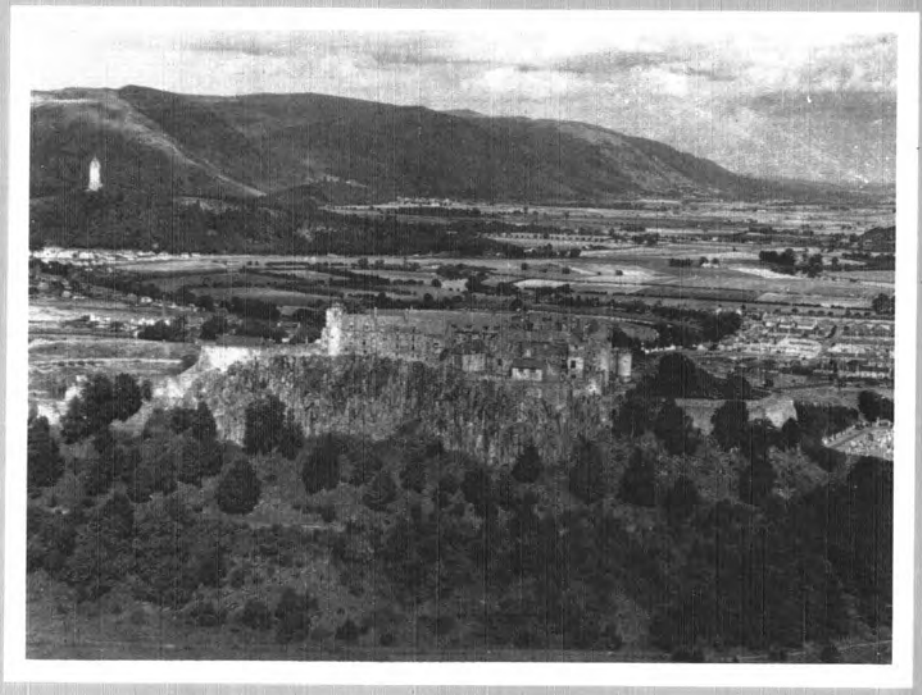
Soil Survey of Scotland

SOUTH-EAST SCOTLAND



1:250 000 SHEET 7

The Macaulay Institute for Soil Research
Aberdeen 1982

SOIL SURVEY OF SCOTLAND

Soil and Land Capability for Agriculture

SOUTH-EAST SCOTLAND

By C. J. Bown, BSc and B. M. Shipley, BSc
with a contribution by J. S. Robertson, BSc

The Macaulay Institute for Soil Research
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Front cover: *Stirling Castle and the Ochil scarp below which noncalcareous gleys of the Stirling Association (map unit 488) developed on stone-free silty clays of the Post-Glacial raised beach form the flat carse lands. On the scarp face are brown forest soils of the Sourhope Association (map unit 479). The Castle rock and the Wallace Monument eminence are sills of quartz-dolerite, a parent rock of soils of the Darleith Association.* Aerofilms.

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Preface

Prior to 1978 soil maps within the South-East Scotland region had been published for the following areas: Kilmarnock, Ayr, Girvan and Carrick, Stranraer and Wigtown, Stirling, Airdrie, Perth and Arbroath, Kinross and Elie, Peebles and Edinburgh, Haddington and Eyemouth, Kelso and Lauder, and Jedburgh and Morebattle. 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. Mapping in the Midland Valley and the Highland area 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 authors of the South-East Scotland Handbook were C. J. Bown and B. M. Shipley. Analytical results quoted in the text were produced at the Macaulay Institute for Soil Research, Aberdeen, mostly in the Department of Mineral Soils. The vegetation assessments were carried out by field staff according to a system designed by E. L. Birse and J. S. Robertson; correlation was the responsibility of the latter who also wrote the account of the plant communities. The handbook has been edited by R. E. F. Heslop and D. W. Futty.

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 and administrative maps. The soil map was drawn at Ordnance Survey and the

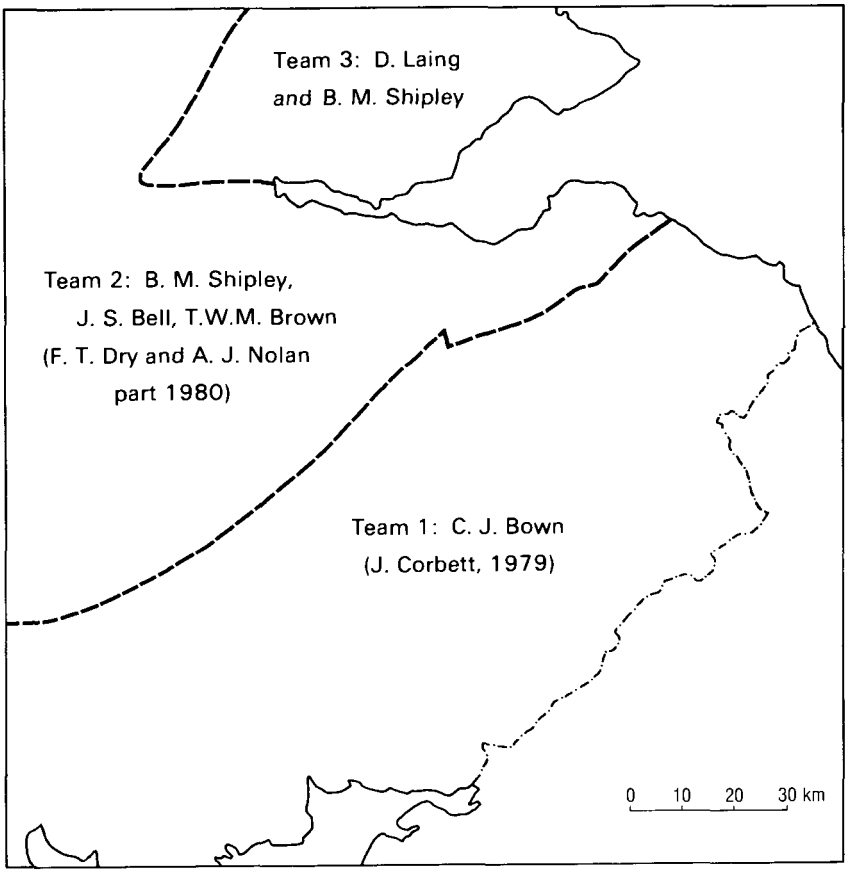


Figure 1. *Survey teams' map areas*

Land Capability for Agriculture map was drawn by W. S. Shirreffs and Miss P. R. Carnegie. The diagrams 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 wishes 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 which advised on the northern and southern areas of the sheet were made by: F. M. B. Houston, W. W. Wallace, C. G. Davidson, W. McGregor and I. G. Alexander (DAFS), D. McKelvie and R. B. Spiers (ESCA), G. E. D. Tiley (WOSAC), J. W. Grant and A. Howie (NOSCA) and J. G. Sinclair, C. A. Lhengh, I. D. Wilson, M. K. Browne, W. J. Donaldson and Miss M. A. Wright (NFU(Scot.)).

Photographs in the text are by members of the Soil Survey Department, Aerofilms Limited, the Institute of Geological Sciences and the Scottish Development Department.

1 Description of the Area

LOCATION AND EXTENT

The region represented by the maps and described in this handbook lies in south-eastern Scotland, an area having great diversity of landscape, including some agricultural lands long noted for the bounty of their crops, and uplands the home of wide-ranging sheep flocks, but providing also traditional country sports and recreations. Many scenes of great events throughout Scottish history lie within the region.

In the north-west, the Trossachs form the gateway to the scenic grandeur of mountains and glens which attract an ever increasing stream of tourists and extend far beyond the bounds of the map. Forestry, greatly expanded in recent decades, now shares this landscape with the more traditional sheep walks.

In contrast, east of the mountains, the River Forth flows through the flat, expansive farm lands of the Carse before passing under the walls of the ancient castle of Stirling rivalling in historic fame and its craggy eminence its sister fortress in Edinburgh, now the haunt of tourists and the site of military celebrations in the national capital. The Firth of Forth divides the ancient Kingdom of Fife on its northern shore from the Lothian counties on its southern. In both, louring heaps of slag, the remnants of declining coal mines and heavy industry, overlook rich farm lands long famed for their fertility. The extensive undulating lowland, interrupted sporadically by hills of volcanic rock, is fringed by coast-lands with tourist resorts and golf courses, amongst which the Old Course at St Andrews has world-wide renown.

Southward to the national boundary with England, the hills of the Southern Uplands enfold the historic border towns, known for their woollen industry, rugby and the celebratory riding of their marches. To the west the smithy at Gretna Green was once the destination of eloping lovers and in the east the lowlands, known as the Merse of Berwickshire, along the lower course of the River Tweed are amongst the most fertile of the national farm lands.

GEOLOGY, PHYSICAL FEATURES, LANDFORMS AND PARENT MATERIALS

The birthplace of many who laid the foundations of geologic science, Scotland has been the subject of long-continued study. Much is known of its rocks and

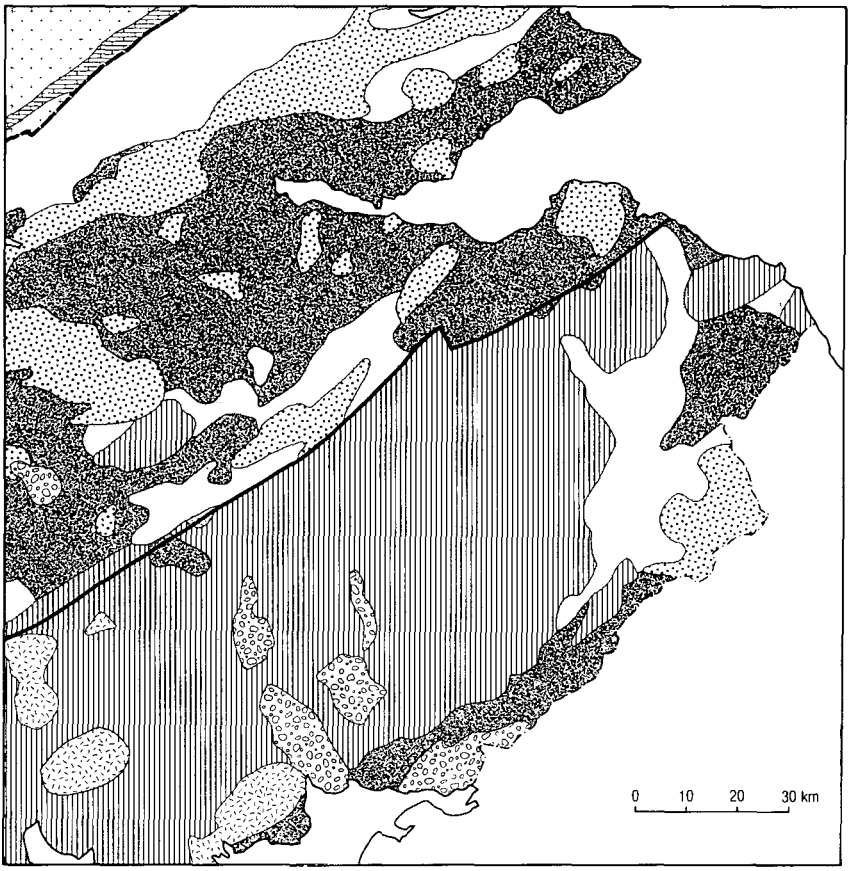
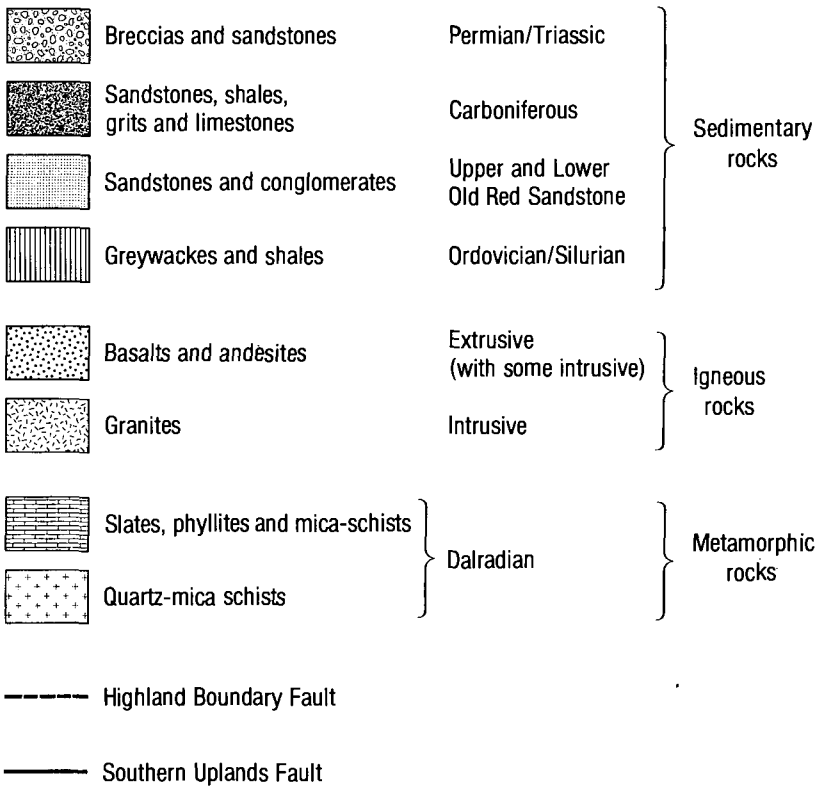


Figure 2. *Geology*

their history of which the British Regional Geology handbooks (Johnstone, 1966; MacGregor and MacGregor, 1948; Greig, 1971) provide excellent accounts. Below, brief reference only is made to the salient rock types, their relationship to landform, and the superficial deposits which form the parent materials of the soils.

South-East Scotland, like the rest of northern Britain, has been endowed by a long and complex geological history with a wide variety of rocks (Fig. 2) and physical features (Fig. 3). Tectonic movements along two major dislocations of the earth's crust, the Southern Uplands Fault and the Highland Boundary Fault, have created three principal structural and physiographic divisions, the Highlands, the Midland Valley and the Southern Uplands.

Each of these subregions has a characteristic assemblage of rocks on which prolonged weathering and denudation have produced long-term effects, often preserved through periodic burial and subsequent erosion and emergence. The differing response by the rocks to these geomorphological processes is influenced largely by the structures into which the strata have been folded and by lithology, principally grain size and mineral composition and degree of cementation or hardness, characteristics that also influence the pedological processes of soil development.



Many major elements of the topography, areas of upland and lowland and hills and valleys, came into existence prior to the Pleistocene glaciations. But sculpted by the erosive power of the ice-sheets or mantled by the detritus they transported, the landscape exhibits an abundance of features typifying its glacial history. The resulting variety of terrain is a predominant factor in determining soil patterns and map units. The three major landform divisions and the morphological subdivisions following Sissons (1976) are shown in Fig. 3.

THE HIGHLANDS

A small proportion only of the Scottish Highlands, extensive to the north, lies within South-East Scotland. A Dalradian age has been ascribed to the assemblage of the metamorphic rocks, mainly schistose grits, quartzose mica-schists, slates and phyllites, that underlie this mountainous area.

Many prominent features of the topography are closely related to the lithology and structure of the rocks. Resistant beds such as grits and slates form a line of prominent mountains, close to the Highland Boundary Fault, which include Ben Lomond, Ben Ledi and Ben Vorlich, while the valleys are often coincident with weaker strata such as limestones, schists and phyllites. Several mountain peaks

approach 915 metres altitude in contrast to the Midland Valley where few summits exceed 610 metres. The dip, strike and fracture of the rocks strongly influence the mountain outlines.

During the Pleistocene glaciations ice movements were largely southerly, south-easterly and easterly along the valleys of the preglacial landscape from the Highlands towards the North Sea basin. Intense erosion of the mountains and valleys has produced an abundance of ice-moulded forms, notably overdeepened steep-sided valleys often containing lochs in rock basins. The lower ground received ice-transported debris in the form of bouldery moraine or stony till. On higher ground, lodgement tills left by the ice and solifluction deposits produced, in a period of intense periglacial conditions, by frost-action on fissile strata form a thin veneer over the rocks which nevertheless, being near the surface, exercise a major influence on the soil pattern.

THE MIDLAND VALLEY

The Midland Valley extends across central Scotland between the mountains of the Highlands and the hills of the Southern Uplands. The variety of relief is wide and includes many hills of 300 metres altitude and some of 600 metres which rise from extensive areas of lowland. The rocks are mainly of Old Red Sandstone and Carboniferous age. Fine-grained, hard lavas resistant to geomorphological erosive processes form many hills and plateaux, but hard conglomerates along the margins of the subregion are also associated with high ground. In contrast the weaker sedimentary rocks of sandstone, shales and marls underlie lowlands thickly blanketed by drift. Although not a centre of snow accumulation, the subregion was engulfed by the principal Pleistocene ice-sheets, moving off the Highlands to the north and Southern Uplands to the south, which (throughout the lowlands) left behind thick deposits of lodgement till. Valley glaciers of the final Loch Lomond glaciation do not appear to have been active, but, while moraines are largely absent, gravels and sands left by the waters flowing from the melting ice-sheets are distributed widely. Deposits associated with the sea-level changes, following the retreat of the ice, occupy coastal and low-lying areas.

Within the subregion, landforms and soil map units are related closely to the rock types and to the geomorphological history of the principal physiographic features (Fig. 3). Along the Highland Boundary Fault, hard conglomerates and sandstones form uplands, reaching 665 metres altitude on Uamh Bheag. Few outcrops of rock occur on the broad, gently sloping flanks of this terrain mantled by till and solifluction deposits, which are thin on the highest ground but thicken as altitudes decrease. Between these uplands and the Ochil Hills to the south-east, the sandstone lowlands of Strathallan are covered by thick deposits of till and hummocky fluvioglacial sands and gravels. Above the spectacularly steep fault line escarpment marking their southern boundary, the Old Red Sandstone andesitic lavas of the Ochil Hills rise to form some of the highest ground in the subregion (721 metres on Ben Cleuch), but decline in altitude as the lavas decrease in thickness towards the north-east. North of their precipitous margin the hills at the western end of the range are smoothly rounded and mantled by shallow stony solifluction deposits and the valleys are narrow and steep-sided. To the east of Glen Farg, however, the hills, which here rarely exceed 300 metres altitude, are lower and less regular, while their flanks are swathed by mixed tills derived from sandstones and lavas.

Beyond and south of the gap in the hills occupied by the wide carse lands of the Forth valley, lavas of the Carboniferous Period form a series of plateaux in scenic

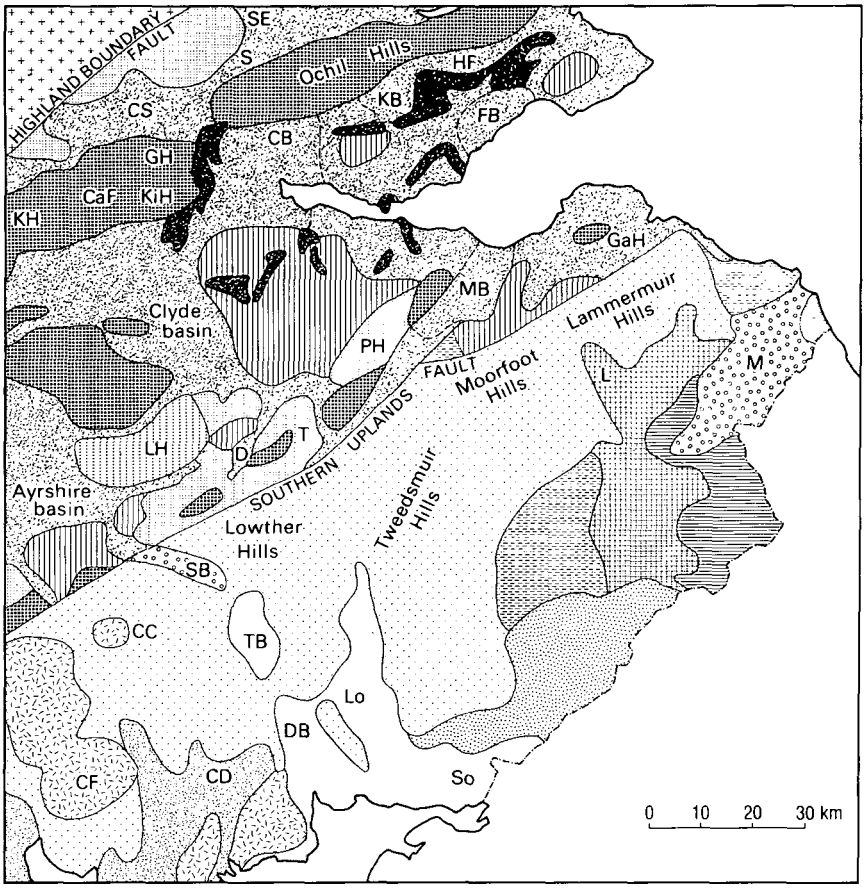
contrast to the rounded outlines of the Ochil Hills. The steep escarpments which bound the Gargunnock Hills, the Kilsyth Hills and Campsie Fells have step-like outlines along which successive lava flows can be traced by the lines formed by the differential erosion of their scoriaceous surfaces and harder basement layers. Talus and scree partially soften the outlines of these moderately rocky slopes, while on the plateaux above, drifts are shallow and stony. Similar uplands occur along the border between Ayrshire and Lanarkshire, but are mantled more extensively by lodgement tills and solifluction deposits. To the south-east of the lava hills undulating lowland terrain is extensive and is blanketed by thick deposits of clayey lodgement tills. Often moulded into elongated low drumlin ridges, the tills largely obscure the underlying rocks. Belonging mainly to the Carboniferous System, the sedimentary strata include shales and sandstones with some coals and occasional limestones and calciferous sandstones. Sissons (1976) writes 'For the most part the ground becomes lower towards the central parts of three main basins (Midlothian-Fife, Lanarkshire-Clackmannanshire and Ayrshire). Coal Measures strata often occupy the lowest ground, probably reflecting the prevalence of weak sandstones and shales'. Rocks of the Calciferous Sandstone Series occupy most of the lowlands beyond these basins, but also form an area of upland west of the Pentland Hills. Throughout the lowlands the fine texture of the tills, deriving largely from the high proportion of shale in the weak strata, is the predominant influence on the soils.

In the Pentland Hills, which form a narrow range of high ground composed of lavas and sandstones to the south-west of Edinburgh, the terrain is steep and the long smooth slopes have a thin cover of solifluction deposits. Farther to the south-west, Silurian greywackes and shales underlie high ground near Lesmahagow, and basaltic lavas and Old Red Sandstone conglomerates make up hills such as Cairn Table (593 metres) south of Muirkirk. The high isolated peak of Tinto Hill is one of several laccolithic sills of felsite cropping out near the Southern Uplands. The hard resistant rocks generally form steep slopes with shallow, very stony, soliflucted deposits and screes. Other intrusive and extrusive rocks, mainly basalts, within the Carboniferous lowlands form topographic features which are often prominent and well known locally. The rocky crags on which stand the castles at Stirling and Edinburgh are interesting examples, but the lavas of the Garleton Hills and Bathgate Hills in the Lothians and the volcanic vents of the Lomond Hills in Fife have greater effect on the soil pattern.

THE SOUTHERN UPLANDS

This hill range, aptly termed the Southern Uplands, and lying across the country from St Abb's Head to Corsewall Point, is the most southerly of the major geographic subregions. Its northern boundary, the Southern Uplands Fault, is marked by steeply rising terrain where the relatively soft, gently dipping sediments of the Midland Valley give way to the weakly metamorphosed strongly folded and harder greywackes and shales. A variety of landforms, soils and map units is produced on the hard granites in the west of the subregion and on the weaker sandstones, shales and marls in ancient valleys and basins in central and eastern areas.

The cover of soft, weathered materials on the pre-existing landscape was swept away by the ice-sheets of the major Pleistocene glaciations, but the erosive topographic effects of this episode are less severe than in the Highland subregion and confined largely to areas affected by the final glacial stage, the Loch Lomond Readvance. The steep rock walls of corries etched into the western hills,



CB	Clackmannan basin	GH	Gargunnock Hills	M	Merse of Berwick
CC	Cairnsmore of Carsphairn	GaH	Garleton Hills	MB	Midlothian basin
CD	Castle Douglas basin	HF	Howe of Fife	PH	Pentland Hills
CF	Cairnsmore of Fleet	KB	Kinross basin	S	Strathallan
CaF	Campsie Fells	KH	Kilpatrick Hills	SB	Sanquhar basin
CS	Carse of Stirling	KiH	Kilsyth Hills	SE	Strathearn
D	Douglas basin	L	Lauderdale	So	Solway plain
DB	Dumfries basin	LH	Lesmahagow Hills	T	Tinto Hills
FB	Fife basin	Lo	Lochmaben basin	TB	Thornhill basin

Figure 3. *Physiographic regions (after Sissons, 1976)*

the Moffat hills and Broad Law are spectacular topographic features, while Loch Doon, Loch Trool and St Mary's Loch occupy glacially overdeepened rock basins. When glaciers were still active in these localities, however, most of the Uplands were free of ice and subjected to periods of periglacial activity. Frost acting on the shale and slate rocks produced abundant rock debris which was transported downslope to form the extensive solifluction deposits that mantle and smooth the hill slopes in central and eastern areas. Rugged ground with rock outcrops is confined largely to the western hills and to lowlands in Kirkcudbrightshire where rock knolls crop out frequently across eroded terrain. Sands and

HIGHLANDS


Mountains of Dalradian metamorphic rocks

MIDLAND VALLEY


Lowlands of Carboniferous and Old Red Sandstone sedimentary rocks


Plateaux of Carboniferous sedimentary rocks


Uplands of volcanic rocks


Uplands of Old Red Sandstone sedimentary rocks


Uplands of Ordovician and Silurian rocks


Major cuesta-forming sills

SOUTHERN UPLANDS


Uplands of Ordovician and Silurian rocks


Low plateaux of Ordovician and Silurian rocks


Lowlands of Ordovician and Silurian rocks


Lowlands and scattered hills of Old Red Sandstone rocks


Uplands of granite and associated metamorphic rocks


Uplands of volcanic rocks


Border Uplands, mainly Carboniferous and Silurian rocks


Lowlands of Carboniferous sedimentary rocks


Lowlands of Permian and Carboniferous rocks

gravels left by waters flowing from the melting ice-sheets occupy many valleys, while around the coasts are the materials of raised beaches formed in periods of still-stand during differential movements of land and sea consequent on the disappearance of the ice.

The close relationship of landforms and soils to the rocks and the geomorphic history of the major physiographic features is illustrated well in this subregion (Fig. 6). The Lowther, Tweedsmuir, Moorfoot and Lammermuir Hills typify the central and eastern parts of the Uplands and the comments by Sissons (1976) are apt. 'Much the greater part of the high ground is composed of folded Ordovician

and Silurian sedimentary rocks, mainly greywackes, shales and mudstones, that are associated with the typical Southern Uplands scenery of rounded hills and smooth slopes. These forms relate largely to the rapid lithological variations and often steep dip that cause individual beds to have narrow outcrops that have not favoured the production of large structurally controlled features. Weathering of these rocks rarely results in the production of boulders, but instead produces mainly small flattish stones and lesser debris that contribute further to the rounded appearance.'

West of the River Nith ice-cover probably persisted longer than farther east and the period when periglacial conditions obtained was shorter. As a consequence, solifluction deposts are thin and broken and have little effect in smoothing the rugged topography produced by erosion and ice-plucking of the rock. Many soil map units, therefore, are typified by rocky or rock-controlled terrain. The most rugged landforms occur, however, on the Galloway granites of Loch Doon–Loch Dee, Cairnsmore of Fleet, Criffel and Cairnsmore of Carsphairn where the scenery of ice-eroded hills with an abundance of bare rock resembles, although on a reduced scale, that of the Highlands. A further large granite mass, The Cheviot, lies south of the Border in north-eastern England, but the Old Red Sandstone andesitic lavas around its northern flanks extend into Scotland to form smooth, rounded hills, the many steep slopes of which are mantled by shallow solifluction deposits and very stony stabilized screes. To the west this steep land gives way to undulating upland and hills underlain by sandstones. Weaker than the adjacent greywackes and lavas, weathering of these rocks of the Carboniferous Period has produced long, gentle and strong slopes smoothed by thick deposits of clayey lodgement tills along the valleys and basal hill slopes, while loamy and sandy soliflucted materials cover the summits and upper hill slopes. Generally simple soil patterns and map units characterized by a few major soil subgroups predominate on these smooth, non-rocky landforms.

Around the upper reaches of the River Teviot and near St Abb's Head on the east coast the greywackes and shales form plateaux at altitudes lower than the nearby hills. Rock knolls and intervening ground with stony rock debris produced by frost action characterize much of the glacially eroded landscape along the River Teviot and form soil patterns and terrain related to lowland areas of Kirkcudbrightshire. Similar land at lower altitudes occurs near St Abb's Head, but here lodgement till on the undulating ground on Coldingham Common covers the rock over much of the area. As on the Teviot plateau, intense glacial erosion of the Ordovician and Silurian rocks in the lowlands of Kirkcudbrightshire has produced an irregular landscape with an abundance of rock knolls, but here there are also many drumlins composed of thick clayey till scattered across the eroded ground, giving landforms typical of lowland Galloway.

Constricted at Enterkinfoot and Auldgirth to narrow, gorge-like reaches overlooked by greywacke hills, the valley of the River Nith is divided into three basins. At Sanquhar, in the uppermost of these, gently dipping, relatively soft, Carboniferous sandstones, shales, mudstones and coals underlie gently sloping terrain, with a thick cover of clayey tills, resembling in most respects the lowlands of the Midland Valley to the north. Although stony drifts and tills predominate on the slopes around Thornhill and Dumfries, the country rocks are largely obscured in the valley by alluvium and fluvioglacial gravels which overlie the Permian sandstones. Till derived from similar strata in the Lochmaben basin forms undulating, partially drumlinized terrain, while thick till deposits derived from weak Carboniferous and Permian sedimentary rocks form the gently undulating coastal plain of eastern Dumfriesshire.

Lowlands are also developed extensively along the eastern part of the Border in the basin of the River Tweed and have been described by Sissons (1976). 'The lower ground of the Tweed basin comprises three morphological units related to geology. The lowest ground in the east is mainly coincident with Carboniferous sedimentary strata largely concealed beneath thick drift that is strongly drumlinized. To the southwest a curved belt of low hills corresponds with a faulted outcrop of Carboniferous lavas. This is succeeded by an area of Old Red sedimentary rocks, interrupted by a series of intrusions that form conspicuous hills. Among the latter are the two Dirrington Laws, composed of felsite, Fans Hill formed of agglomerate, and the Eildon Hills (422 metres), of trachyte and felsite, whose three distinct summits are a prominent landmark in the Border country.'

CLIMATE

One of the principal factors affecting both soil and plant growth, climate also exercises, both directly and indirectly, a major influence on other aspects of agriculture such as crop rotations or housing for stock. Temperature and rainfall, which contribute the energy available for weathering and biotic activity and the water for leaching and gleying, are the principal climatic elements affecting soil formation.

South-East Scotland, like the rest of northern Britain, has a climate which is equable and temperate with a moderate to high rainfall more or less evenly distributed throughout the year and without large fluctuations of temperature. The wind regime is governed largely 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. Some indications of the distribution and strength of winds over the highest ground is given by the anemometer on Lowther Hill which shows a predominance of westerly winds with a frequency of nearly 60 per cent, to which the winds of summer and autumn make the biggest contribution. Winds from the north and east have been recorded as prevalent in spring and early summer at Leuchars, Fife, just beyond the northern limit of the region.

The principal physiographic features greatly influence the penetration of winds into the various sectors of the region and the interaction of air-flows with the main landforms governs the climatic range within the area. The rise of the moist westerly winds over the hills of the western Southern Uplands or the Highlands leads to the high levels of precipitation, 2500 millimetres per annum on the highest ground. Moisture loss increases as the air masses move eastwards and rainfall declines, 1750–2000 millimetres per annum being the maximum on the Lowther and Moffat Hills, the Campsie Fells and the Ochil Hills, and 1000 millimetres on the Moorfoot and Lammermuir Hills farther east. Lying adjacent to the North Sea, the notable arable lowlands of Fife, the Lothians and Berwickshire are protected from westerly moist winds by high ground, and the relatively low average rainfall of 600 to 800 millimetres per annum facilitates cultivations and the harvesting of crops. These areas are, however, open to the cold northerly and easterly winds which can delay the rise of temperatures in the spring. In contrast the lowlands of Dumfriesshire and Galloway are screened from northerly or easterly winds by high ground and warm moist air from the south-west brings the high average precipitation of 1000 to 1250 millimetres per annum conducive to the growth of abundant grass.

'The distribution of rainfall in the arable eastern areas is', as described by Ragg and Futty (1967), 'not the most propitious for agriculture. Normally winters are

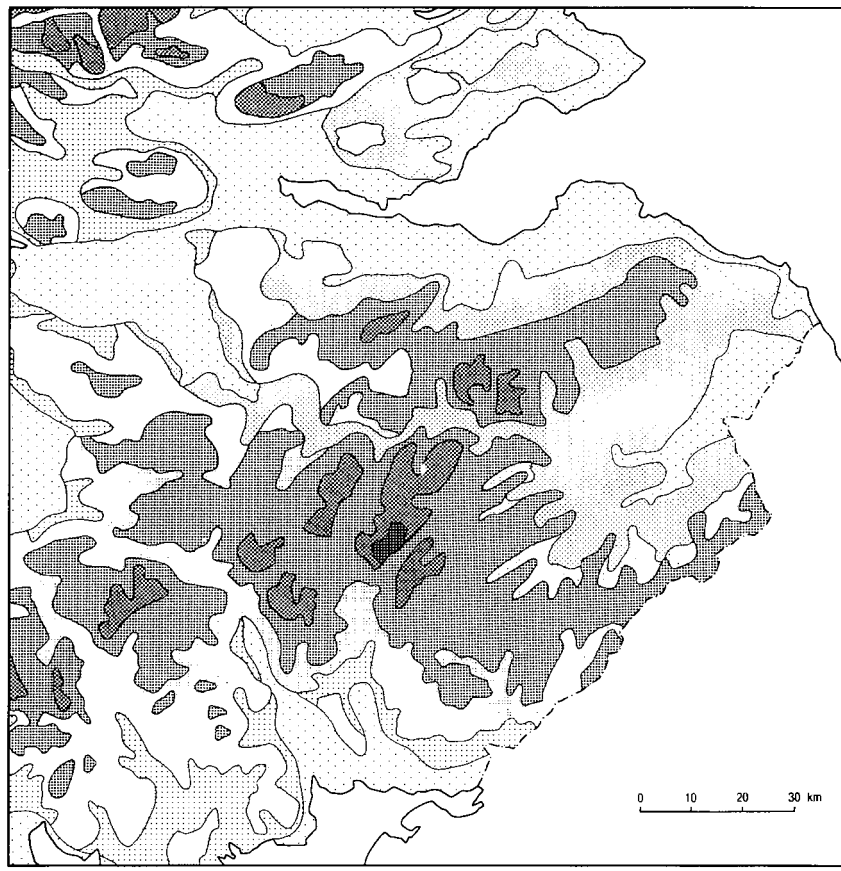
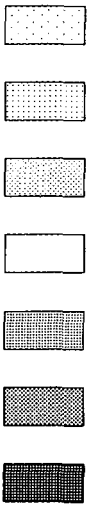


Figure 4. *Climate*

not very wet, springs and early summers are dry, while peak rainfall occurs in late summer.' In western areas autumn and early summer are the wet seasons of the year, about 45 per cent of the annual total precipitation falling during the months October to January. The increased frequency of easterly winds in spring is associated with a marked change in the rainfall pattern with April generally being the driest month. Thunderstorms originating above the hills, but often drifting on westerly winds over the eastern lowlands, 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-East Scotland is probably rather steeper, largely as a result of the prevalence of polar maritime air masses in the region. Mean annual temperatures in the lowlands are generally in the range 8–9°C, and at about 250 metres at Eskdalemuir and Whitchester are 7.1 and 7.3°C respectively; at 400 metres at Leadhills 6.7°C obtains with 4°C at 700 metres on Lowther Hill. The growing season, defined conventionally as the period when daily mean temperature is 5.6°C or above, is in the range 245–260 days in the



warm and moderately dry

warm and wet

fairly warm and moderately dry

fairly warm and wet

cool and wet

cold and wet

very cold and wet

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

Potential Water Deficit Divisions	
RANGE (mm)	DESCRIPTION
›25	moderately dry
‹25	wet*

* The wet division incorporates the 'rather wet' and 'wet' divisions of Birse and Dry

After Birse and Dry (1970)

lowlands of Galloway and Dumfriesshire, on the Lothian plain it is 225–250 days, at St Andrews 245 days and 219 days at Kelso; it declines to 211 days at Whitchester (256 metres altitude), 190 days on the Lammermuir Hills (300 metres altitude) 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 °C, the cool uplands 825–1100 day °C, with even more severe conditions, 275–550 day °C, on the mountain tops. The well-known arable farming districts of the east of the region are mainly in the warm category but many arable crops are also grown in the peripheral, fairly warm (1100–1375 day °C) areas. South of the Southern Uplands, the lowlands of Kirkcudbrightshire and Dumfriesshire are characterized as 'warm'.

Average values for potential evapo-transpiration range from 532 millimetres in coastal Kirkcudbrightshire to 230 millimetres at Talla at 300 metres altitude in the Southern Uplands and decline further with increasing altitude. Values for East Lothian are 470 millimetres, for Berwickshire, East Fife and lowland Kirkcudbright 460 millimetres and coastal Fife 500 millimetres per annum.

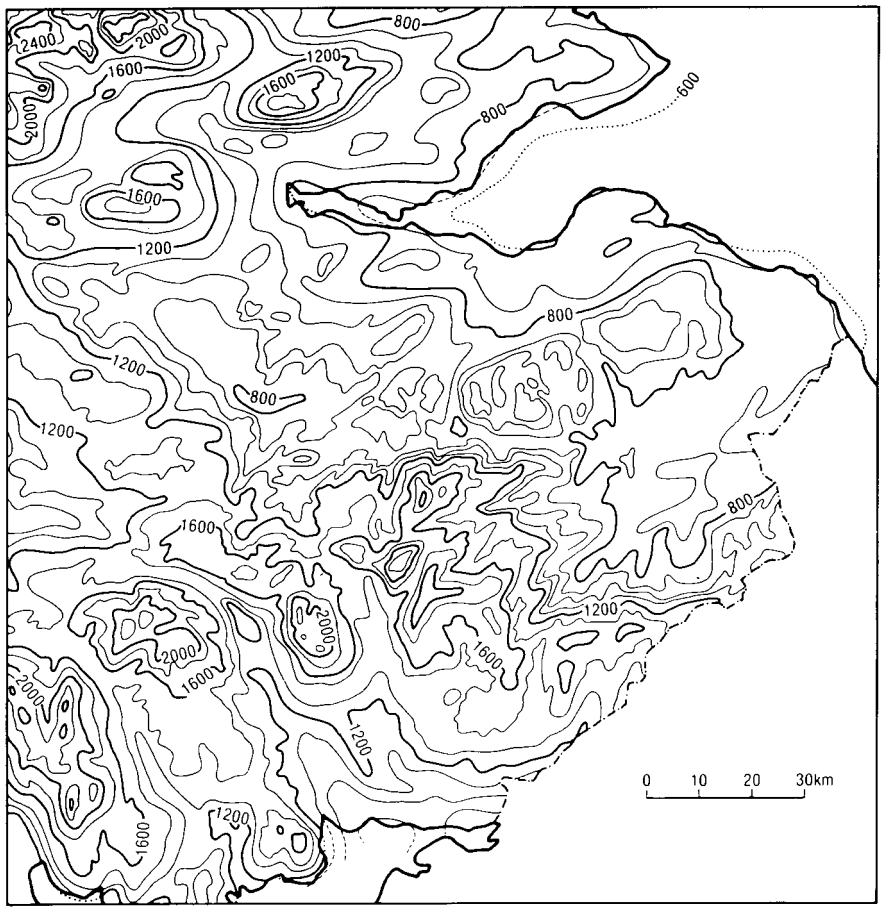


Figure 5. *Rainfall (average annual, mm)*

Humidity, which is generally at sustained high levels in South-West Scotland, can be rather less farther east. In particular, temporary 'foehn' effects result from westerly winds, having lost moisture in crossing the western mountains, being warmed by increased pressure as the air descends into the eastern lowlands with a consequent marked reduction in relative humidity.

A contrasting meteorological phenomenon affecting most eastern coastal areas in spring and early summer is haar. This occurs when warm easterly winds from the continent are cooled by the North Sea to produce fog. The fog-laden air can reduce the amount of sunshine and maintain very moist and unseasonably cool conditions for several kilometres inland from the coast for periods of some days at a time. The eastern coastal lowlands are, however, relatively sunny within the context of Scotland, with 1480 hours per annum at Dunbar, 1461 hours at St Andrews and 1334 hours at North Berwick; 1300 hours is general in most lowlands, 1269 at 152 metres altitude at Marchmont House in lower Tweeddale, declining to 757 hours at 723 metres on Lowther Hill.

Average annual earth temperatures at depths of 30 centimetres are exemplified by values for Dumfries, 9.2°C, Smeaton 9.0°C, St Andrews 8.9°C, Cupar

8.5°C and, on higher ground, Eskdalemuir (262 metres altitude), 8.4°C, and Boghall (195 metres altitude) 8.0°C.

Exposure is defined as the influence of air movements over an extended period on the development and survival of living organisms (Birse and Robertson, 1970). Its effects are complex and difficult to quantify, yet are of undoubted importance to agriculture and forestry. A map produced by Birse and Robertson (1970) shows the coastal areas between Dunbar and Berwick, of western Fife and along the Solway Firth as exposed (average wind speeds in the range 4.4–6.2 metres per second). In most other lowlands, exposure is moderate (2.6–4.4 metres per second) but in many valleys the land is sheltered (less than 2.6 metres per second). Notable examples are the Clyde valley between Crossford and Hamilton, the Tweed and Teviot valleys farther east, the Tyne and Esk valleys in the Lothians, small areas in Fife and the Nith, Annan and Esk valleys in Dumfriesshire. Like the coastal areas, most uplands and hills are exposed, with very exposed land on many summits and extremely exposed conditions on high mountains. An important result of exposure is the effect of wind chill on livestock, especially in wet weather in upland areas.

In general, the severity of frost increases away from the coast and with rising altitude, but its incidence is subject to wide variation between seasons and is strongly affected by the local configuration of the land. Freezing of the ground in winter is often considered beneficial, in that heavy machinery, especially for slurry disposal, can get on to the land and cloddy soils are broken down and soil structure improved. Unseasonable early or late frosts in autumn or spring are feared, however, for the severity of damage to sensitive crops, such as early potatoes, soft fruit or market garden produce. Accumulated frost is used by Birse and Robertson (1970) to indicate the severity of winters, which in most lowlands of this region are fairly mild (20–50 day °C of frost) or moderately severe (50–110 day °C).

In the many narrow valleys of the Southern Uplands, parts of the Ochil Hills and the Highlands, much of the land slopes steeply and aspect influences the local climate. A south-facing slope of 20° can be equivalent to a southerly shift of 8–9 degrees of latitude and a similar north-facing slope to a northerly shift of 12–15 degrees of latitude (Chandler and Gregory, 1976).

Temperature and rainfall are the principal climatic influences on soil formation, with wind important in modifying the effect of temperature. These factors govern 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, but humus-iron podzols, often associated with coarse-textured, siliceous parent materials and moderate or low levels of rainfall, also occur. Peaty soils, mainly peaty podzols, peaty gleys and organic soils occur principally in the cool and cold zones and subalpine and alpine soils in the cold and very cold zones. Soil temperatures tend to be high within the low rainfall eastern areas of the region and in comparison with western high rainfall areas, breakdown of organic matter is rapid.

SOILS

As the mantle of naturally occurring mineral or organic material over the earth's surface that is capable of supporting plant growth (Canada Soil Survey Committee, 1978) the soil is, and has been from time immemorial, the fundamental resource for agriculture, forestry and many other of Man's activities.

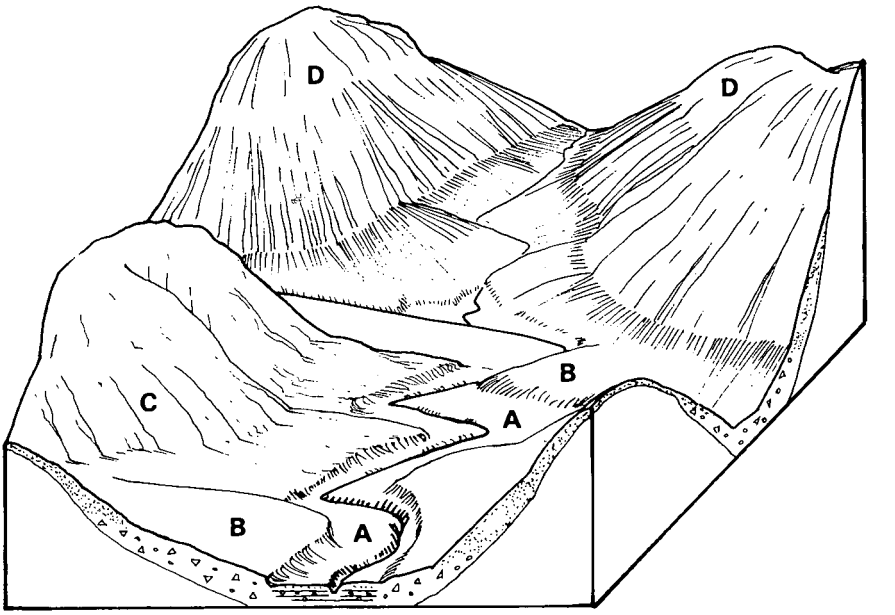
While soils develop during the course of time by the interaction of other environmental factors, principally geology, landform, climate and biology, these are themselves in varying degrees mutually interdependent, so that their effects are complex and are modulated by a variety of processes at present only partially understood.

Organic matter present in the upper layers is one of the principal distinguishing features of soils and forms by the accumulation of plant remains either on the surface or incorporated and intimately mixed with mineral soil constituents. This plant debris provides the energy supply for a vast number of microorganisms and small animals by which it is broken down and converted into humus, a chemically complex soil component consisting of many different entities. Morphologically, humus occurs in forms related to soil acidity, wetness and temperature and their effects on the types and activity of organisms present. Long recognition has been accorded to its agricultural importance as a factor in the promotion and stabilization of soil structure, the creation of a medium favourable to root proliferation and a reserve of plant nutrients. It also has a role in the weathering and leaching of inorganic constituents and the development and differentiation of soil layers or horizons.

The physical weathering of rocks and the geomorphic processes leading to the formation of unconsolidated superficial deposits, the parent materials of soils, have received mention. In Scottish landscapes these materials and the soils are, in a world context, young, often less than 13 000 years old, and in some instances, less than 10 000 years. Many properties of the parent materials, little altered by soil formation, are inherited directly therefore by the soils, while others have a predominating influence on the processes of development. Of major agricultural importance, stoniness is a property of geologic origin; soils with large amounts of stone on gravels, or stone-free soils on estuarine raised beach silts and clays, are but two examples of this relationship. Texture, another agriculturally important inherited characteristic, can in addition, through its predominant influence on soil moisture relationships, have a major effect on the soil forming processes leaching and gleying. Almost invariably freely draining, the soils found on coarse-textured parent materials are strongly leached and the resulting high acidity leads to increased weathering, reduced biotic activity, and movement of inorganic constituents within the soil. At the opposite end of the textural range, permeability to moisture is low in soils with high amounts of clay; waterlogging, periodic or prolonged according to climate or topographic position, induces anaerobic conditions and the resulting gley morphology dominates the soil profile.

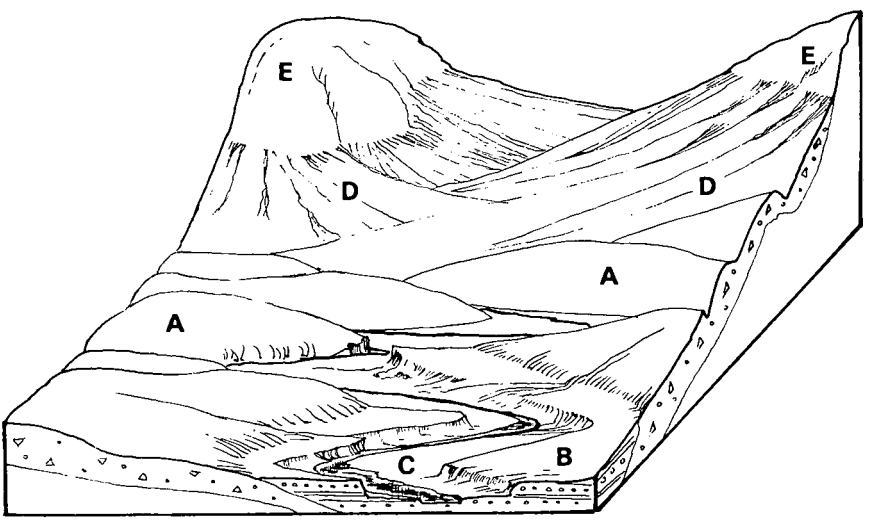
Mineralogy, grain size, chemical composition and hardness have a major effect on the physical breakdown and comminution of rocks into unconsolidated materials and also influence chemical weathering, the formation of clays and poorly-ordered materials, the redistribution of constituents between soil layers and the removal of soluble bases in drainage waters. Igneous rocks give rise to soils dominated in the early stages of formation by primary minerals, crystallized at high temperature, such as quartz, feldspars, micas and ferromagnesian minerals, and their transformation into secondary products stable under the contemporary subaerial weathering environment, clays and poorly-ordered or allophanic materials. Sedimentary rocks, composed of the weathering products of earlier geologic epochs, however, endow the soils on their derived drifts with clays and other materials not necessarily related to conditions in contemporary soils.

Under free natural drainage leaching is a dominant feature of soil formation and acidity develops rapidly in soils on parent materials derived from quartzose



A Alluvial terraces
B Till terraces and footslopes
C Head footslopes
D Thin drift covered hills

Figure 6. *Landforms of the central and eastern Southern Uplands*



A Till plain ridges and drumlins
B Fluvioglacial terrace
C Alluvial terrace
D Hills with till cover on lower slopes
E Stony drifts

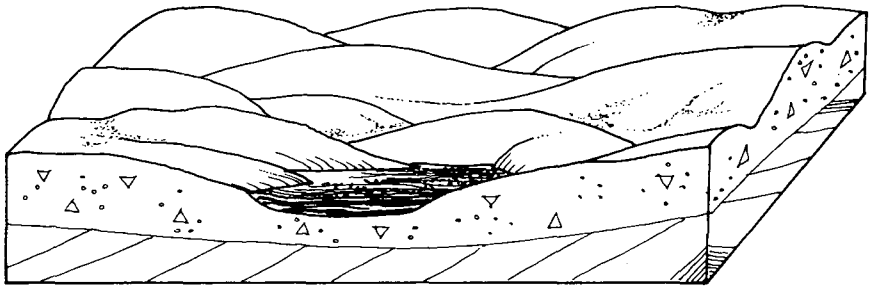
Figure 7. *Landforms of the Berwickshire till plain and adjoining areas*

rocks such as quartzites, gneisses, quartz-schists, granites, felsites and many sandstones. Quartz, itself largely unaffected by contemporary weathering, supplies no nutrient bases, while the potassic feldspars and white micas break down only slowly. Against the strong leaching intensity in cool moist maritime climates weathering maintains only low levels of bases and fertility and biotic activity becomes reduced and acidity strong. Plagioclase feldspars and ferromagnesian minerals in crystalline rocks, such as basalts, dolerites and gabbros, break down more readily, however, and nutrient levels maintained against the impoverishing effects of leaching are greater. Soil acidity develops more slowly and greater biotic activity results in a more rapid turnover of a larger nutrient pool in the biomass. A few soils characterized by high contents of magnesium on ultrabasic rocks, such as serpentine, have certain elements such as nickel present in amounts deleterious to crop growth. Although of very minor extent in Scotland, carbonatic rocks, limestones and chalks, provide parent materials on which soils remain neutral or only moderately acid under all except the most severe leaching conditions. Some sedimentary rocks also are lime rich and shells are present in some unconsolidated deposits.

Gley morphology, greenish grey soil colours and rusty-coloured patches, concretions, and tubules around channels of former roots, is characteristic of soils in which wetness is a dominant factor influencing development. Wet conditions can take the form of either a high ground-water table within the soil profile as often found in low-lying medium- or coarse-textured alluvial soils, or waterlogging in the upper layers of fine-textured soils in areas of high rainfall. Exclusion of oxygen from the soil pores by water and the resulting anaerobic conditions leads to the reduction of elements, such as iron and manganese, able to exist in oxidized and reduced states. Under acid regimes, iron in the reduced form is mobile and can be leached from the soil which becomes pale in colour, but under neutral or only moderately acid conditions it accumulates, giving the soils characteristic greenish grey colours. Plant residues break down only slowly under wet and anaerobic conditions and often remain at the surface as peat or the O horizon of peaty gleys or peaty podzols.

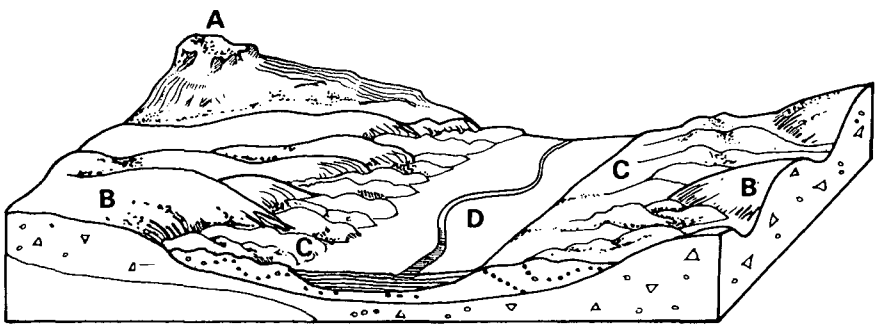
SOIL PATTERNS AND TRENDS

Characteristic trends and relationships of a wide variety are found amongst the many soils of the subregions and localities of South-East Scotland. In the Southern Uplands, 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 typical pedologic development is exemplified in the area around Peebles. Here the stony, medium-textured drifts, mantling the smooth steep slopes to depths of 1 to 10 metres, allow rapid run-off of water and free internal drainage. High rainfall contributes to the leaching of mineral elements without causing waterlogging. The resulting pH levels are low and the soils are subject to weathering in strongly acid conditions with the accumulation 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, the mid-slopes carrying humus-iron podzols, and, with increasing altitude, peaty podzols occupying many upper slopes and hill summits below 600 metres. Above this altitude the soils are transitional over a broad zone to subalpine soils on the high mountains. It is notable, however, that on the hills of the western Uplands, humus-iron podzols are poorly developed or are absent from the sequence.



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

Figure 8. *Landforms of the Midland Valley till plain*



A Volcanic plug
B Drumlins of till plain
C Fluvioglacial terraces and mounds
D Alluvial flat

Figure 9. *Landforms of Fife*

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 biologic agencies. Below the Ah horizon, the B horizon is friable, has moderate or weak blocky or subangular blocky structure and has bright, strong brown or yellow-brown colour with high chroma. The content of poorly-ordered sesquioxidic materials in this layer, although high, does not necessarily much exceed the amount 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 podzols: humus-iron podzols in central and eastern parts of the Uplands, peaty podzols in western areas (Handbook 6 of this series). Occurring mainly on mid-slopes less steep than lower-lying land, the humus-iron podzols predominate under extensive Atlantic heather moor plant communities,

principally dry Atlantic heather moor, although moist Atlantic heather moor is also present as is white bent grassland. The transition from brown forest soil to humus-iron podzol is subject to influences which, although complex, appear to be associated with increased leaching and soil acidity, lower temperatures, an absence of earthworms and lower biotic activity, together with plant litter more resistant to biological breakdown. Decomposed plant remains accumulate at the surface to form a layer of black mor humus, an H horizon, which can be up to 15 centimetres thick and is generally dry and fibrous. The underlying grey and sandy E horizon is typified by the prominent appearance of an abundance of loose uncoated grains, and has weak structure, and low content of ferruginous weathering products due to leaching (generally ascribed to the actions of solutions from the organic layer, although some recent evidence suggests the movement can take place in inorganic form). Below this, a dark reddish brown B horizon with a high content of ferruginous weathering products is enriched by organic matter redeposited from soil solutions seeping from the surface layers. This horizon, which can be cemented or form a pan, overlies an ochreous bright-coloured B horizon with friable blocky structure, similar to that of the brown forest soils. Induration is often present in the lower part of the B horizon and in the parent drift.

In comparison with the transition from brown forest soils to humus-iron podzols, that between humus-iron podzols and peaty podzols on higher-lying land is gradual and takes place over a wide zone. The horizons and profiles of these soils, which can be envisaged as a developmental sequence, are closely related. Higher rainfall, humidity and/or cooler temperatures are associated with a considerable increase in the thickness of the organic matter surface layer, the greater water-holding capacity of which, together with the more humid climate, leads to prolonged wet conditions at the surface, further reduction in the rate of organic matter breakdown and the formation of a peaty layer. The dominant plant communities are moist Atlantic heather moor or heath rush–fescue grassland. Also remaining wet for long periods, the underlying pale-coloured or grey E horizon is subject to both leaching and gleying; structure is weak and the content of ferruginous weathering products low. Sharply demarcating the lower limit of this horizon is a thin iron pan, strongly cemented and impeding root and moisture penetration. It overlies an ochreous, bright-coloured Bs horizon similar to that of the humus-iron podzols and induration is also often present in the lower part of the profile.

Above an altitude of about 600 metres, weak horizon development presages the transition from peaty podzols to subalpine soils on the high mountain summits, a change which is often gradual over 75 metres or so of altitude. Subalpine soils are usually frozen for several months of the year and the chemical breakdown of minerals is very slow, leaching and impoverishment of nutrient bases is intense and biotic activity is low. The soils have a typically loose open fabric, are stony and the surface O horizon is only 10 centimetres or so in thickness. Bleached sand grains and grit particles appear in the underlying E horizon in which the content of dark-coloured organic matter is nevertheless high. The Bh horizon is dominated by dark organic matter and the dense organic coatings on the sand and grit particles are a notable feature. Ochreous layers characterized by sesquioxidic weathering products are often discontinuous or weakly developed.

Similar soil sequences are present in many areas of hilly terrain with long smooth slopes spanning a wide altitudinal range. Notable examples are the lava hills north of The Cheviot and the Ochil Hills, although the differentiation of horizons is often less clear in these soils in which weathering is dominated by the

chemical breakdown of fine-grained igneous rocks of intermediate composition and sand-sized silica particles are largely absent.

In contrast with the smooth slopes typical of most of the Southern Uplands, the landscapes of much of the Highland subregion and of the Galloway granite hills and surrounding uplands are typically rugged with much rock cropping out and the soils developed on the superficial drifts are shallow. Soil changes in this terrain are related principally to slope and occur rapidly over short distances. Wetness, a strong propensity for peat development and topographically controlled complex patterns of run-off are other aspects of the soils. Mapping at almost all scales requires the recognition of soil patterns and groupings related to landforms.

While the soil sequences in the Southern Uplands relate mainly to differences of leaching intensity and the form and type of organic matter, the soils of the Midland Valley are influenced primarily by the thick mantle of lodgement till which forms the smooth undulating landscapes. Similar relationships of landforms, tills and soils are found in the Merse of Berwickshire, the Sanquhar basin and on the Solway plain. Differences of appearance and colour associated with the lithology of the parent rocks typify individual tills, but in the main all are of moderately fine or fine texture, sandy clay loam or clay, and very slowly permeable to excess moisture. The climate is less wet than in the hill ranges lying to the north and south, but rainfall, which ranges widely in amount, 750 millimetres per annum in eastern coastal areas to 1250 millimetres in the west of the subregion, exceeds the loss of moisture by evapo-transpiration. High levels of moisture prevail, therefore, in the soils and upper till layers for periods of the year, the lengths of which vary with rainfall and, under natural conditions, waterlogging is persistent in the winter months. The resulting exclusion of air and oxygen from the soil pores and spaces leads to anaerobic conditions, and gleying becomes a dominant process in the soil. 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 greater where organic matter from Ah horizons promotes microbiological activity and oxygen decreases 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 and 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 tills derived from the Carboniferous shales are extensive in central and western parts of the subregion.

In Fife, the Lothians, the Merse of Berwickshire and the Solway plain, where rainfall is moderate or low, the soils are also characterized by slow permeability, but waterlogging, although a major factor in soil development, is less severe and the formation of gley features is less intense. Gley features, less strong than in the gleys, are also characteristic of the soils developed on red-brown sandy clay loam tills derived from Old Red Sandstone strata, partly on account of the resistance to alteration of the strong haematitic coatings on sand and other particles. Soils with only moderately or weakly developed gley morphology are placed in the major soil subgroup of brown forest soils with gleying.

The moderate levels of leaching, pH and base saturation of the fine-textured

soils of the lowlands are allied with warm and generally moist, but occasionally wet, climatic conditions favouring 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 cultivation has disrupted and mixed the surface layers 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.

Brief mention is given to some other soil and environmental relationships. Blanket peat is developed extensively on some gentle slopes and undulating ground amongst the uplands, promoted by high rainfall, cool temperatures and soil wetness. Where peaty surface layers are less than 50 centimetres thick, peaty gleys developed on clayey tills and drifts are associated with the peat. In north-west Dumfriesshire above Penpont and Moniaive, where the valley sides are steep and concave and the prevailing rainfall is high, loamy often thin drifts carry noncalcareous gleys strongly affected by flushing and seepage from higher ground.

Brown forest soils with free natural drainage predominate on the coarse-textured parent materials on the coastal raised beaches and on fluvioglacial outwash sands and gravels in some valleys and other areas. Distinctive soil patterns related to the effects of glacial erosion and deposition in southern Kirkcudbrightshire form *map units 439* and *440*. Windblown sands, as on Tentsmuir, Fife, have regosols in which soil development is restricted to some organic matter accumulation in weakly developed, thin Ah horizons resting on raw sands. In other coastal areas, mainly along the Solway Firth, saline alluvial soils (shown in the map legend as saline gleys but now reclassified) are developed on marine alluvium lying below the high-water mark of ordinary spring tides and subject to periodic inundation by the sea.

SOIL CLASSIFICATION

The wide environmental range in South-East Scotland and the many interacting pedologic processes have led to the development of soils displaying a large variety of forms and properties. Amongst this diversity, soils having sequences of horizons similar in morphology and chemical characteristics are classified according to the system used by the Soil Survey of Scotland and published in its memoirs. Based mainly on central concepts, this system is typological rather than definitional in the sense of Butler (1980) and is described in Handbook 8 of this series. It comprises three levels, the division, the major soil group and the major soil subgroup, the last being the most commonly used and that principally quoted in the soil column of the map legend. As already mentioned, the young soils of

Scotland have many properties inherited from, or closely linked with, the parent materials and the relationship is expressed through the soil association: a grouping of soils developed on one recognizable parent material. Although not recognized as map units in this wide-ranging small-scale survey, soils in one major soil subgroup and developed on the same type and composition of parent material constitute the basic soil individuals, termed the soil series, which form the principal map units at medium or large scales. Comments on the soil groups as they occur in this region are given briefly below.

Division 1 Immature soils

Major soil group 1.1 Lithosols

Lithosols are associated with very rocky areas and comprise soils less than 10 centimetres thick overlying hard rock. They have been recognized only in *map unit 515* but in association with rankers are present to a small extent in most map units on rocky landscapes.

Major soil group 1.2 Regosols

Regosols are recognized only on unconsolidated windblown sands. There is a thin Ah horizon, formed by the incorporation of organic matter and resting on raw sand.

Subgroup 1.2.1 Calcareous regosols are included in the Fraserburgh Association, a grouping of soils developed on sands having particles of comminuted shells.

Subgroup 1.2.2 Noncalcareous regosols occur on the non-shelly windblown sands of the Links Association. Buried soils are often present.

Major soil group 1.3 Alluvial soils

Alluvial soils are developed on Recent freshwater or marine alluvium usually beside water-courses or at the shore.

Subgroup 1.3.1 Saline alluvial soils are developed on marine alluvium between the normal high-water mark and the limit of highest spring tides, a zone often termed saltings. The soils have a high content of sodium (on the map legend they are shown as saline gleys but are now reclassified).

Subgroup 1.3.2 Mineral alluvial soils are found on mineral alluvium along water-courses and profiles consist of Ah horizons, which can range widely in thickness, up to 1 metre, overlying little-altered unweathered alluvium.

Subgroup 1.3.3 Peaty alluvial soils are not extensive and are found in association with mineral alluvial soils.

Major soil group 1.4 Rankers

Rankers are present in areas of rocky terrain, mainly in south-western or north-western parts of the region, where they consist of topsoils characterized by mull, moder or mor humus forms or peaty layers, overlying rock.

Subgroup 1.4.1 Brown rankers are closely associated with brown forest soils on rocky land and have surface mineral horizons with mull or moder humus overlying rock.

Subgroup 1.4.2 Podzolic rankers occur on steep hill sides with shallow rock rubble and are a component of *map unit 482*.

Subgroup 1.4.3 Peaty rankers consist of a peaty layer resting on rock and are found most commonly on scattered rock knolls at low altitudes or in montane landscapes.

Division 2 Non-leached soils

Major soil group 2.2. Calcareous soils

Subgroup 2.2.1 Brown calcareous soils are restricted to the windblown shelly sand deposits of the Fraserburgh Association.

Division 3 Leached soils

Major soil group 3.2 Brown earths

The brown earths are extensive and comprise a high proportion of arable and improved pasture land. Horizons merge gradually over diffuse boundaries, the humus form is generally mull or occasionally moder, and the reaction is acid.

Subgroup 3.2.1 Brown forest soils, as already described, extend over a wide altitudinal range, sea level to 350 metres, on parent materials of loam or coarser texture. Many soils at altitudes in the middle or upper parts of the range are strongly acid prior to any agricultural improvement.

Subgroup 3.2.2 Brown forest soils with gleying are, as already mentioned developed extensively on clayey tills throughout the lowlands and form the predominant soils of many map units. Some gley features are present in the B horizons and the soils are moderately acid. Waterlogging, consequent on increased rainfall regimes or lower subsoil permeability, leads to the formation of noncalcareous gleys.

Major soil group 3.3 Podzols

Podzols are the predominant soils of the hill areas and include some soils on very coarse-textured or quartzose parent materials at low or moderate altitudes.

Subgroup 3.3.2 Humus-iron podzols are extensive on hill slopes above about 300 metres altitude in the eastern Southern Uplands, on gravels in central Fife, and are components of a number of scattered map units. Most of these soils at low and moderate altitudes, where they occur mainly on coarse-textured parent materials, have been cultivated and the disruption and mixing of the upper horizons renders classification without elaborate chemical analyses difficult.

Subgroup 3.3.4 Peaty podzols are the predominant soils in the hill areas of the region and their characteristics and occurrence in the Southern Uplands have been described earlier.

Subgroup 3.3.5 Subalpine podzols are not extensive but predominate in the zone lying above that of the peaty podzols; in South-East Scotland they occur at altitudes exceeding 600 metres. On the map legend these soils with others of the zone are listed as subalpine soils.

Subgroup 3.3.6 Alpine podzols are minor components of two map units on the high mountains of the Highland subregion.

Division 4 Gleys

Major soil group 4.1 Surface-water gleys

Surface-water gleys exhibit gley morphology strongly developed in the horizons below the organic layers, which can be of the mull or peaty form. Gleying becomes less prominent with depth. In many strongly gleyed soils, however, the distinction between the effects of surface- and ground-water can be difficult. Most gleys, with the exception of those on coarse-textured parent materials, have been interpreted as surface-water gleys.

Subgroup 4.1.4 Noncalcareous gleys are characterized by surface horizons with mull humus and are found principally on fine-textured parent materials, either in low-lying topographic positions or in situations affected by flushing. They occur widely in the lowlands and valleys amongst the hills and form a component of a large number of map units.

Subgroup 4.1.5 Humic gleys have dark-coloured A horizons with a high content of organic matter. They occur principally on hill slopes and in valleys where extremely wet conditions are maintained by springs and water seeping from higher ground, but are also found where the organic matter of former peaty surface layers has been mixed with mineral soil by cultivation and the base status raised by liming and fertilizers.

Subgroup 4.1.6 Peaty gleys are found mainly in association with peat. They occur on gentle or strong slopes in upland areas and on medium- or fine-textured parent materials. Organic matter accumulation at the surface under wet, acid and low temperature conditions forms O horizons up to 50 centimetres thick.

Major soil group 4.2 Ground-water gleys

Ground-water gleys have gley morphology which becomes more strongly developed as depth increases.

Subgroup 4.2.1 Noncalcareous gleys have an A horizon of mull humus and have been recognized on coarse-textured parent materials, sands or gravels, in depressions. They are a minor component of a number of map units.

Subgroup 4.2.3 Humic gleys occur in hollows and depressions on coarse-textured parent materials. The A horizons, characterized by dark colours and a high content of organic matter, have been formed through the mixing of surface layers during cultivation.

Subgroup 4.2.5 Subalpine gleys and 4.2.6 Alpine gleys occur on high mountains where water is held up in declivities in the rock or is formed by the slow melting of snow banks. Placed, in the map legend, with the more extensive subalpine or alpine podzols to form the groups of subalpine or alpine soils, they form a minor component of a few map units.

Division 5 Organic soils

Major soil group 5.1 Peats

Peats have a surface organic horizon more than 50 centimetres thick. As individual soils they are extensive throughout the area and are major components

of many map units. Although in many instances a clear distinction is difficult to draw, deposits accumulated in basins or depressions under the influence of ground-water are recognized separately from formations in conditions of high rainfall, low temperatures and high humidity.

Subgroup 5.1.1 Eutrophic flushed peat is confined to areas with base-rich ground-water.

Subgroup 5.1.2 Mesotrophic flushed peat is confined to areas affected by mineral-rich springs or ground-waters.

Subgroup 5.1.3 Dystrophic flushed peat is affected by weakly base-enriched seepage waters from higher ground. It occurs widely on the lower slopes of hills and in valleys under high rainfall in the hill areas of the western parts of the region.

Subgroup 5.1.4 Dystrophic peat is unflushed and extensive. Most peats on hill summits and upper slopes belong to this subgroup.

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 under each soil associaton description (Chapter 2) 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.

The plant communities that occur within any given area are an expression of the range in its geology, soils, climate, landform and land use and this region—comprising as it does part of the south-eastern edge of the Highlands, much of the Midland Valley and the bulk of the Southern Uplands—displays a great diversity in these properties. Consequently a wide range of plant communities is found also. Within this diversity, broad trends can be recognized, the most obvious being that along the east–west axis there is a gradual change from the dry grasslands and moorlands of the low rainfall areas to the east to the wetter vegetation of the west which is often dominated by flying bent (*Molinia caerulea*). Similarly, with an increase in altitude or exposure, there is a related change in the vegetation from the more lowland forms to those of the uplands and mountains.

GRASSLAND

The principal areas of arable agriculture are concentrated on the fine- and moderately fine-textured till soils of the Midland Valley and Galloway and on the

coarse, sandy soils of the coastline round the Firth of Forth. These coarse-textured raised beach soils are representative of some of the best arable land in Scotland, forming the 'golden fringe to the beggar's mantle' in Fife and the 'Garden of Scotland' along the Lothian coastal plain. Cereals and root crops are extensively grown and there are considerable areas of market gardening in the Lothians. The finer-textured till soils are also widely cultivated in the east where their drainage is usually imperfect, but under the higher rainfall conditions of the west, poorly drained gleys predominate and these soils are best suited to the production of grass as hay or silage or as longer-term pastures. Ley or permanent pastures with a high proportion of perennial rye-grass (*Lolium perenne*) are the commonest form (Lolio-Cynosuretum), but some timothy (*Phelum pratense*) pasture is still grown on the silts and clays of the Carse of Stirling for seed (the *Festuca pratensis–Phleum pratense* Association). Some wet pastures (part of Lolio-Cynosuretum) have developed on the more poorly drained soils and on the flushed peats bordering cut-over lowland mosses to the west of the region and these are characterized by the presence of marsh foxtail (*Alopecurus geniculatus*). Where the fertility of sown-out permanent pastures has been allowed to deteriorate, the sward may become dominated by species such as smooth meadow-grass (*Poa pratensis*), sweet vernal (*Anthoxanthum odoratum*), common bent (*Agrostis tenuis*) and Yorkshire fog (*Holcus lanatus*). This replacement community has been named meadow-grass–bent pasture (the *Galium saxatile–Poa pratensis* Community) and it may also develop from natural rough grasslands that are subjected to a high grazing and dunging regime. Bracken (*Pteridium aquilinum*) may form a dense canopy over the grass sward, especially on the imperfectly drained brown forest soils of morainic mounds in the north-west, and this significantly reduces the dry matter production and hence the grazing value of the vegetation.

The wet, undrained soils of the lowlands and foothills carry a range of swamp, rush and sedge communities of which the most extensive and widespread is sharp-flowered rush pasture (Potentillo-Juncetum acutiflori), a community characteristic of the south-west although it is also found farther east on the finer-textured soils. The species-rich form occurs on the better base status noncalcareous and humic gleys and the species-poor form on more acidic noncalcareous gleys, peaty gleys and flushed peat. A large tract of land between Edinburgh and Glasgow, where the soils have been extensively disturbed by mining and where grazing pressure has been greatly reduced from higher levels in the past, now carries tall stands of grasses, herbs and rushes which are probably closely related to this pasture. The other commonly encountered but less extensive rush community is that of soft rush pasture (the *Ranunculus repens–Juncus effusus* Community), a characteristic vegetation of wet alluvial flats, depressions and flushed channels on low base status noncalcareous gleys, peaty gleys and peat. It often forms a mosaic with sharp-flowered rush pasture, outlining open drains or channels through the latter community. Tussock-grass (*Deschampsia cespitosa*) may occur as an element of the soft rush pasture or its coarse, dense tussocks may dominate to form tussock-grass pasture (the *Deschampsia cespitosa* Community)—a community often found when land has been enclosed for tree planting. Many other flush communities may be found throughout the landscape, but these are usually of much less areal extent than the rush pastures and are confined to narrow channels and basins. The presence of any one particular community is dependent on the base status and nutrient level of the flush water and so inevitably the more eutrophic vegetation will be found on the receiving sites of the lowlands and the dystrophic communities on the peaty flushes of the higher hill

slopes. Base-rich swamp communities of the lowlands include meadow-sweet meadow (Valeriano-Filipenduletum), marsh marigold meadow (the *Caltha palustris* Community), yellow flag swamp (the *Iris pseudacorus* Community), reed grass swamp (Phalaridetum arundinaceae) and reed swamp (Phragmitetum communis). These communities are usually found on the moderate to high base status noncalcareous gleys, humic gleys and eutrophic peats of alluvial flats. Intermediate or mesotrophic vegetation such as few-flowered spike-rush mire (Carici dioici-Eleocharitetum quinqueflorae), flea-sedge mire (Caricetum hostiano-pulicaris) and bog rush mire (the *Schoenus nigricans* Community) is confined to similar soils of lower base status in channels and depressions, and the dystrophic peats, peaty gleys and noncalcareous gleys of drainage systems within the peaty soils zone of the higher hills carry bog moss water track (the *Juncus effusus–Sphagnum recurvum* Community), common sedge flushes (*Carex nigra* Communities) and star sedge mire (Caricetum echinato-paniceae). This last-named community becomes more extensive in the north-west where it takes the place of sharp-flowered rush pasture on the reclaimed peats. In general, flush vegetation is more widespread and less confined in the higher rainfall areas of the west.

Semi-natural rough grasslands form a major element of the landscape in the Southern Uplands which have been under intense grazing management for many years, the most striking feature being the mosaic of bent–fescue (Achilleo-Festucetum tenuifoliae) and heath rush–fescue grasslands (Junco squarrosi-Festucetum tenuifoliae) on the smooth rounded hills of Ettrick Forest. The brown forest soils of the steep valley slopes carry the herb-rich form of bent–fescue grassland while the more widespread and extensive acid bent–fescue is found on the brown forest soils and occasional freely drained podzols of the gentler slopes and low summits. Where topography is a limiting factor to land use, the acid grassland may be dominated by bracken (*Pteridium aquilinum*) whose canopy, although suppressing the growth of the underlying vegetation, is never as dense as that of bracken-dominated meadow-grass–bent grassland. A community of shallow brown forest soils associated with igneous rock outcrops in eastern Scotland—the crested hair-grass grassland (the *Galium verum–Koeleria cristata* Community)—occurs on the hills of Fife and Kinross. White bent grassland (part of Junco squarrosi-Festucetum tenuifoliae) is commonly found on the imperfectly drained podzols and peaty podzols to the north and east of the region, but in the west and on the finer-textured soils in the east where peaty gleys predominate, its place is taken by flying bent grassland, a community of the same association. A herb-rich form of white bent grassland with heath grass (*Sieglingia decumbens*) and sedges such as carnation-grass (*Carex panicea*) and ribbed sedge (*C. binervis*) occurs locally on the humic gleys of hill side flushes.

MOORLAND

Outwith the areas long associated with sheep farming, moorland communities usually form the dominant vegetation of the hills and unimproved lowlands, especially on the less fertile parent materials derived from rocks such as granites and felsites. The most widespread community is Atlantic heather moor (Carici binervis-Ericetum cinereae)—typical of the Lammermuir Hills, the dry form occurring on humus-iron and peaty podzols and the moist form on peaty podzols and peaty gleys. Some bog heather moor (Narthecio-Ericetum tetralicis) is found locally on peaty gleys or shallow peat fringing areas of basin or blanket peat. Lowland blanket bog (part of Erico-Sphagnetum papillosi) is the typical com-

munity of unflushed dystrophic peat on till plains and lower hill slopes throughout the region. Notable examples are Flanders Moss to the north, Auchencorth Moss and Fala Moor to the east, Mossmulloch and Airds Moss to the west and Silver Flowe and Kirkconnell Flow to the south. Cranberry (*Vaccinium oxycoccus*) is often present in the vegetation and bog rosemary (*Andromeda polifolia*) occurs locally in the mosses to the south. Exposure and rainfall can each influence the plant species present and hence the plant communities within a given area. The more exposed blanket bogs of the west may contain plants indicative of the northern (exposed) form of the association, namely woolly fringe-moss (*Racomitrium lanuginosum*) and the lichens *Cladonia arbuscula* and *C. uncialis*. The higher rainfall to the west also results in the presence of flushed forms of blanket bog, usually on slopes and in channels associated with the more typical form. Flushed blanket bog communities may be dominated by cotton-grass (*Eriophorum vaginatum*) or, more typically, by flying bent (*Molinia caerulea*), and bog myrtle (*Myrica gale*) may be an important element in the latter vegetation.

OROARCTIC COMMUNITIES

Further increase in exposure or altitude can result in the replacement of Atlantic heather moor by its boreal equivalent (Vaccino-Ericetum cinereae) which, when present, usually occupies a narrow, ill-defined zone before the full arctic communities are encountered. This boreal zone can become much broader on hills isolated from the main massifs, an outstanding example being the extensive boreal heather moor on the felsite hill of Tinto. The blanket peats of these higher altitudes usually carry the upland form of blanket bog with crowberry (*Empetrum nigrum*) and hooked moss (*Rhytidiadelphus loreus*) or the separate association of mountain blanket bog (Rhytidiadelpho-Sphagnetum fusci). Exposed ridges and summits of the higher hills and mountains carry wind-cut oroarctic vegetation of which the fescue–woolly fringe-moss heath (Festuco-Racomitrietum lanuginosi) is the most widespread. A community more typical of the Eastern Highlands—the alpine azalea—lichen heath (Alectorio-Callunetum vulgaris)—occurs on some hills in the east of the region. These communities of the exposed, relatively snow-free tops are found on the more freely drained alpine and subalpine podzols and often occur as sparsely vegetated patches in a mosaic with rock debris. The more poorly drained, peaty-topped soils of late snow-lie depressions and flushed slopes carry stiff sedge–fescue grassland (the *Carex bigelowii–Festuca vivipara* Association) in which either heath rush (*Juncus squarrosus*) or stiff sedge (*Carex bigelowii*) is the dominant species. A form of this grassland dominated by viviparous fescue (*Festuca vivipara*) occurs on some of the gentle rounded summits of the high hills, especially in areas where sheep have been excluded by fencing.

WOODLAND

There are many coniferous plantations within the region, especially to the south and south-west, and these are more fully described elsewhere. Many of the broadleaved woodlands were also planted, usually for amenity purposes around the many large mansions, but these plantations have now been established for many years and the vegetation beneath their canopies is relatively stable. The association of broadleaved woodland found in such policies—and also on the alluvial terraces of narrow dens and valleys—is elmwood (Querco-Ulmetum

glabrae) although the canopy may also be dominated by sycamore, ash or oak. The soils are usually freely or imperfectly drained brown forest soils of moderate to high base status. Poorly drained gleys and flushed peat of river terraces, alluvial flats and wet valley slopes may carry narrow strips of alderwood (the *Crepis paludosa–Alnus glutinosa* Association). Ash–oakwood (Primulo-Quercetum)—a woodland or scrub community of the west with dominant ash or hazel—may occur locally within the area on freely drained brown forest soils of high base status. The communities of oak and birch are perhaps all that remains of the natural woodland cover although now of limited distribution and extent. Dry western oakwood and birchwood (Blechno-Quercetum) is found only in the extreme west within the hyperoceanic sub-sector and is recognized by the presence of mountain fern (*Thelypteris limbosperma*) and hard-fern (*Blechnum spicant*) in the vegetation. Southern oakwood (Galio saxatilis-Quercetum) is far more widespread and was the principal association of the former Ettrick Forest, the best remaining example being at Elibank near Innerleithen. The presence of honeysuckle (*Lonicera periclymenum*) differentiates this woodland from the western oakwood, although there is a relatively wide zone in which the two associations meet where the vegetation may contain character species of both. Both associations are found on freely drained brown forest soils of low to moderate base status and, to a lesser extent, on humus-iron podzols of steep valley sides and lower hill slopes.

FORESHORE AND DUNES

Communities of dunes and links are very widespread and extensive along the shores of the Firth of Forth but are mainly restricted to Southerness Point on the Solway Firth. Outstanding examples of the full sequence of dune vegetation can be seen in the nature reserves of Dumbarnie Links in Fife and Aberlady Bay in East Lothian. The foreshore community of orache strand-line (the *Salsola kali–Atriplex glabriuscula* Association) is succeeded by northern sea couch-grass dune (Elymo-Agropyretum boreo-atlanticum) which then gives way to northern marram grass dune (Elymo-Ammophiletum). Dry, level or gently sloping areas to the rear of the dune systems carry a closed-turf vegetation characteristic of the eastern seaboard—the milk vetch–red fescue dune pasture (Astragalo-Festucetum arenariae)—but this has often been destroyed by cultivation, modified by heavy grazing and dunging to a form of meadow-grass–bent grassland (the *Galium saxatile–Poa pratensis* Community) or adapted for use as golf links. The soils of the dunes and dry flats are usually derived from shelly sand and are freely or excessively drained calcareous regosols. Wet dune slacks and depressions with calcareous gleys can carry a wide range of swamp, rush and sedge communities very similar to that found on wet alluvial flats and depressions elsewhere, but the coastal community of silverweed pasture (the *Potentilla anserina–Carex nigra* Community) is confined to this habitat and is usually present here, and the two nature reserves noted above are sites of the rare variegated horsetail community (the *Anagallis tenella–Equisetum variegatum* Association).

SALTINGS

The vegetation of the coastal saline alluvial soils is dominantly that of sea poa salt-marsh (Puccinellietum maritimae) at or slightly below the high-water mark and mud rush salt-marsh (Juncetum gerardii) at a slightly higher level. Extensive

areas of saltings occur at the mouth of the Eden estuary, at Kincardine on the Forth and on Wigtown Sands, the last site also being an extensive station of glasswort salt-marsh (Salicornietum dolichostachyae), a pioneer community. Reed swamp (Phragmitetum communis) may occur along the landward edges of these salt-marshes.

2 The Soil Map Units

THE ALLUVIAL SOILS

(Map units 1 and 2)

Alluvial soils are developed on materials deposited during recent times from suspension in water in marine or freshwater environments. Freshwater alluvium is found along most water-courses throughout the area but soils formed on marine alluvium have been mapped only below the high-water mark of ordinary spring tides along estuaries opening into the Solway Firth. In all, these soils have been mapped in areas occupying 460 square kilometres (2.3 per cent of South-East Scotland), but in association with soils developed on fluvioglacial gravels alluvial soils are also important components in *map units 164, 198, 200* and *579.*

Map unit 1 occupies 437 square kilometres and comprises soils developed on freshwater alluvial deposits of riverine or lacustrine origin, the former being very much the more extensive. The materials are unconsolidated and their content of mineral species is governed principally by the rocks in the catchment of the rivers from which they were deposited. Old Red Sandstone and Carboniferous sediments and lavas predominate in Fife and the Midland Valley, and greywackes make up the Southern Uplands, although Carboniferous sediments underlie the Merse of Berwickshire and occur along the English Border, while north of the Highland Boundary Fault the strata are predominantly metamorphic rocks of the Dalradian Assemblage. The textures of the deposits are related to the energy or rate of flow of the waters from which the materials settled and range widely, often showing much local variation. Loams and sandy loams are predominant and usually overlie gravel at 30 to 100 centimetres depth. The soils have been mapped along most major water-courses and form fertile tracts along the River Nith north of Dumfries and at Thornhill, the Tweed at Kelso, the Earn near Forteviot, and at the confluence of the Gryfe and the Black Cart Water at Renfrew. Much of this land lies below 30 metres altitude and is level or very gently sloping, but the margins are often marked by steep banks. The climate is mainly warm and moderately dry with rainfall ranging from 600 millimetres per annum in the Tweed valley and 750 millimetres along the Earn in the east to 1100 millimetres at Dumfries and Renfrew reflecting the marked east-to-west rising trend of precipitation.

The relative youth of the alluvial sediments is reflected in the soils in which only minor effects of chemical weathering are evident and the formation of distinct horizons is poorly exhibited. Apart from the amount and type of humus formation and accumulation within the surface layers, soil differences are mainly of texture, inherited from the parent material, and the depth to the water-table. Many soils are naturally freely draining in the upper layers, but in the lowest landscape positions, where water cannot move to natural outlets because of high river levels, soils are waterlogged. In a few areas prolonged severe waterlogging has led to the accumulation of peaty alluvial soils.

The soils are naturally fertile and generally form arable ground in this region. In the east, as along the River Tweed, the land is incorporated into rich arable farms, but in the west cropping is generally managed in conjunction with the needs of dairy herds, as along the River Nith north of Dumfries. Crops, to provide supplementary feed for sheep and cattle, are also grown on the alluvial tracts amongst the hills, along the upper reaches of rivers and their tributaries, but this land is broken up less often than that in the lowland areas. Pastures, however, are of good quality and of particular value in supplementing the rough grazings on the hills and valley sides.

There is usually a risk of periodic damaging floods, but this is often difficult to assess and is judged best according to local experience. Under-drainage is required for the efficient utilization of naturally waterlogged soils and is dependent on achieving suitable outfalls.

Map unit 2 comprises saline gley soils, now reclassified as saline alluvial soils, mainly in the river estuaries of the Cree and the Nith, and occupies 23 square kilometres (0.1 per cent of South-East 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 which to a large extent prevents 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 exclude the sea the land cannot be improved, but does provide healthy grazing for stock and is much valued by farmers with rights of access. Care in management is necessary to avoid stock losses 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 in thickness. They are extensive and have been mapped over 1338 square kilometres of South-East Scotland (6.7 per cent of the region). Basin peats are found mainly in the lowlands where they are confined amongst surrounding mineral soils, having originated in basins and depressions, but also included with these deposits are some peats on lowland valley floors. Blanket peats are widespread in the uplands on gentle or strong slopes. Peat also occurs widely in small areas of insufficient extent to be separately mapped and organic soils are therefore major components of many other soil map units. In Kirkcudbrightshire, between the upper reaches of the Waters of

Table A Areas of soil map units

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
ALLUVIAL SOILS (460 sq. km., 2.3%)	1	437	2.2	95
	2	23	0.1	5
ORGANIC SOILS (1338 sq. km., 6.7%)	3	271	1.4	20
	4	1067	5.3	80
ARBIGLAND	16	4	<0.1	100
ASHGROVE (38 sq. km., 0.2%)	39	25	0.1	65
	40	13	<0.1	35
BALROWNIE (459 sq. km., 2.3%)	41	271	1.4	59
	42	67	0.3	15
	43	37	0.2	8
	44	29	0.1	6
	45	22	0.1	5
	46	33	0.2	7
	49	<1	<0.1	<1
BARGOUR	51	78	0.4	100
BEMERSYDE (61 sq. km., 0.3%)	53	24	0.1	40
	54	5	<0.1	10
	55	32	0.2	50
BENAN	56	2	<0.1	100
BLAIR (28 sq. km., 0.1%)	68	13	<0.1	45
	69	15	<0.1	55
CAIRNCROSS	77	30	0.2	100
CANONBIE (284 sq. km., 1.4%)	84	40	0.2	14
	85	213	1.1	75
	86	3	<0.1	1
	87	13	<0.1	5
	88	15	<0.1	5
CARPOW/PANBRIDE	89	86	0.4	100
CARTER (307 sq. km., 1.5%)	90	8	<0.1	3
	91	104	0.5	34
	92	5	<0.1	2
	93	36	0.2	12
	94	7	<0.1	2
	95	147	0.7	48

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA(sq. km)	% Land Area	% Association
CORBY/BOYNDIE DINNET	97	3	<0.1	100
COUNTESSWELLS/ DALBEATTIE/ PRIESTLAW (416 sq. km., 2.1%)	113	44	0.2	11
	114	57	0.3	14
	117	11	<0.1	3
	119	98	0.5	24
	120	6	<0.1	1
	122	41	0.2	10
	124	20	0.1	5
	126	94	0.5	23
	129	25	0.1	6
	133	16	<0.1	4
	134	4	<0.1	<1
CRAIGDALE (9 sq. km., <0.1%)	138	2	<0.1	20
	139	7	<0.1	80
CREETOWN (37 sq. km., 0.2%)	141	18	<0.1	50
	142	7	<0.1	20
	143	12	<0.1	30
DARLEITH/ KIRKTONMOOR (743 sq. km., 3.7%)	147	178	0.9	24
	148	97	0.5	13
	149	87	0.4	12
	150	119	0.6	16
	151	11	<0.1	1
	152	4	<0.1	<1
	153	33	0.2	4
	154	69	0.4	9
	155	57	0.3	8
	156	14	<0.1	2
	158	70	0.4	9
	159	1	<0.1	<1
	161	3	<0.1	<1
DARVEL (331 sq. km., 1.7%)	163	196	1.0	59
	164	135	0.7	41
DOUNE	168	20	0.1	100
DREGHORN (106 sq. km., 0.5%)	169	89	0.4	85
	170	17	<0.1	15
DRONGAN	171	52	0.3	100
DURISDEER (15 sq. km., <0.1%)	179	11	<0.1	75
	180	4	<0.1	25

Table A Areas of soil map units

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
ECKFORD/INNERWICK (306 sq. km., 1.5%)	196	118	0.6	39
	197	21	0.1	7
	198	72	0.4	24
	199	2	‹0.1	‹1
	200	93	0.5	30
ETTRICK (6149 sq. km., 30.8%)	205	9	‹0.1	‹1
	206	392	2.0	6
	207	196	1.0	3
	208	100	0.5	2
	209	390	2.0	6
	210	323	1.6	5
	211	43	0.2	‹1
	212	44	0.2	‹1
	213	55	0.3	‹1
	214	68	0.3	1
	215	22	0.1	‹1
	216	76	0.4	1
	217	4	‹0.1	‹1
	218	327	1.6	5
	219	39	0.2	‹1
	220	214	1.1	3
	221	851	4.3	14
	222	45	0.2	‹1
	223	327	1.6	5
	224	71	0.4	1
	225	180	0.9	3
	226	285	1.4	5
	227	171	0.9	3
	228	374	1.9	6
	229	537	2.7	9
	230	282	1.4	5
	231	176	0.9	3
	232	163	0.8	3
	233	236	1.2	4
	234	28	0.1	‹1
	235	37	0.2	‹1
	236	84	0.4	1
FORFAR	239	4	‹0.1	100
FOUDLAND (102 sq. km., 0.5%)	240	7	‹0.1	5
	241	23	0.1	20
	243	32	0.2	30
	244	4	‹0.1	‹5
	246	10	‹0.1	10
	248	5	‹0.1	‹5
	250	7	‹0.1	5
	252	8	‹0.1	10
	253	5	‹0.1	‹5
	255	1	‹0.1	‹5
FRASERBURGH	259	23	0.1	100
GLENALMOND/MAYBOLE (103 sq. km., 0.5%)	265	21	0.1	20
	266	21	0.1	20
	267	18	‹0.1	15
	268	13	‹0.1	15
	269	2	‹0.1	‹5
	270	27	0.1	25
	272	1	‹0.1	‹5
GLENEAGLES/ AUCHENBLAE	273	51	0.3	100
GOURDIE/ CALLANDER/ STRATHFINELLA (106 sq. km., 0.5%)	274	70	0.4	65
	275	26	0.1	25
	276	10	‹0.1	10
	277	‹1	‹0.1	‹5
HAYFIELD (28 sq. km., 0.1%)	287	11	‹0.1	40
	288	6	‹0.1	20
	289	11	‹0.1	40
	290	‹1	‹0.1	‹5
HINDSWARD (174 sq. km., 0.9%)	291	78	0.4	45
	292	55	0.3	30
	293	41	0.2	25
HOBKIRK (577 sq. km., 2.9%)	295	16	‹0.1	3
	296	317	1.6	55
	297	67	0.3	12
	298	16	‹0.1	3
	299	61	0.3	11
	300	6	0.1	1
	301	49	0.3	9
	302	45	0.2	8

Table A Areas of soil map units

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
HOLYWOOD (140 sq. km., 0.7%)	303	51	0.3	35
	304	23	0.1	15
	305	64	0.3	45
	306	2	‹0.1	‹5
KILMARNOCK (228 sq. km., 1.1%)	331	210	1.0	92
	332	18	‹0.1	8
KIPPEN/LARGS (202 sq. km., 1.0%)	337	77	0.4	38
	338	26	0.1	13
	339	42	0.2	21
	341	7	‹0.1	3
	342	1	‹0.1	‹1
	343	14	‹0.1	7
	344	32	‹0.2	16
	346	1	‹0.1	‹1
	347	2	‹0.1	‹1
KIRKCOLM	348	1	‹0.1	100
KIRKWOOD (45 sq. km., 0.2%)	349	28	0.1	60
	350	17	‹0.1	40
KNOCKSKAE (27 sq. km., 0.2%)	352	12	‹0.1	45
	353	3	‹0.1	10
	354	2	‹0.1	5
	355	2	‹0.1	5
	356	7	‹0.1	25
	357	1	‹0.1	‹5
LANFINE (86 sq. km., 0.4%)	359	77	0.4	90
	360	9	‹0.1	10
LAUDER (173 sq. km., 0.9%)	362	107	0.5	60
	363	4	‹0.1	‹5
	364	37	0.2	20
	365	15	‹0.1	10
	366	3	‹0.1	‹5
	367	7	‹0.1	‹5
LAURENCEKIRK	368	2	‹0.1	100
LETHANS (17 sq. km., ‹0.1%)	374	2	‹0.1	10
	375	1	‹0.1	5
	376	1	‹0.1	5
	377	13	‹0.1	75
	378	‹1	‹0.1	‹5

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
LINFERN	379	1	‹0.1	100
LINKS	380	8	‹0.1	100
MAUCHLINE/ AUCHINLECK	401	46	0.2	100
MINTO (114 sq. km., 0.6%)	407	38	0.2	35
	408	21	0.1	20
	409	22	0.1	20
	410	15	‹0.1	15
	411	15	‹0.1	15
	412	3	‹0.1	‹5
MOUNTBOY (127 sq. km., 0.6%)	413	27	0.1	20
	414	70	0.4	55
	415	12	‹0.1	10
	416	5	‹0.1	5
	417	13	‹0.1	10
	418	‹1	‹0.1	‹5
NIGG/PRESTON (4 sq. km., ‹0.1%)	420	2	‹0.1	50
	421	2	‹0.1	50
REPPOCH (132 sq. km., 0.7%)	432	31	0.2	25
	433	23	0.1	15
	434	5	‹0.1	‹5
	435	32	0.2	25
	436	41	0.2	30
RHINS (140 sq. km., 0.7%)	439	100	0.5	70
	440	40	0.2	30
ROWANHILL/ GIFFNOCK/ WINTON (2309 sq. km., 11.6%)	444	412	2.1	18
	445	1061	5.3	46
	446	500	2.5	22
	447	74	0.4	3
	448	29	0.1	1
	449	‹1	‹0.1	‹1
	450	232	1.2	10
	451	1	‹0.1	‹1
SMAILHOLM	464	35	0.2	100

Table A Areas of soil map units

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA (sq. km)	% Land Area	% Association
SORN/HUMBIE/BIEL (362 sq. km., 1.8%)	465	54	0.3	15
	466	169	0.8	47
	467	94	0.5	26
	468	1	‹0.1	‹1
	469	2	‹0.1	‹1
	470	42	0.2	12
SOURHOPE (830 sq. km. 4.2%)	472	324	1.6	39
	473	47	0.2	6
	474	236	1.2	28
	475	6	‹0.1	‹1
	476	98	0.5	12
	477	10	‹0.1	1
	478	12	‹0.1	1
	479	53	0.3	6
	482	44	0.2	5
STIRLING/DUFFUS/ POW/CARBROOK (312 sq. km., 1.6%)	487	51	0.3	16
	488	261	1.3	84
	489	‹1	‹0.1	‹1
STONEHAVEN (41 sq. km., 0.2%)	490	8	‹0.1	20
	492	5	‹0.1	10
	493	24	0.1	60
	494	2	‹0.1	‹5
	495	‹1	‹0.1	‹5
	496	2	‹0.1	‹5
BUILT-UP AREAS		858	4.3	

ASSOCIATION (sq. km., % Land Area)	MAP UNIT	AREA(sq. km)	% Land Area	% Association
STRICHEN (346 sq. km., 1.7%)	497	33	0.2	10
	498	22	0.1	6
	499	6	‹0.1	2
	500	13	‹0.1	4
	501	16	‹0.1	5
	502	2	‹0.1	‹1
	503	56	0.3	16
	504	5	‹0.1	1
	505	32	0.2	9
	506	82	0.4	24
	507	41	0.2	12
	509	9	‹0.1	3
	512	26	0.1	8
	513	2	‹0.1	‹1
	515	1	‹0.1	‹1
SYMINGTON	516	29	0.1	100
TYNEHEAD (56 sq. km., 0.3%)	562	32	0.2	55
	563	22	0.1	40
	564	2	‹0.1	‹5
WHITESOME (412 sq. km., 2.1%)	574	102	0.5	25
	575	310	1.6	75
YARROW/FLEET (336 sq. km., 1.7%)	576	155	0.8	46
	577	7	‹0.1	2
	578	71	0.4	21
	579	103	0.5	31
ROCK		5	‹0.1	

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.

Urr and Ken, peats with scattered drumlins form distinctive map units. Peat has developed under a wide range of climate, but most blanket peat occurs under wet conditions, with 1000–2000 millimetres per annum average rainfall, and temperature regimes ranging from fairly warm to cold. Basin peats are generally found in warm lowlands which can range from moderately dry to wet. 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 occupies 271 square kilometres in South-East Scotland and consists of organic soils developed on basin and valley peats. The peat is thick, generally ranging in depth from 1 to 5 metres. Some of the most extensive and well-known deposits occur below 50 metres altitude on estuarine raised beach silts and clays of Recent origin. Flanders Moss is a remnant of the former extensive peat cover in the Forth valley and along the Solway Firth the Moss of Cree occurs along the estuary of the River Cree. The Lochar Moss near Dumfries is also underlain by fluviatile materials, silts and sands, of Recent age, and the relationship between the formation of the mineral deposits and formation of the Moss has been discussed by Jardine (1980). Peat deposits developed in the undulating till-covered areas of the Midland Valley, Fife and the lowlands along the Solway range up to 300 metres in altitude and are exemplified by Nutberry Moss, near Annan, which is presently being cut-over and removed for use in horticulture, Airds Moss near Cumnock and Gardum Moss north of Slamannan. The Silver Flowe is a well-known bog, with dubh lochans, which originated in basins along the Cooran Lane in an intermontane valley of the Southern Uplands.

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 water-courses, as carried out recently along the Lochar Water near Dumfries, is a prerequisite to improvement measures on individual farms. The drainage of small bogs is often within the compass of an individual, but requires the creation of suitable outfalls and a large amount of capital. Most basin peats are currently utilized as rough grazing with low stock-carrying capacity, but some, such as Nutberry Moss already cited, are being cut to provide material for horticulture or fuel; others such as Flanders Moss, the Lochar Moss or the Moss of Cree have been planted with coniferous trees, and the Silver Flowe is a nature reserve.

Map unit 4 is extensive, occupying 1067 square kilometres (5.3 per cent of South-East Scotland), and comprises organic soils developed on blanket peat. These soils are also a major component of a number 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 on broad summits and plateaux in the hills and uplands where the climate is cool, and moist or wet. Leaching is intense under the high average rainfall and the acid soils, wet conditions and low levels of biotic activity lead to the accumulation of organic matter. At the highest altitude and in coldest conditions above about 700 metres organic matter production is much reduced and peat deposits are few or absent.

The natural fertility of the soils is very low and the requirement of lime, phosphate and other fertilizers for the establishment of improved pastures is high. However, the waterlogging of the soils for long periods of the year, their low bearing strength and the cool wet climate are generally unfavourable to the maintenance of improved grass swards. The liability of improved areas to severe poaching damage leading to sward deterioration and the ingress of rushes demands skilful grazing management. These soils carry mainly semi-natural plant communities which include blanket and flying bent bogs and upland and mountain blanket bogs and provide rough grazing of poor quality. Considerable areas have been ploughed, surface-drained and planted as coniferous forest with Sitka spruce and lodgepole pine the principal tree species, but growth is very dependent on altitude, exposure and the nutrient status of the peat.

THE ARBIGLAND ASSOCIATION

(Map unit 16)

The soils of the Arbigland Association are developed on till derived largely from Lower Carboniferous sediments, with some admixture of material from greywackes and granites. The till is brown and generally clay loam, but in low-lying situations partial water-sorting is evidenced by coarser textures such as sandy loams and loamy sands in the upper till layers. The association occupies 4 square kilometres (less than 0.1 per cent of South-East Scotland) on a broad ridge with gentle slopes near Kirkbean, south of Dumfries. The land lies below 60 metres altitude and has a climate characterized as warm and moderately dry with average rainfall of 1200 millimetres per annum. The soils are brown forest soils with gleying and noncalcareous gleys, and carry arable crops and ley pastures.

Map unit 16 comprises brown forest soils with gleying and noncalcareous gleys, developed on brown clay loam tills and modified tills with coarser textures in the upper layers. The fine texture of the parent till and coarse prismatic structures in the subsoil are associated with slow permeability to moisture and liability to waterlogging in the upper soil layers. Under-drainage with permeable infill in the drain-lines and secondary moling or subsoil treatment are essential for the efficient use and cropping of this land. Nevertheless, wet soil conditions at seed-time or harvest are likely to remain in some degree continuing hazards on these soils and the careful timing of cultivation is an important aspect of management. Barley and wheat, both spring and winter sown, are the principal crops, but some forage and roots are also grown. Grassland is highly productive but the liability to damage by poaching necessitates the careful management of grazing and can restrict utilization in wet periods.

THE ASHGROVE ASSOCIATION

(Map units 39 and 40)

The soils of the Ashgrove Association are developed on drifts derived from shales and sandstones of Carboniferous age and having an admixture of limestone in some areas. Shale-derived materials generally predominate in this 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 association occupies 38 square kilometres (0.2 per cent of South-East Scotland) and occurs mainly in the Lothians to the west of Edinburgh but there are some smaller areas lying south and west of Glasgow. The terrain is undulating lowland with gentle slopes, and lies mainly between 50 and 100 metres altitude near Edinburgh and 100 to 150 metres near Glasgow. In the west the climate is warm and wet with average rainfall ranging from 1200 to 1500 millimetres per annum, but this declines to 600–700 millimetres in the eastern areas where the climate is warm and moderately dry.

Under the moderately dry conditions the soils are mainly brown forest soils with gleying, the loamy textures in the topsoils of which contrast with the clayey textures of the noncalcareous gleys under the wetter climate to the west. Notable differences of both soils and climate are found between the eastern and western areas of the association and largely account for the contrasts in agriculture and aspect of the landscape. Where some limestone fragments are present in the parent tills, pH values are high, 7.5–8.0 in the Cg horizons, but amounts of free

calcium carbonate are small and the soils have not been classed with those of calcareous major soil subgroups.

Map unit 39 occupies 25 square kilometres (65 per cent of the association) and comprises mainly brown forest soils with gleying; noncalcareous gleys are very restricted in extent. The natural drainage is imperfect. The land is utilized for arable crops and pasture but cultivations should be carefully timed to avoid damage to soil structure. Clayey textures and slow permeability in the subsoils give rise to a risk of waterlogging in the surface layers at seed-time or at harvest, while pastures are subject to damage from poaching and require careful grazing management, particularly in spring and autumn. These problems can be ameliorated by under-drainage systems, which are necessary for the efficient use of this land. Installations should incorporate permeable infill in the drain-lines and moling or subsoiling as secondary treatments to improve structure and permeability in the subsoil.

Map unit 40 occupies 13 square kilometres (35 per cent of the association) and comprises mainly noncalcareous gleys with some peaty gleys and humic gleys in hollows. Under the wet climate in the west of the region the clayey textures and coarse structures in the subsoils give rise to poor and very poor natural soil drainage. The soils are difficult to work and are maintained mainly in pasture with occasional arable cropping prior to reseeding of grass swards.

Improvement of the poor internal soil drainage is necessary for the maintenance and efficient utilization of pastures as well as for arable cropping, and systems should include permeable infill in the drain-lines and moling or subsoiling secondary treatments.

THE BALROWNIE ASSOCIATION

(Map units 41–46 and 49)

The soils of the Balrownie Association are developed on drifts derived mainly from sandstones of Lower Old Red Sandstone age. The drift is principally a compact loam or sandy clay loam till and is usually several metres thick, but on some ridges sandstone rock lies close to the surface. On the lower ground below 100 metres altitude the drifts have often been water-modified and are coarser in texture. The materials are bright reddish brown in colour and have a moderate stone content.

The association occupies 460 square kilometres (2.3 per cent of South-East Scotland) in a belt which lies to the south-east of the Highland Boundary Fault and extends from Loch Lomond to Strathearn. The land is mainly lowland, but can range in altitude from 15 metres on the shores of Loch Lomond to almost 300 metres on moorlands in the foothills which skirt the edge of the Highlands. In the lowlands of Lower Strathearn the climate is warm and moderately dry with average rainfall of 800 to 1100 millimetres per annum but farther west it is warm and wet with 1100–1500 millimetres of rainfall which increases to 1500–2000 millimetres on higher-lying ground near the Highlands.

In the cultivated areas of the lowlands the soils are mainly brown forest soils with gleying, but where rock is near the surface some shallow brown forest soils are found. Noncalcareous gleys occur on gentle slopes around areas of higher-lying land where humus-iron podzols, peaty podzols and peaty gleys occur on exposed sites.

Map unit 41 occupies 271 square kilometres (59 per cent of the association) and is both extensive and agriculturally important. From Loch Lomond it extends north-eastwards to Strathearn and the Tay estuary south-east of Perth. The soils are mainly brown forest soils with gleying, but there are also some brown forest soils and small areas of noncalcareous gleys. The internal soil drainage is generally imperfect. The dominant soils have surface layers of loamy texture and moderate blocky or crumb structure and the underlying subsoils are generally loams or sandy loams, the latter being predominant on soils developed on water-worked parent materials. Structures in these subsoils are generally moderately developed but coarser than in the topsoil. The horizon is moderately permeable. Moisture movement is impeded, however, in the underlying sandy clay loam or clay loam till where structure is weakly developed and permeability low. High contents of fine sand in the topsoils can lead to the breakdown of structure and 'capping' can develop in fine seed-beds in wet weather. There is also some risk of poaching damage to grassland. The moderate stone content poses few problems to arable agriculture but on slopes greater than 7 degrees there is likely to be some tractor wheel slip.

Map unit 42 occupies 68 square kilometres (15 per cent of the association) and consists mainly of noncalcareous gleys, but some humic gleys and peaty gleys are present on gentle slopes and in hollows and depressions. The natural drainage in these soils is poor. The topsoils have loamy texture and moderately developed structures and overlie sandy clay loam or clay loam subsoils with weak structural development and low permeability. Problems of 'capping' on bare, cultivated ground and poaching on pasture land are more severe than in *map unit 41*. Under the wet climate prevailing in western areas much of the land carries permanent pasture or rough grazing. Comprehensive drainage systems incorporating permeable infill in the drain-lines and secondary treatments to improve subsoil structure and permeability are necessary for the efficient use of improved pastures or for arable agriculture on this land. Trace element problems can be encountered where areas of rough grazing are improved rapidly.

Map unit 43 occupies 37 square kilometres (8 per cent of the association) and comprises brown forest soils with some brown forest soils with gleying. The natural drainage is free or imperfect and the soils are often thin and occur on strong irregular slopes underlain by rock which occasionally crops out at the surface. In prolonged spells of dry weather crops and pastures are likely to be severely affected by drought. The topsoils are usually fine sandy loam in texture, have moderately developed structure and overlie stony sandy loam or loamy sand subsoils with weakly developed structures. The problems associated with surface 'capping' are less severe than in *map unit 41*, but, as in *map unit 42*, some trace element problems can be encountered.

Map unit 44 occupies 29 square kilometres (6 per cent of the association) and comprises mainly humus-iron podzols with some brown forest soils and peaty podzols. The natural soil drainage is generally free, but in a few areas it is imperfect. The land occurs on hill slopes bordering Strathallan and the south side of Glen Artney. Much of the terrain is similar to that of *map unit 43* but the soils are more acid and climatic conditions are cool and exposed. Trace element problems are likely to be prevalent where permanent pastures are run down or reverting to rough grazing.

Map unit 45 occupies 22 square kilometres (5 per cent of the association) on the gentle slopes of hills and uplands between Strathallan and Strathearn. The soils are mainly peaty podzols with some humus-iron podzols and peaty gleys. Most areas carry dry and moist Atlantic heather moor or bog heather moor but can be reclaimed for improved pastures if adequately drained. Trace element problems are likely to be encountered if improvements on these acid peaty soils are rapid, and advice should be taken as to the most appropriate methods of husbandry.

Map unit 46 occupies 33 square kilometres (7 per cent of the association) and consists mainly of peaty gleys developed on stony sandy clay loam till, with some peat in depressions or on gentle slopes, and peaty podzols on local steep slopes. The land lies mainly between 250 and 300 metres altitude and is moorland with moist Atlantic or bog heather moor communities. Comprehensive drainage is necessary for successful reclamation and pasture improvement, and as in *map unit 45* trace element problems are likely to be encountered if these acid peaty soils are improved rapidly. In areas of high rainfall improved pastures are likely to be difficult to maintain.

Map unit 49 occupies less than 1 square kilometre and comprises brown forest soils and humus-iron podzols developed on sandy colluvial deposits. It occurs on a steep, moderately rocky ridge overlooking the southern shore of Loch Lomond. Pasture improvement is difficult on the steeply sloping ground, but the semi-natural acid bent–fescue grassland provides rough grazing of good quality.

THE BARGOUR ASSOCIATION

(Map unit 51)

The soils of the Bargour Association are developed on clay loam tills derived mainly from Barren Red Measures sandstones, but with some admixture from other Carboniferous strata and Old Red Sandstone sandstones. The red sandstone of Old Red Sandstone origin forms a greater component of the tills in the northern part of the association area than farther south.

The association occupies 78 square kilometres (0.4 per cent of South-East Scotland), mainly in central Ayrshire but with small areas near Uddingston, and Douglas in Lanarkshire. The land ranges between 40 and 250 metres altitude and the climate is warm and moderately dry or wet with rainfall ranging from 900 to 1100 millimetres per annum.

The principal landform is undulating lowland with drumlin ridges, and slopes are usually gentle but occasionally strong. Brown forest soils with gleying predominate, but some noncalcareous gleys and humic gleys occupy channels and depressions between drumlins and also occur in areas of subsidence overlying underground coal workings.

Map unit 51 comprises mainly brown forest soils with gleying developed on brown, massive clayey till derived mainly from red sandstones. The topsoils are generally loam or sandy clay loam in texture, have moderately developed structure and few stones. Structure in the underlying clayey subsoil is moderately developed, but is very coarse prismatic.

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 imperfect. •

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

THE BEMERSYDE ASSOCIATION

(Map units 53–55)

The soils of the Bemersyde Association have been previously mapped in the eastern Southern Uplands (Ragg, 1960) and are developed on drifts derived from extrusive rhyolites and trachytes. The rocks are fine-grained, hard and resistant to weathering and the drifts are mainly thin stony colluvial deposits.

Extending to 61 square kilometres (0.3 per cent of South-East Scotland) the association includes the Eildon Hills, the Dirrington Laws and Bemersyde Hill, all well-known landscape features in the eastern Borders, and Tinto Hill in Lanarkshire. Tinto reaches 700 metres in altitude but the Border hills are lower, about 400 metres. The climate ranges from fairly warm and moderately dry to cold and wet with 1500 millimetres per annum average rainfall at Tinto and 750 millimetres near Melrose. Brown forest soils, humus-iron podzols and peaty podzols are the principal soils.

Map unit 53 occupies 24 square kilometres (40 per cent of the association) and comprises brown forest soils developed on shallow stony drifts. The soils are acid, strongly leached, and have free natural drainage. The semi-natural bent–fescue grassland provides rough grazing of good quality, but where gradients allow some improved swards have been established.

Map unit 54 occupies 5 square kilometres (10 per cent of the association) and comprises brown forest soils with some iron podzols and rankers. It resembles *map unit 53* but includes some rock outcrops and patches of scree. The bent–fescue grassland and dry Atlantic heather moor provide rough grazings which range widely in value.

Map unit 55 occupies 32 square kilometres (50 per cent of the association) and comprises peaty podzols developed on thin stony colluvial drifts. In the eastern Borders some humus–iron podzols are included in this map unit. The land lies at higher altitude than *map units 53* and *54* and the steep slopes, shallow stony soils and peaty surface layers make reclamation and improvement difficult. The Atlantic heather moor and white bent grassland communities provide rough grazing of poor or moderate quality.

THE BENAN ASSOCIATION

(Map unit 56)

The soils of the Benan Association have been previously mapped in south Ayrshire (Bown, 1973) and are developed on drifts from lower Ordovician conglomerates of the Barr series. These conglomerates are derived mainly from basic igneous rocks and carry thin, stony sandy loam and loam drifts.

Occurring mainly in South-West Scotland, the association occupies only 2

square kilometres in South-East Scotland (less than 0.1 per cent of the region). The land rises to 360 metres altitude and consists mainly of the prominent hill ridge, the Big Hill of the Baing, near the headwaters of the River Girvan. With 1500 millimetres per annum average rainfall, the climate is fairly warm and wet. The brown forest soils carry mainly herb-rich bent–fescue grassland.

Map unit 56 comprises brown forest soils developed on thin stony sandy loam drifts overlying permeable conglomerate rock. The natural drainage is free and the soil profiles show weak horizon differentiation. Strong slopes predominate on the hilly terrain and much of the land is utilized as rough grazing, which is of high quality on the herb-rich bent–fescue swards, but some improved pastures occupy basal slopes. Where conditions of slope allow, these soils are relatively easily reclaimed and the improved grass swards are resistant to damage by poaching.

THE BLAIR ASSOCIATION

(Map units 68 and 69)

The soils of the Blair Association are developed on drifts, principally lodgement tills, of mixed origin comprising materials derived from greywackes and Old Red Sandstone sandstones and felsites. The association occupies 28 square kilometres (0.1 per cent of South-East Scotland) in this region but is more extensive in South-West Scotland. It occurs in small areas north of Loch Doon in the upper parts of the valleys of the River Doon and the Water of Girvan, 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 or 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 300 metres and frequently occupies the lower parts of concave slopes in the upland valleys. The climate is fairly warm and wet with average annual rainfall reaching 1500 millimetres.

The soils are found generally on sites affected by run-off and seepage from higher ground and internal soil drainage is poor. Gleying is perhaps the principal feature of the soils, which are mainly noncalcareous and peaty gleys but also include some brown forest soils with gleying. Under the wet climatic and soil conditions the semi-natural vegetation is mainly sharp-flowered rush pasture, sedge mire and flying bent grassland.

Map unit 68 occupies 13 square kilometres (45 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. The high rainfall, slowly permeable clay loam till subsoils and topographic position on concave and gentle slopes, all contribute to create the wet conditions of this land. The semi-natural vegetation of sedge mire and sharp-flowered rush pasture provides good quality rough grazing. Improved pastures have been established on some areas which have been drained, but grazing requires careful management to avoid excessive damage by poaching.

Map unit 69 occupies 15 square kilometres (55 per cent of the association) and comprises noncalcareous gleys, peaty gleys and peat. The internal soil drainage is poor and very poor and the ground is waterlogged for considerable periods. The land is higher-lying than that of *map unit 68* and under the cool temperature and

wet climate the propensity for peat formation is high. The semi-natural vegetation, which includes sharp-flowered rush pasture, flying bent grassland and bog heather moor, provides rough grazing ranging widely in value. Under the wet conditions of soil and climate the establishment and maintenance of improved pastures on land where peaty surface layers predominate is difficult.

THE CAIRNCROSS ASSOCIATION

(Map unit 77)

The soils of the Cairncross Association have been previously described in Berwickshire (Ragg and Futty, 1967) and are developed on drifts derived from Lower Old Red Sandstone rocks which include sandstones, conglomerates, sandy ash beds, felstone and other porphyrys. The till derived principally from these rocks can also have a variable admixture of greywackes. Areas where the till is thin with rock near the surface or is partially water-worked in the surface layers are common.

The association is not extensive, covering 33 square kilometres (0.2 per cent of South-East Scotland), and occurs mainly near Ayton, north-west of Berwick.

The undulating lowland terrain lies mainly below 150 metres altitude. Both the gentle slopes and warm moderately dry climate with low average rainfall (700 millimetres per annum) are favourable to arable agriculture. The soils are brown forest soils and brown forest soils with gleying and carry crops or pasture.

Map unit 77 comprises brown forest soils and brown forest soils with gleying developed on thin stony drifts and water-worked tills respectively. On the thin drifts and deeply modified tills the natural drainage is generally free, but more commonly the soils are developed on till and are imperfectly drained. The latter soils have a surface layer of brown loam with fine blocky structure overlying a reddish brown gritty sandy loam indurated layer which passes down into the reddish brown gritty clay loam till.

Pastures and long-ley grassland are common where rock is near the surface but elsewhere the land is generally farmed in rotations including a major proportion of arable crops.

THE CANONBIE ASSOCIATION

(Map units 84–88)

The Canonbie Association comprises soils developed on drifts derived from Permian and Carboniferous sandstones and shales in the Canonbie, Gretna and Annan district of Dumfriesshire. The soils closely resemble those of the Clifton series described in northern England, south of the Scots' Dike (Kilgour, 1979; Jarvis *et al.*, in preparation). The drifts are principally thick reddish brown tills of clay loam or clay texture. Near the Solway coast between Dornock and Gretna and in some other low-lying situations, however, the upper layers of some tills have been partially sorted to depths of 1 to 2 metres and textures are sandy loam or loamy sand. On some hills south-west of Langholm the drifts are shallow and textures are sandy loam, loam or sandy clay loam. In general, the tills closely resemble deposits of similar origin in Cumbria and which are extensive in the north of England as far south as Cheshire.

The association is restricted to the Solway plain in east Dumfriesshire, where it occupies 284 square kilometres (1.4 per cent of South-East Scotland). The land

ranges in altitude from 20 to 200 metres and the principal landform is an undulating plain from which rise a few small hills with strong slopes. A number of enclosed basins are occupied by formations of deep peat.

The average rainfall is in the range 850–1250 millimetres per annum and the climate is mainly warm and moderately dry or moderately wet.

Arable and permanent pastures predominate on the brown forest soils with gleying and noncalcareous gleys of the till plain, but rush pastures occur where drainage has been neglected or is unimproved. On higher-lying ground, near the altitudinal limit of the association, flying bent grassland, Atlantic heather moor and blanket bog communities occur respectively on peaty gleys, peaty podzols and peat.

Map unit 84 occupies 40 square kilometres (14 per cent of the association) and occurs around Comlongon Castle, in an area south of Carrutherstown and along the Solway coast between Annan and Gretna. The land is undulating lowland with gentle slopes and the soils comprise brown forest soils with gleying developed on fine-textured tills and brown forest soils which are restricted mainly to strongly sorted tills having coarser textures in the upper layers. The natural drainage, which is mainly free or imperfect, is also largely associated with the textures in the upper 2 metres of till. The land is mainly pasture but includes some ground well suited to arable agriculture, and grain, forage roots and some potatoes are grown.

Map unit 85 covers 213 square kilometres (75 per cent of the association) and is the principal map unit of the Solway plain of east Dumfriesshire. The soils are brown forest soils with gleying and noncalcareous gleys developed on the red-brown clay loam tills typical of the association. Although strongly developed, the prismatic structure in the subsoils is coarse and permeability to moisture is low. Impeded natural drainage is characteristic of the soils of this map unit which differ mainly in intensity of gleying and the degree of waterlogging. The tills, like other reddish brown parent materials, tend to be resistant to the development of gley features and severe waterlogging of undrained soils can be associated with moderate amounts of grey and ochreous mottles.

The terrain is undulating lowland with gentle slopes and arable and permanent pastures are predominant, but rush pastures and sedge mires are found in unimproved areas. Barley, the main arable crop, is grown mainly as a supplementary feed for stock and to allow renewal of the grass swards. The principal enterprise is dairying, but care in the management of grazing is especially important if poaching is not to damage swards severely. Adequate housing to allow animals to be kept off land when it is wet and under-drainage with permeable infill in the drain-lines and secondary treatment to improve subsoil permeability are especially important.

Map unit 86 is not extensive, occupying 3 square kilometres (1 per cent of the association) in several areas south of Ecclefechan. The brown forest soils are developed on shallow stony drifts derived from Carboniferous sandstones on small hills rising from the till-covered lowlands. The natural drainage is free.

Average rainfall is 1000 millimetres per annum and the warm moderately dry climate favours both arable pasture and plantation woodland, which are the present forms of land use.

Map unit 87 occupies only 13 square kilometres (5 per cent of the association) and occurs in upland areas at altitudes of 160 to 220 metres between Waterbeck

and Langholm. The terrain is predominantly gently sloping and the soils are peaty gleys developed on sandy clay loam tills or sandy loam drifts. Some noncalcareous gleys occur in 'flush' sites or low-lying areas while peaty podzols are restricted to local strong or moderately steep slopes where drifts are shallow and moderately coarse in texture. The vegetation consists mainly of flying bent grassland, sharp-flowered rush pasture and moist Atlantic heather moor and provides rough grazing with a wide range in quality.

Although improved pastures can be obtained on this land following drainage and reseeding, the difficulties of utilization and maintenance of the swards produced are considerable.

Map unit 88 occupies 15 square kilometres (5 per cent of the association) and is closely related to *map unit 87*. The soils, which are mainly peaty gleys and peat with some noncalcareous gleys, are developed on sandy clay loam tills mantling gently sloping hill sides and depressions. The semi-natural plant communities, flying bent grassland, blanket bog and sharp-flowered rush pastures, reflect the waterlogged conditions which obtain frequently in these gleyed soils. The vegetation provides rough grazing of generally poor quality and pasture improvements are dependent largely on the possibilities for drainage, which in depressional or low-lying sites can be difficult. Wetness is likely to pose continuing problems to the utilization and maintenance of pastures.

THE CARPOW/PANBRIDE ASSOCIATIONS

(Map unit 89)

The soils of the Carpow/Panbride Associations, first described in the Perth, Angus and Fife areas (Laing, 1974), are developed on raised beach sands and gravels derived mainly from Old Red Sandstone sediments and lavas. The beach deposits occur along both open coasts and estuaries. Along the margins of estuaries these coarse-textured materials often overlie the silts and clays of a lower beach level and the free natural drainage characteristic of most soils of the associations is replaced by imperfectly draining conditions.

The associations occupy 86 square kilometres (0.4 per cent of South-East Scotland) and occur in the Endrick and Blane valleys near Drymen, in the Forth valley near Arnprior, Thornhill and Stirling and in the Earn valley near Crieff and extending intermittently eastwards to Newburgh on the Tay estuary. The land ranges in altitude between 10 and 60 metres and the average rainfall decreases from 1300 millimetres per annum in the warm wet conditions in the western areas of the association to 750 millimetres in the warm moderately dry climate of the lower parts of the Earn valley and the Tay estuary.

The soils are predominantly brown forest soils, but some brown forest soils with gleying occur where coarse-textured beach materials overlie silts and a few gleys are encountered in hollows. On terraces the soils tend to be gravelly, while sands generally occur as low mounds.

Map unit 89 comprises mainly freely draining brown forest soils. The topsoils are loamy, moderately deep and have well-developed structure, while the subsoils are sandy, with moderate development of structure and pass down into sands or sandy gravel. The soils are permeable and well suited to arable agriculture. Stoniness causes few problems and the compaction, which can occur in the lower subsoil horizons, can help maintain soil moisture levels. The brown forest soils

with gleying have imperfect natural drainage and the contents of fine sand and silt, which are notably higher than in the freely drained soils, can lead to minor 'capping' problems, but there are few other limitations to arable agriculture.

THE CARTER ASSOCIATION

(Map units 90–95)

The soils of the Carter Association have long been known in the east Borders area (Muir, 1956) and are developed on drifts derived from Lower Carboniferous sandstones of the Calciferous Sandstone Series. The sediments are mainly whitish, but in a few areas are red. On the footslopes of hills and in valleys the predominant drifts are thick clayey tills, but shallow sandy loams or loams occupy many upper slopes and ridge crests. Lime-rich strata in the parent rocks have had little apparent effect on the tills.

The association is restricted to the country along the border with England between Rowanburn near Canonbie to Hungry Hill east of Carter Bar and occupies 307 square kilometres (1.5 per cent of South-East Scotland). The land ranges in altitude from 100 to 550 metres and the landforms include hills, undulating uplands and valley sides. The terrain comprises mainly smooth, gently sloping, till-covered ground at low and moderate altitudes with steeper land at higher elevations. Rugged topography with rock outcrops is restricted to a few small areas. The average rainfall is high, 1250–1750 millimetres per annum, and the climate ranges from fairly warm and wet to cool and wet. Under conditions dominated by the effects of clayey parent materials, gentle or strong slopes and moist climate, wetness is the principal influence on soil formation and gleys are the most extensive soils. On the lower hill slopes and valley sides noncalcareous gleys and brown forest soils with gleying are predominant. Brown forest soils are restricted to hill sides at moderate elevations carrying stony sandy drifts. In the cooler, wetter conditions at higher altitudes peat develops readily and peaty gleys with peat layers 20–50 centimetres thick are widespread and occur in association with areas of peat. Peaty podzols occupy a few strong or steep hill slopes. Permanent and sharp-flowered rush pastures with some tussock-grass pastures predominate on the noncalcareous gleys and brown forest soils with gleying and flying bent grassland, blanket bog and moist Atlantic heather moor are extensive on the peaty gleys, peat and peaty podzols.

Map unit 90 occupies 8 square kilometres (3 per cent of the association) and comprises brown forest soils and brown forest soils with gleying. The stony sandy loam drifts, on which the soils are developed, are often shallow and overlie Carboniferous sandstone rocks from which they are derived. Slopes are strong and gentle near Rowanburn, but in the Esk valley at Langholm the land is steep. Where slopes allow, some grasslands have been improved and arable and permanent pastures are maintained, while on the steeper land acid bent–fescue grassland provides rough grazing of good quality.

Map unit 91 comprises noncalcareous gleys and brown forest soils with gleying and is extensive, occupying 104 square kilometres (34 per cent of the association). It occurs mainly in the valley of the Liddell Water and its tributaries on smooth, gentle or strong slopes generally at less than 200 metres altitude, but reaching 300 metres in the upper reaches of the valley. The soils are developed on greyish, clayey tills which are generally thick and are only slowly permeable to moisture.

The natural drainage is poor or imperfect and sharp-flowered rush pasture or tussock-grass pasture are predominant on unimproved land. However, arable and permanent pastures are extensive on areas with efficient systems of underdrainage. The plasticity and slow permeability of the fine-textured soils and high annual rainfall make the land very liable to poaching damage. The improved pastures are generally utilized for stock-rearing and hill sheep in conjunction with rough grazings on higher-lying land. Some grass conservation for winter feed is carried out, but little arable cropping is possible.

Map unit 92 occurs on the north-west facing slope of Larriston Fell in the Liddell Water valley and occupies 5 square kilometres (2 per cent of the association). The steep hill slope is irregular and moderately rocky with many springs and seepage lines. The brown forest soils and noncalcareous gleys reflect the varied drainage pattern; so do the plant communities, principally acid bent–fescue grassland, sharp-flowered rush pasture and tussock-grass pasture. Pasture improvements are not possible, but the semi-natural vegetation provides rough grazing of good quality. Some of the land has been planted with coniferous trees.

Map unit 93 comprising peaty podzols in association with peaty gleys and peat, occupies 36 square kilometres (12 per cent of the association). The soils are developed on shallow, stony sandy loam drifts mantling smooth, strong or steep upper hill slopes and summits and derived from Carboniferous sandstones. The peaty gleys are restricted mainly to less-steep areas and locally, fine-textured or thick drifts. The semi-natural plant communities are mainly moist Atlantic heather moor, flying bent grassland or blanket bog which provide rough grazing of poor or moderate quality. Under the wet climate improved pastures are difficult to establish and maintain and on much of the land reclamation is unlikely to be economic. Some areas have been planted with coniferous trees.

Map unit 94 occupies 7 square kilometres (2 per cent of the association) and occurs to the west of Wauchope Forest. The soils are mainly noncalcareous gleys and peaty gleys with small areas of peat and are developed on sandy clay loam tills and soliflucted materials. The landforms include concave slopes and depressions subject to moisture seepage from higher ground, the effects of which are evident in the semi-natural plant communities. The sharp-flowered rush pasture and flying bent grassland provide rough grazing of moderate value.

Map unit 95 is the most extensive in the Carter Association and occupies 147 square kilometres (48 per cent of the association). The soils are mainly peaty gleys and peat and are predominant throughout the hills and uplands, contrasting with the noncalcareous gleys of *map unit 91* on lower-lying ground. Downwasting of the sandstone rocks has given relatively subdued undulating hill and upland landscapes with smooth gentle or strong slopes on which clayey tills and shallower stony drifts form the soil parent materials.

Waterlogging and a strong tendency for peat development are characteristic of this land, and under the wet climate the establishment and maintenance of improved pastures is difficult and over much of the area is uneconomic or restricted to small patches. The semi-natural plant communities, which include bog heather moor, flying bent grassland, blanket bog and flying bent bog, provide rough grazing of generally low value. Some plantations of coniferous forest have been established, but effective drainage of these soils is difficult and trees are likely to be shallow rooting and consequently become liable to windthrow as they grow to critical heights.

THE CORBY/BOYNDIE/DINNET ASSOCIATIONS

(Map unit 97)

The soils of the Corby, Boyndie and Dinnet Associations have been grouped together to form units appropriate for representation at the 1:250 000 scale. The associations have long been recognized in Eastern Scotland (Glentworth and Muir, 1963; Laing, 1974) but in South-East Scotland only soils of the Boyndie Association have been encountered. These are developed on fluvioglacial materials, mainly sands, but including some gravel lenses, derived from acid rocks of the Dalradian Assemblage. The deposits occur mainly as terraces and low mounds in the lower reaches of the River Earn valley near the junction with the River Tay.

In the warm, moderately dry lowland of lower Strathearn the average rainfall is generally less than 750 millimetres per annum. The soils are principally humus-iron podzols together with some brown forest soils and have been cultivated.

Map unit 97 occupies only 3 square kilometres and comprises humus-iron podzols developed on sands of fluvioglacial origin. The soils, which are naturally freely drained, have been cultivated for long periods and are now similar in many respects to brown forest soils. Their sandy loam topsoils, which have well-developed fine structure and overlie sandy subsoils, provide a good medium for crop growth. Although generally well suited to arable agriculture, the soils have a low water-holding capacity and in dry seasons crop growth and yields can be reduced by drought. The soils are highly permeable and readily leached and careful attention to lime and fertilizer applications are required to maintain levels of fertility.

THE COUNTESSWELLS/DALBEATTIE/PRIESTLAW ASSOCIATIONS

(Map units 113, 114, 117, 119, 120, 122, 124, 126, 129, 133 and 134)

The soils of the Countesswells, Dalbeattie and Priestlaw Associations have been grouped together into 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 two small areas along the Whiteadder Water (Ragg and Futty, 1967). The soils of these associations are developed on drifts derived from granites and similar coarse-textured acid igneous rocks such as tonalites, quartz-diorites and related hybrid rocks. The 'Galloway granites' of south-west Scotland, intruded into the greywackes of the Southern Uplands during Old Red Sandstone times, are the principal granite masses. Farther east, two small contemporaneous intrusions range in composition from adamellite to granite and granodiorite and typically are deeply weathered (Ragg and Futty, 1967). The south-western granite rocks, however, are hard and generally form areas of hill and mountain which have been subject to intense erosion and have large amounts of rock cropping out. On the drifts are generally thin, stony, gritty greyish brown sandy loams, while thicker grey-brown tills are found mainly in low-lying areas and on footslopes. Deposits of coarse, loamy sand, indurated, humocky moraine occur in some valleys.

The associations are extensive, occupying 416 square kilometres (2.1 per cent of South-East Scotland) and are confined largely to the granite outcrops

mentioned above. Altitudes range from sea level to 750 metres and relief is mountainous and hilly with steep and strong slopes. Fields of *roches moutonnées* and similar ice-smoothed rock outcrops and of hummocky moraine occupy a few intermontane valleys and there are some steep rock walls and corries. Lowland areas with smooth slopes occur in Kirkcudbrightshire and the Whiteadder valley. In western areas the climate ranges from fairly warm to cold, and is wet with average rainfall of 1500 to 2500 millimetres, but in the Whiteadder valley conditions are moderately dry with 750 millimetres per annum rainfall.

Intense glacial erosion and ice-cover, persisting until the last stages of the glacial period, have given rise to landscapes with rock outcrops 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 footslopes, 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 as Loch Riecawr, 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 can be associated with rock outcrops or occupy small areas of smooth terrain as at Auchencairn or in the Whiteadder valley.

On the Dalbeattie Association, which is extensive in Galloway, 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 on peaty gleys, and peaty podzols with moist Atlantic heather moor are 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 rock outcrops, 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 and on the areas of the Priestlaw Association in the Whiteadder valley.

Map unit 113 covers 44 square kilometres (11 per cent of the associations) mainly in southern Kirkcudbrightshire, but with two small occurrences in the Whiteadder valley. 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 sandy loam tills and drifts. Some soils in the Whiteadder valley are on deeply weathered rock. The terrain is generally undulating lowland with rock-controlled, irregular slopes that make arable cropping difficult, but some smoother ground occurs near Auchencairn and in the Whiteadder valley. Arable and improved permanent pastures have been established on much of the land

and grass production is favoured by the warm wet climate. Drier conditions obtain on the small eastern occurrences of this map unit. 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 57 square kilometres (14 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 they occur at altitudes below 250 metres on irregular, strongly sloping, rock-controlled terrain with moderate amounts of rock outcrops. Although the warm wet climate and brown forest soils tend to favour pasture improvement, this is often made difficult by rugged topography and rock outcrops. 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 11 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 98 square kilometres (24 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 here the drifts are often less than 1 metre thick. High levels of precipitation and down-slope moisture movement over underlying bed-rock 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 to the presence of thin, moundy 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 41 square kilometres (10 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 mounds 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 present of acid bent–fescue grassland, Atlantic heather moor, flying bent grassland and blanket bog. Pasture improvements have not been attempted and are only possible in small scattered patches. Some coniferous plantations have been established.

Map unit 124 occupies 20 square kilometres (5 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 94 square kilometres (23 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 129 occupies 25 square kilometres (6 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 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.

THE CRAIGDALE ASSOCIATION

(Map units 138 and 139)

Of small extent, the Craigdale Association occupies 9 square kilometres (less than 0.1 per cent of South-East 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 footslopes 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 gleys 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 2 square kilometres (20 per cent of the association), and comprises brown forest soils and peaty podzols 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 7 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 Kirkbean and in the valley of the Skyre Burn where they were deposited by ice moving off the granites of the Cairnsmore of Fleet and Criffel hills on to the underlying greywackes. Ice moving from greywackes on to granites left similar drifts on slopes to the south of Kirkgunzeon.

The association is not extensive, occupying only 37 square kilometres (0.2 per cent of South-East 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 to 1500 millimetres per annum.

Brown forest soils are developed on mounds and terraces and on 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 18 square kilometres (50 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 7 square kilometres (20 per cent of the association) at altitudes of 100 to 200 metres on gently sloping hill sides 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 moor 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 (30 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, 159 and 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 plateaux margins.

The associations are extensive, occupying 743 square kilometres (3.7 per cent of South-East Scotland), and encompass the eastern parts of the Clyde Plateau Basalts which extend southwards into Ayrshire and northwards into Stirlingshire. The Lomond and Cleish Hills in Fife and Cairnpapple Hill at Torphichen are prominent local features. Altitudes range from 10 metres in the Clyde estuary to 500 metres in the Campsie Fells and on the Lomond Hills. Rainfall, which is 750 millimetres in the warm moderately dry lowlands near Burntisland in Fife, increases to 1000 millimetres on the fairly warm wet foothills around the Lomond and Cleish Hills and to 1800 millimetres in the cool wet foothills and uplands of the 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 178 square kilometres (24 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 is found on some hills or steep valley sides.

Map unit 148 is extensive, occupying 97 square kilometres (13 per cent of the associations), and comprises mainly brown forest soils with gleying and 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 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 and maintained.

Map unit 149 occupies 87 square kilometres (12 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.

Long-ley 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 119 square kilometres (16 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-ley 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 11 square kilometres (1 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 or 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 4 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 33 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 or 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 69 square kilometres (9 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 to 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 57 square kilometres (8 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 (2 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 70 square kilometres (9 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. The land occurs between high ground underlain by hard rocks, such as the ice-eroded plateau basalts of the Stirlingshire and east Renfrew hills and the Fife hills of volcanic origin, and the surrounding softer, till-covered, sedimentary strata. The development of terraced landforms is less marked than on Mull or Skye, but the strong slopes are slightly rocky. The naturally occurring acid bent–fescue grassland provides good quality rough grazing. In Stirlingshire there are some areas of deciduous woodland and although the terrain is generally too steep and rocky for reclamation there are some areas of improved grassland.

Map unit 159 occupies only 1 square kilometre (less than 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 in the eastern Carrick district of Ayrshire. 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 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 grassland and herb-rich Atlantic heather moor are not improvable because of the steepness of slope and amount of rock outcrop. 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) and are developed on interbedded sands and gravels of fluvioglacial origin derived mainly from Carboniferous rocks. The sedimentary strata include sandstones, shales and some marls and the igneous rocks are mainly basaltic lavas and some basic intrusive rocks. The soils are coarse-textured and readily cultivated.

The association occupies 331 square kilometres (1.7 per cent of South-East Scotland and occurs mainly along the Irvine, Ayr and Lugar valleys in Ayrshire, the Clyde and Douglas Water valleys in Lanarkshire, the Kelvin, Carron and Avon valleys in Stirlingshire, the Almond, North Esk and Tyne valleys in Midlothian and the Leven valley in Fife. 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 as in Fife and the Lothians, but becomes fairly warm with rainfall of 1250 millimetres per annum at higher elevations inland, as in the Clyde valley and Ayrshire.

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 196 square kilometres (59 per cent of the association) and comprises mainly brown forest soils on broad moundy 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. Irrigation is likely to confer considerable advantages in areas of low rainfall.

Map unit 164 extends to 135 square kilometres (41 per cent of the association) and comprises brown forest soils and alluvial soils. The sand and gravel fluvioglacial outwash deposits form both moundy 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, but are generally free-draining fine sandy loams or silty 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 DOUNE ASSOCIATION

(Map unit 168)

The soils of the Doune Association are developed on fluvioglacial 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-East Scotland where it occupies 20 square kilometres (0.1 per cent of the region) and is found in the valleys of the Forth and Teith and in Strathallan near Bridge of Allan. The land lies below 50 metres altitude and the climate ranges from warm and moderately dry to warm and wet, with average rainfall from 1100 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. Most of the land has long been under cultivation but some areas have been worked for gravel and since restored to agriculture.

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 moundy areas cultivation is restricted by steep slopes and wet hollows. Acid bent–fescue grassland and broadleaved woodland form small areas of semi-natural vegetation. Topsoils, in areas restored to agriculture after gravel working, often range widely in depth and can be very shallow and stony.

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 106 square kilometres (0.5 per cent of South-East Scotland) and occurs mainly along the river and estuary of the Forth: from Bridge of Allan intermittently to Fife Ness along the northern bank and from Stirling intermittently to Dunbar on the southern.

The land ranges in altitude from 20 to 40 metres near Stirling, from 15 to 20 metres on the coast of Fife and from 15 to 40 metres on the Lothian coast. Average annual rainfall ranges from 900 to 1000 millimetres per annum in western areas and from 600 to 900 millimetres farther east. The climate is warm and moderately dry.

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 89 square kilometres (85 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, are often deep, 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 is often used for production of vegetables and early potatoes.

Map unit 170 occupies 17 square kilometres (15 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. It occurs where sandy deposits on gently undulating raised beaches are shallow and underlain by silts, as at Aberlady and East Linton. The high contents of fine sand and silt lead to soils with structures which are less stable than in *map unit 169*. Permeability in the subsoils can be low. After prolonged wet periods the land requires careful management, but with adequate drainage crops produce good yields.

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 52 square kilometres (0.3 per cent of South-East 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 is 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 or clay tills. They are slowly permeable, have imperfect natural drainage and occur in undulating lowland landscapes with drumlin ridges and gentle and strong slopes. 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 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-East 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 ECKFORD/INNERWICK ASSOCIATIONS

(Map units 196–200)

The soils of the Eckford and Innerwick Associations have long been recognized in South-East Scotland (Ragg, 1960; Ragg and Futty, 1967) and are developed on fluvioglacial sands and gravels. These are red-brown and derived mainly from Old Red Sandstone sediments. Some sandy materials in the Borders are lacustrine in origin and gravels predominate near Cockburnspath and Auchtermuchty. The deposits, which form mounds, terraces and undulating ground, occur mainly in valleys or where valleys open on to lowlands. Recently formed flood plains and terraces along rivers excavating older Late-Glacial materials are important elements in several map units.

The associations occupy 306 square kilometres (1.5 per cent of South-East Scotland) and are distributed widely as small scattered areas in Fife, the Lothians and the Borders. The land lies mainly below 100 metres but a few higher areas rise to 250 metres altitude. The climate ranges from warm and moderately dry with rainfall of 750 millimetres per annum in Fife, the Lothians and Berwickshire to fairly warm and wet with 1350 millimetres per annum at Drumclog.

The soils are predominantly brown forest soils with some humus-iron podzols in Fife and have free natural drainage. Peaty, humic and non-calcareous gleys are restricted to kettleholes and other depressions while alluvial soils occupy small tracts along water-courses. Arable crops and ley grassland are extensive on the freely draining land with bent–fescue grassland on a few unimproved areas. Rush pasture, sedge mires and flying bent grassland predominate on soils subject to waterlogging. Copper deficiencies have been encountered on some areas of the Eckford Association.

Map unit 196 extends to 118 square kilometres (39 per cent of the associations) and comprises brown forest soils developed mainly on red-brown fluvioglacial sands or, in a few areas, gravels. Noncalcareous and humic gleys are generally of very limited extent. The land is low-lying, and although gentle slopes predominate on the undulating mounds and terraces, some short strong slopes are encountered. Under the warm dry climatic conditions the soils, generally of sandy loam texture in the surface layers, are easily cultivated and arable crops can be established readily. Textures in the subsoils are coarse, however, and the soil water-holding capacity is low and crop yields are likely to be reduced in some years by drought.

The content of organic matter can decline to low levels under continuous arable cropping, leading to some risk of windblow and erosion, in dry springs, of bare seed-beds with fine tilth and to compaction where soil aggregation and structure are weak. Most crop rotations include periods in pasture. Near Innerwick and Cockburnspath some stony soils are less easily worked than those developed on sands. Areas of unimproved land are generally very small and carry bent–fescue grassland where drainage is free or rush pastures and sedge mires in localized depressions subject to waterlogging.

Map unit 197 occupies 21 square kilometres (7 per cent of the associations) and comprises brown forest soils on mounds of fluvioglacial sand and peat and peaty alluvial soils in hollows and along small water-courses. The land closely resembles that of *map unit 196*, but low-lying areas subject to waterlogging are more extensive. On the brown forest soils, pastures are likely to be maintained for longer periods without being broken for arable cropping, while pasture improvement on the peat and peaty alluvial soils is dependent on the existence of suitable outfalls and other conditions permitting successful drainage.

Map unit 198 occupies 72 square kilometres (24 per cent of the associations) and comprises brown forest soils and alluvial soils. It occurs mainly in valleys and other areas where terraces of fluvioglacial sands have been eroded by rivers along which flood plains and recent alluvial terraces form an important part of the unit. As in *map unit 196* the brown forest soils are sandy loams on coarse-textured subsoils and can be readily cultivated, but where they occur as narrow tracts are often utilized principally for pasture. The alluvial soils on the river flood plains range widely in texture and natural drainage, but are generally loams and sandy loams, often overlying gravels, and have free or imperfect drainage. These tracts carry mainly improved pastures but some crops are grown where the risk of flooding allows. Rush pastures and sedge mires provide rough grazing of good quality on unimproved land subject to waterlogging.

Map unit 199 occupies only 2 square kilometres (less than 1 per cent of the associations) and comprises mainly noncalcareous gleys with minor occurrences of humic and peaty gleys. The soils are underlain by, and are developed on, sands which form gently sloping and flat land below about 110 metres altitude around the shores of Loch Leven. Due to the proximity of the loch the water-table is high and permanent pasture the predominant form of land use. A few arable crops are taken, however, in favoured areas, and sedge mires and rush pasture occupy unimproved land.

Map unit 200 occupies 93 square kilometres (30 per cent of the associations) and comprises humus-iron podzols with some gleys and alluvial soils. In areas of gently undulating lowland the parent materials are mainly sands while gravels predominate on moundy terrain with strong slopes. The humus-iron podzols have free or imperfect natural drainage and are generally under cultivation, but low soil water-holding capacity can lead to reduction of yield in dry seasons. Stoniness and slope patterns can also interfere with some cultivations on gravelly soils, some of which, near Ladybank, have been planted with coniferous woodland. Hollows and flat alluvial areas subject to waterlogging support sedge mires and rush pastures.

THE ETTRICK ASSOCIATION

(Map units 205–236)

The Ettrick Association has long been known in South-East 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 moraine, solifluction and colluvial deposits, screes, and cryic materials on mountain tops. The lodgement tills are mainly grey-brown clay loams which are widespread in valleys and on the lower slopes of hills, and also occur as drumlins in Kirkcudbrightshire. However, on many slopes around the Thornhill, Dumfries and Lochmaben basins the tills have a red-brown colour ascribed to additions of small amounts of fine material carried by ice moving off the nearby Permian sediments. In the valleys of the Carsphairn Lane and the Water of Ken hummocky moraines are coarse-textured, loamy sand and sandy loam, with abundant stones and boulders. The smooth, rounded, steep-sided hills, which typify the Lowther, Moorfoot and Lammermuir Hills and make up most of the Southern Uplands east of the River Nith, carry grey-brown stony loamy drifts. Ranging in thickness from several metres to less than one metre, these materials 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 associated screes are prominent features in the Kells, Merrick and Moffat hill ranges and screes partially colonized by vegetation occur on a few scattered very steep hill sides throughout the Uplands. Areas with thin drift and rock outcrops are restricted mainly to Galloway.

The Ettrick Association is the most extensive in Scotland south of the Highland Boundary Fault, and occupies 6149 square kilometres in South-East Scotland (30.8 per cent of the region). The Southern Uplands are typified by smooth, rounded, steep-sided hills with narrow valleys which can be partially U-shaped and floored with lodgement tills carrying gleys or V-shaped with hill sides descending almost directly to a small stream or narrow alluvial tract. In western parts of the Uplands 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 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, some with corries and rock walls at their heads.

Fields of hummocky moraine occupy some valleys. A number of hills such as those west of Clatteringshaws Loch or Pibble Hill above Creetown are rugged with complex rock-controlled slopes or have moderate amounts of rock outcrops. East of New Galloway and in the country round Crocketford drumlins of thick till occur scattered across undulating uplands and ice-eroded terrain with many rock outcrops.

The association includes a wide range of soils. On the stony loamy drifts on hill and valley sides below about 300 metres (200 metres in western areas) 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. The peaty podzols have a peaty surface horizon 20–40 centimetres thick, a grey gleyed E horizon, and a thin iron pan, often continuous and strong, overlying a strong brown B horizon rich in sesquioxidic weathering products. The vegetation ranges widely on these soils, but is generally moist Atlantic heather moor or flying bent or white bent grassland. In the hills of the Lammermuir and Moorfoot groups and around Peebles where the rainfall is less than farther west, many hill slopes carry humus-iron podzols. These soils have an H horizon of dry fibrous raw humus from 5 to 15 centimetres in thickness overlying a grey sandy loam aerobic E horizon. The B horizons include a dark reddish brown layer enriched in humus and iron, which can include an incipient iron pan, and an underlying yellow-brown or strong brown layer rich in sesquioxidic weathering products. The vegetation is generally dry or moist Atlantic heather moor. 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 north of Johnstonbridge or east of Lockerbie and the till-covered footslopes of some hills and valleys such as form the western flank of the Leader Water and occur along the River Tweed west of St. Boswells, the clay loam tills, ranging from red-brown to grey-brown in colour, 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 on 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 to 100 centimetres. The soils generally support flying bent bog, bog heather moor, or moist Atlantic heather moor communities.

Map unit 205 occupies 15 square kilometres (less than 1 per cent of the association) and comprises brown forest soils developed on water-modified stony tills. It is restricted to a few areas of undulating terrain with gentle slopes between about 100 and 200 metres altitude near Ayton. All the land has been cultivated and in the warm dry climate the soils are well suited to arable cropping.

Map unit 206 is extensive, occupies 392 square kilometres (6 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. In South-East Scotland, however, the land extends to higher altitudes, 300 metres, than in South-West Scotland where it is generally below 200 metres.

It forms notable areas along the Eye Water and west of Lauder, while farther west it occupies gentle and strong slopes in mid- and lower Nithsdale and parts of Annandale. Slopes are generally less than 15 degrees, steeper land with similar soils having been placed in *map unit 221*. The climate ranges from warm and moderately dry to fairly warm and 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 absence of steep slopes or severe climate are favourable to cultivation. Although the soils can be stony, grain and root crops for fodder are often grown in the moderate and low rainfall areas of this region. Much of the land, however, is found in association with upland and hill and is worked in accordance with the requirements of individual farm units. Permanent pastures forming 'inbye' land are important on some hill farms, but generally the length of periods in grass leys is shorter in South-East Scotland than farther west.

Map unit 207, occupying 196 square kilometres (3 per cent of the association), is extensive in southern Kirkcudbrightshire and also occurs at St Abbs Head and near Hawick. 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. The land is generally gently, or occasionally strongly sloping, but knolls and rock outcrops create complex slope patterns. Similar land on steeper slopes with greater amounts of rock outcrops has been placed in *map unit 223*. The climate is generally warm or fairly warm and wet with average annual rainfall in the range 1000–15000 millimetres, but near St Abbs Head it is moderately dry with 800 millimetres rainfall. 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 outwintered on this land, which is not prone to damage by poaching.

Map unit 208 occupies 100 square kilometres (2 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 rock outcrops. 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 290 square kilometres (6 per cent of the association) with major areas occurring along the Ale Water, on the western slopes of the Leader Water and around Lockerbie and elsewhere bordering the Lochmaben basin. The soils are predominantly brown forest soils with gleying with some noncalcareous gleys and are developed on 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. Generally the tills are brown or grey-brown in colour but in the country around the Lochmaben basin they are red-brown. Climatic conditions range widely from warm and moderately dry with 850 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. In the low rainfall areas of the east much of the land is worked in rotations of arable crops and ley grassland. Under wetter conditions farther west short arable breaks with long-ley grassland are predominant, but there are also some permanent pastures and some undrained, higher-lying land carrying sharp-flowered rush pasture which provides rough grazing of good quality. For efficient agricultural utilization these soils require effective underdrainage with permeable infill over the drains and secondary subsoiling treatments. Careful timing of cultivations is necessary on this land to minimize the risks of structural damage and the poaching of pastures is a major hazard during wet seasons.

Map unit 210 occupies 323 square kilometres (5 per cent of the association) and occurs in extensive areas south of Melrose, in the catchment of the River Teviot, in valleys west of Peebles and on Corrie Common, east of Lockerbie. The soils are principally noncalcareous gleys and some brown forest soils with gleying and are developed mainly on 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. In the area east of Lockerbie some tills are red-brown. Without effective under-drains the soils are subject to prolonged waterlogging, mainly due to 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. Efficient under-drains, however, allow the establishment of grass leys and the maintenance of improved permanent pastures. In favoured areas, especially where the climate is relatively dry in the eastern parts of the region, the ground may be worked for grain and forage crops. More generally, under wetter climatic conditions, careful management of grazing and stock are required to avoid severe poaching of grass swards.

Map unit 211 occupies 43 square kilometres (less than 1 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. Usually more than 1 metre in depth, the peat occupies areas which also often include glacially eroded rock knolls and these features are predominant south of Balmaclellan. The land is generally less than 200 metres 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 44 square kilometres (less than 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 55 square kilometres (less than 1 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 broken occasionally by *roches moutonnées*. Some pasture improvement by the use of lime, fertilizers and direct reseeding, or by ploughing and reseeding 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 68 square kilometres (1 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 hills of Carrick and Galloway. 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 in a number of areas.

Map unit 215 occupies 22 square kilometres (less than 1 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 and are surrounded by gently sloping areas of valley, blanket or basin peat. 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 76 square kilometres (1 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 rock outcrops 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 327 square kilometres (5 per cent of the association) and comprises peaty podzols, peaty gleys and peat. The land occurs mainly in the northern areas of Kirkcudbrightshire and in Dumfriesshire on hills less strongly dissected and with smooth slopes which are less steep 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, 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 39 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 214 square kilometres (3 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, generally 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, blanket bog and flying bent bog provide poor and moderate quality rough grazing. Some plantations of coniferous forest have been established.

Map unit 221, one of the most extensive in South-East Scotland, occupies 851 square kilometres (14 per cent of the association) and is widespread in the eastern and central Southern Uplands. It is a typical component of the landscapes of the Lammermuir and Moorfoot Hills, the hills around Peebles and, farther south, of the hills around Langholm and Moffat. Smaller areas are found in the Lowther Hills. Comprising only one soil type, brown forest soils, this map unit shows a uniformity that is notable in such an extensive unit. Strong dissection of the hills prior to glaciation and, in the central and eastern parts of the Uplands, vigorous downcutting by the principal rivers and their tributary streams, has given rise to narrow valleys with steep, smooth, long slopes on which the brown forest soils can extend up to about 330 metres altitude. 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 206* 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 humus-iron podzols in *map unit 227* or peaty podzols in *map units 228* or *229*. The steep slopes of much of this land can make cultivation and sward improvements difficult, but the predominant semi-natural 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 45 square kilometres (less than 1 per cent of the association) mainly in Galloway and Dumfriesshire and comprises brown forest soils with some brown rankers and moderate amounts of rock outcrops. 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 327 square kilometres (5 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 74 square kilometres (1 per cent of the association) mainly in the hill areas of the central Southern Uplands, and comprises rankers, podzols and brown forest soils. The soils are shallow, very stony and developed on stabilized screes 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 180 square kilometres (3 per cent of the association), mainly in the valleys of the White Esk, the Ettrick Water and the Yarrow Water. The small valleys of the tributary streams of these rivers are often U-shaped with steep sides and more gently sloping floors. Brown forest soils are developed on loamy stony drifts and solifluction deposits on the hill sides, and noncalcareous gleys on clay loam tills on the gently sloping lower hill slopes and in the valleys. The land lies mainly between 50 and 300 metres altitude and the climate is wet and fairly warm or cool with rainfall in the range 1100 to 1500 millimetres per annum. The brown forest soils carry mainly acid bent–fescue grassland, often with bracken, and sharp-flowered rush pastures predominate on the noncalcareous gleys. Both communities provide grazing of good quality and much of the land is utilized as rough grazing. Where slopes allow and drainage is feasible, pasture improvement is possible and has been carried out in some favoured, accessible areas. The land generally provides some of the most valuable grazing in the localities where it occurs. Some plantations of coniferous trees have been established, notably in Upper Eskdale.

Map unit 226 is extensive, occupying 285 square kilometres (5 per cent of the association), and comprises brown forest soils and peaty podzols. It occurs mainly in the Lammermuir, Moorfoot and Lowther Hills where it has been mapped on smooth rounded hills with convex slopes and intervening narrow V-shaped valleys with steep and very steep slopes. 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 average annual rainfall of 1500 millimetres in the Lowther Hills, but declining eastward to 750 millimetres in the Lammermuirs. 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, common 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 areas and, where slopes allow, are generally possible up to 450 metres altitude. On the brown forest soils, improvements once established should be readily maintained.

Map unit 227 is largely confined to the eastern Southern Uplands, notably the Moorfoot and Lammermuir Hills, where it occupies 171 square kilometres (3 per cent of the association). The soils, which are mainly humus-iron podzols, are developed on grey-brown stony sandy loam or loam hill side drifts and solifluction deposits. These materials are often thin and are generally compact or indurated. The smooth, convex, steeply and strongly sloping rounded hills typical of south Scotland are the principal landforms and range from 300 to 600 metres in altitude. The climate is described as cool or cold and wet, but the average annual rainfall of 750 to 1000 millimetres is relatively low for hill land in Scotland and this is reflected in the free or very free natural drainage of the soils and the dry heath which comprises much of the vegetation. The typical plant community is dry Atlantic heather moor together with some moist Atlantic heather moor, while acid bent–fescue grassland occurs on some brown forest soils included with the predominant humus-iron podzols. Agriculturally the land is utilized largely as rough grazing, of generally poor quality, for hill sheep, but for sporting purposes it is often a valuable part of grouse-moors. Where the land is accessible to machinery, conditions of slope allow its use, and the exposure and low temperatures associated with high altitudes are not excessive, the soils are moderately well suited to pasture improvements and swards, once established, should be readily maintained with appropriate lime and fertilizer treatments. The land should be resistant to the effects of poaching. Forest plantations have been established in a few areas, notably at Glentress, near Peebles.

Map unit 228 occupies 374 square kilometres (6 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, Moorfoot and Lammermuir Hills. 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 average annual precipitation ranging from 2000 millimetres in the Lowther Hills to 750 millimetres in the drier hills to the east. In many respects this map unit resembles *map unit 227*, but the upper layers of the peaty podzols are wetter than in the humus-iron podzols, although drainage in the deeper layers of both soils is free. The principal plant communities, moist Atlantic heather moor and white bent grassland, together with some dry Atlantic heather moor, boreal heather moor and flying bent grassland, provide rough grazing of moderate or poor quality. Little reclamation of this land has been carried out, but below about 430 metres the establishment of improved swards should be possible. Care in the stocking and management of pastures is likely to be necessary to prevent the ingress of rushes.

Map unit 229 occupies 537 square kilometres (9 per cent of the association) and comprises peaty podzols with some peaty gleys and peat. It 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 throughout much of the Southern Uplands on smooth rounded hills and undulating uplands with strong and steep slopes. In eastern areas where the climate is drier than in the west, slopes are more generally gentle and strong and some less steep land is included in this map unit. 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, 200–600 metres, and the climate is fairly warm and wet to cold and wet with rainfall levels of 750 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 in western areas of this map unit. 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 282 square kilometres (5 per cent of the association) and occurs mainly in northern areas of Kirkcudbrightshire and 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 to 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 176 square kilometres (3 per cent of the association) and, like *map unit 230* to which it is closely related, occurs mainly in Galloway and 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 to 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 163 square kilometres (3 per cent of the association) and occurs mainly in Galloway and western Dumfriesshire where it comprises noncalcareous 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 glacial erosion and are exemplified west of Moniaive by the Shinnel, Dalwhat and Craigdarroch 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 altitudes 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 236 square kilometres (4 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 is not extensive, occupying 28 square kilometres (less than 1 per cent of the association). It occurs mainly in the central parts of the Southern Uplands on ridge crests and hilltops at 400–600 metres altitude. The soils, peaty podzols, peaty gleys and peat, reflect the propensity for peat development on gentle slopes at these elevations under the cold wet climate with 1500 millimetres per annum average rainfall. 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 37 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. 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 84 square kilometres (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 central and western 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 basement 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 FORFAR ASSOCIATION

(Map unit 239)

The soils of the Forfar Association are developed on water-sorted drifts derived from Lower Old Red Sandstone sediments. It is believed the drifts have been reworked by waters from wasting ice under periglacial conditions in Late-Glacial and immediate Post-Glacial times.

The association is not extensive in this region, where it occupies 4 square kilometres (less than 0.1 per cent of South-East Scotland) and is confined to Stratheden and the Howe of Fife, but is of much greater extent in Eastern Scotland. The land lies mainly between 35 and 70 metres altitude and the climate is warm and moderately dry with average rainfall of 800 millimetres per annum.

The soils, which are principally humus-iron podzols with some brown forest soils and gleys, have generally been cultivated with consequent mixing and alteration of the upper horizons.

Map unit 239 comprises mainly humus-iron podzols and brown forest soils with very minor occurrences of gleys. The natural drainage is generally free and the principal soil has a sandy loam topsoil overlying a loamy sand subsoil which passes down, at depths greater than 60 centimetres, into loam or sandy clay loam till. The land is utilized mainly for arable agriculture for which it is well suited, although in dry seasons the moderately coarse textures of the upper soil layers and moderate water-holding capacity can cause drought to affect some crops.

THE FOUDLAND ASSOCIATION

(Map units 240, 241, 243, 244, 246, 248, 250, 252, 253 and 255)

The Foudland Association, first described in north-east Scotland (Glentworth, 1954; Glentworth and Muir, 1963), comprises soils developed on drifts derived from slates, phyllites and other weakly metamorphosed argillaceous rocks. In this region the rocks are mainly hard Aberfoyle slates and associated slaty schists which outcrop along a narrow belt parallel to the Highland Boundary Fault. The drifts are yellowish brown or olive-brown, fairly compact, fine sandy loam to loamy fine sand, and contain many tabular slate and slaty schist fragments. The proportions of silt and fine sand particles are high and account for the smooth, 'soapy' feel of the material when handled.

The association occupies 102 square kilometres (0.5 per cent of South-East Scotland) in a band, 3–5 kilometres wide, extending from Loch Lomondside north-westward through Aberfoyle and the Leny Pass to the Forest of Glen Artney. Altitudes range from 20 metres on Loch Lomondside to 700 metres on Stuc à Chroin, north of Callander. Rainfall, which is 1500 millimetres per annum in the warm wet lowlands near Loch Lomond, increases to 2500 millimetres in the cold wet uplands and mountains of the Forest of Glen Artney.

The prevailing wet climate and low content of bases in the parent materials produce conditions in which brown forest soils are restricted to lowlands and steep colluvial slopes. Humus-iron podzols are extensive and predominate on the strong and steep slopes of the lower hills and on valley moraines. Noncalcareous gleys occur on the gentle or strong slopes of the lowlands and foothills while peaty gleys and peaty podzols occupy the upper slopes of hills. Subalpine and alpine soils are restricted to ridge crests at high altitudes.

Map unit 240 occupies 7 square kilometres (5 per cent of the association) mainly in the valleys of the Trossachs and in Glen Artney. The soils, principally brown forest soils together with some brown rankers and noncalcareous gleys, are generally shallow with rock near the surface and occur on valley sides with gentle or strong slopes. The land is utilized mainly for improved pasture and cultivation is generally restricted to reseeding and sward improvement. Acid bent–fescue grassland or woodland with broadleaved trees occurs on some steep slopes.

Map unit 241 covers 23 square kilometres (20 per cent of the association) and comprises noncalcareous gleys and peaty gleys with some humic gleys and peat in flushed sites. Occurring mainly in the Trossachs, in Glen Artney and north of Callander, it occupies gentle or strong, non-rocky slopes in areas of lowland or foothill. The soils are developed on compact loamy tills which are often stony and have high proportions (25–50 per cent) of silt (2–50 μm) The natural drainage is poor or very poor and under the prevailing high rainfall efficient under-drainage systems are required for the maintenance of improved pastures. Unimproved areas carry mainly sharp-flowered rush pasture, sedge mire or flying bent grassland and provide rough grazing of moderate quality.

Map unit 243 comprises humus-iron podzols with some brown forest soils, noncalcareous gleys, peaty gleys and peaty podzols. It occupies 32 square kilometres (30 per cent of the association) in hills extending from the Trossachs to Glen Artney and occurs on gentle or steep, non-rocky slopes. The soils are developed on fine sandy loam or loamy fine sand drifts which, on steep slopes, are often colluvial. The semi-natural plant communities are mainly acid bent–fescue grassland, Atlantic and boreal heather moors and the land is utilized mainly as rough grazing or for forestry. Improved pastures can be established in favoured areas at moderate altitudes.

Map unit 244 comprises mainly peaty podzols with some humus-iron podzols, with peat and gleys in depressions. It occupies only 4 square kilometres (less than 5 per cent of the association) in the Forest of Glen Artney where it occurs on non-rocky hills and valley sides with gentle or steep slopes. The semi-natural plant communities include dry Atlantic heather moor, boreal heather moor, white bent grassland and flying bent bog and provide rough grazing of poor or moderate quality. Some areas are utilized as deer-forest.

Map unit 246 comprises peaty gleys and peat with some peaty podzols and minor occurrences of humic gleys in flush sites. Occupying 10 square kilometres (10 per cent of the association) near Dun Damph in Loch Ard Forest, it occurs on lower hill slopes which, although rock-controlled, lack rock outcrops. Gradients are usually gentle or strong. The soils are developed on shallow drifts, which are often colluvial, and the semi-natural vegetation, moist Atlantic heather moor, bog heather moor and flying bent bog, provides rough grazings of poor quality. Some plantations of coniferous trees have been established.

Map unit 248 comprises humus-iron podzols with some brown forest soils, peaty podzols, gleys and peat. It occupies 5 square kilometres (less than 5 per cent of the association) in upper Glen Artney and the Keltie Glen, east of Callander, where it occurs on hummocky moraines in the bottoms and on the lower slopes of the valleys. The mounds of morainic debris derived from slates and slaty schists carry the podzolic soils while gleys and peat occupy the intervening hollows. Improved pastures can be readily established where mounds are of a suitable extent and slopes are gentle, but the intervening hollows require drainage. The semi-natural plant communities include acid bent–fescue grassland and white bent–fescue grassland on mounds with rush pastures and sedge mires in hollows, and provide rough grazing of good or moderate quality.

Map unit 250 comprises brown forest soils and humus-iron podzols with some humic gleys and peaty gleys in wet areas and brown rankers around rock outcrops. Occupying 7 square kilometres (5 per cent of the association) in the Pass of Leny near Callander and between Aberfoyle and Loch Ard it occurs on strong, steep or very steep, moderately rocky slopes. The soils are developed on stony colluvial drifts which are often shallow and have rock near the surface. Humus-iron podzols are restricted to the upper slopes and the gleys occur mainly in 'flush' sites. The semi-natural plant communities, acid bent–fescue grassland, rush pastures and sedge mires, provide rough grazing of good or moderate quality. Some areas are utilized for forestry and have trees of broadleaved species.

Map unit 252 comprises humus-iron podzols, peaty podzols and peaty rankers with some noncalcareous gleys, peaty gleys and peat. It occupies 8 square kilometres (10 per cent of the association) near Aberfoyle and Callander. The landforms and soil parent materials are similar to those of *map unit 250*, but altitudes are greater and peaty podzols and peaty rankers replace brown forest soils and brown rankers. The semi-natural plant communities include dry and moist Atlantic heather moors, white bent grassland and blanket bog and provide rough grazing of poor or moderate quality. Some forest plantations have been established.

Map unit 253 comprises peaty gleys, peaty podzols with some peat and rankers. It occupies 5 square kilometres (less than 5 per cent of the association) in Achray Forest and in the hills north of Callander where it occurs on slightly rocky, gentle or steep slopes. The soils are developed on shallow drifts which are often colluvial, and while the terrain exhibits many similarities to that of *map unit 250* the proportion of poorly draining soils and wet land is much greater. The semi-natural vegetation, moist Atlantic heather moor, bog heather moor, heath rush–white bent grassland and soft rush pasture, provides rough grazing of generally poor quality. Some areas are utilized for forestry.

Map unit 255 is not extensive, occupying only 1 square kilometre (less than 5 per cent of the association), and comprises subalpine soils with some peat and rankers. It is confined to the Sròn na Maoile ridge in the Forest of Glen Artney where the terrain is moderately rocky with gentle or steep slopes. The semi-natural vegetation, stiff sedge grassland, mountain blanket bog and fescue–woolly fringe-moss heath, provides rough grazing of poor quality. Some areas are utilized as deer-forest.

THE FRASERBURGH ASSOCIATION

(Map unit 259)

The soils of the Fraserburgh Association are developed on aeolian sands containing a high proportion of shell fragments. The sands often overlie raised beach material; in Fife and parts of East Lothian these deposits are sandy but elsewhere in East Lothian consist of silts and clays.

Occupying 23 square kilometres (0.1 per cent of South-East Scotland), the association occurs in coastal situations as at Largo Bay in Fife, Aberlady and Gullane Bays near North Berwick and in other small bays near Dunbar. Altitudes range from 5 to 30 metres and the climate is warm and moderately dry with 600 millimetres per annum average rainfall.

Brown calcareous soils predominate, but there are some calcareous regosols and brown forest soils with occasional gleys in dune slacks. The high content of shells is associated with pH values of 7.5 to 8.5 in the C horizons.

Map unit 259 comprises brown calcareous soils and calcareous regosols; some brown forest soils occur where shells are absent and gleys are present in low-lying sites where the water-table is high. The natural drainage is predominantly free, but can be imperfect where the sands overlie silts or clays. The calcareous regosols are found mainly on active or stabilized dunes and the semi-natural vegetation comprises northern dunes and dune pasture communities. The land is utilized principally as permanent pasture, but some crops are grown in sheltered sites. The moisture-retention capacity in these soils is low and crop growth and yields are affected by drought in most seasons. Proximity to the sea is associated with high levels of exposure to winds laden with salt spray.

THE GLENALMOND/MAYBOLE ASSOCIATIONS

(Map units 265–270 and 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 conglomerate incorporating pebbles derived from igneous rocks or greywackes. The drift is principally a compact reddish brown sandy clay loam till.

In this region, the soils belong to the Glenalmond Association and occupy 103 square kilometres (0.5 per cent of South-East Scotland), mainly around Straiton and eastward, along the northern edge of the Southern Uplands Fault, in the Glespin valley, on Middle Muir, south of Douglas and around Lesmahagow and Tinto Hill. Rainfall ranges from 1000 to 1550 millimetres per annum and the climate from warm and moderately dry to cool and wet.

In the lowlands the soils are principally brown forest soils with gleying with

some brown forest soils while noncalcareous and peaty gleys predominate in the foothills and uplands. Peaty podzols occupy locally steep hill sides.

Map unit 265 is widespread, occupying 21 square kilometres (20 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 21 square kilometres (20 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, 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 18 square kilometres (15 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 13 square kilometres (15 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 2 square kilometres (less than 5 per cent of the associations) and comprise peaty gleys, peaty podzols, noncalcareous gleys and peat. It occurs mainly near Crawfordjohn and in the hills of south Lanarkshire. 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.

Map unit 270 occupies 27 square kilometres (25 per cent of the associations) and comprises peaty gleys, peat and some noncalcareous gleys. It occurs mainly in uplands near Muirkirk and Douglas. The parent materials are reddish brown sandy clay loam and loam tills and colluvial drift 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 272 is not extensive, occupying only 1 square kilometre (less than 5 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 fluvioglacial 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. The associations occupy 51 square kilometres (0.3 per cent of South-East Scotland) mainly in west Perthshire and the Howe of Fife. The terrain consists of mounds and terraces with a wide range of slopes and lies at altitudes of 50 to 150 metres. In the warm moderately dry lowlands of the east average rainfall is 750 millimetres per annum, but this increases to 1150 millimetres in the warm wet lowlands farther west.

Map unit 273 comprises mainly podzols developed on gravels deposited as mounds while colluvial soils, gleys or peat occupy the intervening hollows. The gravels are highly permeable and the soils, which although subject to strong leaching, have generally been cultivated. They require generous additions of fertilizers for optimum yields of grass or arable crops. Stoniness of the land can affect cultivations, grass conservation and the harvesting of arable crops, while in many years yields are affected by drought. Nevertheless rotations of arable crops and ley grassland are followed on much of this land. Depths of topsoil can range widely on land restored to agriculture following extraction of gravel. Podzol characteristics are developing on previously cultivated land in west Perthshire following the planting of coniferous trees.

Plate 1. *The Carse of Stirling (map unit 488) and the Teith lowlands (map units 41 and 274) looking north-westwards to the Highlands with Ben Each, Stuc à Chroin and Ben Vorlich, which lie beyond the Highland edge, on the skyline. To the right of these hills is the rounded outline of Uamh Bheag, formed of Old Red Sandstone conglomerates.* Photograph A. D. S. Macpherson.

Plate 2. *The Tough Hills. The succession of lava beds appears as long parallel lines on the scarp face as a result of differential erosion of the softer scoriaceous surfaces and harder basal rocks of individual flows. The soils, which belong to the Darleith Association, form map unit 158. The grassy and wooded slopes are in the Kippen Association (map unit 337) and Sorn Association (map unit 467).* Aerofilms.

Plate 3. *Mid-Glen Devon in the Ochil Hills with alluvial soils, together with brown forest soils of the Gleneagles Association (map unit 273) on gravel terraces, in the valley. The lava hills are in the Sourhope Association: brown forest soils (map unit 472) occupy the lower parts of the hill slopes and peaty podzols (map unit 476) form the higher-lying ground.* Photograph A. D. S. Macpherson.

Plate 4. *A landscape near Fauldhouse typifying the wet terrain and soils of the Carboniferous lowlands. Peat and peaty gleys of map unit 450 appear in the foreground and noncalcareous gleys of map unit 446 surround the mining settlement.* SDD Crown Copyright.

Plate 5. *Glencorse Reservoir in the Pentland Hills. Soils of the Bemersyde Association (map unit 55) form the highest ground with land (map unit 470) of the Sorn/Humbie/Biel Associations on the lower slopes. In the foreground are soils of the Sourhope Association (map unit 474).* Aerofilms.

Plate 6. *Harvesting at Old Liston Farm. Land with brown forest soils with gleying and brown forest soils in the Rowanhill/Giffnock/Winton Associations (map unit 444) forms highly productive arable ground under warm dry climatic conditions with low (750 millimetres per annum) average annual rainfall.* Photograph Scotsman Publications.

Plate 7. *The Lothian plain to the east of Edinburgh as seen from the Lammermuir Hills. Land in map units 331 and 445 provides productive arable ground. North Berwick Law is in the distance.*

Plate 8. *Cairnsmore of Fleet from the valley of the Palnure Burn. The silty clays of the Stirling Association (map unit 488) in the foreground are succeeded on the lower hill slopes, in the middle distance, by eroded rocky terrain with brown forest soils (map unit 223) of the Ettrick Association and by rocky granite hill sides of the Dalbeattie Association (map units 118 to 126). Subalpine soils (map unit 134) occupy the mountain summit.*

Plate 9. *Rising above the enclosed land granitic rocks of the Criffel hill mass form the eroded slopes of Drumburn Hill with thin peaty soils of the Dalbeattie Association (map unit 126). On the lower-lying ground brown forest soils of the Creetown Association (map unit 141) occur on drifts of mixed, granitic and greywacke origin. The village of Kirkbean occupies the foreground.* Aerofilms.

Plate 10. *Langholm, on the banks of the River Esk at its confluence with the Wauchope Water and the Ewes Water. The smooth slopes of the greywacke hills rise steeply from the alluvial valley bottom land (map unit 1) and carry brown forest soils of the Ettrick Association (map unit 221) at altitudes up to 300 metres.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Plate 11. *Upper Annandale near Moffat. In the foreground drifts derived from Permian sandstones and breccias carry brown forest soils with gleying and brown forest soils (map unit 303) of the Holywood Association. The forestry plantations occur on brown forest soils, noncalcareous gleys and peaty podzols of the Ettrick Association (map units 221, 225 and 228).*

Plate 12. *The Tweed valley at Walkerburn. The valley is occupied by alluvial soils (map unit 1) and brown forest soils on gravels of the Yarrow Association (map unit 579), while brown forest soils on stony loamy drifts (map unit 221) of the Ettrick Association occupy the steep smooth hill slopes up to 400 metres altitude.* Aerofilms.

Plate 13. *Wet organic soils (map unit 4) on the undulating peat uplands at about 350 metres altitude north of Kirkconnel provide rough grazing in land capability for agriculture Class 6.3.*

Plate 14. *The Eildon Hills near Melrose with thin stony soils (map unit 54) of the Bemersyde Association on fine-grained acid intrusive rocks. Brown forest soils with gleying (map unit 209) on greywacke-derived till form much of the surrounding land.* Institute of Geological Sciences photograph published by permission of the Director; NERC copyright.

Plate 15. *Hilly terrain with the rounded summits and smoothly sloping sides which typify much of the high ground of the Dumfries–Roxburgh border. The soils are mainly peaty podzols of the Ettrick Association (map unit 228).*

Plate 16. *Brown forest soils with gleying (map unit 575) on clayey tills of the Whitsome Association provide fertile farm land in the undulating lowlands of Berwickshire.*

THE GOURDIE/CALLANDER/STRATHFINELLA ASSOCIATIONS

(Map units 274–277)

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 conglomerates) and igneous rocks (mainly of intermediate and basic types). The drifts, which are pale yellow-brown where metamorphic rocks predominate and sandstones are grey, are reddish brown where sandstones and conglomerates are red; they range from indurated coarse sandy loam to compact fine sandy loam and are often massive, bouldery and very stony.

The associations occupy 106 square kilometres (0.5 per cent of South-East Scotland) mainly in a zone along the Highland Boundary Fault from Loch Lomondside north-eastward through Callander to Glen Artney. Rainfall ranges from 1500 to 1750 millimetres per annum in the warm wet lowlands to more than 2000 millimetres in the cool wet uplands of west Perthshire. The soils are mainly brown forest soils with gleying together with some brown forest soils. Noncalcareous and peaty gleys are restricted to depressions and humus-iron podzols occur on some hill sides.

Map unit 274 occupies 70 square kilometres (65 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, seed-beds 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 26 square kilometres (25 per cent of the association) and comprises noncalcareous gleys with some peaty gleys and humic gleys. The soils are developed on loam or sandy clay loam tills which are compact, have weakly developed structure and are slowly permeable to moisture. The natural drainage is poor or very poor and comprehensive under-drainage with permeable infill in the drain-lines and secondary treatment to improve subsoil structure and permeability are required for the establishment and maintenance of improved grass swards. The semi-natural plant communities, flying bent grassland, rush pastures, blanket and flying bent bog occupy much of the land and provide rough grazing of poor quality.

Map unit 276 occupies 10 square kilometres (10 per cent of the association) and comprises humus-iron podzols with some brown forest soils, peaty podzols and gleys. It occurs on the hills and uplands, such as Lennieston Muir near Callander where the undulating terrain includes a wide range of slopes and the drifts are predominantly stony. Much of the land is suited for reclamation and pasture improvement but is currently utilized for rough grazing or coniferous forest plantations. The semi-natural vegetation includes dry and moist Atlantic heather moors and white bent grassland.

Map unit 277, occupying less than 1 square kilometre (less than 5 per cent of the association), comprises peaty podzols and humus-iron podzols with some gleys

and peat. In this region it is restricted to the summit of Leny Hill near Callander where the land is exposed and suited only for use as rough grazing. The semi-natural vegetation includes dry and moist Atlantic heather moors and acid bent–fescue grassland and provides rough grazing of moderate quality.

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 is restricted to the Thornhill basin in the valley of the River Nith where it occupies 28 square kilometres (0.1 per cent of South-East 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 11 square kilometres (40 per cent of the association) and comprises 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 (20 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. Ley grassland 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 11 square kilometres (40 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 174 square kilometres (0.9 per cent of South-East 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. It occurs also in Fife. The climate in Ayrshire, which is fairly warm to cool and wet with average rainfall of 1250 to 1500 millimetres per annum, contrasts with that of the warm moderately dry lowland in Fife with 800 to 900 millimetres per annum rainfall.

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 78 square kilometres (45 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. Arable crops are grown more commonly in Fife than in Ayrshire.

Map unit 292 occupies 55 square kilometres (30 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 pasture.

Map unit 293 occupies 41 square kilometres (25 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 HOBKIRK ASSOCIATION

(Map units 295–302)

The Hobkirk Association has long been known in the Borders of Scotland (Muir, 1956; Ragg, 1960) and comprises soils developed on drifts derived from sandstones and marls of Upper Old Red Sandstone age. The sandstones are generally red and highly siliceous, but yellow strata with interbedded red or purplish brown shales are also encountered. The drifts are usually less than 2 metres thickness and have sandy loam textures, although some soils are formed on disintegrating soft sandstones and some, in low-lying areas, are on sandy clay loam tills or water-worked tills.

The association is extensive in the eastern Southern Uplands, the Borders and the Pentland Hills, and occupies 577 square kilometres (2.9 per cent of South-East Scotland). The land is generally undulating lowland with gentle or strong slopes at altitudes of less than 250 metres, but some higher-lying ground occurs in the Pentland Hills at 300–600 metres altitude. The climate is generally fairly warm and moderately dry with average rainfall of 750 millimetres per annum, but in the Pentland Hills it is cool and wet and rainfall is 1000 millimetres.

Much of the land is utilized for arable crops and ley grassland, while the semi-natural plant communities, which include Atlantic heather moor, white bent grassland, flying bent grassland, blanket bog and bog heather moor, are most extensive in the Pentland Hills. Brown forest soils predominate throughout much of the association area with noncalcareous gleys restricted to hollows. In the Pentland Hills, however, peaty podzols and humus-iron podzols in association with blanket peat are the principal soils. Peaty gleys occur on some gentle slopes in areas of upland.

Map unit 295 occupies 16 square kilometres (3 per cent of the association) mainly near Chirnside. It comprises brown forest soils developed on water-worked sandy loam tills in gently undulating lowland terrain. The free natural drainage, loamy textures, gentle slopes and warm dry climate make this land well suited to arable agriculture and intensive cropping is possible.

Map unit 296 is extensive, occupying 317 square kilometres (55 per cent of the association) mainly in the eastern Borders with some small areas in East Lothian. It comprises predominantly brown forest soils, with minor occurrences of noncalcareous gleys and humic gleys, developed on sandy loam drifts, which are generally thin or occasionally on sandstones weathering *in situ*. The natural drainage is free and the soils are sandy loams or loams occurring below 250 metres altitude in undulating lowlands with gentle or strong slopes. The climate is fairly warm and moderately dry with about 750 millimetres per annum average rainfall. These conditions of soil, climate and topography are well suited to the needs of arable farming and the land is generally highly productive for a range of crops which includes barley, wheat, turnips and potatoes. A few local steep slopes

carry acid bent–fescue grasslands, and sedge mires or rush pastures may be found in wet hollows difficult to drain.

Map unit 297 occupies 67 square kilometres (12 per cent of the association) and comprises brown forest soils and noncalcareous gleys. It occurs mainly in the Borders on broad gently sloping ridges or hill sides with intervening depressions, and the soils are developed on sandy loam tills (generally less than 2 metres thickness) and thicker sandy clay loam tills. The pattern of soils with naturally free or poor drainage is not generally complex, but in most fields both soil types are likely to be present. The semi-natural plant communities are of very limited extent but include acid bent–fescue grassland, rush pastures and sedge mires. Most of the land, however, has been cultivated and is farmed in rotations of arable crops with short periods in grass leys. Efficient under-drains are required in the noncalcareous gleys but some of the effects of slow soil permeability and wetness, although considerably ameliorated, are likely to persist and affect the utilization of many fields.

Map unit 298 is not extensive, occupying 16 square kilometres (3 per cent of the association). The soils, which are principally noncalcareous gleys, with some brown forest soils with gleying and peaty gleys, are developed on sandy clay loam tills or sandy loam drifts. Lying between 100 and 300 metres altitude in the eastern Borders, the terrain includes hill sides and depressions with gentle slopes. The natural drainage of these gleys is poor and the land can lie wet for long periods. In the more favoured areas under-drains have been installed extensively and the land cultivated for grain crops and ley grassland. Permanent pastures are maintained in some areas and on unimproved remote land the semi-natural plant communities include rush pastures, tussock-grass pastures and acid bent–fescue grassland and provide rough grazing of good quality.

Map unit 299 occupies 61 square kilometres (11 per cent of the association) mainly in south-western areas of the Pentland Hills, and comprises peaty podzols and humus-iron podzols with some gleys and peat. Lying between 250 and 600 metres altitude, the hilly terrain has strong and steep slopes that are mantled by shallow, stony, sandy loam drifts carrying peaty podzols and humus-iron podzols. Rock outcrops are generally absent. Thin blanket peat occupies the more gently sloping hill summits and gleys form small areas at the base of slopes. The semi-natural vegetation includes Atlantic heather moor, white bent grassland and flying bent grassland and provides rough grazing of poor or moderate quality. Unless the slopes are too steep, the soils with free drainage in the subsoils are moderately well suited, at altitudes up to about 400 metres, to reclamation and the establishment of improved pastures.

Map unit 300 is not extensive, occupying only 6 square kilometres (1 per cent of the association) in an area of undulating terrain with gentle slopes near Westruther. It comprises a heterogeneous assemblage of soils which includes brown forest soils and peaty gleys with some noncalcareous gleys and peat. The brown forest soils are utilized for arable and permanent pastures and some areas with poor natural drainage have been drained and support improved pastures. The semi-natural plant communities include moist Atlantic heather moor, rush pastures and sedge mires.

Map unit 301 occupies 49 square kilometres (8 per cent of the association) and,

like *map unit 300*, comprises a heterogeneous assemblage of soils which includes peaty gleys and peaty podzols with some noncalcareous gleys and brown forest soils. It occurs mainly in the Borders and parts of the Pentland Hills on undulating upland with gentle slopes and rolling hills at altitudes of less than 350 metres. The soils are developed on stony sandy loam drifts or sandy clay loam tills. The semi-natural vegetation, which is varied, includes Atlantic heather moor, flying bent grassland, rush pastures, sedge mires and acid bent–fescue grassland and provides rough grazing of poor or moderate quality. On the brown forest soils permanent or ley pastures have been established in a few areas. The peaty gleys and peaty podzols provide more difficult conditions for reclamation although slope and climate are often favourable and some improved pastures have been established.

Map unit 302 occupies 45 square kilometres (8 per cent of the association) and comprises peaty gleys and blanket peat, mainly in the Borders and the Pentland Hills. The soils are developed on sandy loam or sandy clay loam drifts in undulating upland terrain with gentle slopes. Blanket bog and flying bent bog, with some moist Atlantic heather moor and bog heather moor, are the principal semi-natural plant communities and provide rough grazing of generally poor quality. Improved pastures are difficult to establish and maintain on this land and soil wetness, the incursion of rushes and damage by poaching are continuing hazards.

THE HOLYWOOD ASSOCIATION

(Map units 303–306)

Soils of the Holywood 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 occurs in the Thornhill, Dumfries and Lochmaben basins of Dumfriesshire and occupies 140 square kilometres (0.7 per cent of South-East Scotland). Lying below 250 metres altitude, the terrain is mainly undulating lowland with some hill and valley sides especially around the Thornhill and Dumfries basins. The climate is warm and moderately dry or warm and wet with average rainfall of 1000 to 1250 millimetres per annum.

Much of the land has been cultivated and supports arable and permanent pastures, but acid bent–fescue grassland, rush pastures and sedge mires are the semi-natural plant communities on a few small areas of unimproved ground.

Brown forest soils and brown forest soils with gleying dominate the association; brown forest soils are formed largely on the stony drifts of hill sides and on strongly water-worked tills, and brown forest soils with gleying occur on red-brown compact or indurated loam and clay loam tills. Noncalcareous gleys are restricted to hollows and depressions and brown rankers occur only in *map unit 306*, characterized by rock outcrops. The association provides productive arable and pasture land in Dumfriesshire.

Map unit 303 occupies 51 square kilometres (35 per cent of the association) and comprises brown forest soils with gleying and brown forest soils. The soils are developed on red-brown, often compact, loam or clay loam tills and associated

water-worked tills in undulating lowland terrain generally below 150 metres altitude near Lochmaben and Dumfries. Most of the land has been cultivated and carries ley grassland or arable crops, principally barley or roots for animal feed. On the brown forest soils with gleying, under-drainage systems with permeable infill in the drain-lines and subsoiling to improve subsoil structure and permeability are necessary for arable farming. Dairying is the principal agricultural enterprise.

Map unit 304 occupies 23 square kilometres (15 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. It occurs near Lochmaben and Dumfries and in small areas at Closeburn and Crawfordjohn. The soils, which are developed on sandy loam water-worked tills and clay loam or loam tills, occur mainly on footslopes or depressions and are often affected by run-off from higher ground. The natural drainage is imperfect or poor but much of the land has been drained and carries mainly ley grassland or permanent pastures, but with some arable cropping in favoured areas. Rush pastures and sedge mires occupy small areas difficult to improve.

Map unit 305 occupies 64 square kilometres (45 per cent of the association) and comprises brown forest soils. The terrain is mainly hill and valley sides with strong and steep slopes and shallow stony sandy loam drifts, but near Lockerbie and Lochmaben there are some areas of undulating lowland with strongly water-worked tills. The soils are naturally free draining and the land carries mainly arable and permanent pastures utilized for dairy farming but on land where slopes are favourable grain and root crops are grown.

Map unit 306 occupies only 2 square kilometres (less than 5 per cent of the association) west of Dumfries and comprises brown forest soils with some brown rankers. The land lies at about 100 metres altitude and is moderately rocky with complex strong slopes. Permanent pastures utilized for dairying and stock-rearing are the main land use.

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 or clay 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 228 square kilometres (1.1 per cent of South-East Scotland) in two contrasting areas, the north Ayrshire till plain, north of the River Irvine, and the East Lothian plain, south of North Berwick. In the western area the climate is warm and moderately dry or wet with average rainfall of 1000 to 1250 millimetres per annum while in the east it is warm and moderately dry with 700 millimetres rainfall.

On the gently undulating till plain 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 with occasional barley and forage crops in the west, while arable crops predominate in the east.

Map unit 331 extends to 210 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 or 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. In the west 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. Although slowly permeable and having imperfect natural drainage, the soils in the drier climate of East Lothian can be cultivated more readily than in western areas and arable crops are dominant in the landscape. Drainage, however, 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 18 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. Underdrainage 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 KIPPEN/LARGS ASSOCIATIONS

(Map units 337–339, 341–344, 346 and 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. The drift is principally a reddish brown loam or sandy clay loam, but on the steep slopes of the Lomond Hills in Fife colluvial drifts are also common.

The associations extend to 202 square kilometres (1.0 per cent of South-East Scotland) in an area 5 kilometres wide from Kippen south-west through Killearn and Dumbarton Muir to Dumbarton on the Clyde estuary. It also occurs on the slopes of the Lomond Hills in Fife and isolated areas occur in the uplands of Ayrshire on Auchmannoch Muir, and south of Muirkirk on Wardlaw Hill and Cairn Table.

The climate ranges from fairly warm and moderately dry with 1000 millimetres per annum rainfall in Fife to warm and wet with 1200 millimetres rainfall in Stirlingshire and Dunbartonshire and cool and wet with 1500 to 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 77 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 or 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. On slopes in the foothills some soils are developed on colluvium, which is usually loamy but can be sandy where rock is close to the surface. 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 high 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 26 square kilometres (13 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 42 square kilometres (21 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 341 occupies 7 square kilometres (3 per cent of the associations) and comprises humus-iron podzols developed on thin sandy drift overlying red sandstone. It occurs on upland above Kippen, and on Stone Hill in Lanarkshire, and includes some very sandy and thin soils and moderate amounts of rock outcrops. The dry Atlantic heather moor and common 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 1 square kilometre (less than 1 per cent of the associations) and comprises peaty podzols, humus-iron podzols and some gleys. It occurs on the uplands south of Muirkirk in Ayrshire 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 moors and white bent grassland, provides moderate quality rough grazing. The climate is unfavourable to pasture improvement.

Map unit 343 occupies 14 square kilometres (7 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 32 square kilometres (16 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 loam 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 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 similiarities 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 moors and common 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, generally below 15 metres altitude and often bounded inland by rocky former sea cliffs.

The association occupies 1 square kilometre (less than 0.1 per cent of South-East Scotland) and the climate is warm and moderately dry, with average rainfall of 1000 to 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. The land carries mainly pasture.

THE KIRKWOOD ASSOCIATION

(Map units 349 and 350)

The soils of the Kirkwood Association are developed on drifts derived from sandstones of Carboniferous age, igneous rocks and greywackes. The rocks include arenaceous sandstones with some mudstones and limestone beds, the Birrenswark basaltic lavas and greywackes and shales. The drifts are reddish brown loam or clay loam tills.

The association occupies 45 square kilometres (0.2 per cent of South-East Scotland) in Dumfriesshire between Dalton and Langholm. The land ranges from 50 to 250 metres in altitude and consists of gently and strongly sloping hill sides in a zone between uplands to the north and lowlands to the south. The climate ranges from warm and moderately dry to fairly warm and wet with average rainfall of 1000 to 1250 millimetres per annum.

Much of the land is arable or permanent pasture, but on higher-lying unimproved ground the semi-natural plant communities include sharp-flowered rush pasture, moist Atlantic heather moor and flying bent grassland. Brown forest soils with gleying predominate on the slowly permeable tills while brown forest soils are restricted to shallow or partially water-sorted sandy loam tills or drifts. Noncalcareous and peaty gleys occur mainly in higher-lying climatically wetter areas.

Map unit 349 occupies 28 square kilometres (60 per cent of the association) and comprises brown forest soils with gleying and brown forest soils. The soils are developed on tills which are usually clay loam, but in some instances are partially water-sorted or shallow overlying rock, in which cases they are sandy loams. The undulating lowland terrain lies mainly between 50 and 150 metres altitude and slopes are gentle or strong. Much of the land has been cultivated and carries arable or permanent pastures utilized for dairying or stock-rearing, but some grain and root crops for animal feed are also grown. Under-drains are necessary for the optimum use of much of the land and careful grazing management is required to avoid excessive damage through poaching.

Map unit 350 occupies 17 square kilometres (40 per cent of the association) and comprises noncalcareous and peaty gleys with some brown forest soils and peaty podzols. The soils are developed on tills, which are generally clay loam or loam, are often thin, and can sometimes be sandy. The land is higher-lying, 150–250 metres altitude, than *map unit 349* and much of the undulating terrain carries unimproved semi-natural plant communities. These include sharp-flowered rush pasture, moist Atlantic heather moor and flying bent grassland and provide rough grazing of moderate or poor quality. Some improved permanent pastures, utilized mainly for stock-rearing, are maintained on some areas of lower-lying ground.

THE KNOCKSKAE ASSOCIATION

(Map units 352–357)

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 27 square kilometres (0.2 per cent of South-East 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 352 occupies 12 square kilometres (45 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 rock outcrops, including acid porphyrys and greywackes. The land ranges up to 150 metres altitude and the climate is warm and wet with 1250 millimetres per annum rainfall. The natural vegetation is acid bent–fescue grassland, but much of the land, where the pattern of rock outcrops 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 3 square kilometres (10 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 or moderate 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 area at NS 450010, numbered 354, should be map unit 233. The colour is correct for that unit). 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 rock outcrops. 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 rock outcrops. 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 7 square kilometres (25 per cent of the association) and comprises humus-iron podzols, with some rankers and rock outcrops. It occurs near Kirkcudbright on undulating lowland and on 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 is not extensive, occupying only 1 square kilometre (less than 5 per cent of the association), and occurs in an area on Bentudor hill near Auchencairn. Here the soils are mainly peaty podzols, peaty rankers and some peaty gleys, and are developed on shallow, very stony, rock-shattered debris. In the absence of drift, the outlines of the hills are little softened and are rugged, moderately rocky and strongly or steeply sloping. The semi-natural plant communities include moist Atlantic heather moor and provide rough grazing of poor or moderate quality.

THE LANFINE ASSOCIATION

(Map units 359–360)

The soils of the Lanfine Association are developed on drifts 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 86 square kilometres (0.4 per cent of South-East Scotland and occurs mainly in central Ayrshire south of the Irvine valley, but with other small areas near Douglas and Carnwath in Lanarkshire. Rainfall ranges from 1000 to 1250 millimetres per annum in the warm and fairly warm moderately dry or wet lowlands and foothills of central Ayrshire, to 1250 to 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. Gleys are common in the foothills and uplands where rainfall is greater.

Map unit 359 occupies 77 square kilometres (90 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 9 square kilometres (10 per cent of the association) and comprises noncalcareous gleys with some brown forest soils with gleying and peaty and humic gleys. 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.

THE LAUDER ASSOCIATION

(Map units 362–367)

The soils of the Lauder Association, first described near the town of that name (Ragg, 1960), are developed on drifts derived from Upper Old Red Sandstone conglomerates. The rocks are bright red and derived mainly from the greywackes, which make up the clastic components, ranging from pebbles to large cobbles. The drifts are predominantly thin, stony, reddish brown sandy loams having a high content of rounded greywacke stones; of lesser extent are some red clay loam or sandy clay loam tills.

The association is restricted to eastern areas of the Southern Uplands where it is predominant in Lauderdale and extends southwards from Spott to Longformacus and Duns. In all it occupies 173 square kilometres (0.9 per cent of South-East Scotland), mainly broad valleys and hills, some of which have been strongly dissected, and ranges in altitude from 100 to 400 metres. In common with other eastern areas of the Uplands, the climate is relatively dry (fairly warm and moderately dry with 750 millimetres average rainfall), and this is reflected in both soils and vegetation. Acid bent–fescue grassland, dry and moist Atlantic heather moors and white bent grassland are extensive, while rush pastures, tussock-grass pasture and blanket bog communities are restricted to areas with poor natural drainage.

At altitudes less than 300 metres brown forest soils predominate on extensive, shallow stony drifts. Noncalcareous gleys occur on clayey tills at the base of slopes or in depressions, while peaty podzols with some areas of peaty gley and thin blanket peat form the land above 300 metres. In East Lothian, at moderate altitudes the soils are included with the 'Dunbar Red Soils' and are intensively cultivated, but more generally the land carries ley pastures which are occasionally broken for crops of cereals and roots. Above 300 metres altitude much of the land is utilized for rough grazing, but offers good opportunities for reclamation and the establishment of improved pastures.

Map unit 362 is extensive, occupying 107 square kilometres (60 per cent of the association), and comprises principally brown forest soils and some brown forest soils with gleying. It occupies much of Lauderdale and is widespread on hill and valley sides with strong or steep, smooth slopes between Spott and Longformacus. There is some more gently sloping ground around Spott and Innerwick. The land lies mainly between 100 and 350 metres altitude. The predominance of free natural drainage and of brown forest soils is ascribed to the interplay of a number of factors, such as the thin, red, stony, sandy loam parent materials overlying permeable conglomerate rock, the sloping terrain and low rainfall.

Much of the land is cultivated. Near the northern limit of the map unit the soils form part of a group known as the 'Dunbar Red Soils' much favoured for potatoes and well suited to a range of arable crops. Farther south crop rotations

generally include cereals, forage roots and grass leys of moderate duration; on higher-lying ground or more steeply sloping land the proportion of pasture is greater. In the least favoured situations semi-natural acid bent–fescue grassland provides rough grazing of good quality, but pasture improvements are often possible.

Map unit 363 is not extensive, occupying only 4 square kilometres (less than 5 per cent of the association) and comprises noncalcareous gleys. It occurs as small areas near Longformacus at about 200 metres altitude on the lower parts of hill slopes. The soil parent materials are reddish brown clay loam tills and the natural drainage is poor. Where under-drains have been installed much of the land is maintained as permanent pasture, but undrained soils generally carry sharp-flowered rush pastures and tussock-grass pastures which provide nutritious rough grazing.

Map unit 364 occupies 37 square kilometres (20 per cent of the association) and comprises humus-iron podzols and brown forest soils; there are also some peaty podzols. As in *map unit 362* the soils are developed principally on thin reddish brown stony sandy loam drifts overlying conglomerates. These subsoil materials are highly permeable and the natural drainage is generally free. Lying mainly between 200 and 400 metres altitude along the Monynut Water the landforms are strongly dissected and consist of steep hill and valley sides with some less steep land on upper slopes and hill crests. Reflecting the somewhat greater altitudes, the climate, which is cool and wet, is cooler than in much of the rest of the association but the average rainfall of 750 millimetres per annum is low in the context of hill land in Scotland.

The natural vegetation consists mainly of dry and moist Atlantic heather moor, white bent grassland and acid bent–fescue grassland and provides rough grazing ranging from good to poor quality. The soils of this map unit are, however, well suited, where slopes allow, to reclamation and the establishment of improved productive pastures. Around farmsteads some pastures have been long established and a few areas have some potential for crops.

Map unit 365 occupies 15 square kilometres (9 per cent of the association) and comprises a heterogeneous group of soils, peaty podzols, noncalcareous gleys and brown forest soils, in an area near Longformacus. Mantling undulating uplands and in depressions, between 200 and 350 metres altitude, the soil parent materials include both thin red sandy loam drifts and thicker clay loam tills. Natural drainage conditions range from free to poor and the semi-natural plant communities include Atlantic heather moors, rush pastures and acid bent–fescue grassland. Much of the land is utilized as rough grazing of good and moderate quality, but, on some areas, improved pastures are maintained and could be established more extensively by the use of lime, fertilizers and cultivation with attention to drainage of the gleys.

Map unit 366 occupies only 3 square kilometres (less than 5 per cent of the association) and includes brown forest soils and peaty gleys. It occurs at about 350 metres altitude as undulating upland with gentle and strong slopes on Carfrae Common. The climate is somewhat more cool and wet than elsewhere in the association and the semi-natural plant communities include acid bent–fescue grassland, bog heather moor and Atlantic heather moor. Rough grazing of both good or poor quality is the principal land use, but some improved pastures have been established.

Map unit 367 occupies 7 square kilometres (less than 5 per cent of the association) and comprises peat and peaty gleys in a few areas near Longformacus. The land is mainly undulating upland with gentle slopes lying between 250 and 300 metres altitude. The semi-natural vegetation includes blanket bog, bog heather moor and moist Atlantic heather moor and provides rough grazing of generally poor quality. Improved pastures are difficult both to establish and to maintain on this land.

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 mainy 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-East 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 and slaking is often associated with 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 17 square kilometres (less than 0.1 per cent of South-East 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 form hills with strong and steep slopes, reaching 500 metres altitude.

The climate is cool or cold and is wet with 1500 to 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 semi-natural communities and includes Atlantic heather moors, bent–fescue grassland, blanket bog, sharp-flowered rush pasture and flying bent grassland.

Map unit 374 occupies 2 square kilometres (10 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 or 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 13 square kilometres (75 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 Linfern Association are developed on morainic drifts derived from sandstones, greywackes and basic igneous rocks. The association occupies 1 square kilometre (less than 0.1 per cent of South-East Scotland) and occurs as a small area of moundy ground at about 250 metres altitude to the south-west of Queensberry hill. The climate is cool and wet with rainfall of 1500 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 mounds and peat in intervening hollows.

Semi-natural plant communities include Atlantic heather moor, blanket bog and acid bent–fescue grassland while small patches have been reclaimed for improved pasture.

THE LINKS ASSOCIATION

(Map unit 380)

The soils of the Links Association are developed on windblown, largely quartzose sands. The sands often overlie coastal raised beaches and occur mainly as dunes anchored by marram grass along the seaward margin. Grass swards, mainly the eyebright—red fescue dune pasture community, occur on older dunes situated to landward. There are also some wet 'dune slack' areas.

The association occupies 8 square kilometres (less than 0.1 per cent of South-East Scotland) along the Fife coast, principally around St Andrews Bay with some smaller areas near Largo Bay.

The climate is warm and moderately dry with 700 millimetres per annum average rainfall. The predominant soils are regosols.

Map unit 380 comprises regosols developed on stabilized dunes or planed-off raised beach. Dunes with a discontinuous or thin cover of vegetation, often marram grass, are likely to become unstable and blow in high winds. Plant communities, such as eyebright–red fescue dune pasture, in providing a continuous vegetation cover create more stable soil conditions and can be utilized for rough grazing or be improved by surface seeding and the use of fertilizers. Treading by animals or man, or heavy grazing which weakens the vegetation cover can result in blow-outs and erosion. The land is generally well suited for golf courses of which there are many in Fife, some of championship standard.

THE MAUCHLINE/AUCHINLECK ASSOCIATIONS

(Map unit 401)

Red desert sandstones of Permian age occupy part of the Ayrshire plain between Mauchline and Tarbolton. The soils were mapped during the 1950s and 1960s and two soil associations on parent materials derived partly from Permian sandstone were recognized. The Mauchline Association is developed on a till derived from sandstones including some igneous pebbles; the till of the Auchinleck Association includes also some Coal Measures sandstones, shales and marls. For the purposes of the current survey these associations have been grouped together. The tills are mainly sandy clay loams or loams, with textures that are rather coarser where sandstone rock is near the surface and finer where Carboniferous sediments are present.

The association occupies 46 square kilometres (0.2 per cent of South-East Scotland) in central Ayrshire. Average rainfall is 1000 millimetres per annum and the climate is warm and moderately dry. Brown forest soils with gleying predominate in a landscape of undulating lowland typical of much of the Midland Valley, and are devoted to grassland and arable agriculture.

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. 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.

THE MINTO ASSOCIATION

(Map units 407–412)

First mapped in the eastern Borders (Muir, 1956), the soils of the Minto Association are developed on drifts of mixed origin derived from sediments of Old Red Sandstone, Ordovician and Silurian age. The Old Red Sandstone rocks are mainly marls and sandstones and the Ordovician and Silurian strata, greywackes and shales. The principal drifts are reddish brown clayey tills in which the stones are mainly greywacke.

The association occupies 114 square kilometres (0.6 per cent of South-East Scotland), the main occurrences being near Hobkirk and between Minto and St Boswells with other small widely scattered areas between Langholm and Hobkirk and near Longformacus. The landforms include both undulating lowlands and depressions with gentle slopes and hills with strong and steep slopes, while the altitudinal range is wide, from 70 metres at the Tweed near Maxton to 500 metres on the hills near Langholm. Related to the differences of elevation, the climate is fairly warm and moderately dry in the lowland and cool and wet in the upland with average rainfall of 750–1500 millimetres per annum.

Brown forest soils with gleying, developed on the red clayey tills, are the principal soils of the lowlands together with some areas of noncalcareous gleys having poor natural drainage. On higher ground peaty gleys occur in association with noncalcareous gleys, while peaty podzols and peat are found on the hills. The lowlands are mainly cultivated and carry crops of permanent pastures while Atlantic heather moor, blanket bog and flying bent bog are found in the hills and sharp-flowered rush pastures on some gleys.

Map unit 407 occupies 38 square kilometres (35 per cent of the association) and comprises brown forest soils with gleying developed on red-brown clayey tills. The natural drainage is mainly imperfect. Altitudes are generally less than 200 metres and the land is principally undulating lowland with gentle slopes, but some hill and valley sides are strongly sloping. Like the soil and topography, the fairly warm, moderately dry climate with 750 millimetres per annum rainfall is favourable for arable agriculture and much of the land is cultivated. Barley, wheat and root crops are grown in rotations with breaks in ley pastures. Under-drains are necessary for this type of intensive agricultural use and particular care should be taken to avoid working the ground when the soil is in an unsuitable moisture condition.

Map unit 408 occupies 21 square kilometres (20 per cent of the association) and comprises brown forest soils with gleying and noncalcareous gleys. Under natural conditions the soils are imperfectly or poorly drained and occur in an undulating lowland landscape, in which hollows and depressions are an important element. The climate is similar to that of *map unit 407*, as are the parent materials, but

the noncalcareous gleys require more intensive drainage and soil moisture conditions unfavourable to cultivation are likely to be more persistent. The land tends to remain, therefore, for longer periods in pasture and crops are more likely to be restricted to barley or wheat. Fields comprising mainly brown forest soils with gleying, without large patches of gleys, are cropped like those of *map unit 407*.

Map unit 409 occupies 22 square kilometres (20 per cent of the association) and comprises noncalcareous gleys developed on red-brown clay loam tills. The soils occur in depressions and on gentle slopes, generally below 200 metres altitude, where run-off of moisture from surrounding areas and the slow permeability of the tills contribute to the development of naturally poor drainage.

The climate, however, is fairly warm, moderately dry and favourable to arable agriculture. Nevertheless the land requires careful drainage using gravel infill in the drain-lines and secondary treatment to improve subsoil permeability. Rotations of good quality pasture and some cropping with grain are generally possible. Sharp-flowered rush pastures are found in unimproved areas.

Map unit 410 occupies 15 square kilometres (15 per cent of the association) and comprises noncalcareous gleys and peaty gleys. Occurring as small, scattered areas to the north-west of Langholm, the land lies mainly between 250 and 400 metres altitude and the terrain comprises depressions and the footslopes of hills where the soils are often affected by run-off from higher ground. Average rainfall is generally high, 1500 millimetres per annum. Much of the land carries semi-natural plant communities, sharp-flowered rush pasture, flying bent grassland and moist Atlantic heather moor, which provide rough grazing ranging widely in value. In favoured areas soil drainage and pasture improvement are possible, but wetness is likely to be a continuing restriction on the utilization of swards. Careful management will be required to avoid unacceptable damage from poaching and on the peaty gleys difficulties are likely to be severe.

Map unit 411 occupies 15 square kilometres (15 per cent of the association) in an area north-west of Langholm and comprises peaty podzols, peaty gleys and peat. The soils are developed on thin, stony sandy loam drifts which blanket long, smooth hill sides with strong and steep slopes lying between 300 and 500 metres altitude. Some patches with surface boulders are present. Average rainfall is 1500 millimetres per annum. The semi-natural plant communities include moist Atlantic heather moor, blanket bog, flying bent grassland and flying bent bog and provide rough grazing of low or moderate quality. The land is not well suited for reclamation, but some improved pastures can be established where conditions of soil, slope, climate and altitude are relatively favourable.

Map unit 412 is not extensive, occupying only 3 square kilometres (less than 5 per cent of the association), and comprises peaty gleys with some peaty podzols.

The soils occur on the lower and middle parts of mainly gentle slopes of hills and are affected by run-off from higher ground. The flying bent grassland and moist Atlantic heather moor plant communities provide rough grazing of moderate or poor quality. In low-lying areas improved pastures are likely to be difficult to establish and maintain and higher ground is unsuited to reclamation.

THE MOUNTBOY ASSOCIATION

(Map units 413–418)

The soils of the Mountboy Association are developed on drifts derived from Old Red Sandstone lavas, principally intermediate and basic types, and sediments, mainly sandstones and conglomerates.

The predominant drifts, which mantle lowlands and the lower slopes of hills, are loam or sandy clay loam tills, but colluvial, more sandy drifts occur on the slopes of higher-lying or steep ground.

The association occupies 127 square kilometres (0.6 per cent of the area) and occurs in the Pentland Hills and adjacent valleys. There are smaller areas near Symington, Lanarkshire, and Abernethy and Cupar in Fife. Rainfall ranges from 1150 to 1250 millimetres per annum in the cool wet climate of the Pentland Hills and around Symington, from 900 to 1000 millimetres in the fairly warm wet conditions of West Linton, and from 750 to 900 millimetres in the fairly warm moderately dry areas of Fife.

Brown forest soils with gleying occupy the lowlands where they are developed mainly on sandy clay loam tills, but in some broad valleys there are brown forest soils where water-working of the upper till layers has given rise to more coarse-textured, sandy subsoils. Gleys are common on some gentle hill slopes, while on high ground, steep slopes carry humus-iron podzols with peaty podzols occurring on gentle slopes.

Map unit 413 occupies 27 square kilometres (20 per cent of the association) and comprises brown forest soils. The soils are mainly freely drained and developed on tills in which the water-modified upper layers are sandy loam or loamy sand. In the surface horizons the development of structure is weak. Compaction, which is often present in the sandy loam or loam subsoils, does not usually restrict crop growth. The terrain is mainly gently undulating lowland, with some strong slopes on till ridges. Much of the land lies between West Linton and Dolphinton where it is utilized for mixed arable and stock farming. Rotations usually include long periods in grass between arable crops.

Map unit 414 extends to 70 square kilometres (55 per cent of the association) and comprises mainly brown forest soils with gleying, with some brown forest soils and noncalcareous gleys. The soils are developed on tills which are loams or sandy clay loams, with some stony loams on hill sides and clay loams in depressions. The natural drainage is mainly imperfect. The subsoils are generally stony, have moderately developed blocky or prismatic structures, and are moderately permeable, but permeability and structural development are often poor in the deeper till layers, which can be massive. The land is utilized mainly for arable agriculture, but grassland predominates in the wet climate of western areas and inadequately drained areas are often rush-infested—a problem little in evidence under drier conditions farther east. Modern drainage should incorporate permeable infill in the drain-lines and secondary subsoiling treatments to improve subsoil structure and permeability. It is suggested that where possible drains be laid across slopes to intercept down-slope movement of moisture.

Map unit 415 occupies 12 square kilometres (10 per cent of the association) and comprises mainly noncalcareous gleys together with some peaty gleys and brown forest soils with gleying. The natural drainage is generally poor. Occurring mainly in the Pentland Hills, the land is predominantly permanent pasture. Rush

pastures, sedge mires and flying bent grassland are found in hollows where conditions are wettest. As in *map unit 414* under-drainage is usually feasible.

Map unit 416 occupies 5 square kilometres (5 per cent of the association) and comprises mainly humus-iron podzols with some peaty podzols and minor occurrences of brown forest soils and gleys. It occurs on steep slopes in the Pentland Hills.

Acid bent–fescue grassland and white bent grassland are widespread as semi-natural plant communities and provide rough grazing of good or moderate quality. Dry Atlantic heather moor occurs on high-lying exposed ground and provides rough grazing of poor quality. Where slopes are favourable pasture improvements are possible.

Map unit 417 occupies 13 square kilometres (10 per cent of the association) and comprises peaty podzols with some humus-iron podzols, peat and gleys. It occurs on high ground in the Pentland Hills and the soils are developed on stony, compact, loamy drifts. The semi-natural vegetation includes dry Atlantic heather moor, white bent grassland and blanket bog and provides rough grazing of only poor quality.

Map unit 418 occupies less than 1 square kilometre (less than 5 per cent of the association) and comprises humus-iron podzols and peaty podzols with some gleys and peat. It is confined to the Pentland Hills and is similar in many respects to *map unit 416*, differing mainly on account of having moderately rocky terrain on steep or very steep slopes. The semi-natural plant communities include white bent grassland, dry Atlantic heather moor and blaeberry heath and provide rough grazing of moderate quality.

THE NIGG/PRESTON ASSOCIATIONS

(Map units 420 and 421)

The soils of the Nigg and Preston Associations are developed on undifferentiated raised beach deposits. Although grouped together for the purposes of the current survey, the soils of these associations occur in widely separated areas. The Nigg Association is found around the shores of the Moray Firth while the Preston Association forms a small area on the Kirkcudbrightshire coast west of Southerness. The parent materials of the Preston Association are stone-free, closely sorted and range from fine sandy loams of fluvial origin to coarse sands, to which a raised beach origin has been ascribed, but which may in part be windblown.

The Preston Association occupies 4 square kilometres (less than 0.1 per cent of South-East Scotland) on Preston Merse. The raised beach terrace is gently sloping and includes some areas of gently undulating, stable, former dunes. Rainfall is 1125 millimetres per annum and the climate warm and moderately dry.

Noncalcareous gleys having a high ground-water table and developed on fine sandy loam deposits occur on the landward, lower-lying parts of the terrace. Elsewhere on the terrace, in a belt separated from the coast only by a narrow line of dunes, the soils are regosols developed on coarse sands having a notably loose, open fabric. Some arable crops, barley and roots, are grown, but the land is mainly pasture.

Map unit 420 occupies 2 square kilometres (50 per cent of the association) and comprises regosols developed on coarse sands of possible raised beach or windblown origin. Although dry or moist for most of the year the subsoils generally exhibit a few prominent ochreous mottles, which probably represent the effects of a deep, but fluctuating, water-table. Despite the low organic-matter content in the topsoils and coarse, sandy textures, some barley and root crops are grown, but the land is mainly permanent pasture.

Map unit 421 occupies 2 square kilometres (50 per cent of the association) and comprises noncalcareous gleys. These are developed on stone-free loamy fine sands or loamy sands, of fluvial origin on raised beach terraces. The ground-water table is high but is largely controlled by under-drains and open ditches. The land is cultivated and rotations include barley and roots for fodder as well as long-ley grassland.

THE REPPOCH 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 132 square kilometres (0.7 per cent of South-East 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 with peaty podzols occupying 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 31 square kilometres (25 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 (15 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 rock outcrops. 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 32 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 (30 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 mostly 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 439 and 440)

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 and in western Galloway 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. It is unlikely, however, that ice from these areas affected Kirkcudbrightshire and the origin of the red colour of the tills would seem to be uncertain although at some stage during the glaciation some material may have been brought from the Solway Firth. Available analyses indicate a close similarity between the trace element suites of the Rhins and Ettrick Associations and support the view that the greywacke-derived contribution to the till is predominant.

The association has been mapped only in Galloway, where it occupies 140 square kilometres (0.7 per cent of South-East Scotland) in Kirkcudbrightshire. The tills of the association have been deposited almost entirely as drumlins in lowlands below 200 metres altitude. The drumlins are scattered and the strongly ice-eroded intervening country has many rock outcrops. The climate is warm and moderately dry, or warm and wet, with average rainfall ranging from 1250 to 1500 millimetres per annum.

Brown forest soils with gleying predominate on the drumlins 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 occupy areas of strongly eroded country with scattered greywacke outcrops.

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.

Land with rock outcrops carries mainly improved pasture, but some acid bent–fescue grassland occurs on the most rocky ground.

Map unit 439 occupies 100 square kilometres (70 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* and *440*. The red-brown clay loam till, the parent material of the brown forest soils with gleying, occurs as drumlins scattered across strongly glacially eroded lowland with typical *roches moutonnées* and other rock knolls. 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 outcrops. Most of the land has been cultivated and carries arable and permanent pastures. Drainage similar to that described for *map unit 440* 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 40 square kilometres (30 per cent of the association) and comprises brown forest soils with gleying, brown forest soils, brown rankers and rock outcrops. 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 under-drains, 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 rock outcrops, but improved pastures, generally allowing conservation of grass, can usually be maintained with some cropping possible in favoured situations.

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 been mapped extensively in the Midland Valley. The Winton Association has been described in East Lothian (Ragg and Futty, 1967) while the soils have also been mapped in Fife, Midlothian and farther west in the Midland Valley. 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 2309 square kilometres (11.6 per cent of South-East

Scotland) and extend from the Ayrshire plain north-eastwards to Glasgow, the Slamannan plateau and the Stirlingshire drift plain. In the east the soils are extensive in Midlothian, East Lothian and Fife. In the warm moderately dry lowlands of Ayrshire and Stirlingshire average rainfall is 900 to 1000 millimetres per annum, rising to 1000 to 1250 millimetres per annum in the warm wet lowlands and foothills of the Slamannan plateau and declining to 500 to 700 millimetres in the warm dry lowlands east of Edinburgh.

Brown forest soils with gleying extend throughout the association area and are the predominant soils of the till plains, especially in eastern areas. Noncalcareous gleys are common under the high rainfall of western areas but of rare occurrence under the dry conditions of the east. Peaty gleys are restricted to upland areas in West Lothian, Stirlingshire, Lanarkshire and Ayrshire, while humus-iron podzols and peaty podzols occur on sandstone ridges with thin drifts.

Map unit 444 occupies 412 square kilometres (18 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 to 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, which form some of the best agricultural land in the areas where they occur, have few limitations to sustained arable use and in eastern areas are utilized for intensive arable farming. Even where rainfall is relatively high this land is more readily cultivated than the clayey soils of related map units.

Map unit 445 occupies 1061 square kilometres (46 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. Under the low rainfall of the Lothians and Fife, amelioration of the unfavourable soil moisture conditions consequent on slow permeability can be more readily effected. Much of the land in these areas is cropped frequently and yields can be high. In dry seasons moisture retention by the clayey subsoils benefits crop growth.

Map unit 446 occupies 500 square kilometres (22 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 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. In the low rainfall areas of the east, soil conditions are less difficult and crops are grown more commonly. Nevertheless the underlying problems remain and careful management is required.

Map unit 447 occupies 74 square kilometres (3 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, Stirlingshire, Fife and the Lothians. 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 or by an indurated layer. Much of the land carries permanent pasture and some crops requiring only a short growing season are grown. In East Lothian up to three horticultural crops per annum are taken on some steeply sloping land. Acid bent–fescue grassland presents few difficulties for pasture improvement but occupies only small areas.

Map unit 448 occupies 29 square kilometres (1 per cent of the associations) and comprises mainly humus-iron podzols developed on thin drifts overlying sandstone or occurring 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 232 square kilometres (10 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 nevertheless 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 provides rough grazing of moderate quality. Although improved pastures can be established they are often difficult to maintain.

THE SMAILHOLM ASSOCIATION

(Map unit 464)

First mapped near Kelso (Ragg, 1960), the soils of the Smailholm Association are developed on drifts derived from Lower Carboniferous basaltic lavas and Upper Old Red Sandstone sediments. The drifts are mainly stony, reddish brown loams and are often shallow.

The association occupies 35 square kilometres (0.2 per cent of South-East Scotland) on undulating lowland with gentle and strong slopes to the north and west of Kelso. The climate is fairly warm and moderately dry with 750 millimetres average annual rainfall. The soils are brown forest soils.

Map unit 464 occupies 35 square kilometres and comprises brown forest soils in undulating lowland terrain. The soils are freely draining, are locally stony and developed on reddish brown drifts which can be shallow with rock near the surface. Much of the land is utilized for arable cropping.

THE SORN/HUMBIE/BIEL ASSOCIATIONS

(Map units 465–470)

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 cementstones, 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 are the principal type of drift.

The associations occupy 362 square kilometres (1.8 per cent of South-East Scotland) and occur mainly in Ayrshire, Dunbartonshire, Stirlingshire, Lanarkshire and the Lothians. Rainfall of 1000 to 1250 millimetres per annum in the fairly warm wet lowlands and foothills in western parts of the area, and 1200 to 1500 millimetres in the cool wet lowlands, foothills and uplands of south Lanarkshire and West Lothian, contrasts strongly with 750 to 900 millimetres in the fairly warm moderately dry lowlands of Midlothian and East Lothian.

Brown forest soils with gleying are the predominant soils, especially in eastern parts of the association area, while noncalcareous gleys occur mainly in western areas. In the uplands, peaty gleys are common together with peaty podzols in some small areas.

Map unit 465 occupies 54 square kilometres (15 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 generally 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 169 square kilometres (47 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 moling because the channels can be unstable and collapse readily. Rush pastures, sedge mires and some flying bent grassland can occur in hollows. Around Haddington and Dunbar, and other eastern areas with relatively dry climatic conditions, these soils provide good quality arable land. The clayey textures and high moisture-holding capacity of these soils enable crops to resist the effects of drought, and under the low rainfall the periods when soil conditions are unfavourable to cultivation and seeding are less prolonged than in western areas.

Map unit 467 occupies 94 square kilometres (26 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. In western areas, 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. Arable crops are grown more frequently under the drier climatic conditions in eastern areas, nevertheless in wet seasons cultivation of these soils is difficult and very careful management is required.

Map unit 468 occupies only 1 square kilometre (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 2 square kilometres (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 42 square kilometres (12 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 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*.

THE SOURHOPE ASSOCIATION

(Map units 472–479 and 482)

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 830 square kilometres (4.2 per cent of South-East Scotland). It forms major areas in the Ochil Hills, the Pentland Hills and parts of the Cheviot Hills as well as small areas south-east of Douglas. Rainfall ranges from 1000 to 1500 millimetres per annum in the fairly warm wet climate of the Ochil and Pentland Hills and from 1400 to 2000 millimetres in the cool wet conditions in the highest-lying parts of the Cheviot and 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 324 square kilometres (39 per cent of the association) and comprises brown forest soils, with some brown forest soils with gleying and gleys, developed on loamy tills. The brown forest soils are 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, but arable agriculture is important in the eastern Ochils near Cupar, Fife. Elsewhere some crops are grown in favourable areas, but are often restricted by steep slopes and climate. In the hills of the Pentlands and Cheviots acid bent–fescue grassland provides good quality rough grazing on slopes too steep for the use of mechanical implements. On less steep slopes the land is well suited for the establishment and maintenance of improved pastures. Rush pastures can occur on inadequately drained land in hollows.

Map unit 473 occupies 47 square kilometres (6 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 low 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 236 square kilometres (28 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 6 square kilometres (less than 1 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 common white bent grassland provides rough grazing of moderate quality, but improved swards can be established by cultivation and reseeding.

Map unit 476 occupies 98 square kilometres (12 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, common 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 reseeding or, in difficult areas, by surface seeding. On the highest hills the severe climate is unfavourable to the establishment and maintenance of improved pastures.

Map unit 477 occupies 10 square kilometres (1 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 12 square kilometres (1 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 53 square kilometres (6 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 rock outcrops.

Map unit 482 occupies 44 square kilometres (5 per cent of the association) and comprises podzolic rankers and brown rankers developed on very stony hillside talus derived from the underlying andesitic rocks. It occurs in the Cheviot area on very steep hills and valley sides. The very steep slopes preclude pasture improvements and the semi-natural plant communities, herb-rich bent–fescue grassland, dry Atlantic heather moor and common white bent grassland provide rough grazing of good or moderate quality.

THE STIRLING/DUFFUS/POW/CARBROOK ASSOCIATIONS

(Map units 487–489)

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 Futty, 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, occuring at about 15 metres above sea level, consists of grey silty clays infilling estuaries and buried valleys such as the Carse of Stirling. 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 about 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 312 square kilometres (1.6 per cent of South-East Scotland) mainly in the Forth valley, but other areas occur in the Earn valley, as well as in the river estuaries of the Nith and Cree and elsewhere along the Solway Firth. Rainfall ranges from 900 to 1500 millimetres per annum in the Forth valley, from 600 to 800 millimetres in the Earn valley and East Lothian and from 900 to 1250 millimetres along the Solway. In western areas the climate is predominantly warm and wet and in the east it is warm and moderately dry.

Map unit 487 occupies 51 square kilometres (16 per cent of the associations) and occurs almost entirely in the Forth and adjacent valleys 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.

Under lower rainfall in the east root crops are grown and high yields of potatoes are produced, but harvesting can be difficult in wet seasons and the risk of soil structural damage high. 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 261 square kilometres (84 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 seed-beds 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.

Map unit 489 is restricted to less than 1 square kilometre near Ruthwell in Dumfriesshire where it comprises peaty gleys developed on grey silts and clays overlying sands at a shallow depth. In recent years, much of the land has been drained with open ditches and under-drains, but blockage of drains by 'red ochre' is often a cause of difficulties in these soils. The land is utilized mainly as permanent pasture, but in areas without under-drains or where drainage systems have become blocked the plant communities include soft rush pasture and, in the wettest areas, blanket bog and bog heather moor.

THE STONEHAVEN ASSOCIATION

(Map units 490 and 492–496)

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 41 square kilometres (less than 0.2 per cent of South-East Scotland) between Loch Lomond and Callander, and east of Glen Artney. 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 (20 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 492 occupies 5 square kilometres (10 per cent of the association) and comprises brown forest soils with some gleys and rankers. The soils are developed on shallow, stony, sandy drifts on gentle or strong slightly rocky slopes. The natural drainage is free or imperfect and the semi-natural plant communities include acid bent–fescue grassland and broadleaved scrub woodland. The land is utilized mainly as rough grazing which is of good quality, but reclamation for improved pasture is often possible. This map unit is restricted to the basal slopes of Torlum Hill near Glen Artney.

Map unit 493 occupies 24 square kilometres (60 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 494 occupies only 2 square kilometres (less than 5 per cent of the association) on the highest parts of the Menteith Hills and comprises peaty podzols with some humus-iron podzols and gleys. The soils are developed on shallow, stony, sandy drifts mantling hills with rounded summits and smooth steep slopes. Rock outcrops are few. The semi-natural plant communities include dry and moist Atlantic heather moors, bog heather moor and heath rush–fescue grassland, and provide rough grazing of poor quality.

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 (less than 5 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 497–507, 509, 512, 513 and 515)

The Strichen Association was first mapped by Glentworth (1954) in north-east Scotland. In South-East 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 to 50 μm) 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.

The association is extensive, occupying 346 square kilometres (1.7 per cent of South-East Scotland), but is restricted to ground north-west of the Highland Boundary Fault. It covers large areas east of Loch Lomond, around Loch Katrine and on Ben Vorlich. The relief is largely hilly or mountainous with intervening valleys, slopes are often steep and hummocky moraines occupy some valley floors.

On Loch Lomondside the climate is warm and wet with average rainfall of 1500 millimetres per annum, but in the mountains of west Perthshire conditions are severe and the climate is cold and wet with 2500 millimetres per annum rainfall.

Under the prevailing wet climate and on the quartzose acid parent materials brown forest soils are restricted to lowlands and the lower parts of the steep sides of valleys. Humus-iron podzols are extensive on higher-lying steep land and occur also on valley moraines while peaty podzols and peaty gleys also occupy considerable areas of high-lying hill land. Subalpine and alpine soils are restricted to the high mountain summits. Noncalcareous gleys occupy small areas of gently sloping land at low and moderate altitudes.

The principal plant communities include dry and moist Atlantic heather moors on the humus-iron podzols and peaty podzols and acid bent–fescue grassland on brown forest soils on steep land. Bog heather moors occur on some peaty gleys and blanket bog on peat soils on gentle slopes.

Map unit 497 occupies 33 square kilometres (10 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 and on some undulating lowland and on valley sides. The sandy clay loam tills on which the soils are developed are much more extensive in Eastern Scotland. The land is gently or strongly sloping (less than 10 degrees), non-rocky and gently undulating. The noncalcareous gleys carry mainly permanent pastures 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 22 square kilometres (6 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 Loch Ard Forest east of Loch Lomond and on the middle slopes of valleys, such as Glen

Ample in west Perthshire, 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 semi-natural plant communities, Atlantic and boreal heather moors with some acid bent–fescue grassland, provide rough grazing of poor or moderate quality but in some areas the land has been largely planted with coniferous forest.

Map unit 499 occupies 6 square kilometres (2 per cent of the association) and comprises peaty podzols and humus-iron podzols with some gleys. It occurs on the upper slopes of two valleys leading from Balquhidder and is related to *map unit 498* but is higher-lying, steeper and peaty podzols are extensive. The semi-natural plant communities, which include Atlantic and boreal heather moors, bog heather moor and heath rush–fescue grassland, provide rough grazing of generally poor qualtiy. Although in some areas improved pastures can be established, swards are likely to be difficult to maintain.

Map unit 500 occupies 13 square kilometres (4 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 and elsewhere on hill and valley sides. 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, 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 16 square kilometres (5 per cent of the association) and comprises peaty gleys and peat with occasional peaty podzols. The natural drainage is generally very poor or poor with wet conditions persisting for long periods, notably in the surface layers of the 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 2 square kilometres (less than 1 per cent of the association), 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 moor afford rough grazing of low quality. The map unit is more extensive in Western and Eastern Scotland.

Map unit 503 occupies 56 square kilometres (16 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. It is found in the valleys and footslopes on the eastern shores of Loch Lomond and in valleys at Strathyre and Ballimore. 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 much of this land and some arable crops are grown where rainfall is moderate but good rough grazing and forestry are also widespread. Reclamation and sward improvement are possible in most areas.

Map unit 504 occupies only 5 square kilometres (1 per cent of the association) but is widespread in areas to the west and north. It comprises mainly peaty podzols with some peaty gleys and peat. The terrain consists of hummocky valley moraines with some smooth, gullied slope moraine. The deposits are loamy sands and sandy loams, often indurated. 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 unit 503* and *504*. It covers 32 square kilometres in South-East Scotland (9 per cent of the association), and is found below approximately 200 metres altitude. 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 similar 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 82 square kilometres (24 per cent of the association) and comprises peaty podzols and humus-iron podzols with some peaty gleys and rankers. The soils are developed on shallow stony tills and colluvial drifts on hill and valley sides which are moderately rocky and have strong or very steep slopes. The peaty podzols are widespread on steep slopes while the humus-iron podzols are confined to the steepest land between rock outcrops. Peaty gleys occur on less steep land.

The semi-natural plant communities include dry Atlantic heather moor, boreal heather moor and white bent grassland with some rush pastures and sedge mires. The land is utilized mainly for rough grazing of poor or moderate quality and the soils, terrain and wet climate make reclamation and sward improvement difficult.

Map unit 507 occupies 41 square kilometres (12 per cent of the association) and comprises mainly peaty gleys and peat with some peaty podzols and rankers. It is related to *map unit 506* but the proportion of poorly and very poorly drained soils is greater and it is restricted to the north-western margins of the region. The terrain consists mainly of hill sides with strong or gentle, moderately rocky slopes with peaty podzols on the steepest land and peat on gentle slopes or in hollows. The plant communities are mainly bog heather moor, blanket bog, Atlantic and

boreal heather moors and heath rush–fescue grassland. The peaty, poorly drained soils restrict land use to rough grazing and forestry. The grazings are generally of poor quality.

Map unit 509 is not extensive, occupying 9 square kilometres (3 per cent of the association), and comprises rankers and peaty podzols with some humus-iron podzols and peaty gleys. The soils are developed on stony shallow colluvial drifts associated with scree deposits, and patches of open scree are common. The terrain is rugged and hilly with very rocky strong and steep slopes. The semi-natural plant communities are mainly dry Atlantic heather moor, boreal heather moor, white bent grassland and blaeberry heath which provide rough grazing of poor quality.

Map unit 512 occupies 25 square kilometres (8 per cent of the association) and comprises subalpine soils, both podzols and gleys, and some rankers and peat. The terrain ranges widely, but lies above 750 metres altitude, comprises rounded mountain summits and steeply sloping mountain sides and includes both non-rocky and very rocky land. The semi-natural plant communities include fescue–woolly fringe-moss heath, stiff sedge–fescue grassland and mountain blanket bog and for short periods of the year provide rough grazing of moderate quality. Exposure renders the land unsuitable for forestry.

Map unit 513 occupies only 2 square kilometres (less than 1 per cent of the association) and is restricted to mountain summits. It is related to *map unit 512* but peat is more extensive and there are some alpine soils as well as subalpine soils. The natural vegetation, mountain blanket bog, fescue–woolly fringe-moss heath and stiff sedge–fescue grassland, provides grazing of moderate quality for very short periods of the year.

Map unit 515 occupies only 1 square kilometre (less than 1 per cent of the association) and the terrain consists of very rocky mountain summits with strong or steep slopes. The soils are largely rankers and lithosols with some alpine soils and the vegetation includes blaeberry heath, bog whortleberry heath, alpine azalea–lichen heath and stiff sedge–fescue grassland. The plant cover is generally discontinuous with many patches of bare ground and provides poor quality rough grazing for very short periods.

THE SYMINGTON ASSOCIATION

(Map unit 516)

The soils of the Symington Association are developed on fluvioglacial sands and gravels derived mainly from andesites. In extent the areas of sand and of gravel are roughly equivalent and both comprise terraces and moundy terrain.

The association is confined to the Clyde valley in areas around Thankerton and Symington where it occupies 29 square kilometres (0.1 per cent of South-East Scotland). The climate is fairly warm and moderately dry or fairly warm and wet, and rainfall ranges from 900 to 1100 millimetres per annum. The soils are predominantly brown forest soils.

Map unit 516 comprises brown forest soils developed on fluvioglacial sands or

gravels and occurs on terraces and moundy areas along the River Clyde. Slopes are generally short but range widely in steepness. The topsoils are generally loams or sandy loams, have moderately developed blocky or crumb structure and, where underlain by gravels, are stony. The sandy subsoils pass down into unweathered sand or gravel and the soils have high permeability but low water-holding capacity. Sand and gravel have been extracted from a few areas but most of the land is arable or permanent pasture. A few hollows or depressions with high water-tables are rush-infested.

THE TYNEHEAD ASSOCIATION

(Map units 562–564)

The soils of the Tynehead Association are developed on drifts derived from Carboniferous sandstones and Ordovician greywackes. The drifts range from loamy tills on low-lying areas to drifts rich in sandstone on higher ground with some sandstones weathering *in situ*.

The association extends to 56 square kilometres (0.3 per cent of South-East Scotland) and occurs south of Penicuik along the northern margin of the Southern Uplands.

The climate is fairly warm and moderately dry with average rainfall in the range from 750 to 900 millimetres per annum. The soils are predominantly brown forest soils with gleying. Noncalcareous gleys are common on gentle slopes and podzols occur around Fala Moor.

Map unit 562 occupies 32 square kilometres (55 per cent of the association) and occurs on gently or strongly sloping ground in a transition zone between the Midland Valley and the Southern Uplands. The soils are mainly brown forest soils and brown forest soils with gleying and are developed on loamy tills. The topsoils are generally sandy loams with moderately developed crumb or blocky structure and pass down into subsoils in which the clay content increases with depth, structure is weakly developed, and bulk density is high and permeability to moisture low. The underlying tills are generally sandy clay loams with massive structure. At moderate altitudes the land is utilized mainly for arable agriculture while permanent pastures predominate on steep slopes and higher-lying ground.

Map unit 563 occupies 22 square kilometres (40 per cent of the association) and comprises mainly noncalcareous gleys with some brown forest soils with gleying and humic gleys. It occurs on gentle slopes in association with *map unit 562* and the natural drainage is generally poor. Structural development is moderate or weak in the loamy topsoils and weak in the closely packed subsoils. The underlying clay loam tills are generally massive in structure and are only slowly permeable. Under-drainage is required for the efficient agricultural use of this land and systems should include permeable infill in the drain-lines and secondary treatments to improve subsoil structure and permeability. The land is predominantly permanent pasture although some arable cropping is possible in favoured areas.

Map unit 564 is restricted to the fringe of Fala Moor, where it occupies only 2 square kilometres (less than 5 per cent of the association). It comprises mainly peaty podzols with some humus-iron podzols and gleys, developed on thin stony sandy drifts. The semi-natural plant communities include dry Atlantic heather

moor, white bent grassland, rush pastures and sedge mires. The land is utilized mainly for rough grazing of moderate or poor quality but reclamation and pasture improvement using normal techniques are possible.

THE WHITSOME ASSOCIATION

(Map units 574 and 575)

First described by Ragg (1960), the soils of the Whitsome Association are developed on drifts derived from Lower Carboniferous sediments and basic lavas, Upper Old Red Sandstone sandstones and Silurian greywackes. The drifts are principally clay or clay loam tills derived from a variety of rocks, but having shales and marls as major components. Limestones are generally present and the unweathered till is often calcareous. Coarser-textured materials form a thin veneer over the till in some areas.

The association is restricted to the lowlands of Berwickshire where it occupies 412 square kilometres (2.1 per cent of South-East Scotland). The undulating lowlands of the lower valley of the Tweed lie mainly below 150 metres altitude and include many drumlin-like till ridges. Slopes are characteristically gentle and the climate is warm and moderately dry with rainfall generally less than 700 millimetres per annum.

Brown forest soils with gleying developed on the slowly permeable clayey tills predominate throughout the association. Noncalcareous gleys are restricted to low-lying ground between drumlin ridges, and brown forest soils occur where the surface veneer of coarse-textured materials is of appreciable thickness. The land is characterized by large well-laid-out farms which are highly mechanized. Cropping follows intensive arable rotations.

Map unit 574 comprises brown forest soils with gleying and brown forest soils and occupies 102 square kilometres (25 per cent of the association). The soils are developed on the red-brown clayey tills typical of the association or on tills with a surface veneer of coarse-textured materials. Where these coarser materials are one metre or so in thickness the soils are brown forest soils and the natural drainage is free. Elsewhere the clayey subsoils are slowly permeable and the soils are brown forest soils with gleying and the natural drainage is imperfect. Gentle slopes predominate in an undulating lowland landscape which presents a vista of large well-appointed farmsteads set in a patchwork pattern of large fields carrying a wide variety of arable crops. Where coarse-textured materials overlie the tills, the soils are easily worked and a wide range of crops can be grown. Cultivation is also favoured by the warm dry climate and low average rainfall but in some years drought may affect crops where subsoils are coarse. The brown forest soils with gleying developed on clayey tills provide land similar to that of *map unit 575*.

Map unit 575 occupies 310 square kilometres (75 per cent of the association) and comprises mainly brown forest soils with gleying with some noncalcareous gleys. The soils are developed on red-brown clayey tills which are often calcareous and contain limestone fragments. They are naturally fertile, but the subsoils are only slowly permeable and the natural drainage is imperfect. As in *map unit 574* the landscape is of undulating lowland with gentle slopes in which the tills have been moulded into long drumlin-like ridges. In the intervening hollows between ridges the natural drainage is often poor and the soils noncalcareous gleys. The natural

fertility of the land is high and has been increased during a long period of intensive farming and fertilizer usage. Arable crops generally form a high proportion of most farm rotations and periods in grass leys are usually short.

The farms are large and highly mechanized. Nevertheless, despite the warm dry climate and low rainfall these fine-textured soils with impeded natural drainage require careful management to avoid damage to soil structure. Under-drains with permeable infill in the drain-lines and secondary treatments to improve subsoil structure and permeability are necessary for efficient cultivation.

THE YARROW/FLEET ASSOCIATIONS

(Map units 576–579)

The Yarrow Association, well known from previous surveys (Ragg, 1960; Bown, 1973), and the Fleet Association have been grouped together on the 1:250 000 soil map. Both are developed on gravels and sands derived mainly from greywackes, but with some additions of granitic materials in Galloway. The deposits are principally fluvioglacial in origin, but also included are some found on upper river terraces and Late Glacial ('70-foot') raised beaches. The associations occur mainly in the river valleys of the Southern Uplands. Landforms are mainly mounds and terraces but in some areas kettleholes and similar depressional features are found.

The associations occupy 336 square kilometres (1.7 per cent of South-East Scotland). Rainfall ranges widely, 1000 to 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 associations but in some map units they occur with alluvial soils or peat. 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, and soft rush pasture on poorly drained alluvial soils.

Map unit 576 occupies 155 square kilometres (46 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. In western areas 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; arable crops are more frequent in low rainfall eastern areas. Stoniness can affect the use of some implements.

Map unit 577 occupies 7 square kilometres (2 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 71 square kilometres (21 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 peaty alluvial soils.

Map unit 579 occupies 103 square kilometres (31 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.

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 are large enough to be represented separately on the 1:250 000 soil map. Such areas amount to only 5 square kilometres (0.6 per cent of South-East 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 858 square kilometres (4.3 per cent of South-East 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-East Scotland is 142 square kilometres.

3 Land Evaluation

Earlier chapters of this book have described the main natural resource attributes of South-East 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-East 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-EAST SCOTLAND

Climate South-East Scotland, lying east of major areas of high ground, encompasses lowland districts such as Berwickshire, the Lothians, Fife and Strathallan renowned for excellence in arable agriculture and characterized by warm, moderately dry summers, cold winters and low or moderate rainfall. The soil moisture is below field capacity throughout the year except for a short period from November to February and conditions are favourable to cultivation and seed-bed preparation. High accumulated temperatures in spring and early summer combine with adequate moisture to encourage crop growth, while high midsummer soil moisture deficits promote crop ripening. Weather at harvest is a major concern throughout Scotland, but the hazards prevailing in these lowlands are less than in all but the most favoured areas elsewhere.

On somewhat higher-lying land peripheral to the principal arable areas, cooler temperatures, shorter growing seasons and higher rainfall are associated with increased proportions of pasture and farming is based largely on stock, both rearing and finishing. In eastern areas under moderate rainfall, however, ancilliary crops of barley, oats or forage remain important, generally as winter feed for animals. The effects of increased exposure on animal health in the uplands lead to the predominance of stock-rearing and sheep-farming enterprises. 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.

Higher levels of rainfall allied with summer warmth on the lowlands bordering the Solway Firth and in Ayrshire favour an abundance of pasture; the predominant enterprise is intensive dairying, with silage conservation preferred to hay on climatic as well as nutritional grounds.

Special advantages of high insolation, air movement during periods of frost risk and moderate rainfall, in conjunction with socio-economic factors, has allowed the development of market garden enterprises between Lanark and Carluke in the Clyde valley. Similar but less marked features of climate are also associated with the growth of soft fruits in lower Strathmore.

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 carse at Stirling, together with small areas bordering the Solway, and alluvial tracts along the principal rivers, provide level ground where any restrictions on the use of machinery cannot be ascribed to slope. However, problems associated with the soils and wetness are encountered. The widespread and extensive undulating lowlands with gentle slopes present few problems, except to very specialized implements.

The effects of strong slopes (7–15 degrees) which restrict the use of some silage-making equipment, and of gradients of more than 11 degrees severely limiting

arable cropping, are evident in uplands and foothills. 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 Southern Uplands, the Ochil Hills, the Campsie Fells and the Highlands, 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 high repute of arable farming in this region lends emphasis to soil type as a major influence on agriculture. Intensive rotations of arable crops involve frequent working of the ground through ploughing, seed-bed preparation and sowing: each requires suitable conditions and the avoidance of structural damage is a major concern. In the lowlands, deep, loamy, easily worked alluvial soils occur along rivers such as the Tweed, the Earn, the Clyde and the Nith, but are usually subject to other limitations. More typical of the lowlands, however, are the soils, developed on lodgement tills, with loamy or clayey textures, which can lead to cultivation difficulties and a tendency to persistent wetness, a major limitation on arable agriculture. On the Carse of Stirling and along the Cree and Nith estuaries, 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. The tendency for fine seed-beds in some soils to slake under heavy rainfall is generally linked to high contents of fine sand or silt and has been noted for some map units of the Balrownie Association. Tracts of gravels, mainly in valleys or on raised beaches, carry soils which impose almost no limitations on the timing of cultivations, but are stony and have a low capacity to retain moisture. In Galloway and areas adjacent to the Highlands stony ground often has areas where soils are too shallow to plough, but these are mainly small patches around scattered rock outcrops. The picking of stones from fields has a long tradition in such areas and is evidenced farther north by fields bounded by wide consumption dykes made up of stones removed from the land. In the uplands, land use is affected by a variety of environmental factors, but limitations imposed by soil are less important to grazing management than to cultivation in the arable lowlands. Strong acidity and low fertility are features of almost all peaty land.

Wetness Although the warm moderately dry climatic conditions favour arable agriculture in many parts of the region, soil wetness is nevertheless a major influence on the management of cultivations. In Berwickshire and the Midland Valley, subsoils with clayey textures and coarse prismatic structures are slowly permeable. The tendency to surface waterlogging is persistent and high soil moisture at critical times in the farming year affects winter ploughing, spring seed-bed preparation and trafficability at harvest. In western areas, under higher rainfall than in eastern arable districts, surface waterlogging, although ameliorated by systems of under-drainage, is often a severe limitation on land use and there is a continuing risk of damage to pastures by treading. Soils are, on average, at field capacity for less than 175 days in the year in eastern arable districts compared with more than 200 days in uplands and most western areas (Bibby *et al.*, 1982).

On the shallower soils of the Southern Uplands west of the River Nith 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, season and frequency 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 southern Scotland, are often used mainly for silage rather than for arable crops.

Erosion In many countries overseas, 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 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 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 rock outcrops 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, as with 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 to 7 unsuited to arable use. There are no divisions within Classes 1, 2 and 7; two divisions in each of Classes 3 and 4; and three divisions in Classes 5 and 6. A full description of the classification system and national guidelines is available as a Soil Survey monograph (Bibby *et al.*, 1982). The following is a condensed description of the classes and divisions:

Land suited to arable cropping

Class 1 *Land capable of producing a very wide range of crops*
Cropping is highly flexible and includes the more exacting crops such as winter-harvested vegetables. The levels of yield are consistently high.

Class 2 *Land capable of producing a wide range of crops*
Cropping is very flexible and a wide range of crops can be grown but difficulties with winter vegetables may be encountered in some years. The level of yield is high but less consistently obtained than in Class 1.

Class 3 *Land capable of producing a moderate range of crops*
Division 1 The land is capable of producing consistently high yields of a narrow range of crops (cereals and grass) or moderate yields of a wider range (potatoes, field beans and other vegetables and root crops). Grass leys of short duration are common.
Division 2 The land is capable of average production but high yields of grass, barley and oats are often obtained. Grass leys are common and 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 expressions of current knowledge and revision may be necessary with new experience or technological innovations.

THE CLASSES AND DIVISIONS IN SOUTH-EAST SCOTLAND

Class 1

This land is capable of producing a wide range of crops, including those that are most exacting in their requirements, and is highly flexible in its use. It occupies 41 square kilometres (0.1 per cent of South-East Scotland) mainly to the east and west of Edinburgh. Some other areas, insufficiently large for separation at the present map scale, but important on individual farms, may also be encountered. The soils are brown forest soils and include deep, freely draining sandy loams and loams of the Dreghorn Association on raised beach deposits and of the Rowanhill/Giffnock/Winton Associations on strongly water-worked tills. Some small areas of deep, freely draining loamy alluvial ground may fall within the class, as long as they are not subject to flooding. Cultivations and seed-bed preparation can be carried out easily, under good husbandry, without risks of damage to structure. The deep topsoils have a good moisture holding capacity and provide abundant room in which roots can proliferate and obtain nutrients. Fertility has been increased during a long history of good husbandry and the soils respond well to fertilizers. Normally favourable conditions for seeding, growth and harvest can be expected under the warm moderately dry climate and land in this class is amongst the most valuable in the country for the production of food.

Table B Areas of land capability for agriculture map units

CLASS and DIVISION	SHEET 7 SQ. KM.	SHEET 7 % LAND AREA	SCOTLAND SQ. KM.	SCOTLAND % LAND AREA
1	24	0.1	41	0.1
2	753	3.8	1723	2.2
3	4401	22.1	11724	15.2
3.1	1806	9.1	4586	5.9
3.2	2595	13.0	7138	9.3
4	3846	19.3	8219	10.7
4.1	1943	9.8	3690	4.8
4.2	1903	9.5	4529	5.9
5	5197	26.0	14270	18.5
5.1	766	3.8	1810	2.4
5.2	2457	12.3	5899	7.6
5.3	1974	9.9	6561	8.5
6	4816	24.1	37329	48.4
6.1	431	2.2	1556	2.0
6.2	1047	5.2	5463	7.1
6.3	3338	16.7	30310	39.3
7	59	0.3	2548	3.3
BUILT-UP AREAS	858	4.3	1233	1.6
TOTAL	19954		77087	

1 sq. km. = 100 hectares

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

Class 2

Class 2 land occupies 753 square kilometres (3.8 per cent of South-East Scotland) and occurs widely scattered in the valleys and coastal areas of Fife and the Lothians, and in Berwickshire. Elsewhere, notably near Dumfries and in the Annan–Gretna district, small areas have been included with land of other classes owing to the small scale of the map. The ground is gently sloping and the climate is warm and moderately dry with rainfall in the range 600 to 850 millimetres per

annum. The land is capable of producing a wide range of crops and is flexible in its use with only few difficulties encountered. Environmental limitations are only slight and much of the land is of broadly similar type. For the purposes of description, however, the soils may be considered in groups. Around the coasts very gently sloping raised beach and other terraces carry brown forest soils of the Dreghorn, Carpow and Panbride Associations which are freely drained and have deep sandy loam topsoils over coarse- or moderately coarse-textured subsoils. Near Drem, East Lothian, brown forest soils with gleying, also of the Dreghorn Association, have high contents of fine sand and silt, structures are weak, seed-beds are liable to slake and seedling emergence can be affected by 'capping'. In scattered inland areas brown forest soils and humus-iron podzols of the Darvel and Eckford Associations are developed on fluvioglacial sands and are freely drained with sandy loam textures in the plough layer. A third more diverse group includes soils in the Whitsome, Hobkirk, Mountboy, Kippen/Largs, Rowanhill/Giffnock/Winton and Kilmarnock Associations developed on tills strongly affected by water-sorting processes. The sandy loam or loam topsoils overlie sandy loams in the subsoil which pass down into loam or clay loam tills. The soils, which include both brown forest soils and brown forest soils with gleying, have free or imperfect natural drainage. A few soils with clay loam tills directly below the plough layer in areas of very low rainfall are also in this class, mainly in East Lothian and Berwickshire.

Where subsoils are sandy the land is very easily cultivated and seed-beds can be obtained with few implement passes, but some limitations of yield due to drought may be experienced in dry years. The fertility of such soils owes much to 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.

The soils developed on the tills, including those with a water-sorted, upper layer, are generally of medium texture and retentive of moisture and nutrients. Some difficulties associated with wetness during harvesting of root crops or vegetables in late autumn or winter are likely on this land, but crop yields can be consistently high.

Class 3

Although land in this class predominates in the eastern districts of Fife, the carse at Stirling, the Lothians and Berwickshire, all well known for arable agriculture. It occurs also in the west of the region, in the areas of central Ayrshire, Dumfries and Galloway having a high reputation for dairying. The class therefore exhibits considerable diversity and is usually regarded as average arable land. 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 crops, including potatoes and some vegetables. The conditions restricting the choice, yield or consistency of crops are expressed more strongly however 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-East Scotland slowly permeable soils are extensive and differences in the use of the land are governed largely by the moisture regime as influenced by the local climate. The class also includes the clayey carse lands at Stirling, sandy and gravelly soils of localized occurrence but widely distributed in the lowlands, and loamy or sandy loamy freely draining land having limitations associated with climate or slope. On the slowly permeable soils, cropping predominates in eastern areas under the prevailing dry climate, but under the wetter conditions in the west of the region

farming enterprises are based on dairying. Areas with coarse-textured subsoils are easily cultivated but tend to be affected by drought. A very specialized rotation is traditionally followed on the carse lands. In all, Class 3 land occupies 4401 square kilometres (22.1 per cent of South-East Scotland).

Division 1 Land in this division occupies 1806 square kilometres (41 per cent of the class). Predominant in Berwickshire, it extends into the adjacent lowlands and valleys of Roxburghshire; in the Lothians it is extensive in the East Lothian plain and the environs of Edinburgh, and is found in the Eden valley and coastal areas of Fife as well as occupying much of Strathearn. In the south-west of the region, land in the Dumfries and Lochmaben basins and the coastal areas of Dumfriesshire is in this division. In eastern areas the warm dry climate and low or moderate rainfall favour the intensive cultivation and cropping characteristic of the traditional systems of arable agriculture established during the agrarian revolution of the late eighteenth and early nineteenth centuries. More recent changes involving high degrees of mechanization and fertilizer usage have led to further intensification of cropping. Field layouts well adapted to mechanized operations and large farm size are notable features associated with this land, particularly in Berwickshire. In Dumfriesshire, greater and more reliable rainfall favours the abundant and consistent growth of grass; cropping, although more common than in the grassland-based systems of farming predominant in other western areas, is mainly to provide winter feed for dairy and other stock.

In broad terms the division can be seen as comprising land of three types: (1) with slowly permeable subsoils in areas of low rainfall, (2) with coarse-textured gravelly or sandy subsoils, and (3) land with loamy soils and climatic or other limitations.

Brown forest soils with gleying, together with associated gleys, belonging to the Whitsome, Ettrick, Minto and Cairncross Associations in Berwickshire and adjacent areas, the Rowanhill/Giffnock/Winton, Kilmarnock, Humbie and Biel Associations in the Lothians and the Rowanhill/Giffnock/Winton/ Associations in Fife and developed on clayey tills, form land of the first type. Although the soils are slowly permeable, soil moisture is at field capacity for only 150 days or less in most years and high levels of deficit develop in summer. The moisture state of the land therefore generally allows good opportunities for cultivation and seeding in most seasons without undue risk of soil structural damage. But unseasonably high rainfall and plastic conditions in wet soils can pose problems in some years. The land is retentive of both moisture and plant nutrients and fertility is generally maintained at high levels. The landscape is subject to constant seasonal change as bare furrows are succeeded by emergent and then maturing and ripening grain crops to form a patchwork with the green short-ley pastures and, in recent years, also with the chrome yellows of fields of flowering oil-seed rape.

Land with coarse-textured subsoils, the second type, is widely distributed, occurring in Strathearn, along the Teviot, and near Gordon, as well as near Dumfries, Kirkintilloch and Rutherglen. Consisting mainly of brown forest soils of the Darvel, Eckford, Innerwick and Yarrow Associations, the land is very easily worked. The soils, however, have a low capacity to retain moisture, and even in western areas of the region where average rainfall may be 1000 millimetres per annum, this can lead to reduced crop yields in periods without rain, as have occurred in several recent seasons. Irrigation on land with sandy soils, usually possible only on small areas, can lead to good yields of a wide variety of crops. Soils of the Carpow/Panbride Associations in this division are generally affected by slightly adverse climate.

In Dumfriesshire, areas with sandy and gravelly soils occurring with peat and peaty alluvial land are numbered in this division, with Class 5 or 6 in parentheses indicative of the strong contrast in land type and difficulties of representation posed by scale.

In the country along the Teviot and extending north to Polworth, land with loamy brown forest soils and brown forest soils with gleying in the Hobkirk and Smailholm Associations is in this division. Much of the ground with Hobkirk soils has lower accumulated summer temperatures than nearby areas and some of the Smailholm soils have restricted depth or are stony. Characteristically, soils of the Rowanhill Association are developed on clayey tills, but in a few small areas near Glasgow and elsewhere in the Midland Valley, some brown forest soils and brown forest soils with gleying are of medium texture and the land is more readily worked and more easily managed than surrounding areas. On drifts of the Holywood Association and modified tills in the Canonbie Association loamy brown forest soils with gleying and brown forest soils under moderately high rainfall form land utilized mainly for pasture and dairying but generally cropped more frequently and cultivated more easily than most other ground in Dumfriesshire.

Division 2 Occupying 2595 square kilometres (59 per cent of the class), land in this division is the most extensive of those in South-East Scotland having a capability for arable agriculture. It is extensive in central and southern Fife, on the carse at Stirling and in Ayrshire. Less extensive areas are found along Strathearn, in Strathallan, around Glasgow, in the Lothians, in Lauderdale, in the upper valley of the Teviot and its tributaries, at Castle Douglas, in the Nith valley and on the Solway plain of Dumfriesshire.

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, usually tills, (3) scattered areas, mainly in valleys, with coarse-textured subsoils and climatic limitations, (4) small areas with loamy soils and limitations of climate, slope or stoniness, and (5) small alluvial tracts liable to flooding.

Traditionally, a highly specialized 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 to 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, while climatic differences between districts have a major influence on systems of farming. In the west of the region, in Ayrshire, around Castle Douglas, in the Nith valley and on the Solway plain, in a warm moist climate with high annual rainfall, grass leys maintain good yields and are 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. The land comprises soils from the Canonbie, Holywood, Rhins, Kilmarnock, Bargour, Rowanhill and Sorn Associations. Farther east in Fife and the Lothians, where the soils belong mainly to the Rowanhill Association, the climate is notably drier, with lower rainfall and greater summer soil moisture deficits and soils are at field capacity for about 175 days in the year. Lower accumulated temperatures are also evident. Under such

conditions pastures are less favoured in comparison to cultivation than in western districts and cereals and root crops which are prominent in the landscape make a major contribution to agricultural returns. Many farms are mixed therefore with crops and cattle and sheep kept for meat production, although some are dairy enterprises. In the areas bordering Strathearn and the valley of the Forth, and in Strathallan, the soils, belonging mainly to the Balrownie Association, provide conditions for cultivation somewhat less difficult than in Ayrshire and despite high rainfall the pattern of farming tends to be mixed with crops and meat production important elements. Overall, however, wetness is the chief characteristic of all this land; in the east limitations on the choice and performance of crops are of major concern, while in the west there are restrictions on the 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. Stoniness and moundy landforms often affect their use, but the most common limitation is adverse climate. In Fife, humus-iron podzols of the Eckford Association are notable at Ladybank and around Loch Leven, but elsewhere brown forest soils predominate: those of the Gleneagles Association in Strathallan, the Doune Association in the Teith valley, the Darvel Association at Lanark and near Cumnock, and the Yarrow Association in the valleys of the Southern Uplands as at Selkirk, Drumelzier Glen and Closeburn. The Symington Association near the village of that name also forms land in this division. The land is often the most easily cultivated in the areas in which it occurs and in valleys amongst the hills is valuable for the growth of crops as winter feed for stock, but the weather often makes harvesting difficult. The moisture and nutrient retention capacity of these soils is low. Freely draining loamy soils in areas affected by the adverse climate also provide land in this division. Notable examples are soils of the Lauder Association in Lauderdale where grain and root crops are an important element on sheep and stock farms, soils of the Sourhope Association in eastern areas of the Sidlaw Hills where stoniness and slope are important factors, and soils of the Darleith Association in southern Fife where the effects of stoniness and depth are predominant.

At Closeburn, Dumfriesshire, and along water-courses elsewhere, 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, but cultivation problems can also arise from stoniness, lack of soil depth, or steep slopes. Seed-bed 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, although absent from the mountainous Highland subregion, occurs widely throughout much of South-East Scotland. In the Midland Valley there are extensive areas having severe wetness limitations as on the Slamannan plateau, near Mauchline, around Glasgow and fringing higher-lying land as at Cumnock, around the Saline Hills in Fife and the Kilsyth Hills. Farther south in the Southern Uplands freely draining soils in the foothills between 200 and 300 metres altitude as at Abbey St Bathans or south of Morebattle, as well as freely draining land in valleys amongst the hills is placed in this class; difficulties associated with stoniness and slope are often combined with the effects of adverse climate. In Dumfriesshire much land in this class is affected by both slow soil permeability and climatic difficulties, although around Dunscore stoniness and slope combine with climate as major factors restricting use. Westward in Galloway 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 are broad generalizations only. Class 4 land occupies 3846 square kilometres (19.3 per cent of South-East Scotland).

Division 1 Land in this division comprises a wide diversity of terrain, from coastal raised beaches, through patterns of drumlins and fields with rock outcrops, to valleys amongst the uplands. Mainly, however, it occurs in areas peripheral to the hills in both the Midland Valley and the Southern Uplands, occupying in all, 1943 square kilometres (50 per cent of Class 4). Grassland predominates throughout the division supporting enterprises that include dairying, usually in western or high rainfall areas, and sheep and cattle farms, mainly in areas bordering uplands, most commonly in the east of the region. In the hills and uplands the capability of coarse- or medium-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, in the environs of Glasgow, in Lanarkshire, on the western slopes of Lauderdale, in Dumfriesshire near Lockerbie and west of the Water of Ae, and in Kirkcudbrightshire to the north and east of the Castle Douglas basin where slowly permeable soils, mainly brown forest soils with gleying and having imperfect natural drainage, occur under moderately high rainfall on clayey or fine loamy tills. 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, Drongan, Lanfine, Ettrick and Rhins 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 sowing and, in the resulting shortened growing seasons, yields are below average. Weather conditions at harvest are frequently difficult and their effect increases as crop areas on any farm become greater.

Bordering the Solway Firth, south of Newton Stewart, near Carsethorn, and at the mouth of the Lochar Water, 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 on gravelly parent materials, mainly of the Yarrow, Eckford, Symington and Darvel Associations, occurs scattered in small patches as at Darvel, Sanquhar, between Liberton and West Linton, to the south of Gifford and near Carronbridge, Dumfriesshire. Climate, especially the risk of bad weather at harvest in western areas and moderate or low temperatures in the growing season farther east, 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, and careful attention should be paid to lime and fertilizer requirements. Land with brown forest soils of the Ettrick, Hobkirk, Lauder, Darleith, Sourhope, Tynehead, Dalbeattie, Creetown and Callander Associations, in foothills or uplands as in Berwickshire, and Roxburghshire around the Merse of Berwick, along the Southern Uplands border in East Lothian, in the Renfrew uplands south of Glasgow, on valley sides and in areas peripheral to hills in Dumfries and Galloway, and to the west of Doune, is also placed in this division; principally on account of climatic limitations, but often in combination with soil factors, such as stoniness or lack of depth, or moderately steep slopes.

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 shallow brown forest soils of the Darleith Association south-west of Glasgow, and near Stirling, and of the Sourhope Association in the uplands of the eastern Ochil Hills. Grassland is easily managed and, on this freely draining land, is relatively free from poaching risk, but large implements are difficult to use and some patches in cropped fields usually remain untilled. Seed-beds, although stony, can generally be readiy prepared and average yields obtained from worked areas.

Division 2 Land in this division, which occupies 1903 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 comprises mainly cattle and sheep-rearing, particularly in eastern areas, but in the west includes some large productive dairy farms as well as others more lightly stocked than on less difficult land. Arable cropping is limited mainly by wetness, both of climate and soil, but low temperatures and short growing seasons affect some higher-lying ground in eastern areas. High rainfall and exposure affect crop growth, ripening and harvesting directly, and indirectly lead to wet conditions in many soils having clayey texture, coarse subsoil structures and low permeability.

Many areas of intrinsically wet land with noncalcareous gleys are widely distributed, as in central Ayrshire, on the Slamannan plateau, at Cumnock, between Lockerbie and Canonbie in Dumfriesshire, and farther east, to the north of Westruther, west of Bowden and near Bonchester Bridge, while in Fife similar ground surrounds the Saline Hills. Developed on a variety of clayey tills, the soils are in many different associations, notable amongst which are the Rowanhill, Ashgrove, Sorn, Darleith, Kilmarnock, Hindsward, Ettrick, Minto and Canonbie Associations. 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 in 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, although the possibilities for cropping are somewhat greater in eastern parts of the region where the climate is less wet than in the west. Management is often concerned with problems of grazing which centre largely round 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 the 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 gleys and the risk of poaching, although of concern, is similarly reduced. Drainage remains an important requirement on this land which occurs in upper Annandale, at Balmaclellan, near Kirkpatrick Durham, in Nithsdale near Thornhill, and south of Loch Lomond, while the soils belong mainly to the Ettrick, Rhins, Holywood, Hayfield, Mountboy and Balrownie Associations. Climate is the principal limitation, however, affecting land with coarse-textured soils such as those of the Yarrow Association in the Cairn, Yarrow and other valleys 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.

Freely draining land in this division with loamy brown forest soils is restricted in its use by a variety of factors, amongst which climate, slope, stoniness and lack of soil depth, acting often in combination, are predominant. It occurs largely in uplands, areas peripheral to hills and in some valleys, principally in eastern parts of the Southern Uplands, as in East Lothian and Midlothian, Berwickshire or Roxburghshire, but is found also around Dunscore and in other areas of Dumfriesshire, and the soils belong mainly to the Ettrick, Sourhope, Hobkirk or Tynehead Associations. Sheep and cattle-rearing are the main farm enterprises, but some small dairy herds are maintained in Dumfriesshire. Arable agriculture is difficult and only occasional grain or forage crops for winter feed are taken, but the grazing management of pasture poses problems which are less severe and associated usually with the effects of drought on thin soils in occasional dry seasons, of winter exposure on stock or of moderate or restricted growing season on the general farm economy. Harvesting or grass conservation is often difficult.

The frequency and extent of flooding is extremely difficult to assess, yet its effects on crops and animals can be severe. Damaging floods have several times affected land in the Lochmaben basin and in consequence some alluvial tracts have been placed in this division. Other alluvial land in the valleys of the Esk and Ewes Water near Langholm, the Lidell and Borthwick Waters and the River Teviot as well as other water-courses is affected by climate as well as flooding risk.

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 land or 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 in association 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 5197 square kilometres (26 per cent of South-East Scotland).

Division 1 Land in this division is extensive in southern Galloway, in the hills and uplands of the eastern Southern Uplands and in scattered areas near Selkirk,

Hawick and Oxnam. Other occurrences are in the eastern Ochil Hills, in valleys in Dumfriesshire and small patches peripheral to the lava hills in the Midland Valley. It occupies 766 square kilometres (15 per cent of Class 5) and the soils belong principally to the Ettrick, Darleith, Sourhope, Lauder, Strichen, Knockskae and Kippen Associations. There are small areas also in the Links and Fraserburgh 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 shallow soil, high quality pastures can often be maintained on this land by controlled grazing and 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. Farther east near Selkirk and Hawick similar land is found at rather higher altitudes, up to 300 metres, and under drier, cooler conditions of climate.

Non-rocky terrain with brown forest soils and humus-iron podzols occupies considerable areas around the valleys of the Gala, Lauder and Monynut Waters. Much of the land is at 250–350 metres altitude and the soils, mainly in the Ettrick and Lauder Associations, can be shallow and stony. Improved pastures can be readily established, maintained and managed, but the cool climate with shorter growing seasons and greater exposure than on lower-lying ground is less favourable to stock than in Galloway. Areas with shallow, stony, brown forest soils of the Darleith and Sourhope Associations unsuitable for cultivation are found in the eastern Ochil Hills south of Abernethy, near the Lomond Hills in Fife and north of Milngavie. Pastures on this land present few constraints to grazing management and some conservation is generally possible.

The use of sandy land with regosols of the Fraserburgh and Links Associations, at Gullane in East Lothian and Southerness in Kirkcudbrightshire, is restricted to pasture by the risks posed by wind erosion to bare ground or areas with broken turf.

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 rock outcrops, 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 2457 square kilometres (47 per cent of Class 5) in South-East Scotland. In Galloway, on the greywackes and some granites, and farther east near Selkirk and Hawick and at St Abb's Head, 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 valleys of the Doon, the Nith at Kirkconnel, the Shinnel above Penpont, and the Liddel at Newcastleton, as well as on Corrie Common near Lockerbie and extensively on the Slamannan plateau. Noncalcareous gleys and brown forest soils with gleying from a variety of associations such as the Rowanhill, Hindsward, Bargour, Sorn,

Lanfine, Ettrick, Canonbie and Carter Associations occurring principally around the periphery of upland areas, and, under high annual rainfall, 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. 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 the productivity of the existing rush pasture and bent–fescue grasslands.

In the Southern Uplands some land with peaty podzols and humus-iron podzols of the Ettrick Association on freely draining, stony, loamy drift subsoils is in this division. The terrain includes the smooth slopes and rounded summits of hills at altitudes up to about 450 metres and upland or plateau areas with irregular ground or drumlins. On the lava hills some small areas with podzols of the Darleith and Sourhope Associations are also included. 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. Much of the land lies at altitudes at which exposure is an important factor affecting the management of stock.

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 semi-natural hill and moorland plant 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 periods of 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 and Bargaly 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 and occurs as small areas widely scattered on the sides of the hills and valleys in the central and eastern parts of the Southern Uplands and in the Highlands.

Smooth undulating terrain dominated by wet soils, mainly peaty gleys with associated noncalcareous gleys and peat, occurs on high-lying parts of the Midland Valley, for example near Armadale and Whitburn, Cumnock and Sanquhar, and above Eaglesham; in Fife there is similar ground on the Cleish Hills and in Dumfriesshire between Lockerbie, Langholm and Newcastleton. 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 considerable range of wetness is widespread on the greywackes in the western Southern Uplands, 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, moundy morainic landforms with complex soil patterns ranging widely in drainage and wetness are also in this division, as is some land with scattered drumlins and soils with peaty surface layers such as that around Loch Urr and other areas nearby.

Land in this division occupies 1974 square kilometres (38 per cent of Class 5).

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-East Scotland land in Class 6 occupies 4816 square kilometres (24.1 per cent of the region) and covers large areas in the hills of the Southern Uplands, forms a high proportion of ground in the Highland subregion, and in the Midland Valley is restricted mainly to the lava hills. 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 Bibby *et al.*, (1982). 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 Class 5.3 land

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.

Steep land with smooth slopes and brown forest soils of the Ettrick Association occurs widely on the sides of hills and valleys in the Southern Uplands, most frequently in central areas as near St Mary's Loch, in the valleys of the Manor, Ettrick and Ewes Waters, and along the Black Esk and the middle reaches of the Tweed. The Sourhope Association provides similar terrain along the northern flanks of The Cheviot and in the Ochil Hills, while in the Highland subregion there is steep land with soils of the Strichen Association on the slopes above Loch Voil, of the Stonehaven Association near Aberfoyle, and of the Foudland Association in Glen Artney. Irregular terrain is provided by the Sourhope Association on the scarp of the Ochils and slightly rocky ground in the Darleith Association occurs on the slopes of the lava plateaux in the Midland Valley. More rugged slopes in the Foudland and Strichen Associations near the Trossachs and Strathyre are also in this division, as are some areas of irregular terrain and brown forest soils in the western Southern Uplands near New Galloway and beside the Water of Fleet.

Some steep slopes with noncalcareous gleys of the Ettrick 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. Noncalcareous gleys of the Strichen Association on steep slopes near Loch Doine provide similar land.

Coastal marshes or saltings found below the high-water mark occur along the Solway Firth and the salt-marsh communities provide valuable grazings despite the necessity to remove stock during regular periods of inundation.

In South-East Scotland this division occupies 431 square kilometres (9 per cent of Class 6).

Division 2 Diverse in character, land in this division occupies 1047 square kilometres (22 per cent of Class 6) and is widely scattered throughout the upland and hill areas of South-East Scotland.

The herbage provides grazing of moderate value from communities such as common white bent and flying bent grasslands, herb-rich Atlantic heather moor, some rush pastures, or mosaics of communities with high and low grazing values. Such mosaics dominate the areas mapped in this division in the Southern Uplands. At the head of very narrow valleys, as in the Lowther Hills, near the Camps reservoir and along the Leithen Water, 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. In western areas of the region 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 Ettrick Association. In the upper valley of the Ken there are patterns of bent–fescue grassland and bog communities on moundy morainic topography.

Hills with rock-controlled and more rugged slopes with outcrops as on the Keir Hills and other areas of high ground overlooking the Cairn valley 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.

Steep hill sides with a few rock crags and stabilized and partially stabilized screes, along the valleys of the Moffat Water, the River Tweed below Tweedsmuir and near Innerleithen, as well as some slopes near the Talla reservoir and in the south-western Lowther Hills, carry dry Atlantic heather moor and rich bent–fescue grassland with some oak and birchwood scrub are also in this division.

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. In the Ochils, high-lying smooth hill slopes in the Sourhope Association carry dry Atlantic heather moor, white bent grassland and rich bent–fescue grassland.

Land in this division in the Highland subregion is provided by the Strichen Association on steep slopes above Loch Ard and on morainic landforms in Glen Finglas.

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 in valleys and undulating terrain at moderate altitudes in western parts of the Southern Uplands as well as on basin peats. 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-East Scotland where it covers 3338 square kilometres (69 per cent of the class).

Class 7

Land in this class has extremely severe limitations that cannot be removed or rectified. In South-East Scotland it consists mainly of the rock walls and screes which form the corries of the Southern Uplands, mainly in the hill masses of the Merrick, Kells, Lamachan and Cairnsmore of Fleet in the west of the region and the Moffat Hills in the central area. In the Highland subregion areas of rock and scree extending to high altitudes on Ben Ledi and Ben Vorlich are in this class, as is an area of subalpine soils and rankers on the summit of Ben Venue. Parts of such areas, particularly the corries, 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-East Scotland is discussed below.

FORESTRY

Although the most severe effects of exposure are sustained in the coastal areas and mountains of western Scotland, high average wind speeds and periodic gales nevertheless have a major influence on the distribution, growth and management of forests in this region. Forestry for commercial purposes is not possible on the exposed, cold hills and mountain summits, while 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-East Scotland, while the limit of planting extends to notably higher altitudes in some eastward-facing valleys, as at Ettrick Head, the source of the Ettrick Water, and some north–south trending valleys sheltered from the west, such as Eskdalemuir, have been particularly favoured for forest development. 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 wide expansion of forestry plantations on the middle slopes of many hills in the western and central parts of the Southern Uplands, notably in the Glen Trool National Forest Park, the Forest of Ae, in the valley of the White Esk, and at Craik.

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, as elsewhere in Scotland, 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, where necessary, a 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 Ettrick Association in the Southern Uplands, notably in Eskdalemuir, 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 western Southern Uplands and is usually associated with moderate flushing. Blanket bog communities generally indicate conditions of low fertility. 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 and rocky terrain as found in Galloway, 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 soil 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 St Andrews and North Berwick, 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-East Scotland, however, the extensive uplands are not yet as well known as some other mountainous areas, although increasing numbers visit Glen Trool and the Merrick range, and the Pennine Way enters Scotland in the east of the region. 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 in the west of the region achieving the quality of those in the east.

Deer-stalking is mainly restricted to remote parts of the Highlands 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.

References

Bibby, J. S., Douglas, H. A., Thomasson, A. J. and Robertson, J. S. (1982). Land Capability Classification for Agriculture. Monograph. Aberdeen: The Macaulay Institute for Soil Research.

Birse, E. L. (1971) Assessment of climatic conditions in Scotland. 3. The bio-climatic sub-regions. Aberdeen: The Macaulay Institute for Soil Research.

Birse, E. L. (1980). Plant communities of Scotland. Revised and additional tables. Aberdeen: The Macaulay Institute for Soil Research.

Birse, E. L. (1982). The main types of woodland in North Scotland. *Phytocoenologia,* **10,** 9–55.

Birse, E. L. and Dry, F. T. (1970). Assessment of climatic conditions in Scotland. 1. Based on accumulated temperature and potential water deficit. Aberdeen: The Macaulay Institute for Soil Research.

Birse, E. L. and Robertson, L. (1970). Assessment of climatic conditions in Scotland. 2. Based on exposure and accumulated frost. Aberdeen: The Macaulay Institute for Soil Research.

Birse, E. L. and Robertson, J. S. (1976). Plant communities and soils of the low-land and southern upland regions of Scotland. Aberdeen: The Macaulay Institute for Soil Research.

Bown, C. J. (1973). The soils of Carrick and the country round Girvan (Sheets 7 and 8). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Bown, C. J. and Heslop, R. E. F. (1979). The soils of the country round Stranraer and Wigtown (Sheets 1, 2, 3, 4 and part 7). *Mem. Soil Surv. Scot.* Aberdeen: The Macaulay Institute for Soil Research.

Butler, B. E. (1980). Soil Classification for Soil Survey. Monographs on Soil Survey. Oxford: Clarendon Press.

Canada Soil Survey Committee, Sub committee on Soil Classification. (1978). The Canadian system of soil classification. Can. Dep. Agric. Publ. 1646. Ottawa: Supply and Services Canada.

Chandler, T. J. and Gregory, S. (eds.) (1976). The Climate of the British Isles. New York: Longman.

Clapham, A. R., Tutin, T. G. and Warburg, E. F. (1962). *Flora of the British Isles* (2nd edn). London: Cambridge University Press.

Glentworth, R. (1954). The soils of the country round Banff, Huntly and Turriff. (Sheets 86 and 96). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Glentworth, R. and Muir, J. W. (1963). The soils of the country round Aberdeen, Inverurie and Fraserburgh. (Sheets 77, 76 and 87/97). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Greig, D. C. (1971). The South of Scotland (3rd edn.). *Br. reg. Geol.* Edinburgh: HMSO.

James, P. W. (1965). A new check-list of British lichens. *Lichenologist,* **3,** 95.

Jardine, W. G. (1980). Holocene raised coastal sediments and former shorelines of Dumfriesshire and eastern Galloway. *Trans. Dumfriesshire and Galloway Nat. Hist. and Antiquarian Soc.* LV, 1.

Jarvis, R. A., Bendelow, V. C., Bradley, R. I., Carroll, D. M., Furness, R. R., Kilgour, I. N. L. and King, S. J. (In preparation). The soils and their use in Northern England (Sheet No. 1). Soil Survey Bulletin No. 10.

Johnstone, G. S. (1966). The Grampian Highlands (3rd edn). *Br. reg. Geol.* Edinburgh: HMSO.

Kilgour, I. N. L. (1979). Soils in Cumbria II (Sheet NY 36/37, Longtown). *Soil Survey Record No. 59.* Dorking: Bartholomew Press.

Laing, D. (1974). The soils of the country round Perth, Arbroath and Dundee. (Sheets 48 and 49). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

MacGregor, M. A. and MacGregor, A. G. (1948). The Midland Valley of Scotland (2nd edn.) *Br. reg. Geol.* Edinburgh: HMSO.

Mitchell, B. D. and Jarvis, R. A. (1956). The soils of the country round Kilmarnock (Sheet 22 and part of Sheet 21). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Muir, J. W. (1956). The soils of the country round Jedburgh and Morebattle (Sheets 17 and 18). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Ragg, J. M. (1960). The soils of the country round Kelso and Lauder (Sheets 25 and 26). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Ragg, J. M. and Futty, D. W. (1967). The soils of the country round Haddington and Eyemouth (Sheets 33 and 34 and part 41). *Mem. Soil Surv. Scot.* Edinburgh: HMSO.

Sissons, J. B. (1976). The geomorphology of the British Isles: Scotland. London: Methuen.

Smith, A. J. E. (1978). *The moss flora of Britain and Ireland.* London: Cambridge University Press.

The following soil maps deal with areas in South-East Scotland:

Bown, C. J., Futty, D. W., Jardine, W. G., Walker, A. D., Heslop, R. E. F. and Strachan, W. R. (1968). Soil map of Carrick and part of Girvan (Sheet 8 and part of 7). Scale 1:63 360. Southampton: Ordnance Survey.

Bown, C. J. and Heslop, R. E. F. (1971). Soil map of Kirkmaiden, Whithorn, Stranraer and Wigtown (Sheets 1, 2, 3, 4 and part 7). Scale 1:63 360. Southampton: Ordnance Survey.

Grant, R., Bown, C. J. and Birse, E. L. (1967). Soil map of Ayr (Sheet 14 and part of 13). Scale 1:63 360. Chessington: Ordnance Survey.

Laing, D., Romans, J. C. C., Lawrence, E., Walker, A. D., Bown, C. J. and Law, R. D. (1968). Soil map of Perth and Arbroath (Sheets 48 and 49). Scale 1:63 360. Southampton: Ordnance Survey.

Laing, D., Lawrence, E., Robertson, J. S. and Merrilees, D. W. (1975). Soil map of Kinross, Elie and Edinburgh (Sheet 40 and parts of Sheet 41 and 32). Scale 1:63 360. Southampton: Ordnance Survey.

Mitchell, B. D., Jarvis, R. A., Muir, J. W. and Davies, D. T. (1956). Soil map of Kilmarnock (Sheet 32 and part of 21). Scale 1:63 360. Chessington: Ordnance Survey.

Muir, J. W., Mulcahy, M. J., Ragg, J. M., Mitchell, B. D., Harper, P. C. and Smith, J. (1955). Soil map of Jedburgh and Morebattle (Sheets 17 and 18). Scale 1:63 360. Southampton: Ordnance Survey.

Ragg, J. M. Smith, J., Muir, J. W. and Birse, E. L. (1959). Soil map of Kelso (Sheet 25). Scale 1:63 360. Chessington: Ordnance Survey.

Ragg, J. M., Smith, J., Muir, J. W. and Birse, E. L. (1959). Soil map of Berwick upon Tweed. (Sheet 26). Scale 1:63 360. Chessington: Ordnance Survey.

Ragg, J. M., Futty, D. W. and Bown, C. J. (1966). Soil map of Haddington, Eyemouth and N. Berwick (Sheets 33, 34 and part 41). Scale 1:63 360. Chessington: Ordnance Survey.

Ragg, J. M., Bibby, J. S., Orbell, G. E. and Duncan, N. A. (1975). Soil map of Peebles and part of Edinburgh (Sheet 24 and part 32). Scale 1:63 360. Southampton: Ordnance Survey.

Ragg, J. M., Shipley, B. M., Duncan, N. A., Bibby, J. S. and Merrilees, D. W. (1977). Soil map of Airdrie (Sheet 31). Scale 1:63 360. Southampton: Ordnance Survey.

Shipley, B. M., Stevens, J. H., Lawrence, E. and Jarvis, R. A. (1968). Soil map of Stirling and part of Airdrie (Sheet 39 and part of 31). Scale 1:63 360. Southampton: Ordnance Survey.

Shipley, B. M., Stevens, J. H., Merrilees, D. W., Morris, R. J. F. and Wright, G. G. (1983). Soil map of Crieff (Sheet 47). Scale 1:63 360. Southampton: Ordnance Survey.

Handbooks of the Soil Survey of Scotland

1 Orkney and Shetland

2 The Outer Hebrides

3 Northern Scotland

4 Western Scotland

5 Eastern Scotland

6 South-West Scotland

7 South-East Scotland

8 Organization & Methods of the 1:250 000 Soil Survey