status and fertility.

The thick till mantle, undulating smooth slopes and lowland landscape afford relatively uniform conditions for soil development. In many properties, important agriculturally and pedologically, changes are few and take place gradually across soil boundaries which merge over diffuse zones, often in association with differences in the lithologic composition of the till.

The subregion is typified therefore by brown forest soils with gleying and non-calcareous gleys but other soils are found, although of restricted extent, and usually on locally occurring parent materials on areas of high ground. Brown forest soils with free natural drainage occur in small areas scattered throughout the subregion and are predominant on the coarse-textured parent materials on the raised beaches along the coast and on fluvioglacial outwash sands and gravels in some of the main valleys. The thin stony drifts derived from basaltic and andesitic lavas forming areas of higher ground also carry brown forest soils, generally on slopes at altitudes up to 300 metres, and some map units are characterized by moderate amounts of outcropping rock.

Blanket peat is developed extensively on some gentle slopes and undulating ground amongst the uplands, promoted by high rainfall, cool temperatures and soil wetness. On the moors and uplands east of Cumnock and around Muirkirk, where peaty surface layers are less than 50 centimetres thick, peaty gleys developed on clayey tills and drifts are the principal soils associated with the peat. But on the hills above Largs, the Campsie Fells, the Kilpatrick and Kilsyth Hills and on the southern slopes of the Ochil Hills west of Alva, the steeper slopes and thinner drifts with free internal drainage have peaty podzols above about 250 metres altitude. Some map units include outcropping rock, but in general throughout the subregion slopes are smooth and rock outcrops are very restricted in extent. On the lower slopes around the hills the thicker tills carry non-calcareous gleys. Along the coast north of Ayr windblown sands have regosols in which soil development is restricted to some organic matter accumulation in weakly developed, thin Ah horizons resting on raw sand.

### THE SOUTHERN UPLANDS

The Southern Uplands are characterized geologically by the great extent of the Lower Palaeozoic greywackes and shales and physiographically by the smooth, rounded, strongly dissected and steep-sided hills. The western end of this upland range lying in South-West Scotland and referred to here as the Southern Uplands subregion includes, however, a variety of landscapes and diverse pedological trends. Soil development and pattern are related to particular localities rather than typifying the subregion. Notable aspects are: (1) the prevalence of peaty

podzols and brown forest soils in the Lowther Hills, (2) marked short-range soil variation on the Galloway granite hills and surrounding uplands, (3) extensive peat formation in the Galloway moorlands, (4) gleys on steep valley slopes in western Dumfriesshire, (5) the influence of distinctive glacial erosion and deposition patterns on the soils of lowland Galloway.

The Lowther Hills north of Thornhill, Dumfriesshire, exemplify the pedologic development that occurs in much of the Southern Uplands. The stony, medium-textured drifts mantling the steep smooth slopes of the rounded hills (Plate 12) to depths of 1 to 10 metres generally allow rapid run-off of water and free internal soil drainage. High rainfall contributes to the strong leaching of mineral elements without causing waterlogging such as typifies soils on high ground in the Highland and Islands subregion. The resulting soil pH levels are low and both brown forest soils and peaty podzols undergo weathering in strongly acid conditions with accumulation in the subsoils of ochreous, poorly-ordered residual iron and aluminium compounds and leaching of more soluble elements. The soils are closely related to altitude and slope, with brown forest soils occurring below 250–300 metres on very steep land and peaty podzols at higher elevations or on less steep slopes. The brown forest soils have friable, brown surface Ah horizons with well-developed subangular blocky or crumb structure and moderate or high humus (mull or moder) content. The vegetation, formerly broadleaved woodland and now mainly acid bent-fescue grassland, provides litter for incorporation into the mineral soil where a balance between addition and breakdown is maintained by the activity of earthworms and other degradative biotic agencies. Below the Ah horizon the B horizon is friable, has moderate or weak blocky or subangular blocky structure, and has a bright strong brown or yellow-brown colour with high chroma. The contents of poorly-ordered sesquioxidic materials in this layer, although high, do not necessarily much exceed the amounts in the overlying Ah horizons. Over a wide range of climate, slope and altitude (up to 250–300 metres) there are few marked or major changes in the profiles of the brown forest soils.

As altitudes increase, however, the brown forest soils are replaced over a zone of rapid soil change by peaty podzols. These predominate on the higher-lying land under vegetation that formerly included forest but is now mainly Atlantic heather moor and heath rush-fescue grassland. The influences governing the transition from brown forest soil to peaty podzol are complex, but appear to be associated with increased soil acidity, lower temperatures, an absence of earthworms and lower biotic activity, together with plant litter more resistant to biological breakdown. In the transitional zone, surface layers of organic accumulation can be thin H horizons of decomposed plant remains, but are more generally well-developed peaty O horizons. The underlying E horizon is very pale or grey in colour and has weak structure, and low contents of ferruginous weathering products due to leaching (generally ascribed to the action of solutions from the peaty layer, although some recent evidence suggests movement can take place in inorganic form). Below this horizon a thin iron pan, strongly cemented and impeding root and moisture penetration, overlies an ochreous bright-coloured Bs horizon with friable blocky structure and high content of iron and aluminium products, a proportion of which are redeposited from solutions leaching from the E horizon. Induration is often present in the lower part of the B horizon and in the parent drift.

Brown forest soils occur at lower elevations than peaty podzols in the Lowther Hills, but on moraine mounds in the Minnoch valley and on drumlins of the south Ayrshire moors the distribution of these soils is associated with slope. Within an altitudinal span of less than 25 metres, brown forest soils are found on

the steep sides and peaty podzols on the more gently sloping mound crests. This distribution is influenced principally by the effect of slope on water movement, mainly run-off. On some sites gleying may develop subsequent to the formation of a peaty horizon.

Contrasting with the more easterly hills, the landscape of the Galloway granite hills and surrounding uplands bears a close resemblance to parts of the Highlands and Islands in being typically rugged with much outcropping rock and in having thin drifts and shallow soils. As in the more northerly part of the region, soil changes in such terrain occur rapidly over short distances and mapping at almost all scales is based on the recognition of soil patterns and groupings related to landforms.

To the west of these mountains the moorlands of south Ayrshire and Wigtownshire span a moderate altitudinal range from 100-300 metres and comprise extensive areas of very gently sloping land, broken by scattered ice-eroded rock knolls, drumlins and low hills, some of which are rocky. Peat, often deep, is developed widely under the influence of warm equable temperatures, high rainfall and poor drainage. The initiation of some extensive bogs such as those at Derskelpin, Dornal or Eldrig began in small isolated hollows and as these filled, the peat extended and the deposits coalesced. Organic soils on these moors are the principal element of most map units and dominate the soil pattern.

The wide variety of soil pattern and terrain in the subregion is further exemplified in north-west Dumfriesshire above Penpont and Moniave where the valley sides are steep and concave. Under the prevailing high rainfall the soils are strongly flushed from springs and seepage from higher ground. Despite the steep slopes and loamy, often thin drifts, gleying of varying degrees of intensity is predominant in most soils. Pale brown Ahg horizons at the surface have ochreous staining along root channels, weak to moderate subangular blocky structure and generally moderate organic-matter content, but in the most strongly waterlogged areas topsoils can be dark coloured and humose and the soils humic gleys. Below the topsoils the Eg horizons are pale grey, with a few ochreous mottles, and their structure is weakly developed. Although ochreous mottles are more evident in the Bg horizon, pale grey colours predominate; structural development is weak. Much water movement appears to occur down-slope through the upper soil horizons, especially where the underlying parent drift is indurated.

Southern and western Galloway, mainly the Rhins and Machars of Wigtownshire and parts of Kirkcudbrightshire, have distinctive soil patterns due to the effects of glacial erosion and deposition which are described on page 7 and in *map units 438 to 442*.

## VEGETATION

In the following account, the distribution of the plant communities and their relationship with the soils of the region 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.

South-West Scotland includes a wide range of rocks and derived parent materials within its bounds and is subjected to a variety of environmental influences, these features being reflected in the number and distribution of the plant communities occurring there. To the west, the oceanic influence of relatively mild, frost-free winters, coupled with high humidity and strong winds, results in the presence of flushed and, to a lesser extent, northern (or exposed) forms of plant association which occur less frequently or are absent altogether in the drier, euoceanic east. With increased altitude, the plant communities of the lowland regions give way to alpine vegetation on the mountains of the Rhinns of Kells and on other high hills of the area.

### GRASSLAND

Much of the lowland till plain areas are under some form of cultivation, either for root or cereal crops or, more commonly, for ley or permanent grass pastures (*Lolio-Cynosuretum*). Under conditions of high rainfall the fine textured soils of the lowlands are suited to the production of grass as silage, hay or permanent pastures that have either been sown out or have been brought in from rough grasslands by surface treatment. Some pastures have been established on the flushed peat fringing cut-over lowland mosses—especially in the counties of Ayr and Lanark—where drainage systems have been installed. These wet pastures are characterized by the presence of marsh foxtail (*Alopecurus geniculatus*). A community closely related to the permanent pastures, meadow-grass-bent pasture (the *Galium saxatile-Poa pratensis* Community) is found on sites that have been allowed to deteriorate through loss of fertility, but it can also develop from natural rough grasslands that have been subjected to a heavy grazing/dunging regime. Where the landform is a hindrance to improvement, these latter sites often carry a dense cover of bracken that downgrades the productivity and hence the grazing value of the underlying vegetation. Meadow-grass-bent pasture is a typical community of freely drained soils on river terraces and alluvial flats and the bracken facies is commonly found on the imperfectly drained soils of the moraine fields of Loch Lomondside.

The wet, undrained soils of the lowlands and foothills support rush pastures of which the most widespread and extensive is sharp-flowered rush pasture (*Potentillo-Juncetum acutiflori*), a community characteristic of the south-west. The species-rich form is found on the better base status noncalcareous and humic gleys and the species-poor form on the more acidic noncalcareous gleys, peaty gleys and flushed peat. Soft rush pasture (the *Ranunculus repens-Juncus effusus* Community) is common but less extensive, being more confined to drainage channels and wet peat-filled depressions and it is the characteristic vegetation of wet alluvial soils. Tussock-grass (*Deschampsia cespitosa*) may be a co-dominant with soft rush (*Juncus effusus*) on these sites or it may be the dominant species, forming tussock-grass pasture (the *Deschampsia cespitosa* Community). A wide range of swamp and sedge communities occur on the wet flushed soils of channels, flats and depressions that are not readily improvable. The presence of a particular community depends to a large extent on the base status and nutrient

level of the flush water. Thus, on the more acid sites, the communities are bog moss water track (the *Juncus effusus*-*Sphagnum recurvum* Community), common sedge flushes (*Carex nigra* communities) and star sedge mire (Caricetum echinato-paniceae) on dystrophic peat, peaty gleys or low base status noncalcareous gleys. Better base status soils carry few-flowered spike-rush mire (Carici dioici-Eleocharitetum quinqueflorae), flea-sedge mire (Caricetum hostiano-pulicaris) and bog-rush mire (the *Schoenus nigricans* Community), while eutrophic peats, humic gleys and moderate to high base status noncalcareous gleys support yellow flag swamp (the *Iris pseudacorus* Community), meadow-sweet meadow (*Valeriano-Filipenduletum*) and reed swamp (Phragmition). Star sedge mire is a more widespread and extensive community on the reclaimed peats fringing the remnant mosses south of Glasgow in conjunction with soft rush pasture.

Semi-natural rough grassland communities are extensive in the hill areas outwith the influence of cultivation. The principal associations are bent-fescue grassland (Achilleo-Festucetum tenuifoliae) on brown forest soils and humus-iron podzols and heath rush-fescue grassland (*Juncus squarrosus*-Festucetum tenuifoliae) on peaty podzols, peaty gleys and flushed peat. The herb-rich form of bent-fescue grassland occurs on the steep slopes of mounds and valley sides, especially where the soils are shallow or derived from basic rocks. The low base status brown forest soils and podzols of the more open hill slopes carry acid bent-fescue grassland which may often be dominated by bracken. Brown soils developed on base-rich materials such as the limestones of the Deecastle Association or the magnesium-rich rocks included in the Darleith Association support crested hair-grass grassland (the *Galium verum*-*Koeleria cristata* Community), but these are usually very limited in extent and confined to the immediate vicinity of the rock outcrops. Heath rush-fescue grassland is present in all three of its forms. Common white bent (*Nardus stricta*) grassland is found mainly on peaty podzols, the herb-rich form with heath grass (*Sieglingia decumbens*) on more flushed sites with gleyed soils often lacking an organic surface horizon and flying bent (*Molinia caerulea*) grassland on poorly drained peaty gleys and some flushed dystrophic peats. The proportion of each of the grassland communities present at any one site is a reflection of the amount of rainfall, flying bent grassland being dominant in the west but giving way to the drier vegetation types in the east. Flying bent also extends farther eastwards on the finer textured soils than it does on those of coarser texture.

## MOORLAND

Moorland communities tend to be more common to the south and west of the area where the higher hills are concentrated and where the influences of land management, especially grazing, are less intense. The principal association of the foothills and uplands is Atlantic heather moor (Carici binervis-Ericetum cinereae), the dry form being found mainly on humus-iron and peaty podzols and the moist form on peaty podzols and peaty gleys. Some peaty gleys may also support bog heather moor (Narthecio-Ericetum tetralicis), especially where these soils fringe areas of blanket peat. Blanket peat vegetation is chiefly represented by one large association (*Erico-Sphagnetum papillosum*) which includes the communities of lowland blanket bogs and raised mosses and of upland blanket peat. Lowland blanket bog is found extensively throughout the unimproved valley and hill areas and also occurs on the large remnant mosses within the zones of cultivation. The bog often includes carpets of cranberry (*Vaccinium*

*oxycoccus*), and bog rosemary (*Andromeda polifolia*) is also present in the mosses to the south. Some of the more exposed lowland sites carry the northern form of the association with woolly fringe-moss (*Racomitrium lanuginosum*) and the lichens *Cladonia arbuscula* and *C. uncialis*, and the terminal phase of blanket bog with a pool and hummock surface can also be present. Good examples of both forms can be seen on the moss of Silver Flowe near Glen Trool. As the amount of rainfall and hence the degree of flushing increases, so too does the proportion of flying bent (*Molinia caerulea*) and cotton-grass (*Eriophorum vaginatum*) bog on the gentle slopes, depressions and channels of the blanket peat until these forms become the dominant bog vegetation present in the west. Bog myrtle (*Myrica gale*) can be an important species on these flushed dystrophic peats, often co-dominating with flying bent.

### OROARCTIC COMMUNITIES

As the influence of altitude and exposure increases, so this is reflected in the composition of the plant communities. On the better drained peaty soils of the uplands, Atlantic heather moor may be present in its lichen-rich northern form or, more frequently, it may be displaced altogether by a narrow zone of boreal heather moor (*Vaccinio-Ericetum cinereae*) before the mountain top communities are encountered. The blanket peats here carry the upland form of blanket bog (part of *Erico-Sphagnetum papilloso*) characterized by the presence of crowberry (*Empetrum nigrum*) and the moss *Rhytidiadelphus loreus* or the separate association of mountain blanket bog (*Rhytidiadelpho-Sphagnetum fuscii*) with cloudberry (*Rubus chamaemorus*). Flushed slopes and depressions of the high hills and mountain tops are the sites of stiff sedge-fescue grassland (the *Carex bigelowii-Festuca vivipara* Association) on subalpine or alpine gleyed podzols and gleys. The vegetation is usually dominated by white bent (*Nardus stricta*) or heath rush (*Juncus squarrosus*). The more freely drained soils of the exposed ridges and summits support fescue-woolly fringe-moss heath (*Festuco-Racomitrietum lanuginosi*) which often contains least willow (*Salix herbacea*).

### WOODLAND

Coniferous plantations are extensive and there are also many examples of what might be considered natural or semi-natural remnant woodlands of which the commonest type is that of oak and birchwood. Brown forest soils and, to a lesser extent, humus-iron podzols on steep valley sides and lower hill slopes of the coastal fringe and islands within the hyperoceanic subsector support dry western oakwood and birchwood (*Blechno-Quercetum*). Distinctive species are mountain fern (*Thelypteris limbospemra*) and hard-fern (*Blechnum spicant*). Farther east in the euoceanic subsector, this association is replaced by southern oakwood (*Galio saxatilis-Quercetum*) in similar habitats, characterized by the presence of honeysuckle (*Lonicera periclymenum*). Where the two associations meet, there can be a relatively wide zone in which the vegetation can contain character species of both, for example, the Wood of Cree near Newton Stewart. Woodlands or scrub with canopies dominated by ash or hazel are classed as ash-oakwood (*Primulo-Quercetum*), again a predominantly hyperoceanic association but occurring on brown forest soils with a higher base status than those of western oakwood. Alderwood (the *Crepis paludosa-Alnus glutinosa* Association) sometimes occurs on the flushed peats, peaty gleys or humic gleys of alluvial flats, river terraces or valley sides. A widespread association of broadleaved woodland is found throughout the area on the base-rich soils of mixed bottom land or as long-

established policies woodland round many of the estate mansions. The canopy can be made up of a wide variety of deciduous species, but the association has been named elmwood (*Quercus-Ulmetum glabrae*). Vegetation of the woodland floor can include ramsons (*Allium ursinum*), dog's mercury (*Mercurialis perennis*), enchanter's nightshade (*Circaea lutetiana*), moschatel (*Adoxa moschatellina*) and many other base- and shade-loving species.

#### FORESHORE AND DUNES

Coastal communities are widely distributed but seldom extensive, the best examples of dunes and dune pasture being those on the non-shelly sand deposits along the western seaboard of Islay, Irvine Bay and Luce Bay and on the shelly sand of Colonsay and Oronsay. Where land management has permitted, the full sequence of fore dune or northern sea couch-grass dune (*Elymo-Agropyretum boreo-atlanticum*), yellow dune or northern marram grass dune (*Elymo-Ammophiletum*) and grey dune or eyebright-red fescue dune (*Euphrasio-Festucetum arenariae*) can be present. The last named association also occurs on the freely drained soils of the sandy flats behind the dune systems and it is usually intensively grazed by both sheep and cattle. Under heavy grazing and dunging, it may become altered to meadow-grass-bent pasture (the *Galium saxatile-Poa pratensis* Community). Wet depressions in these flats carry a range of swamp, rush and sedge communities on gley soils.

#### SALTINGS AND SPLASH ZONE

The vegetation of coastal saline gleys (saline alluvial soils), for example those of Wigtown Bay, is dominantly that of two associations, the sea poa salt-marsh (*Puccinellietum maritimae*) at or slightly below high-water mark, and mud rush salt-marsh (*Juncetum gerardii*) at a slightly higher elevation. Reed swamp (*Phragmitium*) may occur along the landward edges of these saltings. A narrow zone of heath and grassland influenced by sea spray may occur on some of the more exposed cliffs and headlands of the west coast. The communities here are the sea plantain-crowberry heath (the *Plantago maritima-Empetrum nigrum* Community) and the vernal squill maritime pasture (the *Scilla verna-Festuca rubra* Community) and they usually occur together as a closely grazed mosaic. A further indication of the maritime influence of the western seaboard is the presence of dwarf furze (*Ulex galii*) in the dry moorland of the Rhins peninsula, a species common to the maritime heaths farther south.

#### LAND USE

Agricultural land use in South-West Scotland is diversified by, and in its broad pattern closely related to, physiography and climate. On the lowlands of the Midland Valley and the Solway Firth, high rainfall, equability of temperature and oceanicity of climate favour grass growth rather than arable cropping and Ayrshire and Galloway are renowned for the quality of their dairy industry. The main characteristic of the land is the slow permeability of the soils, which need efficient under-drainage for intensive production and adequate housing for stock to increase the possibility of grazing control and to reduce poaching damage during wet seasons.

Traditionally, a specialized rotation of cropping with hay production from timothy grass leys and short breaks in grain crops has been followed on the Carse of Stirling where it is well adapted to soil conditions.

On the hills of both the Southern Uplands and the Highlands and Islands

sheep and cattle are managed extensively. Here, improved land or land capable of improvement has a special value in producing winter keep and better quality grazing for animals during periods of stress and allowing economic stocking on poor-quality hill pastures.

In recent years forestry has become important in the hill regions, and the establishment of extensive Forest Parks in Carrick and Galloway and in Argyll are notable developments. Timber production is expected to increase throughout the coming decade as earlier plantings mature.

Hill and upland areas not easily improved or reclaimed form natural habitats important for endangered predatory and other birds and animals as well as containing sites, such as the Silver Flowe peat moss, preservation of which are desirable on scientific grounds.

The need for public access to areas of open countryside is likely to continue to develop and again it is in the hills and uplands of Galloway and the Highlands and Islands where areas of natural beauty are likely to become increasingly popular. The traditional field sports of grouse shooting, deer stalking and fishing are still followed vigorously on the great estates, and in the case of fishing are followed by a much wider public. However, the moist climate and poorly draining soils of south-west Scotland are less favourable for the maintenance of grouse moors than the drier areas of east and north-east Scotland.



## 2 The Soil Map Units

### THE ALLUVIAL SOILS

(Map units 1 and 2)

Alluvial soils are developed on recently deposited alluvia originating in freshwater or marine environments and occupy 235 square kilometres (1.6 per cent of South-West Scotland). Freshwater alluvium is found along most watercourses throughout the region, but soils on marine alluvium have been mapped only below the high-water mark of ordinary spring tides in estuaries opening into the Solway Firth. In association with soils developed on fluvio-glacial gravels, alluvial soils are also important components in *map units 98, 99, 103, 164, 198, 200 and 579*.

**Map unit 1** occupies 225 square kilometres and comprises soils developed on freshwater alluvium of riverine or lacustrine origin. The alluvial drifts are derived from the rocks in the catchments of the watercourses from which they are deposited: north of the Highland Boundary Fault the strata are predominantly metamorphic rocks of the Dalradian Assemblage, in the Midland Valley Old Red Sandstone and Carboniferous sediments and lavas occur and in the Southern Uplands there are Lower Palaeozoic greywackes and shales. The textures of the deposits range widely, often showing a high degree of local variation; loams and sandy loams are predominant and generally overlie gravels at 30 to 100 centimetres depth. The soils have been mapped along most major watercourses but are found also along minor burns as narrow tracts too small for representation at the scale employed. Below 30 metres altitude the soils are extensive but higher-lying tracts are also encountered. The land is level or gently sloping with minor undulations, but there are often steep banks at the margins. Climatic conditions are generally warm, moderately dry or wet lowland with average rainfall in the range of 1000 to 2000 millimetres per annum.

Alluvial soils are young and the effects of chemical weathering or the formation of well-differentiated horizons are only poorly exhibited. Apart from the amount and type of humus formation and its accumulation within the surface layers, soil differences are principally of texture, inherited from the parent material, and the depth of the local ground-water table. Many soils are naturally free-draining in the upper layers but are waterlogged on very low-lying land where water cannot move to natural outlets because of high river levels.

Prolonged, severe waterlogging has led to the accumulation of peat-alluvium as in Glendaruel (Plate 5), alongside the Crinan Canal or in parts of the alluvial area west of Campbeltown.

The soils usually form only a small proportion of any farm and their use is greatly influenced by the character of the surrounding land, although liability to flooding, extent, situation and climate, which range widely in different localities, are also important. Alluvial soils with free natural drainage can be deep and well suited to the growth of arable crops as for example along the River Nith at Penpont, the lower reaches of the Water of Girvan, at New Galloway and on Arran. The risk of periodic damaging floods must, however, be assessed locally according to experience. Under-drainage is required for the efficient utilization of naturally waterlogged soils and is dependent on achieving suitable outfalls. Along the Machrihanish Burn at Campbeltown the water-table has been lowered successfully by dredging and straightening of the watercourse and at Gruinart Flats on Islay parallel open ditches drain an area of low-lying alluvium from which silage is now taken.

In the Highlands and Islands the alluvial soils are often highly valued in relation to the surrounding land and are cultivated for crops for animal feed or carry arable or permanent pasture. The output from these areas is thus able to meet the demands of stock at seasons when other keep is not available or the nutritional requirements of animals are especially high. Alluvial land fulfils a similar role in the hills of the Southern Uplands, but along the Solway lowlands and in the Midland Valley pressure on these soils is less and use is determined by ease of cultivation as affected by texture, wetness and climate. Where high water-tables and poor outfalls preclude effective drainage, the natural rush pastures or sedge mires form rough grazing of moderate or good quality. Near Bridgend, on Islay, selective drainage of alluvial soils has provided good forestry land.

**Map unit 2** comprises soils represented on the map as saline gleys, but which are better classed as saline alluvial soils. It occurs mainly in the estuary of the River Cree and occupies 10 square kilometres in South-West Scotland. The soils are developed on stone-free, silty marine alluvium below the high-water mark of ordinary spring tides and are periodically inundated by the sea. In consequence, the soils are strongly saline and the land, generally referred to as 'saltings', has a network of open channels allowing ingress and drainage of tidal waters, but usually preventing vehicles traversing the ground. The vegetation consists of halophytic species and the principal communities are sea poa salt-marsh, mud rush salt-marsh and reed swamp.

Without earthworks to keep out the sea the land cannot be improved, but it does provide healthy grazing for stock and is much valued by farmers with rights of access. Care in management is necessary to avoid losses of stock during periods of inundation.

## THE ORGANIC SOILS

(Map units 3 and 4)

Organic soils are developed on deposits of peat with an organic content of more than 60 per cent and more than 50 centimetres thick. They are some of the most extensive soils and have been mapped over 1394 square kilometres (9.7 per cent of South-West Scotland). In the rugged and mountainous terrain north of the Highland Boundary Fault and in the hills of Carrick the moist climate favours the

## SOUTH-WEST SCOTLAND

Table A Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association	ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
ALLUVIAL SOILS (235 sq. km., 1.6%)	1	225	1.6	96	COUNTRESSWELLS/ DALBEATTIE/ PRIESTLAW (456 sq. km., 3.2%)	113	25	0.2	5
	2	10	<0.1	4		114	41	0.3	9
ORGANIC SOILS (1394 sq. km., 9.7%)	3	215	1.5	15		117	12	<0.1	3
	4	1179	8.2	85		119	80	0.6	18
ARRAN (60 sq. km., 0.4%)	37	24	0.2	40		120	6	<0.1	1
	38	36	0.3	60		122	40	0.3	9
ASHGROVE (112 sq. km., 0.8%)	39	3	<0.1	<5		123	41	0.3	9
	40	109	0.8	95		124	20	0.1	4
BALROWNIE (290 sq. km., 2.0%)	41	111	0.8	38		126	95	0.7	21
	42	77	0.5	27		127	18	0.1	4
	43	6	<0.1	2		129	23	0.2	5
	44	1	<0.1	<1		131	24	0.2	5
	46	15	0.1	5		132	9	<0.1	2
	47	17	0.1	6		133	16	0.1	4
	48	46	0.3	16		134	4	<0.1	<1
	49	6	<0.1	2	135	2	<0.1	<1	
BARGOUR	51	90	0.6	100	CRAIGDALE (15 sq. km., 0.1%)	138	3	<0.1	20
	52	2	<0.1	100	139	12	<0.1	80	
BARNCORKRIE	56	29	0.2	65	CREETOWN (29 sq. km., 0.2%)	141	9	<0.1	30
	57	2	<0.1	<5		142	8	<0.1	30
BENAN (46 sq. km., 0.3%)	58	15	0.1	35	143	12	<0.1	40	
	BLAIR (54 sq. km., 0.4%)	68	21	0.2	40	147	128	0.9	13
69		33	0.2	60	148	122	0.9	12	
CARPOW/PANBRIDE	89	29	0.2	100	149	139	1.0	14	
	CARTER (2 sq. km., <0.1%)	90	1	<0.1	50	150	217	1.5	22
92		1	<0.1	50	151	45	0.3	4	
CORBY/BOYNDIE/ DINNET (146 sq. km., 1.0%)	98	8	<0.1	5	152	8	<0.1	<1	
	99	80	0.6	55	DARLEITH/ KIRKTONMOOR (1006 sq. km., 7.0%)	153	44	0.3	4
	100	2	<0.1	<5	154	130	0.9	13	
	101	10	<0.1	5	155	69	0.5	7	
	103	15	0.1	10	156	14	0.1	1	
	104	8	<0.1	5	158	75	0.5	7	
DOUNE	105	18	0.1	10	159	11	<0.1	1	
	106	5	<0.1	<5	160	1	<0.1	<1	
	DEECASTLE (21 sq. km., 0.2%)	161	3	<0.1	<1	163	66	0.5	40
		162	3	<0.1	<1	164	97	0.7	60
DARVEL (163 sq. km., 1.1%)	163	66	0.5	40	DOUNE	165	21	0.2	100
	164	97	0.7	60		166	<1	<0.1	<5
DEECASTLE (21 sq. km., 0.2%)	165	21	0.2	100		168	5	<0.1	100
	166	<1	<0.1	<5					

Table A Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association	ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association	
DREGHDRN (92 sq. km., 0.6%)	169	87	0.6	95	FOUDLAND (687 sq. km., 4.8%)	241	32	0.2	5	
	170	5	<0.1	5		242	95	0.7	14	
DRONGAN	171	53	0.4	100		243	3	<0.1	<1	
						246	61	0.4	9	
DURISDEER (15 sq. km., 0.1%)	179	11	<0.1	75		247	56	0.4	8	
	180	4	<0.1	25		248	5	<0.1	<1	
DURNHILL (432 sq. km., 3.0%)	184	39	0.3	9		249	45	0.3	7	
	185	30	0.2	7		250	61	0.4	9	
	186	3	<0.1	<1		251	43	0.3	6	
	188	213	1.5	49		252	34	0.2	5	
	190	108	0.8	25		253	182	1.3	26	
	191	28	0.2	6		254	69	0.5	10	
	193	11	<0.1	3		255	1	<0.1	<1	
ECKFORD/INNERWICK (7 sq. km., <0.1%)	196	2	<0.1	30		FRASERBURGH (6 sq. km., <0.1%)	259	<1	<0.1	<5
	198	5	<0.1	70			260	2	<0.1	35
206	146	1.0	5	261			4	<0.1	65	
207	250	1.7	8	264			15	0.1	5	
208	134	0.9	5	265			132	0.9	47	
209	79	0.6	3	266			23	0.2	8	
210	34	0.2	1	GLENALMOND/ MAYBOLE (279 sq. km., 1.9%)			267	30	0.2	11
211	177	1.2	6				268	12	<0.1	4
212	37	0.3	1				269	5	<0.1	2
213	111	0.8	4				270	52	0.4	19
214	129	0.9	4			271	9	<0.1	3	
215	189	1.3	6		272	1	<0.1	<1		
216	57	0.4	2	GLENEAGLES/ AUCHENBLAE/ COLLIESTON/DARNAWAY	273	13	<0.1	100		
217	4	<0.1	<1		GOURDIE/ CALLANDER/ STRATHFINELLA (39 sq. km., 0.3%)	274	17	0.1	45	
218	123	0.9	4	275		22	0.2	55		
219	16	0.1	<1	287		7	<0.1	40		
ETTRICK (2954 sq. km., 20.6%)	220	111	0.8	4	HAYFIELD (18 sq. km., 0.1%)	288	6	<0.1	35	
	221	176	1.2	6		289	5	<0.1	30	
	222	37	0.3	1		290	<1	<0.1	<5	
	223	220	1.5	7	HINDSWARD (150 sq. km., 1.0%)	291	51	0.4	35	
	224	28	0.2	<1		292	49	0.3	35	
	225	4	<0.1	<1		293	50	0.4	35	
	226	65	0.5	2	HOLYWOOD (16 sq. km., 0.1%)	303	5	<0.1	30	
	228	33	0.2	1		304	7	<0.1	45	
	229	140	1.0	5		305	4	<0.1	25	
	230	223	1.6	8						
231	219	1.5	7							
232	96	0.7	3							
233	66	0.5	2							
234	3	<0.1	<1							
235	26	0.2	<1							
236	21	0.2	<1							

Table A Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association	ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
INCHKENNETH (27 sq. km., 0.2%)	308	15	0.1	55	LINFERN	379	2	<0.1	100
	309	<1	<0.1	<5	LINKS (37 sq. km., 0.3%)	380	25	0.2	70
	310	4	<0.1	15		381	10	<0.1	25
	311	8	<0.1	30		382	2	<0.1	5
KILMARNOCK (251 sq. km., 1.8%)	331	230	1.6	92	LOCHINVER (25 sq. km., 0.2%)	389	1	<0.1	<5
	332	21	0.2	8		394	23	0.2	90
KINTYRE (484 sq. km., 3.4%)	333	92	0.6	19		395	1	<0.1	<5
	334	94	0.7	19	MAUCLINE/ AUCHINLECK (83 sq. km., 0.6%)	401	46	0.3	55
	335	136	1.0	28		402	13	<0.1	15
	336	162	1.1	33		403	9	<0.1	10
KIPPEN/LARGS (219 sq. km., 1.5%)	337	84	0.6	38		404	15	0.1	20
	338	52	0.4	24	REPPPOCH (123 sq. km., 0.9%)	432	25	0.2	20
	339	14	0.1	6		433	23	0.2	20
	340	7	<0.1	3		434	5	<0.1	<5
	341	2	<0.1	<1		435	29	0.2	25
	342	6	<0.1	3		436	41	0.3	35
	343	14	0.1	6		RHINS (443 sq. km., 3.1%)	437	25	0.2
	344	33	0.2	15	438		177	1.2	40
	345	4	<0.1	2	439		144	1.0	33
	346	1	<0.1	<1	440		73	0.5	16
	347	2	<0.1	<1	441		6	<0.1	1
KIRKCOLM	348	9	<0.1	100	442		17	0.1	4
	351	1	<0.1	<5	443		1	<0.1	<1
KNOCKSKAE (45 sq. km., 0.3%)	352	11	<0.1	25	ROWANHILL/ GIFFNOCK/ WINTON (912 sq. km., 6.3%)	444	76	0.5	8
	353	7	<0.1	15		445	340	2.4	37
	354	2	<0.1	5		446	329	2.3	36
	355	2	<0.1	5		447	36	0.3	4
	356	6	<0.1	15		448	16	0.1	2
	357	16	0.1	35		449	<1	<0.1	<1
	358	<1	<0.1	<5		450	114	0.8	13
	359	83	0.6	80		451	1	<0.1	<1
LANFINE (102 sq. km., 0.7%)	360	13	<0.1	15	SHAWHILL	458	3	<0.1	100
	361	6	<0.1	5		465	18	0.1	7
LAURENCEKIRK	368	2	<0.1	100	466	96	0.7	37	
	374	1	<0.1	5	467	123	0.9	47	
LETHANS (15 sq. km., 0.1%)	375	1	<0.1	5	468	2	<0.1	<1	
	376	1	<0.1	5	469	1	<0.1	<1	
	377	12	<0.1	80	470	15	0.1	6	
	378	<1	<0.1	<5	471	8	<0.1	3	

Table A Areas of soil map units

ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association	ASSOCIATION (sq. km., % Total Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
SOURHOPE (71 sq. km., 0.5%)	472	6	<0.1	10	TARVES (135 sq. km., 0.9%)	519	36	0.3	25
	473	5	<0.1	5		525	18	0.1	10
	474	10	<0.1	15		526	29	0.2	20
	475	3	<0.1	<5		528	51	0.4	40
	476	16	0.1	25		529	1	<0.1	<5
	477	7	<0.1	10		531	<1	<0.1	<5
	478	10	<0.1	15		TOROSAY (33 sq. km., 0.2%)	546	5	<0.1
479	14	<0.1	20	548	11		<0.1	35	
STIRLING/OUFFUS/ POW/CARBROOK (208 sq. km., 1.5%)	487	27	0.2	13	549		11	<0.1	35
	488	181	1.3	87	550		6	<0.1	20
STONEHAVEN (14 sq. km., <0.1)	490	8	<0.1	55	TORRIGON (80 sq. km., 0.6%)	552	11	<0.1	15
	493	4	<0.1	30		554	1	<0.1	<5
	495	<1	<0.1	<5		555	3	<0.1	<5
	496	2	<0.1	15		556	13	<0.1	15
STRICHEN (941 sq. km., 6.6%)	497	10	<0.1	1	557	30	0.2	40	
	498	15	0.1	2	558	22	0.2	30	
	500	2	<0.1	<1	YARROW/FLEET (197 sq. km., 1.4%)	576	70	0.5	35
	501	3	<0.1	<1		577	20	0.1	10
	502	<1	<0.1	<1		578	37	0.3	20
	503	12	<0.1	1		579	66	0.5	35
	504	34	0.2	4		580	4	<0.1	<5
	505	114	0.8	12		ROCK	26	0.2	
	506	59	0.4	6					
	507	470	3.3	50	BUILT-UP AREAS	711	5.0		
	508	43	0.3	5					
	509	15	0.1	2					
	510	79	0.6	8					
511	80	0.6	9						
512	3	<0.1	<1						
513	2	<0.1	<1						

development of peat, which is widespread but often not in sufficient unbroken areas to be separately mapped. Organic soils are therefore major components of many other soil map units and cover a large area in addition to that of *map units 3 and 4*.

In Wigtownshire and south Ayrshire low-lying peats with scattered drumlins form distinctive patterns—*map units 211 and 213*. Basin peats occur throughout the lowlands and, having originated in basins and depressions, are generally confined within the surrounding mineral soils, but included with them are some peats on raised beach terraces and on lowland valley floors. Blanket peats are widespread in the uplands and include some formations which originated in basins within the hills. Where peat on lowland terraces is contiguous with hill peats or extensive areas of organo-mineral soils, it has been mapped with blanket peats.

Peat has developed under a wide range of climate but most blanket peat occurs in the fairly warm, cool and cold wet foothill and uplands, while basin and other lowland peats are found in warm, moderately dry or wet lowland. Blanket peat generally receives high average annual precipitation, in the range 1250 to 2000 millimetres. The characteristic plant communities of these organic soils include blanket and flying bent bogs, upland and mountain blanket bogs and some small areas of swamp, sedge mires and rush pastures on lowland peats.

**Map unit 3**, consisting of organic soils developed on basin and valley peats, occupies 215 square kilometres in South-West Scotland. The peat is generally thick, 1 to 5 metres, widely distributed and found mainly below 100 metres altitude, but with some areas, such as Airds Moss, at 200 metres.

In Argyll and the islands, basin peats on the Laggan, west of Campbeltown, have been reclaimed for productive grassland, and unreclaimed strongly flushed basins are found on Colonsay and Islay. Along the Barr River, valley peat is heavily flushed and an area of terrace peat has been mapped on the Moine Mhor, near Lochgilphead. In the Midland Valley, Flanders Moss is a remnant of the former extensive cover of peat in the Forth valley, and Airds Moss exemplifies deposits in the basins of the undulating till-covered lowlands. The Silver Flowe is a well-known bog with dubh lochans which originated in basins along the Couran Lane, an intermontane valley of the Southern Uplands, and in Wigtownshire extensive peats occupy ice-scoured basins on the moorlands east of Glenluce (Plate 14).

The peats are waterlogged for most of the year and extensive and specialized drainage is necessary for their improvement. On the larger areas the cutting of new drainage channels or the clearing and deepening of existing watercourses, organized co-operatively by a number of farmers or by a local drainage authority, is a prerequisite to improvement measures on individual farms. The drainage of small bogs is often within the compass of an individual but requires suitable outfalls and a large amount of capital. Apart from the Laggan, already cited, most basin peats are currently utilized as rough grazing with low stock-carrying capacity. The Silver Flowe is a nature reserve. Coniferous forest plantations, with lodgepole pine an important component species, have been established in some areas.

**Map unit 4**, comprising organic soils developed on blanket peat, is extensive, occupying 1179 square kilometres in South-West Scotland (8.2 per cent of the region), and in addition the soils are widespread as a component of other map units. The peat is generally thin, 0.5 to 1 metre in thickness, but is of greater

depth locally and in some areas is eroded and hagged. It is developed mainly on gentle slopes, but is sometimes found on steeper areas in the uplands and hills where the cool, moist climate with high average annual rainfall has led to intense leaching, acid soil conditions and low levels of biotic activity. At the highest altitudes and in the coldest conditions above about 750 metres, organic matter production is much reduced, and there is little or no peat.

Waterlogging of the soils for long periods of the year and the cool wet climate are unfavourable to the maintenance of improved grass swards. Where improvements have been made skilful grazing management is required to avoid the ingress and spread of rushes or severe poaching damage to the sward. The land provides rough grazing of poor quality from blanket and flying bent bog and upland and mountain blanket bog communities. Considerable areas have been ploughed, surface-drained and planted with conifers, mainly Sitka spruce, but growth is very dependent on altitude, exposure and nutrient status of the peat.

## THE ARRAN ASSOCIATION

(Map units 37 and 38)

The parent material of the Arran Association is a red-brown till derived from Triassic marls, cornstones and sandstones. In South-West Scotland it is confined to the Island of Arran, but it also occurs near Stornoway in the Isle of Lewis (The Outer Hebrides, Sheet 2). Similar rocks occur between Annan and Gretna Green (South-East Scotland, Sheet 7), but the overlying drifts also include materials from other sources. The reddish brown till has a sandy clay loam texture but where it has been strongly water-modified, particularly in the larger valleys and below 30 metres altitude, it is sandy loam even at depth. Because of the soft nature of the parent rocks, outcrops are rare. The terrain is gently undulating with subdued drumlins and till ridges. Areas of till banked against adjacent hard rocks are also frequently found.

Tills derived from Permian sediments are also found on southern Arran and a number of mixed tills, intergrades between the parent materials of the Arran and Mauchline Associations, have been encountered. The Arran Association occupies 60 square kilometres (0.4 per cent of South-West Scotland).

Near the coast the climate is warm and moist with an average annual rainfall of 1200 millimetres, rising inland over warm wet foothills to 1400 millimetres.

**Map unit 37** occupies 24 square kilometres (40 per cent of the association) and consists mainly of noncalcareous gleys, with some humic gleys in hollows and flush sites. However, below 30 metres altitude much of the drift has been reworked by glacial meltwaters or by the sea when it stood at higher levels in comparison with the land than at present, and on these coarser textured materials the natural drainage is less impeded and brown forest soils and podzols (usually cultivated) are found.

A soil profile from the bank of the Slidery Water exemplifies the soils developed on partially water-modified drifts. Ochreous mottles are present in the plough layer, which is 36 centimetres thick and underlain by 19 centimetres of a sandy loam, mottled reddish yellow Bg horizon. Below this, the sandy clay loam till is grey and strongly gleyed in its upper 25 centimetres, but gleying decreases in the deeper layers, which are reddish brown in colour with yellowish brown mottles. The well-developed gley features indicate that the soil has been subject to prolonged, if seasonal, waterlogging.



The land is utilized for the growth of crops and as permanent pastures; the coarser textured soils on gentle south-facing slopes as at Kilchonan and west of Bannan Head are the most readily cultivated.

**Map unit 38** occupies 36 square kilometres (60 per cent of the association) and comprises peaty gleys and peat with some humic gleys on locally steeper slopes or in 'flushes'. The soils of this map unit become predominant in the landscape over those of *map unit 37* as altitude and rainfall increase.

A profile from north-east of Kilmory has an O horizon 27 centimetres thick underlain by a mottled, reddish brown, sandy loam, below which the C horizon at 60 centimetres is similar in colour but of sandy clay loam texture.

Plantations of coniferous trees have been established on significant areas of land, but much remains as rough grazing and carries moist Atlantic heather moor, bog heather moor and blanket and flying bent bog communities. A few areas at low altitudes have been improved by reseeding, where the rainfall is less than on the higher ground, the soils more permeable and the surface organic horizons thin.

## THE ASHGROVE ASSOCIATION

(Map units 39 and 40)

First mapped in north Ayrshire (Mitchell and Jarvis, 1956), the Ashgrove Association comprises soils developed on drifts derived from shales and sandstones of Carboniferous age and which, in some areas, have an admixture of limestone. Shale-derived materials generally predominate in the drift, which is a compact clayey till, but some less fine textures—stony clay loams—are encountered where rock is close to the surface. The clayey nature of the till is inherited by the soils, which are amongst the most fine-textured in South-West Scotland.

The association occupies 112 square kilometres (0.8 per cent of South-West Scotland), mainly north of the River Irvine on the undulating till plain of Ayrshire with a few smaller areas farther south.

Near Ayr at about 25 metres altitude the climate is warm and moderately dry with rainfall of about 1000 millimetres per annum, and at about 150 metres at Uplaw Moor it is warm and wet with average precipitation of 1300 millimetres per annum.

The principal soils are noncalcareous gleys. Brown forest soils with gleying are less extensive and humic gleys occupy very small areas only. Where some limestone fragments are present in the parent tills, pH values are high, 7.5–8.0, in the Gc horizons but amounts of free calcium carbonate are small.

**Map unit 39** occupies only 3 square kilometres (less than 5 per cent of the association) and comprises brown forest soils with gleying and some noncalcareous and humic gleys. The natural soil drainage is mainly imperfect but is poor or very poor in the gley soils. The land has better cropping potential than that of *map unit 40* and although of small extent is considered separately. The strong slopes in the generally gently undulating till plain tend to be the areas where the rock is nearer the surface, the drift is thinner and less fine in texture, and the soil structure is better developed and internal drainage less impeded than elsewhere in the association. The land is accordingly less liable to suffer damage to the soil structure during cultivation and opportunities for arable cropping are increased.

**Map unit 40** extends to 109 square kilometres (95 per cent of the association) and comprises mainly noncalcareous gleys; some peaty gleys, humic gleys and peat are present in hollows. The natural drainage is predominantly poor, but can be very poor in low-lying areas. In these clayey soils structure is poorly developed and under the prevailing wet climate their cultivation is difficult. Land use, therefore, is confined mainly to permanent pasture with occasional arable cropping to allow reseedling of the grass sward. The clayey soils have poorly developed coarse structures in the subsoil, are only slowly permeable to moisture and have poor internal drainage. For the maintenance of grass swards under modern levels of stocking or for cultivation of crops efficient systems of under-drainage are necessary and should include permeable infill in the trench-lines and mole ploughing as a secondary treatment.

## THE BALROWNIE ASSOCIATION

(Map units 41-44, 46-50)

The soils of the Balrownie Association have long been known in Strathmore and are developed on drifts derived mainly from sandstones of Lower Old Red Sandstone age. The drift, generally several metres thick, is principally a compact loam to sandy clay loam till. Below 100 metres altitude the upper layers of the till are often water-modified and of sandy loam to loamy sand texture. On the upper slopes of some ridges sandstone rock occurs near the surface and the thin drifts are generally sandy loams. Colluvial drifts predominate in some western areas which have significant amounts of outcropping rock. The drifts and tills are moderately stony and their bright reddish brown colours are inherited from the parent rocks.

The association occupies 290 square kilometres (2.0 per cent of South-West Scotland) in the lowlands and extends north-eastwards from Kintyre through Helensburgh, Loch Lomond, Drymen and Buchlyvie to Thornhill in the Forth valley (Plate 8) and Bridge of Allan at the southern end of Strathallan. It is also widespread in Eastern Scotland (Sheet 5) and in South-East Scotland (Sheet 7). The land is mainly undulating lowland, between 80 and 100 metres altitude, but along the shores of Kintyre and Loch Lomond it extends down to 15 metres and on the moorland north of Drymen it reaches heights of 270 metres.

Rainfall ranges from 1100 millimetres per annum in the warm moderately dry lowlands of the east to 1500 millimetres per annum in the western warm wet lowlands and to over 2000 millimetres in the warm wet foothills of Drymen and Helensburgh.

In the cultivated lowlands, brown forest soils with gleying predominate and noncalcareous gleys are found mainly on the gentle slopes of the moorlands and lower slopes of hills. Shallow brown forest soils occur on some strong or steep slopes where rock is near the surface, and on the higher-lying land peaty gleys are common. Humus-iron podzols and peaty podzols occupy steep slopes.

**Map unit 41** is extensive and occupies 111 square kilometres (38 per cent of the association), mainly between Loch Lomond and Bridge of Allan. Brown forest soils with gleying predominate on the gentle slopes of the undulating lowland, but brown forest soils occur on strong or steep slopes and noncalcareous gleys in hollows. The principal soil has a loamy, moderately structured surface horizon overlying a water-sorted, moderately structured, loamy and readily permeable subsoil layer. Below this, the parent sandy clay loam to loam till is poorly

structured and only slowly permeable. The fine sand fraction is generally high in the plough layer and soils with seedbeds worked to a fine tilth are liable to 'capping' in wet weather. Grassland is likely to become poached and suffer soil structural damage if heavily stocked in wet seasons. Slopes are generally favourable to arable agriculture, although there is likely to be some wheel slip on gradients greater than 7 degrees, and stones, generally present in moderate amounts, present few problems to cultivation and cropping.

**Map unit 42** is widespread and occupies 77 square kilometres (27 per cent of the association). On the gentle slopes and depressions of the undulating lowland the soils are mainly noncalcareous gleys, with some humic gleys and peaty gleys. The natural drainage of these soils is poor. Brown forest soils with gleying occupy the few strong or steep slopes. Loamy textures and moderate structures predominate in the topsoils. Subsoils are generally sandy clay loam or clay loam, have weakly developed structure and are only slowly permeable to moisture. The problems of poaching and 'capping' associated with this land are, under the poor internal drainage conditions, more severe than the similar difficulties described for *map unit 41*. Permanent pastures and rough grazings predominate under the relatively wet climate of the westerly areas. Under-drainage systems with permeable infill in the drainage lines, followed by secondary subsoil treatments to improve subsoil structure and permeability, are necessary if the land is to be improved and high stocking rates maintained or arable crops grown. Trace element deficiencies can be encountered if the land is improved rapidly.

**Map unit 43** occupies only 6 square kilometres (2 per cent of the association) and comprises brown forest soils and some brown forest soils with gleying. The natural drainage is free or imperfect and the soils are shallow with rock near the surface. Slopes are commonly strong and frequently uneven with occasional rock outcrops. The topsoils are mainly sandy loams with moderate structure and overlie poorly structured fine sandy loams or loams. The problems of 'capping' and poaching are generally less severe than on the soils of *map unit 41*, but trace element problems can arise as in *map unit 42*.

**Map unit 44** occupies only 1 square kilometre (less than 1 per cent of the association) and comprises podzolic soils which are generally free draining on landforms and thin parent tills similar to those of *map unit 43*.

**Map unit 46** extends to 15 square kilometres (5 per cent of the association) and comprises peaty gleys developed on stony sandy clay loam tills, some peat formed in depressions and on gentle slopes, and some peaty podzols on locally steep slopes. The natural drainage is generally poor and very poor, but in the lower horizons of the peaty podzols it is generally free. The land is mainly moorland occurring at altitudes up to 300 metres and is utilized as rough grazing. Comprehensive drainage and application of lime and fertilizer are necessary for successful reclamation. Care may be necessary to maintain satisfactory trace element levels for herbage and stock. In areas of high rainfall improvements are unlikely to be economic.

**Map unit 47** occupies 17 square kilometres (6 per cent of the association) and comprises noncalcareous gleys with some humic gleys. These soils are developed mainly on sandy clay loam till, but occasionally, in areas where rock crops out, they are on sandy colluvial drift. Apart from the presence of rock outcrops and

colluvial drifts, which are permeable and often carry brown forest soils, the land is similar to that of *map unit 42*. Permanent grassland and rough grazing are the main forms of land use and measures necessary for pasture improvement or cultivation are similar to those described for *map unit 42*.

**Map unit 48** occupies 46 square kilometres (16 per cent of the association) north of Helensburgh and in Kintyre. The undulating lowlands are generally similar to those of *map unit 47*, but are higher-lying. The soils are principally peaty gleys developed on sandy clay loam tills or sandy colluvium, but include some peat and peaty podzols with iron pans. The moist Atlantic heather moor, bog heather moor and blanket bog vegetation provides rough grazing of only poor quality.

**Map unit 49** occupies 6 square kilometres (2 per cent of the association) and occurs on steep, moderately rocky slopes near Helensburgh and on Arran. The sandy colluvium on which the soils are developed is free-draining and the dominant soils are brown forest soils and humus-iron podzols. Slopes are generally too steep to allow the establishment of improved grass swards, but the rough grazing on the acid bent-fescue grasslands of the brown forest soils is of good quality, although the grazing is only moderate or poor on the dry Atlantic heather moor of the podzolic soils.

**Map unit 50** occupies 11 square kilometres (4 per cent of the association) and occurs on the moderately rocky gently undulating terrain with gentle and strong slopes in Arran, Kintyre and near Balloch. The dominant soils are peaty gleys and peat with rare peaty podzols, all developed on sandy loam colluvium. The semi-natural vegetation of bog heather moor and blanket bog provides only low-quality rough grazings. The wet climate precludes sustained improvement.

## THE BARGOUR ASSOCIATION

(Map unit 51)

The Bargour Association, first recognized in central Ayrshire, comprises soils developed on clay loam tills derived mainly from Barren Red Measures sandstones, but having some admixture from Carboniferous strata and Old Red Sandstone sandstones.

The association occupies 90 square kilometres (0.6 per cent of South-West Scotland) and occurs mainly in central Ayrshire with two small isolated areas near Uddingston and Douglas in Lanarkshire. The land lies at moderate altitudes, mainly between 40 and 250 metres, and the climate ranges from warm and moderately dry to warm and rather wet. Rainfall is generally 900–1000 millimetres per annum but reaches 1150 millimetres per annum in south Lanarkshire.

The principal landform is undulating lowland with drumlin ridges and slopes are generally gentle (Plate 11) but occasionally strong. Brown forest soils with gleying predominate on most of the landscape, although noncalcareous and humic gleys occupy hollows and depressions and also occur in areas affected by subsidence over coal workings.

**Map unit 51** comprises mainly brown forest soils with gleying developed on reddish brown clay loam tills. They generally have topsoils of sandy clay loam to loam texture, moderate structure and few stones. Structure in the underlying

clayey subsoil is a moderately developed, but very coarse, prismatic, and the soil is slowly permeable and, under wet conditions, is plastic and difficult to manage. There is little evidence of structural development in the red-brown clay loam till which forms the parent material. The natural drainage is generally imperfect.

The land is maintained mainly as permanent pasture, but some arable crops are grown where the risk of soil waterlogging is reduced due to locally steep slopes, increased soil permeability or low rainfall. Efficient tile drains, with permeable infill, and secondary treatments of mole ploughing or subsoiling are necessary for intensive grazing or for arable cropping.

### THE BARNCORKRIE ASSOCIATION

(Map unit 52)

Occupying only 2 square kilometres (less than 0.1 per cent of South-West Scotland), the Barncorkrie Association comprises the soils developed on red-brown drifts containing greywacke stones and having an admixture of granitic material. The drift is principally a clay loam till, although in some areas the surface layers have been partially water-sorted and are sandy loams. The association occurs near the southern end of the Rhins of Galloway where it occupies the central part of a granite intrusion down-weathered to form a basin rimmed by ridges of granite and greywacke. The land lies below 100 metres altitude and slopes are gentle. Brown forest soils and brown forest soils with gleying are the principal soils.

**Map unit 52** comprises brown forest soils with free natural drainage developed on the partially water-sorted sandy loam drifts and brown forest soils with gleying on the unaltered clay loam lodgement tills. In the last-named soils, structures in the Bg horizons are coarse prismatic and the subsoils are only slowly permeable to moisture. The natural drainage is imperfect and efficient under-drains with permeable infill and secondary subsoiling treatments are required for the productive utilization of the soils.

The land is cultivated, generally in a rotation of 6 to 10 years grassland and a 3-year break of barley and forage root crops. The warm and moderately dry climate with 1000 millimetres per annum average rainfall is well suited to grass production and dairy farming is the principal enterprise.

### THE BENAN ASSOCIATION

(Map units 56–58)

The soils of the Benan Association, originally mapped in the Carrick district of Ayrshire (Bown, 1973), are developed on drifts derived from Lower Ordovician conglomerates of the Barr series—the Benan and Kirkland conglomerates. These conglomerates are derived mainly from basic igneous rocks and their high content of nutrient bases and ready permeability strongly influence the soils developed on their derived drifts. These drifts are mainly thin sandy loams and loams with many small and medium rounded stones. Moderately thick reddish brown loam and clay loam tills are present on lower more gentle hill slopes and in local depressions.

Covering 46 square kilometres (0.3 per cent of South-West Scotland), the association is confined to the middle and lower river catchments of the River

Stinchar and Water of Girvan. Downwasting of the conglomerates gives rise to landforms in which the hill slopes show a pattern of minor undulations and small hummocks and hollows. The land lies below 330 metres altitude; the average rainfall is 1250 millimetres per annum and the climate is fairly warm and wet.

Although high rainfall and permeable parent rocks favour soil leaching, the parent materials are base-rich and mineral breakdown and nutrient release in the soils prevent undue depletion of bases. Brown forest soils, with little differentiation of horizons, are predominant and carry mainly herb-rich bent-fescue grassland or arable and permanent pasture. On the clay loam tills the soils are generally brown forest soils with gleying and noncalcareous gleys. They are only slowly permeable, are affected by periodic waterlogging, and the semi-natural vegetation is sharp-flowered rush pasture.

**Map unit 56** occupies 29 square kilometres (65 per cent of the association) and comprises brown forest soils developed on thin stony sandy loam drifts and rock debris overlying permeable conglomerate rock. The natural drainage is free and soil profiles show weak differentiation of horizons. The surface horizons are brown in colour and have a strongly developed stable crumb structure. Strong slopes predominate on the hill and valley sides and the land rises to about 330 metres altitude.

Much of the land is utilized as rough grazing which is of high quality on the predominant herb-rich bent-fescue swards. There are some improved permanent pastures and small areas of arable crops. Steep slopes make reclamation difficult in some areas, but improvements to the sward by application of lime and fertilizer and by reseeding are possible on much of this land.

**Map unit 57** occupies only 2 square kilometres (less than 5 per cent of the association) and comprises brown forest soils with some noncalcareous gleys. The land is similar to that of *map unit 56* apart from the presence on gentle slopes of gley soils with poor natural drainage. The herb-rich bent-fescue grassland and sharp-flowered rush pasture provide rough grazing of good quality. Drainage of the gley soils is generally necessary for the establishment of leys and pastures on this land.

**Map unit 58** occupies 15 square kilometres (35 per cent of the association) and comprises noncalcareous gleys with some brown forest soils. The soils are developed generally on stony loamy drifts but are affected by spring lines and down-slope seepage of moisture. The natural drainage is usually poor and the soils are wet for prolonged periods. Some slowly permeable soils developed on clay loam tills are also encountered. The sedge mire and sharp-flowered rush communities provide good quality rough grazing. In a few areas brown forest soils on scattered low hummocks occur amongst the gleys but land use is little affected and is influenced mainly by the poor drainage of the predominant gleys. Under-drainage adapted to the soil pattern and landform is necessary for pasture improvement or arable cropping on this land. Arable crops are grown in a few of the more favoured areas and some improved pastures have been established, but generally the cost of drainage should be considered in relation to the value of the good quality of the rough grazing.

## THE BLAIR ASSOCIATION

(Map units 68 and 69)

The soils of the Blair Association, originally mapped in central Ayrshire, are developed on drifts, principally lodgement till, of mixed origin, comprising materials derived from greywackes and Old Red Sandstone sandstones and felsites. The association occupies 54 square kilometres (0.4 per cent of South-West Scotland) and occurs in the upper parts of the Stinchar, Doon and the Water of Girvan valleys, where Lower Old Red Sandstone sediments intruded by fine-grained acid igneous rocks crop out adjacent to the extensive Lower Palaeozoic greywackes. Reddish brown clay loam to loam lodgement till comprising material derived from these rocks in widely ranging proportions was deposited by ice moving north-westwards off the greywackes.

The land ranges in altitude from 150 to 350 metres and frequently occupies the lower parts of concave slopes in the upland valleys. The climate is generally fairly warm and wet with high (1500 millimetres) average annual rainfall.

Permeability to moisture in the parent tills is slow and the soils are found generally in sites affected by run-off and seepage from surrounding higher-lying land. Internal drainage, therefore, is generally poor and the soils are mainly noncalcareous gleys and peaty gleys; brown forest soils with gleying show marked gley features. Under the wet conditions of climate and soil the natural vegetation is mainly sharp-flowered rush pastures, sedge mires and flying bent grassland.

**Map unit 68** occupies 21 square kilometres (40 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. Gley features are well developed in both soils, which differ principally in their degree of mottling. The high rainfall, slowly permeable clay loam till and topographic position on concave and gentle slopes, all contribute to the wet conditions characteristic of this land.

The semi-natural vegetation of sedge mires and sharp-flowered rush pastures provides good quality rough grazing, and, within the context of hill land, the 'flushed' soils are relatively fertile and form the 'inbye' land of hill farms. In favoured areas at moderate elevations some arable crops are grown where drainage and other improvements have been carried out.

**Map unit 69** occupies 33 square kilometres (60 per cent of the association) and comprises noncalcareous gleys, peaty gleys and peat. The land of this map unit is generally higher-lying than that of *map unit 68* and the low temperatures, high precipitation and topographic situations account for the marked peat-forming propensity and the well-developed peaty horizons on many of the gley soils and for the presence of blanket peat. The soils are all characterized by poor internal drainage and under natural conditions are waterlogged for considerable periods. Most of the land is unimproved and the sharp-flowered rush pasture, flying bent grassland and bog heather moor provide rough grazing of high, moderate and low value respectively. Under the wet soil and climatic conditions improvements can be carried out only with difficulty.

## THE CARPOW/PANBRIDE ASSOCIATIONS

(Map unit 89)

The soils of the Carpow and Panbride Associations, first mapped in eastern Scotland (Laing, 1974), are developed on raised beach sands and gravels derived mainly from Old Red Sandstone sediments and lavas. The deposits are found along the former shores of both open seas and estuaries, and in the last-named situation the coarse-textured materials are often thin and overlie silts laid down on an older lower beach.

The associations occupy 29 square kilometres (0.2 per cent of South-West Scotland) and occur along the Clyde estuary between Helensburgh and Dumbarton, in the Endrick and Blane valleys near Drymen, and in the Forth valley near Arnprior, Thornhill, Gargunnoch and Stirling. In the western areas the climate is warm and wet with 1300 millimetres average annual rainfall. This decreases, however, to 1000 millimetres per annum in the Forth valley where the climate becomes warm and moderately dry.

Brown forest soils predominate throughout the associations, but brown forest soils with gleying are developed where, in former estuaries, the parent sands and gravels are thin and overlie silts. A few gleys are encountered in depressions or where the silts are very near the surface. On terraces, the soils are developed principally on gravels but sands are found in some mounded areas.

**Map unit 89** consists mainly of brown forest soils in which the natural drainage is free together with some brown forest soils with gleying. The topsoils are loamy, moderately deep and well structured, and the subsoils are sandy, moderately structured and permeable and overlie sands or sandy gravels. The soils are readily cultivated and present few difficulties to the growth of arable crops. The stone content is generally moderate or low and has little effect on cultivation, and the compaction, which can occur in the lower subsoil horizons, can help to maintain soil moisture levels. The higher content of fine sand and silt of the brown forest soils with gleying can lead to 'capping' of seedbeds.

## THE CARTER ASSOCIATION

(Map units 90 and 92)

The soils of the Carter Association, first described in the east Borders area (Muir, 1956), are developed on drifts derived from sandstones of Lower Carboniferous age. The rocks are mainly whitish, but in a few areas are red, and most of the derived drifts are thick clayey lodgement tills, but stony sandy loam colluvial materials are found on a few steep slopes.

The association, which is much more extensive in South-East Scotland, occupies only 2 square kilometres (less than 0.1 per cent of South-West Scotland) on the Kirkcudbrightshire coast. The land lies below 100 metres and the climate is warm and wet with an average rainfall of 1125 millimetres per annum.

The soils are mainly brown forest soils with gleying developed on the clayey tills, with brown forest soils on the thin colluvial drifts. Much of the land is permanent pasture or, where utilized as a military area, is now reverting to semi-natural grassland. Acid bent-fescue grassland is found on some steep slopes.

**Map unit 90** occupies only 1 square kilometre and comprises brown forest soils and brown forest soils with gleying; the latter predominate near Abbey Head.



The land is mainly permanent pasture, although arable crops were formerly grown near Abbey Head.

**Map unit 92** occupies only 1 square kilometre and comprises brown forest soils developed on thin, stony sandy loam colluvial drifts. Land in this map unit is more extensive in South-East Scotland where it occurs on moderately rocky, steep slopes along the Liddel valley and includes noncalcareous gleys and brown forest soils. Near Abbey Head the land is used for military purposes and the pasture is reverting to semi-natural plant communities.

### THE CORBY/BOYNDIE/DINNET ASSOCIATIONS

(Map units 98–101, 103–106)

Soils of the Corby, Boyndie and Dinnet Associations have been grouped together in map units suitable for representation at the 1:250,000 scale. The associations have long been recognized in north-east Scotland (Glentworth and Muir, 1963). In South-West Scotland, however, only soils of the Corby Association have been encountered, although soils of the Boyndie Association may be distinguished during future large-scale surveys. The Corby Association comprises soils developed on gravels derived from acid rocks of many different types. Although in some deposits materials from a single source predominate, mixtures derived from different rocks occur more commonly. The principal source rocks include Dalradian schists, quartzites, phyllites and slates but, in areas near their outcrops, Lewisian gneisses, Torridonian sandstones, and granites and felsites contribute to local deposits. The gravel deposits occur mainly as raised beach terraces around the coast or as fluvio-glacial outwash fans in broad low-lying valleys, although some moundy fluvio-glacial ice-contact deposits have also been encountered, notably in Glen Fruin near Helensburgh, and on Arran. The rounding of the gravel stones and the degree of sorting and bedding of the materials range widely and are affected by the distance of transport and conditions of deposition.

The associations occur north-west of the Highland Boundary Fault and occupy 146 square kilometres (1.0 per cent of South-West Scotland). The land is generally low-lying and the climate warm and wet; there is 1300 millimetres per annum average rainfall, which in a few places amongst the hills rises to 2400 millimetres per annum.

A wide range of soils has been encountered and includes humus-iron podzols, noncalcareous gleys, peaty podzols, peaty gleys and peat. In marked contrast with other associations in the Highlands and Islands subregion of South-West Scotland the humus-iron podzols predominate over the peaty podzols and peaty gleys. The semi-natural plant communities, which include rush pastures, heather moors and blanket and flying bent bogs, are mainly confined to soils with peaty surface horizons. However, much of the land occurs in low-lying situations with gentle slopes, free-draining soils and climate favourable to arable agriculture. Although widely cultivated, the soils have a high stone content, are strongly leached and have a low inherent fertility.

**Map unit 98** occupies only 8 square kilometres (5 per cent of the associations) and is found in Glen Fruin, north-east of Helensburgh. The soil pattern is complex and consists of humus-iron podzols and peaty podzols developed on mounds of gravel, noncalcareous, humic and peaty gleys occupying intervening

hollows, and mineral and peaty alluvial soils and peat on broad flats and river terraces. The fluvioglacial gravels, the parent materials of the podzols, occur as eskers and kames which formed close to the terminus of the Loch Lomond glacier and have been dissected later by the east-flowing Fruin Water. The free-draining soils have been cultivated but where the natural drainage is poor the land remains as rough grazing, often sheltered by woodland and ranging widely in quality.

**Map unit 99** covers 80 square kilometres (55 per cent of the associations). It comprises mainly humus-iron podzols as on Loch Lomondside, south of Luss, although more intricate patterns of soil and drainage also occur as on Bute, between Kames Bay and Ettrick Bay, where cultivated podzols, noncalcareous gleys, humic gleys and alluvial soils are all present. The soils are developed on fluvioglacial outwash and raised beach gravels, which are generally planar, gently undulating or, where there are old shingle bars, have gently ridged topography. Occasional terrace risers give local steep slopes. The raised beaches below about 10 metres altitude are generally very gravelly and horizons in the soils are only weakly developed, while materials on the beaches at the higher levels (10–30 metres altitude) have significant contents of silt and less sand than those of lower levels. The alluvial soils are developed on both loamy flood plain alluvium in the broader valleys, as beside the River Add north of Lochgilphead, and on gravelly alluvial fans, as in small areas on Loch Lomondside.

Rush pastures and deciduous woodland occur as a few small patches, but in many mainland areas of the Highlands land of this map unit provides the only arable ground.

**Map unit 100** is restricted to the Island of Arran and covers only 2 square kilometres (less than 5 per cent of the associations). It occupies areas of mounded ground inland from Machrie Bay which, to judge from the number of standing stones and stone circles, was from early times chosen for settlement. The soils are predominantly humus-iron podzols, although some wetter hollows with gleys occur. The Machrie Water passes through the unit and there is some alluvium along its banks. The land is now used for grazing. A further area is crossed by the road from Brodick to Blackwaterfoot. To the east the ground is mounded but to the west the fields slope more evenly and some arable crops are obtained.

**Map unit 101**, 10 square kilometres (5 per cent of the associations) in extent, is confined to the islands of Arran and Islay. Like *map unit 100* the main area on Arran is in the valley north of Blackwaterfoot on the west of the island. Strongly mounded topography supports peaty podzols, with peat or peaty gleys in hollows. Some land near Dougarie has been mapped in the same unit. The peaty surface horizons remain wet for long periods and the land is used for rough grazing, although some patch reclamation of the mounds may be possible. An area of hill ground known as An Rumach on Islay has similar characteristics.

**Map unit 103** occupies 15 square kilometres (10 per cent of the associations) and occurs mainly as small patches along coasts. The generally level topography is interrupted by occasional rock knolls on which the soils are shallow. The unit comprises a wide range of soils including humus-iron podzols, noncalcareous gleys, peaty podzols, peaty gleys, alluvial soils and peat. Arable fields and permanent pastures have been established on the humus-iron podzols but the soils with peaty horizons carry heather moors, blanket bog and rush pastures used for rough grazing.

**Map unit 104** occupies 8 square kilometres (5 per cent of the associations) and differs from *map unit 103* only in that all the soils have peaty surface horizons. The land remains, therefore, as rough grazing, although some patch reclamation may be possible. The semi-natural vegetation is mainly Atlantic heather moor and blanket bog. On Jura raised beaches with large rounded cobbles and soils with peaty surface layers have been placed in this map unit.

**Map unit 105** occupies 18 square kilometres (10 per cent of the associations) and occurs along the coasts as small patches, mainly around Rhunahaorine Point on Kintyre and Carse House in Knapdale, with smaller areas on Jura and Islay. On small raised beaches around Rhunahaorine Point and on Islay shingle bars form low ridges parallel to the coast and the soil pattern is complex with humus-iron podzols on the ridges and gleys in the intervening hollows. The map unit also includes peaty podzols, peaty gleys and peat but has no outcrops of rock.

Some uniform areas of humus-iron podzols have been used for arable fields but more generally the semi-natural plant communities, rush pastures, Atlantic heather moor and blanket bog, provide rough grazings. Plantations of conifers have been established on a few small areas.

**Map unit 106** covers only 5 square kilometres (less than 5 per cent of the associations) principally on Islay and comprises peaty gleys and peaty podzols with some peat and peat-alluvium. Atlantic heather moor, bog heather moor and blanket bog are the most extensive plant communities.

#### THE COUNTESSWELLS/DALBEATTIE/PRIESTLAW ASSOCIATIONS

(Map units 113, 114, 117, 119, 120, 122–124, 126, 127, 129, 131–135)

The soils of the Countesswells, Dalbeattie and Priestlaw Associations have been grouped together in map units suitable for representation at the 1:250,000 scale. The Countesswells Association is well known in north-east Scotland (Glentworth and Muir, 1963), the Dalbeattie Association has been described in Carrick and Galloway (Bown, 1973) and the Priestlaw Association is found in a small area of South-East Scotland (Ragg and Fuddy, 1967). The soils of the Countesswells and Dalbeattie Associations are developed on drifts derived from granites and similar coarse-textured acid igneous rocks such as tonalites, quartz-diorites and related rocks. The principal granite masses are the 'Galloway granites', intruded during Old Red Sandstone times, and the granites of Arran dating from the Tertiary period. A few other small outcrops of similar rocks are found in the Midland Valley and Wigtownshire. The granite rocks are hard and generally form areas of hill and mountain which in South-West Scotland have been subject to intense erosion and have large amounts of rock cropping out. On hills the drifts are generally thin, stony, gritty, greyish brown sandy loams with grey-brown loam till found mainly in low-lying areas and on foot slopes. Deposits of coarse, loamy sand, indurated, hummocky moraine occur in some valleys.

The associations are extensive, occupying 456 square kilometres (3.2 per cent of South-West Scotland) and confined largely to the granite outcrops mentioned above. Altitudes range from 100 to 750 metres and relief is mountainous and hilly with steep and strong slopes. Fields of *roches moutonnées* and similar ice-smoothed outcropping rocks and of hummocky moraine occupy a few inter-montane valleys and there are some steep rock walls and corries. The climate ranges from fairly warm to cold, and is wet with average levels of annual rainfall of 1500–2500 millimetres.

Intense glacial erosion and ice-cover, persisting until the last stages of the glacial period, have given rise to landscapes with outcropping rock as a major component of many soil patterns. Subalpine soils with boulders and rock occupy the mountain tops, while on the slopes and hills below 600 metres altitude peaty rankers, peaty podzols and peaty gleys predominate. Generally these soils are developed on very shallow stony parent materials and, with the character of many soil profiles poorly defined, they show considerable short-range variation. On the foot slopes, the tills are thicker and carry mainly peaty gleys, and the valleys are occupied by hummocky moraines with peaty podzols and peaty gleys or in a few areas, as near Loch Reicawr, by peaty rankers on rock knolls protruding through thick valley peat. Brown forest soils are restricted to low altitudes where they occur in patterns with peaty gleys and peaty podzols, or in areas, such as southern Kirkcudbrightshire, where they are associated with outcropping rock.

On this extensive group of associations the plant communities range widely and like the soils often change over short distances. On the brown forest soils acid bent-fescue grassland predominates, but some arable and permanent pastures are found in southern Kirkcudbrightshire. Flying bent grassland is extensive in Galloway on peaty gleys and peaty podzols with moist Atlantic heather moor also widespread, as are the bog heather moor and blanket bog communities on peats and on peaty gleys with thick peaty horizons.

Rush pastures and sedge mires are of restricted extent and subalpine communities, such as stiff sedge-fescue grassland and fescue-woolly fringe-moss heath, predominate at altitudes above 600 metres.

The hilly and mountainous terrain with outcropping rock, peaty soils and cool wet climate are unfavourable to pasture improvement and much of the land is utilized as rough grazing of poor or moderate quality. Plantations of coniferous trees have been established on large tracts of the Dalbeattie Association in Galloway and a National Forest Park has been created in the Loch Trool area. Some other areas are devoted primarily to the conservation of wildlife. Stock rearing on improved pasture and rough grazing of good quality is carried out mainly in southern Kirkcudbrightshire.

**Map unit 113** covers 25 square kilometres (5 per cent of the associations) in southern Kirkcudbrightshire. The soils, brown forest soils, mainly with free natural drainage, and some brown rankers, are often thin with rock occasionally cropping out and are developed on stony sandy loam tills and drifts. The terrain is generally undulating lowland with rock-controlled, irregular slopes that make arable cropping difficult. Arable and improved permanent pastures have been established on much of the land and grass production is favoured by the warm and wet climate. Unimproved areas carry acid bent-fescue grassland, often with bracken, which affords good quality rough grazing. The rearing of cattle and sheep are the main agricultural enterprises but there are also some dairy farms on this land.

**Map unit 114** occupies 41 square kilometres (9 per cent of the associations) and like *map unit 113*, to which it is closely related, is found mainly in southern Kirkcudbrightshire. The soils are brown forest soils and brown rankers and occur at altitudes below 250 metres on irregular, strongly sloping, rock-controlled terrain with moderate amounts of outcropping rock. Although the warm wet climate and brown forest soils tend to favour pasture improvement, this is often made difficult by the rugged topography and outcropping rock. Established improved pastures are, however, readily maintained and can be grazed without

undue damage by the treading of stock. On unimproved land the acid bent-fescue grassland, which often contains bracken, affords good quality rough grazing. Sheep and cattle-rearing enterprises are the principal forms of agricultural use.

**Map unit 117** occupies 12 square kilometres (3 per cent of the associations) in an area north of Kirkconnel. The soils are peaty podzols with some humus-iron podzols, peaty gleys and humic gleys and are developed on thin, stony, sandy loam drifts covering smooth rounded hills with slopes ranging from gentle to steep. The moist Atlantic heather moor, bog heather moor and common white bent grassland vegetation afford rough grazing of below average quality. Pasture improvements have not been attempted.

**Map unit 119** is extensive, occupying 80 square kilometres (18 per cent of the associations) and comprises mainly peaty gleys and peat with some peaty podzols. The unit has been mapped mainly on the gentle and strong, middle and lower, drift-covered slopes of hills. The drifts are generally lodgement tills, but include some soliflucted materials, and are grey gritty loams or sandy loams more than 1 metre thick and often indurated. Rock outcrops are generally absent on these slopes, but some more steeply sloping hill sides with low flat slabs of granite are present and the drifts are often less than 1 metre thick. High levels of precipitation and downslope moisture movement over underlying bedrock or indurated till maintain waterlogged conditions in the soils for long periods. Peaty surface horizons are well developed and often of sufficient thickness for the formation of organic soils. On strong slopes with thin drifts and scattered rock at the surface the soils show a high degree of short-range variation.

Under the wet soil and climatic conditions flying bent grassland and flying bent bog are the principal plant communities with moist Atlantic heather moor and blanket bog of lesser extent. The herbage affords rough grazing of low or moderate quality, but the wet conditions and remoteness of much of the land mean that stocking rates for hill sheep or cattle are often very low. Pasture improvements are not generally possible on this land and in Galloway plantations of conifers have been established over extensive areas.

**Map unit 120** occupies only 6 square kilometres (1 per cent of the associations) and comprises peaty gleys and peat with some brown forest soils. The unit occurs at relatively low altitudes, less than 250 metres, on gentle or strong slopes which are irregular due to control by underlying rock or due to the presence of thin, mounded coarse-textured morainic drifts. Apart from the brown forest soils, which are restricted to local steep slopes, the soils are strongly affected by seepage from higher-lying ground and are waterlogged for long periods. The peaty surface horizons are often well humified and some humic gleys are found.

The vegetation comprises mainly acid bent-fescue grassland, often with bracken, and flying bent grassland, with some flying bent bog and blanket bog. It affords rough grazing, generally rated as of moderate value, but ranging widely with the best areas having a high proportion of acid bent-fescue grassland. Pasture improvements, except in small scattered patches, are not generally possible, but some forest plantations have been established and include plantings of larch on the brown forest soils.

**Map unit 122** occupies 40 square kilometres (9 per cent of the associations) and comprises humus-iron podzols with some peaty gleys and peat. In Galloway some

areas with peaty podzols, peaty gleys and peat have also been included in this unit. The soils are developed on coarse-textured loamy sand and sandy loam moraine left by wasting valley glaciers and forming irregular moundy terrain, generally in valley bottoms. The relative proportions of podzols formed on the mounds, and peaty gleys and peat occupying hollows range widely according to the depositional pattern of the moraines. The land is utilized as rough grazing, which ranges in value according to the proportions of acid bent-fescue grassland, Atlantic heather moor, flying bent grassland and blanket bog present. Pasture improvements have not been attempted and are only possible in small scattered patches. Some coniferous forest plantations have been established.

**Map unit 123** occupies 41 square kilometres (9 per cent of the associations) and in South-West Scotland has been mapped only in Arran. The soils are principally peaty podzols, peaty gleys and peat developed on gritty, coarse-textured, bouldery, hummocky moraines in valleys. Moundiness is pronounced in some areas but in others landscapes are smoother and slopes gentle. Moraines consisting of mainly granitic material, but occurring beyond the border of the granite outcrop, generally contain significant admixtures of material from the country rocks. The peaty podzols on the mounds have a strongly developed thin iron pan below the gleyed Eg horizon, but gleying is absent below the pan and the subsoils are free draining. Atlantic heather moor communities predominate on the peaty podzols with bog heather moor on the peaty gleys and blanket bog communities on the peat. The land is utilized as rough natural pasture of low grazing value.

**Map unit 124** occupies 20 square kilometres (4 per cent of the associations) and comprises blanket or valley peats in broad gently sloping areas, often valley bottoms, with thin peaty ranker soils on scattered knolls of ice-smoothed rock. Blanket and flying bent bogs, often with bog myrtle, predominate on the peat and moist Atlantic heather moor on the peaty rankers. Improvements have not been carried out on this land, which provides rough grazing of poor quality, although in recent years considerable areas have been planted with coniferous forest.

**Map unit 126** covers 95 square kilometres (21 per cent of the associations) and comprises peaty podzols and humus-iron podzols, together with peaty gleys and rankers. The unit has been mapped extensively on hills and valley sides with irregular, rock-controlled, strong and steep slopes with thin, grey sandy loam drifts derived from the underlying granite. The terrain is moderately rocky, and the soils show a high degree of short-range variation in depth and profile type associated with the irregularity of the slopes and the thickness of the parent drifts. The soils are strongly leached, have well-developed peaty surface horizons and are generally waterlogged for long periods. The semi-natural vegetation, mainly moist Atlantic heather moor and flying bent grassland, affords rough grazing of low quality and pasture improvements have not been attempted. Plantations of coniferous forest have been established over considerable areas.

**Map unit 127** occupies 18 square kilometres (4 per cent of the associations) on Arran and comprises peaty gleys and peat with some peaty podzols and peaty rankers. The soils are developed on thin bouldery colluvial drifts and the terrain is moderately rocky with many surface boulders. Bog heather moor and blanket bog communities occur extensively on the predominant peaty gley and organic soils and afford rough grazing of poor quality.

**Map unit 129** occupies 23 square kilometres (5 per cent of the associations) on very rocky hill summits and steep slopes in Galloway. The soils, peaty rankers and peaty podzols with some peaty gleys and humus-iron podzols, are very shallow and developed on very thin stony rock debris. Rock outcrops are abundant and often rock slabs form pavement-like areas. Atlantic (locally boreal) heather moor and heath rush-fescue grassland are the principal plant communities, but the vegetation cover is not complete and any rough grazing it affords is of very poor quality. The shallow soils make afforestation difficult, but the land has some value for wildlife and amenity.

**Map unit 131** occupies 24 square kilometres (5 per cent of the associations) on Arran on moderately to very rocky hill and mountain slopes, steeper than 15 degrees, often bouldery, and forming the sides of glacially eroded valleys. The landscapes are related to those of *map units 127* and *132* but are characterized by steeper slopes. The soils are peaty gleys and peaty rankers, but with some peaty podzols on the steepest slopes, and are developed on thin colluvial drifts overlying weathered rock. The Bg horizons of the peaty gleys are often humose, as a result of organic matter deposited from laterally seeping ground-water. Bog heather moor is found on the 'flushed' and other waterlogged soils with some dry and moist Atlantic heather moor on the less wet areas. The land affords rough grazing of low value and sward improvements are not generally practicable.

**Map unit 132** occupies 9 square kilometres (2 per cent of the associations) on Arran. The soils include peat and peaty gleys and peaty rankers developed on colluvial drifts and residual weathered granite. The B horizons of the peaty gleys, like those of *map unit 131*, have a high content of organic matter which masks the colour of the mineral soils and obscures mottles that may otherwise have been present. Peat is widespread in this map unit and carries mainly blanket bog, while bog heather moor and moist Atlantic heather moor occur on the peaty gleys and peaty rankers. The land affords rough grazing of low quality, improvements are not generally possible and forest plantations are difficult to establish in the rocky terrain.

**Map unit 133** occupies 16 square kilometres (4 per cent of the associations) and is restricted to bare rock walls, corries and associated very steep scree slopes. The soils are mainly peaty rankers and are very shallow with a range of plant communities which include Atlantic and boreal heather moors. The land has some value for wildlife and amenity but agricultural or forestry use is not possible.

**Map unit 134** is not extensive, occupying 4 square kilometres (less than 1 per cent of the associations) and is restricted to mountain summits and slopes above 600 metres. The soils, which are strongly affected by freeze-thaw processes, are developed on light brown, thin stony loams derived from the underlying granite and occur in association with a few small areas of thin blanket peat and some rock outcrops and boulders. Under the conditions of high altitude and exposure, the montane plant communities, fescue-woolly fringe-moss heath, mountain heath rush grassland and mountain blanket bog, provide some summer grazing for sheep, but the principal value of this land is for wildlife and amenity; afforestation is not possible.

**Map unit 135** covers 2 square kilometres (less than 1 per cent of the associations) and comprises subalpine soils, peat and some alpine soils developed on thin drifts derived from fine-grained granite. The grazing values of the plant communities are low.

### THE CRAIGDALE ASSOCIATION

(Map units 138 and 139)

Of small extent, the Craigdale Association occupies 15 square kilometres (0.1 per cent of South-West Scotland) and is restricted to areas along the northern boundary of the Southern Uplands between Straiton and New Cumnock. The soils are developed on greyish brown tills and drifts of mixed origin which are derived from greywackes, shales and basic lavas and occur mainly on the foot-slopes of hills and in depressions but also occasionally on hills with strong slopes. The land is in the altitudinal range 150–350 metres and the climate is cool and wet with average rainfall of 1500 millimetres per annum. Noncalcareous gleys and peaty gleys predominate on gently sloping foothills and peaty podzols and brown forest soils occur on strong convex slopes. Sharp-flowered rush pasture and flying bent grassland are found on the gley soils and acid bent–fescue grassland, common white bent grassland and Atlantic heather moor on the brown forest soils and peaty podzols.

**Map unit 138** occupies only 3 square kilometres (20 per cent of the association), and comprises brown forest soils and peaty gleys developed on stony drifts and thin tills on strongly sloping convex hill sides. The acid bent–fescue and common white bent grasslands and Atlantic heather moor afford rough grazing of good and moderate quality and in some areas pasture improvements have been undertaken.

**Map unit 139** occupies 12 square kilometres (80 per cent of the association) and comprises noncalcareous gleys and peaty gleys developed on clay loam and loam tills on hill footslopes and in depressions. The semi-natural vegetation, sharp-flowered rush pasture and flying bent grassland, affords rough grazings of high or moderate value.

### THE CREETOWN ASSOCIATION

(Map units 141–143)

The soils of the Creetown Association are developed on drifts of mixed origin derived from greywackes and granite in widely varying proportions. The drifts include some coarse-textured moraines, but are mainly thin, grey or grey-brown loam and clay loam tills on the slopes above Creetown and in the valley of the Skyre Burn where they were deposited by ice moving off the granite of the Cairnsmore of Fleet hills on to the underlying greywackes.

The association is not extensive, occupying only 29 square kilometres (0.2 per cent of South-West Scotland), but is found on a variety of different landforms. These include morainic mounds and terraces in gently sloping uplands, gentle and strong hill slopes, and valleys and depressions. The land does not exceed 300 metres altitude and the climate is warm and moderately dry or wet with average rainfall of 1250–1500 millimetres per annum.



Brown forest soils are developed on mounds and terraces and on some strongly sloping hill sides, and noncalcareous and peaty gleys occur in valleys and depressions and in a few higher-lying areas on gentle slopes. Much of the land has been improved by drainage and cultivation but the semi-natural communities include bent-fescue grasslands on brown forest soils, sharp-flowered and soft rush pastures on noncalcareous gleys and flying bent bog and rush pastures on peaty gleys.

**Map unit 141**, occupying 9 square kilometres (30 per cent of the association), comprises brown forest soils developed on thin stony loam tills and drifts on hill and valley sides with mainly strong, but with a few gentle slopes. The soils occur in association with hill and upland at higher altitudes and are utilized for arable and permanent pastures, with crops for winter and supplementary stock-feed grown on favoured areas. On unimproved areas acid bent-fescue grassland provides good quality rough grazing.

**Map unit 142** occupies 8 square kilometres (30 per cent of the association) on gently sloping hill sides at altitudes of 100–200 metres above Creetown. The gentle slopes are broken by scattered mounds and terraces of coarse-textured morainic drifts carrying mainly brown forest soils, but with some peaty podzols, which generally have been cultivated and reclaimed. Between these mounds and terraces the soils are peaty gleys and peat, some of which have in the past been drained, but more generally the ground remains waterlogged for long periods. Scattered areas in this map unit, lying between unimproved hills and moors and improved pastures and cultivated ground at lower altitudes, have been subject to reclamation and reversion at different periods in the past. The peaty gleys generally carry flying bent bog and provide rough grazing, but some improved pastures have been established, although reversion to rush pastures is a serious risk. Pasture improvements on the brown forest soils are more easily maintained but difficulties associated with the soil pattern are often encountered.

**Map unit 143** occupies 12 square kilometres (40 per cent of the association) and comprises mainly noncalcareous gleys and peaty gleys with some brown forest soils. The soils are developed on grey loam and clay loam tills in valleys and on concave footslopes receiving run-off from higher-lying land and the natural drainage is poor or very poor. In the more favoured areas under-drains have been installed and pasture improvements and cropping with turnips and barley undertaken, but careful management is required to avoid reversion to rush pasture. On unimproved areas sharp-flowered rush pasture provides good quality rough grazing.

## THE DARLEITH/KIRKTONMOOR ASSOCIATIONS

(Map units 147–156, 158–161)

The Darleith and Kirktonmoor Associations were first described in north Ayrshire (Mitchell and Jarvis, 1956) and have subsequently been mapped more widely in south Scotland. The soils of these associations, which have been grouped together for representation at the 1:250,000 scale, are developed on drifts derived from basaltic rocks, including extrusive lavas, intrusive sills and dykes, and rocks plugging volcanic vents. The drifts are generally thin, brown or reddish brown loamy tills with a high content of basic igneous stones. In valleys

and on slopes bordering till plains, the tills are clay loam or clay, have a sticky consistence and a lower stone content than elsewhere, but on the plateaux the thin drifts are very stony and moraines in some valleys are very sandy. Colluvial drifts are common on steep slopes around plateau margins.

The associations are extensive, occupying 1006 square kilometres (7.0 per cent of South-West Scotland) with large areas around the Clyde estuary underlain by the Clyde Plateau Basalts. Altitudes range from 10 metres in the Clyde estuary to 500 metres in the Renfrew Hills and on the Campsie Fells. Rainfall, which is 1000 millimetres per annum in the warm moderately dry lowlands around Stirling, increases to 1250 millimetres on the warm wet lowlands around the Clyde, and to 2200 millimetres in the cool wet foothills and uplands of the Renfrew Hills and Campsie Fells.

Brown forest soils predominate in both the lowlands and uplands, but brown forest soils with gleying occur widely on the till plains. Noncalcareous, humic and peaty gleys are found mainly in the foothills and peaty podzols and peat on hills.

**Map unit 147** occupies 128 square kilometres (13 per cent of the associations) and comprises mainly brown forest soils with small areas of brown forest soils with gleying and some gleys in hollows and depressions. The predominant brown forest soils are free-draining, have friable loamy topsoils with well-developed crumb structure and often have a moderately high content of silt or fine sand. The subsoil is generally a gritty loam with moderately developed structure and few stones, and generally passes down into reddish brown, closely packed and weakly structured stony loam till. In some areas, however, a compacted, stony loam layer with massive structure is present in the lower subsoil, and gritty sandy tills are found where the parent rocks are coarse grained. The land is mainly undulating lowland with gentle slopes, or hill slopes without rock outcrops, and is generally cultivated for the growth of crops or improved pastures, but acid bent-fescue grassland or broadleaved woodland are found on some tills or steep valley sides.

**Map unit 148** is extensive, occupying 122 square kilometres (12 per cent of the associations), and comprises mainly brown forest soils with gleying with a few gleys. The natural drainage of the principal soil is imperfect and the topsoil is a friable loam with few stones. In the sandy clay loam subsoil the medium prismatic structure is moderately developed, and the grey and ochreous mottling is evidence of intermittent waterlogging. With increasing depth structural cracking becomes less well developed while the clay loam till parent material is generally massive, has a moderate stone content, and is only slowly permeable to moisture.

Much of the land has been cultivated and crop rotations generally consist of long periods in grass leys and short breaks in cereals. Cultivation, however, requires considerable skill on gently sloping land with impeded natural drainage in the wet climate of the western areas. The till is thin and stony on the hill land of Renfrew and Stirlingshire and on steep slopes or at altitudes approaching 300 metres the unimproved vegetation is acid bent-fescue grassland, with rush-infested pastures in wet areas. Comprehensive under-drainage systems with permeable infill and a secondary treatment to improve soil structure and permeability are required if arable crops are to be grown or improved pastures established.

**Map unit 149** occupies 139 square kilometres (14 per cent of the associations) and comprises noncalcareous gleys and humic gleys with some brown forest soils

with gleying and peaty gleys. The natural drainage of the predominant noncalcareous gleys is poor and the loamy topsoils are friable with weakly developed subangular blocky structure, few stones, and mottles indicative of intermittent waterlogging. Structural development is weak in the clay or clay loam subsoil, weathered stones and gley features appear prominently and permeability to moisture is poor. The underlying till is generally massive without structural cracks and has very poor permeability to moisture. Near Ballantrae the till is of mixed origin and includes spilitic lavas and serpentine with some greywacke stones, and is less clayey and more gritty than farther north.

Long-leys grassland and permanent pastures, often rush-infested, are the predominant forms of land use. The semi-natural rush pastures and sedge mire communities are widespread, however, and provide rough grazing of good quality. Efficient under-drainage systems with permeable infill in the drain-lines and secondary treatment to improve subsoil structure and permeability are necessary for cultivation or intensive utilization of grassland.

**Map unit 150** occupies 217 square kilometres (22 per cent of the associations) and comprises brown forest soils with some brown forest soils with gleying and minor occurrences of brown rankers. The soils are mainly free-draining and similar to those of *map unit 147*, but the landform is rock-controlled and rock outcrops, although not numerous, generally inhibit arable agriculture. The predominant brown forest soil has a friable loam topsoil with well-developed medium crumb or subangular blocky structure, but is often stony. The subsoils are generally loam or sandy loam and pass down into thin stony loamy tills or weathered, frost-shattered rock.

Permanent pastures or long-leys grassland occupy much of the land, but some arable crops are grown where rock outcrops are few. On steep valley sides or in the hills the semi-natural plant communities, bent-fescue grassland, crested hair-grass grassland or heath grass-white bent grassland, provide rough grazing of good quality.

**Map unit 151** occupies 45 square kilometres (4 per cent of the associations) and comprises mainly humus-iron podzols with some freely drained brown forest soils on locally steep slopes at low altitudes, gleys in depressions and peaty podzols on higher-lying land. The humus-iron podzols are free-draining and developed on thin stony sandy loam and loam drifts on slopes that are gentle to steep and slightly rocky. On the steepest slopes reclamation is precluded, but much of the less steep land is suitable for improved grass swards which can readily be maintained and can be utilized without significant liability to damage by poaching. The semi-natural vegetation is mainly dry and moist Atlantic heather moors on podzolic soils, acid bent-fescue grassland on brown forest soils and white bent grassland on peaty podzols. It provides rough grazing of moderate or low quality.

**Map unit 152** occupies 8 square kilometres (less than 1 per cent of the associations), comprises peaty gleys, brown forest soils and some rankers, and is restricted to the Carrick district of Ayrshire. The soils are developed on thin, stony drift on ice-eroded hills with slightly to moderately rocky gentle and strong complex slopes. Shallow brown forest soils and rankers with bent-fescue grassland occupy shedding sites around rock knolls. Intervening depressions have peaty gleys developed on stony drifts and carry flying bent grassland and moist Atlantic heather moor. The semi-natural vegetation provides rough grazing of

moderate quality, but improvements are restricted by rock outcrops and the irregular pattern of wet soils.

**Map unit 153** occupies 44 square kilometres (4 per cent of the associations) and comprises peaty podzols with some humus-iron podzols, peaty gleys and peat. The peaty podzols are developed on stony loamy drifts on gentle and strongly sloping, slightly rocky hill and valley sides, generally between 300 and 500 metres altitude. The land carries mainly white bent grassland and dry and moist Atlantic heather moors and is utilized as rough grazing of moderate or poor quality. The unfavourable climate and steep slopes generally preclude reclamation on this land but the establishment of improved grass swards is possible on some relatively low-lying areas.

**Map unit 154** extends to 130 square kilometres (13 per cent of the associations) and comprises peaty podzols, peaty gleys and peat, with some rankers. The peaty podzols are the most extensive soils and are developed at altitudes ranging from 200–500 metres on slightly rocky hills with gentle and strong slopes. The lower-lying land generally carries common white bent grassland and dry and moist Atlantic heather moors which provide rough grazing of moderate or poor quality, but the establishment of improved pastures is possible in some areas. On the higher-lying land bog heather moor provides poor quality rough grazing and the high rainfall and the exposure do not favour reclamation.

**Map unit 155** occupies 69 square kilometres (7 per cent of the associations) and comprises peaty gleys and peat with some humic gleys in flush sites. The peaty gleys have poor or very poor natural drainage and are developed on loamy drifts on hills with non-rocky smooth strong or gentle slopes. Some high-lying land is slightly rocky. Rush pastures on low-lying slopes provide rough grazing of moderate or good quality and improved grassland can be established, but requires comprehensive drainage and careful management. More generally, the moist Atlantic heather moor, bog heather moor and flying bent grassland provide rough grazing of poor quality and improvements are possible only in scattered patches.

**Map unit 156** occupies 14 square kilometres (1 per cent of the associations), comprises brown forest soils on mounds of moraine and peaty gleys in the intervening hollows, and is confined to two small areas—the Eaglesham platform in north Ayrshire and the upper Carron valley in Stirlingshire. The hummocky moraines are stony, sandy loams and loamy sands and slopes are gentle or strong. On these mounds permanent pastures provide valuable grazing and improvements to the swards are generally possible on the acid bent-fescue rough grazings. Reclamation of the wet peaty gleys in the hollows is more difficult and involves drainage.

**Map unit 158** occupies 75 square kilometres (7 per cent of the associations) and comprises brown forest soils with some rankers and minor areas of gleys. The brown forest soils are naturally freely drained and developed on thin, stony, often colluvial drifts on steep slopes (Plate 7). The land occurs between the hard, ice-eroded basalts of the Stirlingshire, Renfrew and Ayrshire hills and adjacent soft, till-covered sedimentary rocks. The development of terraced landforms is less marked than on Mull or Skye. The strong slopes are slightly rocky and the naturally occurring acid bent-fescue grassland provides good quality rough

grazing. In Stirlingshire there are some areas of deciduous woodland and in Ayrshire some areas of improved grassland, but slopes are generally too steep and rocky for reclamation.

**Map unit 159** occupies 11 square kilometres (1 per cent of the associations) and comprises peaty podzols, humus-iron podzols and some brown forest soils and peaty gleys. The soils are developed on stony loamy drifts on slightly rocky hill slopes near Pinwherry in the Stinchar valley and on Skerry Fell Fad south of Machrihanish, on Blashill near Southend on Kintyre and on Ben Bowie east of Helensburgh. The dry and moist Atlantic heather moors and acid bent-fescue grassland provide rough grazing of moderate quality and in some favoured areas sward improvement is possible.

**Map unit 160** is not extensive, occupying only 1 square kilometre (less than 1 per cent of the associations) and comprises peaty gleys and peat with some peaty podzols. The soils are developed on thin, stony, colluvial drift on slightly or moderately rocky hills with gentle and strong slopes. The moist Atlantic heather moor, bog heather moor and blanket and flying bent bog vegetation provides rough grazing of poor quality and the establishment of improved grass swards is not generally possible.

**Map unit 161** occupies only 3 square kilometres (less than 1 per cent of the associations) and comprises mainly brown forest soils developed on thin, stony, colluvial, loamy drift on steep moderately rocky hill sides with cliffs. The good quality rough grazings of herb-rich bent-fescue grasslands and herb-rich Atlantic heather moor are not improvable because of the steepness of slope and amount of outcropping rock. Deciduous woodlands occur in a few areas.

## THE DARVEL ASSOCIATION

(Map units 163 and 164)

The soils of the Darvel Association have long been recognized in north Ayrshire (Mitchell and Jarvis, 1956) are developed on interbedded sands and gravels of fluvioglacial origin and derived mainly from Carboniferous rocks. The sedimentary strata include sandstones, shales and some marls and the igneous formations are mainly basaltic lavas and some basic intrusive rocks. The soils are coarse-textured and readily cultivated.

The association occupies 163 square kilometres (1.1 per cent of South-West Scotland) and occurs mainly along the Irvine, Ayr and Lugar valleys in Ayrshire, the Clyde and Douglas Water valleys in Lanarkshire and the Kelvin and Carron valleys in Stirlingshire. The land ranges in altitude from 20 metres near the coast to 200 metres in the upper reaches of valleys. The climate is warm and moderately dry with average rainfall of 850 millimetres per annum in low-lying areas, but becomes fairly warm with rainfall of 1250 millimetres per annum at higher elevations inland, as near Muirkirk and Douglas.

The soils are mainly brown forest soils, but a few brown forest soils with gleying are found where the sands and gravels are thin and overlie clayey tills. Humus-iron podzols are found in some higher-lying inland areas and a few gleys and soils with peaty horizons occur in hollows between mounds where water-tables are locally high.

**Map unit 163** occupies 66 square kilometres (40 per cent of the association) and comprises mainly brown forest soils on broad mounded areas with strong slopes or on sinuous, gently undulating river terraces. The topsoils are generally sandy loams with moderate subangular blocky or crumb structure and pass down into sandy loam or loamy sand subsoils. Except in some higher-lying areas the climate is generally favourable to arable cropping and the soils are permeable and free-draining. Most of the land is utilized for arable agriculture, but in some more gravelly areas stones can interfere with harvesting of potatoes. Although inherently fertile, the soils are readily leached and benefit from regular applications of lime and fertilizers.

**Map unit 164** extends to 97 square kilometres (60 per cent of the association) and comprises brown forest soils and alluvial soils. The sand and gravel fluvioglacial outwash deposits form both mounded land with strong slopes and terraces, which, like the alluvial areas, are gently sloping. The alluvial soils show considerable short-range variation in texture and depth to the ground-water table, but are generally free-draining fine sandy loams or silt loams with some waterlogged areas where the water-table is high. The brown forest soils are more stony than in *map unit 163* and this can interfere with cultivations. On the alluvial areas there is a risk of flooding. Much of the land is utilized for arable agriculture with some permanent pastures found on alluvial soils with high water-tables or in higher-lying areas.

## THE DEECASTLE ASSOCIATION

(Map units 165 and 166)

The parent material upon which soils of the Deecastle Association are found is derived from limestones, often massive but sometimes flaggy and occasionally interbedded with phyllite. In South-West Scotland these rocks occur in Islay and north of Campbeltown, from where they run in a thin band northwards to Glendaruel in Cowal. The limestones of Islay provide well-defined landscape features and a soil resource that was settled early in the history of the area; those of Campbeltown are more restricted in extent but are quarried.

The association occupies just over 21 square kilometres (0.2 per cent of South-West Scotland). The proximity of the rock to the surface and differential erosion into ridges and hollows severely restrict the size of workable areas of soil, a constraint less important in the days of hand labour and subsistence farming than in modern mechanized farming. Despite their shallowness, however, the soils, which are predominantly mineral, are still utilized intensively for grassland. The areas in which they are found are warm and moist (rainfall is between 1200 and 1400 millimetres per annum), but proximity to the sea prevents extremes of summer heat or winter frost. The plant communities are dominated by pastures where the land is worked or by herb-rich bent-fescue grassland where the soils are too shallow for working. The rockiest knolls support crested hair-grass grassland, which has the highest relative grazing value of any semi-natural community.

**Map unit 165** is very much the largest unit of the association, accounting for 21 square kilometres. It is composed of shallow brown forest soils with an appreciable portion of brown rankers. In hollows some humic gleys occur. The parent material is principally colluvial in origin although some contamination by

red till may occur both on Islay and at Campbeltown. Despite their origin from calcareous parent materials the soils are usually decalcified. Topsoils are frequently dark grey in colour and of a silty loam texture. They are often humose (10 per cent organic matter). No drainage measurements are available and the dark grey colours of the profile make assessment from morphological characteristics difficult. The soils are probably freely drained except in hollows where ponding in the rock basins occurs. Soil structures appear strongly developed but are liable to break down rapidly under cultivation owing to the high silt contents. There is a strong resemblance to soils of the Foudland Association and the siltiness and high organic-matter levels lead to poaching in wet weather. Soils of this unit occur patchily from Bridgend to Port Askaig on Islay (Plate 2) and north of Campbeltown at Knock Scalbart and Calliburn and on the island of Danna.

**Map unit 166** contains a majority of soils with organic surface layers, either humus-iron and peaty podzols on ridge crests or peaty gleys and peat in hollows. The unit is very restricted in extent, occupying about 1 square kilometre at Ard Caol west of Ballygrant, Islay.

### THE DOUNE ASSOCIATION

(Map unit 168)

The soils of the Doune Association are developed on fluvio-glacial sands and gravels derived from acid schists of the Dalradian Assemblage and Lower Old Red Sandstone sediments—mainly hard red sandstones—with some lavas and intrusive igneous rocks. The deposits are mainly gravels but some sand lenses are present. The association is not extensive in South-West Scotland where it occupies only 5 square kilometres (less than 0.1 per cent of the region) and is found in the Leven valley at the southern end of Loch Lomond and in the Forth valley near Flanders and Blair Drummond Mosses. The land lies below 50 metres altitude and the climate ranges from warm and moderately dry to warm and wet, with average rainfall from 1150 to 1500 millimetres per annum. The soils are brown forest soils with some humus-iron podzols in areas with forest plantations and gleys in hollows between gravel mounds.

**Map unit 168** comprises mainly brown forest soils developed on gravels deposited in valleys as mounds and terraces with slopes ranging widely from gentle to steep. The sandy loam topsoils are sometimes thin and gravelly, and stones can interfere with arable cropping or require lifting from grass swards established after cultivation below the normal depth. Much of the land is used for arable cropping or permanent pasture. In mounded areas cultivation is restricted by steep slopes and wet hollows. Acid bent-fescue grassland and broadleaved woodland form small areas of semi-natural vegetation.

### THE DREGHORN ASSOCIATION

(Map units 169 and 170)

The soils of the Dreghorn Association are developed on raised beach sand and gravel deposits derived mainly from Carboniferous rocks but with some Old Red Sandstone materials. As on contemporary beaches, the deposits include some

bands of fine sand or silt interbedded with the predominant sands and gravels, and marine shells are found in some areas.

The association occupies 92 square kilometres (0.6 per cent of South-West Scotland) and occurs mainly along the Clyde estuary and along the Ayrshire coast as far south as Girvan. There is a further area near the Forth estuary between Stirling and Falkirk.

The land ranges in altitude from 10 to 20 metres on the Clyde and Ayrshire coasts and from 20 to 40 metres in the Forth valley. Average annual rainfall is generally in the range 900–1200 millimetres per annum but in the Forth valley is less than 1000 millimetres per annum; the climate is warm and moderately dry to wet.

The soils are mainly brown forest soils, but some gleys occur in depressions and together with brown forest soils with gleying are associated with the presence of silt bands in the parent materials.

**Map unit 169** occupies 87 square kilometres (95 per cent of the association) and comprises brown forest soils. Brown forest soils with gleying and gleys are restricted to very small areas. The raised beach landforms provide very gently sloping land well suited to most forms of arable agriculture. The soils are naturally free-draining, have sandy loam topsoils, which are friable with well-developed crumb or subangular blocky structure, and pass down into friable sandy loam and loamy sand subsoils. The sandy friable soils generally have few stones and provide a good medium for root development. The ground is easily cultivated and provides good quality arable land, which in Ayrshire is widely used for the production of early potatoes.

**Map unit 170** extends to only 5 square kilometres (5 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. The unit has been mapped around Hunterston on very gently undulating topography on the raised beach where the sandy beach deposits are thin and overlie brick earths or silts. Efficient under-drains are required for intensive agricultural use of these soils.

## THE DRONGAN ASSOCIATION

### (Map unit 171)

The soils of the Drongan Association are developed from red-brown clay loam or clay tills which are derived mainly from red marls of the Coal Measures, but include some sandstone, shale and coal fragments.

The association occupies 53 square kilometres (0.4 per cent of South-West Scotland) mainly in central Ayrshire and the Clyde valley near Motherwell and Lanark. The land lies between 50 and 170 metres above sea level and the climate is warm and moderately dry with 900 millimetres average annual rainfall in the Clyde valley and warm and wet with 1150 millimetres rainfall in Ayrshire.

The soils are mainly brown forest soils with gleying. Noncalcareous gleys and humic gleys occupy small areas in channels and depressions between drumlin ridges or occur in areas of subsidence over underground coal workings.

**Map unit 171** comprises mainly brown forest soils with gleying which are developed on red-brown clay loam to clay tills. They are slowly permeable, have



imperfect natural drainage and occur in undulating lowland landscapes with drumlin ridges and gentle and strong slopes (Plate 9). Topsoil textures are often silty clay loams and the high silt contents are associated with subangular blocky structures which are only moderately developed and liable to slake when heavy rain falls on bare ground. Cultivation is often difficult and careful management is necessary to avoid damage to the structure. The subsoils are closely packed, have a coarse prismatic structure and are very slowly permeable to moisture. On gentle slopes lateral run-off of excess water is slow and bare ground on steeper land is liable to erosion during periods of heavy rainfall. Cultivation and arable cropping can be difficult and much of the land is maintained as permanent pasture. For intensive agriculture efficient under-drains are necessary and should include permeable infill in the drain-lines and secondary subsoiling or moling to improve subsoil structure and permeability. Undrained land generally carries rush pasture or sedge mires.

### THE DURISDEER ASSOCIATION

(Map units 179 and 180)

The soils of the Durisdeer Association are developed on drifts of mixed origin derived from sandstones of Permian and Carboniferous age, greywackes and basic igneous rocks. The drift is mainly a reddish brown loam to clay loam till, ranging widely in thickness and in the relative proportions of material derived from the different parent rock types. Some tills have been modified by partial water-sorting and have upper layers of sandy loam or loamy sand. The association is restricted to the valley and low ridges running south-west from Durisdeer where it occupies 15 square kilometres (0.1 per cent of South-West Scotland) and ranges in altitude from 120 to 250 metres.

The climate is fairly warm and wet with 1250 to 1500 millimetres average annual rainfall. The thin drifts and modified tills are generally permeable, and on the convex slopes of the undulating ridges run-off of excess moisture is good and the principal soils are brown forest soils and brown forest soils with gleying. In some depressions receiving moisture seepage from surrounding slopes noncalcareous gleys are common. Most of the land carries arable and permanent pastures, while a few fields are in arable crops, and sharp-flowered rush pasture is found on gley soils lacking under-drainage systems.

**Map unit 179** occupies 11 square kilometres (75 per cent of the association) and comprises brown forest soils and brown forest soils with gleying developed on sandy loam or loam tills and modified tills. Slopes in the undulating topography are mainly gentle and strong and, although the high annual rainfall does not favour arable agriculture, a few crops are grown. Most of the land, however, carries improved pasture utilized for dairying and stock rearing in conjunction with the rough grazing on the nearby Lowther Hills.

**Map unit 180** occupies 4 square kilometres (25 per cent of the association) and comprises noncalcareous gleys and brown forest soils with gleying on gentle slopes and in depressions. Where under-drainage systems are present improved permanent pastures are generally maintained, but where they are absent the naturally occurring sharp-flowered rush pasture provides good quality rough grazing.

## THE DURNHILL ASSOCIATION

(Map units 184–186, 188, 190, 191 and 193)

The Durnhill Association has been previously described in north-east Scotland (Glentworth and Muir, 1963) and comprises soils formed on drifts derived from quartzites. In South-West Scotland the association is restricted to Islay and Jura and the parent rocks are mainly false-bedded quartzites and pebbly quartzites with intercalations of flaggy shales and mudstones. The derived drifts are highly siliceous, stony and of coarse texture. Colluvial materials predominate throughout much of the association, lodgement tills are of restricted extent, moraines occur mainly near the Paps of Jura and cryic deposits are found on the mountains.

The association covers 432 square kilometres (3.0 per cent of South-West Scotland). The land ranges from sea level to over 500 metres altitude with gently undulating lowlands in the northern areas of Islay and Jura and fringing the Paps of Jura. In south-eastern Islay and southern Jura the land is hilly. The terrain ranges from non-rocky, fairly even, till-covered ground found extensively on Jura, through moderately rocky land to very rocky rugged topography in a few localities. In climatic terms the area is warm or fairly warm changing to cool and cold on the hills and mountains. On the lower ground rainfall is 1300–1600 millimetres per annum, but rises to over 2000 millimetres on the Paps of Jura.

The siliceous nature of the parent materials and the high rainfall are conducive to the formation and accumulation of organic matter and peat, and soils with peaty surface horizons form the predominant map units of the association. The natural drainage conditions are generally poor and the principal soils are peaty gleys with peaty podzols restricted to shedding sites on very steep slopes or to morainic mounds. Below the peaty surface layers the mineral soil horizons also have high contents of organic matter. Peaty rankers are found in rocky areas but humus-iron podzols and brown forest soils are of very limited extent. Subalpine soils occupy small areas above about 400 metres on the hills of Islay and near the Paps of Jura on which rock and scree have also been mapped. Heather moors predominate on the hills and sloping ground and flying bent bog and flying bent grassland communities are widespread on gently sloping undulating terrain on Jura:

**Map unit 184** occupies 39 square kilometres (9 per cent of the association) mainly on Jura and comprises peaty gleys and peat developed on sandy loam to loamy sand tills with high stone contents. Soils formed on the red-brown till of the Kintyre Association, also seen on Islay and Jura, may be included with this map unit, particularly in the south-west of Jura. The land is gently undulating with slopes of less than 15 degrees and there is no outcropping rock. The peaty gleys consist of a well developed peaty surface horizon overlying a layer with stones, (30–40 centimetres diameter) and interstitial organic matter. Below this is a thin gleyed mineral soil horizon and the indurated till; a thin iron pan can occur at the surface of the induration. Flying bent and blanket bogs are extensive on the areas of peat and moist Atlantic heather moor on the peaty gleys.

Land use on these peaty soils is restricted to rough grazing, generally of poor quality. After suitable drainage and ploughing, coniferous forest plantations can be established.

**Map unit 185** occupies 30 square kilometres (7 per cent of the association) mainly in valleys and on lowlands adjacent to the Paps of Jura with small areas on Islay.

The soils are peaty podzols and peat with some peaty gleys developed on coarse-textured hummocky moraine. On the west of Jura the hummocks are subdued and merge with the undulating land of *map unit 184* and west of Lowlandman's Bay the moraine overlies silty till of the Foudland Association. Surface stones, up to 50 centimetres diameter, occur frequently and the terrain is characteristically hummocky with many relatively dry shedding sites on which the peaty podzol soils are found. The profiles of these soils are generally typical of the major soil subgroup but the E horizons are thicker than usual and the Bs horizons are at a greater depth. The peat and peaty gleys are also widespread and occur in the inter-moraine channels and hollows where the drainage is poor and the soils waterlogged. Dry and moist Atlantic heather moors predominate on peaty podzols and flying bent grassland, flying bent bog and bog heather moor on the peaty gleys and peat. The land is used for rough grazing of low value, but there is potential for forestry in the relatively sheltered eastern valleys near the Paps of Jura.

**Map unit 186** is of limited extent, occupying only 3 square kilometres (less than 1 per cent of the association) in northern Jura, and comprises humus-iron podzols and some peaty gleys developed on very stony colluvial drifts on steep, moderately rocky slopes. Acid bent-fescue grassland and rush pastures provide rough grazing of moderate or high value and broadleaved woodlands give shelter for stock.

**Map unit 188** is the most extensive in the Durnhill Association in South-West Scotland where it occupies 213 square kilometres (49 per cent of the association) and comprises peaty gleys with some peaty rankers and peat. The soils are developed on thin colluvial drifts in slightly or moderately rocky terrain in gently undulating lowland and on hill sides with slopes of less than 15 degrees. Peaty gleys are the predominant soils, but peat occurs on some gently sloping land and peaty rankers are found where the drift is very thin; Bs horizons are absent. Flying bent grassland and bog communities predominate on the peaty gleys and peat of Jura and bog heather moor on Islay. Rough grazing, mainly of low value, is the present land use, but some forestry potential exists.

**Map unit 190** occupies 108 square kilometres (25 per cent of the association) and the soils are similar to those of *map unit 189*, peaty gleys, peaty rankers and some peat, but the terrain is very rocky. The soils are developed on thin stony colluvial drifts in landscapes of rugged lowland or hill sides with slopes less than 15 degrees. Flying bent grassland and bog heather moor are found on the peaty gleys and peaty rankers and flying bent bog and blanket bog on peat. The land is used mainly for rough grazing, the quality of which is low.

**Map unit 191** occupies 28 square kilometres (6 per cent of the association) and comprises peaty gleys, peaty rankers and peaty podzols. The soils are developed on thin stony colluvial drifts on moderately to very rocky hill and valley sides with slopes steeper than 15 degrees. The peaty podzols are mainly restricted to the steepest and driest sites. The dry and moist Atlantic heather moors, the main plant communities, provide rough grazing of low value.

**Map unit 193** occupies 11 square kilometres (3 per cent of the association) and comprises subalpine soils and peat on very rocky mountain summits. The mountain heath communities and wind-clipped dry Atlantic heather moor, the principal types of vegetation, provide rough grazings of low value.

## THE ECKFORD/INNERWICK ASSOCIATIONS

(Map units 196 and 198)

The soils of the Eckford and Innerwick Associations were first recognized in South-East Scotland (Ragg, 1960; Ragg and Fuddy, 1967) and are developed on fluvioglacial sands and gravels derived mainly from Upper Old Red Sandstone sediments. The deposits form mounds and terraces in valley bottoms in small areas near Lanark and Drumclog where the associations occupy 7 square kilometres (less than 0.1 per cent of South-West Scotland). Near Lanark the climate is warm and moderately dry with rainfall of 900 millimetres per annum and at Drumclog it is fairly warm and wet with 1350 millimetres per annum rainfall. The soils are predominantly brown forest soils with some alluvial soils and the land is generally cultivated or carries arable and permanent pastures.

**Map unit 196** occupies only 2 square kilometres in the Mouse Water valley near Lanark and comprises brown forest soils developed on sands and gravels forming mounds and terraces. The soils are highly permeable to moisture and naturally free-draining and can be cultivated without damage to structure under a wide range of conditions, but the low water-holding capacity is likely, in dry seasons, to have some effect on yields. The land is utilized mainly for arable crops and grass leys.

**Map unit 198** occupies 5 square kilometres in the Glengavel Water valley near Drumclog and comprises brown forest soils developed on mounds and terraces, and alluvial soils developed on the present river flood plain, cut in recent times into the older deposits. The brown forest soils are free-draining and can be readily cultivated, but under the high rainfall conditions harvests are likely to be difficult and the land is utilized mainly for permanent pastures or rough grazing, of good quality, on the acid bent-fescue swards.

## THE ETTRICK ASSOCIATION

(Map units 206-226 and 228-236)

The Ettrick Association has long been known in south-eastern Scotland (Muir, 1956; Ragg, 1960) and has been described also in South-West Scotland (Bown, 1973; Bown and Heslop, 1979). The soils are developed on drifts derived from Lower Palaeozoic greywackes and shales. The greywackes have been described as 'a form of sandstone, with a variety of mineral and rock fragments and a paste-like matrix of the same material' (Greig, 1971), and are interbedded with finer grained siltstones and shales. Folded and hardened by compression, these rocks make up most of the Southern Uplands of Scotland and their derived drifts include lodgement tills, valley and piedmont moraine, solifluction and colluvial deposits, screes, and cryic materials on mountain tops. The valley tills are mainly grey-brown clay loams which are widespread in valleys and on the lower slopes of hills, and also occur as drumlins throughout the lowlands of Galloway. In the valleys of the Merrick and Kells hill ranges hummocky moraines are coarse textured, loamy sand and sandy loam, with abundant subangular stones and boulders. On the Lowther Hills and south-west of New Cumnock, the smooth rounded steep-sided hills carry grey-brown stony loamy drifts, which range in

thickness from several metres to less than one metre, and are either till of glacial origin or solifluction deposits formed by cryic processes in the Late Glacial or immediate Post Glacial periods. Rock crags and screes are restricted to the Kells and Merrick hill ranges, but thin drifts and outcropping rock are extensive throughout much of the Galloway hills.

The Ettrick Association is the most extensive in Scotland south of the Highland Boundary Fault, and occupies 2954 square kilometres in South-West Scotland (20.6 per cent of the region). The Southern Uplands are typified by smooth, rounded, steep-sided hills with narrow valleys, but in South-West Scotland these are restricted to the western parts of the Lowther Hills and hills south-west of New Cumnock. Other landforms are associated with the metamorphic hardening of rocks around the Galloway granite intrusions and with the erosive and depositional effects of glaciation which are expressed in a greater range of landscapes at the western end of the Uplands than farther east. The Merrick and Kells Hills, rising to 864 metres on Merrick itself, form the highest land and comprise broad, rounded mountain summits and ridges into which have been etched steep-sided U-shaped valleys, with corries and rock walls at the heads of some valleys. Fields of hummocky moraine occupy some valleys and extend across the uplands beyond, as at Fardin and Ferter west of the Minnoch valley. Many of the hills below about 600 metres altitude are rugged with complex rock-controlled slopes or have moderate amounts of outcropping rock. In northern Wigtownshire and southern Ayrshire, west and south-west of Barrhill, drumlins of thick till occur scattered across undulating upland and in the southern parts of Wigtownshire and Kirkcudbrightshire similar drumlins are found widely distributed across ice-eroded lowlands with many rock outcrops.

The association includes a wide range of soils. On the stony loamy drifts on hill and valley sides below about 200 metres, on some moraines and drumlins and on stony frost-shattered rock debris, free-draining brown forest soils predominate, with acid bent-fescue grassland, often with abundant bracken, as the principal semi-natural vegetation. Below the friable brown surface horizon the yellow-brown and strong brown B horizons are distinctive and well developed and are typical of soils formed under conditions of strong leaching and acid weathering. At greater altitudes and in areas of high rainfall peaty podzols predominate on the summits and upper slopes of hills, on many moraine deposits and on the drumlins in the moorland areas. The peaty podzols have a peaty surface horizon 20 to 40 centimetres thick, a grey gleyed E horizon, and a thin iron pan, often continuous and strong, overlying a strong brown B horizon rich in sesquioxides weathering products. The vegetation ranges widely on these soils, but is generally moist Atlantic heather moor, or flying bent or white bent grassland. Subalpine soils with fescue-woolly fringe-moss heath or stiff sedge-fescue grassland are restricted to the summits of hills above about 600 metres altitude. On undulating till-covered land, as found south-east of Girvan and on the till-covered footslopes of some hills, the grey-brown and brown clay loam tills carry brown forest soils with gleying and noncalcareous gleys, characterized by slowly permeable, gleyed subsoils and moderately fine textures. Occurring at low and moderate altitudes, many of these soils have been cultivated, but sharp-flowered rush pasture predominates in unimproved areas. At somewhat higher altitudes on gentle slopes and in depressions, peaty gleys with poor or very poor drainage have peaty surface horizons 20 to 50 centimetres thick overlying a grey, strongly gleyed, eluviated subsoil which extends down to compact, little-altered till at depths of 90–100 centimetres. The soils generally support flying bent grassland, flying bent bog, or moist Atlantic heather moor communities.

**Map unit 206** is extensive, occupying 146 square kilometres (5 per cent of the association), and comprises brown forest soils and some brown forest soils with gleying. The soils are developed on loam tills and stony sandy loam and loam drifts in valleys and lowlands, generally below 200 metres altitude, but associated with the hill areas. Slopes are usually less than 15 degrees, steeper land with similar soils having been placed in *map unit 221*. The climate is fairly warm and moderately dry to wet and although much of the land has been cultivated for arable crops or the establishment of improved permanent pastures, the semi-natural vegetation is generally acid bent-fescue grassland.

The freely draining conditions in the loamy soils, the moderate elevation and the absence of steep slopes or severe climate are favourable to cultivation. However, the soils are often stony and rainfall is frequently high. Much of the land is found in association with upland and hill and is worked in accordance with requirements of individual farm units. In South-West Scotland the land is generally maintained for long periods in grass leys with short breaks in arable crops, or carries permanent pastures which on hill farms generally form the 'inbye' land.

**Map unit 207** occupies 250 square kilometres (8 per cent of the association) and is extensive in southern Wigtownshire and Kirkcudbrightshire. The soils are brown forest soils and brown rankers developed on thin, stony, frost-shattered rock debris and the strongly glacially eroded terrain is slightly to moderately rocky (Plate 16). The land is generally gently, or occasionally strongly, sloping, but knolls and outcropping rock create complex slope patterns. Similar land on steeper slopes with greater amounts of outcropping rock has been placed in *map unit 223*. The climate is warm or fairly warm and wet with average annual rainfall in the range 1000–1500 millimetres, and the land lies mainly below 200 metres altitude. Improved grassland and permanent pastures have been established on much of the land and a few arable crops are grown where rock outcrops are widely spaced. On the more rocky areas acid bent-fescue grassland provides good quality rough grazing. The land is mainly utilized for animal production with dairying and grass conservation for winter keep usually possible, but cattle rearing and lowland sheep farming are the main enterprises in the more rocky areas. Stock can be readily overwintered on this land, which is not prone to damage by poaching.

**Map unit 208** occupies 134 square kilometres (5 per cent of the association) and is restricted to the lowlands of Galloway. The terrain comprises drumlins of thick, loamy, compact till scattered across an irregular, glacially eroded surface, with a thin cover of stony, frost-shattered rock debris and a moderate amount of outcropping rock (Fig. 5). The drumlins carry brown forest soils and brown forest soils with gleying and intervening areas are occupied by brown forest soils, brown rankers and rock outcrops. The land lies mainly below 200 metres altitude and the climate is warm and wet with 1250 millimetres per annum average rainfall. Acid bent-fescue grassland provides good quality rough grazing in a few unimproved areas, but arable and permanent pastures are predominant with some land worked for arable crops. Dairying based on long-ley grassland, with short breaks in barley or forage crops, is the main agricultural enterprise but, where conditions are less favourable, cattle and sheep are produced.

**Map unit 209** occupies 79 square kilometres (3 per cent of the association) and comprises brown forest soils with gleying and some noncalcareous gleys. The

parent materials are grey-brown and brown clay loam tills, generally more than 2 metres in thickness, deposited on the footslopes of hills and on undulating lowlands, usually below 250 metres altitude. Significant areas are found south of Ballantrae, on slopes above Pinwherry, and near Mochrum. Climatic conditions range widely from warm and moderately dry with 1000 millimetres per annum average rainfall to fairly warm and wet with 1300 millimetres. The slow permeability of the subsoil, and the gleying and coarse prismatic structures in the B horizons are the principal soil characteristics. The land is generally maintained in arable or permanent pastures, with some areas worked for arable crops and undrained higher-lying land carrying sharp-flowered rush pasture and providing rough grazing of good quality. For efficient agricultural utilization these soils require effective under-drainage with permeable infill over the drains and secondary subsoiling treatments. Dairying, cattle grazing and stock rearing are the principal enterprises but stocking requires careful management to avoid poaching damage.

**Map unit 210** occupies 34 square kilometres (1 per cent of the association) and comprises mainly noncalcareous gleys with some brown forest soils with gleying. The parent materials are principally grey-brown clay loam tills in valleys, depressions and undulating lowland, but similar soils are also found on stony loamy drifts on some concave hill slopes. Without effective under-drains the soils are subject to prolonged waterlogging, mainly due to the slow permeability of the subsoils, but on concave hill slopes due to run-off and seepage from higher ground. The land lies mainly below 300 metres altitude and the climate ranges widely from fairly warm and moderately dry to cool and wet. The semi-natural plant communities are mainly sharp-flowered rush pasture and tussock-grass pasture which provide good quality rough grazing, but efficient under-drains allow the establishment of grass leys and the maintenance of improved permanent pastures. In favoured areas the ground may be worked for some grain or forage crops, but more generally careful management of grazing and stock are required to avoid severe poaching of grass swards.

**Map unit 211** occupies 177 square kilometres (6 per cent of the association) on the moorlands of Galloway where it comprises brown forest soils and peat. The brown forest soils occur on thick, compact, massive, loam tills making up drumlins, which are found as individual features widely scattered throughout extensive low-lying gently sloping areas of peat (Fig. 5). Usually more than 1 metre in depth, the peat occupies areas which also often include glacially-eroded rock knolls. The land is generally less than 200 metres altitude and has a warm and wet climate with average annual rainfall of 1250 millimetres. The brown forest soils are farmed in conjunction with the surrounding moors and generally carry improved permanent pastures as 'inbye' for cattle and Blackface sheep, but occasionally a few grain and forage crops are grown. Acid bent-fescue grassland is found on brown forest soils on a few remote, isolated, unimproved drumlins and blanket bog and flying bent bog predominate on the peat and provide poor or moderate quality rough grazing.

**Map unit 212** occupies 37 square kilometres (1 per cent of the association), mainly in Galloway, and comprises peaty gleys and peat with some brown forest soils. The land is usually at moderate elevations, below 300 metres altitude, generally on the footslopes of hills where irregularities of the rock-controlled terrain are only partially subdued by the thin cover of stony drift. Some low-lying

gently sloping areas with irregular mounds and small knolls are also included. The peaty gleys and thin peat are the principal soils and are usually affected by seepage and flushing from higher ground. The brown forest soils occur as small scattered patches on local steep slopes and shedding sites. Pasture improvement is rare and not generally possible at reasonable expense. The naturally occurring flying bent grassland, flying bent bog, often with bog myrtle, and blanket bog communities, together with some acid bent-fescue swards, provide rough grazing of moderate quality. Some areas have been planted with coniferous forest.

**Map unit 213** occupies 111 square kilometres (4 per cent of the association), and, like *map unit 211*, is restricted to the Galloway moorlands where it comprises peaty podzols, peaty gleys and peat. Thick deposits of massive, compact, loamy till occur as drumlins scattered across low-lying (150–300 metres altitude) undulating land and carry mainly peaty podzols, with some peaty gleys on gentle slopes. The gently sloping, inter-drumlin areas are occupied by thick blanket, valley and basin peats (Fig. 5) broken occasionally by *roches moutonnées*. Some pasture improvement by the use of lime, fertilizers and direct reseeded, or by ploughing and reseeded is possible on the peaty podzols and some peaty gleys on the drumlins. Generally, however, the moist Atlantic heather moor, white bent and flying bent grasslands on these soils are utilized, together with the blanket and flying bent bog communities of the peat areas, as rough grazing of poor quality.

**Map unit 214** occupies 129 square kilometres (4 per cent of the association) and comprises peaty podzols, brown forest soils, peat and peaty gleys developed on very bouldery, indurated sandy loam and loamy sand moraine occurring as hummocks and mounds in the valleys and undulating uplands around the Merrick and Kells Hills in Carrick and Galloway (Fig. 6). The peaty podzols and brown forest soils occur on the moraine mounds and the peaty gleys and peat in the intervening hollows. The climate is fairly warm and wet with 1500 millimetres per annum rainfall. The semi-natural vegetation, which includes moist Atlantic heather moor, flying bent grassland and blanket bog and flying bent bog with some acid bent-fescue grassland, provides rough grazing, generally of low to moderate quality, but around shielings some land has usually been improved and provides 'inbye' enclosures. Plantations of coniferous forest have been established over large areas in the Minnoch valley.

**Map unit 215** occupies 189 square kilometres (6 per cent of the association) in the moorland tracts of Galloway, and comprises peat and peaty rankers. The land occurs mainly in lowlands below 200 metres altitude and in valley floors where glacially eroded rock knolls and moundy moraines form a complex pattern surrounded by gently sloping areas of valley, blanket or basin peat (Plate 14). Improvements are not generally practicable on this land and the semi-natural plant communities, blanket bog and flying bent bog, bog heather moor and moist Atlantic heather moor, provide rough grazing of poor quality. Some areas have been planted with coniferous trees.

**Map unit 216** occupies 57 square kilometres (2 per cent of the association) mainly in the uplands of Kirkcudbrightshire and Dumfriesshire. The soil pattern of peaty podzols, peaty gleys and peat with some brown forest soils and rankers is extremely complex and is developed on thin stony colluvial drifts in undulating uplands, generally between 200 and 300 metres altitude. The irregular terrain



has been severely glacially eroded and the topography is generally rock-controlled with frequent changes in steepness of slope. Like the soils and landforms, the vegetation shows short-range variation with moist Atlantic heather moor, heath rush-fescue grassland and blanket bog the principal communities and there are some smaller areas of acid bent-fescue grassland. Rough grazing is predominant but some areas have been planted with coniferous forest. Pasture improvements are difficult and will generally be limited to surface seeding but the variability of the land makes generalization difficult.

**Map unit 217** is not extensive, occupying only 4 square kilometres (less than 1 per cent of the association), and comprises peaty podzols and peaty gleys with some rankers, peat and brown forest soils. The map unit is similar to *map unit 216* but slight or moderate amounts of outcropping rock are present in the irregular, rock-controlled, undulating terrain. The land is utilized mainly as rough grazing of poor or moderate quality and some forest plantations have been established.

**Map unit 218** occupies 123 square kilometres (4 per cent of the association) and comprises peaty podzols, peaty gleys and peat. The land occurs mainly in the northern areas of Kirkcudbrightshire and Dumfriesshire on hills less strongly dissected and with less steep slopes than in much of the Southern Uplands. The drifts include both thin, stony, loamy solifluction materials and clayey tills, often several metres in thickness. Under the high rainfall, 1250–2000 millimetres per annum, the proportions of peaty gleys and peat are greater than in *map units 227, 228 and 229*. The semi-natural vegetation includes moist Atlantic heather moor, heath rush-fescue grassland and blanket bog and flying bent bog, and provides rough grazing of poor or moderate quality. In climatically favoured areas drier than the average in this map unit, some pasture improvement, probably based on surface seeding and lime and fertilizer application, is possible, but little reclamation has as yet been attempted. A number of plantations of coniferous trees have been established.

**Map unit 219** occupies 16 square kilometres (less than 1 per cent of the association) and comprises peaty gleys and peat, mainly in depressions and undulating ground at 250–400 metres altitude, in the central areas of the Southern Uplands. The soils are developed mainly on loamy and clayey tills with some stony, loamy, solifluction materials on hill sides. They are affected by run-off from higher ground and are waterlogged for long periods. The climate is cool and wet and the average rainfall of 1500 to 2000 millimetres per annum is high. The presence of flying bent grassland and flying bent bog shows the effects of flushing on the vegetation, but moist Atlantic heather moor and blanket bog communities are also extensive. The current land use is mainly rough grazing of poor or moderate quality with some plantations of coniferous trees. Pasture improvements are likely to be very difficult, both to establish and maintain.

**Map unit 220** occupies 111 square kilometres (4 per cent of the association) and comprises peaty gleys and peat and some peaty podzols. The land occurs mainly between 200 and 400 metres altitude, generally as broad undulating areas in the hills or uplands but also in wide valleys. The slopes are mainly gentle with a few locally steep areas or mounds on which the peaty podzols occur. The high rainfall, 1500–2000 millimetres per annum, and cool and wet climate promote the formation of blanket peat which is extensive on gentle slopes and in depressions. The soil parent materials include both clayey tills and stony loamy

drifts and range widely in thickness. The establishment and maintenance of improved pasture is difficult and the semi-natural moist Atlantic heather moor, heath rush-fescue grassland and blanket and flying bent bog provide poor and moderate quality rough grazing. Some plantations of coniferous forest have been established.

**Map unit 221** is extensive, occupying 176 square kilometres (6 per cent of the association), and comprises brown forest soils. The land is steeply and strongly sloping, generally on hill and valley sides up to about 300 metres altitude (Plate 12). The soliflucted, stony, loam drifts on which the soils are developed are frequently indurated and often thin, 1 to 2 metres in thickness, but can range up to 10 metres at the base of slopes or on less steep areas. The soils, which are similar to those of *map unit 208* on less steep land, are free-draining and strongly eluviated and under natural conditions are strongly acid and can have a thin surface mat of raw humus. As altitude increases the soils pass into peaty podzols in *map units 228* or *229*. The steep slopes of much of this land can make cultivation and sward improvement difficult, but the semi-naturally occurring predominant acid bent-fescue grassland, often with bracken, provides productive rough grazing of good quality. On less steep areas the land is well suited to pasture improvement and the free-draining loamy soils are readily cultivated and present no significant problems for grazing management. Steepness, however, is likely to make grass conservation difficult. Grain and forage crops are restricted to the least steep land. Some coniferous trees have been planted in small areas surrounded by poor quality hill grazings.

**Map unit 222** occupies 37 square kilometres (1 per cent of the association) mainly in Galloway and comprises brown forest soils with some brown rankers and moderate amounts of outcropping rock. Smooth, non-rocky, gentle to steep slopes carrying mainly brown forest soils are interspersed with complex moderately rocky terrain having brown forest soils and brown rankers. The land ranges widely from undulating lowlands to steep valley and hill sides, but lies generally below 250 metres altitude. The soils are developed on thin, stony, loamy drifts and frost-shattered rock debris and are free-draining. The climate ranges from warm and wet to fairly warm and wet with 1000 to 1500 millimetres average annual rainfall. In the lowlands with gentle and strong slopes, arable and permanent pastures support some dairying, but are more generally utilized for cattle and sheep rearing. Acid bent-fescue grassland on steep slopes provides good quality rough grazing utilized in conjunction with moderate or poor grazings on higher-lying land. The soils are not readily damaged by poaching.

**Map unit 223** occupies 220 square kilometres (7 per cent of the association) mainly in Galloway and Dumfriesshire and comprises brown forest soils and brown rankers. The soils, although relatively uniform in type, range widely in depth and are developed on thin, very stony, frost-shattered rock debris. The terrain is mainly rugged, with irregular, moderately and very rocky strong or steep, slopes, but a few very rocky areas in the lowlands are on gentle slopes. The land lies mainly below 300 metres altitude. The semi-natural vegetation, which provides good quality rough grazing, is relatively uniform and is predominantly acid bent-fescue grassland with gorse or bracken locally present. Some dry Atlantic heather moor is found on high-lying land. Some improved pastures have been established, but the pattern of slope and rock outcrop largely controls the use of wheeled tractors and other machinery which is often difficult. Where it is

possible, however, addition of lime, phosphatic fertilizers and improved seed mixtures to these acid mineral soils will give major benefits and improved swards, once established, should be resistant to damage by treading and fairly easily maintained.

**Map unit 224** occupies 28 square kilometres (less than 1 per cent of the association) mainly in the hill areas of Dumfriesshire and southern Lanarkshire, and comprises rankers, podzols and brown forest soils. The soils are shallow, very stony and developed on stabilized scree and very stony hill side drifts on very steep valley and hill slopes. There are generally a few crags on the upper slopes and some areas of bare or partially vegetated scree. Surface boulders are abundant and the semi-natural vegetation includes bent-fescue grassland, dry Atlantic heather moor and oak and birchwood. Pasture improvements are not possible on these steep bouldery slopes and the land is utilized for rough grazing.

**Map unit 225** occupies 4 square kilometres (less than 1 per cent of the association) near Crawfordjohn, Lanarkshire, but is extensive in South-East Scotland. It comprises brown forest soils developed on stony, loamy, soliflucted drifts on strongly sloping hill and valley sides and noncalcareous gleys formed on clay loam tills and stony loamy drifts in valleys. The land is utilized mainly as permanent pasture, and some unimproved acid bent-fescue grassland and sharp-flowered rush pasture provide rough grazing of good quality.

**Map unit 226** occupies 65 square kilometres (2 per cent of the association) and comprises brown forest soils and peaty podzols. It occurs mainly on the western edge of the Lowther Hills on smooth round hills with convex slopes and narrow intervening V-shaped valleys with steep and very steep slopes (Plate 12). Altitudes range from 200 to 500 metres, with brown forest soils occupying steep lower hill slopes up to 330 metres and peaty podzols on the upper slopes and rounded hill summits. The climate is mainly cool and wet with 1500 millimetres per annum average rainfall. On the lower slopes brown forest soils support acid bent-fescue grassland and on the higher-lying land peaty podzols carry more varied vegetation of which moist Atlantic heather moor, white bent grassland and flying bent grassland are the main communities. The land is utilized principally for rough grazing which is generally of good and moderate quality. Pasture improvements have been carried out in some small areas. On the brown forest soils, improvements once established should be readily maintained.

**Map unit 228** occupies 33 square kilometres (1 per cent of the association) and comprises peaty podzols with associated humus-iron podzols. It occurs in the Southern Uplands, mainly east of the River Nith in the Lowther Hills, and is much more extensive in South-East Scotland. The parent materials are the grey-brown, stony, loamy, compact or indurated, hill side drifts and solifluction deposits which are typical of the smooth, rounded hills with strong and steep convex slopes. The map unit is restricted mainly to hill summits and the middle and upper parts of slopes, generally at altitudes of 250 to 600 metres. The climate is cool or cold, and wet with 1250-2000 millimetres per annum average rainfall. The moist Atlantic heather moor and white bent grassland, together with some flying bent grassland, and at high altitudes, boreal heather moor, provide natural grazing of moderate or poor quality. Little reclamation of this land has been carried out, but below 430 metres the establishment of improved swards should be possible.

**Map unit 229** occupies 140 square kilometres (5 per cent of the association) and comprises peaty podzols with some peaty gleys and peat. The map unit is of greater extent in South-East Scotland and is closely related to *map units 218* and *228*; peaty gleys and peat are less extensive than in *map unit 218*, and are generally absent in *map unit 228*. The map unit occurs mainly in north-east Kirkcudbrightshire and western Dumfriesshire on smooth rounded hills and undulating upland with strong and steep slopes. The soils are developed mainly on grey-brown, thin, stony, hill side drifts on steep slopes, but there are some thicker loamy or clay loam tills on less steep areas. The altitudinal range of the land is considerable, 250–600 metres, and the climate is fairly warm and wet to cold and wet with rainfall levels of 1250 to 2000 millimetres per annum. Like the soil, topographic and climatic conditions, the vegetation also is varied and includes moist Atlantic heather moor, heath rush–fescue grassland, flying bent grassland, blanket bog and flying bent bog communities. The land is utilized mainly as rough grazing of low or moderate quality and some extensive coniferous forests have been established. Pasture improvements are possible on areas of moderate elevation and rainfall but careful management will generally be necessary to avoid the ingress of rushes to an unacceptable degree or damage to the pasture by poaching.

**Map unit 230** occupies 223 square kilometres (8 per cent of the association) and occurs mainly in northern Kirkcudbrightshire, Carrick and north-western Dumfriesshire where it comprises peaty podzols and peaty gleys with some peat and rankers. The terrain is mainly hilly and the strong and steep slopes are rock-controlled with a thin cover of stony drifts and frost-shattered rock debris only partially subduing the irregularity of the underlying rock. The land lies mainly between 250 and 600 metres and the climate is cool and wet with rainfall of 1250–2000 millimetres per annum. The soil pattern is extremely varied and characterized by short-range changes in soil type related to differences in slope and drift. This is reflected in the vegetation, which is also varied and includes moist Atlantic heather moor, heath rush–fescue grassland, flying bent grassland and blanket and flying bent bogs as widespread communities. Rough grazing of generally poor quality is the predominant land use and pasture improvements are generally difficult under the adverse conditions of soil, climate and topography. Coniferous forest plantations have been established over considerable areas.

**Map unit 231** occupies 219 square kilometres (7 per cent of the association) and, like *map unit 230* to which it is closely related, occurs mainly in Galloway, Carrick and western Dumfriesshire. The soils include peaty podzols and peaty gleys with some rankers, peat and brown forest soils and the strong and steep slopes of the hilly terrain are irregular and moderately or very rocky. The drift cover is thin and frequently consists of colluvial, stony, frost-shattered rock debris. The climate is cool and wet with rainfall of 1250–2000 millimetres per annum. Like the soils the vegetation is characterized by a high degree of short-range variation and includes amongst the principal communities moist Atlantic heather moor, flying bent grassland, blanket bog and acid bent–fescue grassland. The rough grazing is of poor or moderate quality and pasture improvements are not generally possible. Plantations of coniferous trees have been established widely.

**Map unit 232** occupies 96 square kilometres (3 per cent of the association) and occurs mainly in Galloway and western Dumfriesshire where it comprises non-

calcareous gleys and brown forest soils. It occurs mainly on the middle and lower, notably concave, slopes of the hills and valleys. The valleys are usually U-shaped as a result of glacier erosion and are exemplified west of Moniaive by the Shinnel, Dalwhat and Craighdarroch valleys. Thin, stony drifts on the steep middle slopes and thicker loamy drifts and tills on the lower slopes are the principal parent materials and down slope moisture movement from higher ground taking place through the soil and upper drift layers is channelled by minor topographic irregularities to give a complex pattern of freely and poorly drained soils. The land ranges up to 300 metres altitude and the climate is fairly warm and wet with 1250 millimetres per annum average rainfall. The effects of mineral-rich 'flush' water are apparent in the vegetation with both sharp-flowered rush pastures and tussock-grass pastures in their typical forms found on the noncalcareous gleys and acid bent-fescue grassland, locally with bracken, occurring on the brown forest soils. The rough grazing afforded by these communities is palatable to stock, is productive, and is the predominant form of agricultural use. In favoured areas near farmsteads pasture improvements have been made on 'inbye' land, but more generally the difficulties and expense of drainage and other improvement measures have not been thought warranted. The semi-natural grazing is of good quality. Plantations of coniferous trees have been established in some areas and rapid growth can often be expected, but on the wet soils windblow can be an increasing problem as trees reach critical heights.

**Map unit 233** occupies 66 square kilometres (2 per cent of the association) and occurs mainly in the valleys of the upper reaches of small streams and tributaries in the Southern Uplands. The soils are peaty gleys and noncalcareous gleys developed on loamy tills and solifluction deposits and are strongly affected by run-off and seepage waters from the surrounding hill sides and valley slopes. The land lies mainly between 250 and 400 metres altitude and the climate is fairly warm to cool and wet with a wide range in average rainfall. The vegetation, which is strongly influenced by flushing and includes rush pastures, sedge mires and flying bent grassland as well as moist Atlantic heather moor, provides rough grazing of moderate or poor quality. Drainage and pasture improvement are often difficult to effect and maintain on this land and have been undertaken only in relatively favoured areas. Some coniferous forest plantations have been established.

**Map unit 234** occupies 3 square kilometres (less than 1 per cent of the association) and comprises peat, peaty podzols and peaty rankers on the crests of hill ridges at 400 to 600 metres altitude in the Lowther Hills and above the Scaur valley in Dumfriesshire. The effects of altitude are apparent in the vegetation, which includes upland and mountain blanket bogs and moist Atlantic heather moor and provides rough grazing of poor quality and low productivity.

**Map unit 235** occupies 26 square kilometres (less than 1 per cent of the association) and comprises mainly corries with rock walls and scree slopes on which the soils are predominantly rankers and lithosols (Fig. 6). These geomorphic features are prominent in the landscape and contrast with the outlines of the surrounding hills. The vegetation cover is discontinuous and includes Atlantic heather moor and blaeberry heath communities. The land has some value for wildlife and recreation but very little for agriculture or forestry.

**Map unit 236** occupies 21 square kilometres (less than 1 per cent of the association) and comprises subalpine soils with some peat and peaty podzols. It occurs

on mountain tops above about 600 metres altitude in the Merrick, Kells and Lowther Hills of the Southern Uplands, and the soils are developed on thin, stony, brown sandy loams which are either glacial drifts, resulting from frost-weathering in Late Glacial or Post Glacial times, or represent the preserved base-ment of weathered layers formed in the warm preglacial climate. Slopes on the broad mountain summits are generally gentle or strong, some boulders are often present, and stone polygons or solifluction terraces give evidence of frost action. The vegetation is strongly influenced by severe exposure and the cold wet mountain climate and comprises mainly fescue-woolly fringe-moss heath, stiff sedge-fescue grassland and mountain blanket bog. The land provides some rough grazing in the middle and late summer but its principal value is for recreation and wildlife.

## THE FOU DLAND ASSOCIATION

(Map units 241–243, 246–255)

The association was first described in north-east Scotland on drifts derived from argillaceous schists of varying degrees of metamorphism. In South-West Scotland it includes slates and phyllites and also mica-schists in areas of low-grade metamorphism. The inclusion of drifts derived from the latter in the Foudland rather than the closely allied Strichen Association is debatable, but the soil textures appear to be sufficiently fine to warrant the distinction. The Foudland Association covers 687 square kilometres (4.8 per cent of South-West Scotland) and is the sixth largest. It is confined to the north-central part of the region, north of the Highland Boundary Fault. The Luss Hills, Rosneath, southern Cowal including part of Bute (Plate 6), and some parts of southern Lorne and north Kintyre are dominated by soils of this association. The landforms in the north-west of this area, where the drift cover is thin, are strongly controlled by rock structure and repeated sequences of ridges and hollows are common. Between Loch Fyne and Loch Lomond the ridged topography is not obvious, although the hills reflect the strong Caledonoid trend (north-east to south-west) of the Dalradian rocks throughout the southern Highlands. The lower parts of the valleys carry a thicker drift cover and the long and often regular hill slopes rising above them are often less rocky and more reminiscent of the western Southern Uplands than the Highlands.

The texture of the parent material is loam or silty loam with occasional sandy loam where some reworking of the tills or moraines has occurred. Silt contents (2–50  $\mu\text{m}$ ) of the soils are fairly high (between 35 and 50 per cent) compared with a mean of 35 per cent in this association for Scotland as a whole. The drifts are moderately stony (tabular, partially weathered schist and slaty schist comprising the bulk of the stones) and generally of a greenish grey, olive or olive-brown colour, the last-named being more prevalent in the east and under lower rainfall conditions.

The association is found in areas where the climate is warm or fairly warm and wet (1400–2400 millimetres average rainfall), but in the higher hills it is found under cooler conditions and a few of the highest hill summits lie in the orohemiarctic thermal subzone (Birse, 1971). The interaction between wet conditions and fine texture produces gley soils; those at lower levels under higher temperature regimes are noncalcareous or humic gleys, while the cooler hill conditions produce peaty gleys and peat. About 19 per cent of the map units are dominated by noncalcareous and humic gleys and 54 per cent by

peaty gleys and peat. Of the remainder, map units with significant proportions of brown forest soils and humus-iron podzols account for 16 per cent and those with peaty podzols 11 per cent. The proportion of the map units dominated by soils with mineral surface horizons is, for Highland areas, quite high (35 per cent).

The vegetation of the moorland areas is dominated by Atlantic heather moor, bog heather moor and blanket bog, but the drier slopes are dominated by white bent grassland (on peaty podzols) and bent-fescue grassland (on humus-iron podzols and brown forest soils). These, together with bent-fescue grassland and rush pastures on the gleys of the lowlands (where these are not improved) provide moderate and good quality grazing within the context of hill farming.

**Map unit 241** encompasses noncalcareous and humic gleys developed on shallow fine sandy or silty tills. There is little or no outcropping rock, although it is frequently close to the surface. The landscape is strongly undulating lowland and footslopes, sometimes with strongly flushed or peaty hollows. The map unit occupies 32 square kilometres (5 per cent of the association) principally on the Island of Bute between St Ninian's Point and Port Bannatyne, but it also occurs on Ardyne Point, the Rosneath peninsula, around Garelochhead and on Jura. Some of the land is cultivated but, because of drainage problems, long-ley or permanent grassland is common. The high fine sand and silt contents frequently lead to structural instability under cultivation in the wet climate.

**Map unit 242** also contains noncalcareous and humic gleys but has a less regular topography than *map unit 241* and has occasional rock outcrops. Some small areas of podzolized brown forest soils and humus-iron podzols are found on the rocky and shallow areas. The map unit is extensive, covering 95 square kilometres (14 per cent of the association) and is principally developed bordering areas of *map unit 241*, especially in the vicinity of Rosneath, Garelochhead and Rhu. It occurs patchily on Bute and on either side of Loch Long and Loch Fyne where a lodgement till produced by glaciers occupies these major troughs. It also occurs extensively near Lochgilphead.

From the limited analyses available, the gley soils of both *map units 241* and *242* have a topsoil organic-matter content of between 8 to 12 per cent, base status is moderate to high and pH is in the range 5 to 5.5, increasing with depth. The grey or greyish brown fine sandy and silty loam subsoils have yellowish brown mottles and are poorly drained. Owing to the silty textures, proximity to rock and strong slope patterns, combined with high rainfall, land of this type is often in long-ley pasture. It provides valuable grazings. Forest plantations on exposed land with shallow soils are liable to windthrow.

**Map unit 243** comprises humus-iron podzols with brown forest soils, noncalcareous and peaty gleys and peaty podzols. It occurs only in the Loch Ard Forest on the northern margin of the region and occupies 3 square kilometres (less than 1 per cent of the association) but is much more widespread in Eastern and South-East Scotland. The land is generally non-rocky with gentle and strong slopes and contains areas of both till and colluvium. Atlantic heather moor and bent-fescue grassland are the main plant communities where the land is not forested.

**Map unit 246** is developed primarily on a shallow till and supports peaty gley and peat soils with some minor areas of colluvium often occupied by peaty podzols.

Slopes are usually less than 15 degrees and the map unit occupies foothill sites between 100 metres and 300 metres in altitude. It extends to 61 square kilometres (9 per cent of the association) mainly in the south-east and south of the Isle of Jura, but also on low hills in the north of Bute and in the Rosneath peninsula and Garelochhead areas. The vegetation is characterized by moist Atlantic heather moor and bog heather moor with some flying bent bog. These communities are of low grazing value and the peaty surfaces and high rainfall give little prospect of anything but mosaic improvements to encourage stock to range. Forestry is often a suitable and alternative use for this land, although the choice of species is limited and some windthrow on shallow soils may be expected.

**Map unit 247** is almost as extensive as *map unit 246*, occupying 56 square kilometres (8 per cent of the association), and is closely related to it, differing solely in having more rock and more colluvial drift, supporting podzolic soils, around the outcrops. In south-east Islay, Jura and Minard Forest near Lochgilphead small rocky ridges of epidiorite cross this map unit. At larger scales these may be mapped separately as the Tarves Association. The only other area of note is in south-eastern Cowal near Dunoon. Owing to excessive wetness reclamation for grass is difficult; some of the drier knolls give a locally higher grazing potential but the largest areas at Minard and Dunoon are now extensively forested.

**Map unit 248** is of limited extent, occupying 5 square kilometres (less than 1 per cent of the associations) and is mapped on morainic mounds with gentle slopes. It is closely associated with the more extensive *map unit 249* and occurs at the mouth of Glen Luss and in the valley of the Finlas Water to the west of Loch Lomond. The morainic mounds carry the drier humus-iron podzols while wetter soils, consisting of humic or peaty gleys or alluvial soils, occupy the hollows. The humus-iron podzols usually have an indurated horizon within 50 centimetres, have a low base saturation, and have a lower pH than the gleys of the hollows. The gleys, however, suffer from serious physical defects and poach easily. The pattern of wet and dry soils, together with the irregular topography, preclude arable farming, but the land provides valuable grassland especially when improved. In a semi-natural condition the mounds support acid bent-fescue grassland, sometimes with bracken, and the hollows rush pastures. The land is also suitable for forestry and its low elevation and sheltered position make it suitable for many trees including broadleaved species.

**Map unit 249** is the extension of the mounded moraines of *map unit 248* into higher rainfall and lower temperature conditions, which are conducive to the development of a thicker peaty surface horizon and wetter soils. The mounds support peaty podzols or peaty gleys with induration, sometimes with only a thin iron pan separating the indurated horizon from a gleyed E horizon. The hollows are almost universally floored with peat which becomes extensive and sometimes surrounds the mounds completely. The soils are only rarely improved for grassland and the problems of maintenance are such that pastures often revert quickly to rushes. Indeed such infestation of the hollows is common, but the mounds can carry common white bent grassland which allows slightly higher stocking rates. Similar map units in other associations have been used extensively for forestry, but apart from some plantations in lower Glen Luss this map unit is mostly unforested. Map unit 249 occupies 45 square kilometres (7 per cent of the association).



**Map unit 250** is developed on slopes greater than 15 degrees, is moderately rocky, and occupies 61 square kilometres (9 per cent of the association). Brown forest soils and humus-iron podzols are the principal soils, with humic gleys in small flushed hollows and brown rankers around rock outcrops. The parent material is mostly a fine loamy colluvium, often stony and shallow except on footslopes where it reaches considerable thickness and the rockiness is much less. The steep hill slopes make reclamation difficult and roads and ditches cut into them often slump to an alarming extent. The map unit is characterized by acid bent-fescue grassland, often heavily infested with bracken but nevertheless providing valuable grazings. The land is also suitable for forestry and a wide range of species can be grown. Indeed, in many areas the land supports an oakwood community.

**Map unit 251** occupies 43 square kilometres (6 per cent of the association) and is similar in most respects to *map unit 250* except that there is little or no rock outcrop. It can attain altitudes as high as 600 metres where the brown forest soils and humus-iron podzols give way, sometimes surprisingly sharply, to peaty podzols supporting common white bent grassland of a lower grazing value. Like *map unit 250*, this map unit is suited to grazing or forestry.

**Map unit 252** is related to *map units 250* and *251* and, like them, occurs on steep slopes with a loamy, stony, colluvial parent material. It is found, however, at higher altitudes or in more severe climates and comprises peaty podzols and some peaty rankers. It is slightly or moderately rocky. Two extensive areas have been mapped on either side of Loch Caolisport at altitudes ranging from 100 to 300 metres on strongly ridged and slightly less steep land, but inland near Loch Eck it does not occur below 300 metres and extends, on very steep slopes, to over 500 metres. The map unit occupies 34 square kilometres (5 per cent of the association). It supports both common white bent grassland and moist and dry Atlantic heather moors; overall it provides land of moderate grazing value. Some areas are forested.

**Map unit 253** is the most extensive in the association in South-West Scotland, occupying 182 square kilometres (26 per cent of the association). It is developed on a shallow colluvium with rock close to the surface but only occasionally visible. In hollows and in the lee of hills however, patches of till can be found and the map unit has some of the features of *map unit 247*. The principal soils are peaty gleys and peat with peaty podzols on steeper slopes. The colluvial parent material, although silty or fine sandy loam in texture, is not so compact as the tills and is often darker in colour due to the percolation of humus colloids. Map unit 253 is related to *map unit 507* of the Strichen Association which, however, is slightly more rocky in places.

Although few analyses of the principal soil, the peaty gley, are yet available from this area, results indicate that the average pH of the surface horizons is just above 4, rising to 5 in flushed channels. Strong gleying of the B horizons is apparent and the soils are wet for extended periods. Base status is low to moderate. The plant communities are dominated by moorland, in particular moist Atlantic heather moor and bog heather moor. There is subsidiary flying bent bog, flying bent grassland and common white bent grassland. The grazing value is usually low but some moderate values may be found especially where there are extensive 'flush' communities. Wetness is a major drawback to agricultural use. Some areas have been extensively afforested although the choice of species is usually restricted to Sitka spruce and lodgepole pine.

**Map unit 254** is closely allied to *map unit 253* and occupies 69 square kilometres (10 per cent of the association). It is distinguished by its steeper slopes, a marked reduction in the amount of peat and an increase in peaty podzols showing marked gley features. Rock outcrop also increases and flushing is frequent in narrow well-defined channels. The parent materials are colluvial in origin and the soils have similar morphological characteristics to those of *map unit 253*, but with an increase in the number of disturbed profiles due to local erosion and redeposition on the steep slopes. This map unit is extensive in the hills of Cowal and Luss under rainfalls of 2000 millimetres but is much less frequent in the lower, ridged topography around Lochs Fyne and Caolisport. Much of the high rainfall is shed directly as run-off by the steep slopes however, and although gleyed the soils are slightly less waterlogged than similar soils on lower slopes. This is reflected in the vegetation which is characterized by white bent grassland and flushed communities resulting in moderate grazing values. In Eastern Scotland similar sites under lower rainfalls develop peaty podzols, thus map unit 254 is almost exclusively western in distribution.

**Map unit 255** occurs on the summits of a ring of mountains around the head of Glen Luss at altitudes in excess of 600 metres. It occupies slightly more than 1 square kilometre (less than 1 per cent of the association). It is composed principally of subalpine soils and haggling peat. The soils on summits are not as rocky as those of the Countesswells or the Strichen Associations, but the vegetation is windcut due to exposure and this, coupled with the amount of peat, reduces the grazing potential severely. The land is not plantable.

## THE FRASERBURGH ASSOCIATION

(Map units 259–261)

The soils of the association are developed upon aeolian and raised beach sands containing a high proportion of shell fragments. They cover slightly more than 6 square kilometres (less than 0.1 per cent of South-West Scotland), occurring entirely on Colonsay and Oronsay islands which bear the full force of westerly gales across the Atlantic; in this respect the islands are similar to those of the Outer Hebrides, which also have a significant proportion of shell sand deposits. Sands also occur on the western coasts of Islay to the south, some containing shell fragments, but they are predominantly mineral sands and mapped within the Links Association.

Strongly contrasting landscapes are included within the association, ranging from flat to extremely mounded. Since the parent material is of coarse sand texture, the soils are freely and excessively drained, except in a few, low-lying, receiving sites. Other striking features of the parent material are a very light colour, high pH (7–8) and complete base saturation. Sand is still blown over many of the sites from adjoining beaches during storms, and sequences of deposition, but sometimes also erosion, occur. The soils are consequently immature and are classed as calcareous regosols. In sheltered areas brown calcareous soils and calcareous gleys have developed.

The association is restricted to lowland sites with a warm, moist climate. The species-rich, semi-natural grassland communities are noted for the excellence of their grazings.

**Map unit 259** is of very restricted extent (less than 1 square kilometre). It consists

of calcareous regosols and brown calcareous soils, often with humose A horizons, on flat or undulating machair. At larger map scales (e.g. 1:50,000) the soils could be mapped as soil series. The principal agricultural use is as grazing land and owing to the risk of erosion extended arable rotations would be unwise.

**Map unit 260** is very similar to *map unit 259* except for the presence of some rocky knolls and areas where the sand forms a shallow cover over rock. These rocks can impede drainage and cause peaty gleys to develop. Some of the land has been cultivated but there is a severe risk of erosion. The map unit is confined to Oronsay where it occupies 2 square kilometres.

**Map unit 261** is stabilized sand dunes with a strongly hummocky topography. Its principal soils are calcareous regosols and brown calcareous soils, often with humose A horizons, but hollows may be wetter, calcareous gleys with peaty surface horizons being common. The map unit occupies 4 square kilometres and its use is confined to grazing land, owing to topographic and erosion limitations. Since it usually adjoins good beaches it is at risk from recreational pressure, and destruction of some of the vegetation by trampling could undoubtedly accelerate erosion. Fortunately this pressure is light on Colonsay and Oronsay.

## THE GLENALMOND/MAYBOLE ASSOCIATIONS

(Map units 264–272)

The soils of the Glenalmond and Maybole Associations are developed on drifts derived from sandstones of Lower Old Red Sandstone age. The sandstones are quartzose with occasional beds of conglomerates incorporating pebbles derived from igneous rocks or greywackes. The drift is principally a compact reddish brown sandy clay loam till, which in some areas such as the Girvan valley has upper layers of sandy loam or loamy sand texture resulting from modification by water. Around Maybole there are stony sandy loam moraines.

The soils of the associations occupy 279 square kilometres (1.9 per cent of South-West Scotland), mainly in south Ayrshire between the Carrick Hills and the Girvan valley. Smaller areas occur along the north-western margin of the Southern Uplands Fault zone in the Glespin valley, Middle Muir, south of Douglas and around Lesmahagow in south Lanarkshire.

Rainfall ranges from 1000 millimetres per annum near the coast in the warm moderately dry lowlands to 1500 millimetres in the cool wet foothills and uplands of south Lanarkshire.

In the lowlands, the soils are mainly brown forest soils with gleying and some brown forest soils, but in the foothills and uplands noncalcareous gleys, peaty gleys and peat are dominant. On some hills, thin stony drifts of medium or coarse texture carry peaty podzols.

The soils are mainly brown forest soils with gleying and brown forest soils in lowland areas, but in the foothills and uplands noncalcareous gleys, peaty gléys and peat are dominant. On some hills, thin stony drifts of medium or coarse texture carry peaty podzols.

**Map unit 264** occupies 15 square kilometres (5 per cent of the associations) and comprises brown forest soils, brown forest soils with gleying and some noncalcareous gleys. The soils occur mainly in the Girvan valley and are developed on water-modified tills with sandy loam or loamy sand upper layers

overlying sandy clay loam till. The footslopes along the valley are usually gentle, but there is some hummocky ground where tills have been deeply water-modified or are overlain by thin gravels. The loamy topsoils, with friable crumb or subangular blocky structure, overlying sandy loam subsoils are readily cultivated where the natural drainage is free. Where it is imperfect some care is necessary in the timing of operations. The land is utilized for arable crops and ley pastures.

**Map unit 265** is widespread, occupying 132 square kilometres (47 per cent of the associations), and provides valuable pasture and arable land. The soils are mainly brown forest soils with gleying with some brown forest soils and gleys. Topsoils are loamy and underlain by compact sandy clay loam subsoil with moderately developed coarse prismatic structure and passing down into massive red-brown sandy clay loam till. The soils are readily worked, but if left with a fine tilth show a tendency to 'cap' after heavy rain and the timing of cultivations can be much affected by moisture conditions. The subsoils are slowly permeable to moisture and root proliferation below the plough layer is restricted to some extent by coarse subsoil structures. The imperfect natural drainage can be ameliorated by comprehensive under-drainage systems which should incorporate permeable infill above the drains and include a secondary treatment to improve subsoil structure and permeability. Slopes are gentle or strong in the undulating lowlands and the land is farmed in rotations of long-ley grass pastures with three- to four-year arable breaks.

**Map unit 266** occupies 23 square kilometres (8 per cent of the associations) and comprises noncalcareous gleys with some brown forest soils with gleying and peaty gleys. The land occurs on the middle and upper slopes of valleys, as near Dailly, Holybush and east of Sorn, and is related to that of *map unit 265*, but the natural drainage is generally poor rather than imperfect and altitudes are greater. The soils have poorly developed structures and are slowly permeable to moisture. Comprehensive under-drainage incorporating permeable infill in the drain-lines and including a secondary treatment to improve subsoil structure and internal drainage are necessary for the improvement of this land. The naturally occurring sharp-flowered rush pasture provides rough grazing of good quality. Improved areas are utilized mainly for permanent pasture, although some arable cropping is possible.

**Map unit 267** occupies 30 square kilometres (11 per cent of the associations) and comprises brown forest soils with some brown forest soils with gleying, peaty podzols and humus-iron podzols. The terrain is mainly lowland and foothill with rock-controlled gentle and strong slopes, but with few rock outcrops, and the cover of loamy drift is generally thin and stony. The heath grass-white bent grassland and acid bent-fescue grassland communities provide rough grazing of good quality, but much of the land has been improved for permanent pasture and some arable crops are grown. On Wood Hill south of Muirkirk steep slopes prevent reclamation.

**Map unit 268** occupies 12 square kilometres (4 per cent of the associations) and comprises peaty podzols with some peaty gleys and peat. It occurs mainly south of Muirkirk on rounded hills with simple convex strong slopes and carries Atlantic heather moor, flying bent grassland, bog heather moor and blanket bog communities. This vegetation provides rough grazing of generally poor quality and in the wet climatic conditions improvements are likely only on scattered patches, encouraging stock to range.

**Map unit 269** occupies only 5 square kilometres (2 per cent of the associations) and comprises peaty gleys, peaty podzols, noncalcareous gleys and peat. It occurs mainly in the hills above the Girvan valley but it is also found near Crawfordjohn. The soils are developed on red-brown sandy clay loam tills on strongly sloping land and on thin, stony sandy loam drifts on steeper slopes. The vegetation includes heath rush-fescue grassland and moist Atlantic heather moor with sharp-flowered rush pasture occurring on land affected by run-off from higher ground. These communities provide rough grazing of moderate or poor quality, but with appropriate soil drainage some pasture improvements are possible in the Girvan area.

**Map unit 270** occupies 52 square kilometres (19 per cent of the associations) and comprises peaty gleys, peat and some noncalcareous gleys. It occurs mainly in uplands overlooking the Girvan valley and near Muirkirk and Douglas. The parent materials are reddish brown sandy clay loam and loam tills and colluvial drifts in gently undulating upland. The soils are characterized by poor and very poor internal drainage and are excessively wet for much of the year. The flying bent grassland, flying bent bog and sharp-flowered rush communities provide rough grazing of moderate quality and pasture improvements are difficult to carry out and maintain. Soil wetness and consequent liability to damage by poaching will constitute a continuing problem on this land.

**Map unit 271** occupies 9 square kilometres (3 per cent of the association) and comprises brown forest soils and humus-iron podzols with some gleys. It occurs as a narrow belt of moundy land with gentle and strong slopes between Maybole and Kirkoswald in south Ayrshire where the soils are developed on stony sandy loam morainic drifts. The sandy soils are freely drained, easily worked and well suited to arable agriculture, although much of the land is maintained in ley and permanent pastures.

**Map unit 272** is not extensive, occupying only 1 square kilometre (less than 1 per cent of the associations), and comprises peaty podzols developed on mounds of stony coarse-textured moraine and peaty gleys in the intervening hollows. It occurs on the slopes of Little Cairn Table south-east of Muirkirk and the Atlantic heather moor, flying bent grassland and blanket bog communities provide poor and moderate quality rough grazing. Pasture improvements are likely to be difficult to maintain under the prevailing wet climate.

#### THE GLENEAGLES/AUCHENBLAE/ COLLIESTON/DARNAWAY ASSOCIATIONS

(Map unit 273)

The soils of the Gleneagles and Auchenblae Associations are developed on fluvio-glacial sands and gravels derived from Old Red Sandstone sediments and lavas and from acid schists. The sands are mainly restricted to lenses in the predominant gravels which are composed principally of hard red sandstones and some andesitic stones and cobbles of acid schists from the basal conglomerate of the Old Red Sandstone strata.



Plate 1. *Quartzites and limestones, slates and phyllites in eastern Islay. The landscapes of the Highlands are frequently strongly differentiated according to rock type. The quartzites form the higher rocky ground, the limestones, slates and phyllites the lower-lying occasionally farmed land.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright



Plate 2. Near Bridgend, Loch Indaal, Islay, a fringe of saltings separates the sea from the drumlins of map unit 333 (the Kintyre Association). In the middle distance, slightly to moderately rocky terrain supports brown forest soils on the limestones of the Deecastle Association. Map unit 188 (the Durnhill Association) forms the hill land visible in the distance. Aerofilms



Plate 3. *The low rugged hills of Knapdale, Argyll have been glacially scoured. Their soils are extremely shallow and much of the land is afforested.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright



Plate 4. *The dissected plateau of Kintyre (dominated by map unit 507 of the Strichen Association) is frequently fringed by tills of the Kintyre Association producing map units dominated by gleyed soils (front centre) often in combination with rock outcrops. The foreground is occupied by raised beach sands and gravels (the Corby Association) which provide the best farmland of the area.* SDD Crown Copyright





Plate 5. Complex soil patterns within broad landscape types are exemplified in Glendaruel, Argyll. The mineral and peaty alluvial soils of the valley bottom (map unit 1) give way to moraine on the lower hill slopes, characterized by humus-iron podzols, brown forest soils and gleys (map unit 503). The upper hill slope is composed of colluvium from the Green Beds (map unit 525). Aerofilms



Plate 6. On the Island of Bute the slates and phyllites forming the parent material of the Foudland Association weather to give gently rounded hills and shallow soils. The valleys contain till or deeper colluvial deposits and, owing to the silty textures and high rainfall, noncalcareous gleys are the predominant soils.



Plate 7. Exposed grassy slopes on the Campsie Fells with brown forest soils and brown rankers (map unit 158) of the Darleith Association. Similar lava hills are common on both sides of the Clyde estuary. Land of map unit 337 in the relatively sheltered Strathblane valley is seen in the foreground. Institute of Geological Sciences photograph published by permission of the Director; NERC copyright



Plate 8. The Carse of Stirling (map unit 488) looking north-westwards to the Highlands. Soils of the Balrownie Association (map unit 41) form the 'dryfield' land in the middle distance. Photograph ADS Macpherson



Plate 9. *The Clyde valley, near Crossford, Lanarkshire, with glasshouses on the sheltered, steep valley sides (map units 164 and 445) contrasting with grassland on slowly permeable soils of the Drongan Association (map unit 171) on the adjacent till plain. SDD Crown Copyright*



Plate 10. *The Darvel valley, Newmilns, Ayrshire, looking north across the town and mills built on alluvial land (map unit 1) to undulating lowland of map unit 331 in the Kilmarnock Association. The thick tills which underlie this land are typical of central Ayrshire. The soils are slowly permeable. SDD Crown Copyright*

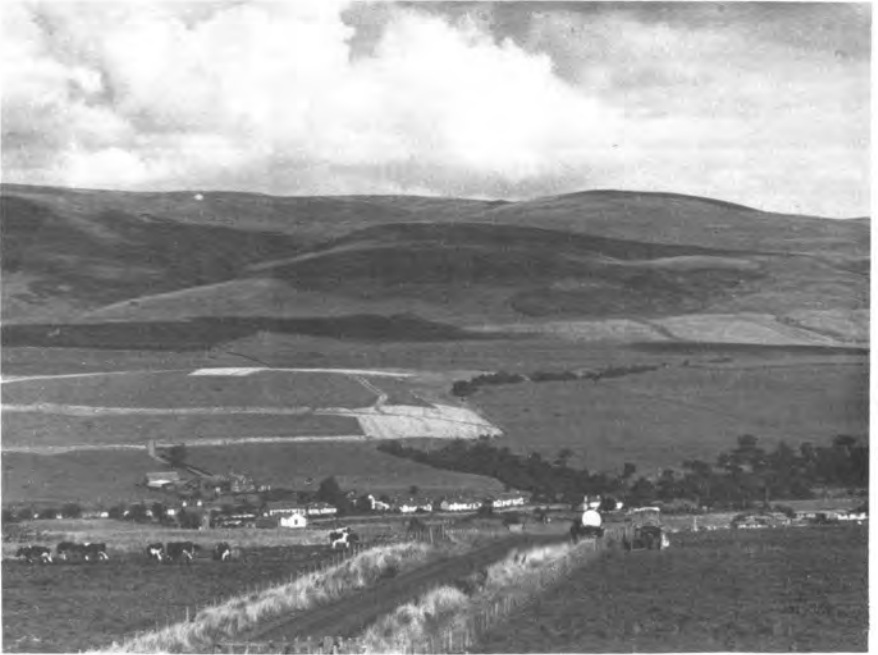


Plate 11. *The Nith valley at Kirkconnel. Subject to more rapid down-wasting than the harder greywackes of the high ground, the sedimentary Carboniferous rocks underlying the foreground and middle distance provide gentle slopes on which the clayey tills characteristically carry slowly permeable soils (map units 51 and 446)*



Plate 12. *The smooth round forms and strong dissection of the Lowther Hills are seen here on the borders of the Mennoch valley. Such ground is typical of much of the central parts of the Southern Uplands. The land is mainly in map units 221 and 226 of the Ettrick Association. Institute of Geological Sciences photograph published by permission of the Director; NERC copyright*



Plate 13. *The Ken valley, Kirkcudbrightshire. Glacial erosion has left much irregular ground with rock outcrops. The integrated pattern of land use includes sheep and cattle farming on the lower valley slopes, rough pasture and forestry on the mid-slopes of the hills, and sparse grazing for sheep on the mountain tops. In the middle distance is one of a series of dams used for hydro-electricity generation*



Plate 14. *The Knock of Luce looking south-eastwards across the Moors of Wigtownshire with peat lands of map unit 3, seen here broken by areas with many ice-eroded knolls of rock and forming map unit 215 of the Ettrick Association*



Plate 15. The landscape around the Haugh of Urr exemplifies the pattern of drumlins and rock-controlled areas which make up map unit 440 of the Rhins Association. The fine-quality pasture land can also be cropped for the needs of the dairy farms predominant in the area. Beyond is formerly glacially-eroded land with rock outcrops in map units 207 and 223 of the Ettrick Association. Aerofilms



Plate 16. Throughout Galloway areas of glacially eroded terrain are extensive and carry patterns of brown forest soils, brown rankers and rock knolls (map unit 207) as exemplified near Borgue, Kirkcudbrightshire. These areas provide good pasture, resistant to damage by treading or poaching. Aerofilms



The associations are not extensive, occupying 13 square kilometres (less than 1 per cent of South-West Scotland) in the Mull of Kintyre and Arran where they occur on gently undulating terraces below 50 metres altitude. The rainfall ranges from 1200 to 1400 millimetres per annum and the climate is warm and moderately dry or wet. The brown forest soils and humus-iron podzols are naturally free-draining and have been under cultivation for a long period.

**Map unit 273** comprises mainly brown forest soils developed on gravels deposited in a series of undulating terraces. Dissection of these terraces has led to the formation of tracts of alluvium on which peat has developed in some areas. Under the high rainfall of the west coast the gravel soils have been subject to strong leaching and in their natural state are often podzolized. Nevertheless, despite liability to drought in dry spring seasons, these soils form some of the best land in the Highlands and Islands subregion of South-West Scotland.

### THE GOURDIE/CALLANDER/STRATHFINELLA ASSOCIATIONS

(Map units 274 and 275)

The soils of the Gourdie and Callander Associations are developed on mixed drifts derived from acid metamorphic rocks (mainly schistose grits and slates), Lower Old Red Sandstone sediments (mainly red and grey sandstones), and igneous rocks (mainly of intermediate and basic types, although in Arran they are granitic). The drifts, which are brown in Arran and pale yellow-brown around Drymen in Stirlingshire, range from indurated coarse sandy loam to compact fine sandy loam and are often massive, bouldery and very stony.

The associations occupy 39 square kilometres (0.3 per cent of South-West Scotland) and occur mainly along the Highland Boundary Fault between Loch Lomond and Drymen and in central parts of Arran. The climate is warm or fairly warm and wet, and average rainfall ranges from 1600 to 2000 millimetres per annum. Peaty gleys and noncalcareous gleys predominate in the wet climate of Arran, but under the drier conditions of Stirlingshire brown forest soils and brown forest soils with gleying are extensive, while noncalcareous gleys occupy small areas.

**Map unit 274** occupies 17 square kilometres (45 per cent of the associations) and comprises brown forest soils with gleying and brown forest soils with some noncalcareous and humic gleys mainly in wet hollows and flushes. It occurs in undulating lowlands and foothills on gentle and strong slopes and the soils are developed on very stony, weakly structured, coarse-textured till. Fine sandy textures predominate in the topsoils and, in the prevailing wet climatic conditions, seedbeds are liable to 'cap'. The land is utilized mainly as pasture and the wet hollows are often rush-infested and require drainage for the maintenance of productive swards. Cobalt deficiency can be encountered on these soils.

**Map unit 275** occupies 22 square kilometres (55 per cent of the associations) and is most widespread in Arran where it consists mainly of peaty gleys and some noncalcareous gleys developed on compact or indurated tills. In Stirlingshire, noncalcareous gleys and humic gleys predominate with some peaty gleys in very wet hollows. These soils are developed on stony, compact, coarse loamy tills, have a low permeability to moisture and require under-drainage and subsoiling if improved grass swards are to be established and maintained. In the areas of

highest rainfall, as in Arran, much of the land has been planted with forest, but with drainage it can support improved pastures. The semi-natural vegetation includes flying bent bog and rush pastures and is generally of low grazing value. Trace element deficiencies, particularly of cobalt, can be encountered.

## THE HAYFIELD ASSOCIATION

(Map units 287–290)

Soils of the Hayfield Association are developed on drifts derived from sediments of Carboniferous and Permian age. Red-brown clay loam tills occur on most valley slopes but some red-brown sandy loam water-modified tills are found in low-lying situations. There are also small areas of poorly sorted sandy loam and loamy sand drifts, hummocky moraines and some thin stony loam drifts overlying rock.

The association is not extensive and restricted to the Thornhill basin in the valley of the River Nith where it occupies 18 square kilometres (0.1 per cent of South-West Scotland). The land lies between 50 and 250 metres altitude and the climate is warm and moderately dry with an average rainfall of 1250 millimetres. Most of the land has been cultivated and carries long-ley grassland with small areas of barley and fodder root crops. On the clay loam tills, brown forest soils with gleying and some noncalcareous gleys are predominant. Brown forest soils occur on water-sorted tills and coarse-textured moraine, and peaty gleys and peaty podzols, partially affected by measures for pasture improvements, are very small in extent.

**Map unit 287** occupies 7 square kilometres (40 per cent of the association) and comprises brown forest soils and brown forest soils with gleying. These soils are developed on red-brown clay tills and sandy loam water-sorted tills and occur on the gentle and strongly sloping valley sides north of Penpont. Much of the land is cultivated and rotations generally include fairly long periods of ley grassland and short breaks in barley and fodder root crops. The freely draining soils developed on sandy loam modified tills are readily worked but careful timing of cultivations and maintenance of under-drains is necessary on the imperfectly drained, slowly permeable soils on the clay loam tills.

**Map unit 288** is not extensive, occupying only 6 square kilometres (35 per cent of the association) south of Penpont, Dumfriesshire, where it comprises brown forest soils developed on sandy loam and loamy sand hummocky moraine and noncalcareous gleys in inter-moraine hollows. Arable and permanent pastures predominate on the brown forest soils and on some gleys which have been drained. Low topographic positions and poor outfalls make improvements difficult on some wet soils and these carry rush pastures and sedge mires.

**Map unit 289** occupies 5 square kilometres (30 per cent of the association) on the valley slopes east of Carronbridge, Dumfriesshire, and comprises brown forest soils with gleying and noncalcareous gleys developed on red-brown clay loam tills. The soils are slowly permeable to moisture, but have generally been drained with closely spaced laterals. New drainage systems would benefit from the use of permeable infill in the drain-lines and secondary moling or subsoiling treatment. The land is utilized mainly for ley grassland and permanent pasture but some barley crops are grown. Care in the timing of cultivations and in the management

of grazing is necessary to avoid damage to soil structure and the poaching of pastures.

**Map unit 290** occupies less than 1 square kilometre (less than 5 per cent of the association) near Closeburn, Dumfriesshire, where it comprises peaty gleys, peaty podzols and noncalcareous gleys developed on thin stony drift overlying sandstone rock. Improved permanent pastures have been established on part of the area but there are also some rush pastures and Atlantic heather moor communities.

## THE HINDSWARD ASSOCIATION

(Map units 291–293)

The soils of the Hindsward Association are developed on drifts derived from Carboniferous sediments and basic igneous rocks. The principal drift is a grey clayey till, but some very stony sandy loam water-worked materials are also found.

The association occupies 150 square kilometres (1.0 per cent of South-West Scotland) where the thick tills of the lowlands lap against the adjoining foothills and uplands in the Cumnock and Doon valley districts of south Ayrshire. The climate is fairly warm to cool and wet, and average rainfall is 1250–1500 millimetres per annum.

The soil pattern shows the effects of rainfall and temperature on soils developed on a relatively uniform parent material. Brown forest soils with gleying and noncalcareous gleys predominate in the lowlands, but in the foothills where temperatures are lower and rainfall is higher, the soils are mainly peaty gleys, noncalcareous gleys and some peat.

**Map unit 291** occupies 51 square kilometres (35 per cent of the association) and comprises brown forest soils with gleying and some noncalcareous gleys. The soils are developed on grey clayey tills and, although prismatic structure is moderately developed in the subsoils, are very slowly permeable to moisture. Under the wet climate the land is difficult to manage and requires under-drainage. Modern systems should include permeable infill in the drainage-lines and moling or subsoiling treatments to improve subsoil structure and permeability. Cultivations for arable crops require careful timing to avoid damage to soil structure and much of the land is maintained as pasture.

**Map unit 292** occupies 49 square kilometres (35 per cent of the association), and comprises noncalcareous gleys and some brown forest soils with gleying and peaty gleys. The underlying clayey till has a coarse prismatic or massive structure, is very slowly permeable to moisture, and the natural soil drainage is poor. The land is difficult to work and is generally maintained as pasture. Under-drainage is necessary in these soils and should include permeable infill in the drain-lines and moling or subsoiling treatments to improve permeability and soil structure. Grazing requires careful management to avoid poaching or rush infestation of pastures.

**Map unit 293** occupies 50 square kilometres (35 per cent of the association) and comprises peaty gleys and peat. The natural drainage of the soils is very poor and the gently undulating foothills and uplands are very wet with semi-natural vegetation which includes moist Atlantic heather moor, bog heather moor, flying

bent bog and blanket bog. These communities provide only poor quality rough grazing and improvements are likely only on scattered patches, encouraging stock to roam.

## THE HOLYWOOD ASSOCIATION

(Map units 303-305)

Soils of the Hollywood Association are derived from sandstones and conglomerates of Permian age. The rocks are mainly red desert sandstones with associated breccias and the drifts include—on the lower ground—red-brown loam and clay loam tills which are often water-worked, with sandy loams and loamy sands in the surface layers, and—on higher-lying steeper land—thin stony sandy loam colluvial materials.

The association occupies only 16 square kilometres (0.1 per cent of South-West Scotland) near Thornhill, Dumfriesshire, but is more extensive in South-East Scotland. The land lies below 250 metres altitude and the climate is warm and moderately dry with 1250 millimetres per annum average rainfall.

The soils are mainly brown forest soils, brown forest soils with gleying and some noncalcareous gleys. Most of the land has been cultivated and is utilized for pasture although a few arable crops are grown to provide feed for stock.

**Map unit 303** occupies 5 square kilometres (30 per cent of the association) and comprises brown forest soils with gleying and brown forest soils. These soils are developed on red-brown tills which are often compact loams or clay loams, but, where affected by water-working, they have sandy loam upper layers. Soils developed on the unaltered tills are naturally imperfectly drained and generally benefit agriculturally from the installation of under-drainage and subsoiling. The land is maintained principally in pasture but some arable crops are grown.

**Map unit 304** occupies 7 square kilometres (45 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. It occurs as small areas near Closeburn, Dumfriesshire and Crawfordjohn, Lanarkshire. The natural soil drainage is imperfect or poor and the land is utilized mainly as permanent pasture. On the area near Crawfordjohn sheep and cattle rearing are the only form of agriculture, but near Closeburn some arable crops are grown.

**Map unit 305** occupies only 4 square kilometres (25 per cent of the association) and comprises brown forest soils on gently and strongly sloping land near Thornhill, Dumfriesshire. The free-draining soils are developed on stony sandy loam drifts and water-worked tills, and the land is utilized mainly for pasture, but on favourable slopes is well suited to cultivation and arable crops.

## THE INCHKENNETH ASSOCIATION

(Map units 308-311)

The Inchkenneth Association is mapped where soils are developed upon parent material predominantly derived from Jurassic and Cretaceous rocks. Landward outcrops of rocks of these ages are confined to inclusions in a volcanic vent on Arran, where their contribution to the surrounding soil material is insignificant. Extensive sub-sea basins, including Jurassic and Cretaceous rocks, lie between the

Kintyre peninsula and Islay, however, and it is from these that fine-textured tills overlying the coarse-textured Lewisian and Torridonian strata of the Rinns of Islay and Colonsay are thought to be derived.

The association is not extensive, occupying 27 square kilometres (0.2 per cent of South-West Scotland), but it is an important soil resource in the islands where it occurs as large drumlins in otherwise rocky and peaty terrain. The reddish brown till always has significantly higher clay percentages than surrounding soils, but this varies within wide limits as does the degree to which local rock types are incorporated. The cultivated soils are principally noncalcareous gleys, but the organic-matter content of the topsoils is high and humic variants are not uncommon. Indeed, almost half of the association is dominated by peaty gleys.

Although rainfall is generally low (1200–1300 millimetres per annum) for the region, its interaction with fine texture causes continuing soil wetness problems for the agriculturalist. Accumulated temperatures are greater than 1375 day °C and a long growing season makes these areas ideal for grass production. The noncalcareous gleys carry pasture communities and arable land, and the peaty soils have heath rush–fescue grassland, rush pastures, sedge mires, bog heather moor and occasionally blanket bog.

**Map unit 308** is the largest of the four units in the association. It occupies 15 square kilometres (55 per cent of the association) and provides farmland at Kiloran on Colonsay and near Port Charlotte, Foreland, Rockside and Lossit on the Rinns of Islay. Analyses indicate clay contents from 40 per cent (Rockside) to 23 per cent (Lossit), with base saturation (70 per cent in the surface) and pH (about 6.0), both increasing steadily with depth. The soils are reddish brown and heavily mottled below the topsoil, indicating poor drainage. Soil structures in the subsoil are coarse prismatic. The landscape is one of gently rounded drumlins, often banked against rock.

**Map unit 309** occurs in the crofts of Upper Kilchattan, Colonsay, and occupies less than 1 square kilometre. The soils are similar to those of *map unit 308* but are shallower and there are rock outcrops.

**Map unit 310** occurs in isolated patches on the Rinns of Islay and occupies 4 square kilometres (15 per cent of the association). It is composed of peaty gleys but with occasional humic gleys on knolls and shallow peat in hollows. There is little or no rock outcrop. A range of plant communities has been found from heath rush–fescue grassland through rush pastures to bog heather moor, their distribution depending not only on underlying soil type but on management and past land use history.

**Map unit 311** occurs on the south-west coast and in central parts of the Rinns of Islay and occupies 8 square kilometres (30 per cent of the association). It consists of till lodged among outcrops of Lewisian gneiss and the soils are very similar to those of *map unit 310*, but are shallower. The rock outcrops and short steep slopes cause problems in utilizing the land, even for grass production, but some small areas have been reclaimed.

## THE KILMARNOCK ASSOCIATION

(Map units 331 and 332)

The soils of the Kilmarnock Association are developed on drifts derived from igneous rocks, mainly basalts, and sedimentary rocks—sandstones and shales—of Carboniferous age. Thick, brownish, clay loam tills cover much of the landscape but in valleys and other low-lying areas some tills have coarse loamy, partially water-sorted, upper layers.

The association occupies 251 square kilometres (1.8 per cent of South-West Scotland) in north Ayrshire where it occurs on the till plain north of the Irvine valley (Plate 10), and between East Kilbride and Strathaven. The climate is warm and moderately dry to wet and rainfall is in the range 1000–1250 millimetres per annum.

On the gently undulating till plain landscape with drumlin-like ridges, the clay loam tills carry mainly brown forest soils with gleying and noncalcareous and humic gleys are restricted to inter-ridge hollows. The land is utilized mainly for pasture but occasional barley and forage crops are grown.

**Map unit 331** extends to 230 square kilometres (92 per cent of the association) and comprises brown forest soils with gleying on drumlin-like ridges and noncalcareous and humic gleys in channels and hollows. The loamy topsoils overlie clayey subsoils with moderately developed medium prismatic structure. The underlying clay loam to clay till is reddish brown or brown, of considerable thickness, and generally lacks pedological structure or cracks. The soils are slowly permeable to moisture and the natural drainage is generally imperfect. The land is farmed mainly in a rotation of ley grassland and arable cropping in which the period in pasture is usually fairly long and is related to rainfall and soil wetness. Drainage is essential for the effective use of these soils and should include permeable infill in the drain-lines and secondary treatment to improve structure and permeability of the subsoil. Inadequately drained land is characterized by rush-infested pastures.

**Map unit 332** occupies 21 square kilometres (8 per cent of the association) and comprises noncalcareous gleys with some humic gleys and brown forest soils with gleying. The soils are developed on clayey tills, often of finer texture than in *map unit 331*, have very low permeability and the natural drainage is poor. Such soils are extremely difficult to manage and are best suited to grassland. Under-drainage similar to that described for *map unit 331* is essential on this land for use other than as rough grazing. Rush pastures predominate on unimproved soils.

## THE KINTYRE ASSOCIATION

(Map units 333–336)

The drifts of the Kintyre Association occur in southern Islay, southern Cowal, northern Bute, Knapdale and Kintyre. Despite its broad distribution and variable provenance, the parent material is usually a reddish brown to red, fine sandy loam to silty loam till. It has been derived from schists and phyllites of the Dalradian Assemblage, together with a red component. This is of diverse origin, but comes chiefly from sandstones and marls of Old Red Sandstone, Permian and Triassic ages lying mainly on the sea floor rather than outcropping on land.

The landscape is usually undulating with subdued drumlins or consists of till banks which swathe the flanks of rock-controlled hills and are deeply incised by streams. Areas with rock outcrops are rarely extensive although as the tills thin with increasing altitude, rock appears more frequently. Below 100 metres altitude the soils are mainly noncalcareous gleys, although a few steep slopes with a mantle of colluvium carry brown forest soils. At higher altitudes and in receiving sites much of the land is waterlogged due to high rainfall or slow run-off from the predominantly gentle slopes, and the soils are mainly peaty gleys and peat.

The association is extensive, covering 484 square kilometres (3.4 per cent of South-West Scotland). The climate ranges from warm and moist with 1200 millimetres per annum average rainfall to fairly warm and wet with 1800 millimetres rainfall.

Peaty gleys and peat, utilized for rough grazing and forestry, occupy about 60 per cent of the association, and map units comprising principally mineral soils cover 40 per cent and provide much of the arable land and permanent pasture in the area north of the Highland Boundary Fault.

Soils are often developed on tills intermediate in composition between those of the Kintyre Association and other associations occurring nearby. In south Kintyre some tills are less red and of finer texture than usual and have some of the features of the Balrownie Association; in southern Jura and on eastern Islay soils in the Durnhill Association developed on red rather than grey tills have features similar to those of the Kintyre Association; on Bute and on Islay tills of paler, less intense red colour, merge with those of the Foudland Association.

**Map unit 333**, extending to 92 square kilometres (19 per cent of the association), comprises mainly noncalcareous and humic gleys, although brown forest soils and peaty gleys are sometimes found respectively on steep slopes and in wet hollows. The terrain (Plate 2) is undulating with only rare outcrops of rock or areas of shallow soil. A common feature of the drift, particularly in areas below 30 metres altitude and in the larger river valleys, is the sandy loam to sand texture in the upper till layers brought about by reworking of the material by glacial meltwaters and by wave action during periods of elevated sea level. The depth and degree to which fine particles have been washed away range widely from removal of some of the fine particles in only the top few centimetres of till to redeposition of coarse material as sands and gravels. These very coarse-textured materials generally carry soils of the Corby Association, but some small areas are included in this map unit on account of the scale of the map.

On the soil map in the vicinity of Ardlamont Point, Cowal, the colours and numbering of areas of this unit have been inadvertently transposed with those of *map unit 334*.

A humic gley profile at Kintra, Islay has a humose sandy loam plough layer 22 centimetres thick, and a gleyed loam B horizon 38 centimetres thick in which the intense red colour largely obscures the mottles. The C horizon, which commences at 60 centimetres, is a firm massive silty loam. Exchangeable cations are low, base saturation is moderate and the pH ranges from 4.9 in the surface to 5.4 in the C horizon.

Owing to intricate and small-scale variations in soil texture and related drainage characteristics, the farming pattern and potential can vary widely. On the more deeply water-modified areas arable crops will grow most successfully; on the more silty drift where compact till is close to the surface, severe waterlogging and workability problems may be encountered. The high fine sand and silt

contents of the till impart low permeability, and infilling above drains with more porous material (crushed aggregate) is often necessary. Nevertheless, the soils are often not sufficiently stable to hold mole-drains. Capping of the surface under the fairly heavy rainfall of the area is also a problem.

**Map unit 334** covers 94 square kilometres (19 per cent of the association) and occupies subdued undulating terrain similar to that of *map unit 333*, which it replaces as slopes become more gentle and altitude and rainfall increase. Two areas shown as *map unit 333* near Ardlamont Point, Cowal, should be *map unit 334*. The soils are mainly peaty gleys with peat and humic gleys in varying amounts, and there are some peaty podzols on slopes with colluvial or water-modified materials. The peaty gleys are acid, having pH values of 5 throughout the profile, while the degree of base saturation is moderate in the peaty surface horizons but decreases to low in the subsoil. The upper mineral horizons are sandy loams and their light grey and pale brown colours are evidence of strong gleying. The C horizons, however, are reddish and the loam textures are finer than those in the overlying layers.

Soils below 200 metres that have thin peaty surface horizons often carry moist Atlantic heather moor and rush communities, and can generally be reclaimed for improved pastures. But in higher-lying areas where rainfall is heavy and slopes gentle the proportion of peat-covered land is relatively high and the vegetation is mainly flying bent bog and bog heather moor. The semi-natural vegetation provides rough grazing of poor to moderate quality, but forest plantations can usually be established more easily on this land than elsewhere in the Highlands and are rapidly expanding.

**Map unit 335** occupies 136 square kilometres (28 per cent of the association) and is similar in many features to *map unit 333*, but is characterized by the presence of occasional rock outcrops, humus-iron podzols on colluvial materials and brown rankers in addition to the predominant noncalcareous, humic and peaty gleys. On the rock knolls where till cover is absent the soils are developed on materials derived from the phyllite, schist and epidiorite country rocks and are similar to those of the Foudland, Strichen and Tarves Associations. The land is utilized mainly as pasture, but the rock outcrops are widely spaced and some arable agriculture is possible.

**Map unit 336** is the largest in the association, covering 162 square kilometres (33 per cent of the association), and occupies landforms similar to those of *map unit 335*. The soils, however, are principally peaty gleys and peat and, as in *map unit 335*, those on the rock knolls are developed on locally derived colluvial materials rather than the more general reddish till. The vegetation includes moist Atlantic heather moor, blanket and flying bent bogs and rush pastures and the land is utilized mainly as rough grazing or for forestry, but reseeding is possible on some soils with thin peaty horizons on smooth terrain.

## THE KIPPEN/LARGS ASSOCIATIONS

(Map units 337–347)

The Largs Association has been previously described in north Ayrshire (Mitchell and Jarvis, 1956) and the soils of both this association and the Kippen Association are developed on drifts derived mainly from Upper Old Red Sandstone



sandstones. Along the Highland Boundary Fault conglomerates containing material derived from acid metamorphic rocks contribute to the drifts as do the Dalradian schists from north of the fault. The drift is principally a reddish brown loam to sandy clay loam, but on the steep hill slopes above the Ayrshire coast colluvial drifts are also common.

The associations extend to 219 square kilometres (1.5 per cent of South-West Scotland) in an area 5 kilometres wide from Kippen south-west through Killlearn and Dumbarton Muir to Dumbarton on the Clyde estuary. Isolated areas occur around Helensburgh, in southern Bute and Great Cumbrae, and a further area 5 kilometres broad stretches along the Clyde coast from Inverkip through Largs to Ardrossan. Inland, small areas occur in the uplands of Ayrshire on Auchmannoch Muir, and south of Muirkirk on Wardlaw Hill and Cairn Table.

The climate ranges from warm and wet with 1200 millimetres per annum rainfall in Stirlingshire and Dunbartonshire to fairly warm and wet with 1250–1500 millimetres rainfall along the Clyde estuary and cool and wet with 1500–2000 millimetres rain in the hills near Muirkirk.

In the lowlands and on slopes of the foothills the soils are mainly brown forest soils and brown forest soils with gleying although gleys are extensive on some till-covered slopes under high rainfall and in lowland depressions. On higher-lying land podzols occupy steep slopes, and peaty gleys and peat predominate on undulating less steep terrain.

**Map unit 337** occupies 84 square kilometres (38 per cent of the associations) and comprises brown forest soils and brown forest soils with gleying. These soils are freely and imperfectly drained respectively and developed mainly on bright reddish brown loam to sandy clay loam tills or on thin loamy colluvium mantling some steep slopes. Where the natural drainage is free the loamy topsoils are friable and generally have well-developed crumb or subangular blocky structures, but structures are less well formed under imperfectly drained conditions. Much of the land is undulating lowland with gentle and strong slopes well suited to cultivation and is utilized mainly for arable agriculture and permanent pasture. In higher-lying areas with steep slopes and higher rainfall, cultivations are difficult and the land is maintained in permanent pasture. Small unimproved areas support bent–fescue grassland or broadleaved woodland.

**Map unit 338** occupies 52 square kilometres (24 per cent of the associations) and comprises mainly noncalcareous gleys and some humic gleys in areas strongly affected by seepage or flushing. The soils are poorly drained, have weakly structured subsoils and are developed on slowly permeable sandy clay loam tills, which in some low-lying areas have sandy loam water-modified upper layers. Much of the land occurs as gentle slopes around the margins of the uplands or as depressions in the lowlands. The topsoils are loamy, but in the high rainfall areas subangular blocky structures are only weakly developed. Efficient under-drains are necessary if these soils are to be worked for arable crops or productive permanent pastures maintained. Permeable infill in the drain-lines is recommended, together with a form of secondary treatment to improve subsoil permeability. Much of the land is permanent pasture but in unimproved areas sedge mires and rush pastures provide moderate or good quality rough grazing.

**Map unit 339** occupies 14 square kilometres (6 per cent of the associations) and comprises brown forest soils developed on thin, generally colluvial drifts. The terrain is commonly steep hill sides in the lowlands or foothills, and rock, usually

close to the surface, occasionally crops out. On higher-lying exposed slopes some humus-iron podzols are present. The semi-natural vegetation includes acid bent-fescue grassland, oak or birchwood and, on higher land, dry Atlantic heather moor and provides moderate to good quality rough grazing. Except on the steepest slopes the land can be improved and pastures established.

**Map unit 340** occupies 7 square kilometres (3 per cent of the associations) and occurs only on south Bute. The terrain is similar to that of *map unit 338*, but some rock crops out. The soils are principally gleys but are shallow and have rock near the surface. The land is utilized mainly for grassland.

**Map unit 341** occupies only 2 square kilometres (less than 1 per cent of the associations) and comprises humus-iron podzols developed on thin sandy drift overlying red sandstone. It occurs on upland above Kippen, on Great Cumbrae Island and on Stone Hill in Lanarkshire and includes some very sandy and thin soils and moderate amounts of outcropping rock. The dry Atlantic heather moor and white bent grassland provide moderate quality rough grazing. Pasture improvement is possible where rock outcrops are well separated, and some land is used for forestry.

**Map unit 342** occupies 6 square kilometres (3 per cent of the associations) and comprises peaty podzols, humus-iron podzols and some gleys. It occurs mainly on the uplands near the north Ayrshire coast where the soils are developed on loamy drifts on hill sides with gentle and strong slopes. The vegetation, which includes dry and moist Atlantic heather moor, and white bent grassland, provides moderate quality rough grazing. The climate is unfavourable to pasture improvement.

**Map unit 343** occupies 14 square kilometres (6 per cent of the associations) and comprises peaty podzols and peat with some peaty gleys. It occurs mainly on the moorlands between Kippen and Dumbarton and the soils are developed on loamy, sometimes shallow, drift on gently or strongly sloping terrain. The peaty podzols are mainly on the steeper land. The dry and moist Atlantic heather moors, common white bent grassland, bog heather moor and blanket bog communities provide rough grazings of poor quality. Pasture improvement is possible on some lower-lying land but generally the wet climate and soils are unfavourable to reclamation.

**Map unit 344** occupies 33 square kilometres (15 per cent of the associations) and consists of peaty gleys and peat with some peaty podzols. Like *map unit 343*, it occurs mainly on the moorlands between Kippen and Dumbarton. The soils are developed on loamy or sandy clay loam drifts mantling undulating terrain in which the steepest slopes generally carry peaty podzols on thin drifts overlying rock, which crops out occasionally in association with small patches of ranker soils. The semi-natural moist Atlantic heather moor and bog heather moor communities provide poor quality rough grazing. Some permanent pastures have been established, but improvements are generally dependent on the installation of efficient under-drainage. Improved pastures on these soils are difficult to sustain under very high rainfall.

**Map unit 345** occupies only 4 square kilometres. It comprises peaty gleys, peat and some peaty podzols in an irregular landscape with rock knolls, the presence

of which distinguishes the land from the closely related *map unit 344* and inhibits measures for pasture improvement. Land use is mainly permanent pasture and rough grazing.

**Map unit 346** is limited to 1 square kilometre and comprises peaty podzols, peaty gleys and peat formed on hummocky moraine in the hills south of Muirkirk. It has close similarities to *map unit 343*, with loamy drift parent materials, but the rainfall is greater and precludes improvement of the natural rough grazings, which are generally of moderate or poor quality.

**Map unit 347** occupies 2 square kilometres and comprises mainly peaty podzols on strong and steep moderately rocky slopes with boulders. It is confined to hills south of Muirkirk where rainfall is very high and the Atlantic heather moor and white bent grassland provide rough grazing of poor or moderate quality. Pasture improvements are not generally possible.

### THE KIRKCOLM ASSOCIATION

(Map unit 348)

The soils of the Kirkcolm Association are developed on gravels, with some sands, derived from greywackes, and occur on the Post Glacial raised beach around the coasts of Galloway. The gravels are varied and range from fine gravel with some sand to deposits with large cobbles, and include some former shingle banks; shell fragments are present in some areas. The gently sloping raised beach terraces occur as narrow coastal strips, often bounded inland by rocky former sea cliffs, and generally lie below 15 metres altitude.

The association occupies 9 square kilometres (less than 0.1 per cent of South-West Scotland) and the climate is warm and moderately dry, with average rainfall of 1000–1250 millimetres per annum. Proximity to the sea confers relative freedom from frost in spring, but is associated with high levels of exposure.

**Map unit 348** comprises brown forest soils, often having a high stone content, sandy loam or loamy sand textures in the plough layer and free natural drainage. Subsoil horizons are generally not well developed and topsoils can merge gradually into underlying gravels. Most of the land has been cultivated and traditionally formed much of the valuable ground of South-West Scotland used for early potatoes for which freedom from late frosts makes it especially suitable. Land not growing potatoes carries mainly arable or permanent pastures.

### THE KNOCKSKAE ASSOCIATION

(Map units 351–358)

The Knockskae Association, previously described in the Carrick district of Ayrshire (Bown, 1973), comprises soils developed on drifts derived from felsites and allied igneous rocks. These rocks are generally pinkish in colour and fine-grained, but often have white feldspar phenocrysts. They are hard, acid in composition, and resistant to physical and chemical weathering. The drifts are mainly thin, very stony, frost-shattered rock debris and solifluction materials of generally loamy texture.

The association is not extensive, occupying only 45 square kilometres (0.3 per

cent of South-West Scotland), but occurs as small widely scattered areas with a variety of landforms, ranging from depressions and rocky lowland to steep hills, and climates which span the range from warm and wet to cool and wet.

There are some improved permanent pastures, but the vegetation, which is extremely varied, comprises mainly semi-natural plant communities amongst which are acid bent-fescue grassland, sharp-flowered rush pasture, Atlantic heather moor, flying bent and white bent grasslands, bog heather moor and blanket bog. Short-range variation and multiplicity of types are also characteristic of the soils, which are generally shallow and stony and include brown forest soils, brown rankers, humus-iron podzols, peaty podzols, noncalcareous gleys, peaty gleys and blanket peat. Land use is mainly rough grazing of moderate or poor quality, with stock rearing on permanent pastures.

**Map unit 351** occupies 1 square kilometre (less than 5 per cent of the association), comprises noncalcareous gleys with some peaty gleys, and occurs in a small depressional area with gentle slopes amongst the hills bordering the upper Stinchar valley. The soils are developed on a loamy till which includes some material derived from nearby sandstone, and the vegetation includes sharp-flowered rush pasture and flying bent bog utilized as rough grazing of moderate quality.

**Map unit 352** occupies 11 square kilometres (25 per cent of the association) and comprises brown forest soils and brown rankers. It occurs near Kirkcudbright on formerly severely eroded, undulating lowland having gentle and strong complex slopes with knolls of outcropping rocks including acid porphyrys and greywackes. The land ranges up to 150 metres altitude and the climate is warm and rather wet with 1250 millimetres per annum rainfall. The natural vegetation is acid bent-fescue grassland, but much of the land, where the pattern of outcropping rock allows, carries improved permanent pastures. Stock rearing and dairying are the principal enterprises and the free-draining soils are not readily damaged by poaching or grazing pressure, but conservation of grass crops can be difficult because of the effects of rock outcrops on the use of machinery.

**Map unit 353** occupies 7 square kilometres (15 per cent of the association) and comprises humus-iron podzols with some gleys and peaty podzols. The soils are developed on thin drifts and solifluction deposits occurring on hills with strong and steep simple slopes between 150 and 250 metres altitude. The acid bent-fescue and white bent grasslands provide good quality rough grazing.

**Map unit 354** occupies 2 square kilometres (5 per cent of the association) and comprises peaty podzols with some peaty gleys and peat. The soils are developed on thin, stony frost-shattered rock debris on hills with strong and steep slopes at about 300 metres altitude near Straiton. The vegetation includes moist Atlantic heather moor, common white bent grassland and blanket bog and provides rough grazing of poor quality. Pasture improvements are generally restricted to scattered patches.

**Map unit 355** occupies 2 square kilometres (5 per cent of the association) and comprises peaty gleys and peaty podzols with some rankers and outcropping rock. It occurs near Kirkcudbright at about 170 metres altitude on undulating terrain with smooth gentle slopes and depressions, together with formerly eroded complex slopes with knolls of outcropping rock. Parent materials include both

stony loamy tills and thin stony frost-shattered rock debris. The vegetation includes a wide range of communities such as moist Atlantic heather moor, blanket and flying bent bog and flying bent grassland and is utilized as rough grazing, but pasture improvements are possible on much of this land.

**Map unit 356** occupies 6 square kilometres (15 per cent of the association) and comprises humus-iron podzols, with some rankers and outcropping rock. It occurs near Kirkcudbright on undulating lowland and hills with gentle and strong, complex, moderately rocky slopes at 150–200 metres altitude. The soils are developed on thin stony frost-shattered rock debris and carry mainly acid bent-fescue grassland, but some improved permanent pastures have been established. The land is utilized mainly for stock rearing.

**Map unit 357** occupies 16 square kilometres (35 per cent of the association), comprises peaty gleys with some peaty rankers, peaty podzols and peat, and occurs on Arran, Island Davaar, in an area west of Loch Fyne and in Galloway. The soils are developed on stony colluvial drifts on moderately rocky terrain which is generally gently or strongly sloping, but can include some steep land. The peaty gleys comprise a peaty horizon resting on a stony Bhg horizon of angular stones with interstitial organic matter, which passes down into rock; a C horizon is only rarely present. The peaty rankers comprise a peaty horizon over rock. The vegetation includes moist Atlantic heather moor and bog heather moors on the peaty gleys and peaty rankers with blanket bog communities on the peat and provides poor quality rough grazing. Ploughing for forestry is hampered by stoniness, and the risk of windthrow, on the shallow and wet soils, is exacerbated by exposure.

**Map unit 358** occupies less than 1 square kilometre near Campbeltown and is related to *map unit 357*, but the terrain is very rugged and rocky. The soils are principally peaty gleys, peaty rankers and peat and carry moorland communities which provide rough grazing of low value. The amount of rock outcrop impedes forestry operations.

## THE LANFINE ASSOCIATION

(Map units 359–361)

The soils of the Lanfine Association are developed on drifts derived from basic igneous rocks and red sandstones of Permian and Old Red Sandstone age. The drift is mainly a thick, reddish brown, sandy clay loam or clay loam till which is often stony, and the stones are strongly weathered. The till is usually massive with little development of structure.

The association occupies 102 square kilometres (0.7 per cent of South-West Scotland) and occurs mainly in central Ayrshire south of the Irvine valley, but with other small areas above Inverkip and West Kilbride near the Clyde coast and also near Douglas in Lanarkshire. Rainfall ranges from 1000–1250 millimetres per annum in the warm and fairly warm moderately dry and wet lowlands and foothills of central Ayrshire, to 1500–1700 millimetres per annum in the fairly warm wet foothills near the Clyde and 1250–1550 millimetres per annum in the cool wet lowlands, foothills and uplands of Lanarkshire.

Brown forest soils with gleying, the predominant soils, occupy most of the lowlands and valley sides while gleys are common in the foothills and uplands

where rainfall is higher, and peaty podzols and humus-iron podzols occur on the hills above West Kilbride.

**Map unit 359** occupies 83 square kilometres (80 per cent of the association) and, in the undulating terrain with frequent drumlin ridges, the soils are mainly brown forest soils with gleying, but some noncalcareous gleys occupy channels between ridges. The topsoils are generally loamy with moderate subangular blocky structure and rest on sandy clay loam subsoils with moderate prismatic structure and containing many weathered stones. The underlying till is usually massive and very slowly permeable to moisture. The natural drainage of the soils is generally imperfect, but in channels and on gentle slopes it is poor and pastures are often rush-infested.

For arable agriculture or the maintenance of good quality pasture systematic under-drainage is generally necessary and should include permeable infill in the drain-lines and subsoiling or moling to improve structure and permeability in the subsoil.

**Map unit 360** occupies 13 square kilometres (15 per cent of the association) and comprises noncalcareous gleys with some brown forest soils with gleying and peaty and humic gleys. Peaty gleys are more extensive above Inverkip than elsewhere. The topsoils are loamy with blocky structures and the clay loam subsoils have weak coarse prismatic structure and are very slowly permeable to moisture. The natural drainage of the soils is poor and the land is mainly permanent pasture. Under-drainage of these soils, similar to that described for *map unit 359*, is required if pasture of good quality is to be maintained. In unimproved areas the flying bent bog, rush pasture and sedge mire communities provide rough grazing of moderate quality.

**Map unit 361** occupies 6 square kilometres (5 per cent of the association) and comprises mainly peaty podzols and humus-iron podzols with some gleys and peat. It occurs on the uplands above West Kilbride where the stony sandy loam drift is often compact, has platy structure and at depth has poor permeability. Sustained pasture improvement is difficult and the semi-natural vegetation, which includes dry Atlantic heather moor, bog heather moor, rush pastures and sedge mires, provides rough grazing of poor or moderate quality.

## THE LAURENCEKIRK ASSOCIATION

(Map unit 368)

The soils of the Laurencekirk Association are developed on drifts derived from Lower Old Red Sandstone marls and mudstones. The drift is mainly a rich red, loamy till, relatively stone-free except in the basal layers near rock, and with weakly developed structure.

The association occupies only 2 square kilometres (less than 1 per cent of South-West Scotland) near Gartmore in Stirlingshire but is much more extensive in Eastern Scotland. The climate is warm and wet with 1750 millimetres per annum rainfall, and the soils are mainly brown forest soils with gleying and small areas of noncalcareous gleys in depressions.

**Map unit 368** comprises mainly brown forest soils with gleying developed on loamy tills forming two hog's-back ridges extending south-westwards from

Gartmore. The loamy topsoils have a high silt content and structural stability, in conditions of high rainfall, is low with slaking often associated, and slow permeability to moisture. Much of the land is pasture of good quality, but some arable crops are grown. In the hollow between the ridges the noncalcareous gleys often carry rush-infested pastures, and under-drainage, with secondary treatment to improve subsoil structure and permeability, is required to allow improvement of the swards.

## THE LETHANS ASSOCIATION

(Map units 374–378)

The parent rocks of the Lethans Association are Lower Old Red Sandstone conglomerates derived from basic igneous materials, and the soils are developed on drifts, mainly thin stony loams and some sandy clay loams, formed from these rocks. The association occupies only 15 square kilometres (0.1 per cent of South-West Scotland) and occurs in a belt of land aligned south-west to north-east to the north of Kirkconnel. The conglomerates are harder than the Carboniferous sediments of the Kirkconnel basin and rise to form hills with strong and steep slopes, reaching 500 metres altitude.

The climate is cool to cold and is wet with 1500–1750 millimetres per annum average rainfall. The soils, which are developed on the thin permeable drifts, are mainly peaty podzols and brown forest soils; some noncalcareous and peaty gleys occur on sandy clay loam tills on gentle low-lying slopes. The vegetation comprises almost entirely naturally occurring communities and includes Atlantic heather moors, bent-fescue grassland, blanket bog, sharp-flowered rush pasture and flying bent grassland.

**Map unit 374** occupies 1 square kilometre (5 per cent of the association) and comprises brown forest soils developed on thin, stony sandy loam drifts on strong and steep lower slopes of hills. The bent-fescue grassland provides rough grazing of good quality and pasture improvements have not been attempted on this land, although on suitable slopes the soils are well suited for permanent pasture.

**Map unit 375** occupies only 1 square kilometre (5 per cent of the association) and comprises noncalcareous gleys with some peaty gleys developed on reddish brown loam to sandy clay loam till. Occurring on gentle concave slopes below more steeply sloping hill sides, the soils are affected by mineral-rich seepage waters and the sharp-flowered rush pasture and flying bent grassland provide rough grazing of moderate quality. Under the wet conditions of both soil and climate, pasture improvements are difficult.

**Map unit 376** occupies only 1 square kilometre (5 per cent of the association) and comprises peaty podzols and brown forest soils developed on thin stony drifts. Hills with strong and steep slopes are the main landform. The land lies between 350 and 450 metres altitude and the Atlantic heather moor and acid bent-fescue grassland provide rough grazing of moderate or good quality. Pasture improvements have not been attempted on this land and are restricted mainly by steepness of slope.

**Map unit 377** occupies 12 square kilometres (80 per cent of the association) and comprises peaty podzols with some thin blanket peat. The soils are developed on thin stony sandy loam drifts on hills ranging between 350 and 500 metres

altitude. Areas of blanket peat are restricted mainly to gently sloping hill crests or low-lying areas between hills. The plant communities include moist Atlantic heather moor, heath rush-fescue grassland and blanket bog and provide rough grazing of relatively poor quality. Under the prevailing high rainfall, pasture improvements on the peaty soils are likely to be restricted to scattered patches to encourage more extensive grazing by stock.

**Map unit 378** occupies less than 1 square kilometre and is related closely to *map unit 376* but occurs on steep slightly and moderately rocky hills.

## THE LINFERN ASSOCIATION

(Map unit 379)

Soils of the Linnern Association are developed on morainic drifts derived from sandstones, greywackes and basic igneous rocks. The association occupies 2 square kilometres (less than 0.1 per cent of South-West Scotland), and occurs as a small area of moundy ground at about 300 metres altitude amongst the hills south of Straiton. The climate is cool and wet with rainfall of 1750 millimetres per annum.

**Map unit 379** is the only map unit in the association and has a complex soil pattern of peaty podzols and brown forest soils on morainic mounds and blanket peat in intervening hollows. Formerly open moorland with moist Atlantic heather moor, blanket bog and acid bent-fescue grassland as the principal plant communities, most of the land has been planted in recent years with coniferous trees.

## THE LINKS ASSOCIATION

(Map units 380-382)

Soils of the Links Association are developed on windblown sands which are of mixed origin, noncalcareous and occur almost entirely as dunes and stabilized dunes around the coasts. The main areas are in Wigtownshire at Luce Sands, on the Ayrshire coast at Troon and Prestwick and on the islands of Islay and Arran. The soils lie largely below 30 metres altitude and occupy 37 square kilometres (0.3 per cent of South-West Scotland). The sands are mainly quartzose but are calcareous in small areas where shell fragments are present. Soils developed on more extensive areas with shell fragments are mapped as the Fraserburgh Association.

The climate is warm and moderately dry with average annual rainfall in the range 900-1250 millimetres and the degree of exposure is generally detrimental to tree and shrub growth.

Many dune systems are only partially stabilized or have been stabilized for relatively short periods, so that soil horizon development is rudimentary and profiles are immature. Noncalcareous regosols, the predominant soils, have a surface layer in which humus has been incorporated with the sand and some weak development of structure is present. Below the upper 10-25 centimetres the sand is raw and little altered by weathering. Gleys, present in dune slacks, are distinguished by pale grey and blue-grey colours and ochreous mottles around the roots of deeply rooting plants. The more strongly developed humus-iron podzols have been encountered in dunes stabilized for a relatively long period.



Northern dunes and dune pastures are the principal plant communities, with some bent-fescue grassland and permanent pastures and, in dune slacks, silverweed pasture, sedge mires and rush pastures.

**Map unit 380** occupies 25 square kilometres (70 per cent of the association) and comprises mainly noncalcareous regosols with small areas of gleys. The soils are developed on windblown sands forming partially stabilized and stabilized dunes with gentle and strong slopes. Northern dunes and dune pastures are the principal plant communities with some bent-fescue grassland and arable and permanent pastures on stable areas. Both vegetation and soils are very sensitive to damage from excessive treading by human feet or animal hoofs and erosion by wind is likely to follow destruction of turf. The land is often used for golf courses.

**Map unit 381** occupies 10 square kilometres (25 per cent of the association) and comprises humus-iron podzols and humic gleys with some peat and alluvial soils. It occurs mainly on Islay but is also found on Arran and at Machrihanish. The parent material is a windblown silica sand forming stabilized dunes with some undulating areas of raised beach and dune slacks. Humus-iron podzols with some noncalcareous regosols predominate on the stabilized dunes with humic gleys, peat and alluvial soils in intervening depressions and slacks. The dune pastures and bent-fescue grassland of the dunes provide rough grazing of good or moderate quality. Erosion of the turf has allowed some recommencement of sand movement. Subdued, gently undulating areas of dune or raised beach are usually cultivated and rush pastures, sedge mires and yellow flag swamp occupy undrained hollows.

**Map unit 382** occupies 2 square kilometres (5 per cent of the association) in an extensive area of beach or dune slack in Luce Sands, Wigtownshire. The soils are gleys with humic and peaty surface layers and are waterlogged for prolonged periods. The vegetation includes silverweed pasture, sedge mires and rush pastures.

## THE LOCHINVER ASSOCIATION

(Map units 389, 394 and 395)

The soils of the Lochinver Association are developed on drifts derived from Lewisian gneisses. The drifts are mainly thin colluvium but some tills occur and these often have similarities with, and merge into, tills forming the parent material of the Inch Kenneth Association. The land ranges from undulating lowland with occasional outcrops of rock to very rugged hills with very steep slopes.

The association occupies 25 square kilometres (0.2 per cent of South-West Scotland) on the Rinns of Islay, but is more extensive in Western and Northern Scotland. The climate is warm and rather wet with 1300 millimetres per annum rainfall, and moist Atlantic heather moor and blanket bog are the principal plant communities.

**Map unit 389** occupies 1 square kilometre (less than 5 per cent of the association) and comprises brown forest soils and humus-iron podzols with some rankers and gleys. It occurs as a few small patches of irregular and rugged, very rocky terrain and the acid bent-fescue grassland and Atlantic heather moor communities provide rough grazing which ranges considerably in quality.

**Map unit 394** occupies 23 square kilometres (90 per cent of the association) and is the principal map unit on the Rinns of Islay. The undulating lowland terrain is slightly to moderately rocky with mainly peaty gleys, some peat, and peaty rankers and peaty podzols on rock knolls. Plant communities include heather moors, blanket bog and rush pastures and the land is utilized mainly as rough grazing but the potential for forestry is presently being realized.

**Map unit 395** occupies only 1 square kilometre (less than 5 per cent of the association) and is similar to *map unit 394* but the terrain is more rugged and very rocky. Ranker soils are more extensive and are associated with peaty gleys and peaty podzols. The land is likely to remain as rough grazing, being too rocky and wet for forestry.

## THE MAUCLINE/AUCHINLECK ASSOCIATIONS

(Map units 401–404)

Red desert sandstones of Permian age occupy two areas in South-West Scotland: part of the central Ayrshire plain extending from Mauchline to Tarbolton and part of the Island of Arran from Brodick to Dippin Head. The Ayrshire district was mapped during the 1950s and 1960s and two soil associations on parent materials derived partly from Permian sandstone were distinguished. The Mauchline Association is developed on a till derived from sandstones including some igneous pebbles; the till of the Auchinleck Association also includes some Coal Measures sandstones, shales and marls. For the purposes of the current survey these associations have been grouped together. The tills of Arran had not been previously mapped, but the soils have been placed with the Mauchline Association during the course of the current survey. The associations cover 83 square kilometres (0.6 per cent of South-West Scotland).

The parent material of the associations is a red or reddish brown till, often fairly shallow, and of a sandy clay loam to sandy loam texture depending on water-working, the proximity to rock and the presence of other rock types such as shales or marls. The soils range from brown forest soils with gleying through poorly drained noncalcareous gleys to peaty gleys, each of these major soils subgroups forming the basis of a map unit. On steep slopes humus-iron podzols with coarse textures and free drainage form the basis of the fourth map unit, the drift of which is probably colluvial in origin. The landscapes are dominated by undulating lowland typical of the till plains of much of the Midland Valley and eastern Scotland, and are devoted to grassland and arable agriculture. Only in Arran, where the rainfall is higher and the tills are banked against the hills, is moorland found. The climate over most of the areas of the association is warm and the rainfall is approximately 1200 millimetres per annum except on Arran where the foothills are cooler and the rainfall rises to over 1800 millimetres.

**Map unit 401** comprises brown forest soils with gleying and some noncalcareous and humic gleys. It is confined to Ayrshire, where it incorporates all the soils previously mapped as the Mauchline and Auchinleck Associations, occupying 46 square kilometres (55 per cent of the associations). The dominant soil is developed on a sandy clay loam or sandy loam till moulded into gently sloping drumlins but with local areas of strong slopes where rock is close to the surface near the edge of the Permian sandstone outcrop. A commonly occurring feature of the soil profile is a sharp change in texture from sandy loam to sandy clay loam

between 30 and 45 centimetres. This is thought to be due to loss of clay in seepage waters during the melting of ice at the end of the glacial period. Soils of this map unit are often coarser textured and better structured than most of the soils of the till plain and are utilized for arable agriculture to a greater extent. Comprehensive drainage schemes to improve the agricultural potential should nevertheless incorporate permeable infill in the trench-lines and secondary treatment to improve permeability. Unimproved areas carry rush pastures or, in wetter hollows, sedge mires.

**Map unit 402** occupies 13 square kilometres (15 per cent of the associations) and is confined to Arran, where it occupies low ground north and south of Brodick, north of Lamlash and the agricultural areas at Kingscross and Whiting Bay. The till and the soils derived from it are similar to those described in *map unit 401* but the drainage class of the mineral soils is poor and many of the hollows support humic gleys. Soil drainage and surface wetness, resulting in poaching by stock, is a more serious problem than in *map unit 401* and the comments concerning soil drainage apply here. Some of the land is quite strongly undulating but the ground is practically all farmed.

**Map unit 403** is 9 square kilometres (10 per cent of the associations) in extent and is found where the tills extend into the foothills and low temperatures and high rainfall encourage the formation of peaty surface horizons. The soils are dominated by peaty gleys, which are often very colourful soils with black peat underlain by light grey, bleached, gleyed E horizons, in turn underlain by pinkish grey, strongly mottled B horizons. At depth the red-brown till is encountered. Hollows in the landscape may be occupied by peat. The map unit is found in forest land to the south of Brodick and as open hill on the north side of the Ross road. Typical plant communities are moist Atlantic heather moor, bog heather moors, blanket bog with some flying bent bog, and grassland and rush pastures in hollows and flushes. Grazing values are usually low.

**Map unit 404** extends to 15 square kilometres (20 per cent of the associations) and occurs discontinuously on strongly and steeply sloping land from north of Brodick almost to Whiting Bay. The lower slopes of the hills are formed of till but the steeper, upper slopes are composed of shallow, sandy colluvium over weathering rock. Humus-iron podzols with humic gleys in flushes are the main soils, though occasional peaty podzols occur. The map unit represents an important grazing resource, bearing a bent-fescue grassland vegetation with rush pastures in the flushed land. Patches of dry Atlantic heather moor are also common. Parts of the map unit are forested and there is a wide choice of species.

## THE REPOCH ASSOCIATION

(Map units 432–436)

The soils of the Reppoch Association are developed on drifts derived from Downtonian sandstones and shales. The drifts are often reddish brown, but can be brown in some areas where greywackes are present, and on the hills are generally thin, stony sandy loams and on lower-lying areas are sandy clay loam tills.

The association occupies 123 square kilometres (0.9 per cent of South-West Scotland) and occurs mainly in the Kyle Uplands between the valleys of the Ayr

and the Irvine with a smaller area in the hills south-east of Muirkirk. Rainfall ranges from 1250 to 1750 millimetres per annum in the cool wet lowlands and foothills of Kyle, but is 2000 millimetres per annum south-east of Muirkirk.

The soils are mainly gleys and in the prevailing cool wet climate usually have peaty surface layers. Peaty gleys and peat are common in the uplands where peaty podzols occupy the steepest slopes and in the lower-lying areas brown forest soils are found on steep slopes and noncalcareous gleys on gently sloping land.

**Map unit 432** occupies 25 square kilometres (20 per cent of the association) and comprises mainly brown forest soils and some brown forest soils with gleying and noncalcareous gleys. The soils are developed on moderately permeable stony loams and generally have free or imperfect natural drainage. Much of the land is utilized for permanent pasture with areas of arable crops restricted by the high rainfall. On steep slopes acid bent-fescue grassland provides good quality rough grazing. In hollows noncalcareous gleys carry rush pastures and sedge mires and here drainage incorporating permeability aids is likely to allow improvement.

**Map unit 433** occupies 23 square kilometres (20 per cent of the association) and comprises mainly noncalcareous gleys and some brown forest soils with gleying and peaty gleys. The soils are developed on sandy clay loam tills, have weakly developed coarse prismatic or massive structure in their lower horizons, are very slowly permeable and require drainage for successful agricultural use. Drains should intercept down-slope moisture seepage and incorporate permeable infill and secondary moling or subsoil treatments. Much of the land is presently utilized for rough grazing which on the predominant rush pastures, flying bent grassland and acid bent-fescue grassland is usually of good quality.

**Map unit 434** occupies only 5 square kilometres (less than 5 per cent of the association) and comprises mainly peaty podzols and humus-iron podzols developed on stony, loamy drifts on steep hill sides free of outcropping rock. The white bent grasslands and Atlantic heather moors provide rough grazing of moderate quality. Under the wet climate pasture improvements can be difficult but are likely to be possible on lower-lying land.

**Map unit 435** occupies 29 square kilometres (25 per cent of the association) and comprises peaty podzols, peaty gleys and peat. It is higher-lying than *map unit 434*, occasional outcrops of rock are present and the soils are developed on thin, stony drifts. The climate is severe, making improvement difficult on those peaty soils, and the semi-natural Atlantic heather moor, bog heather moor and flying bent bog communities provide rough grazing of poor quality.

**Map unit 436** occupies 41 square kilometres (35 per cent of the association) and comprises peaty gleys and peat with some peaty podzols. The land is similar in many respects to *map unit 435* but soils with poor and very poor drainage are more extensive and slopes are generally gentle. Rough grazing is generally of poor quality on the blanket and flying bent bog, moist Atlantic heather moor and flying bent grassland. Pasture improvements are likely to be restricted to scattered patches.

## THE RHINS ASSOCIATION

(Map units 437–443)

The soils of the Rhins Association are developed on red-brown clayey tills containing Ordovician and Silurian greywacke stones. The association has been previously described in South-West Scotland (Bown and Heslop, 1979). Much of the fine material of the till probably derives from the underlying greywackes, but the red colour of the matrix is ascribed to material brought by ice moving over soft red rocks below the Firth of Clyde and Irish Sea. Available analyses indicate a close similarity between the trace elements suites of the Rhins and Ettrick Associations and support the view that the greywacke-derived contribution to the till is predominant. Partial water-sorting has given rise to sandy loam textures in the upper layers of some tills, and some soils developed on thin, stony red-brown sandy loam drifts are also included in the association.

The association has been mapped only in Galloway, where it occupies most of the Rhins of Galloway, the Machars of Wigtownshire and an area in south-west Kirkcudbrightshire; in all it occupies 443 square kilometres (3.1 per cent of South-West Scotland). The tills of the association have been deposited almost entirely as drumlins in lowlands below 200 metres altitude. On the Rhins peninsula the drumlins are closely spaced and impinge on each other but elsewhere they are scattered and the strongly ice-eroded intervening country has many rock outcrops or deposits of basin peat. The climate is warm moderately dry or wet with average rainfall ranging from 1000 to 1500 millimetres per annum.

Throughout much of the area brown forest soils with gleying are predominant and typically the brown topsoil or plough layer rests on the weakly gleyed, poorly structured or massive till subsoil in which bulk density is high and drainage imperfect. Brown forest soils with free natural drainage are restricted to very strongly water-sorted tills or thin, stony sandy loam drifts. Noncalcareous gleys occur in small local hollows and peaty podzols, peaty gleys and humus-iron podzols are of minor extent. Some map units include areas of strongly eroded country with scattered greywacke outcrops and brown forest soils developed on stony frost-shattered rock debris.

Most of the land has been cultivated and carries ley pastures which are occasionally broken for a few years of grain crops and, traditionally, fodder roots. Unimproved areas are small and the natural communities include acid bent-fescue grassland and flying bent grassland.

**Map unit 437** occupies 25 square kilometres (6 per cent of the association) and comprises brown forest soils developed on thin, stony sandy loam drifts overlying greywacke rocks or very severely water-sorted tills. It occurs at the northern end of the Rhins of Galloway and in an area south of Garlieston, in areas of undulating lowland with mainly gentle, but with a few strong, slopes. Most of the land carries arable and permanent pastures, but arable cropping is more common than in most of the other map units of the association and some potatoes are grown. Stoniness can interfere with cultivations.

**Map unit 438** occupies 177 square kilometres (40 per cent of the association) and comprises brown forest soils with gleying developed in the red-brown clay loam tills typical of the association. The undulating lowland landscape consists of closely spaced drumlins and does not exceed 200 metres altitude. The natural

drainage is imperfect and for productive agriculture on these slowly permeable soils efficient underdrains are necessary, preferably with permeable infill over the drain-lines and subsoiling treatment to loosen the dense subsoil tills. The dairy industry, traditional on this land, is well known for its high quality and is based on the productivity of the grass ley pastures in the warm moist climate with a growing season relatively long for Scotland. Arable cropping is generally restricted to short breaks when pastures are reseeded.

**Map unit 439** occupies 144 square kilometres (33 per cent of the association) and comprises brown forest soils with some brown rankers and rock outcrops, and some brown forest soils with gleying. It is closely related to *map units* 207, 438 and 440. The red-brown clay loam till, the parent material of the brown forest soils with gleying as in *map unit* 438, occurs as drumlins scattered across strongly glacially eroded lowland with typical *roches moutonnées* and other rock knolls (Fig. 5). These formerly eroded areas carry brown forest soils on stony frost-shattered rock debris derived from greywackes and are similar to land in *map unit* 207. *Map unit* 440 comprises similar landscape elements, but the proportion of drumlins to eroded country is much greater. The semi-natural vegetation is mainly acid bent-fescue grassland and is restricted to areas with abundant rock outcrop. Most of the land has been cultivated and carries arable and permanent pastures. Drainage similar to that described for *map unit* 438 is necessary for productive agriculture on the brown forest soils with gleying. Dairying is the principal farming enterprise but some rearing and fattening of stock are also undertaken.

**Map unit 440** occupies 73 square kilometres (16 per cent of the association) and comprises brown forest soils with gleying, brown forest soils, brown rankers and rock outcrops (Plate 15). The soils are developed on similar parent materials and in a landscape made up of the same elements as *map unit* 439 but the proportion of drumlins carrying brown forest soils with gleying is greater and formerly eroded areas with brown forest soils and rock knolls are less extensive in this map unit. Most of the land carries arable and permanent pastures utilized for dairying, and unimproved acid bent-fescue grassland is restricted to a few remote areas and to the most rocky land. Efficient underdrains, preferably with permeable infill in the drain-lines and subsoiling to loosen the compact massive tills, are necessary for efficient use of the brown forest soils with gleying. Utilization of the areas with brown forest soils and brown rankers is dependent on the amount and frequency of outcropping rock, but improved pastures, generally allowing conservation of grass, can usually be maintained with some cropping possible in favoured situations.

**Map unit 441** occupies 6 square kilometres (1 per cent of the association) and comprises brown forest soils with some brown rankers and rock outcrops. The land has been severely glacially eroded as evidenced by ice-smoothed outcropping greywacke rock knolls. The soils between these knolls are developed on thin stony red-brown drifts. The land closely resembles some elements of *map units* 439 and 440 in this association and *map unit* 207 in the Ettrick Association. The vegetation includes permanent pastures and semi-natural acid bent-fescue grassland. Rock outcrops, the main factor influencing land management, can make pasture improvement difficult.

**Map unit 442** occupies 17 square kilometres (4 per cent of the association) and comprises brown forest soils with gleying and some peaty podzols and peaty gleys.

It occurs between 150 and 180 metres altitude between Portpatrick and Stranraer on the spine of the Rhins of Galloway. The soils are developed on the red-brown clay loam till deposited as drumlins and typical of the association, and the presence of peaty podzols and peaty gleys reflects the fairly warm lowland climate with 1250 millimetres per annum average rainfall. The land is at the upper altitudinal range of this lowland association. Flying bent grassland and moist Atlantic heather moor are found on the peaty podzols and peaty gleys, but the brown forest soils with gleying carry mainly pastures utilized for stock rearing and dairying. Drainage and the establishment of improved pastures are possible on most of the land, but careful management, dependent on local conditions of wetness, is necessary to avoid excessive damage by poaching.

**Map unit 443** occupies 1 square kilometre (less than 1 per cent of the association) and comprises humus-iron podzols developed on thin stony drift on the Mull of Galloway. The Mull is a small peninsula between 30 and 60 metres altitude, with gentle slopes and is very exposed. The plant communities include Atlantic heather moor, white bent grassland and acid bent-fescue grassland, but pasture improvements have been carried out on much of the land which is used mainly for sheep and stock rearing.

#### THE ROWANHILL/GIFFNOCK/WINTON ASSOCIATIONS

(Map units 444–451)

The soils of the Rowanhill, Giffnock and Winton Associations are developed on drifts derived from Carboniferous sandstones, shales and limestones. The Rowanhill and Giffnock Associations were first described in north Ayrshire (Mitchell and Jarvis, 1956) and have since been mapped extensively in the Midland Valley. The Winton Association occurs in South-East Scotland. Clay loam tills are the principal drifts, but sandy clay loams occur where the proportion of sandstone-derived material is high. Thin tills or stony drifts overlying sandstones are often sandy loams. They are usually colluvial and occur on strong or steep slopes. Tills, modified by the washing of the upper layers and removal of much of the clay and silt, often by glacial meltwaters, and having sandy loams and loamy sands overlying clay loams, are found in valleys and other low-lying areas.

The associations occupy 912 square kilometres (6.3 per cent of South-West Scotland) and extend from the Ayrshire plain north-eastwards to Glasgow, the Slamannan plateau and the Stirlingshire drift plain. Other small isolated areas occur in eastern Ayrshire and mid-Lanarkshire. Rainfall ranges from 900–1000 millimetres per annum in the warm moderately dry lowlands of Ayrshire and Stirlingshire, to 1000–1200 millimetres in the fairly warm wet lowlands and foothills around Glasgow and the Slamannan plateau and 1250–1400 millimetres in the cool wet lowland and foothills of east Ayrshire and Lanarkshire.

On the undulating till plain of the western areas the soils are mainly noncalcareous gleys, brown forest soils with gleying being restricted to steep or strong slopes. In an easterly direction the brown forest soils with gleying first become co-dominant with the noncalcareous gleys and then in eastern areas are the dominant soils. Peaty gleys occur in higher-lying areas and podzols on exposed sandstone ridges.

**Map unit 444** occupies 76 square kilometres (8 per cent of the associations) and comprises mainly brown forest soils with gleying and some brown forest soils. Occurring in areas of undulating lowland with drumlins and other till ridges, the soils are developed on water-modified tills with sandy or gravelly upper layers underlain by sandy clay loam till at 60–75 centimetres depth. Sandy loam or loam topsoils with well-developed crumb or medium subangular blocky structure rest on sandy loam or loamy sand subsoils with moderately or weakly developed blocky structure, but with good permeability to moisture. The underlying clay loam or sandy clay loam till has weakly developed structure and is only moderately or slowly permeable to moisture. The soils form some of the best agricultural land in the areas where they occur and have few limitations to sustained arable use. Even where rainfall is relatively high this land is more readily cultivated than the clayey soils of related map units.

**Map unit 445** occupies 340 square kilometres (37 per cent of the associations) and is dominated by brown forest soils with gleying with some noncalcareous and humic gleys. The soils are developed on sandy clay loam or clay loam tills forming drumlins and ridges in undulating lowland plains, and the natural drainage is generally imperfect but can be poor in low-lying or gently sloping areas. The topsoils are loamy with moderately developed subangular blocky structures and rest on sandy clay loam subsoils in which the prismatic structure is moderately developed and permeability to moisture ranges considerably. The underlying clay loam till is often massive or has weak coarse prismatic structure and permeability to moisture is low. The land is slow to drain after prolonged rain and hollows can readily become rush-infested. Drainage is generally necessary if arable crops are to be grown or productive grassland maintained and cultivations and grazing should be managed carefully to reduce damage to soil structure and to pastures. It should incorporate permeable infill in the drain-lines and include subsoiling or moling treatments to improve subsoil structure and permeability.

**Map unit 446** occupies 329 square kilometres (36 per cent of the associations) and comprises mainly noncalcareous gleys with some peaty gleys and brown forest soils with gleying. Drumlins are less prominent and the undulating landscape (Plate 11) is more subdued than in *map unit 445* but the soils are developed on similar clay loam tills.

Topsoils are loamy with weak or moderate blocky structure and the clayey subsoils which have weak coarse prismatic or massive structures are very slowly permeable to moisture. Most of the land carries grassland. Arable crops are limited to those which require a short growing season or little cultivation. Drainage is essential for productive use and must include permeable infill in the drain-lines and moling or subsoiling treatments to improve subsoil structures and increase water movement. Pastures on undrained land are likely to be severely rush-infested.

**Map unit 447** occupies 36 square kilometres (4 per cent of the associations) and comprises mainly brown forest soils developed on thin sandy drifts having rock near the surface. The soils are freely drained and occur mainly in Lanarkshire between Lesmahagow, Coalburn and Douglas Water. The loamy topsoils have moderate subangular blocky structures and rest on sandy loam subsoils which are often stony but have moderate blocky structures and are permeable. Rooting depth can be limited by rock near the surface and the land is mainly permanent pasture, but crops requiring only a short growing season can be grown. The



naturally occurring acid bent-fescue grassland can generally be readily improved.

**Map unit 448** occupies 16 square kilometres (2 per cent of the associations) and comprises mainly humus-iron podzols developed on thin drifts overlying sandstone or directly on the very quartzose sandstones which crop out occasionally at the surface. The sandy, stony, often shallow soils carry mainly dry Atlantic heather moor and acid bent-fescue grassland usually utilized for rough grazing. Except on very rocky land improved pastures can generally be established by mechanical means.

**Map unit 449** occupies less than 1 square kilometre (less than 1 per cent of the associations) and comprises peaty podzols and peaty gleys on an exposed hill side in the Kennox valley south-west of Glespin. Apart from the peaty surface horizons of the soils, the terrain is similar to that of *map unit 448*, but the Atlantic heather moor, bog heather moor and common white bent grassland provide rough grazing of only moderate or poor quality and are not readily improved.

**Map unit 450** occupies 114 square kilometres (13 per cent of the associations) and comprises peaty gleys with some peat and noncalcareous gleys. The land is related to that of *map unit 446*, but occurs on the plateaux east of Glasgow and in the foothills around Coalburn and Glespin under higher rainfall and cooler climate. The soils are naturally poorly drained and are developed on massive tills with little development of structure. Persistent waterlogging has led to the build-up of organic matter on the surface. Much of the land is utilized for grazing, usually of poor or moderate quality on vegetation which includes flying bent grassland, flying bent and blanket bog and moist Atlantic heather moor. Improved pastures can be established by drainage and reseeding where rainfall and soil waterlogging are less severe than usual but are difficult to maintain.

**Map unit 451** occupies only 1 square kilometre (less than 1 per cent of the associations) and comprises peaty podzols, peaty gleys, noncalcareous gleys and brown forest soils which are developed on hummocky moraines in the Glespin valley. The heath rush-fescue grassland, rush pastures, sedge mires and acid bent-fescue grassland provide rough grazing of moderate quality. Although improved pastures can be established they are often difficult to maintain.

## THE SHAWHILL ASSOCIATION

(Map unit 458)

Soils of the Shawhill Association are developed on morainic drifts derived from granites, greywackes and Carboniferous sandstones. The association occupies only 3 square kilometres (less than 1 per cent of South-West Scotland) and the climate is warm and wet, is exposed, and has 1250 millimetres per annum rainfall.

The land lies below 30 metres altitude, is gently or strongly sloping and the brown forest soils have generally been cultivated.

**Map unit 458** is the only map unit of the association and comprises brown forest soils developed on stony loamy sand morainic drifts. The soils are highly permeable, naturally free draining, have a moderate to low water-holding

capacity and, although the average rainfall is high, can suffer drought in occasional dry seasons. The land carries mainly pasture utilized for dairying and, although stony, it is easily cultivated and barley and root crops are grown.

## THE SORN/HUMBIE/BIEL ASSOCIATIONS

(Map units 465-471)

The Sorn Association has long been known in Ayrshire (Mitchell and Jarvis, 1956) and the Humbie and Biel Associations belong mainly to South-East Scotland (Ragg and Futty, 1967).

The soils of these associations are developed on drifts derived from Lower Carboniferous and Upper Old Red Sandstone sediments and lavas. The Carboniferous rocks are mainly Calciferous Sandstone Measures sandstones and cement stones, the Old Red Sandstone strata are sandstones and cornstones and the lavas mainly basaltic or andesitic. Many of these rocks are reddish and impart this colour to the clayey tills which, except in Arran, are the principal type of drift. In Arran the drifts are generally locally derived and colluvial.

The associations occupy 263 square kilometres (1.8 per cent of South-West Scotland) and occur mainly in Ayrshire, Dunbartonshire, Stirlingshire and Lanarkshire with a smaller area in Arran. Rainfall ranges from 1000-1250 millimetres per annum in the fairly warm wet lowlands and foothills which comprise most of the area, to 1200-1500 millimetres in the cool wet lowlands, foothills and uplands of south Lanarkshire and eastern Ayrshire.

Noncalcareous gleys are the predominant soils and brown forest soils with gleying are important in areas with lower than average rainfall. In the foothills and uplands of Lanarkshire peaty gleys are common and some brown forest soils with gleying are locally important on water-modified drifts.

**Map unit 465** occupies 18 square kilometres (7 per cent of the associations) and comprises mainly brown forest soils with gleying and some brown forest soils and noncalcareous gleys. The natural drainage is mainly imperfect and the soils are developed on clayey tills with water-modified sandy upper layers. The topsoils are loamy with moderate subangular blocky structure and the sandy subsoils have moderate blocky structure and are permeable to moisture. The unmodified tills are generally at depths of more than 60 centimetres and are clayey and massive. Their permeability to moisture is low. Where the tills contain a high proportion of material derived from shales, marls or mudstones, the soils often have silty textures. The land is used mainly for arable agriculture and often provides some of the best ground in the areas in which it occurs.

**Map unit 466** occupies 96 square kilometres (37 per cent of the associations) and comprises mainly brown forest soils with gleying and noncalcareous gleys. The soils are developed on very firm, massive, sandy clay loam and clay loam tills forming undulating lowland terrain with some drumlins. The natural soil drainage is generally imperfect but in hollows is often poor. The topsoils are loamy with moderate subangular blocky structure. In the clayey subsoils, both prismatic structure and permeability to moisture are moderate but become very weak or poor respectively in the underlying parent till. The soils are used mainly for arable agriculture and permanent pastures, which, where under-drainage is inadequate, can be rush-infested. Drainage should include permeable infill in the drain-lines and secondary treatment to improve subsoil permeability and

structure. Some subsoils have silty textures, and are unstable and unsuitable for mowing because of the ready collapse of the channels. Rush pastures, sedge mires and some flying bent grassland can occur in hollows.

**Map unit 467** occupies 123 square kilometres (47 per cent of the associations) and comprises mainly noncalcareous gleys with some humic gleys, peaty gleys and brown forest soils with gleying. The soils are naturally poorly drained and are developed on weakly structured or massive, slowly permeable, clayey tills which make up the gently undulating terrain. The loamy topsoils often have a high content of silt, show weak structure and are liable to poach readily, especially on gentle slopes where run-off of excess water is slow. Although some arable cropping is possible, the land is mainly permanent pasture and rush-infested swards are common where drainage is inadequate. Drainage schemes should include permeable infill in the drain-lines and secondary treatment to improve subsoil structure and permeability.

**Map unit 468** occupies only 2 square kilometres (less than 1 per cent of the associations) and comprises brown forest soils, noncalcareous gleys, peaty gleys and peaty podzols. It is confined to the Glenmuir valley and the hills south of Muirkirk and is used mainly for permanent pasture and rough grazing which, on the acid bent-fescue grassland, rush pastures, sedge mires and heath rush-fescue grassland, is of moderate quality. Much of the land can be improved by mechanical means.

**Map unit 469** occupies only 1 square kilometre (less than 1 per cent of the associations) and comprises peaty podzols and peaty gleys. It is associated with *map unit 468* but occurs at higher altitudes. The heath rush-fescue grassland provides rough grazing of moderate quality and, on the waterlogged soils under the prevailing high rainfall, pasture improvements are restricted to scattered patches.

**Map unit 470** occupies 15 square kilometres (6 per cent of the associations) and comprises peaty and humic gleys with some peaty podzols and peat. It occurs in small areas on the moorlands skirting the hills behind Helensburgh, and near Killearn and Muirkirk. The peaty surface layers, fine-textured subsoils and severe waterlogging restrict land use to rough grazing and forestry. Pasture improvement of the moist Atlantic heather moor, rush pastures, sedge mires and blanket bog communities is difficult and can be maintained only after substantial drainage. Schemes should be similar to those described for *map unit 467*.

**Map unit 471** occupies 8 square kilometres (3 per cent of the associations), is confined to Arran and comprises brown forest soils and humic gleys. The soils are developed on colluvial drifts on the strong and steep slopes at the north end of the island. Brown forest soils predominate on the steeper slopes with rapid run-off of excess water. Where sandstone contributes to the drift the soils are podzolic, and on the gentler slopes mantled with thicker deposits humic gleys are common. The semi-natural vegetation of acid bent-fescue grassland, rush pastures and sedge mires provides good to moderate rough grazings which because of the slopes and occasional rock outcrops are not readily improvable.

## THE SOURHOPE ASSOCIATION

(Map units 472–479)

The soils of the Sourhope Association, first recognized in Roxburghshire (Muir, 1956), are developed on drifts derived from Old Red Sandstone intermediate lavas. The rocks are mainly andesites. Loam and clay loam tills which are generally pinkish red mantle the valleys and lower slopes of hills, and thin, colluvial, stony, gritty loams, generally brownish in colour, occur on higher ground.

The association occupies 71 square kilometres (0.5 per cent of South-West Scotland) and occurs mainly in the Ochil Hills north of Stirling and in the hills south-east of Douglas. It is more extensive in Eastern and South-East Scotland. Rainfall ranges from 1000–1750 millimetres per annum in the fairly warm foothills of the Ochil Hills and from 1400–2000 millimetres in the cool wet foothills and uplands of south Lanarkshire and higher ground in the Ochil Hills.

Brown forest soils are dominant on steep hill slopes below about 300 metres altitude and peaty podzols on the often less steep higher-lying land. Gleys are common in the valleys and on the basal slopes of hills.

**Map unit 472** occupies 6 square kilometres (10 per cent of the association) and comprises brown forest soils, with some brown forest soils with gleying and gleys, developed on loamy tills. The principal soil is freely drained with stony loam topsoils and the subsoils, which are also stony loam in texture, are often compact, have weakly developed structure and are less permeable than the topsoil. Run-off of excess water, however, is fairly rapid on the strongly sloping land. Permanent pasture is the predominant land use, although some arable cropping is possible. Rush pastures can occur on inadequately drained land in hollows.

**Map unit 473** occupies 5 square kilometres (5 per cent of the association) and comprises mainly noncalcareous gleys and some brown forest soils with gleying and peaty gleys. The soils are naturally poorly drained and are developed on compact loamy tills of moderate or slow permeability. Run-off of excess moisture on the mainly gently sloping land is slow. Permanent pasture is the principal form of land use, but, where drainage is inadequate, the swards are commonly rush-infested and can include flying bent and sedges. The maintenance of good quality pasture is dependent on adequate systems of under-drainage and these should include permeable infill in the drain-lines and secondary treatment to improve subsoil structure and permeability.

**Map unit 474** occupies 10 square kilometres (15 per cent of the association) and comprises mainly brown forest soils with some brown forest soils with gleying. The soils are similar to those of *map unit 472* but are developed on thinner more stony drift with rock generally close to the surface and occasionally cropping out. The terrain is generally steep. The land is used mainly for permanent pasture but some areas without rock outcrops can be cultivated for arable crops. On steep or rocky land herb-rich bent–fescue grassland provides good quality rough grazing.

**Map unit 475** occupies only 3 square kilometres (less than 5 per cent of the association) and comprises mainly humus-iron podzols with some peaty podzols and brown forest soils. The land forms a transition zone between that at lower altitudes carrying brown forest soils and higher ground with peaty podzols. The

semi-natural vegetation of dry Atlantic heather moor, acid bent-fescue grassland and white bent grassland provides rough grazing of moderate quality, but improved swards can be established by cultivation and reseeded.

**Map unit 476** occupies 16 square kilometres (25 per cent of the association) and comprises mainly peaty podzols with some humus-iron podzols and peat. The soils are developed on stony, loamy colluvial drifts in hills and uplands with rounded strong slopes, but some land is steep, often carrying humus-iron podzols. The semi-natural vegetation of dry Atlantic heather moor, white bent grassland and blanket bog provides rough grazing of only moderate quality. But, apart from on some very steep slopes, improved pastures can be established by ploughing and reseeded or, in difficult areas, by surface seeding.

**Map unit 477** occupies 7 square kilometres (10 per cent of the association) and comprises peaty podzols and peat with some peaty gleys and a few rock outcrops. It is closely related to *map unit 476* but includes peaty gleys as well as greater areas of peat. The land can generally be improved by the normal techniques of reclamation but the semi-natural vegetation of dry Atlantic heather moor, common white bent grassland, bog heather moor and blanket bog provides only rough grazing of moderate or poor quality.

**Map unit 478** occupies 10 square kilometres (15 per cent of the association) and comprises peaty gleys and peat with some peaty podzols and a few rock outcrops. It is related to *map unit 477* but the proportion of land with soils subject to waterlogging is greater. The semi-natural vegetation includes bog heather moor, blanket bog, moist Atlantic heather moor and heath rush-fescue grassland, and provides only poor quality rough grazing. Although improved swards can be established on this land, wet conditions make them difficult to maintain.

**Map unit 479** occupies 14 square kilometres (20 per cent of the association) and comprises brown forest soils with some brown rankers and humic gleys. The land is moderately rocky and steep, or very steep as on the face of the Ochil scarp. The soils are predominantly free-draining but gleys occur in 'flush' areas. The acid bent-fescue grassland and dry Atlantic heather moor provide rough grazing of good and moderate quality. Pasture improvements are generally very difficult on account of steep slopes or outcropping rock.

#### THE STIRLING/DUFFUS/POW/CARBROOK ASSOCIATIONS

(Map units 487 and 488)

The Stirling Association has been well known for a long time in the type area from which it takes its name and has been previously described (Ragg and Futt, 1967; Laing, 1974).

The soils of the Stirling and Carbrook Associations are developed on estuarine and lacustrine raised beach silts and clays. Two deposits are evident; the most widespread occurs at about 15 metres above sea level and consists of grey silty clays infilling estuaries and buried valleys such as the Carse of Stirling (Plate 8). Associated with these grey materials, but at about 30 metres above sea level and less widespread, are silty clays which are reddish in colour. On the terrace at 15 metres altitude the soils are mainly noncalcareous gleys, whereas on the terrace at 30 metres they are brown forest soils with gleying with a few noncalcareous gleys.

The associations occupy 208 square kilometres (1.5 per cent of South-West Scotland) and occur mainly in the Forth valley but are found in the estuary of the Cree (Front cover) and elsewhere along the Solway Firth. Rainfall ranges from 900 to 1500 millimetres per annum (1250 millimetres in the Solway area) and the warm and wet climate in the west of the association area becomes warm and moderately dry in the east.

**Map unit 487** occupies 27 square kilometres (13 per cent of the associations) and occurs almost entirely in the Forth valley at about 30 metres altitude. It comprises mainly brown forest soils with gleying on undulating raised beach terraces underlain by massive, reddish brown silty clays. The topsoils are usually silty loams, but can be silty clay loams, and have moderately developed subangular blocky structure. The subsoils range in texture from silty clay loam to clay, have moderately developed prismatic structure and their permeability to moisture is moderate to poor. The underlying silty clays are generally slowly permeable, except when drying leads to the deep penetration of cracks. Improved permeability can thus obtain in autumn and early winter, but as the soils become wet and cracks close permeability is reduced. The land is mainly arable, carrying cereals and long-ley grassland, but under high rainfall in the west permanent pastures predominate. Drainage is required for both arable cropping and productive pasture and should incorporate permeable infill in the drain-lines and some form of secondary treatment to improve subsoil structure and permeability.

**Map unit 488** occupies 181 square kilometres (87 per cent of the associations) and comprises mainly noncalcareous gleys, with some humic and peaty gleys in hollows especially in high rainfall western areas. The soils are developed on gently undulating raised beach terraces at about 15 metres above sea level and are underlain by thick deposits of grey silty clays. The topsoil is usually a silty loam and has moderate or weakly developed blocky or subangular blocky structure according to the length of the period it has been cultivated for grain crops. Development of structure increases under ley grassland. Under cultivation, structures in the topsoil are liable to slake in wet conditions and soil aeration and permeability become poor and the land difficult to manage. The subsoils are silty clay loams or silty clays and have moderate prismatic structure, and are moderately permeable when soil moisture is below field capacity in summer. As the soils become wet in winter structural cracks close and permeability is reduced to low levels. In dry summers extensive cracking of the ground surface can occur. Drainage is required for the optimum utilization of these soils and should incorporate permeable infill in the drain-lines and include a secondary treatment to improve structure and permeability of the subsoils in wet periods of the year. Satisfactory seedbeds are difficult to obtain on these soils, which are often dry and cloddy or wet and plastic, and arable crops are restricted to cereals. Under the high rainfall of the western areas permanent pastures predominate and where drainage is inadequate rush pastures and sedge mires can occur.

## THE STONEHAVEN ASSOCIATION

(Map units 490, 493, 495 and 496)

The soils of the Stonehaven Association are developed on drifts derived from Lower Old Red Sandstone conglomerates and lavas. Of the cobbles in the conglomerate many are andesitic lavas and a high proportion are acid

metamorphic rocks. The drifts are stony, loamy or sandy and often colluvial, but some tills occur on gentle slopes.

The association is restricted to a zone along the Highland border and occupies 14 square kilometres (less than 0.1 per cent of South-West Scotland). It is more extensive in Eastern Scotland. Rainfall ranges from 1600 millimetres per annum in the warm wet lowlands on the shores of Loch Lomond to 2200 millimetres in the cool wet foothills and uplands.

Brown forest soils predominate at low altitudes and on steep slopes, humus-iron podzols on the slopes of higher-lying ground and peaty podzols and peat on the summits of the rounded hills where conglomerate rock frequently crops out.

**Map unit 490** occupies 8 square kilometres (55 per cent of the association) and comprises mainly brown forest soils with some humus-iron podzols and noncalcareous gleys. Conditions of both free and imperfect natural drainage obtain in the brown forest soils. The soils are all developed on stony loamy drifts mantling gentle to strong slopes. Some local areas of steep land occur. Topsoils are loamy and readily permeable, subsoils are stony, sandy and moderately permeable and the underlying drift is often compact, with little structure, and is only slowly permeable. Although suitable for permanent pasture and good quality grazing, forest plantations have been established on much of the land.

**Map unit 493** occupies 4 square kilometres (30 per cent of the association) and comprises humus-iron podzols with some peaty podzols and gleys. The soils are developed on thin, stony, sandy drifts which are often colluvial and occur on land with a wide range of slopes. The semi-natural vegetation includes dry Atlantic heather moor and acid bent-fescue and white bent grasslands, and affords rough grazing of moderate quality. Pasture improvements are difficult under the prevailing climate.

**Map unit 495** occupies less than 1 square kilometre (less than 5 per cent of the association) and comprises brown forest soils, with some humus-iron podzols and brown rankers. The soils are developed on stony, sandy colluvial drifts and occur on a moderately rocky hog's-back ridge overlooking Loch Lomond. The acid bent-fescue grassland provides rough grazing of good quality but steep slopes, rockiness and climate make pasture improvement difficult. There are some scrub woodlands.

**Map unit 496** occupies only 2 square kilometres (15 per cent of the association) on Gualann hill. It comprises mainly humus-iron podzols, with some brown forest soils, brown rankers and gleys and is closely similar to *map unit 495*, but occurs at higher altitudes and the soils are more strongly leached and acid. The semi-natural vegetation, which includes dry and moist Atlantic heather moors and white bent grassland, affords rough grazing of only moderate quality.

## THE STRICHEN ASSOCIATION

(Map units 497, 498, 500–513)

The Strichen Association was first mapped by Glentworth (1954) in north-east Scotland. In South-West Scotland the association has been mapped on drifts derived from rocks of the Dalradian Assemblage, principally schistose grits, quartz-schists, hornblende-schists and chlorite-mica-schists. The rocks show

considerable short-range variation in lithology and narrow bands of the parent rocks of other associations also occur, notably quartzites of the Durnhill Association and slates of the Foudland Association.

The soil parent materials derived from these rocks are varied, but sandy loam colluvial drifts, generally with less than 30 per cent of silt (2–50  $\mu\text{m}$ ) are by far the most extensive. Sandy loam hummocky moraines and sandy clay loam tills are not extensive. Cryic deposits occupy small areas on mountain tops. The drifts are generally yellowish brown or olive, and stony. In many areas the content of fine sand, in association with appreciable amounts of silt, is high and the soils exhibit problems of structural instability, for example ‘capping’ of seedbeds, poaching, and collapse of drainage ditches, which are exacerbated by the high rainfall.

The association is extensive, occupying 941 square kilometres (6.6 per cent of South-West Scotland), but is restricted to ground north-west of the Highland Boundary Fault. It covers large tracts of Kintyre, Cowal and Knapdale and there are smaller areas on the islands of Arran and Bute and in the country east of Loch Lomond. The relief ranges from the mountains of northern Cowal, where several summits lie between 500 and 780 metres altitude, to lower-lying terrain in Kintyre farther south and west where many hills are between 250 and 450 metres. On this lower ground the landscape is formed of weakly developed broad ridges aligned north-east to south-west. The lowest-lying ground occurs around the coasts and on the banks of Loch Lomond and is slightly to very rocky with strong or steep slopes. There are small areas of till-covered, gently undulating non-rocky lowlands east of Loch Lomond and on Arran and Kintyre. Hummocky moraines occur in Cowal and near Loch Lomond, but are not extensive.

The climate is wet with summer rainfall exceeding evapo-transpiration by more than 500 millimetres over large areas of Cowal. Average annual rainfall ranges from 1400 millimetres on the lower ground and much of Kintyre to 2800 millimetres on the hills in Cowal and near Loch Lomond. The lowlands are generally warm, but the uplands and hills are cool or cold.

Soils with peaty surface horizons, peaty gleys with peat and peaty podzols, predominate over much of the association and reflect the wet climatic conditions, but gentle slopes contribute to slow run-off and wet soil conditions. Humus-iron podzols and brown forest soils are extensive at low and moderate altitudes and noncalcareous and humic gleys occupy small areas. Subalpine soils are restricted to the highest land.

The principal plant communities include bog heather moor on the peaty gleys and blanket bog on peat soils on gentle slopes. Dry and moist Atlantic heather moors occupy soils with peaty surface layers on knolls and steep slopes, and white bent grasslands are extensive on steep land in Cowal. On steeply sloping, moderately to very rocky land there is acid bent-fescue grassland, sometimes with bracken, and some broadleaved woodland.

**Map unit 497** occupies 10 square kilometres (1 per cent of the association) and comprises noncalcareous gleys with some humic gleys, peaty gleys and peat. It is found in a few localities on the middle slopes of hills east of Loch Lomond, on Kintyre and on Arran. The sandy clay loam tills on which the soils are developed are much more extensive in Eastern Scotland. The land is gently and strongly sloping (less than 10 degrees), non-rocky except on Arran where it is slightly rocky, and gently undulating. The noncalcareous gleys carry mainly permanent pastures and acid bent-fescue grassland and the very poorly drained soils and flush areas have rush pastures and sedge mires. These communities provide



valuable grazings. Although some deciduous scrub woodlands are present, forestry is not extensive.

**Map unit 498** occupies 15 square kilometres (2 per cent of the association) and comprises mainly humus-iron podzols with some brown forest soils; there are minor areas of noncalcareous and peaty gleys in receiving sites. It occurs in the Duchray valley, Loch Ard Forest east of Loch Lomond, and, as in *map unit 497*, the soils are developed on the sandy clay loam, slowly permeable, compact and stony tills which are much more extensive in Eastern Scotland. The terrain is non-rocky and gently undulating with slopes ranging up to 15 degrees. The former naturally occurring communities of Atlantic and boreal heather moors, with some acid bent-fescue grassland, have been largely planted with coniferous forest.

**Map unit 500** occupies only 2 square kilometres (less than 1 per cent of the association) and comprises peaty podzols and peat with some peaty gleys. It occurs on the upper limits of Loch Ard Forest, east of Loch Lomond. The soils are developed on thin stony drifts on non-rocky slopes of between 5 and 15 degrees, but peat occurs on gentle slopes in small basins. The strong thin iron pans of the peaty podzols impede surface drainage but this is improved on steep slopes by increased run-off. The peaty podzols support Atlantic and boreal heather moors, and blanket bog occurs on peat and bog heather moors on the peaty gleys. This vegetation provides rough grazing of poor quality. There is also some forestry potential although the choice of species is limited.

**Map unit 501** occupies 3 square kilometres (less than 1 per cent of the association) and comprises peaty gleys and peat with occasional peaty podzols. These soils are developed on similar parent materials and terrain to *map unit 500* and occur on the mid-slopes of Beinn Uird east of Loch Lomond. Bog heather moors and blanket bogs with some Atlantic heather moor provide rough grazing of relatively low value.

**Map unit 502** is not extensive, occupying less than 1 square kilometre, and comprises peaty gleys and peaty podzols as the dominant soils. It is related to *map unit 501* but slopes are steeper, and it occurs on one hill side east of Loch Lomond. Atlantic heather moor and bog heather moors afford rough grazing of low quality.

**Map unit 503** occupies 12 square kilometres (1 per cent of the association) and comprises humus-iron podzols and brown forest soils on well-drained sites with some noncalcareous gleys and humic gleys in poorly drained hollows and 'flush' sites (Plate 5). It is found in the mountain glens between Loch Eck and Loch Fyne and on footslopes on the eastern shores of Loch Lomond. The soils are developed on stony sandy loam morainic drifts forming hummocky terrain similar to *map unit 504* but occurring at lower altitudes. The free-draining soils support acid bent-fescue grassland and permanent pastures and the waterlogged soils have mainly rush pastures. Conservation of grass for silage is possible on some of this land, especially north of Balnaha where it is less hummocky and the soils are less stony, but good rough grazing and forestry are also widespread.

**Map unit 504** occupies 34 square kilometres (4 per cent of the association) and comprises mainly peaty gleys and peaty podzols with some peat. The terrain

consists of hummocky valley moraines, with some smooth, gullied slope moraine and the deposits, although sandier than the sheet tills in *map units 497–502*, have higher silt contents than is usual in morainic drifts. The landscape is less bouldery and the hummocks less pronounced than in the related map units of the Countesswells and Durnhill Associations. Dry and moist Atlantic heather moors occupy the peaty podzols and peaty gleys of the moraine hummocks. On the slopes flying bent and common white bent grasslands replace the heath communities and provide rough grazing of moderate value. Blanket bog communities on the peats of the inter-moraine hollows have low rough grazing values.

**Map unit 505** has a landform of slightly to moderately rocky steep slopes which can be planar in cross-section, but are more usually irregular. Farther north, in Western Scotland, land in this unit is less extensive because its position in the landscape is taken up by moraines of *map units 503 and 504*. It covers 114 square kilometres in South-West Scotland (12 per cent of the association), and is found below approximately 200 metres altitude around the coasts of the Cowal peninsula and north Kintyre. The drift is mainly sandy loam colluvium and, where the deposit is deep, freely drained soils are found. The principal soils are brown forest soils and humus-iron podzols with humic or peaty gleys in flushed sites or on rocky ledges. The brown forest soils often have brightly coloured B horizons, which appear similiar to those of podzols and suggest some movement of iron and aluminium weathering products down the profile. The plant communities are acid bent-fescue grassland and broadleaved woodland on the more freely draining soils with rush pastures and sedge mires on the poorly drained and flushed soils. These communities provide good to moderate rough grazings. The land is well suited to tree growth, but slope and rockiness hamper ground preparation and silvicultural and harvesting operations.

**Map unit 506** covers 59 square kilometres (6 per cent of the association) and consists of moderately rocky, gently undulating land with slopes generally less than 15 degrees. It occurs in the lower rainfall area in the western fringe of the association and is characterized by dry Atlantic heather moor, and bent-fescue grassland with bracken. The drift is colluvial, a sandy loam or loamy sand, and is usually shallow over schist rock. The principal soils are peaty podzols with iron pans, supporting dry Atlantic heather moor, and some humus-iron podzols under bent-fescue grassland with bracken. There is also a small amount of peat, supporting blanket bog, not mentioned in the map key. Peaty soils restrict land use to rough grazings of low quality, but there is some forestry potential if subsoiling is used to disrupt the iron pans.

**Map unit 507** is by far the most extensive in the association, covering 470 square kilometres (50 per cent of the association). It is found between sea level and about 400 metres altitude, and is seen throughout the length of the Kintyre peninsula and on the low-lying ground of Cowal. The landform (Plate 4) consists of gently to strongly undulating terrain with a moderate amount of rock outcrop and slopes generally less than 15 degrees. Some areas are only slightly rocky. The principal soils are peaty gleys on the ridges, knolls and undulating ground, with peat on the gentler slopes and in hollows. Peaty rankers are fairly common near rock outcrops where the drift is thin. Peaty podzols become more plentiful on steeper slopes and in areas of lower rainfall in west Kintyre and parts of Knapdale. The soils are developed on sandy to loamy, moderately stony, colluvial

drifts. The peaty gleys have the usual horizon sequence of surface O horizon, an underlying E horizon followed by B horizons with well-developed mottling, although this mottling can often be obscured by translocated humus, giving the horizon a dark colour. Rock is often found below the Bg horizon, but a C horizon is found where there is deeper drift. The plant communities are mainly bog heather moor on the peaty gleys, with local flying bent grassland. Dry and moist Atlantic heather moors are seen on the peaty podzols and there are some areas of boreal heather moor above about 250 metres. Blanket and flying bent bog communities occur on the peat. The peaty, poorly drained soils restrict land use to rough grazing and forestry. The grazings are of low quality, occasionally rising to moderate where there is flying bent grassland.

**Map unit 508** is similar to *map unit 505* in its landscape and soils, the principal difference being in the amount of rock outcrop. This unit covers 43 square kilometres (5 per cent of the association), is very rocky, and occurs on steep rugged slopes, which are often tree-covered. There are three main localities, at the Mull of Kintyre, on the slopes above the west side of Loch Eck, and in Knapdale Forest south of Loch Crinan. The unit is forested, except in the exposed Mull of Kintyre areas. The drift is a shallow stony colluvium and rankers are frequently seen. The soils are mostly humus-iron podzols and brown forest soils on the steep slopes, but in Knapdale there are peaty gleys and peat in the deep hollows between the steep-sided ridges. The plant communities, apart from on forested ground, are mainly bent-fescue grassland with bracken on the freely drained soils, and rush pastures and sedge mires in the wetter sites. They provide grazings of moderate to good quality.

**Map unit 509** covers 15 square kilometres (2 per cent of the association) and is rockier than *map unit 506*, which it resembles in other respects. The unit consists of rugged hills with strong, locally steep, slopes and is very rocky. It is found in south Knapdale in a slightly lower rainfall area. The principal drift is shallow colluvium and the soils are peaty podzols with dry Atlantic heather moor, and humus-iron podzols under bent-fescue grassland with bracken. The area provides rough grazings of low to moderate value.

**Map unit 510** occupies 79 square kilometres (8 per cent of the association) and comprises mainly peaty gleys, some humic gleys with humose A horizons are also found, and on more freely drained sites there are peaty podzols and at lower altitudes humus-iron podzols. It occurs in the hilly terrain between Loch Long and Loch Fyne with some smaller areas on the Kintyre peninsula. The land is steep and slightly to very rocky. In this area the soils of this map unit rise to nearly 600 metres altitude, the lower limit of the orohemiarctic thermal subzone (Birse, 1971), compared to 400 metres in Western Scotland. Extensive areas of white bent grassland provide rough grazings of moderate value and there are also some dry and moist Atlantic heather moors affording grazings of low quality and acid bent-fescue grassland on humus-iron podzols. In Cowal, this land is extensively forested.

**Map unit 511** occupies 80 square kilometres (9 per cent of the association) and is mainly located in Kintyre with smaller areas in Cowal. The topography is very rocky and rugged with slopes generally less than 15 degrees, although short steep slopes are also frequently seen. The drift is principally shallow colluvium and the land in this map unit is similar to *map unit 507* but is more rocky. Peaty gleys are

the dominant soils and are shallow on rock, with C horizons only found in areas of thicker drift. Peaty rankers are seen close to rock outcrops and peat occurs in channels between rock outcrops and on gently sloping ground. Peaty podzols are of restricted extent occurring mainly on short, steep slopes where drainage is free. Bog heather moor is the dominant plant community on the poorly drained soils, Atlantic heather moor occurs on the peaty podzols and blanket and flying bent bog on the peat. The value of the natural grazing is low and forestry potential is limited by rockiness and shallow soils.

**Map unit 512** occupies 3 square kilometres (less than 1 per cent of the association) and is restricted to Beinn Bheula west of Loch Long. The steep slopes are rocky and have subalpine soils, mainly podzols, and some alpine soils are found on the summit. Mountain white bent grassland provides grazings, valued as moderate, in the summer months. Exposure renders the land unsuitable for forestry.

**Map unit 513** occupies 2 square kilometres (less than 1 per cent of the association) and is found on gently and moderately sloping, rocky hill summits between Loch Long and Loch Fyne and on one hill summit in Knapdale. The land lies mainly above 600 metres altitude in the orohemiarctic thermal subzone. The drifts are cryic and the principal soils are peat and subalpine podzols. The peat is usually hagged and supports mountain blanket bog communities, while mountain heaths are found on the subalpine soils. Mountain white bent grassland provides some limited areas of moderate grazing. As in *map unit 512*, this land is not suited to forestry.

## THE TARVES ASSOCIATION

(Map units 519, 525, 526, 528, 529 and 531)

The soils of the Tarves Association are developed on drifts derived from rocks of intermediate composition (both igneous and metamorphic) or from drifts containing a mixture of acid and basic rocks. In South-West Scotland the major rock types contributing to the association are: (1) epidiorites, originally extrusive and intrusive basic igneous rocks, now metamorphosed, and (2) a series of calcareous and pelitic sediments also metamorphosed, in this case to chlorite-schist, epidote-schist and hornblende-schist and collectively known as the 'Green Beds'. The texture of the parent material is dominantly fine sandy loam, with some sandy loam on water-modified tills. The deposits are frequently stony, particularly those derived from epidiorites. Parent materials derived from epidiorites are reddish brown, and those derived from 'Green Beds' yellowish brown. Both groups of rocks were involved in the Caledonian orogeny and the distribution of this association reflects the strong north-east to south-west orientation imposed at this time. The epidiorites occur mainly in south Lorne and, sporadically, on either side of the Sound of Jura, whereas the 'Green Beds' lie southwards from Strachur on upper Loch Fyne to Tighnabruaich on lower Loch Fyne. They cross on to the Kintyre peninsula but are narrower and, although influencing soils locally in small areas, they are rarely extensive enough to map.

The association occupies 135 square kilometres (0.9 per cent of South-West Scotland) ranging from sea-level to 400 metres altitude, the topography often exhibiting strong ridging. Hills formed from epidiorites are frequently rocky and

bouldery, contrasting with the longer, more even slopes derived from the 'Green Beds'. Climatically, accumulated temperatures are mostly in the warm and fairly warm categories and rainfall ranges from 1200 to over 2000 millimetres per annum.

The Tarves Association has a high percentage of soil map units containing brown forest soils, humus-iron podzols and humic gleys (63 per cent) which make it fairly attractive to agricultural and forestry enterprises in the harsh hill lands of the north-west of the region. The vegetation of the association is typically western; acid bent-fescue grassland, Atlantic heather moor, bog heather moor and blanket bog. Occasional bands of herb-rich bent-fescue grassland occur over narrow bands of limestone which are associated with both the epidiorites and the 'Green Beds'.

**Map unit 519** occupies 36 square kilometres (25 per cent of the association) and consists of humic gleys and brown forest soils, the latter often showing signs of strong leaching. The humic gleys are almost always found in lowlands and lower hill slopes and are developed on fine sandy loam or loam tills. The high silt and fine sand content and degree of packing (slight induration is often found) result in low permeability and organic-matter contents of the topsoils may reach 15 per cent. In hollows peaty gleys sometimes develop. The freely drained brown forest soils, in contrast, are associated with strong slopes and ridge crests and in higher areas peaty podzols are found as a regular, though minor, component. The landforms of the unit are not severe; slopes are usually less than 15 degrees and altitudes below 250 metres. The unit is slightly and moderately rocky, but can be very bouldery.

Although occurring mainly east of the Moine Mhor, near Lochgilphead, it is also present on the Island of Danna, Gigha Island and around Loch Sween. Apart from two small areas on the narrow band of 'Green Beds' in Kintyre it is entirely confined to epidiorite. In agricultural terms, the pattern of the soils is sometimes complex but reclamation for grassland is often possible and some areas are suitable for arable use. Where the land is not reseeded, soft rush pasture occupies the wetter hollows and acid bent-fescue grassland the drier slopes. Where limestones occur, some herb-rich bent-fescue grassland develops. The land is suited to a fairly wide range of tree species and some has been forested.

**Map unit 525**, occupying 18 square kilometres (10 per cent of the association), is closely related to *map unit 519* but occurs on steeper land (slopes more than 15 degrees) and is associated with the 'Green Beds' outcrops of Cowal (Plate 5, Glendaruel). It has less till and consequently less humic gley but some of the brown forest soils are imperfectly drained and 'flush' channels and spring lines are common. Although rarely reclaimable, the acid bent-fescue grassland and rush pastures provide valuable grazings.

**Map unit 526** occupies 29 square kilometres (20 per cent of the association) and is closely related to *map unit 519*. It is composed of similar soil types (humic gleys and brown forest soils) but there are more rock outcrops and brown rankers. It has an acid bent-fescue vegetation. Reclamation is rarely possible but the land provides valuable grazings. Shallowness of some soils may cause problems of windthrow for forestry.

**Map unit 528** extends to 51 square kilometres (40 per cent of the association). Peaty gleys and peat are the most extensive soils on this predominantly wet land

with some peaty podzols on the crests and flanks of the steeper ridges. Beneath the peaty surface horizon, textures are loamy, but the soils are often stony. The parent materials are colluvial in origin, but on the lower ridge flanks some areas of lodgement moraine are present in which induration is found. Peat occupies the majority of hollows. The map unit occurs on both epidiorites and 'Green Beds'.

Although the landforms within the map unit are not severe, the high altitudes (200–400 metres) and the wetness of the soils preclude extensive reclamation. Occasional improvement on a mosaic pattern to encourage sheep to range and assist better utilization of the unimproved areas is occasionally practised. The grazing resource is poor however. Moist Atlantic heather moor is found on the peaty podzols and peaty gleys but bog heather moor is restricted to the peaty gleys and peat. Some blanket bog occurs on peat and 'flushes' support acid sharp-flowered rush pasture or soft rush pasture. Much of the land is under forestry, where the principal species are Sitka spruce and lodgepole pine.

**Map unit 529** occupies 1 square kilometre (less than 5 per cent of the association) and is found in one locality north-east of Loch Caolisport in Knapdale. The terrain is steep and moderately rocky. The soils are principally brown forest soils and humus-iron podzols with some brown rankers. Bent-fescue grasslands provide high value rough grazings except where they are invaded by bracken. Heather moors are also present and furnish low value grazings. Forestry potential is good on this land.

**Map unit 531** is restricted to the north end of Gigha where it covers less than 1 square kilometre. The terrain is very rocky and rugged. Peaty gleys and peaty rankers are the principal soils with some peat, and support bog heather moors and blanket bog communities which provide rough grazings of low value. Forestry potential is very low owing to rockiness and exposure.

## THE TOROSAY ASSOCIATION

(Map units 546, 548–550)

The centres of Tertiary igneous activity in the west of Scotland are well known and geologists have documented their composition and history in some detail. They contain a wide variety of rock types ranging from acid to basic in composition and are broken by complex structures, for example cone-sheets and ring-dykes. When an igneous rock occurs in a uniform mass, its weathering products characterize the drifts and its soils are allocated to the appropriate association. However when several rock types occur in juxtaposition and, in addition, incorporate metamorphosed members of the basement rocks through which they burst, a mixed drift is found. Such is the parent material of the Torosay Association; it is heterogeneous and has many local variants. The association is recognizable, however, as a distinct soil-landform relationship. The only areas in South-West Scotland are associated with the intrusions of Arran. The vent agglomerates, granites and metamorphosed Old Red Sandstone sediments of Ard Bheinn in the heart of the island and the olivine-dolerite, quartz-dolerite, tholeiite, crinanite, teschenite, craignurite and riebeckite-trachyte of the south-east and east of the island are contributory rocks. All the map units are developed on a shallow, stony, brown, colluvial drift and are all moderately or very rocky. The soils are often heavily humus stained.

The Torosay Association covers 33 square kilometres (0.2 per cent of South-

West Scotland). It is found under a range of climates from coast to hill summit (1200–2000 millimetres per annum rainfall). The wetness is reflected in the soil distribution, over 85 per cent of the land having soils with a peaty surface horizon. The map units are therefore dominated by Atlantic heather moor, bog heather moors and blanket bog communities, although considerable areas of white bent grassland are to be found on the steeper slopes.

**Map unit 546** occupies only 5 square kilometres (15 per cent of the association) and occurs in five small patches on Holy Island, the Ross above Lamash, at Dippen Head, above Claughlands and at Levenarroch Hill. In almost all cases the podzolized brown forest soils and brown rankers occur on steep slopes, sometimes too steep for agriculture. There is a wide variation in soil depth and rock outcrops are common. Where the land is not cultivated, the soils support bent–fescue grassland often infested by bracken. The map unit is confined to land below 200 metres altitude.

**Map unit 548** occupies the gently or moderately sloping upper hills and is frequently peripheral to areas of hill peat. It occupies 11 square kilometres (35 per cent of the association). The principal soil types are peaty gleys and peat with occasional podzols and peaty rankers. The soils are often shallow and rock occasionally crops out. The vegetation is moist Atlantic heather moor and bog heather moor. In Arran little or no endeavour to reclaim the land as grassland has been made for it often lies at altitudes in excess of 200 metres. Some parts have been forested, but shallowness creates a risk of windthrow.

**Map unit 549** is developed on the steep hill flanks above 100 metres. It extends over 11 square kilometres (35 per cent of the association) and supports bent–fescue grassland, common white bent and flying bent grasslands, and rush pastures in flushes, all of which provide good grazings for sheep. The land is never cultivated but several areas have been afforested. The soils are principally podzols but peaty rankers and peaty gleys also occur. Many of the soil profiles are disturbed by soil-creep and by wash-outs, and buried profiles are common. There is strong short-range variation in depth, type and degree of development of the soils.

**Map unit 550** is closely similar in soil types and position in the landscape to *map unit 548*. It is however considerably more rocky. It occupies the summit of Ard Bheinn and surrounding slopes and in all covers some 6 square kilometres (20 per cent of the association). It has severe limitations for forestry and offers no scope for reclamation.

## THE TORRIDON ASSOCIATION

(Map units 552, 554–558)

The soils of the Torridon Association are developed on drifts derived mainly from Torridonian rocks. As in Western Scotland, these fall into two categories, the metamorphic types (slates and phyllites) of the Diabaig Group found west of the Gruinart Flats and the sandstone types (grits and arkoses) of the Applecross Group to the east.

The Torridonian country rocks are often buried by tills derived mainly from other sources, but including some material from the underlying strata. Around

Sunderland, tills consisting of materials from Jurassic and Cretaceous rocks form the parent materials of the Inchkenneth Association and near Bridgend the till is of mixed origin and carries soils of the Kintyre Association. Elsewhere tills derived principally from the Torridonian rocks can include small proportions of materials similar in origin to the parent drifts of these associations. An indurated brown loam till from Corsapool, for instance, has some stone fragments and patches with red colours that indicate affinities with tills of the Kintyre Association. The drifts forming the parent materials of soils in the Torridon Association include tills, morainic drifts and colluvium.

The association occupies 80 square kilometres (0.6 per cent of South-West Scotland) and is confined to the islands of Colonsay and Islay. The rainfall, ranging from 1200 to 1400 millimetres per annum, and the warm moist climate favour arable agriculture, but most of the land with mineral soils is used for permanent pastures. Outwith the improved areas the vegetation includes rush pastures, heather moors and blanket bog.

**Map unit 552** occupies 11 square kilometres (15 per cent of the association) in north-west Islay, and comprises noncalcareous gleys with some flushed humic and peaty gleys. There are few rock outcrops in the undulating landscape, but rock is often present within a metre of the surface and thus has only a thin cover of till. This is commonly indurated and generally loamy in texture, but in some areas water-working has produced sandy loams. Where the drift is derived largely from phyllite, the soils can have high silt contents and show similarities to those of the Foudland Association.

**Map unit 554** occupies 1 square kilometre (less than 5 per cent of the association) on Islay and comprises peaty podzols, peaty gleys and peat. The soils are developed in a landscape of hummocky moraine on indurated sandy loam drifts with abundant angular stones. The vegetation includes Atlantic heather moor and blanket bog and affords rough grazing of poor quality.

**Map unit 555** is confined to the island of Colonsay, where it occupies a number of small areas together amounting to 3 square kilometres (less than 5 per cent of the association). The map unit is found on strong to very steep slopes, usually small scarps or slopes with gullies and is moderately rocky. The slopes are often covered in scrubby oak, birch or hazel woodland. Although principally formed from colluvium, other drift types have had to be included owing to the small map scale. They include small areas of raised beach gravel (at Scalasaig), small areas of lodgement till (at Scalasaig and Baleromindubh) and even blown sand on the exposed promontory south-west of Ardskenish. This variety of topography and parent material gives rise to a very varied selection of soils. Brown forest soils, with some signs of podzolization, and brown rankers are found on the colluvial drift and humic gleys and peaty alluvial soils occupy hollows. Some areas have enough cultivable land to form small crofts but in general the land is of very limited potential. Apart from the woodlands previously mentioned, rush pastures and sedge mires interspersed with small areas of bent-fescue grassland form the principal vegetation and provide moderate grazing.

**Map unit 556** occupies 13 square kilometres (15 per cent of the association) and occurs in subdued undulating terrain, like that of *map unit 552*. The soils, however, are peaty gleys and peat with some peaty podzols. As in *map unit 552*, the till is rarely deep and rock often occurs within a metre of the surface. The



vegetation includes moist Atlantic heather moor, bog heather moor, rush pastures and blanket bog, and affords rough grazing of low quality.

**Map unit 557** occupies 30 square kilometres (40 per cent of the association) and comprises peaty gleys and peat with some peaty podzols and peaty rankers. The soils are developed on colluvium and a few patches of lodgement till in moderately rocky terrain, with peaty podzols and peaty gleys on knolls and peat in intervening hollows and flats. This pattern of landform and soils is common in the Highland area. Land use is limited to rough grazing on moist Atlantic heather moor, and blanket and flying bent bog.

**Map unit 558** occupies 22 square kilometres (30 per cent of the association) and comprises soils and vegetation similar to those of *map unit 557*. The terrain, however, is more rugged and very rocky and the proportion of peaty rankers is greater and the amount of peat less.

## THE YARROW/FLEET ASSOCIATIONS

(Map units 576–580)

The Yarrow Association is well known from previous surveys (Ragg, 1960; Bown, 1973) and the soils of this and the Fleet Association have been grouped together at the 1:250,000 scale. They are developed on gravels and sands derived mainly from greywackes, but with some additions of granitic materials in Galloway. The deposits are principally fluvio-glacial in origin, but also included are some found on upper river terraces and Late Glacial ('70-foot') raised beaches. The association occurs mainly in the river valleys of the Southern Uplands but is also extensive in some lowland areas, notably between Loch Ryan and Luce Bay and on Galdenoch Moor. Landforms are mainly mounds and terraces but in some areas kettleholes and similar depressional features are found.

The associations occupy 197 square kilometres (1.4 per cent of South-West Scotland). Rainfall is in the range 1000–1500 millimetres per annum and the climate is warm and moderately dry or wet.

Brown forest soils with free or excessive natural drainage dominate the association but in some map units they occur with alluvial soils or peat. Humus-iron podzols occur on Galdenoch Moor. Except in *map unit 577*, the soils have high contents of hard rounded stones which can affect cultivations and the mechanical harvesting of potatoes, but most of the land has been improved and arable and permanent pastures are extensive. The semi-natural communities include acid bent-fescue grassland on brown forest soils, dry Atlantic heather moor on humus-iron podzols and soft rush pasture on poorly drained alluvial soils.

**Map unit 576** occupies 70 square kilometres (35 per cent of the associations) and comprises brown forest soils developed on gravels derived from greywackes. Occurring mainly below 100 metres altitude, the terrain consists of mounds and terraces with gentle slopes. The soils have stony sandy loam topsoils, yellow-brown or strong brown stony loamy sand B horizons and coarse gravelly subsoils. The natural drainage is free or excessive, the water-holding capacity low, and in dry periods crops on these soils often suffer drought. Much of the land is farmed in a rotation of long-ley grass with short arable breaks when barley and some oat crops are grown. Stoniness can affect the use of some implements.

**Map unit 577** occupies 20 square kilometres (10 per cent of the associations) and comprises brown forest soils developed on sands of mainly fluvioglacial origin. The stone-free, sandy loam topsoils are underlain by loamy sand B horizons and by coarse sands in the deeper subsoil. The natural drainage is very free or excessive, the moisture-retaining capacity of the soils is low and in dry periods crops are affected by drought. Dairy farming, based on grass leys of 6 to 8 years and short arable breaks in barley with some potatoes or fodder root crops, is the principal agricultural enterprise.

**Map unit 578** occupies 37 square kilometres (20 per cent of the associations) and comprises brown forest soils, peat and peaty alluvial soils. The brown forest soils occur on discontinuous mounds and terraces of fluvioglacial gravels with peat and peaty alluvial soils formed in intervening hollows. Slopes are mainly gentle but can be locally strong or steep at terrace edges. The brown forest soils are similar to those of *map unit 576* and are generally utilized for dairy farming. Intensive under-drainage is required for the improvement of the peat and peat-alluvial soils.

**Map unit 579** occupies 66 square kilometres (35 per cent of the associations) and comprises brown forest soils developed on fluvioglacial and upper river terrace gravels and alluvial soils on river flood plains or other alluvial tracts. It lies below 150 metres altitude in narrow river valleys and slopes are predominantly gentle, but some steep banks occur at terrace margins. The land is utilized mainly for arable and permanent pastures but some soft rush pasture is found on the poorly drained alluvial tracts.

**Map unit 580** occupies only 4 square kilometres (less than 5 per cent of the associations) and comprises humus-iron podzols developed on fluvioglacial gravels and sands together with some areas of peat. It lies below 100 metres altitude on mounded terraces and intervening hollows as the main landforms. The natural Atlantic heather moor and blanket bog communities afford rough grazing of moderate or poor quality but some improved grass swards have been established in recent years.

#### MISCELLANEOUS LAND UNITS

**Bare rock, scree and cliffs** In hill and mountain areas the presence or absence of rock frequently plays a leading role in dictating the ease with which land can be used for various purposes. It has been used, therefore, to discriminate between otherwise fairly similar soil groupings to give different map units (soil-landscape units). Occasionally areas dominated by rock occur in sufficiently large areas to be represented separately at the 1:250,000 scale (e.g. the Goatfell range in Arran). Such areas amount to 26 square kilometres (0.2 per cent of South-West Scotland). Although rock dominates these areas, they are variable and include bare scree, lithosols, rankers and minor amounts of other soil subgroups.

**Built-up areas** Towns and cities occupy 711 square kilometres (5 per cent of South-West Scotland) and occur mainly in the Midland Valley.

**Freshwater lochs** For the purposes of calculation of regional area percentages freshwater lochs have been excluded as part of the total land area, but the total area of these lochs in South-West Scotland is 163 square kilometres.

### **3 Land Evaluation**

Earlier chapters of this book have described the main natural resource attributes of South-West 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 these resources are variable with 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 can 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.

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

In Scotland, a system of land capability classification for general agricultural purposes has been constructed. An explanation of its broad principles and the parameters used in its application in South-West Scotland form the bulk of this chapter. A final section attempts to provide some comments on the effects of natural resources on other uses, for which fuller classification systems have not yet been constructed.

#### **LAND CAPABILITY CLASSIFICATION FOR AGRICULTURE**

The land capability classification for agriculture has as its objective the integration of 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 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 Indicating 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 SOUTH-WEST SCOTLAND

**Climate** South-West Scotland has, in common with other western areas, high levels of rainfall and relative humidity as major factors producing a predominance of stock farming in many different forms based on ley grasslands, permanent pastures and rough grazings. Temperature, which ranges widely and falls with increasing altitude, also plays a principal role in governing the distribution of farming systems of differing intensity and type. In the lowlands of Galloway and the Midland Valley, warmth and moisture promote an abundance of plant growth during a fairly long season, especially in coastal areas. Intensive dairying, with silage conservation preferred to hay on climatic as well as nutritional grounds, is the predominant enterprise.

At a slightly higher altitude in areas peripheral to the hills and mountains, cooler temperatures and shorter growing seasons are allied with the effects of increased exposure on animal health, and stock rearing and sheep farming tend to replace dairying. The greater difficulty of hay-making is partially offset by the lower demands of less intensive stocking. On the hills and mountains the cold wet climate with high degrees of exposure and short growing season is perhaps the most important of a number of interacting factors restricting farming to low intensity systems.

Intensive arable farming is rarely possible in the region, but restricted areas of arable crops can be grown on most lowland farms, although wet weather creates a hazard in varying degrees to both seedbed preparation and harvesting. Freedom from late frosts along narrow coastal tracts is crucial to the important early potato crops. Special advantages of high insolation, air movement during periods of frost-risk and moderate rainfall favour market garden crops between Lanark and Carlisle in the Clyde valley.

**Gradient** The agricultural importance of slope operates mainly through its effects on the use of farm machinery. Restrictions become progressively more severe as gradients increase but the configuration of the land and the nature of the surface also play some part in determining any operations possible and any classification is necessarily general. The region has only small areas of level or gently sloping land, mainly raised beaches and alluvial or fluvio-glacial terraces which present no restrictions on the use of machinery, and the much more extensive undulating lowlands present few problems, except to very specialized implements. However, the drumlins of Galloway and similar features in the Midland Valley often have strong slopes (7–15 degrees) which restrict the use of some silage-making equipment and there are occasional gradients of more than 11 degrees severely limiting arable cropping.

It is in the hills, however, that the effects of gradient are most dramatic. By preventing altogether the reclamation of land steeper than 25 degrees, and in practice little land over 15 degrees is considered for improvement, gradient contributes significantly to the persistence of low intensity systems of farming in

the Highlands and Islands and in the Southern Uplands, particularly where readily improvable free-draining soils occur on severe slopes. In other situations the effects of gradient are compounded by wet peaty soils on which wheeled tractors are prone to slip. Many areas of hill land that have been improved are nevertheless restricted to grazings by the difficulty of using machinery for grass conservation.

**Soil** The region encompasses a wide range of soils presenting a variety of opportunities and problems to the cultivator. Although grazing management is affected by a variety of environmental factors, arable agriculture is subject to soil conditions to a much greater degree. A few deep, loamy, easily worked alluvial soils occur along rivers such as the Nith, but are usually subject to other limitations. However, tracts of gravels, mainly in valleys and on raised beaches, carry soils which are easily worked but are stony and have a low capacity to retain moisture. In Galloway, the Highlands and other hill areas, many soils are stony and picking of stones from fields has a long tradition. Stony land often has areas where soils are too shallow to plough, but these are mainly small patches around scattered rock outcrops. More typical of the lowlands are the loamy or clayey textures which lead to cultivation difficulties and a tendency to persistent wetness in many soils. On the Carse of Stirling and along the Cree estuary, land can only be worked over a narrow moisture range without unacceptable structural damage; plasticity when wet and hard clods when dry impose a requirement for very careful management. High contents of fine sand and silt in soils are associated with the tendency for fine seedbeds to slake under heavy rainfall, a problem most notable in parts of the Highlands and Islands subregion. Strong acidity and low fertility are features of almost all the peaty land.

**Wetness** Many factors combine, often rather differently between regions, to make soil wetness a major limitation to farming in South-West Scotland. In the Midland Valley, subsoils with clayey textures and coarse prismatic structures are slowly permeable, even under rainfalls as low as 1000 millimetres per annum. The tendency to surface waterlogging is marked, despite attempts to reduce it by under-drainage systems which have, however, ameliorated its most serious effects.

High soil moisture at critical times in the farming year continues to affect winter ploughing, spring seedbed preparation, trafficability at harvest and, under pasture, damage to swards by treading. In the Highlands and Islands, although clay contents are lower, high fine sand contents and massive subsoils produce similar problems, and the slightly cooler temperatures and higher rainfall levels at lower elevations than in the Midland Valley or Southern Uplands lead to high organic-matter contents and a prevalence of peaty topsoils on the tills.

On the shallower soils of the western Southern Uplands, as well as in the Highlands and Islands, wetness is a principal cause of the widespread development of organic soils. It restricts their use to low intensity grazing or to forestry. Spring and surface seepage, often along lines where colluvial parent materials of the hills meet the tills of the valleys and lowlands, create wet conditions on some strongly sloping valley sides and add to the costs of land improvement.

Along the rivers and other water courses many alluvial soils suffer intermittent flooding, the severity, frequency and season of which range widely, creating degrees of risk to agriculture difficult to assess, but, nevertheless, real. Deep fertile soils on low-lying alluvial tracts, termed 'holms' in South-West Scotland, are often used mainly for silage rather than for arable crops.

**Erosion** In many overseas countries, the risk of erosion is the most feared danger to agriculture, since soil can be completely destroyed. But in this region, as elsewhere in Scotland, erosion is mainly a slow natural process whose effects are apparent only over very long periods. In some situations and on some soils, however, human activity can lead to an acceleration of the effects of this natural process. Tilled land on strong or steep slopes left bare in winter or spring is subject to the formation of minor rills and gullies and loss of topsoil washed down-slope. Slow down-slope movement in regularly worked fields commonly leads to soils being shallow along the up-slope boundary fence and deep at the bottom. Prolonged overgrazing and weakening of the natural vegetation on steep hill land can lead to slopes failing catastrophically and the formation of major gullies which, without improved grazing management, are liable to extend. At high altitudes, under cold exposed conditions, plant growth and the recovery of the natural vegetation after damage are slow. Prudence suggests that modern vehicles and machinery should be used with care on subalpine and alpine soils.

Wind as an agent of erosion affects mainly dunes, machair and links soils near the coast and cultivation and grazing require careful management to minimize periods when the soil is bare and prevent turf becoming broken by excessive treading. The danger to this land in the future, however, seems most likely to arise from treading underfoot by tourists seeking recreation and concentrated in areas of high popularity.

**Pattern** Complex terrain with many different soil types occurring as small patches and with irregular slopes and rock outcrops typifies much of the Highlands and Islands and western Southern Uplands, and poses difficulties to agriculture. Problems have become more acute in modern times, for as machines have increased in size and workrate, so has their requirement for large unbroken areas. Many stony but freely draining mineral soils in Galloway are restricted in their use for arable agriculture, grass conservation or improved pasture to varying degrees by outcropping rock and shallow soils. Present levels of farming owe much to traditional systems established with small shallow-working horse-drawn equipment. Elsewhere, intricate patterns of freely draining and waterlogged soils occur on gently undulating slopes with strong overall gradients, and land use is governed by the character of the least tractable areas. In the hills and uplands irregularity of terrain and soil mean that improvement measures cannot be adapted to the whole range of conditions encountered. The presence of peaty waterlogged soils, like outcrops of rock, can often interfere with the use of otherwise favourable land.

## THE CLASSIFICATION

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

Land in Classes 1 to 4 is suited to arable use and that in Classes 5–7 unsuited to arable use. There are no divisions within Class 1, 2 and 7; two divisions in each of Classes 3 and 4; and three divisions in Classes 5 and 6. A full description of the

classification system and national guidelines is available as a Soil Survey Monograph (Bibby *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 of longer duration 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 grazing

- Class 5 Land capable of use as improved grassland.*  
*Division 1* Land well suited to reclamation and to use as improved grassland.  
*Division 2* Land moderately suited to reclamation and to use as improved grassland.  
*Division 3* Land marginally suited to reclamation and to use as improved grassland.
- Class 6 Land capable only of use as rough grazing.*  
*Division 1* Land with high grazing value.  
*Division 2* Land with moderate grazing value.  
*Division 3* Land with low grazing value.
- Class 7 Land of very limited agricultural value.*

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

- 1 The classification is designed primarily 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 SOUTH-WEST SCOTLAND

### Class 1

No land in Class 1 has been mapped in South-West Scotland since only the built-up areas at Ayr have a suitable climate. Although warm, South-West Scotland is wet and no land higher in quality than Class 2 has been recognized, owing principally to the balance of soil moisture and seasonal temperatures.

### Class 2

Class 2 land occupies 37 square kilometres (0.3 per cent of South-West Scotland) and is confined to small areas around Ayr and Falkirk where rainfall is approximately 800–900 millimetres per annum, near Girvan with 1000 millimetres, and at Kirkcolm, Wigtownshire, with 1125 millimetres. Elsewhere, small areas have been included with land of other classes owing to the small scale of the map. Most of the ground is very gently sloping raised beach terrace, and the soils are mainly naturally freely draining brown forest soils, often having moderately deep sandy loam surface horizons and sandy subsoils. There is a small patch of loamy alluvial soil at Girvan. The sandy textures and free drainage allow ready working in most seasons with only moderate power requirement, seedbeds being obtained with relatively few implement passes. Freedom from late frosts in the coastal lands of Ayrshire has led to early potato crops followed by summer and autumn forage crops having a near monopoly on some fields, but other areas frequently carry cereals and the land offers scope for the production of a wide range of crops. Yields are normally good but can be slightly affected by drought in some seasons. Fertility is good, having been built up by high levels of management and fertilizer application over long periods. To obtain continuing good yields on these rather coarse-textured soils it is important that this fertility be maintained.

### Class 3

This land can be said to comprise average arable land, but in character and capability it is diverse. In general, either good yields of a narrow range of crops, such as cereals and grass, can be obtained or moderate yields of a wider range of



## SOUTH-WEST SCOTLAND

*Table B Areas of land capability for agriculture map units*

CLASS and DIVISION	SHEET 6		SCOTLAND	
	SO. KM.	% LAND AREA	SO. KM.	% LAND AREA
1	0	0	41	0.1
2	37	0.3	1723	2.2
3	2038	14.2	11724	15.2
3.1	349	2.4	4586	5.9
3.2	1689	11.8	7138	9.3
4	2621	18.2	8219	10.7
4.1	1309	9.1	3690	4.8
4.2	1312	9.1	4529	5.9
5	3235	22.5	14270	18.5
5.1	478	3.3	1810	2.4
5.2	1287	9.0	5899	7.6
5.3	1470	10.2	6561	8.5
6	5662	39.4	37329	48.4
6.1	494	3.4	1556	2.0
6.2	1017	7.1	5463	7.1
6.3	4151	28.9	30310	39.3
7	73	0.5	2548	3.3
BUILT-UP AREAS	711	5.0	1233	1.6
TOTAL	14377		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.*

crops, including potatoes and some vegetables. The conditions restricting the choice, yield, or consistency of crops are however more strongly expressed in this class than in Class 2, and consequently the land ranges more widely in type and requires a greater variety of management practices and farm systems for efficient use. In South-West Scotland Class 3 includes parts of the clayey carse lands at Stirling, sandy and gravelly soils as at Stranraer, extensive areas of slowly permeable land in central Ayrshire and elsewhere in the Midland Valley and loamy or sandy loam freely draining land having limitations associated with climate. A very specialized rotation is traditionally followed on the carse lands and under the prevailing moist climate dairy farming predominates on the slowly permeable soils. Areas with coarse-textured subsoils are relatively easily cultivated and tend to be cropped more frequently than other land. However, this light land is not extensive and is managed according to the requirements of the predominant dairy farming. Class 3 land occupies 2038 square kilometres (14.2 per cent of South-West Scotland).

*Division 1* Land in this division occupies 349 square kilometres (17 per cent of the class) and occurs widely scattered from mid-Nithsdale to western Galloway, near Campbeltown, along the Ayrshire coastal lands and in the environs of Glasgow and Falkirk. With the exception of some Class 2 land this division includes most of the readily worked crop land in the region. Nevertheless, although early potatoes are regularly grown on some fields, the tradition of high quality intensive dairying in the lowlands is the dominant influence on the farming. In addition, the warm climate, long growing season in coastal areas and soils of medium and fine texture, favour abundant growth of grass.

In broad terms the division can be seen as comprising land of five types: (1) with slowly permeable subsoils in areas of moderate rainfall, (2) with very coarse-textured, gravelly or sandy subsoils, (3) with loamy soils, (4) land with loamy stony soils, and (5) with sandy loam soils and climatic limitations.

On the Rhins of Galloway between Ardwell and Kirkmaiden, and around Port William on the Machars of Wigtownshire, brown forest soils with gleying of the Rhins Association form land of the first type in a landscape dominated by ley grassland, but interrupted more commonly than farther north by fields of barley. (Some similar land is found around Whithorn and elsewhere on the southern Machars but is broken by intervening ground with stony brown forest soils, often having scattered rock outcrops.)

Land with coarse-textured subsoils, the second type, is widely distributed and is moderately extensive south of Stranraer; it occurs also on the Rhins of Galloway and near Garlieston, Thornhill (Dumfriesshire), Kirkintilloch and Rutherglen. Consisting mainly of brown forest soils of the Yarrow and Darvel Associations, the land is very easily worked and although a high proportion carries grass leys, these are not often maintained for long periods and cultivation for grain and forage crops is generally frequent. Some potatoes are grown and in favoured fields these are the valuable early type. Although the average rainfall is in the region of 1000 millimetres per annum, the low capacity of the soil to retain moisture can lead to reduced crop yields in periods without rain, such as have occurred in several recent seasons.

Although the characteristic soils of the Midland Valley rest on clayey tills, some brown forest soils with gleying and brown forest soils of the Glenalmond Association in the Girvan valley and the Rowanhill Association near Glasgow are of medium texture and the land is more readily worked and more easily managed than the surrounding areas.

Around the northern tip of the Rhins of Galloway land with freely draining, loamy, brown forest soils of the Rhins Association is frequently moderately stony and has been placed in this division. Some less stony areas of Class 2 land are also included owing to limitations of the scale of the map. Although devoted mainly to dairying based on ley grassland, the land can be worked for grain crops despite the presence of stones necessitating care in the harvesting of roots. A small area of soils of the Auchenblae Association near Campbeltown can also be included in this group. Although it lies in an area with generally adverse climate, the limitation is principally of exposure and local shelter is available from the prevailing south-west winds.

Very gently sloping land with sandy loam soils of the Dreghorn Association in coastal areas of north Ayrshire and near Falkirk is easily worked and seedbeds readily obtained, but it occurs either in association with wetter land or is subject to climatic restrictions. Some early potatoes are grown in the coastal areas.

*Division 2* Occupying 1689 square kilometres (83 per cent of the class), land in this division is the most extensive of those in South-West Scotland having a capability for arable agriculture. It is extensive on the carse at Stirling, on the Rhins of Galloway and around Kilmarnock, Ayr and Castle Douglas. Less extensive areas are found at East Kilbride and Motherwell, at Lanark, on Bute, at Dundrennan, Kirkcudbrightshire, and at Ballantrae and in the Stinchar and Duisk valleys and the Laggan of Campbeltown, as well as many other small patches including some on Islay and at Kingarth, Blackwaterfoot and Lamlash Bay on Arran.

Land of five broad types can be recognized in the division:

(1) Stirling carse lands with specialized soils and agriculture, (2) extensive areas having fine-textured slowly permeable subsoils, (3) scattered patches around coasts and in valleys with coarse-textured subsoils and climatic limitations, (4) small areas with loamy soils and climatic limitations, and (5) small alluvial tracts liable to flooding.

Traditionally, a highly specialized crop rotation has been followed on the Stirling carse lands. Timothy grass leys maintained for about 8 years and used principally for hay have been followed by 3 or 4 years of grain. Despite extensive drainage improvements, which have resulted in an extension of the period during which the stoneless soils of the Stirling Association can be worked in spring or support the use of machinery during harvest, crops are still subject to risk in poor seasons and skilful management is required. High yields are often obtained however.

Land of the second type is also characteristically difficult to manage under an arable regime, and in the moist climate grass leys maintain good yields and are also retained for long periods. These pastures support many fine dairy herds and the ability of the land to produce successful barley and root crops as home-grown winter feed is reflected in farming economies. Occurring in widely separated areas from slopes bordering the Forth valley to central Ayrshire, Wigtownshire, and even a sheltered part of Islay, the land comprises soils from a large number of associations, such as those of the Kilmarnock, Bargour, Rowanhill, Glenalmond, Sorn, Rhins, Balrownie and Etrick Associations. Subsoils with clay loam and sandy clay loam textures, coarse structures and slow permeability lead to surface waterlogging. In western areas, the more extreme effects of heavy rainfall are often reduced by the presence of a sandy, water-modified horizon between the topsoil and the till proper which allows increased drainage. Islay, Kintyre, parts of southern Bute and Cardross have soils of this type. Wetness is, however, the

chief characteristic of the land; it limits the choice and performance of crops and affects management of grazing. Drainage, as described for the appropriate map units in Chapter 2, is essential for efficient agriculture, but timeliness in cultivations, the provision of adequate housing for stock and the management of grazing and machinery movement to avoid poaching damage remain important considerations.

Small areas with freely draining topsoils and coarse-textured sandy or gravelly subsoils are widely distributed throughout the region. Patterns of stoniness or uneven development of wetter soils due to an irregular underlying till have led to their inclusion in this division, but the most common limitation is adverse climate. Thus small areas occur on Arran, Bute, southern Cowal and along the Clyde coast at Rosneath and Cardross, at Kingarth and in some inland valleys as near Lanark, Lesmahagow, Newton Stewart and New Luce. The land is often the most easily cultivated in the areas in which it occurs and is valuable for the growth of crops as winter feed for stock, but the weather often makes harvesting difficult. The soils, which belong to the Carpow, Panbride, Corby, Darvel, Shawhill and Yarrow Associations, have low waterholding capacity and grass growth is benefited by the high rainfall.

Small areas with freely draining loamy soils of the Darleith and Maybole Associations are also affected by the adverse climate and placed in this division. The land carries mainly ley pasture grazed by dairy cattle, but is more readily cultivated for arable crops than the surrounding areas and less subject to damage by poaching. Wet weather makes harvests difficult.

At Closeburn, Dumfriesshire, land with deep loamy freely draining alluvial soils is subject to a degree of flooding which, although difficult to assess, is nevertheless considered important to agriculture. Silage conservation and grazing by dairy cattle are the main forms of use, but some arable crops are grown.

#### **Class 4**

Land in this class is suitable for enterprises based primarily on grassland with short arable breaks. Yields of arable crops can be variable, mainly due to soil, wetness or climatic factors. Seedbed preparation is often delayed by unfavourable soil conditions and the risk of the harvest being affected by bad weather is high. The moderately severe limitations restrict the choice of crops and demand careful management. Crops are generally forage or winter feed, grown to support stock-farming enterprises. Yields of grass are often high, but difficulties are likely to be encountered in conservation and management of grazing.

Land of this type occurs scattered widely throughout the region. It is mainly restricted to narrow coastal strips in the Highland and Islands where on the only available cropping land it can provide highly valuable support in maintaining stock on extensive adjacent areas of poor land. Occurrences are found on Islay, Arran and Kintyre, and near Dumbarton, Rothesay and the southern end of Loch Lomond.

In the Midland Valley there are extensive areas having severe wetness limitations as on the Slamannan plateau, around Lugton and Dalry, Ayrshire, near Mauchline, around Glasgow and fringing higher-lying land as at Cumnock and around the Kilsyth Hills. Farther south, in the Southern Uplands freely draining soils in valleys subject to adverse climate are in this class as well as high-lying parts of the Rhins of Galloway. On the Machars of Wigtownshire the land varies in quality over short distances and areas of Class 4 and 5 frequently occur intermingled in the landscape. The resulting difficulties of representation on

small scale maps are therefore considerable and many separations in the lowland areas bordering the Solway Firth are broad generalizations only. Class 4 land occupies 2621 square kilometres (18.2 per cent of South-West Scotland).

*Division 1* Occupying 1309 square kilometres (50 per cent of Class 4) land in this division is found mainly in Galloway and in the Midland Valley with only scattered areas in the Highlands and Islands subregions. It comprises a wide diversity of landscape, from coastal raised beaches to valleys amongst the uplands, and soils ranging from those on freely draining gravels to gleys on silts and clays. Grassland predominates throughout the division supporting dairy, or sheep and cattle enterprises; the last-named are usually in high rainfall areas bordering uplands where the capability of the often coarse-textured soils to produce forage crops and grain for stock feed is especially valuable.

For purposes of description the land can be grouped into a number of broad types and brief mention is made of each. Most extensive are the areas in Central Ayrshire, the environs of Glasgow, in Lanarkshire and south of Loch Lomond, where slowly permeable soils, mainly brown forest soils with gleying and having imperfect natural drainage, occur on clayey or fine loamy tills under moderately high rainfall. Wetness resulting from the interaction of soil and climate is the principal limitation on these soils which include representatives from a large number of associations such as the Kilmarnock, Sorn, Rowanhill, Mauchline, Hindsward, Darleith, Balrownie and Drongan Associations. Drainage is essential for the productive use of this land and should include permeable infill in the drain-lines and secondary moling or subsoiling treatment to improve subsoil permeability and structure as described under the appropriate map units in Chapter 2. High levels of grass production can be anticipated but the growing season and period when grazing is possible can be relatively short, making hay can be difficult and wet conditions can pose risks of poaching. Careful soil management and timeliness of cultivations are essential for arable crops. Wetness can delay seeding and in the resulting shortened growing seasons, yields are often below average. Weather conditions at harvest are frequently difficult and their effect increases as crop areas on any farm become greater.

South of Newton Stewart and at the western end of the Forth valley small areas of stone-free, gleyed, silty clay soils of the Stirling Association under high rainfall also have wetness limitations and require careful management. But although risks to crops are high, yields on this land can be good.

Land with coarse-textured brown forest soils and humus-iron podzols on gravelly parent materials, mainly of the Yarrow, Carpow, Darvel and Corby Associations occurs scattered in small patches as at Blackwaterfoot, Darvel, Sanquhar, and on southern Islay. Climate, especially the risk of bad weather at harvest, is the main factor limiting cropping although, apart from some very gravelly areas, the ground is easily worked. Leaching of these coarse-textured soils is often strong, leading to low nutrient levels, especially in the Corby Association, and careful attention should be paid to lime and fertilizer requirements. Some land with brown forest soils of the Ettrick, Darleith and Largs Associations is also placed in this division on account of climatic limitations, principally high rainfall.

Pattern and lack of soil depth are the main limitations affecting irregular terrain with scattered rock outcrops and stony brown forest soils of the Ettrick, Dalbeattie and Rhins Associations in Galloway. These limitations also affect land with thin brown forest soils of the Darleith Association near Bridge of Weir and the Largs Association on Great Cumbrae Island. Grassland is easily managed and

relatively free from poaching risk on this freely draining land, but large implements are difficult to use and some patches in cropped fields usually remain untilled. Seedbeds, although stony, can generally be readily prepared and average yields obtained from worked areas.

*Division 2* Land in this division, which occupies 1312 square kilometres (50 per cent of Class 4), remains for long periods in grassland and has very limited potential for the growth of arable crops. High levels of grass production can be achieved but difficulties of conservation and utilization are severe. Grain crops are grown occasionally, especially when pastures need renewal, but risks are high and yields often moderate or low. Forage crops can be produced. Stock farming is predominant and, together with cattle rearing and sheep enterprises, includes some large productive dairy farms as well as others more lightly stocked than on the less difficult land. Arable cropping is limited mainly by wetness, both of climate and soil. High rainfall and exposure affect crop growth, ripening and harvesting directly, and indirectly lead to wet conditions in many soils having clayey textures, coarse subsoil structures and low permeability.

Many areas of intrinsically wet land with noncalcareous gley soils are widely distributed throughout west central Scotland, as in central Ayrshire, on the Slamannan plateau and at Cumnock, with some smaller patches in the Southern Uplands and Highlands and Islands subregions. Developed on a variety of clayey tills, the soils are in many different associations, notable amongst which are the Rowanhill, Ashgrove, Sorn, Lanfine, Ettrick, Kippen and Inchkenneth Associations. The soils of the Kintyre and Foudland Associations can also be included in this group, although the parent materials have high fine sand contents rather than clay. Severe wetness is however the principal problem. Drainage is essential, but many old systems are only partially effective and although modern installations of a type described in Chapter 2 reduce periods when the soil is unacceptably wet and lead to improvement of surface conditions, the land nevertheless remains difficult for agriculture. The severity of problems affecting cultivation are such that pastures are only infrequently broken up for tillage and cropping. Management is often mainly concerned, therefore, with problems of grazing which centre largely around the risk of poaching. High levels of grass production induced by modern fertilizer practices and seed mixtures allow stock to be maintained in much greater numbers than was formerly possible and the risk of damage to swards by treading is consequently greatly increased. Ample provision of housing allows animals to be kept off wet pasture land, but this and restriction of the spring and autumn grazing seasons have important economic implications.

Although they are also slowly permeable, brown forest soils with gleying are usually less wet than the noncalcareous gleys, but have been placed in this division where climate and soil wetness combine to limit arable agriculture. Lateness of ripening and wet weather at harvest are major hazards as are difficulties of cultivation and seeding, but these tend to be less than on land with gley soils and the risk of poaching, although of concern, is similarly reduced. Drainage remains an important requirement on this land which occurs on parts of the Rhins of Galloway and at Glenluce, Balmaclellan and Kirkpatrick Durham where the soils are greywacke-derived and in central Ayrshire where they are on tills from Carboniferous rocks. Climate is the principal limitation, however, affecting land with coarse-textured soils such as those of the Corby and Carpow Associations in small areas for example on Islay and south-west of Loch Lomond in the Highlands and Islands and those of the Yarrow Association in the

Cairn valley in the Southern Uplands. The land can be readily cultivated and despite the unreliability of the weather is of major importance to the economies of local farms. Between Loch Ochiltree and Barrhill in South Ayrshire an area of brown forest soils on drumlin ridges and intervening peat has been symbolled 4.2(6) because of the agricultural importance and contrast between two types of land which cannot be separated at small map scales.

### Class 5

Land in this class is not suitable for arable cropping but has potential for the production of grass from swards composed of modern palatable species. Terrain allowing the use of machinery for the establishment and maintenance of improved pastures is an essential feature of the class and treatments can range from complete ploughing and cultivation through rotavation and discing to surface scarifying operations. Factors such as slope, drainage and soil properties largely govern the choice of improvement methods but those selected should be possible within the long-term economic climate. During the initial stages of reclamation pioneer forage crops such as rape may be grown, but the conditions are unsuitable for the introduction of rotations, including any arable crops. Grass production can be high but can range widely according to local conditions, and although in some areas conservation is possible, difficulties of utilization are common.

Despite its restriction to pasture the class often has a particular value in the uplands where it mainly occurs. The high levels of production, palatability and early growth of grass in comparison with the natural vegetation of the hills afford increased nutrition for stock at critical periods of the year, enabling land in remote areas otherwise under threat of abandonment to be retained in agriculture. At present, however, much of the land in this class carries the naturally occurring herbage and the capability for improvement has yet to be realized. Reclamation decisions are dependent on a variety of factors such as farm structure, management and finance, but the ease with which improved swards can be established and maintained, their utilization for conservation or limitation to grazing and the persistence of the sown species are further important considerations. A number of different types of land can be recognized according to the operation of factors such as wetness, the presence of peaty surface layers or outcropping rock, and steepness of slope. Climate, often a major limitation on arable agriculture, affects grassland less severely.

Naturally freely draining soils in difficult climatic areas provide land on which improved pastures are easily established and maintained with little risk of poaching damage. Conservation, however, is possible only on gentle or moderate gradients and where rock outcrops, if present, are widely spaced. The risks of severe poaching damage and difficulties of management and maintenance of pastures are increased considerably on wet noncalcareous gleys. On land with these soils drainage requires heavy expenditure and wetness often affects the use of machinery and inhibits conservation. Low soil permeability associated with peaty surface layers, peaty gleys and some peats causes major management problems and the land is only marginally suited to improvement. Sward establishment is difficult, the low bearing strength of the peaty soils when wet restricts machinery movements and utilization is subject to major limitations or accompanied by severe treading damage leading to rapid pasture reversion. Conservation is not generally possible.

*This class encompasses a wide range of terrain and conditions, providing a*

valuable resource for animal production and on many stock farms presenting an opportunity for grazing improvement, increased stock numbers and more flexible management. It occupies 3235 square kilometres (22.5 per cent of South-West Scotland).

*Division 1* Occupying 478 square kilometres (15 per cent of Class 5), land in this division is distributed across much of southern Galloway, in valleys through the hills of the Southern Uplands and Highlands and Islands subregions and as fringes to the hills where these abut lowland areas. It occurs in a wide range of associations.

In Galloway stony brown forest soils with scattered rock outcrops occupy characteristically glacially eroded landscapes at altitudes up to 200 metres with a warm and moderately dry or wet climate. Although restricted to grassland principally by the pattern of outcropping rock and areas of very thin soil, high quality pastures can often be maintained on this land by controlled grazing and with moderate inputs of fertilizer. Considerable flexibility of management is possible, the liability to poaching damage is low, stock can remain on the land for long periods and conservation is often possible. Similar considerations apply to non-rocky terrain with brown forest soils which are often thin along the Cairn valley and elsewhere in the Southern Uplands, but the cooler wetter climates are less favourable to stock and hay-making. Areas with thin stony brown forest soils of the Largs and Darleith Associations, unsuitable for cultivation, are found along the north Ayrshire and Clyde coasts, and north of Milngavie. Pastures on this land present few constraints to grazing management and some conservation is generally possible.

On Islay, the Dalradian limestones produce very thin stony soils, often broken by rock outcrops but extensively used for improved pasture and grass conservation despite problems caused by the pattern. Some wetter, alluvial soils at Gruinart are also included in this division since the water-table is controlled by an intricate series of ditches. In the Laggan of Campbeltown, a number of peat-alluvial basins have been affected by the arterial drainage scheme and deepening of the Backs Water, and the substantial improvement has allowed establishment of good grass swards. Difficulties are still encountered during wet periods due to the low bearing strength of the topsoil, and the soils are probably marginal for the division, as are a number of other areas on noncalcareous and brown forest soils developed on sandy tills in south Kintyre, Arran, and Bute.

*Division 2* Land in this division is moderately suited to reclamation and use as improved grassland. Sward establishment, utilization and maintenance are subject to moderately severe limitations due to combinations of factors such as outcropping rock, wetness and climate, which tend to produce a range of distinctive land types. Sward establishment can usually be readily achieved, but problems of maintenance are associated with wetness and, where present, rock outcrops usually prevent conservation.

The division occupies 1287 square kilometres (40 per cent of the class) in South-West Scotland. On the greywackes and some granites in Galloway rock outcrops and brown forest soils form a distinctive terrain similar to that described in division 1, but with steeper slopes and more rock. There is little risk of treading damage to the improved swards but mechanized operations tend to be more difficult and restricted to fertilizer application by rock outcrops and slope. Grass conservation is not generally possible.

Wet land is found in a number of areas as at Cumnock, in the Doon valley and



at New Mains in the Midland Valley. Noncalcareous gleys and brown forest soils with gleying form a variety of associations, such as the Rowanhill, Hindsward, Bargour, Sorn, Kippen, Lanfine and Glenalmond Associations occurring around the periphery of upland areas, and under high annual rainfall they are restricted to use as grassland. With suitable under-drainage and careful management good levels of grass production can be achieved, but susceptibility to damage by treading and machinery is high, generally curtailing the grazing season and, together with weather, interfering with conservation. Wet noncalcareous gleys and some drier brown forest soils on strong slopes form a distinctive pattern along the sides of a number of valleys west of Moniaive in the Southern Uplands. Drainage to intercept down-slope moisture seepage is required for improvement on this land, a feature of which is productivity of the existing rush pasture and bent-fescue grasslands. Wet soils of the Foudland, Kintyre and Inchkenneth Associations make a valuable contribution to the restricted opportunities for land reclamation in the Highlands and Islands.

Also included are some peaty podzols of the Etrick, Glenalmond, Darleith, Kippen and Corby Associations on freely draining, stony, loamy drift or gravel subsoils. Difficulties of sward establishment and maintenance are greater than on most land with mineral soils, and high lime and fertilizer requirements in the early years after reclamation are important considerations. The advent of modern machinery and recently developed improved methods of sheep grazing management have brought increased awareness of the benefits of reclamation.

*Division 3* Land in this division is marginally suited to reclamation and use as improved grassland. Wetness, peaty surface layers, and low bearing strength often make swards difficult and expensive to maintain and pose a continuing threat of reversion to pastures dominated by rushes or the coarse species of natural hill and moorland communities. Rockiness and topography, while not preventing the seeding of improved swards, can militate against frequent mechanical maintenance operations. Sward establishment is likely to be limited to particularly favourable weather conditions and to be based on surface treatments.

In Galloway this division includes some very rocky terrain with brown rankers and thin brown forest soils as on some country overlooking the valleys of the Ken, Bargaly and Luce Waters. The need for bracken control is a common problem and mechanical operations are difficult, but established swards are likely to withstand treading and seasonal high stocking. Steep land with smooth slopes and brown forest soils presents somewhat similar problems but is less extensive.

Smooth undulating terrain dominated by wet soils, mainly peaty gleys with associated noncalcareous gleys and peat, occur on high-lying parts of the Midland Valley, for example at Cumnock, Dumbarton Muir, Airdrie and Coalburn. It also occurs extensively at lower altitudes in Arran, Kintyre and the islands of Islay and Jura. Generally subject to high rainfall, the land can be difficult and expensive to drain and only moderate amelioration of the wet conditions is achieved. The high risk of damage by treading or machinery traffic makes management difficult and stocking on improved swards is likely to be light and, because of the low bearing strength of peaty soils when wet, may be restricted to sheep rather than the heavier cattle. Some well-known deep peat areas such as Flanders Moss are in this division, but, although the reseeding of such land is possible, reclamation is likely to be attempted only at times when the need for improved grazing is great. Maintenance of improved swards is subject to severe difficulties. Elsewhere, under less advantageous climates, deep peats are considered unreclaimable for grassland.

Irregular rock-controlled terrain, having complex patterns of soils developed on thin stony drifts and with peaty surface horizons and a wide range of wetness, is widespread on the greywackes of the Southern Uplands and is also important in northern parts of the Highlands and Islands subregion, but is not extensive in the Midland Valley. Reclamation will generally be by surface treatment and swards are likely to be poor, although much more productive than the existing herbage. Utilization will generally be restricted to low intensity grazing. In the Carsphairn valley, mounded morainic landforms with complex soil patterns ranging widely in drainage and wetness are also in this division.

Land in this division occupies 1470 square kilometres (45 per cent of the class).

## Class 6

Land in this class suffers from physical limitations of such severity that reclamation by mechanical means is not possible. The semi-natural vegetation, however, has some sustained grazing value. The productivity and, in all but a few instances, the palatability of the plant communities is very limited in comparison with improved pastures and, except in division 1 of this class, stocking rates on the rough grazings are very low. Traditionally output has justified only low levels of investment in fencing, housing and other fixed equipment. However, recently developed systems of management, which involve control of grazing areas and the utilization of rough grazings in conjunction with improved pastures, have shown that considerable increases in numbers of stock and output can be achieved. Nevertheless farming on this land remains of low intensity.

By far the most extensive class in Scotland as a whole, in South-West Scotland land in Class 6 occupies 5662 square kilometres (39.4 per cent of the region) and covers large areas in the hills of the Highlands and Islands and Southern Uplands subregions where it encompasses a wide variety of landscapes, soils and vegetation. Within the class recognition has been given to three divisions based on an interpretation of the grazing value of the existing herbage and related to productivity, palatability and digestibility. A description of the system of grazing evaluation is given in Handbook 8 of this series. In broad terms the plant communities and characteristics affecting grazing are related to soils and altitude. The relatively productive and palatable bent-fescue grassland and rush pasture grazings found on brown forest soils and noncalcareous gleys respectively are generally valued highly and are often preferred to land that is marginally improvable but difficult and expensive to maintain.

*Division 1* Land in this division has vegetation with a high proportion of palatable and productive species as in the bent-fescue grassland and rush pasture communities. The dominant bent-fescue grasslands are mainly on brown forest soils on very steep or rocky land generally below 300 metres altitude. Similar soils on less severe terrain are well suited to cultivation or improved pasture, but in this division physical difficulties preclude the use of machinery. The land is valued on hill and upland farms and is often preferred to peaty land in Class 5 division 3 where realization of the capability for improved pastures requires high levels of expenditure. Stock tend to congregate on the grasslands which have the advantage of being resistant to poaching. Bracken is a common deleterious weed on much of this land, which is its principal habitat. Although productivity of the grass sward is reduced by severe shading, it nevertheless remains markedly above that of the coarse grass and moorland communities in the lower divisions. Bracken can be controlled by spraying or frequent cutting, but the follow-up

treatments needed to prevent its re-establishment are difficult on this terrain and only occasionally carried out.

In the Southern Uplands, the Etrick Association provides notable areas of brown forest soils on steep smooth slopes as above Cairnryan, in Glen App, at Thornhill and in the Scaur, Dalwhat and Stinchar valleys. Irregular terrain in this association occurs above Glenluce and at Monreith and in the Darleith Association at Knockdolian. The Darleith Association also provides slightly rocky terrain on the slopes of the lava plateaux in the Midland Valley and there is similar ground in the Largs Association along the Clyde coast and in the Sourhope Association on the scarp of the Ochils. In the Highlands and Islands, brown forest soils fringing the Cowal lochs (Loch Striven, Kyles of Bute, Glendaruel) give land in this division, which also includes ridged rocky ground too bouldery for reclamation in the Tarves Association on southern Islay, as well as large areas on very rocky ridged land in the Strichen and Tarves Associations near Loch Crinan. Some patch reclamation is possible.

Some steep slopes with noncalcareous gleys in the Etrick Association in the valleys north-west of Moniaive carry sharp-flowered rush pastures and tussock-grass pastures and provide palatable grazings, but can be associated with diseases such as liver fluke.

Coastal marshes or saltings found below the high-water mark of spring tides occur along the Solway Firth and the salt-marsh plant communities provide valuable grazings despite the necessity to remove stock during the regular periods of inundation. Grazings on the stabilized dune areas of Islay and Colonsay are in this division.

In South-West Scotland land in this division occupies 494 square kilometres (9 per cent of Class 6).

*Division 2* Occupying 1047 square kilometres (18 per cent of Class 6), land in this division is variable in character and widely scattered throughout the upland and hill areas of South-West Scotland. The herbage provides grazing of moderate value from communities such as common white bent and flying bent grasslands or mosaics of communities with high and low grazing values. Such mosaics dominate the areas mapped in this division in the Southern Uplands. In the Lowther Hills at the heads of very narrow valleys, steep slopes carry acid bent-fescue grasslands on brown forest soils at their base and a variety of less productive communities including heather moors at higher altitudes and provide useful grazing. Farther west, smooth slopes are restricted and complex soil patterns are associated with irregular terrain. In the Forrest Glen, near New Galloway, patterns of acid bent-fescue grassland with bracken and flying bent grassland occur on strongly flushed hill slopes associated respectively with brown forest soils and peaty gleys in the Etrick Association. On the Galloway moorlands there are patterns of acid bent-fescue grassland and flying bent and blanket bog communities, and bent-fescue grasslands and bog communities are also found on moundy morainic topography in the upper valley of the Ken.

Hills with both rock-controlled and more rugged slopes with outcrops, such as Craignarget Fell, Barclay Hill, Knochgray Hill and land near Gatehouse Station, carry a wide range of poorly productive communities, but also have some patches of bent-fescue grasslands which raise the overall value of the grazing.

Heather moor and bent-fescue communities occur intermingled on slightly and moderately rocky terrain in the Darleith Association as found on the Campsie Hills and Dumbarton Muir. Above Largs there is similar land on Old Red Sandstone sandstones.

A number of very long steep slopes in southern Cowal and in the Luss hills north of Glen Fruin with white bent grasslands and mountain grasslands are in the division.

*Division 3* Land in this division carries a wide range of vegetation; dry and moist Atlantic heather moors, bog heather moor and blanket bog are some of the principal communities. They are typical of the hills and uplands and occur mainly on acidic soils with peaty surface layers, but are also found at low altitudes on the peats of the western Galloway moorlands, on basin peats and in some areas of the Highlands and Islands the communities come down almost to sea level. The herbage is generally slow growing, coarse and provides grazing of low value. Stock are usually dispersed at low densities over wide areas and tend selectively to graze young shoots of the most palatable species. Periodic burning of vegetation which would otherwise become old and rank is of benefit in maintaining herbage quality.

Although physical difficulties make the land unsuitable for reclamation, some improvements are generally possible on small relatively favoured areas and can encourage stock to range more widely than would otherwise be the case. Land of this type is extensive in South-West Scotland where it covers 4151 square kilometres (73 per cent of the class).

#### **Class 7**

Land in this class has extremely severe limitations that cannot be removed or rectified. In South-West Scotland it consists mainly of areas of rock and scree which extend to high altitudes and are prominent features of the landscape. The Paps of Jura and Goat Fell on Arran are notable examples of the class in the north of the region. In the Southern Uplands there are the well-formed corries on the Merrick and Kells Hills and on Cairnmore of Fleet. Parts of such areas are often inaccessible or dangerous for grazing animals and the cover of vegetation is sparse.

### **LAND CAPABILITY FOR NON-AGRICULTURAL USES**

Although farming in its many forms is the principal industry occupying and dependent on the land as a basic resource, there is also a wide range of other activities, some sharing the ground with agriculture, others taking place separately. Hill walking, wildlife conservation, field sports and civil utility pipelines are examples of sharing activities while the others include forestry and golf courses. Of the many non-agricultural uses, forestry, following considerable expansion in recent decades, now occupies large areas, and caravan sites, golf courses and playing fields are intensive uses on restricted areas. Detailed guidelines defining the links between terrain and its use have not yet been formulated other than for agriculture, but soil type is a key factor affecting the suitability of the environment for many activities. The relationship between properties identified by soil survey and the principal uses of land in South-West Scotland is discussed below.

## FORESTRY

High average wind speeds and periodic gales are characteristic of the climate in South-West Scotland and other western areas and have a major influence on the distribution, growth and management of forests. Forestry for commercial purposes is not possible on the exposed, cold hills and mountain summits and is difficult and subject to hazards in some coastal areas where high winds combine with the effects of salt-spray. The exceptional growth often achieved by trees in sheltered cleughs and glens lends emphasis to the widespread restricting effects of exposure on open sites. The fall-off in tree growth with altitude as the upper limit for commercial plantations is reached is manifest on many hill sides in South-West Scotland. It must be emphasized, however, that high rainfall and moderate equable temperatures in the region allow growth rates which are high for the northern temperate zone of the world. Together with the requirement for a national timber reserve, this has encouraged the wide expansion of forestry plantations on the middle slopes of many hills at the western end of the Southern Uplands, notably in the Glen Trool National Forest Park.

Tree stability and the risk of windthrow pose major problems to forest management. The ability of a tree crop to stand until maturity and achieve maximum rates of increment largely determines whether the final product is pulpwood or saw logs, and is of major importance to the forest economy. In this region the risk of strong gales, and the existence of exposed sites and soil restrictions on rooting combine to create a liability to windthrow as tree heights increase. The prolonged waterlogging typical of blanket peats and peaty and noncalcareous gleys encourages root systems which are widespread but confined near the surface with a weak hold on the soil. Modern techniques of forest drainage can partially reduce soil wetness, but they also limit root spread and susceptibility to high winds remains a persistent hazard. Rock near the surface and shallow induration also restrict rooting, but rock occurs sporadically, affecting scattered trees, while induration is mainly important on exposed sites with freely or moderately well-drained soils.

Application of fertilizers at planting with further periodic additions, often from the air, is normal silvicultural practice, but forests, which in this region are rarely established on land with a history of improvement, are dependent on natural fertility to a much greater degree than are agricultural crops. The soil's ability to supply nutrients is broadly related to the mineralogy of the parent rocks, the major soil subgroups and degrees of leaching and flushing. Alluvial soils, and the brown forest soils and noncalcareous gleys—the gleys frequently affected by flushing—on the greywacke-derived materials of the Etrick Association in the Southern Uplands can be expected to sustain good rates of tree growth. Nutrient availability is lower on the more acid, strongly leached peaty podzols and peaty gleys. The fertility of organic soils is related mainly to the stage of development of the peat and to amounts of minerals brought in by seepage from higher ground, and is reflected in the semi-natural ground vegetation. Flying bent is widespread on the peats of the Southern Uplands and is usually associated with moderate flushing. Blanket bog communities generally indicate conditions of low fertility. In the Highlands and Islands subregion, the soils of the Durnhill and Torridon Associations on quartzites and quartzose sandstones respectively tend to be poor in nutrients. Heather moor communities, found frequently on podzols, pose special problems to forest establishment, which generally requires suppression of the heather.

Mechanized implements used for ploughing, draining and road making during forest establishment are powerful and versatile and can cope with most terrain on slopes up to about 30 degrees. Their ease of operation is affected however by the presence of extensive deep peats as found in Galloway, rocky terrain as in the Highlands and Islands, and steepness of slope. The use of tines to disrupt iron pans and partially loosen indurated layers is a standard aid to ground preparation. The stony moraines typifying a number of map units often provide excellent road-making material. Slope, wetness and rock outcrops are likely to have a major influence on the methods and ease of harvesting.

Sitka spruce is now by far the dominant species and is planted on a wide variety of soils and site types. Larch, formerly established widely on brown forest soils, is often reserved for areas of amenity value and lodgepole pine is important on deep peats and soils of very low fertility.

## RECREATION

Recreation encompasses many and varied pursuits ranging from the amusement amenities of crowded caravan sites to the solitary appreciation of lonely hill and moorland landscapes. Most of these uses make demands on the environment to which the terrain and soils are major contributory elements.

Beaches and other coastal features are a first consideration for many holiday makers and attract people to small areas in large numbers. Many are accommodated in towns, but others prefer to camp or caravan. The coastal raised beach terraces provide conditions well suited to their needs. The ground is level and the soils are highly permeable, with contents of organic matter sufficient to bind the surface against the destructive effects of treading and maintain the bearing strength of the land. Good conditions are also found where brown forest soils are developed on loamy drifts, but strong or steep slopes can give rise to difficulties. Trafficability on slowly permeable soils is generally poor.

Many dune and stabilized dune areas are highly attractive for recreational purposes, but require to be used with care. The soils have very low contents of organic matter and clay, and they are loose and do not withstand well the effects of treading. Management should seek to encourage either the sufficiently wide dispersion of people to give low overall pressure, or a concentration of numbers on small managed sacrifice areas. Traditionally, dune areas have provided fine golf courses as at Troon or Prestwick, but are less suited, except for very short periods, to camping or caravans.

Inland, playing fields are usually situated within or close to population centres and this proximity is a major consideration. However, level freely draining land has a premium value for sports activities and can often be found on terraces of fluvioglacial outwash. Alluvial land, while generally level, is not so consistently freely draining and can be subject to flooding. Care is required for the selection of suitable areas. Curtailment of use due to unsuitable conditions and extra care and expense in maintenance are likely on slowly permeable sites.

Recreational activities ranging over large extensive areas of countryside and involving relatively low numbers of participants can be considered as a second group. Such uses generally share the land with productive agriculture or forestry, and although often secondary to them, are becoming increasingly important to the population as a whole. Hill walking, a leisure pursuit of individuals from many sections of society, has become more popular in recent years. In South-West Scotland, however, the extensive uplands are not as yet as well known as some other mountainous areas, although increasing numbers visit Glen Trool

and the Merrick range. It is perhaps a paradox that of the large areas available to walkers, the attractions of some draw such numbers as to set at risk the environment they seek. Favoured paths can be subject to heavy treading and peaty soils with low bearing strength, especially when wet, are easily broken through at the surface and become eroded on slopes or, on more level ground, become bogs passable only with difficulty. Terrain well suited to walking generally includes a high proportion of freely draining brown forest soils, and humus-iron and iron podzols. Subalpine and alpine soils, although favoured by walkers, are sensitive to the degradative effects of foot and other traffic. The 'going' on peat and peaty gleys is usually difficult.

Field sports, of which the shooting of grouse and pheasant and stalking of deer are principal examples, are usually organized and involve a high degree of protection of the environment for sporting purposes. Control is exercised mainly by the great estates, each covering large areas, and the relatively few numbers of participants involved do not of themselves put stress on the environment. Pheasant shooting is followed mainly in arable and grassland areas and is favoured by a pattern of broadleaved woods and coverts. Grouse shooting requires extensive areas of hill and moor at altitudes ranging up to 600 metres, dominated by vegetation with abundant heather such as dry and moist Atlantic heather moor communities and having moderate rainfall during the breeding season. Closely controlled rotational burning of old heather, 'muirburn', is followed in order to maintain the heath and ensure young shoots as food for the birds. The most favourable conditions for grouse tend to be found where humus-iron, iron and peaty podzols predominate, and particularly where they are developed on mineral-rich parent materials derived from basic igneous rocks. The high rainfall and moist climate on extensive areas of peat and peaty gleys militate against the grouse moors of South-West Scotland achieving the quality of those in the east.

Deer stalking is mainly restricted to remote parts of the Highlands and Islands where very low potential stocking rates make sheep farming only marginally viable. In the Southern Uplands deer are confined mainly to forest areas where close control of numbers and shooting is exercised.

Finally the birds and other wild life that inhabit the remote sparsely populated hills, the cliffs of the sea coast, the arable farming areas as well as our towns and gardens are each adapted to and affected by their environment, and provide a source of enjoyment for all who observe them and add much to the richness of our heritage.

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**The following soil and land use capability maps deal with areas in South-West Scotland.**

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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 Organisation & Methods of the 1:250 000 Soil Survey

