DEPARTMENT OF AGRICULTURE AND FISHERIES
FOR SCOTLAND

Memoirs of the Soil Survey of Great Britain

SCOTLAND

The soils of the country round Stranraer and Wigtown

(*Sheets 1, 2, 3, 4 and part 7*)

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WITH AN ACCOUNT OF THE VEGETATION

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Preface

This publication is the tenth memoir of the Soil Survey of Scotland. The soils of the country round Stranraer and Wigtown were surveyed between 1963 and 1967 by Mr C. J. Bown assisted by Mr R. E. F. Heslop. The vegetation was studied and surveyed by Mr E. L. Birse and Mr J. S. Robertson. Mr J. W. Muir assisted in soil correlation and classification. He also read the manuscript and made many helpful suggestions. Mr W. S. Shirreffs and Mr A. D. Moir of the Soil Survey Cartographic Section prepared the maps and diagrams. Members of staff from other departments of the Macaulay Institute for Soil Research have contributed to the memoir in various ways: Mr J. Logan and staff of the Soil Analysis Section of the Department of Pedology did the standard chemical analyses with the exception of those for exchangeable cations which were carried out by Dr R. L. Mitchell and staff of the Department of Spectrochemistry: Mr J. Logan checked the chapter on analytical data: staff of the Department of Pedology did the analyses of the mineralogy of the fine sand fractions based on microscopical examination, of clay mineralogy based on differential thermal and X-ray analyses, and of materials extracted by selective chemical dissolution techniques, and the relevant sections were written by Mr B. D. Mitchell: staff of the Department of Spectrochemistry carried out the analyses of trace elements for the section contributed by Dr M. L. Berrow: Dr P. D. Hulme, Mr A. T. Nicol and Mr R. A. Robertson wrote the chapter on peat, Dr S. E. Durno providing the section on vegetational history: Mr J. Mitchell, the Institute photographer, took the photographs except for those otherwise acknowledged.

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Contents

LIST OF PLATES

LIST OF FIGURES

LIST OF TABLES

APPENDICES

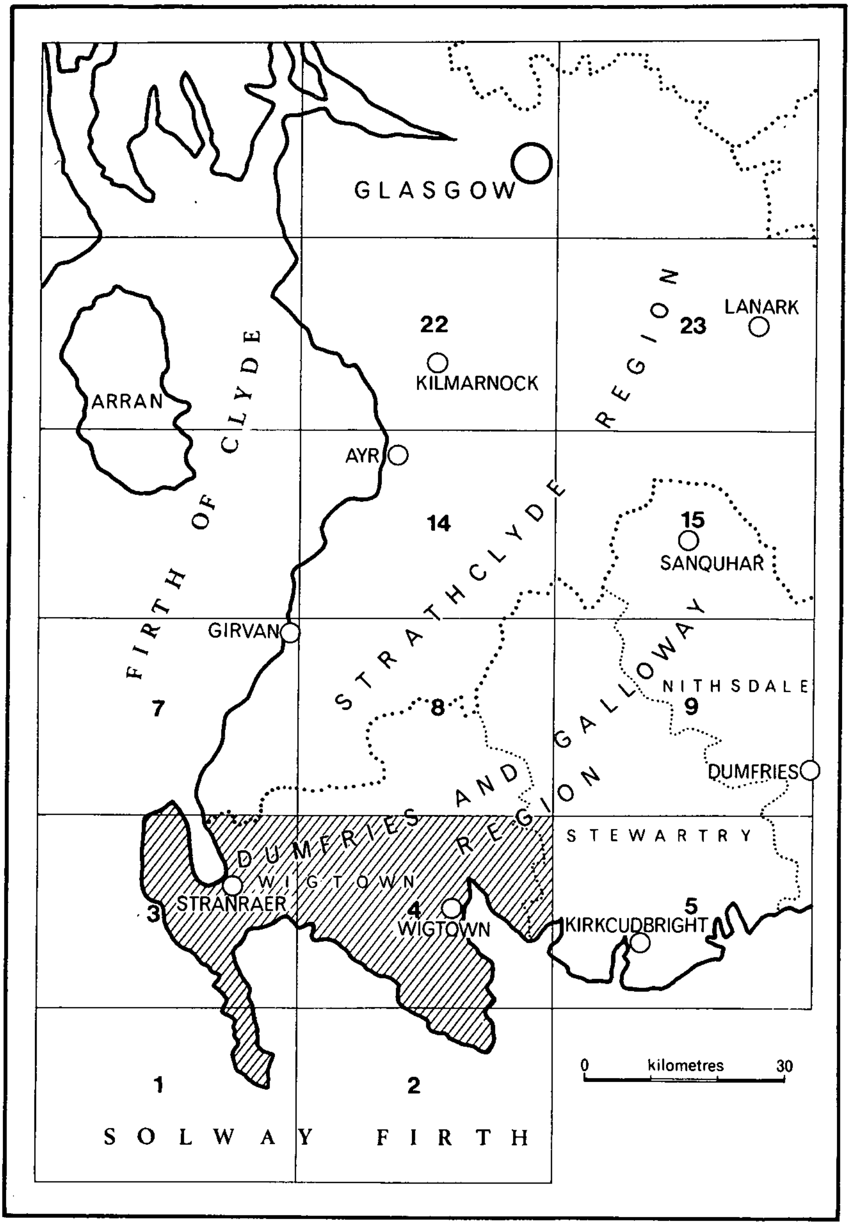


FIG. 1 Location of Area

1 | General Description of the Area

INTRODUCTION

This memoir describes the soils covering 1436 square kilometres in south-west Scotland, including the greater part of the county of Wigtown, part of west Kirkcudbrightshire and a small section of south Ayrshire.

The survey is a continuation of work started in north Ayrshire (Mitchell and Jarvis, 1956) and continued into central Ayrshire (Grant, in preparation) and south Ayrshire (Bown, 1973). The area of the present survey lies immediately to the south. Some of the soils are distinguished for the first time but most have been described by Bown (1973).

The area has a long history of human settlement, as evidenced by remains found near Stoneykirk, south of Stranraer, (Fig. 1), which probably date from Atlantic times (5000–3000 B.C.). The Romans were in Kirkcudbrightshire, for there is evidence of their constructions as far west as Gatehouse of Fleet, and Roman coins have been found in Wigtownshire. After the departure of the Romans, Galloway, which comprises the Stewartry of Kirkcudbright and the county of Wigtown, was subject to many masters, including the earls of Orkney and the lords of Galloway, and did not come under general Scottish law until 1426.

Today, the most important activity is agriculture, mainly dairy farming with subsidiary arable farming on low ground and stock rearing with a little arable farming on the moorlands. The predominance of dairying is partly related to the climate, for a relatively long growing season and a moderately high rainfall ensure that grass grows well. Milk production exceeds local demand, and as large centres of population are some distance away, processing of milk is traditional, with factory creameries now almost entirely replacing domestic production. Forestry is locally important, especially in the area around Newton Stewart where the Forestry Commission has a number of forests which give high timber yields on sheltered sites. A recent census (Locke, 1970) showed that woodland cover in Kirkcudbrightshire is 18 percent, as compared with 7 percent for the United Kingdom. The mild climate close to the sea is favourable for the growth of some exotic frost-tender trees and shrubs for which Logan Gardens on the Rhins Peninsula are particularly renowned.

The main centres of population are Stranraer (population 9000) and Newton Stewart. Stranraer is the port for the shortest sea route to Northern Ireland and has a number of light industries including

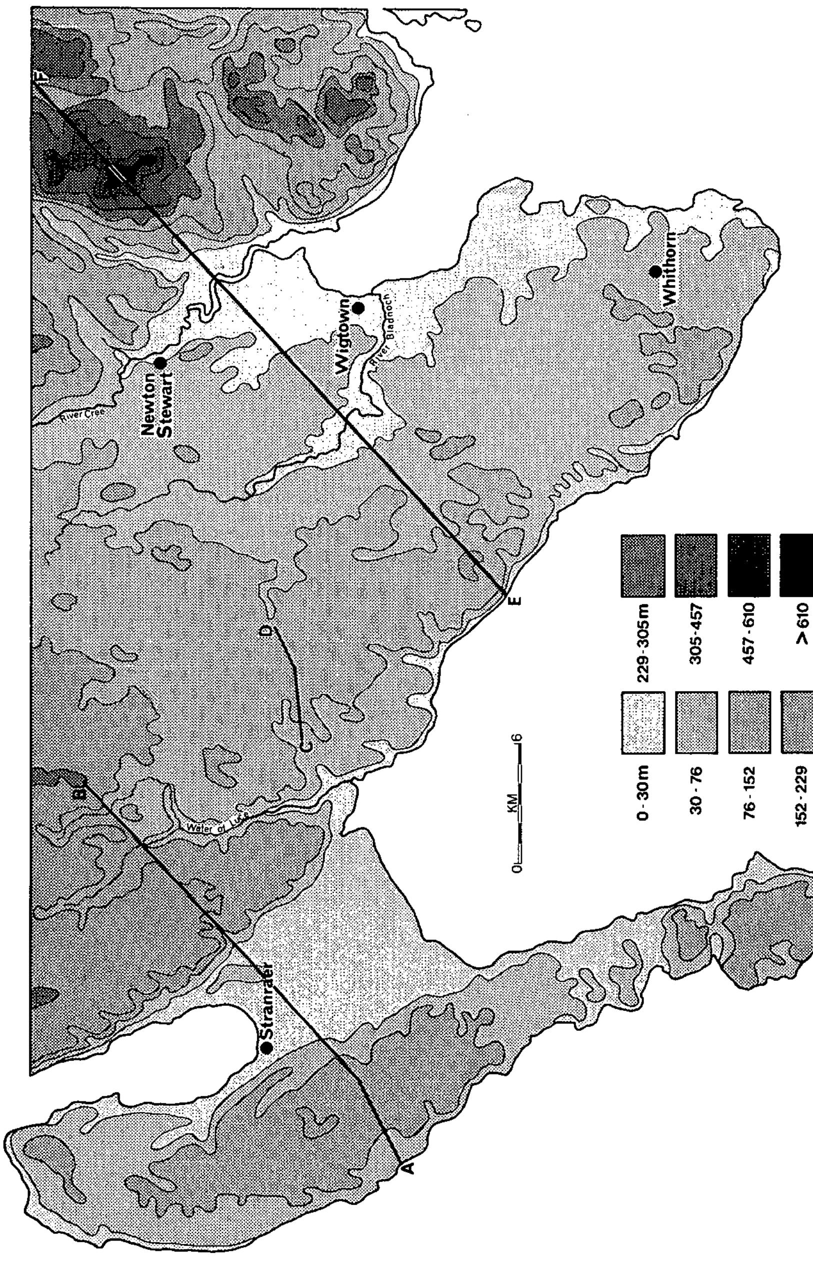
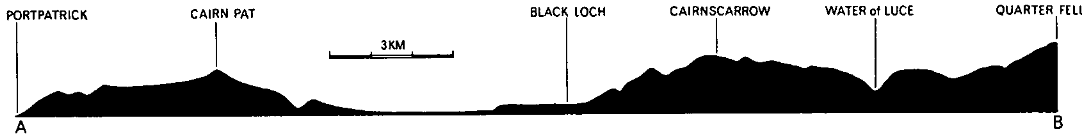
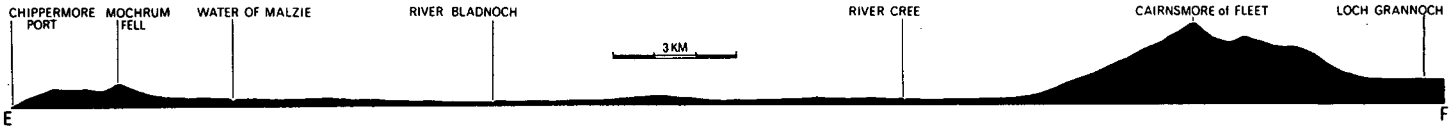
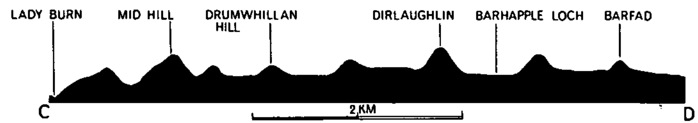


FIG. 2 Physical Features
(*see also page 3*).





On section AB the vertical scale is 6·6 x horizontal, on section EF it is 2·64 x horizontal and on section CD (on which sea level is not shown) the vertical scale is 8·3 x horizontal.



creameries, an oat processing factory and a shoe factory. Newton Stewart has a small mohair weaving mill and a livestock market. Both centres cater for an expanding tourist industry, which is well served by an extensive network of roads carrying a low density of traffic and giving access to excellent golf and fishing facilities and to some fine coastal and hill scenery.

PHYSICAL FEATURES

The area lies at the western extremity of the Southern Uplands of Scotland and is underlain mainly by sediments of Ordovician and Silurian age. Much of the country lies below 150 m (500 feet) O.D., and only the Fleet Hills—a granite intrusion of Old Red Sandstone age—rise above 500 m (1600 feet).

The drainage system of Galloway has been reviewed by Jardine (1959); he concluded that the present system originated in mid-Tertiary time, and has since been modified by changes in the regional base-level of erosion associated with uplift in relation to sea level. The major rivers, the Water of Luce, the Bladnoch and Cree Rivers and the Water of Fleet, flow in a south-easterly direction across the strike of the Palaeozoic strata. The River Bladnoch was originally a larger stream, but some of its headwaters have been captured by the River Cree (Jardine, op. cit.). These rivers and the Water of Fleet flow into Wigtown Bay, while the Water of Luce enters the sea at the northern end of Luce Bay.

Landform Regions

The deeply indented coastline divides the land area into a number of natural units with their long axis aligned north-west to south-east. Each unit has a characteristic topography, which is associated with a characteristic pattern of soils. The constituent elements of the relief—flats and slopes—are related to the geology and to the past and present geomorphology of the area. Features of the topography, geology and geomorphology that influence the soils and soil patterns, and thus also land use, are given special attention in the following account of the landform regions (Fig. 3).

1. RHINS PENINSULA

The narrow Rhins Peninsula stretches from Milleur Point to the Mull of Galloway, a distance of nearly 50 kilometres; nowhere on the peninsula is more than 5 km from the sea.

(a) Sedimentary Uplands

This is the most extensive sub-region on the peninsula and is underlain by Palaeozoic sediments, mainly Ordovician and Silurian greywackes and shales. The Southern Uplands Fault crosses the northern end of the peninsula, its position being marked by a narrow valley or slot aligned south-west to north-east, but the country north of the Fault does not differ significantly from that of the rest of the sub-region. The slopes above

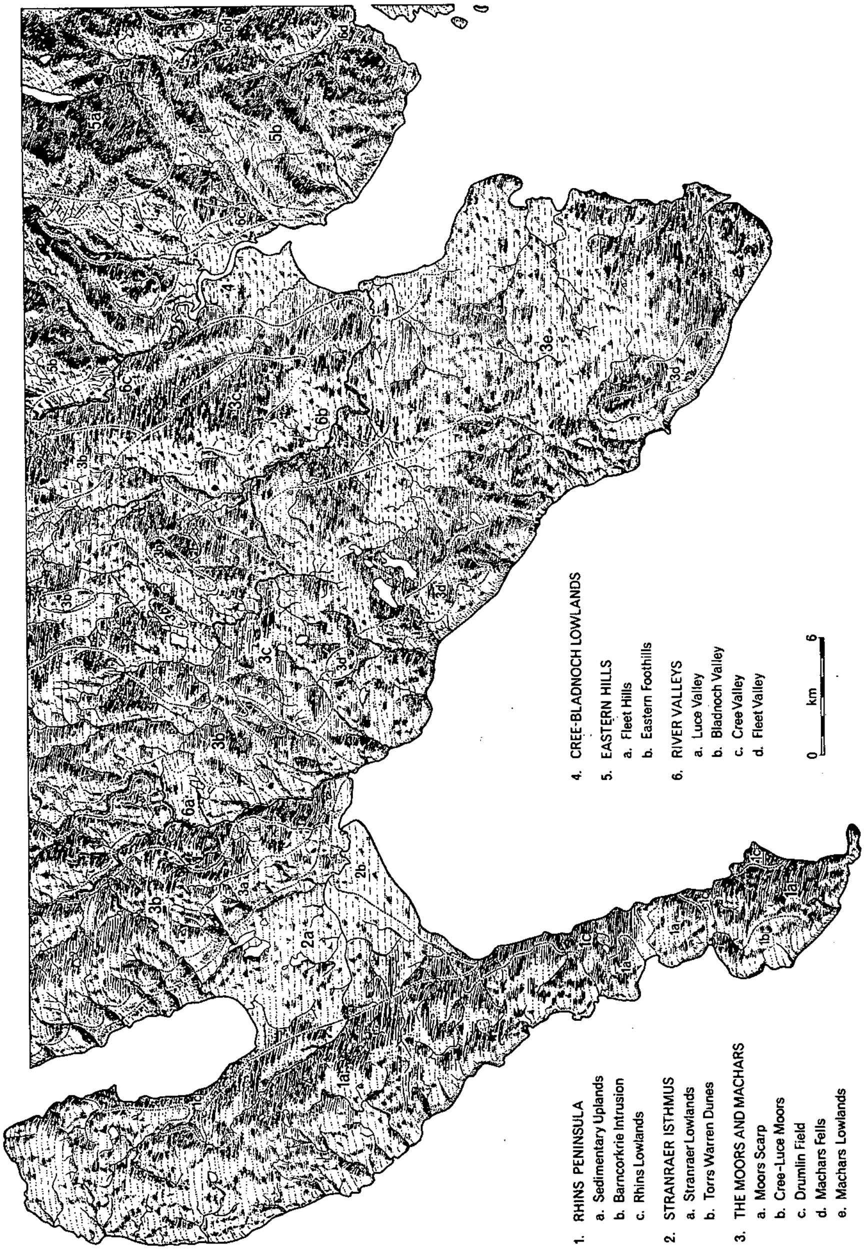


FIG. 3 Landform Regions

Stranraer and Loch Ryan are formed on sediments which include a narrow band of Carboniferous shales and a wider belt of Permian breccias.

The elevation rises to 181 m (593 feet) on Cairn Pat, near to the centre of the peninsula. Smooth elongated drumlinoid hills composed of thick till are interspersed with uneven ice-eroded relief having a thin drift cover, frequent rock outcrops and, less frequently, kame-mounds of fluvioglacial sands and gravels. In general the relief is rolling to strongly undulating rather than hilly, although moderately steep slopes do occur on both craggy and smooth hills, and cliffs are common on the western seaboard.

(*b*) *Barncorkrie Intrusion*

This intrusion crops out near the southern end of the peninsula and is composed mainly of acid rocks. A ring of rugged moorland, largely drift-free and with moderately steep to steep slopes and frequent rock outcrops, surrounds a softer landscape with a rolling, drumlinoid relief and a much thicker till cover. Elevations reach 150 m (500 feet) on Barncorkrie Moor but most of the central area is below 100 m (350 feet).

(*c*) *Rhins Lowlands*

At elevations below about 30 m (100 feet) are the Rhins Lowlands, several areas of low, moundy and terraced relief, composed mainly of fluvioglacial and marine sands and gravels. The coastline is fringed by a discontinuous low raised beach lying below 10 m (35 feet).

2. STRANRAER ISTHMUS

The Stranraer Isthmus is a lowland area having elevations below 45 m (150 feet) which is floored mainly by Permian rocks of the Loch Ryan–Luce Bay basin. The region is bounded to the west by the Rhins Peninsula and to the east by the Moors and Machars (region 3).

(*a*) *Stranraer Lowlands*

These lowlands cover the greater part of the Stranraer Isthmus. Most of the landforms are moundy or terraced and are composed mainly of sands and gravels of fluvioglacial and marine (raised beach) origin. Only a low beach, found below about 10 m (35 feet) is clearly distinguishable. Dissected terraces, such as the flat around Cults, contrast with hummocky mounds and kettle holes, as found between Inch Parks and Mahaar. Red lacustrine clay floors some hollows and flats, indicating pre-existing lochans and lochs, but more extensive is the alluvium of the Piltanton Burn, the only stream of any size draining this region. Between Stoneykirk and Stranraer a number of drumlinoid features composed of thick till rise above the mounds and terraces.

(*b*) *Torrs Warren Dunes*

These dunes border Luce Bay and comprise mounds of blown sand, interspersed with hollows, and dune slacks covering a large area near the present shoreline. Elevations reach 15 m (50 feet) on the larger dunes south of Mid Torrs.

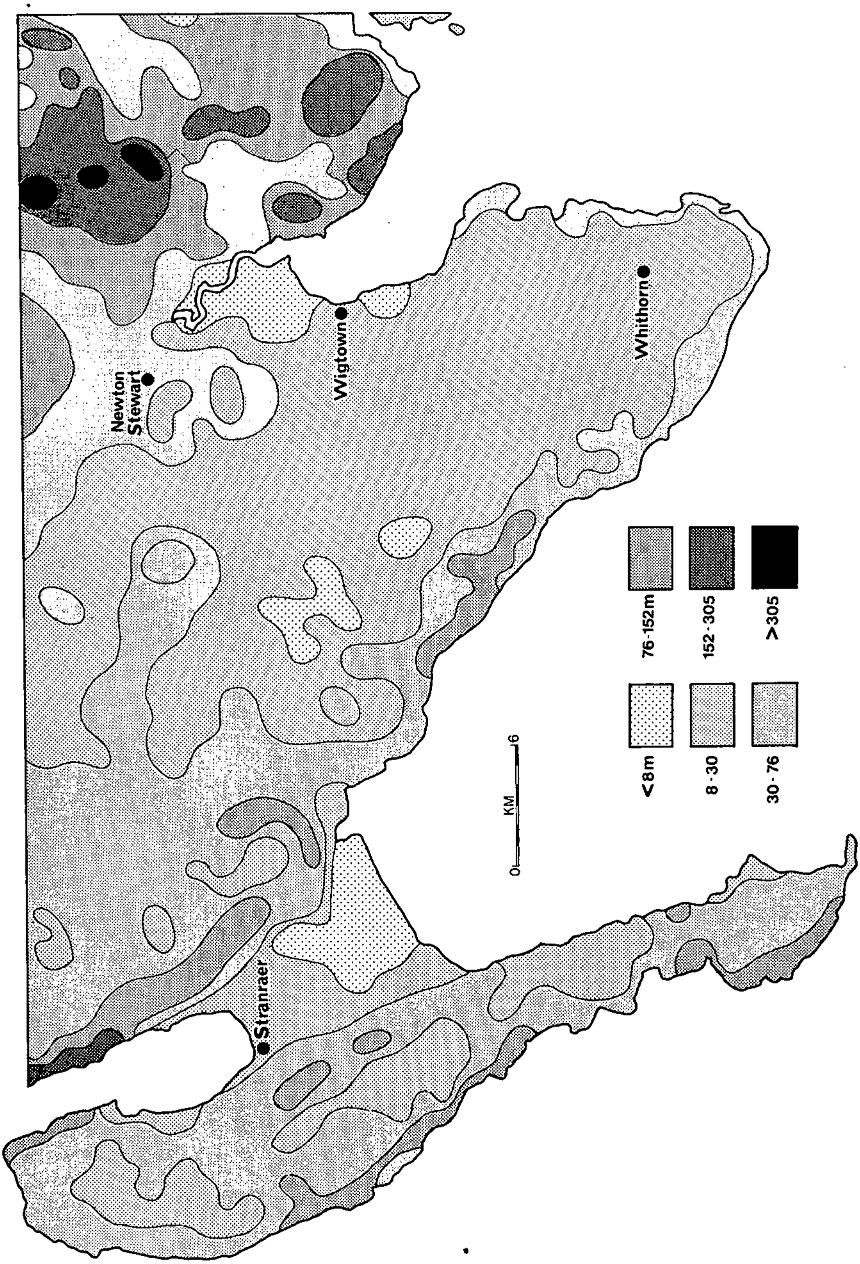


FIG. 4 Slope Analysis—Vertical Intervals per Grid Kilometre Square

3. THE MOORS AND MACHARS

Eastwards from Loch Ryan and the Stranraer Isthmus to the valley of the River Cree is an extensive area of low general relief traditionally known as the Machars and Moors, stretching from Burrow Head at the tip of the Machars Peninsula to the northern edge of the area covered by this memoir. Elevations rise gradually towards the north-west, reaching about 250 m (800 feet) on the Moors. Lower Paleozoic rocks of the Ordovician and Silurian systems, mainly greywackes and shales, underlie nearly the whole region which is dissected by the Water of Luce and the Bladnoch and Cree Rivers.

(*a*) *Moors Scarp*

Forming the western edge of the Moors district, this is probably a fault scarp. Although inextensive, the sub-region has a distinctive relief of moderately steep and steep slopes, most of which are smooth and drift-covered, interrupted by deep channels cut by streams which drain rapidly into Loch Ryan and the Stranraer Isthmus. In a distance of less than 2 km, elevations fall from about 180 m (600 feet) on the upland to almost sea level.

(*b*) *Cree–Luce Moors*

This sub-region lies at the highest elevation, the altitude seldom falling below 120 m (400 feet) and rising to 271 m (888 feet) on Artfield Fell. The moors are dissected by the Rivers Cree and Luce and by the head-waters of the River Bladnoch. It is an area of generally low and rolling relief with many peat flats and some eroded rock surfaces, broken by a number of fells to which a thin drift cover and frequent rock outcrops have given a rugged outline. The most extensive of these, Culvennan Fell, is partly underlain by a granite intrusion. Smooth elongated drumlinoid hills composed of till or moraine do occur, however, especially in the Luce and Bladnoch catchment areas. Slopes on these hills are usually gentle and are often covered by peat.

(*c*) *Drumlin Field*

Bordering the Cree–Luce Moors on their eastern and south-western sides is a drumlin field with an elevation tending to fall from about 150 m (500 feet) in the north to 50 m (150 feet) in the south. Drumlins up to 30 m high and 700 m long, composed of thick drift or till, occur in an ice-scoured landscape of flats and gentle slopes with rock outcrops. The long axes of the drumlins are aligned between north/south and north-east/south-west, reflecting the direction of ice movement. They are occasionally found close together, several making up a composite hillock, but more usually they are isolated. The flats are mostly occupied by peat mosses and by numerous lochs and lochans, the largest being Castle and Mochrum Lochs.

(*d*) *Machars Fells*

Rising above the general level of the country on the western side of the

Machars Peninsula are a number of fells, the highest of which, Mochrum Fell, reaches an altitude of 197 m (646 feet). Slopes are often moderately steep on these craggy hills, which have a thin drift cover.

(*e*) *Machars Lowlands*

Most of the southern end of the Machars Peninsula lies in this sub-region, where the elevation seldom rises above 100 m (350 feet). The relief is generally low and rolling, although moderately steep slopes are more frequent on the south-western seaboard. A narrow discontinuous raised beach below 10 m (35 feet) fringes the coastline of the peninsula. As compared with the Rhins Peninsula the country has more irregular micro-relief, and rock crops out frequently or, as near Garlieston, is not far below the surface. Some flats are peat-covered. Interspersed with the eroded areas are drumlinoid hills and smooth slopes with a thick cover of till and a few mounds and terraces composed of fluvioglacial sands and gravels.

4. CREE–BLADNOCH LOWLANDS

The flat or gently sloping Cree–Bladnoch Lowlands, where the elevation seldom exceeds 10 m (35 feet) are floored by estuarine sediments. The grey silts and clays which form most of this 'carse' land are partly covered by peat, the most extensive deposit being the Moss of Cree. Saltings, though not strictly part of the landform region as they are below the high water mark, are a feature of the Cree–Bladnoch estuary and are dissected by a network of creeks.

5. EASTERN HILLS

East of the River Cree the country becomes much more hilly and rugged, the altitude reaching 710 m (2329 feet) on the Cairnsmore of Fleet. The north-eastern part, which includes all the highest ground, is formed of granite and has been separated as a sub-region from the surrounding foothills which are composed of greywackes and shales, mainly of Silurian age.

(*a*) *Fleet Hills*

The granite outcrop of the Fleet Hills, which range from about 150 m (500 feet) to over 700 m (2300 feet) gives rise to rugged country with steep upper slopes. There are near-vertical cliffs on the rims of the cirque features on the eastern side of the Cairnsmore of Fleet which has a fairly extensive (1 × 0·5 km) domed plateau on its summit. The Cairnsmore is a prominent landmark, especially from the west and south-west. Drainage from the hills tends to be radial; the western and southern slopes are dissected by tributaries of the River Cree whilst the north-eastern and south-eastern sides are part of the Loch Grannoch and Water of Fleet catchment areas respectively. Moraines of moundy relief are found in the Water of Fleet area and smooth slopes underlain by drift occur locally.

(*b*) *Eastern Foothills*

The Eastern Foothills rise to 456 m (1497 feet) on Cairnharrow. Slopes are generally moderately steep or steep, usually with only a thin cover of drift. Rock outcrops are frequent on upper slopes, and where there is uneven micro-relief the rock is often at no great depth on lower slopes. Smooth slopes on lower ground have a thicker drift cover and they sometimes occur alongside mounds of moraine and gravel. The hills are dissected by the River Cree and the Water of Fleet and their tributaries and by a number of other streams, all of which flow in a southerly direction into Wigtown Bay.

6. RIVER VALLEYS

There are four major River Valleys in the area, the valleys of the Luce, Bladnoch, Cree and Fleet. The lower reaches of the Water of Fleet, and the headwaters of the other rivers lie outside the area of the memoir. Nevertheless their valleys cover a significant area (Fig. 3) and each, though related to the others, has a unity of its own.

(*a*) *Luce Valley*

The moderately steep sides of the valley fall from about 120 m (400 feet) on the moorland above to narrow 50 to 500 m wide alluvial tracts, often flanked by fluvioglacial gravel terraces. On the valley sides ice-eroded areas with rock outcrops alternate with smoother till-covered slopes and drumlinoid relief.

(*b*) *Bladnoch Valley*

The Bladnoch is more sluggish and sinuous than the Water of Luce and its alluvial tract can be as wide as 1 km, bordered in places by fluvioglacial mounds and terraces. The valley sides are less steep but are otherwise similar in relief to those of the Luce Valley. Above them is moorland, at an average elevation of no more than 50 m (150 feet).

(*c*) *Cree Valley*

Remnants of the 60 m (200 feet) platform recognized by Jardine (1959) as representing a former base-level of erosion are found near the northern edge of the memoir area, but elsewhere the valley of the River Cree and its tributaries has gentle to moderately steep and locally steep slopes. As a rule the micro-relief is uneven and the drift cover thin, with rock outcrops frequent locally. Thicker drift is found on smooth slopes and drumlinoid features, while mounds of moraine occur in the valley of the Penkiln Burn. Though the alluvium is narrow, on average about 300 m wide, it can be flanked by terraces and mounds of fluvioglacial gravels up to 1 km wide.

(*d*) *Fleet Valley*

The Fleet Valley tends to have moderately steep sides with only a thin drift cover, although less steep slopes and thicker drift occur in the tributary valley of the Skyre Burn and in the moraine fields near Dromore and south of Clanery Hill. Rock outcrops are locally common. Alluvial tracts within the area covered by this memoir are seldom more than 300 m wide but are often flanked by fluvioglacial and marine gravel terraces.

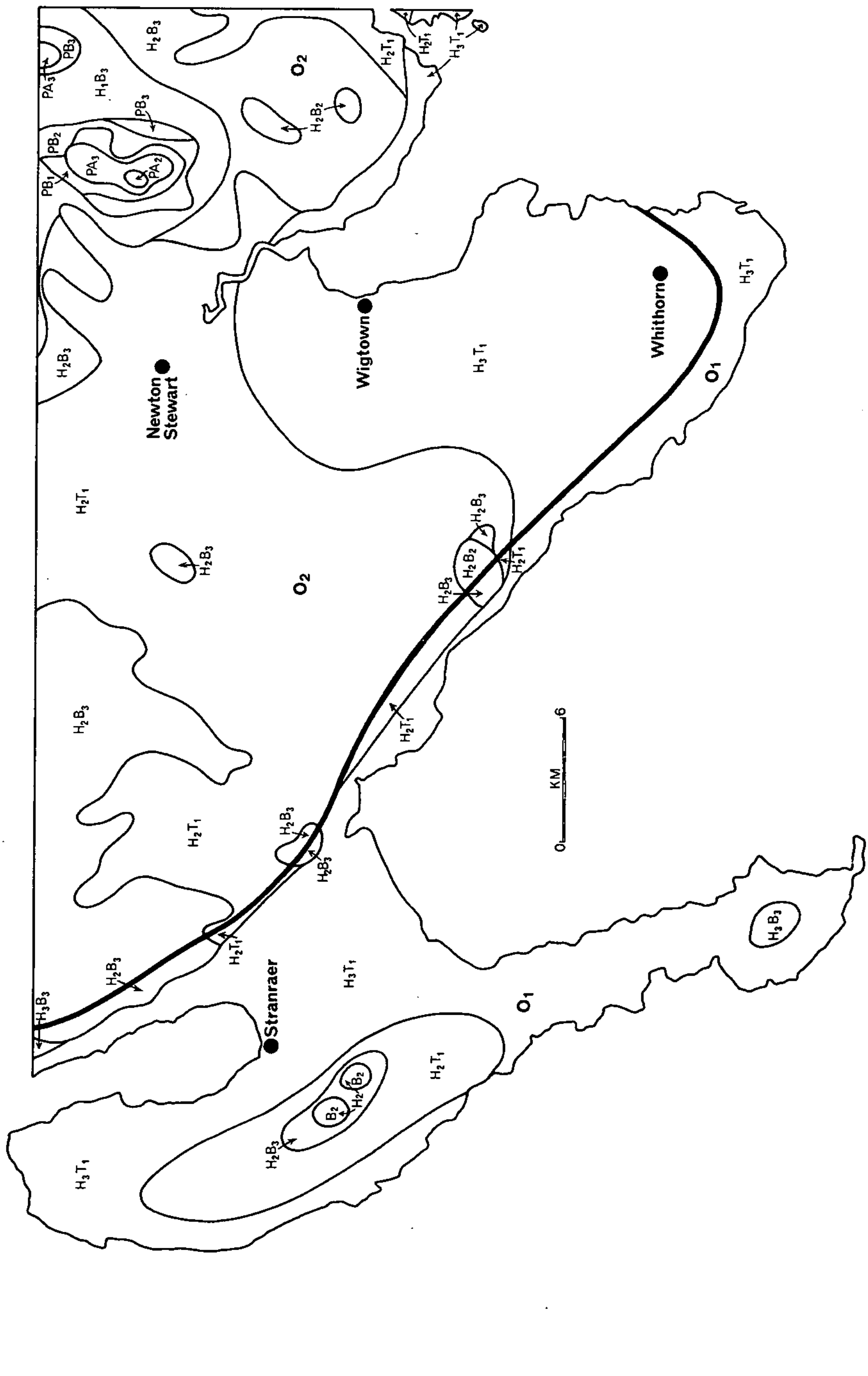
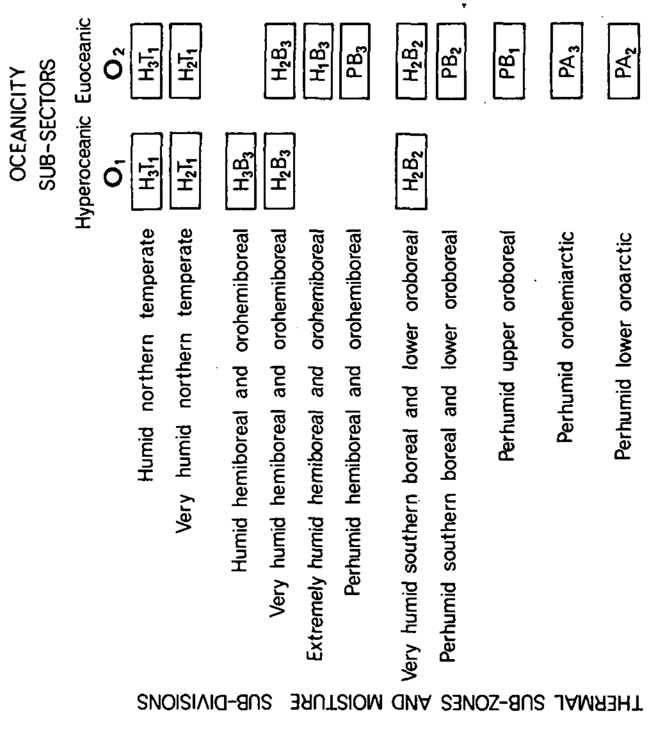


FIG. 5 The Bioclimatic Sub-regions *(see also page 13)*

2 | Climate

This chapter is based on the account in Bown (1973) of the climate in the adjacent Carrick district, supplemented by material from the Meteorological Office and other sources.

The area, lying close to the relatively warm waters of the North Channel and Irish Sea, has the windy oceanic climate characteristic of western Scotland, with the advantage of the rather warmer and drier conditions of lowland south-west Scotland on low ground. Figure 5 (from Birse, 1971) shows that the climate is less oceanic ($O_2 < O_1$) away from the south-west, and is cooler and wetter on the higher ground in the north and east.



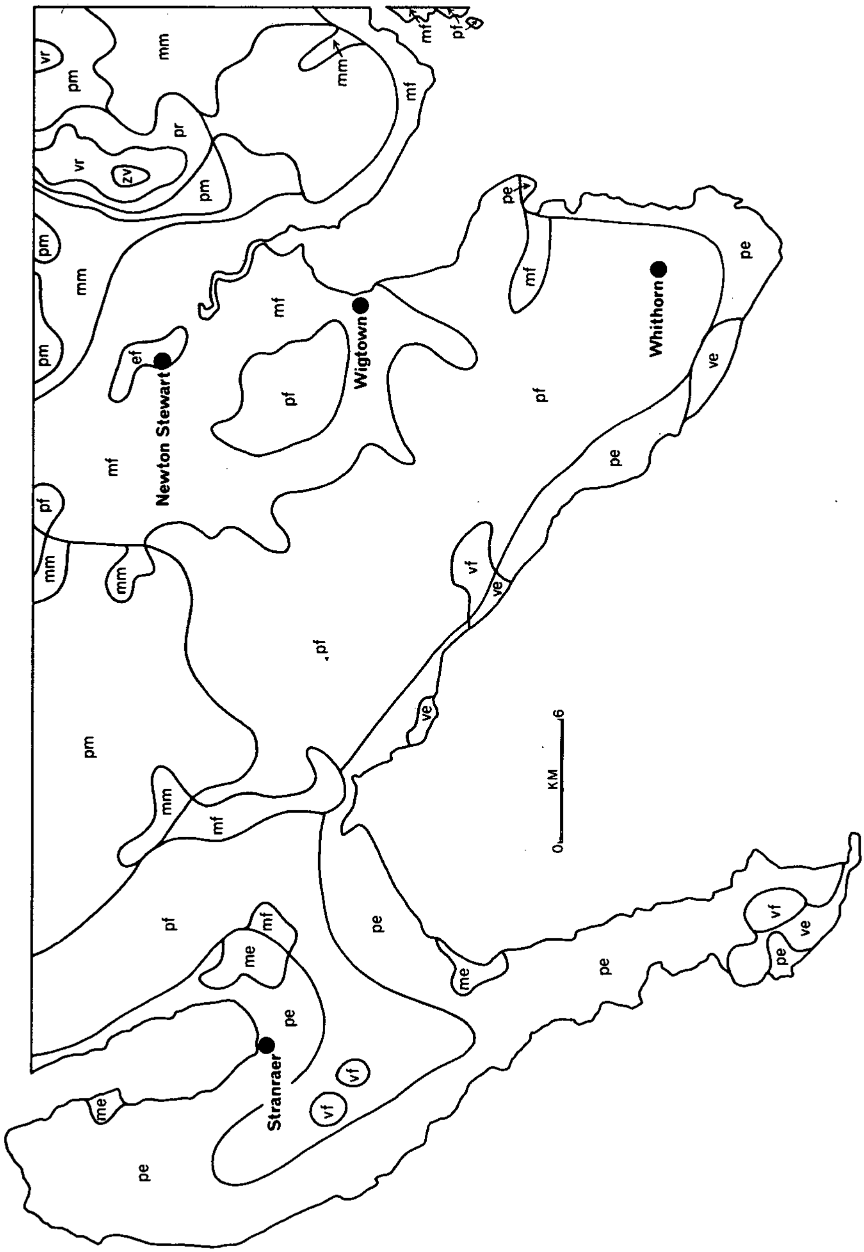


FIG. 6 Exposure and Accumulated Frost (*see also page 15*)

CLIMATIC TYPES

- ef — sheltered with fairly mild winters
- me — moderately exposed with extremely mild winters
- mf — moderately exposed with fairly mild winters
- mm — moderately exposed with moderate winters
- pe — exposed with extremely mild winters
- pf — exposed with fairly mild winters
- pm — exposed with moderate winters
- pr — exposed with rather severe winters
- ve — very exposed with extremely mild winters
- vf — very exposed with fairly mild winters
- vr — very exposed with rather severe winters
- zv — extremely exposed with very severe winters

Winds

The general wind regime is governed for the most part by the approach and passage of the North Atlantic depressions. The area generally falls within the main circulation of the major systems, except when the storm tracks are far to the north. An opposing synoptic pattern, with high pressure centred in northern latitudes, tends to recur during the first half of the year and can be persistent.

Some indication of the distribution and strength of winds on the highest ground of the area—the Cairnsmore of Fleet summit at 710 m (2329 feet)—is given by the anemometer at a similar elevation on Lowther Hill about 60 km to the north-east. The predominance of westerly winds over the year is very marked, with a total frequency of 57 percent, to which the winds of summer and autumn make the largest contribution. In spring, winds from all directions are well represented, and easterly winds are also quite frequent in winter. Wind strengths in spring and autumn are in the 'moderate to fresh' category of 6–11 m/s on about 45 percent of occasions, almost double the frequency of the strong winds of 11–17 m/s. In these seasons gales blow for 5·5–6 percent of the time, but in winter the gale frequency nearly doubles, reaching 9·5 percent, and there is a corresponding increase in the duration of strong winds.

At altitudes below about 600 m (2000 feet) the airflow is no longer unimpeded and two factors affect the velocity. In addition to the normal backing and reduction in speed with decreasing elevation considerable changes in both speed and direction are caused by the prevalence of large scale eddies where the relief is rugged.

Most of the country has little shelter from the prevailing winds. Figure 6 (from Birse and Robertson, 1970) shows that nearly all the western part of the area is in the *exposed* category, wind speeds averaging 4·4–6·2 m/s, whereas to the east the Cree, Bladnoch and Fleet Valleys are only *moderately exposed*, wind speeds averaging 2·6–4·4 m/s.

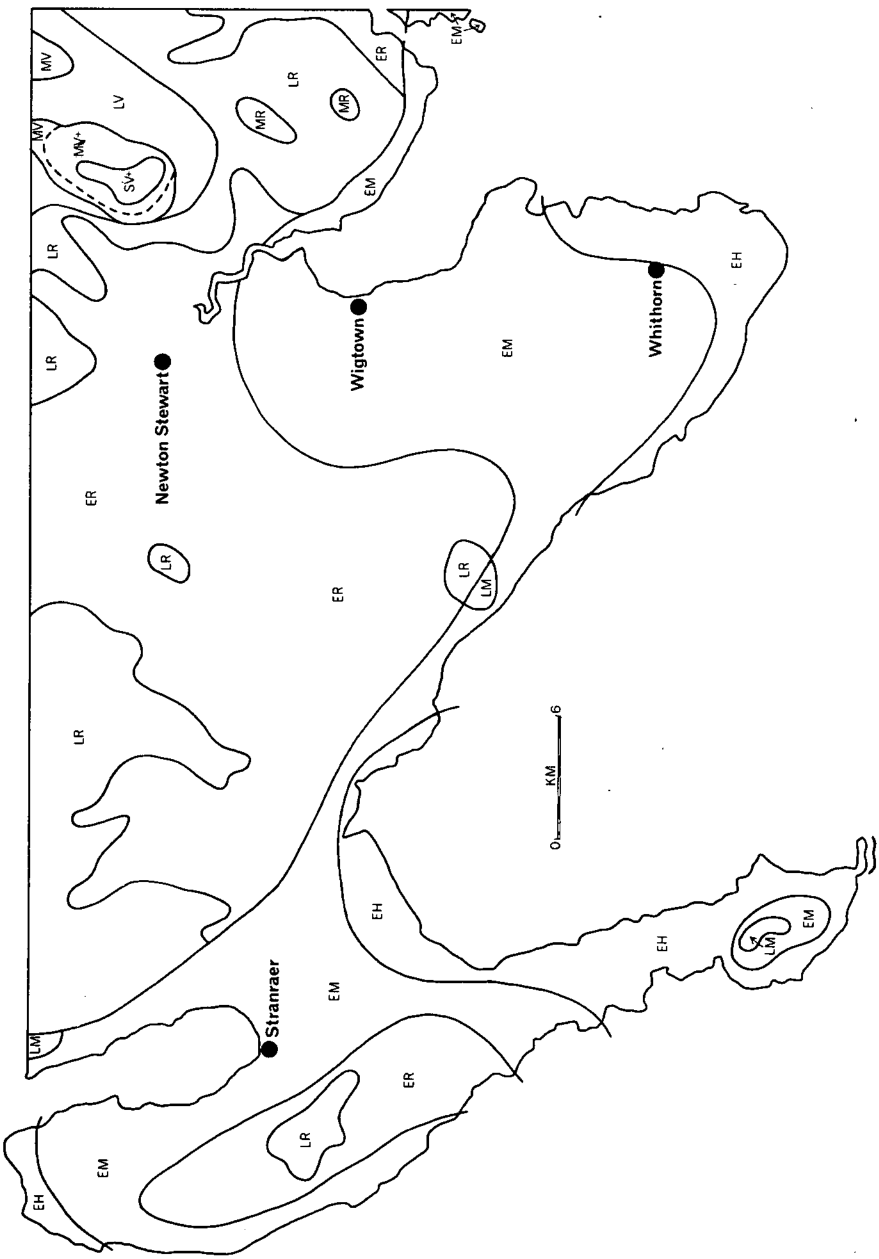


FIG. 7 Accumulated Temperature and Potential Water Deficit *(see also page 17)*

EH	Warm rather dry lowland.
EM	Warm moist lowland.
ER	Warm rather wet lowland.
LM	Fairly warm moist lowland and foothill.
LR	Fairly warm rather wet lowland and foothill.
LV	Fairly warm wet lowland and foothill.
MR	Cool rather wet lowland, foothill and upland.
MV / MV+	Cool wet foothill and upland.
SV+	Cold wet upland.

Rainfall

Smithson (1969) found that over 80 percent of the rainfall recorded at a number of stations in western Scotland came from synoptic categories of predominantly westerly origin—fronts, warm sectors and maritime polar airstreams. Orographic uplift generally increases the intensity and duration of this precipitation, so that the pattern shown in Figure 8 is to be expected. Rainfall rises from about 1000 mm along the southern coastline to some 1250 mm over the Cree–Luce Moors and to 1500–2500 mm over the Fleet Hills. The slow increase in rainfall over the Moors and Machars is correlated with the gradual rise in elevation northwards and the 1250 mm increase in precipitation parallels the abrupt rise from the Cree Valley to the summit of the Cairnsmore of Fleet.

Autumn and early winter is the wet time of the year, about 45 percent of the annual total precipitation falling during the four months October to January. February, with a reduction of nearly 50 percent on the January total, usually initiates a marked change in the rainfall pattern. Successive reductions are associated with the increased frequency of easterly winds in spring until May and June, normally somewhat wetter than the preceding months, signal the approach of the steady increase to the autumn/winter maximum. The summer increase in rainfall is in part attributable to the development of thunderstorms or areas of thundery rain in the high ground both locally and in the Southern Uplands generally.

The average monthly rainfall for a number of stations in the area is shown in Table A.

Table A. Average Monthly and Annual Rainfall in Millimetres—Period 1916–1950

Station and Elevation	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Year
Ardwell House 18 m	115·1	68·3	61·5	56·6	66·3	61·7	78·5	86·1	94·5	115·6	109·2	114·0	1027·4
Camrie Farm 107 m	142·5	88·6	80·8	70·6	80·8	74·4	97·5	107·7	119·4	142·5	136·1	142·5	1283·5
Castle Kennedy 26 m	132·6	81·3	75·4	65·8	75·4	71·9	90·9	100·6	111·3	132·8	125·7	132·6	1196·3
Craighlaw 91 m	149·9	92·2	82·0	71·6	80·5	72·9	97·5	109·2	119·6	144·3	137·9	143·0	1300·7
Culderry 8 m	123·4	72·1	66·8	59·4	67·8	61·5	82·8	90·2	94·5	120·0	111·5	111·5	1061·7
Dunragit Reservoir 104 m	127·5	77·2	71·6	62·5	71·6	67·1	86·4	96·8	103·4	126·2	120·7	126·2	1137·2

Galloway House 6 m	124·0	73·7	68·3	60·7	69·3	64·0	84·6	93·2	96·5	122·7	113·8	113·8	1084·6
Little Barraer 55 m	144·8	89·4	78·5	68·6	75·9	67·3	90·7	103·1	109·2	138·7	130·0	130·0	1226·3
Logan House 18 m	114·6	66·8	63·2	56·9	66·0	63·2	78·7	88·1	95·5	115·3	109·0	112·5	1030·0
Monreith 44 m	120·4	69·9	65·5	58·4	66·5	61·5	79·2	88·6	95·8	116·6	109·5	109·7	1041·7
Palnure 15 m	157·7	99·3	87·1	76·2	84·3	76·2	101·9	114·3	119·6	153·7	144·0	145·5	1359·9
Stranraer Filters 69 m	139·2	85·3	80·3	68·8	80·3	79·0	99·3	108·5	119·9	140·2	135·1	139·2	1275·1
West Freugh 16 m	114·6	69·1	62·0	55·9	64·0	59·9	77·2	85·3	93·2	113·5	107·4	112·5	1014·7

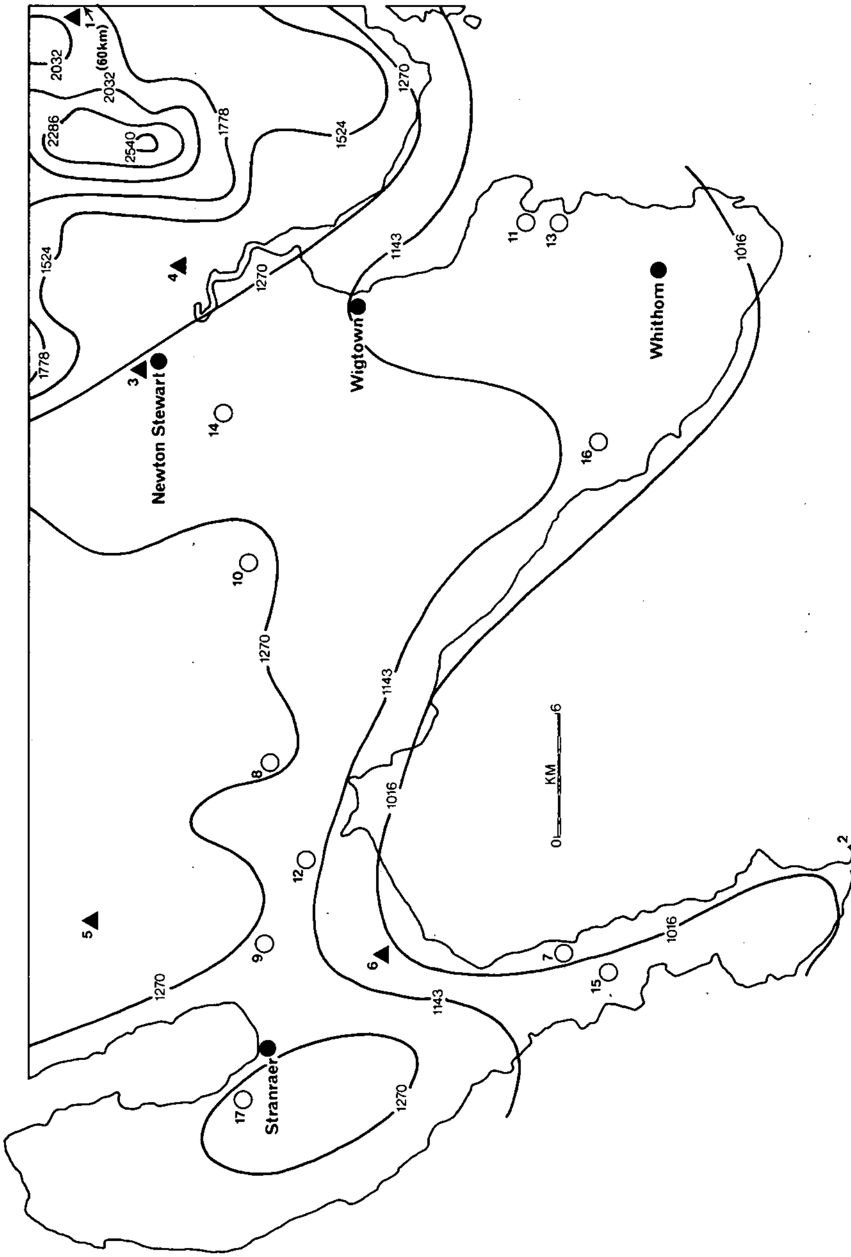


FIG. 8 Average Annual Rainfall in millimetres (1916–1950) *(see also page 21)*

REPORTING STATIONS

▲ CLIMATOLOGICAL AND TEMPERATURE STATIONS

1 Lowther Hill 723m
2 Mull of Galloway 78m
3 Newton Stewart 26m
4 Palnure 15m
5 Penwhirn 166m
6 West Freugh 15m

○ RAINFALL STATIONS

7 Ardwell House 18m
8 Camrie Farm 107m
9 Castle Kennedy 26m
10 Craighlaw 91m
11 Culderry 8m
12 Dunragit Reservoir 104m
13 Galloway House 6m
14 Little Barraer 55m
15 Logan House 18m
16 Monreith 44m
17 Stranraer Filters 69m

Snow

Altitude and distance from the sea strongly influence the occurrence of snow. Below 60 m (200 feet) in the Rhins and southern Machars Peninsulas there are fewer than 10 days with snow falling, rising to about 16 days at Penwhirn (Table B) and probably to over 60 days on the summit of the Cairnsmore of Fleet. Falls of snow tend to be large in amount, the source often being a polar depression moving south-east from north of Ireland, but at lower levels the thaw is rapid. The more snowy winters of central and eastern Scotland affect Galloway in exceptional years, such as those of 1939–40, 1946–47 and early 1963.

Temperature

Birse and Dry (1970) and Birse and Robertson (1970), in assessments of climatic conditions in Scotland, have classed most of the area as *warm* (>1375 day-degrees C of accumulated temperature) *lowland* with *extremely mild* or *fairly mild winters* (Figs. 6 and 7). The Cree–Luce Moors and the Eastern Foothills are *fairly warm* (1100–1375 day-degrees C accumulated temperature) with *moderate winters* (50–110 day-degrees C accumulated frost) and the highest ground is *cool* or *cold* (550–1100 day-degrees C accumulated temperature) with *rather severe winters* (110–230 day-degrees C accumulated frost).

Figure 9 compares temperatures for the oceanic station at Mull of Galloway with those for the less oceanic Newton Stewart, the range of average mean temperature increasing from 9·7°C at the coastal station to 11·8°C. The milder winter, cooler summer and lower diurnal temperature amplitude at the Mull of Galloway are clearly shown. Most inland areas have the advantage of warmer summer days up to elevations

Table B. Climatological Summaries
Average Number of Days of Specified Occurrences
Periods as Indicated

	Lowther Hill (4—5 years)					
	S	H	T	F	AF	G
Jan	12·8	0·4	0·2	19·4	27·8	11·4
Feb	8·2	0·8	0	17·4	24·5	9·4
Mar	9·6	1·0	0	20·2	24·5	9·0
Apr	6·4	1·4	0·2	17·2	12·8	7·0
May	3·4	1·2	1·0	13·2	5·8	8·2
Jun	0·5	0	0·8	13·0	1·2	4·8
Jul	0	0	1·5	16·0	0	5·5
Aug	0·2	0	0·5	20·0	0	6·0
Sep	0	0·5	0·8	18·7	0·6	7·8
Oct	3·3	0·8	1·0	22·8	4·8	9·5
Nov	6·7	0·2	0·2	21·0	16·4	9·3
Dec	13·0	0·5	0	19·3	28·2	10·8
Year	64·1	6·8	6·2	218*	147*	98·7

	Newton Stewart (1964—1968)								
	R	W	S	SL	H	T	F	AF	G
Jan	18	14	2·0	1·2	0·8	0·2	0·8	11	0·6
Feb	15	11	3·0	0·8	0·6	0	0·2	10	0
Mar	19	13	2·8	2·2	0·4	0·2	0·6	5	0
Apr	16	13	1·2	0·4	0·4	0	0	4	0·2
May	18	15	0·4	0	0	0·4	0·2	1	0
Jun	16	12	0	0	0	0·4	0	0	0
Jul	15	11	0	0	0	0·4	0·2	0	0
Aug	17	12	0	0	0	1·0	0	0	0
Sep	16	15	0	0	0	0·4	0·2	0	0·2
Oct	20	16	0	0	0·2	0·6	0·8	1	0·2
Nov	17	15	2·2	1·0	0·6	0·2	0·2	8	0·4
Dec	22	18	2·0	0·2	0·6	0·2	0	19	0·4
Year	209	165	13·6	5·8	3·6	4·0	3·2	59	2·0

	Palnure (1958–1968)								
	R	W	S	SL	H	T	F	AF	G
Jan	17	14	2·7	2·6	1·1	0·3	0·7	17	0·6
Feb	15	12	3·5	1·9	0·2	0	0·3	13	0·4
Mar	17	14	2·7	1·5	0·5	0	0·6	9	0·5
Apr	17	14	0·8	0·4	0·4	0·1	0·2	7	0·5
May	16	13	0·1	0	0·2	0·9	0	2	0·3
Jun	16	12	0	0	0	0·4	0·1	0	0·3
Jul	16	13	0	0	0	0·4	0·3	0	0
Aug	17	14	0	0	0·1	1·1	0·3	0	0·3
Sep	17	15	0	0	0	0·5	0·4	0	0·5
Oct	19	16	0	0	0·4	0·5	0·9	1	0·5
Nov	19	16	1·0	0·7	0·5	0·4	0·5	9	1·0
Dec	18	17	1·9	1·0	0·6	0·1	0·5	14	1·5
Year	204	170	12·7	8·1	4·0	4·7	4·8	72	6·4

	Penwhirn (1958–1968)									
	R	W	S	SL	H	T	F	AF	GF	G
Jan	17	15	3·6	4·9	1·0	0·4	3·0	16	19	2·3
Feb	14	13	3·4	4·6	1·5	0·1	2·5	14	15	1·8
Mar	18	15	3·0	3·5	1·0	0·2	2·5	10	13	1·3
Apr	17	15	0·9	0·5	0·5	0	1·5	6	9	0·6
May	16	13	0	0	0·1	1·5	0·8	1	4	0·5
Jun	15	12	0	0	0	0·6	0·9	0	1	0·3
Jul	15	13	0	0	0·1	0·9	1·1	0	0	0·5
Aug	17	15	0	0	0	0·9	0·9	0	1	0·3
Sep	17	15	0	0	0	0·6	1·4	0	1	0·5
Oct	19	16	0·1	0	0·5	0·7	1·5	0	5	1·4
Nov	19	17	1·7	0·7	1·2	0·2	1·7	7	11	1·3
Dec	20	18	2·8	1·9	0·7	0·8	2·3	12	16	1·9
Year	204	177	15·5	16·1	6·6	6·9	20·1	66	95	12·7

Table B. Climatological Summaries (*contd.*)

	West Freugh (1960–1968)		
	R	W	AF
Jan	16	12	12
Feb	14	11	12
Mar	16	12	6
Apr	16	12	4
May	16	12	1
Jun	15	10	0
Jul	15	10	0
Aug	17	12	0
Sep	18	15	0
Oct	19	14	1
Nov	19	15	7
Dec	19	15	11
Year	200	150	54

Key

R Rain Day (0·25 mm or more)
W Wet Day (0·10 mm or more)
S Snow falling
SL Snow lying at 09 h
H Hail
T Thunder
F Fog
AF Air frost
GF Ground frost
G Gale
* rounded off to whole number

of about 150 m (500 feet), extending probably to higher altitudes in the glens and folds of the more rugged country east of the River Cree.

The bleaker climate characteristic of higher altitudes is typified by the temperature observations at Penwhirn (Table C). In summer this station has daily maxima little higher than those at the Mull of Galloway, and winter is colder here than at Newton Stewart.

There is in general a steady fall in temperature with increasing elevation, the lapse rate of 0·65°C per 100 m used by Birse and Robertson (1970) probably corresponding closely to actuality. When this rate is applied to the Penwhirn data the calculated and observed values of mean monthly temperature at Lowther Hill differ by an average of only 0·3°C. As the topographic position and elevation (*ca.* 700 m, 2300 feet) of Lowther Hill and the Cairnsmore of Fleet are similar, the Lowther Hill data are probably a reliable guide to temperatures on the Cairnsmore summit. Thus mean monthly temperatures are likely to be at freezing point or below for four months of the year (Fig. 9). Freezing temperatures at these heights, virtually in the free atmosphere, are not greatly dependent on light winds and clear skies, and freezing winds with cloud cover on the mountains are sometimes responsible for heavy rime and ice deposits.

**Table C. Mean and Extreme Daily Temperatures—
Estimated Values for Periods Indicated**

	Lowther Hill 1959–1965			Mull of Galloway 1958–71			Newton Stewart 1964–1971		
	°C Max.	°C Min.	°C Mean	°C Max.	°C Min.	°C Mean	°C Max.	°C Min.	°C Mean
Jan	0·9	−3·0	−1·1	6·4	3·3	4·9	6·1	0·7	3·4
Feb	0·8	−3·4	−1·3	6·5	3·2	4·9	7·0	1·1	4·1
Mar	2·4	−2·4	0·0	8·7	3·5	6·1	9·4	2·1	5·7
Apr	6·1	0·0	3·1	10·3	4·9	7·6	12·1	4·0	8·1
May	9·3	2·4	5·9	13·6	7·0	10·3	15·6	6·3	10·9
Jun	12·0	5·3	8·7	16·0	9·7	12·9	18·2	9·5	13·9
Jul	11·7	6·0	8·9	17·2	11·7	14·5	19·3	11·1	15·2
Aug	12·2	6·6	9·4	17·4	11·7	14·5	19·2	10·4	14·8
Sep	10·8	5·5	8·1	15·4	10·8	13·1	16·7	8·9	12·8
Oct	7·7	2·9	5·3	12·3	8·6	10·5	12·9	6·6	9·7
Nov	4·1	−0·1	2·0	9·9	6·4	8·1	9·7	3·6	6·7
Dec	1·3	−2·9	−0·8	8·0	5·0	6·5	7·4	2·1	4·7
Year	6·6	1·4	4·0	11·8	7·3	9·5	12·8	5·5	9·2

	Palnure 1964–1971			Penwhirn 1958–1968			West Freugh 1960–1971		
	°C Max.	°C Min.	°C Mean	°C Max.	°C Min.	°C Mean	°C Max.	°C Min.	°C Mean
Jan	6·3	0·2	3·3	5·4	0·1	2·7	6·6	1·2	3·9
Feb	7·0	0·6	3·8	5·9	0·5	3·2	7·0	1·4	4·2
Mar	9·2	1·6	5·4	7·7	1·6	4·7	9·1	1·5	5·3
Apr	11·6	3·3	7·5	10·4	3·3	6·9	11·0	3·7	7·3
May	15·0	5·7	10·3	14·1	5·7	9·9	14·4	5·8	10·1
Jun	17·4	8·8	13·1	16·4	9·0	12·7	16·5	9·1	12·8
Jul	18·4	10·6	14·5	17·4	10·9	14·1	17·8	10·9	14·3
Aug	18·5	10·2	14·3	17·0	10·5	13·7	17·7	10·4	14·1
Sep	16·2	8·1	12·1	14·8	8·6	11·7	15·8	9·3	12·5
Oct	12·7	5·7	9·2	11·6	5·9	8·7	12·8	6·8	9·8
Nov	9·7	3·2	6·5	8·7	3·1	5·9	9·9	4·2	7·1
Dec	7·5	1·7	4·6	6·7	1·5	4·1	8·0	3·1	5·5
Year	12·5	5·0	8·7	11·3	5·1	8·2	12·2	5·6	8·9

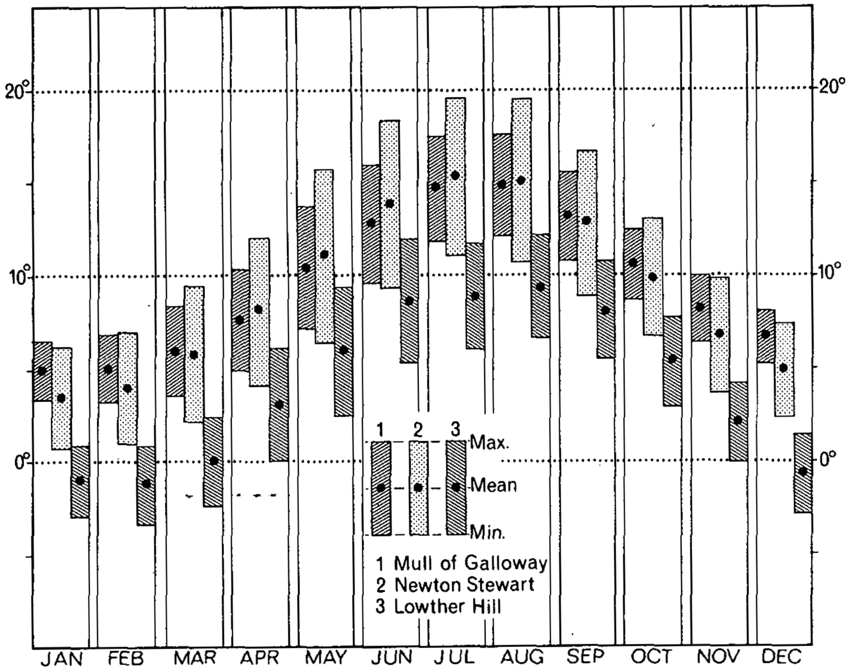


FIG. 9 Temperature Histograms—Degrees Celsius

The Growing Season

The Mull of Galloway in the extreme south-west of the area has a growing season (usually defined as that period of the year during which the daily mean temperature is 5·6°C or above) of about 300 days, from early March to the end of the year. Few places on the Scottish mainland can claim such a favourable growing season. West Freugh, in the Stranraer Lowlands, has the rather shorter season of about 270 days from mid-March to mid-December.

Away from the south-west the climate becomes less oceanic and consequently the growing season shortens. Newton Stewart and Palnure in the lower Cree Valley are at a similar elevation to West Freugh but have a growing season about 10 days shorter, from mid-March until the end of November. The length of the season decreases with increasing elevation. At Penwhirn (166 m, 545 feet) it is about 240 days, from the end of March until mid-November, while on the summit of the Cairnsmore of Fleet at 710 m (2329 feet) it is probably only about 150 days, from mid-May until early October.

Evapotranspiration

Incoming rainfall is balanced by run-off, evaporation and transpiration. During the months April to September when evapotranspiration exceeds

Table D. Average Values of Potential Transpiration—Millimetres

County	Area	Apr	May	Jun	Jul	Aug	Sep	Summer	Winter	Year
Wigtown	Coastal*	58	85	95	88	75	51	452	95	547
	At 75 m†‡	56	81	86	79	64	41	407	67	474
Kirkcudbright	Coastal*	57	85	95	88	74	48	447	85	532
	At 135 m†	51	80	86	79	61	42	399	62	461
	At 190 m‡	49	79	84	74	60	40	386	56	442
	At 365 m O.D.	43	72	78	71	53	31	348	43	391

* Within approximately 8 km of the coast
† Average county elevation below 305 m
‡ Average county elevation

rainfall most of the area has a potential water deficit, as shown on Fig. 7 (from Birse and Dry, 1970). The driest areas are those close to the southern coastline and on the northern tip of the Rhins Peninsula, where the potential water deficit is 50–70 mm. The deficit is less to the north and north-east, and is negligible on the Cree–Luce Moors and on the hills east of the River Cree.

Reinforcing the increasing rainfall, the decline in potential evapotranspiration with rising elevation, and from Wigtownshire to Kirkcudbrightshire, helps to lower the potential water deficit; this is shown in estimated values given in Table D (Ministry of Agriculture, Fisheries and Food, 1967). The values at average county height below 300 m (1000 feet) give an estimate of potential evapotranspiration for the mean height of most arable farmland.

Hail and Thunder

Table B shows that hail is a seasonal phenomenon, confined almost entirely to the months October to May, and usually reaching a maximum in mid winter. Winter storms develop in polar air masses over the relatively warm sea and die out on moving inland, as evidenced by a comparison of the records for incidence of hail at Penwhirn, near the west coast, and the Lowther Hill observations. Hail in springtime develops from convection currents over land heated by the insolation.

Thunder is infrequent in winter and spring (Table B), its onset coinciding with the end of the hail season in May. Summer storms arise mainly by convection, heating of the land surface providing the energy, and the decline in the incidence of thunder after October can probably be ascribed to the rapidly falling heat input. Winter storms are often of frontal origin, but near the west coast, as suggested by the higher frequencies at Penwhirn, another contributor is the brief, heavy thunder shower resulting from surface heating of maritime polar airstreams by the warmer sea (Smithson, 1969).

Fog, Cloud and Humidity

Radiation fogs in the lower lying areas are infrequent in the colder half of the year, partly because there is little or no industrial pollution to contribute to their development or encourage their persistence. In early summer particularly, sea fog formed by warm moist air cooled by the sea sometimes drifts over the land but seldom penetrates far inland.

Much more prevalent than fog is cloud cover, either an expanse of thick low cloud, with or without rain or drizzle, which envelops the higher ground and is usually associated with a mild south-westerly airstream, or cloud patches formed on the windward side of higher ground by the forced ascent of moderately humid air. The highest ground in the area is probably cloud-covered on over 200 mornings annually (Table B: Lowther Hill data). Except perhaps in mid winter, the cloud usually breaks up, with the cloudbase lifting to clear the hill-tops as the day advances.

Table E. Short Period Mean Sunshine Values—Hours

Station	Period (years)	Elevation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
West Freugh	14	15 m	45	70	109	163	215	193	174	160	127	79	54	39	1428
Penwhirn	14	166 m	38	61	97	148	193	182	153	143	107	66	47	32	1267
Lowther Hill	9*–10	723 m	27*	49*	61*	110	154	145	118	98	88	53	34	20	957

Consideration of the oceanic climate with its prevailing moist winds suggests that the area has a fairly high average relative humidity. Humidity decreases in the north-east of the area where the climate is less oceanic, and is lowest in spring and early summer when the drier east winds are more frequent. Maps of average relative humidity (Meteorological Office, 1952) recorded during early afternoon, when values are normally at their lowest, show that in the Rhins Peninsula humidity is over 75 percent, except in June when it falls to 70–75 percent. In this month, the least humid for the area, values fall to 65–70 percent in the country around and to the east of the Cree Valley. From spring to autumn even lower humidities are found in sheltered areas, sometimes as a consequence of local and transient foehn winds. Humidity rises sharply in July and by October only the country east of the Cree Valley has average values below 75 percent. A maximum is reached in December and January when humidities of 80–85 percent are general.

Sunshine

The area is one of the sunniest in Scotland, the average daily duration of bright sunshine being 3·5–4 hours—over 30 percent of the maximum possible (Meteorological Office, 1952). Coastal areas have the most sunshine. The amount falls inland as elevations rise, a decline shown by the data presented in Table E from which it is also seen that May and June are the sunniest months.

3 | Parent Materials

INTRODUCTION: GEOLOGY

All the consolidated sedimentary rocks and their associated igneous intrusions occurring in the area belong to the Palaeozoic era, and the unconsolidated deposits of Pleistocene and Recent times have been derived almost entirely from them.

The geological formations listed below are based mainly on those given on Sheets 1, 2, 3 and 4 of the Geological Survey of Scotland.

Table F. ***Geological Formations***

(a) Unconsolidated formations		
Recent and Pleistocene		Alluvium Blown Sand Peat Estuarine and marine raised beach deposits Fluvioglacial sands and gravels Soliflucted drifts Moraine and till
(b) Consolidated formations		
Permian or late Carboniferous		Breccias and red sandstones
Carboniferous	Namurian	Sandstones, shales and basaltic lava
Old Red Sandstone		Granites, porphyrites, diorites
Silurian	Wenlockian Valentian Llandoverian	Greywackes and shales
Ordovician	Ashgillian Caradocian	Greywackes, shales conglomerates and cherts

Brief accounts of these formations are given below, in order of decreasing age. The areas in which the consolidated formations occur are shown in Fig. 10.

Ordovician and Silurian

Ordovician and Silurian rocks are the oldest and by far the most extensive in the area. They consist mainly of grey greywackes and shales with some conglomerates although cherts and black shales also occur. Walton (1955), following Pettijohn (1949), considers a typical greywacke to be a hard, poorly sorted, usually grey sandstone having as its principal constituents quartz, feldspar and rock fragments set in a fine matrix of clay, chloritic or micaceous material. The ancient rocks from which the greywackes and other sediments are derived were physically rather than

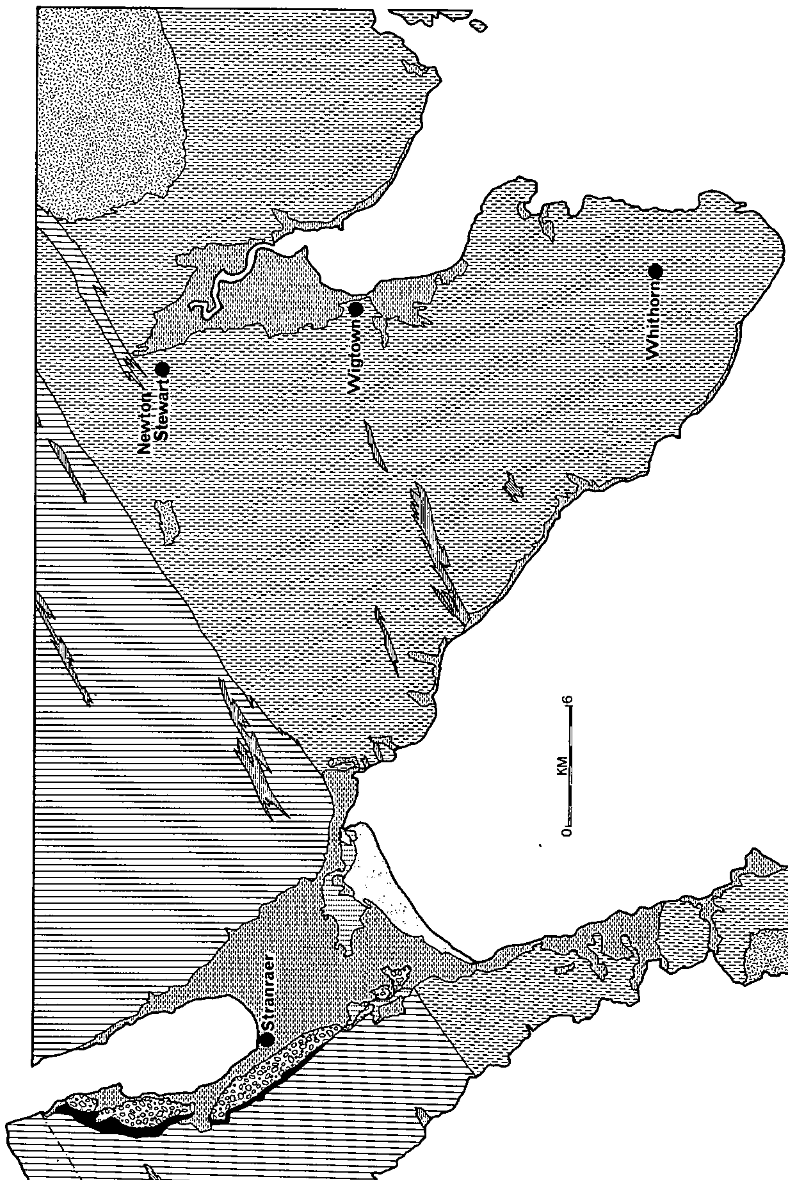
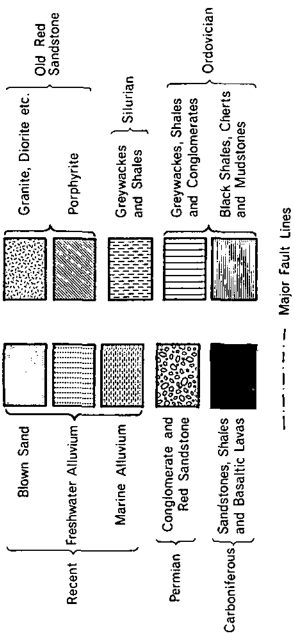


FIG. 10 Geological Map (*see also page 33*)



chemically weathered and were deposited rapidly in a marine environment; thus mineralogical similarities are found in the pre-existing rocks and their derived sediments.

The sediments were laid down as horizontal or gently inclined beds but at the close of Silurian times were subjected to intense lateral pressure which folded the strata into complex structures, further modified by later movements. Walton (1965) has described the overall folding as a series of major monoclines facing north-westwards and the beds do tend to be younger in that direction. Counteracting this effect are major strikefaults which throw predominantly to the south, bringing older strata to the surface again to the north of each fault.

ORDOVICIAN

The Ordovician rocks are mainly greywackes with some shales; Kelling (1961, 1962) has described in some detail those in the Rhins Peninsula where he separated three rock groups, the Corsewall, Kirkcolm and Portpatrick. The age of these rocks has been given as Caradocian, although the Corsewall group may be older and the upper beds of the Portpatrick group as young as Lower Valentian, i.e. of Silurian age (Walton, 1963). The Corsewall and Kirkcolm rocks are separated by the Southern Uplands Fault.

Kelling (1961, 1962) recognized two divisions of the Corsewall rocks: a lower division of flaggy beds and an upper (conglomeratic) division. The modal composition of these rocks proved somewhat basic in character with an igneous index, i.e. the ratio of acid to basic fragments, of 1·05. Peach and Horne (1899) found the largest and most abundant blocks in the conglomerate to be composed of fragments of acid granitoid rocks and pebbles of intrusive basic material similar to the igneous rocks of the Ballantrae volcanic region.

Kelling (1961, 1962) described the rocks of the Kirkcolm group as greywackes with some siltstone, mudstone and black shale, the greywackes being usually coarse- to medium-grained and micaceous. Quartz and siliceous fragments predominate and pyroxene and hornblende are absent; igneous indices ranged from 1·06 to 2·40.

The Portpatrick group Kelling found to be composed of coarse- to medium-grained greywackes with thin partings of fissile siltstones and mudstones. The greywackes are dominated by basic minerals in the upper part of the formation, (igneous index 0·54) and by acid fragments in the lower part (igneous index 2·76).

The Corsewall conglomerate does not outcrop in the Ordovician strata to the east of Loch Ryan where, especially around Camrie and Carscreugh Fells, the rocks are mainly greywackes and shales with some cherts and black shales in lenticular bands.

SILURIAN

Rocks of Valentian age are predominant in the areas of Silurian strata shown in Fig. 10 where they are mainly greywackes with shales and other fine-grained sediments locally common.

In the Glenluce district Gordon (1962) distinguished older Kilfillan rocks adjacent to the Ordovician outcrop and younger Garheugh rocks to the south-east. The Kilfillan greywackes have abundant spilite and andesite fragments, while the Garheugh beds are lithologically similar to those of the Ordovician Kirkcolm rocks (Walton, 1963).

To the south-east of Mochrum Fell the Garheugh beds give way in the area around Whithorn to rocks of the Hawick group described by Rust (1965a and b) as greywackes and red and greenish argillites, the greywackes being of finer grain than the rocks of the Garheugh group to the north-west. Hawick rocks also border Fleet Bay and they are found on the headland of the Mull of Galloway, but at the tip of the Machars Peninsula at Burrow Head they give way to Wenlockian greywackes, siltstones and shales, sediments which can be distinguished from the Hawick rocks by the absence of red mica (Rust, 1965b).

Old Red Sandstone

Considerable igneous activity took place in Lower Old Red Sandstone times. The Cairnsmore of Fleet granite is the most extensive of a number of igneous masses (Fig. 10) which, together with numerous dykes, are briefly described below.

The Cairnsmore of Fleet granite is coarse-grained and grey in colour.

Gardiner and Reynolds (1937) studied this intrusion and its metaphoric aureole and distinguished a large central mass of muscovite-biotite-granite and a discontinuous outer edge of biotite-granite. Analyses of the rock types (op. cit.), reproduced in Appendix V, show that the central granite has 73 percent silica and the biotite-granite 71 percent. The analyses also show that while the potassium content is fairly high, the calcium and magnesium contents are low. The surrounding Silurian rocks (mainly greywackes) have been thermally metamorphosed, often to andalusite schist as found near Dromore and on Culronchie Hill.

Peach and Horne (1899) classed the 'granite' masses near Kirkcowan and Glenluce as diorites, ranging from quartz-diorite (i.e. tonalite) to augite-diorite. The Portencorkrie complex near the Mull of Galloway has been described (Holgate, 1943) as a central dome of acid igneous rock surrounded by less acid pyroxene and hornblende mica-diorites. The high ground surrounding the complex is composed of metamorphosed Silurian sediments. Analyses (op. cit.) given in Appendix V show the central igneous rock as having 68 percent silica and a typical diorite 58 percent.

In a review, Greig (1971) has described the numerous dykes which cut the Ordovician and Silurian rocks in the area; the majority tend to crop out parallel to strike of the country rocks and are porphyritic in texture. Typically, phenocrysts of plagioclase, hornblende and biotite are found in a compact ground-mass of the same minerals associated with quartz and alkali feldspar. Other rock types include diorites, lamprophyres and, near Creetown, granodiorite and granite.

Carboniferous and Permian

A narrow outcrop of Carboniferous rocks west of Loch Ryan is composed of micaceous sandstones, fireclays, shales, clays and decomposed basalt all of which are soft and weakly resistant to weathering (Fuller, 1958).

A band of red breccias with seams of sandstone (Fig. 10: Permian rocks) crops out adjacent to the Carboniferous rocks described above, the breccias being composed almost entirely of greywacke fragments derived from adjacent Lower Palaeozoic rocks. These breccias and sandstones may be of Upper Carboniferous age but are hereafter termed Permian rocks to avoid confusion with the Carboniferous sediments described in the previous paragraph.

Gravity survey indicates the presence of a buried elongated basin containing Permian rocks beneath Loch Ryan and extending to below Luce Bay (Mansfield and Kennet, 1963). Rust (1965b) believes that Permian rocks (formerly more extensive) may also underlie Wigtown Bay; this hypothesis was advanced as an explanation of secondary iron staining of the Silurian rocks bordering the bay. The configuration of Permian basins in south-west Scotland may be controlled by north-west to south-east tectonic hinges, and the parallel trend of Wigtown Bay suggests the presence of a similar basin.

Pleistocene and Recent

During the period of maximum glaciation the Southern Uplands were completely submerged beneath exceedingly thick ice sheets (Greig, 1971). The Loch Doon basin was the main centre of ice accumulation in southern Scotland, although a simple radial flow was prevented by the Highland ice which lay to the north and west (Sissons, 1965). The general direction of the major ice movements can be induced from the distribution of erratics and marine shells and the alignments of roches moutonnées, glacial striae, drumlins and drumlinoid features (Fig. 11). In the area surveyed ice movements probably varied from south-westerly in the southern Machars Peninsula to south-south-westerly in the remainder of the Moors and Machars districts and to southerly in the Rhins Peninsula. Erratics from Ayrshire and Ailsa Craig, and Cretaceous flints from the Firth of Clyde have been found in the till in the Rhins Peninsula (Charlesworth, 1926). This is evidence of a deflection of the north-west-moving Loch Doon ice south-westwards along the Firth of Clyde.

The ice sheets had great erosive power, as evidenced by the abundance of rock outcrops especially on higher ground where the drift cover is frequently less than half a metre thick. The rugged nature of many of the hills appears to have been caused by a combination of the plucking of rock blocks by ice and the differential erosion of soft and hard strata. Although the glacial drift is thicker on the lower ground, the frequency of areas where rock outcrops and where drift is thin, show that the erosive power of the ice must still have been considerable.

Remnants of the regolith that existed before the onset of the last glacial period must have been severely eroded or completely removed and the material incorporated in the glacial drifts. The pre-Pleistocene regolith was probably formed of deeply weathered rock, remnants of which are common in north-east Scotland (Fitzpatrick, 1963) and are also found in the Carrick area (Bown, 1973). The deep weathering is most often observed in coarse-grained rocks, e.g. granites, and was probably caused by exposure to a climate different from that now prevailing.

The drift deposited below actively moving ice—lodgement till—is a compact unsorted material, full of subangular stones, and usually becomes finer in texture with increasing distance from the source of the ice sheet. As would be expected, the nature of the till is dependent on the types of rock over which the ice moved. Thick deposits found in drumlinoid country in the Rhins and southern Machars Peninsulas are composed of a till similar to that of the drumlins between Glenluce and Newton Stewart (landform region 3c, Fig. 3). These latter drumlins are aligned with their long axis parallel to the direction of ice flow, usually with the steeper stoss end facing the direction from which the ice came. The mode of formation of drumlin landscapes is uncertain. Charlesworth (1957) reviewed the evidence relating to the origin of drumlins and suggests that they are an expression of the equilibrium between the erosive action of the ice and the opposing forces of the solidity and

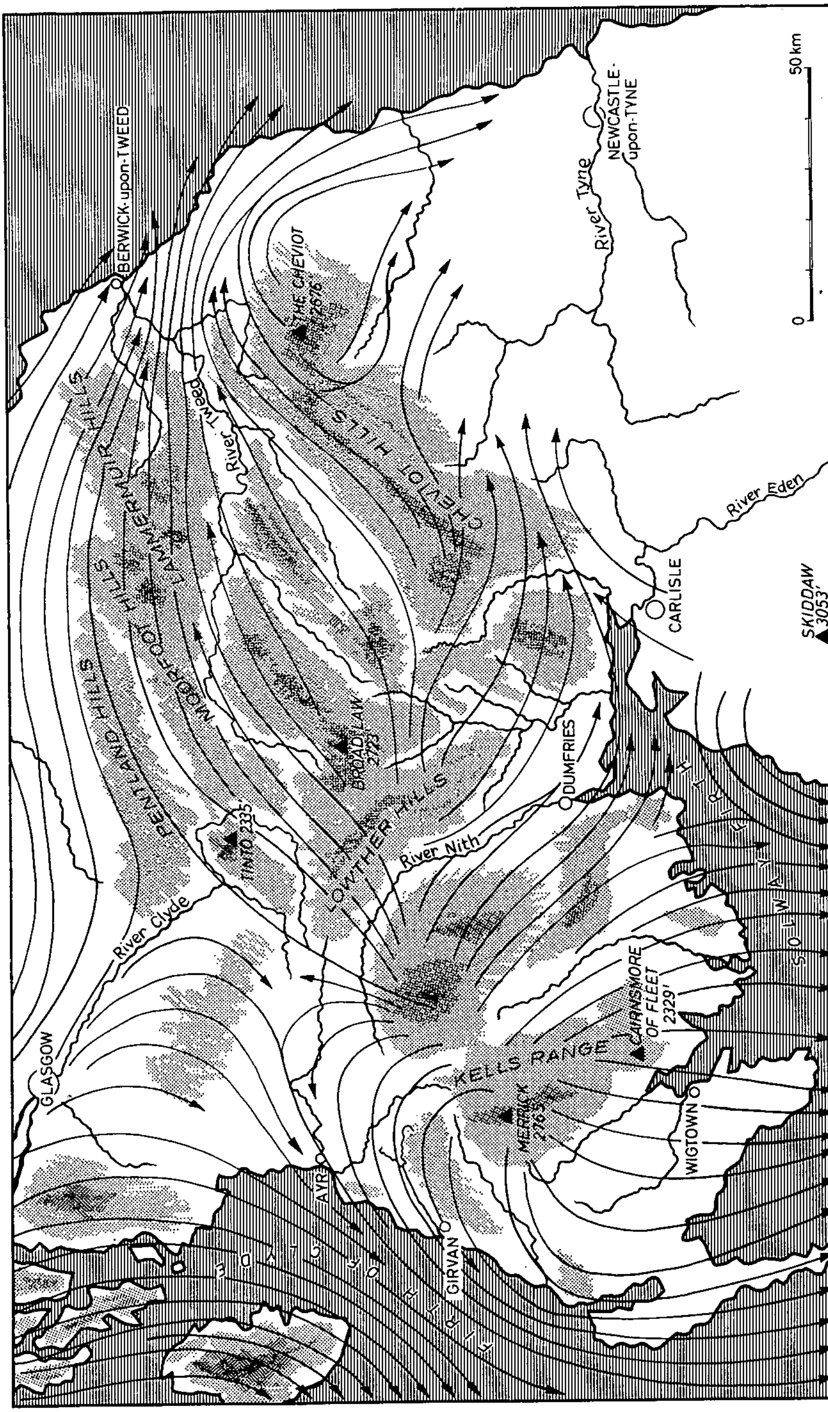


FIG. 11 Generalized Directions of Ice Movements in South Scotland

cohesion of the material; the 'plastering on' and 'rubbing down' processes took place simultaneously or in rhythmic alteration, and the accumulations of till were moulded into drumlins which were limited in their height and other dimensions by the erosive power of the ice. Evidence of erosion is given by ice-scoured, bare rock outcrops between the drumlins.

The wastage of the last ice sheet in Scotland was probably complete by about 12,500 years ago; there are no adequate grounds for asserting that the decay was interrupted by a significant readvance, but there is satisfactory evidence of a subsequent 'Loch Lomond' readvance (Sissons, 1974). The moraines in the upper Fleet Valley, moundy deposits comprising mainly unsorted and coarse-textured material, may be associated with this readvance and subsequent deglaciation.

Water from the melting ice deposited fluvioglacial sands and gravels. Moundy forms characterize deposits accumulated beneath, within, and on the ice, while flat or gently sloping spreads and terraces typify those laid down against and beyond the ice margin (Sissons, 1967). Many examples of both forms occur in the area. The origin of the extensive terraces and mounds at higher levels in the Stranraer Isthmus is uncertain but could be fluvioglacial rather than marine; it is possible that those below about 20 m (70 feet) are beaches of Late Glacial age, but the evidence is not convincing (Sissons, op. cit.). Meltwater has partially sorted the upper layers of till in the Rhins Peninsula and, to a lesser extent, elsewhere; as would be expected, the effect of this is most commonly seen on low ground and on the lower rather than the upper slopes of drumlinoid features.

Towards the end of Pleistocene times the higher hill summits and slopes of the eastern Southern Uplands must have been largely snow-free for long periods and subject to annual freeze-thaw processes leading to the formation of soliflucted drifts showing vertical sorting, the stonier upper layers containing stones that are orientated downslope (Ragg and Bibby, 1966). The hills in the area under survey must also have been subjected to periglacial conditions, but possibly less intense and of shorter duration, as ice cover was probably more persistent in the Merrick–Kells area than further east. Some drifts, for instance screes on steep slopes, may be entirely periglacial, but most drifts on higher ground in the area are probably glacial in origin though subjected to a degree of re-sorting by solifluction. Freeze–thaw processes may account for the stony nature of the upper mineral layers of many uncultivated soils in the area. Contemporary solifluction is insignificant, limited to slow downslope movement of boulders which throw up bow-waves and leave hollows in their wake (Ragg and Bibby, 1966). Terracettes and stone stripes, found at high elevations in the Carrick area to the north, are only weakly developed on the Cairnsmore of Fleet but for this its flat summit may be partly responsible.

After the disappearance of the valley glaciers the sea penetrated farther inland than it does today; Jardine (1966) is of the opinion that Loch Ryan and Luce Bay were not linked by the sea, although the southern part of the Rhins Peninsula may have been breached at Terally.

About 5000 years ago a relative fall in sea level probably caused by isostatic recovery of the land uncovered many square kilometres of raised beaches, mainly in the lower Cree Valley but also fringing the coastline. These Recent beaches are generally below 10 m (35 feet) and range in texture from sands and gravels to the silts and clays of the Cree Valley estuarine sediments.

Also of Recent age are the accumulations of peat (described separately in Chapter 6), blown sand, alluvium and saltings.

PARENT MATERIALS

The Pleistocene and Recent formations described above give rise to most of the parent materials in the area; the bedrock is only occasionally a parent material although, as mentioned previously, it has an important influence on the nature of the unconsolidated deposits. In the account which follows similar or related parent materials are described together. For each of these groups a soil association, i.e. a group of soils developed on similar or related parent materials, has been distinguished; the more extensive associations are shown in Figure. 12.

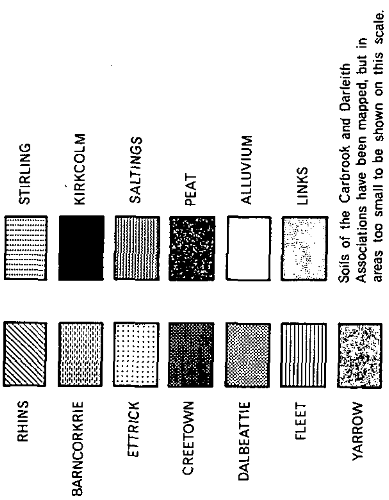
Rhins Association

On the Rhins Peninsula, and in the area of the Machars Peninsula to the south-east of a line approximately from Wigtown to Port William, the till is reddish to reddish brown, despite the predominantly grey colour of the Ordovician and Silurian strata which usually underlie it. In the Stranraer Lowlands (landform region 2a, Fig. 3) a similar reddish brown till forms the drumlinoid features and has been observed in places under the extensive spreads of sand and gravel. These tills are the parent materials of the Rhins Association.

Despite the colour of the matrix, the coarser material of the till consists in the main of grey subangular greywackes; red greywackes, shales and sandstones are generally infrequent. Erratics of granite occur in the till, and Carboniferous and basic igneous material is found locally at the northern end of the Rhins Peninsula.

The red colour of the matrix of the tills can probably be ascribed to the movement of ice over soft red rocks lying below the sea—soft because such sediments would be readily comminuted, whereas hard strata would probably give a greater proportion of identifiable red fragments than is found. Experience in other areas of Scotland suggests that even a little contamination from soft red sediments is sufficient to redden appreciably drifts that would otherwise be grey in colour. The evidence for the presence of red Permo-Carboniferous sediments under the sea is reviewed on page 35; though not conclusive, it strongly suggests that such strata are present. Over the postulated outcrop of these sediments the ice sheets would have moved southwards across the Firth of Clyde and the Loch Ryan–Luce Bay basin and also south-westwards across Wigtown Bay, before passing over the Rhins and Machars Peninsulas respectively.

FIG. 12 Distribution of Soil Associations (*see also page 41*)



Over most of the area covered by the association the texture of the till is clay loam, a generalized description being: Reddish brown (2·5YR4/4*) clay loam, massive, very firm, stony, occasional dark manganiferous staining. Finer textures are sometimes found, for example in areas of the Rhins Peninsula where the till contains material derived from shaly Carboniferous sediments.

The fine sand fractions from the basal horizons of six profiles of the association have been examined mineralogically. The average values for the light and heavy fractions are given in Appendix V, Table 26. It is evident that quartz is the dominant light mineral with weathered material only slightly less abundant. Potash feldspars are significantly in excess of plagioclases, and micas are absent. Heavy mineral fractions normally contain many minerals which serve as indicators of the origin of the parent materials, but characteristic features are often masked where drifts, such as in the Rhins Association, are derived by the mixing of materials from different sources. However, the results indicate that the parent materials of this association have a fairly uniform mineralogical composition. Iron oxides, augite, epidote and hornblende are the principal minerals, with appreciable amounts of rock particles and weathered material having minerals which could not be identified positively.

On the Rhins Peninsula and near Monreith the till is sometimes water-modified, more frequently on the lower ground and the lower slopes of the drumlinoid features. The till in the Stranraer Lowlands is overlain or surrounded by water-laid deposits and, as would be expected, is nearly always water-modified. This modification is shown by coarser textures, often sandy loam in the upper layers.

* Notation used in Munsell soil colour charts (Munsell Color Co. Inc., 1954).

Soils of the Rhins, Ardwell and Glenstockadale series have been mapped where the modified layers are 40 cm or less in thickness and the Portencalzie, Portpatrick, Mull, Auchleach, Balscalloch and Lochnaw series are distinguished on the more deeply modified materials.

In some areas of the Machars Peninsula, especially around Kirkinner and Garlieston, and at the northern end of the Rhins Peninsula the texture of the till is coarser, generally loam. A generalized description is: Reddish brown (2·5YR4/4) loam, massive, indurated, stony. Induration is also common in the loamy tills of the Ettrick Association.

Where these tills are thin and rock is near the surface additional symbols—'G', indicating greywackes, and 'P', indicating Permian rocks—are shown on the soil map. Such areas are more commonly associated with the loamy tills than with the clay loam tills. Another symbol, 'I', has been used to indicate areas where the till has some of the features of the grey Ettrick Association parent materials. Such areas would be expected to occur adjacent to the area of the association, and between Wigtown and Port William the reddish brown colour of the till does fade to a paler reddish brown or to brown.

Barncorkrie Association

To the south of Barncorkrie Moor at the southern end of the Rhins Peninsula the clay loam till of the Rhins Association has an appreciable admixture of acid igneous rocks, mainly granites, derived from the underlying intrusion. This till has been separated as the parent material of the Barncorkrie Association, a generalized description being: Reddish brown (5YR4/3) clay loam, massive, firm, stony. The upper layers of this till are usually water-modified and are consequently of coarser (often sandy loam) texture.

Ettrick Association

The parent materials of the Ettrick Association are the Ordovician and Silurian rocks, mainly greywackes and shales, and the grey tills, moraines and soliflucted drifts derived from them. Chemical analyses (Appendix V) of greywackes and shales, mainly from the Southern Uplands, show that their composition varies from a composition corresponding to that of an acid igneous rock such as granite to a composition of intermediate basicity like that of a diorite. The narrow dykes of Old Red Sandstone age are usually similar in composition to the parent rocks of the Ettrick Association and, being of very limited extent, have been included in the association, together with their derived drifts.

Mineralogical analysis of the fine sand fraction of the C horizon of seven profiles revealed that the light fraction consists principally of quartz and weathered material (Appendix V, Table 26). The latter; essentially grains coated with ferruginous material, probably includes a significant amount of quartz. The potassium feldspar content is appreciable, whereas the plagioclase content is moderate to low. Mica was not observed in any of the profiles. Iron oxides predominate in the heavy fraction with significant amounts of augite, epidote and hornblende. The values for zircon are high compared with those of the sands from other associations in the area. This probably results from repeated weathering, erosion and transportation, in several geological cycles, producing a concentration of zircon in the lower Palaeozoic sediments from which the parent materials of this association are derived. Fragments of fine-grained parent rock and highly weathered material are also noteworthy features of the heavy fraction.

The soils are sometimes formed directly on shattered rock but the more extensive parent materials are the grey drifts; these can be subdivided into two textural groups—clay loam and loam or coarser. It is often difficult to separate the two groups, firstly, because many of the tills are close to the textural boundary between clay loams and loams, and, secondly, because the clay loam till is sometimes capped by a variable thickness of coarser-textured ablation till. The two groups do, however, give rise to soils differing in properties other than textures; these differences facilitate the distinction of the parent materials and justify the separation.

A generalized description of the clay loam till is: Light brownish grey (2·5Y6/2) clay loam, massive, very firm when moist, plastic when wet, stony, with many subangular greywacke stones. It is similar to the clay loam to clay till described by Bown (1973) in the adjacent area to the north but it usually contains less clay. The till is not extensive and is confined to low ground; the main areas are around Glenluce, between Dunragit and Cairnryan on the lower slopes of the escarpment, and the Mochrum area. A few granite erratics are sometimes present.

The coarser-textured group of parent materials occurs widely over the area covered by the association. Granite erratics are sometimes present, becoming more frequent with increasing proximity to the Cairnsmore of Fleet intrusion. The drift cover is often thin, the rock being at or close to the surface. On higher ground solifluction has frequently modified the upper layers of the drift. Morainic mounds are found along some of the tributary valleys of the River Cree; the moraines are coarse-textured (loamy sand to sandy loam) stony deposits which are usually unsorted, although some have beds and lenses of sand and gravel.

On the drumlins and drumlinoid features a thick spread of till is usual. A generalized description of this drift is: Greyish brown (2·5Y5/2) sandy loam or loam, massive with a slight tendency to platy, indurated, stony. Hard subangular greywacke stones varying in size from grit to large boulders are frequent, the smaller rock fragments giving a gritty feel to the matrix of the till. Numerous vesicles similar to those in indurated material described by Glentworth (1944) and later by other authors, occur in this matrix which is brittle when moist and breaks abruptly when subjected to pressure between finger and thumb. Only slow progress can be made when digging a hole without a pick.

The precise genesis of the induration is unclear, as is the nature of the bonding agent or agents. The texture of the material is certainly important, as induration (on world evidence) is seldom found in very coarse and very fine textures. Grossman and Carlisle (1969), reviewing fragipans in soils of the eastern United States, found that most were loamy in texture with a considerable size fraction in the 200–20 μm (fine sand to silt) range; bulk densities were usually more than 1·4 g/cm^3. The induration in the area of the present survey extends to considerable depths—3 m or more—and is a feature of the parent material rather than of the soil. It may be caused partly by the mode of formation of the till, the texture of which is amenable to close packing, and partly by the effects of permafrost.

The induration in the till is less strongly developed than in many of the indurated layers in north-east Scotland where, in order to dig through it, a pick is often essential. The induration in the soils of north-east Scotland is probably different in kind as well as in degree. Romans (1962) suggests that there it is caused by cementation by small amounts of aluminium oxide as a result of pedological processes, although periglacial conditions probably caused the initial compaction and developed the platy structure (Fitzpatrick, 1956). In the south-west area a more pronounced induration is sometimes found in the topmost part of the indurated parent material, a part probably at least partly formed by soil-forming processes.

Just as the tills of the Rhins Association display some of the features of the Ettrick Association tills near the area of that association, so the converse applies and the symbol 'I' on the soil map indicates parent materials which contain some red coloration, giving an overall greyish brown colour.

Creetown Association

The ice sheet from the Cairnsmore of Fleet granite mass moved in a south-westerly or southerly direction across the Silurian rocks surrounding the intrusion, and laid down a mixed drift derived from greywackes, shales and granite. Where the drift thins and the underlying Silurian rock is close to the surface Ettrick Association soils have usually been mapped.

The main areas of the Creetown Association are found near the village of that name, but the association also occurs in the Water of Fleet Valley as far south as Anwoth. A generalized description of the drift is: Brown (10YR6/3) gritty loamy sand, massive, stony. It is easily distinguished from drifts lacking granite material by the presence of numerous grit-sized particles of quartz and feldspar derived from the granite.

Dalbeattie Association

The parent materials of the Dalbeattie Association are granites and drifts derived from them which are ubiquitous within the area of the Cairnsmore of Fleet granite intrusion. Drifts of the association also occur outwith the area of the intrusion, having been carried by the ice sheets in a southerly or south-westerly direction. Similar parent materials also occur within the outcrop of 'granites' in the Kirktown and Glenluce areas and near Barncorkrie in the Rhins Peninsula. Over much of the Cairnsmore and other granite areas the drift left after glaciation is thin and the rock often outcrops or is close to the surface. Solifluction has probably affected most of the glacial drifts on higher ground and low temperatures have been the primary agent in forming screes.

A generalized description of the drift is: Light grey to pale brown (10YR7/2-6/3) gritty loamy sand, massive, stony. The material has a characteristic gritty feel given by the presence of large numbers of coarse particles of quartz and feldspar.

Mineralogical analysis of the light and heavy fractions of the fine sand fraction from the C horizon of several profiles indicated that the light fraction makes up 99 percent of the total fine sand with quartz, plagioclase feldspar and potassium feldspar the dominant minerals (Appendix V, Table 26). The plagioclase content is relatively high and the ratio of potash feldspars to plagioclases is low when compared with that for other soil parent materials found in the area. Micas and weathered material—unidentifiable weathered and coated grains—make up the remainder of the fraction. Iron oxides and biotite/chlorite constitute the principal minerals of the heavy sand fraction. Anatase has been recorded in this area only from the Dalbeattie Association.

The Fleet glacier left prominent moraine fields in the Dromore area and higher up the valley towards Loch Grannoch. These moraines are usually a very stony gritty sand and show some signs of bedding.

Darleith Association

Two porphyrite intrusions and thin drifts derived from them form parent materials which have been grouped with those of the Darleith Association. The areas concerned, in the Machars and Rhins Peninsulas, are both very small.

Fleet Association

The Fleet Association resembles the Creetown Association in so far as both groups of soils are formed on mixed drifts derived from greywackes, shales and granites but its parent materials are laid by water rather than by ice and are of fluvioglacial and Late Glacial raised beach origin. The two associations are found over a similar area, that is near to the granite intrusion of the Cairnsmore of Fleet, but the distribution of the Fleet Association is restricted to the fringes of river and stream courses.

The parent materials are coarse-textured gravels with some inter-bedded sands which contain abundant rounded Silurian (mainly greywacke) and granite stones. Mounds of these deposits occur near Creetown but elsewhere terraces such as those bordering the alluvium of the Water of Fleet are more usual.

Yarrow Association

The parent materials of the Yarrow Association are deposits of fluvioglacial and Late Glacial raised beach origin derived from

Ordovician and Silurian greywackes and shales. These water-laid materials are found extensively in the Stranraer Lowlands and frequently along the river valleys and coastline, at elevations which seldom exceed 100 m (350 feet). The relief in which the association is found is characteristically moundy or terraced; occasionally sinuous ridges (eskers) of gravel occur.

The parent materials have been separated on a textural basis into gravels, sands with some interbedded gravels, and interbanded fine sands and silts, the last-named group covering a very small area. All are derived from Ordovician and Silurian greywackes and shales. The stones in the gravels are usually well rounded, but some of the coastal deposits fringing Wigtown Bay contain many platy stones, mainly shales.

Mineralogical analysis of the fine sand fraction from C horizon samples shows that light minerals comprise 80 percent of the fraction. Quartz and feldspars are equally abundant and the ratio of potash feldspars to plagioclases is 2 : 1. A small amount of mica is present and there is a significant quantity of unidentifiable grains. Iron oxides, augite, rock particles, and weathered material dominate the heavy fraction. The content of zircon is lower than in other parent materials of the area.

In the Stranraer Lowlands the sands and gravels on terrace features are sometimes underlain at no great depth by much less permeable material. Fine-textured till of the Rhins Association has been observed at depths of a metre or less, and it seems reasonable to suppose that lacustrine clay (described below under the Carbrook Association) may sometimes be present in a similar position.

Carbrook Association

A reddish brown (5YR5/4) clay which is massive, firm and practically stone-free is the parent material of the Carbrook Association. It usually occurs near areas of the Yarrow Association and is evidently water-laid, probably lacustrine. The clay is found in the Stranraer Lowlands, in the Rhins Peninsula and near Garlieston; it occurs in flat or gently sloping relief. Excavations in the material mark the sites of tile workings, now abandoned.

Stirling Association

The parent materials of the Stirling Association are grey (10YR5/0–1) estuarine sediments of raised beach origin occurring below about 10 m (35 feet) in the lower Cree and Bladnoch Valleys.

Jardine (1964) concluded that the sediments were laid down in a very variable environment, typical of estuarine conditions where land-derived and marine organic remains become interbedded with the mineral accumulations. He examined an exposure of sediments about 6 m thick and found a succession from the bottom upwards of clays, clayey gravel, gravel with lenses of silt and fine sand, and banded clays and sands. Radiocarbon dating of wood fragments found at about the middle of the succession gave an age of 6000 years before present time.

The upper layers of the sediments as now exposed, that is the effective parent materials, tend to become finer in texture with increasing elevation, allowing separation into three textural groups: silty fine sands, silty clay loams and clay loams, and silts and clays. Most of these parent materials are stone-free. The silty fine sands are found nearest to the rivers and to the coastline of Wigtown Bay and may be the most recent in age. Shells occur in places in the silty clay loams south of Wigtown. The silts and the clays are the most extensive, although basin peat covers some areas and was extensive before man started to remove it.

Mineralogical analysis of the fine sand fraction of the C horizon revealed that the potassium feldspar to plagioclase feldspar ratio is 3 : 1 and one of the highest recorded for parent materials of this area (Appendix V, Table 26). Quartz is, of course, the most abundant mineral of the light fraction and probably the most characteristic mineralogical feature of the parent material is the content of calcium carbonate. The iron oxide component of the heavy fraction is below the average for other parent materials of the area, but there are significant amounts of augite, garnet, hypersthene, epidote and hornblende. The content of apatite is the highest for a C horizon sample from this area.

Kirkcolm Association

The parent materials of the Kirkcolm Association are gravels and sands of Post Glacial raised beach origin derived mainly from Ordovician and Silurian greywackes and shales. They are found intermittently along the coastline at elevations below about 10 m (35 feet). Three groups of parent material have been distinguished: gravels, sands, and shelly sands and gravels. Gravels, the commonest parent material, include storm beaches of abundant rounded cobbles. The shelly sands and gravels are inextensive; usually the proportion of shells is low, but near Carsluith (south of Creetown) parent materials are found which consist almost entirely of shell fragments.

Mineralogical examination of the fine sand fraction of the sands and gravels showed that the light component is predominantly quartz with potassium feldspar next in abundance (Appendix V, Table 26). The 'composite grains'—unidentifiable weathered material—most probably consist of quartz and feldspars. Mica is present in small amounts. The light fraction accounts for more than 98 percent of the fine sand fraction in this association compared with only 80 percent in fluvioglacial sands and gravels, the parent materials of the Yarrow Association. Augite, hornblende and epidote, in addition to iron oxides, are the most common minerals of the heavy fraction.

Blown Sand

The blown sand at the head of Luce Bay occurs in a hummock-and-hollow relief of sand dunes most of which are at least partially fixed by marram grass (*Ammophila arenaria*). The sand is rarely shelly although shells have been found in the dunes close to the present beach.

Alluvium

Alluvium, sometimes interbedded with or covered by peat, is found bordering the channels of the rivers and streams. It also occurs in the flat hollows which may at one time have been occupied by lakes. The deposits, like most alluvium, are very variable in texture both laterally and in depth, but in this area most are moderately coarse, tending to become finer nearer to the sea as the river or stream gradients lessen. Little deposition is now taking place along the lower water courses.

Saltings

Saltings are deposits of marine alluvium, found between the normal high water mark and the limit of the highest spring tides, which are dissected by a network of creeks and fixed by vegetation adapted to the saline environment. They occupy a considerable area of the Cree–Bladnoch estuary where the parent materials are grey stone-free silt loams, loams and fine sandy loams.

4 | Soil Formation, Classification and Mapping

SOIL FORMATION

Soil is a natural body containing mineral and organic matter which covers the earth's surface and supports life. Even rock outcrops and bare scree can be colonized by bacteria and other micro-organisms (Webley *et al.*, 1963) and it can be taken that in the area under review nearly all the land surface that is free of non-natural material is soil. Distinction of soil from non-soil at depth can be difficult, because soil material may have little if any organic matter apparent to the naked eye and yet be affected by soil-forming processes. For practical purposes, however, non-soil can be said to have been reached where the material contains little or no organic matter and shows little alteration with depth other than geologic changes.

In most soils the soil profile, a vertical section through the soil, is differentiated into layers or horizons which vary in character, number, thickness and clarity of form. These horizons have been formed by processes of soil formation which include weathering, leaching and gleying.

Weathering in soils involves the physical and chemical alteration of the parent material. In temperate regions physical weathering is mainly caused by the expansion exerted in pores and fissures as water freezes, resulting in shattering of rock and comminution of rock particles. Oxygen, carbon dioxide and organic acids dissolved in rain water cause chemical weathering, the rate of which varies according to the quantity and temperature of the water. As a result of chemical weathering primary minerals are hydrolysed into the simple salts and oxides of their constituent elements, while soil clays are also formed.

The process of *leaching* involves the removal in the drainage water of soluble salts, leaving less soluble products, such as resistant minerals (e.g. clay minerals and quartz) and aluminium and iron oxides, to accumulate. A proportion of basic cations, such as those of sodium, potassium, calcium and magnesium, can remain associated with clay minerals and organic matter as part of the exchange complex. In the area with which this memoir is concerned the intense leaching resulting from the high rainfall favours the steady displacement of these cations by hydrogen ions. The rate of chemical weathering on materials of only moderate base status is low and often insufficient to maintain the supply of basic cations so that the degree of acidity tends to be greater in the upper horizons than in the horizons beneath. These acid conditions depress the activity of micro-organisms relative to that of higher plants, reducing the rate of mineralization of organic matter which consequently often accumulates on the surface as raw humus. Products of raw humus and plant litter are thought to be responsible for podzolization, a leaching process involving the transport from the upper horizons of iron and aluminium compounds which may be redeposited in the less acid conditions of lower horizons.

Soils under conditions of free drainage are well aerated, and brown, yellow and red colours predominate in layers that are mainly mineral. Where downward water movement is impeded, however, the soil pores and spaces may largely be waterfilled for long periods, thus excluding air and oxygen. Under these anaerobic conditions ferric ions are readily reduced to the ferrous state giving grey and blue hues indicative of *gley* formation. The ferrous compounds are relatively soluble and migrate (often laterally) in the soil, but they become re-oxidized where waterlogging is intermittent and the ferric oxides give rise to ochreous mottles, iron pans or concretions. Manganiferous compounds form oxidized products as a result of a similar process. Under anaerobic conditions the rate of chemical weathering in soils is generally faster, and because downward leaching is often impeded, wet soils usually have a higher content of nutrients available to plants. The rate of breakdown of organic matter is slower, however, and this material generally accumulates on the surface as peat or a peaty layer of the soil.

These processes are controlled by factors which can be grouped (after Jenny, 1941) as parent material, climate, relief, biotic agencies and time. These soil-forming factors interact with one another, and in the case of biotic agencies are in turn affected by the soil conditions. Soils are formed by the combined action of these factors, but by comparison of soils, differences in soil genesis can be inferred and conclusions drawn as to the influence of a particular soil-forming factor.

Parent Material

Parent materials affect the course of soil formation mainly through their base content and the impedance they offer to drainage. As a rule, rock materials that are richer in bases are also more easily weathered, so that bases are both more abundant and more readily released. The majority of parent materials in the area surveyed have low to moderate amounts of exchangeable bases; the shelly sands and gravels, however, are often calcareous, and the exchange complex is completely base saturated.

Soil drainage is affected by the texture and consistence of the parent material, texture being the particle-size distribution and consistence the degree of cohesion or adhesion of the material. Drainage impedance increases as textures become finer and also with increasing compaction or induration. The coarse-textured parent materials of the Yarrow, Fleet and Kirkcolm Associations give mainly freely drained soils, whereas the clay loam and clay textures of the Rhins and Carbrook Associations normally give rise to imperfectly and poorly drained soils, due, in some cases, at least in part to their indurated nature.

Climate

The most important climatic elements affecting soil formation are temperature and rainfall, upon which depend the energy available for weathering and biotic activity and the water for leaching and gleying. Climate has been described in Chapter 2 and much of its variation over the area is attributable to topographic features, temperature falling and rainfall increasing as elevation rises. In Post Glacial times there have been periodic long-term changes in climate, but the continuing overall effect on the soils has been one of leaching and mild weathering.

Allowing for an estimated annual potential evapotranspiration of about 500 mm, there is available annually a surplus of rainfall of between 500–2000 mm. Some of this is lost by run-off but a considerable amount of water remains, especially during the winter months, to effect pedogenic processes. Water can become limiting for plant growth during the summer months, particularly on coarse-textured coastal soils, but otherwise leaching and gleying processes are predominant.

When the climate becomes colder and wetter as elevation rises, podzolization and the build-up of organic horizons are increasingly favoured, and in this area podzolized and organic soils are dominant above 100–150 m (350–500 feet). On the highest ground, however, the still lower temperatures and increased exposure reduce the growth of higher plants and less organic matter accumulates; the cold climate also causes a slower rate of chemical weathering. Freeze–thaw processes during the winter months are thought to be responsible for the physical mixing of mineral and organic matter and for the loose fabric of the upper soil layers. A similar though less intense process operates in all soils from time to time during the winter, the freezing of soil moisture tending to break up clods into smaller aggregates.

Relief

The significant influence of relief on climate has already been mentioned. Relief and parent material are also interrelated, a parent material often occurring on a characteristic topography, as discussed in Chapter 3.

Relief has a more direct influence on soil genesis through its effect on the water relationships of soil. The hydrologic conditions are affected by the influence of slope on infiltration of rainfall and by the effect of relief on the position of the watertable. While increasing steepness of slope, as would be expected, gives a greater likelihood of free drainage through the soil, it also retards soil development as it reduces leaching down the profile and causes downslope soil movement; podzolized soils are thus less likely to occur. Gleying is favoured in receiving sites, i.e. those receiving more water from the slopes above than is lost by run-off, and in such sites the watertable is usually closer to the surface. Where springs occur mineral-rich ground waters often cause waterlogged conditions for long periods, but they also maintain a base status higher than in surrounding areas and may thus retard the build-up of organic matter.

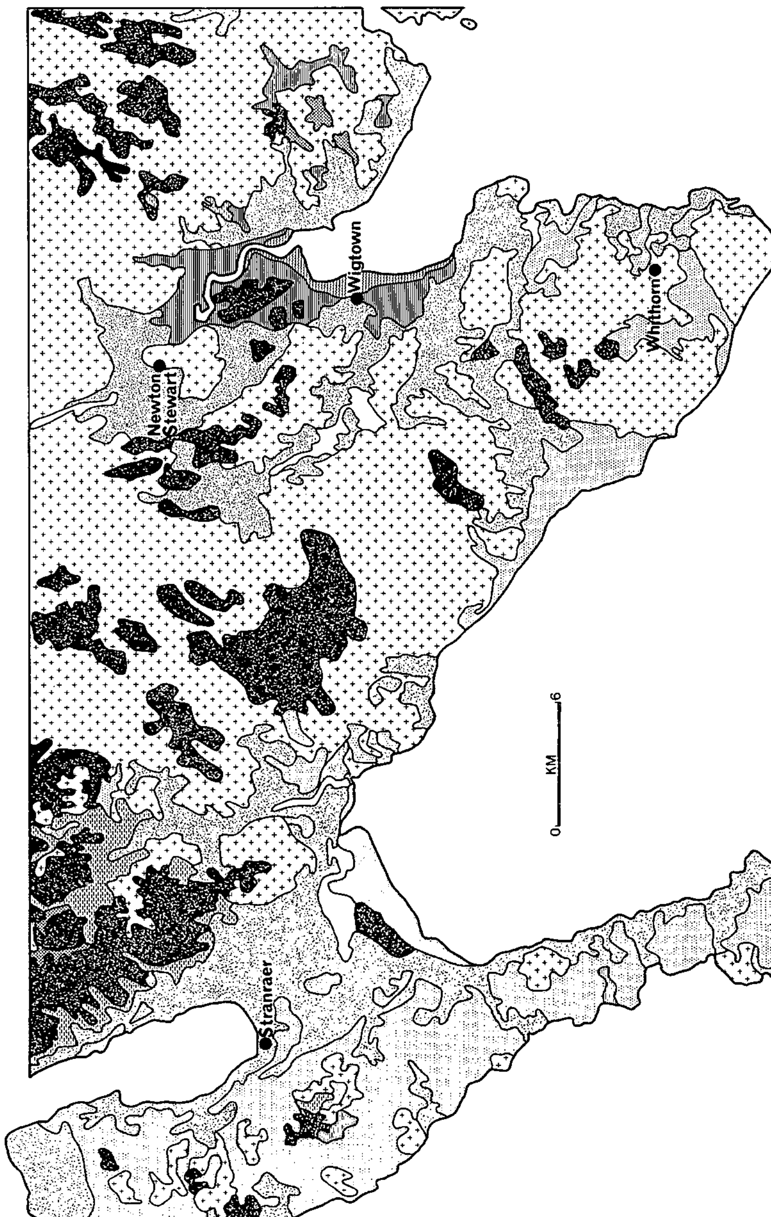
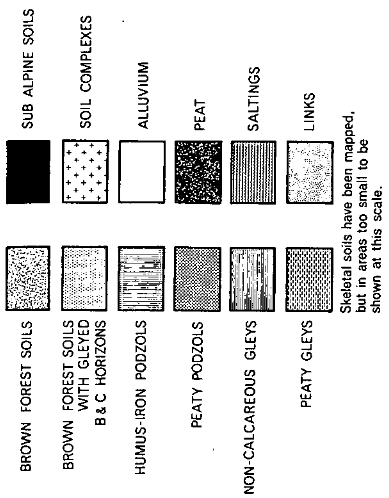


FIG. 13 Distribution of Major Soil Sub-groups (*see also page 53*)



Relief influences micro-climate through the effect of aspect: north-facing slopes receive less radiation, giving lower soil temperatures that are conducive to a build-up of organic matter and to podzolization.

Biotic agencies

Plant communities and the activities of man affect one another and both are affected by soil conditions, so that biotic agencies cannot be regarded as independent variables. Some of the effects of these agencies can nevertheless be inferred from historical evidence and from the character of the present soils.

Established plant communities affect the soil partly through the amount and nature of their leaf litter which in turn affects the form of humus, the rate of mineralization of organic matter, the amount of nutrients available for plant growth and the rate of acidification. The process of leaching can be retarded both by the fixing of nutrients in organic form and by the uptake of nutrients from lower layers of soil and their retention in plants and plant remains. Mixing of soil horizons by tree fall can also counteract leaching.

The soil fauna and flora are much affected by soil conditions. Soils that are no more than moderately acid usually have a large population of micro-organisms and many earthworms which ingest plant remains and soil and excrete them as an intimate mixture, mull humus. The burrowing activity of earthworms parallels the action of plant roots in retarding the leaching of plant nutrients. Earthworms are less numerous, however, in strongly leached and podzolized soils and here fungi and mites aid other micro-organisms in the decomposition of the organic matter, which is usually of the acid or mor form.

Pollen analysis suggests that birch and alder woodland with some oak was fairly widespread in the area until about 2500 years ago when a great increase in ericoid vegetation resulted from cutting of the forests by man, helped no doubt by a deterioration to a wetter and colder climate. The former forest now persists only as scattered remnants, such as the semi-natural oakwood of the Wood of Cree. Under such woodland podzolization appears to be less intense than under heath vegetation growing under similar conditions. The litter produced by heath communities and many coniferous trees is less easily decomposed than that from broadleaved trees; a mor humus is formed and the turnover of plant nutrients is slower. In the area of the present survey nearly all the soils under ericaceous vegetation have an organic surface horizon and are podzolized; it seems reasonable to conclude that had the broadleaved woodland persisted these soils would now be less extensive.

Man's activity as a cultivator has had a marked effect on the soils of the area. His operations, carried out with the objective of improving the environment for agriculture and forestry, include heather burning, ploughing, draining and the application of fertilizer. By the late seventeenth century (Symson, 1684) their effect was considerable, especially in the parishes of Sorbrie, Whithorn and Glasserton. It can be inferred that some heathland was broken to form arable land; in the Stranraer Lowlands, for instance, soils of the Yarrow Association are evidently cultivated podzols for they have bleached sand grains in their humose surface horizons and some also contain traces of iron pan. The combined effect on the soils of several hundred years of cultivation and fertilizer application has been to counter the effects of leaching by raising the base status and reducing the degree of acidity, so that many cultivated soils show no trace of the podzolized surface horizons that may once have been present. Cultivation can also improve soil drainage by disrupting an iron pan or indurated layer, and field drains in poorly drained soils can ameliorate waterlogging to the degree that leaching replaces gleying as the main soil process.

Over the last fifty years the establishment of forest plantations has been increasing and influencing the soil in a number of ways. Drainage and cultivation have reduced gleying and have mixed soil horizons. Fertilizers have been applied, though not in the quantities used in agriculture. Now the tree crops themselves are beginning to affect the soil, mainly through their litter; for example, instances have already been observed in Scotland of increased podzolization of soils under first rotation coniferous plantations.

Time

Soil-forming processes in the area were initiated at the end of the last cold period, about 10,000 years ago. Many of the soils are also of this age, although on the lower raised beaches, blown sand, alluvium and saltings, the soils are younger and usually show less mature development, horizons being only weakly differentiated.

SOIL CLASSIFICATION

A soil series as defined by the Soil Survey of Scotland comprises soils with a similar type and arrangement of horizons developed on similar parent material. In this section the soil series mapped in the area are classified according to a system provisionally adopted by the Soil Survey of Scotland. The highest category of the system is the division, and in this area two divisions can be separated on the basis of the main soil process operating, leaching and gleying. Lower categories, the major soil group and sub-group are distinguished for both divisions.

The horizon nomenclature used in this memoir is described in detail in Appendix I, but the definitions of the main or master horizons can be expressed as follows (adapted from Muir, 1969):

- A: An upper horizon which contains humus formed *in situ* or—Muir's 'E' master horizon—which is depleted by eluviation of one or more constituents.
- B: A layer, formed below the A horizon, which has little humus formed *in situ* but may be augmented with one or more constituents (illuviation).
- C: Material, present below the A horizon, which is little altered by current soil forming processes and is the parent material of the soil.

In the description which follows, the categories of the classification are defined mainly in terms of the characteristics of their master horizons.

Division of Leached Soils

Leached soils are characterized by an absence of free lime and by an acid reaction in their A and B horizons. Their lower horizons may show some gleying expressed as mottling.

MAJOR SOIL GROUP: NORMAL BROWN EARTHS

A uniformly coloured B horizon, a mull or moder humus type and a moderately acid reaction are the characteristic features of the normal brown earth; usually each horizon merges into the one underneath.

Sub-group: Brown Forest Soils of low base status

Brown forest soils of low base status have a moderately acid reaction and humus of the moder type. Each soil horizon merges into the one below.

Sub-group: Brown forest soils with gleyed B and C horizons

Brown forest soils of this type have a moderate base status and a moderately acid reaction, the B and C horizons showing some gleying. The soils are frequently found on parent material of fine texture.

MAJOR SOIL GROUP: PODZOLS

Podzols have a raw humus surface layer and an eluviated grey bleached A horizon with a weak structure. They have a strongly acid reaction, and their B horizons often contain illuviated sesquioxides of iron and aluminium and sometimes also illuviated organic matter.

SUB-GROUP: HUMUS-IRON PODZOLS

Humus-iron podzols are formed mainly on coarse-textured parent materials. The B horizons include a dark-coloured humus-enriched upper layer and a brightly-coloured lower layer which usually contains illuviated iron.

Sub-group: Peaty podzols

Peaty podzols have a thick (usually more than 8 cm) accumulation of organic matter above an eluviated A horizon which usually shows signs of gleying, the impedance being due to a thin often continuous iron pan which is the uppermost B horizon. Below the iron pan a brightly-coloured iron-enriched B layer is usually present.

MAJOR SOIL GROUP: SUB-ALPINE SOILS

Sub-alpine soils occur at high altitudes where low temperatures prevail, freeze–thaw processes are significant and biotic activity is low. Major features of the upper part of the profile are a loose fabric and the presence of humose, and consequently dark-coloured, horizons. Typically, an A horizon containing bleached sand grains is underlain by a B layer where the mineral particles are coated with colloidal humus. The B horizon may show a gain of translocated iron but the eluviated bleached A horizon typical of podzols is not well developed.

Division of Gleys

Gleys develop under conditions of intermittent or permanent water-logging. Often prominent in uncultivated soils is a pale-coloured eluviated and gleyed A horizon beneath which the horizons are grey with a greenish or bluish tinge and with ochreous mottling. These colours are secondary and mask the colour inherited from the parent material.

MAJOR SOIL GROUP: SURFACE WATER GLEYS

In a surface water gley the effects of gleying are prominent in the upper horizons but decrease with depth. The colour inherited from the parent material is more apparent in the lower part of the profile.

Sub-group: Non-calcareous gleys

Non-calcareous gleys have no free calcium in the upper layers. Any accumulation of organic matter on the surface of these soils is slight (less than 2–3 cm).

Sub-group: Peaty gleys

Peaty gleys have no free calcium in the upper mineral layers which, as the soils are seldom cultivated, usually include a prominent gleyed eluviated A horizon. Above the mineral soil is a thick (usually over 8 cm) accumulation of raw humus.

MAJOR SOIL GROUP: GROUND WATER GLEYS

Ground water gleys develop under the influence of a high ground watertable. In these soils the effect of gleying increases with depth and the colour inherited from the parent material is not apparent in the lower part of the profile.

Sub-group: Non-calcareous gleys

Non-calcareous ground water gleys have no free calcium in the upper layers and there is little development of an organic-rich surface horizon.

Table G. Classification of Series

Division	Major Soil Group	Sub-group	Series
Leached soils	Normal brown earths	Brown forest soils of low base status	Portencalzie, Portencorkrie, Linhope, Clanery, Dalbeattie, Fleet, Yarrow, Cairnside, Kirkcolm, Clachan, Kirranrae
		Brown forest soils with gleyed B and C horizons	Rhins, Portpatrick, Barncorkrie, Altimeg, Kedslie, Arkland, Carsnaw, Galdenoch, Cailliness, Harviestoun, Dally Bay
	Podzols	Humus-iron podzols	Mull, Knockarod, Larbrax
		Peaty podzols	Auchleach, Dod, Falbae, Carsphairn, Glenquicken
	Sub-alpine soils		Mulltaggart
Gleys	Surface water gleys	Non-calcareous gleys	Ardwell, Balscalloch, Little-shalloch, Ettrick, Greenburn, Carbrook
		Peaty gleys	Glenstockadale, Lochnaw, Dochroyle, Creetown, Eglin, Poldar
	Ground water gleys	Non-calcareous gleys	Innermessan, Dinduff, Stirling, Newton Stewart, Fordel, Drummore, Portlong Bay

SOIL MAPPING

After a brief reconnaissance to establish the parent materials and soils most extensive in the area, the detailed soil survey was done by systematically traversing the country, in directions as far as possible at right angles to anticipated soil boundaries. Soil boundaries were established by digging small holes or by making auger borings at suitable intervals and recording the results on Ordance Survey 1 : 25,000 maps. Soils are often related to the relief and to the vegetation, and an understanding of these relationships greatly aided the drawing of boundaries. Air photographs were often helpful in moorland country and on saltings where accurate location of ground position on the map might have been difficult. Mapping units, too, were often more easily and more accurately distinguished and delimited by correlating patterns and other fine detail on the photographs with the soils. These relationships, however, had to be established and maintained by regular ground inspection.

The number of soil inspections needed per square kilometre varied from as many as 20 on arable ground to very few where peat was prevalent. Peat soils were mapped where organic surface horizons were more than 30 to 40 cm thick, the deeper limit being used where a mappable area could be identified. Depending on the complexity of the soils and the number of observations made, the country covered by a surveyor ranged from 1 to 10 square kilometres a day.

As much as possible of the detail shown on the field maps is reproduced on the published maps but the limitations of the reduced scale (1 : 63,360) make it impracticable to delineate areas of less than about 1 hectare. The area of a soil series shown on the published map may consequently include small areas of other soil series. Such areas are sometimes more than 1 hectare where they could not be delimited in the field. It must also be appreciated that the boundaries between mapping units are rarely as sharp as represented by the lines on the soil map; there is generally a broad transitional belt over which the soil changes gradually from one mapping unit to another. The boundary is drawn where the critical change is thought to occur, but soils lying near to this line on either side will closely resemble one another, showing greater differences the further they extend from the boundary.

Where the soils occurred in an intricate pattern it was not always possible to distinguish soil series even on the larger scale of the field maps and air photographs. In these cases soil complexes were used as mapping units. The principles used in the separation of complexes in this area have been established by Bown (1973). These mapping units have been classified, as shown on the soil key, on the basis of the topography and the nature of their surface horizons. The complexes were distinguished on the ground after inspection of their component soils; they were usually delimited without difficulty because of their relation to features shown on map or photograph.

Profiles belonging to the soil series were described in detail during the course of the survey. Large pits were dug deep enough—commonly 1 to 1·5 m—to reach unaltered parent material. The description included the location and the general features of the site and the profile, as well as details of each soil horizon as seen in the exposed face of the pit. Standard terms were used for these descriptions and are given in Appendix I. Samples were taken for routine physico-chemical analysis, the results of which are shown in Appendix II and discussed in Chapter 10. Selected samples were further analysed by chemical, mineralogical, differential, thermal, X-ray and spectro-chemical methods. The purpose of these descriptions and analyses was to aid the mapping, characterization and classification of the soil series and to facilitate their correlation with similar soils elsewhere in Scotland.

5 | Soils

Fifty soil series have been distinguished in the area. Of these, eleven are common to south Ayrshire (Bown, 1973), while six have previously been found in south-east Scotland (Muir, 1956, Ragg, 1960, Ragg and Futty, 1967), three near Stirling (Shipley, in preparation) and two in the Dundee area (Laing, 1976). Twenty-four soil complexes have also been mapped, seventeen of which have previously been encountered in south Ayrshire (Bown, op. cit.). Other categories delineated are blanket peat, peat-alluvium, links, saltings and mixed bottom land. The soil series are grouped into ten soil associations.

The areas covered by the soil series and skeletal soils are shown in Table H, the horizontal lines containing soil series belonging to the same association and the vertical columns bringing together soils in the same major soil sub-group and drainage class. The areas of the soil complexes and the miscellaneous categories are given in Table I.

The relative extents of the various categories mapped can be calculated from the data in Tables H and I as percentages of the total area of 1432 square kilometres. The high proportion of land with irregular topography, often with frequent rock outcrops, is reflected in the number of soil complexes; they occupy 32 percent of the area. Peat and peat-alluvium cover a further 20 percent. Taken together these figures indicate that 40 to 50 percent of the land is hill or moorland of low natural fertility utilized mainly as rough grazing, where it is difficult and costly to operate improvement practices. Exceptional is the Achie complex, which occupies 11 percent of the area and is one of the more extensive map units; occurring mainly in the lowland zone, it carries either rough grazing of good quality or improved grassland.

Soil series have been mapped over 38 percent of the area, freely drained brown forest soils being the most extensive. Covering only 19 percent of the map area as a whole these soils represent about half the area mapped as series and about two-fifths of land other than the hill and moorland. Freely drained soils need no drainage and their extent is in part a reflection of the permeability of the related parent materials. The brown forest soils with imperfect drainage occupy 10 percent of the area and predominate on the Rhins Peninsula. Although the degree of gleying in these soils is often moderate, their relatively slow permeability makes the installation of under-drainage necessary if cultivation is to be successful. The brown forest soils, freely and imperfectly drained, together comprise most of the cultivated land in the area, approximately 30 percent of the total. Drainage is even more necessary on the poorly drained non-calcareous mineral gley soils. Soil series characterized by raw humus or peaty surface horizons have been mapped over only 4 percent of the

Table I. Areas of Soil Complexes and Miscellaneous Soils (square kilometres)

Association													
Darleith	Bennane 0·28												0·28
Rhins	Buyoch 26·32												26·32
Ettrick	Minnoch 0·24	Darnaw 32·64	Brochloch 27·52	Finlas 38·08	Stroan 4·08	Bush 26·20	Trool 45·28	Glenlee 32·76	Largmore 4·68	Achie 157·08	Corwall 2·28	Ervie 7·88	378·72
Dalbeattie	Twachtan 8·60	Garrary 21·32	Gala 6·92	Riecawr 0·56	Mullwharchar 1·32	Cairnsmore 0·56	Loch Fleet 4·72	Dinnins 1·08					45·08
Yarrow	Logan 0·16												0·16
Kirkcolm	Corsewall 0·24												0·24
Miscellaneous soils	Links freely drained 8·84	Links imperfectly drained 0·32	Links poorly drained 0·92	Links very poorly drained 2·08	Links complex 0·44	Dune sand 0·60							13·20
	Saltings 9·84	Peat 254·88	Peat-alluvium 35·36	Alluvium 78·64	Mixed bottom land 27·08	Lochs and reservoirs 8·00	Built-up Areas 8·32	Quarries Disturbed ground etc. 1·36					423·48
													887·48

area, the peaty gleys covering 2·1 percent, the peaty podzols 1·3 percent and the humus-iron podzols 0·2 percent. The sub-alpine soils are confined to the mountain tops and cover only 0·1 percent of the area. The remaining area is taken up by alluvium (6 percent) links (1·0 percent) saltings (0·7 percent) mixed bottom land (1·9 percent) and built up areas, lochs, reservoirs etc. (1·2 percent).

A comparison between Tables H and I and similar tables for south Ayrshire (Bown, 1973), south-east Scotland (Muir, 1956, Ragg, 1960, Ragg and Futty, 1967) and for north Ayrshire (Mitchell and Jarvis, 1956) shows a number of differences in the extent of soils in various categories reflecting changes in the soil forming factors between the regions. As in south Ayrshire the soil complexes are of large extent, 30 percent of the area, and reflect the prevalence of rugged drift-free areas in contrast to the rounded hills and talus-covered slopes of the eastern Southern Uplands and the thick till cover present in central and north Ayrshire. Peat, as in Carrick, occupies a high proportion (20 percent) of the area and is much more extensive than in the other areas mapped in south Scotland. In Wigtownshire this is partly on account of large areas of flat and depressional topography but it also reflects the high precipitation particularly in the north of the county. Brown forest soils are much more extensive (30 percent) than in Carrick (15 percent) but markedly less widespread than in other areas surveyed in south Scotland.

Eleven associations have been mapped, six of which have previously been described—four in the account of the south Ayrshire area (Bown, 1973), three in that of the east Borders (Ragg, 1960) and two in the accounts of the Stirling (Shipley, in preparation) and Perth and Arbroath (Laing, 1976) areas. Rhins, Barncorkrie, Creetown, Fleet, and Kirkcolm are new associations described for the first time. The Ettrick Association is the most extensive, occupying 41 percent of the area, and is followed by the Rhins (15 percent), Yarrow (6 percent), Dalbeattie (4 percent) and Stirling (1 percent) Associations. The Barncorkrie, Creetown, Fleet, Carbrook, Kirkcolm and Darleith Associations each cover 1 percent or less of the area.

In the account which follows the various associations and their component series are separately described.

Barncorkrie Association

The Barncorkrie Association is a new association and the soils may well be restricted to this area. It is one of the less extensive soil groupings, consisting of only two soil series and occupying 2·1 square kilometres or 0·1 percent of the area in the south of the Rhins Peninsula.

DISTRIBUTION

The association is restricted to one locality near Portencorkrie in Kirkmaiden Parish, and occurs in a small westward facing basin-shaped area formed by the weathering of the underlying granitic rock.

Table H. Areas of Soil Series (square kilometres)

Association	Brown forest soils		Humus-iron podzols	Peaty podzols	Non-calcareous gleys	Peaty gleys		Sub-alpine soils	Skeletal soils	Totals
	Series									
	Freely drained	Imperfectly drained	Freely drained	Freely drained below iron pan	Poorly drained	Poorly drained	Very poorly drained	Freely drained		
Rhins	Portencalzie 42·48	Rhins 72·32 Portpatrick 48·56	Mull 0·44	Auchleach 1·36	Ardwell 5·68 Balscalloch 13·56	Glenstockadale 3·36 Lochnaw 0·76				188.52
Barncorkrie	Portencorkrie 0·88	Barncorkrie 1·24								2·12
Ettrick	Linhope 136·88	Altimeg 7·80 Kedslie 10·40		Dod 13·76	Littleshalloch 14·32 Ettrick 2·28		Dochroyle 20·68		ERZ 0·28	206·40
Creetown	Clanery 5·24	Arkland 0·60		Falbae 1·00	Greenburn 4·60		Creetown 3·24			14·68
Dalbeattie	Dalbeattie 0·16			Carsphairn 2·24		Eglin 1·68		Mulltaggart 1·28	DEZ 1·52	6·88

Fleet	Fleet 2·36			Glenquicken 0·08							2·44
Yarrow	Yarrow 59·52 Cairnside 19·44	Carsnaw 0·16 Galdenoch 2·68 Cailliness 0·28	Knockarod 1·04 Larbrax 0·68		Innermessan 1·84 Dinduff 3·24						88·88
Carbrook		Harviestoun 1·36			Carbrook 1·00						2·36
Stirling					Stirling 11·96 Newton Stewart 4·28 Fordel 4·12	Poldar 0·96					21·32
Kirkcolm	Kirkcolm 7·84 Clachan 0·76 Kirranrae 0·68	Dally Bay 0·36			Drummore 0·20 Portlong Bay 0·64						10·48
Totals	276·24	145·76	2·16	18·44	67·72	6·76	23·92	1·28	1·80		544·08

PARENT MATERIAL

Most of the granitic rocks in the Barncorkrie area have been overlain by till which forms the parent material of the association. The till is a reddish brown loam to clay loam with a stone content comprised of a mixture of greywackes derived from the surrounding country rocks and granites and granodiorites incorporated from the underlying intrusion. The material resembles the till of the Rhins Association, having a similar texture and reddish brown colour but has been distinguished because of its content of granitic material. As in much of the Rhins till at low elevation, the surface till layers appear to be partially water-sorted and are rather coarser in texture than the underlying unaltered material.

SOILS

Two series only have been distinguished in this association; the Portencorkrie series, a freely drained brown forest soil, occurs where the upper horizons are clearly water-sorted and the Barncorkrie series, an imperfectly drained brown forest soil with gleyed B and C horizons, where watersorting of the surface layers is slight. Apart from a narrow belt along the southern edge of Barncorkrie Moor all the association area is cultivated in a rotation of long ley grassland, roots and grain.

PORTENCORKRIE SERIES

The Portencorkrie series covers 0·9 square kilometres, 41·5 percent of the association. It is a freely drained brown forest soil found mainly on the gently sloping land south-west of Knockencule Farm. It also occurs on the lower slopes of the surrounding higher ground where the parent tills are often shallower, more stony and less fine in texture than is normal. As almost the entire area of this series is cultivated, nothing can be said about the natural vegetation.

Profile Description

Slope:	3°
Vegetation:	arable grassland
Drainage:	free

Horizon	*Depth*	
Ap	0–22 cm	Very dark greyish brown (10YR3/2) loam to sandy loam; moderate medium blocky; friable; organic matter moderate; roots many; stones few; no mottles; moist. Sharp change over 2·5 cm into
B_2	22–32 cm	Brown (7·5YR4/2) sandy loam; massive; firm; organic matter low; roots few; stones few; no mottles; moist. Clear change over 5 cm into
B_3	32–45 cm	Brown (7·5YR4/3) sandy loam; massive; firm; no organic matter; roots rare; stones few; a few fine faint ochreous mottles; moist. Clear change over 5 cm into
B_3/C	45–70 cm	Reddish brown (5YR5/4) sandy loam; massive; indurated; no organic matter; no roots; stones frequent; a few fine distinct ochreous mottles; moist. Gradual change over 10 cm into
C	70+ cm	Reddish brown (2·5YR4/3) loam; massive; firm; no organic matter; no roots; stones frequent; no mottles; moist.

The Ap horizon has been well mixed by ploughing and the organic matter, which is present in moderate amount, is intimately mixed with the mineral matter in the mull form. The moderate medium blocky structure and friable consistence of the surface layer contrasts with the massive structure and firm, or occasionally indurated, consistence of the underlying layers. The B horizon does not show the bright ochreous colours which often characterize freely drained soils, and the faint traces of mottles occurring below 32 cm in the profile described above indicate that in gently sloping situations the drainage is only moderately free. The sandy loam textures in the B and upper C horizons are the result of considerable modification by watersorting in the upper layers. Compaction or induration of the modified layers is less pronounced where they are relatively shallow over unaltered till.

Land use

These soils, like much of the land on the Rhins of Galloway, are utilized for dairy farming based on long ley grassland with short breaks in turnips or potatoes, and barley or oats. The soils are suitable for a wide range of crops with some slight limitations imposed by compaction in the subsoil layers. The climate is relatively favourable to arable cropping with *warm fairly dry* summers and *extremely mild* winters. The area, however, is exposed and sometimes persistent sea mists in the late summer can adversely affect harvests.

BARNCORKRIE SERIES

The Barncorkrie series occupies a small area, 1·2 square kilometres, or 58·5 percent of the association, around Barncorkrie and Knockencule Farms. It has been classified as a brown forest soil with gleyed B and C horizons and the natural drainage is imperfect with waterlogging mainly near the surface because of the slow rate of percolation to the subsoil. Slopes are generally moderate and the entire area has been cultivated.

Profile Description

Slope:		7°
Vegetation:		arable grassland with *Lolium perenne, Holcus lanatus, Cynosurus cristatus, Anthoxanthum odoratum, Trifolium repens, Rumex acetosella,* and *Senecio jacobea*
Drainage:		imperfect
Horizon	*Depth*	
Ap	0–22 cm	Very dark brown (10YR2/2) loam; moderate medium blocky breaking to crumb; friable; organic matter high; roots abundant; stones frequent; no mottles; moist. Clear change over 5 cm into
B_2g	22–45 cm	Pale brown (10YR6/3) loam; weak blocky; firm; organic matter low; roots rare; stones frequent; many coarse prominent strong brown (7·5YR5/6) mottles; moist. Clear change over 5 cm into
B_3g	45–73 cm	Reddish brown (5YR4/3) clay loam to sandy clay loam; coarse prismatic, with widely spaced prominent structural cracks extending downwards to 100 cm, faces pinkish grey (7·5YR6/2); firm; no organic matter; no roots; stones frequent, some large rotten granite; frequent medium distinct strong brown (7·5YR5/6) mottles; moist. Gradual change over 10 cm into

Horizon	*Depth*	
Cg	73 + cm	Reddish brown (5YR5/3) clay loam to sandy clay loam; very coarse prismatic; firm; no organic matter; no roots; stones frequent; frequent medium distinct pinkish grey (7·5YR7/2) mottles, some dark manganiferous staining; moist.

The organo-mineral plough layer has a moderate to high organic content. The sharp change into the underlying B horizon is caused by ploughing. The upper part of the Bg horizon has been modified by partial watersorting, and the consequent lower clay content probably accounts for the weak blocky structure that contrasts with the coarse prismatic structure of the B_3g horizon. This B_2g horizon, immediately below the plough layer, is also the most prone to waterlogging and in it gley features are most strongly developed although the paler red colours are in part associated with the till modification.

Apart from some gleying, the unmodified clay loam till of the B_3g and Cg horizons appears little altered by processes of soil formation, although the relatively wide and deep structural cracks possibly represent the fossil remnants of ice wedges formed during the period of periglacial conditions. The material in the cracks is generally paler and more strongly gleyed than the main matrix. This tends to confirm that percolation from the surface is easiest through those relict features which, during periods of high precipitation, are more readily waterlogged than the more slowly permeable bulk of soil. The unmodified till of the B_3g and Cg horizons appears to have a relatively higher bulk density and few coarse pores, making root penetration and proliferation difficult.

Land Use

Like much of the surrounding area these soils are utilized for dairy farming based on long grass leys with short breaks in roots and grain. The soils are fairly well suited to a wide range of crops, but care in management has to be exercised at some seasons because of slow permeability and surface waterlogging. Systematic under-drainage is necessary for efficient land use. The climate is similar to that of the Portencorkrie series and is generally favourable to arable agriculture. Summers are *warm and fairly dry* and winters *extremely mild*, but the area is *exposed* and can suffer from persistent sea mists in late summer. There may thus also be some climatic restriction on farm operations.

Carbrook Association

Occurring in only a few small scattered localities the Carbrook Association is one of the least extensive soil associations in the area. It occupies 2·4 square kilometres or 0·2 percent of the area and comprises only two soil series. The association is, however, more extensive in the Dundee and Stirling areas where it was originally mapped.

DISTRIBUTION

Soils of this association occupy small areas near Stranraer, to the north of Galdenoch Moor, near Sandhead, and near Garlieston, with a very minor occurrence north of Drummore at Terally.

PARENT MATERIAL

Soils of the Carbrook Association are developed on red, virtually stone-free, clay deposits which occasionally contain shell remains or give some indication of lamellar structure. The deposits occur at or below 30 m (100 feet) elevation, generally in association with coarse-textured raised beach or glacial outwash materials. The material comes from fine particles of the reddish brown tills of the Rhins Association which were washed into shallow lakes or lagoons; it is from these that the red colour has been inherited.

SOILS

Of the two series mapped in this area, Harviestoun series, the brown forest soil with gleyed B and C horizons, is the more extensive; Carbrook series, the poorly drained non-calcareous gley, is restricted to a small area near Garlieston.

HARVIESTOUN SERIES

Occurring in scattered patches, the Harviestoun series occupies only 1·4 square kilometres, 57·6 percent of the association. The soil is only slowly permeable and natural drainage is imperfect with waterlogging near the surface common in winter months. The profile is classified as a brown forest soil with gleying in the B and C horizons. All the area of this series has been cultivated and carries long ley grassland.

Profile Description

Slope:	level
Vegetation:	arable grassland
Drainage:	*imperfect*

Horizon	*Depth*	
Ap	0–20 cm	Dark brown (10YR4/3) clay loam; moderate medium subangular blocky; slightly friable; roots many; organic matter moderate to low; no stones; a few fine diffuse yellowish red (5YR4/6) mottles; moist. Sharp change over 1 cm into
B_2g	20–42 cm	Reddish brown (5YR5/4) clay; strong coarse prismatic, with brown (7·5YR5/2) structural surfaces; very firm; organic matter low; roots frequent; no stones; frequent medium distinct strong brown (7·5YR5/8) mottles; moist. Gradual change over 10 cm into
B_3g	42–67 cm	Reddish brown (5YR5/3) clay; moderate coarse prismatic; very firm; no organic matter; roots rare; no stones; frequent medium faint dark brown (7·5YR4/4) mottles along old root channels; moist. Gradual change over 12 cm into
Cg	67+ cm	Brown (7·5YR4/4) clay; massive; very firm; no organic matter; no roots; no stones; a few medium grey (N7/0) mottles along old root channels and abundant manganiferous staining; moist.

The surface organo-mineral Ap horizon is generally of only moderate or shallow depth, and despite long periods under grassland has only low or moderate organic matter content. The subangular blocky structure is moderately stable and well developed under normal conditions, but is liable to considerable change if worked when the moisture content is unfavourable. The zone of maximum gleying and waterlogging is in the upper part of the Bg horizon where mottles are frequent and quite distinct despite the tendency of the reddish brown colours of the parent material to be somewhat resistant to the effects of gleying. Structural cracks are well developed but peds are coarse with only very fine internal pores. The brown or reddish brown parent material is generally massive in structure and shows little sign of pedological alteration other than some gleying along old root channels, probably of *Equisetum* spp., and some manganiferous segregations.

Land use

The series occurs at moderate elevations and under a relatively favourable climate. The area is characterized as *warm rather dry lowland* or *warm moist lowland*, but it is also *exposed* and average annual rainfall is 1000–1250 mm. The main restriction on land use is wetness in the surface soil layers due to the slow permeability of the subsoil. Efficient under-drainage, whether tiles or some other system, is essential to the proper utilization of this soil. Old tile and brick workings are found in several areas on this series, indicating that the deposit is suitable for the manufacture of bricks and tiles and possibly acknowledging that the soil itself had a drainage problem.

CARBROOK SERIES

A non-calcareous gley soil, the Carbrook series, like the Harviestoun series, is of small extent, occupying 1·0 square kilometres or 42·4 percent of the association. It is restricted to localities near Garlieston and the Isle of Whithorn. The natural drainage is poor and gleying, caused by surface waterlogging, is most intense in the upper soil layers. The entire area of this soil is utilized for arable grassland. The parent material is the reddish brown lacustrine clay characteristic of the association.

Profile Description

Slope:	level
Vegetation:	long ley grassland
Drainage:	poor

Horizon	*Depth*	
Ap	0–15 cm	Dark greyish brown (10YR4/2) clay loam; moderate medium subangular blocky; friable to slightly firm; organic matter low to moderate; roots many; stones few; a few fine faint reddish brown (5YR5/4) mottles; a few earthworms; moist. Clear change over 5 cm, with undulating boundary, into
A_2g	15–37 cm	Dark reddish grey (5YR4/2) clay; moderate coarse prismatic; firm; organic matter low; roots frequent, largely confined to structural cracks; stones few; frequent medium distinct yellowish red (5YR5/6) mottles and pinkish grey (5YR6/2) faces on structural units; moist. Gradual change over 7 cm into
Bg	37–87 cm	Reddish brown (2·5YR5/4) clay; weak coarse prismatic; firm; no organic matter; roots few; stones few; frequent medium distinct pinkish grey (5YR6/2) mottles; moist. Gradual change over 12 cm into

Horizon	*Depth*	
Cg	87 + cm	Reddish brown (2·5YR4/4) silty clay; massive with slight tendency to lamination; firm; no organic matter; no roots; frequent to few faint pinkish grey (5YR6/2) mottles; moist.

As with the Harviestoun series the plough layer is generally shallower than in most cultivated soils. This may be partly accounted for by the rather tenacious plastic nature of the underlying clay which does not readily break down or weather when brought to the surface, so that deep ploughing is generally avoided. Under grassland the structure of the surface layer is moderately stable, but owing to the high clay and low organic contents is liable to deteriorate under arable conditions. Gleying conditions are most intense in the A_2g horizon but the relatively weak development of grey colours may be ascribed to the resistance of red parent materials to alteration under wet conditions. Prismatic structure is moderately developed and water movement is largely confined to the pattern of coarse structural cracks; the pores within the structural units are very fine.

The B horizon appears to be little altered by pedologic processes, apart from the formation of prismatic structure and development of ochreous and grey mottling. These features can still occur in the Cg horizon but in a much weaker form.

Land use

The inextensive area of this soil is utilized for long ley grassland under the system of dairy farming usual on the Rhins and Machars of Wigtownshire. The climate is characterized as *warm fairly dry lowland* and the area is *exposed.* The main restriction on land use is surface waterlogging and an effective system of tile or other drainage is essential for efficient farming of this soil. With good artificial drainage the soil is fertile and well suited to grass production. Grazing, however, has to be carefully controlled to prevent 'poaching', particularly in spring and autumn, and so the length of grazing season may be restricted. Although arable cropping is possible and reasonable yields can be expected, cultivation is practised infrequently.

Creetown Association

The Creetown Association has been established and mapped for the first time in this area, but it will probably also be found in the area immediately to the east. Soils of the association are developed on parent material of mixed greywacke and granite origin and are unlikely to be encountered away from the vicinity of the Galloway granites. In the area of this memoir the soils are confined to valley and foothill locations, occupying 14·7 square kilometres or 1·0 percent of the association. Five soil series have been recognized of which the brown forest soil Clanery series is the most extensive, although in gently sloping situations the non-calcareous gley Greenburn series and the peaty gley Creetown series predominate. Apart from the admixture of some granitic detritus in the parent materials the soils of the Creetown Association closely resemble those of the Ettrick Association developed on stony drifts.

DISTRIBUTION

The Creetown Association occurs east of the River Cree and to the south of Cairnsmore of Fleet, where ice moving off the area of the granite outcrop and across the greywackes has given rise to a till of mixed origin. The mixed drifts have been deposited mainly along the lower slopes of the middle and upper parts of the valleys of the Moneypool Burn, the Skyre Burn and the Water of Fleet. Scattered morainic mounds of similar drifts also occur on the moor south of the Graddoch Burn and on the slopes above Falbae.

PARENT MATERIALS

The parent materials of the Creetown Association are tills or moraines of loam to sandy loam texture consisting of a mixture of granite and greywacke detritus. Most of the drift appears to be of greywacke origin, with some admixture of granite stones and many angular particles of feldspar and quartz derived from the disintegration of granite. The relative proportions of the greywacke and granite in the materials, however, show considerable variation even over short distances but the content of granite is generally greatest in the drifts nearest the granite outcrop, particularly the deeper tills in the valley bottom.

The topography and depth of the till and drift deposit is also varied. Concave slopes are common along the Skyre Burn, with shallow tills on the middle slopes and deeper deposits in the valley bottom; both middle slopes and valley bottoms have predominantly poorly drained soils. Around Glenquicken and Mark the drift often occurs as mounds amongst gravels, shallower drifts and peats, giving rise to a complex pattern of freely and poorly drained soils. On the convex and moderately steep slopes above Creetown the drift is shallow and the soils are generally freely drained. The materials usually have a fairly high content of stones, ranging in size from gravel to large boulders. In uncultivated areas there is often a layer of fairly large stones just below the topsoil. On the convex slopes of valley sides and the upper parts of concave slopes the underlying greywacke rock is often near the surface.

SOILS

Five soil series have been distinguished in the association, three of major importance, accounting for 90 percent of the association area, and two of relatively minor occurrence. All the soils occur in situations marginal to hill and moorland and all are strongly leached and acid with fairly low fertility. Reclamation and improvements have been effected in some areas, but not extensively. Somewhat more than 50 percent of the association area is occupied by soils with poor and very poor drainage.

The freely drained brown forest soil Clanery series, the most extensive in the association, occurs mainly on the steep slopes and mounds along the Moneypool Burn above Creetown and together with the small areas of Arkland series, an imperfectly drained brown forest soil with gleyed B and C horizons, it accounts for most of the arable grassland in the association.

The poorly drained non-calcareous gley soil, Greenburn series, and the very poorly drained peaty gley, Creetown series, each occupy about a quarter of the association. A few small areas of the Greenburn series have been drained and cultivated, but the area covered by both soils is mostly rough grazing or moorland.

The peaty podzol Falbae series is of minor extent and occurs mainly on morainic mounds south of the Graddoch Burn, with a few areas on steep slopes near Upper Rusko.

CLANERY SERIES

Although it is the most extensive soil in the association, the Clanery series occupies a relatively small area, 5·2 square kilometres or 35 percent of the association. The soils are developed on the moderately coarse stony drifts and tills in which granitic detritus appears to contribute significantly to the main bulk of material of greywacke origin. Classified as a brown forest soil of low base status with free natural drainage, the soil closely resembles the Linhope series. The series is found mainly along the Moneypool Burn, where shallow drifts occur on moderately steep slopes, and on mounds of till or moraine around Clanery and Mark. The natural vegetation is generally a form of bent-fescue grassland with bracken (*Pteridium aquilinum*) or, near Cairnsmore House, oakwood with bluebell (*Endymion non-scriptus*).

Profile Description

Slope:		5°
Vegetation:		permanent grassland with *Cynosurus cristatus, Lolium perenne, Holcus lanatus, Agrostis* spp., *Trifolium repens, Festuca* spp., *Cerastium holostoides, Ranunculus repens*
Drainage:		free
Horizon	*Depth*	
Ap	0–20 cm	Dark brown (10YR3/3) loam; moderate medium subangular blocky; friable; organic matter moderate; roots many; stones frequent; no mottles; moist. Clear change over 3 cm into
B_2	20–30 cm	Strong brown (7·5YR5/8) sandy loam; weak fine subangular blocky; friable; organic matter low to moderate; roots frequent; stones frequent; no mottles; moist. Gradual change over 7 cm into
B_3	30–50 cm	Yellowish brown (10YR5/4) sandy loam; weak blocky; friable; roots few; organic matter low; stones frequent; no mottles; moist. Merging change over 7 cm into
C	50+ cm	Greyish brown (10YR5/2) clay loam; massive; compact; no organic matter; no roots; very stony; no mottles; moist.

The main features of the profiles are typical of the brown forest soils with free natural drainage. The brown organo-mineral surface horizon is moderately deep, with well developed structure and friable consistence. The organic matter is of the mull form and probably reflects mixing during occasional periods of cultivation; shallow mor humus layers 2–3 cm thick have, however, been observed in a few locations above 180 m (600 feet). Readily extractable sesquioxides appear to be present in high amounts in the B horizon and are probably partly responsible for the friable consistence of this layer. The stable structure and high porosity of the B horizon allow moisture to penetrate readily and roots to proliferate. The soil is generally stony but the amount and size of stones is very variable; the effect on cultivation is greatest where there is a significant proportion of large stones or small boulders near the surface. The parent material is of sandy loam texture and generally the structure is massive whilst the consistence ranges from friable to indurated.

Land use

Like all the soils of the association in this area, this series occurs in locations marginal to hill and moorland areas, where it forms some of the better land in the locality and is utilized for 'in bye' grazing of sheep and cattle. The grassland has generally been improved by fertilizers and ploughing, but is usually maintained for long periods without renewal. Small patches of the series isolated amongst moorland soils or occurring on very steep slopes are mostly unimproved, while some areas adjoining other improved land, as near Creetown, are farmed in an arable rotation.

The principal features restricting use are the climate of the district and the stoniness of the soil. The climate has been characterized as *warm to fairly warm, rather wet lowland and foothill, moderately exposed* with rainfall rising to 1500 mm in some areas. The degree of stoniness and its effect on cultivation is varied, but is generally greatest in marginal and hill areas.

ARKLAND SERIES

Arkland series occupies only 0·6 square kilometres, or 4·1 percent of the association. The profile has been classified as a brown forest soil with gleyed B and C horizons and the natural drainage is imperfect. The soil is found in two areas—near Creetown, on gentle slopes above Spittal, and near Arkland, where it occurs in a few small patches. The parent material is a sandy loam drift derived from greywacke with some granite; it is generally stony and of variable depth. Much of the series has been intermittently cultivated but under semi-natural conditions the vegetation is generally a form of bent-fescue acid grassland with some rush species present.

Profile Description

Slope:	4°
Vegetation:	improved grassland with *Lolium perenne, Holcus lanatus, Juncus articulatus, Trifolium repens, Ranunculus* spp.
Drainage:	imperfect

Horizon	*Depth*	
Ap	0—25 cm	Dark greyish brown (10YR4/2) loam; moderate medium blocky; friable; organic matter moderate; roots abundant; stones frequent; a few distinct dark reddish brown (5YR3/4) mottles along root channels; moist. Clear change over 4 cm into
B_2g	25—75 cm	Olive-grey (5YR5/2) sandy loam; weak coarse blocky; slightly firm; no organic matter; roots few; stones frequent; frequent medium prominent yellowish red (5YR5/6) mottles; moist. Clear change over 5 cm into
B_3g/Cg	75 + cm	Grey (5Y6/1) loam to sandy loam; massive; indurated; no organic matter; no roots; stones frequent; a few coarse distinct brown (7·5YR5/4) mottles; moist.

The intensity of gleying and degree of waterlogging are relatively high and like many brown forest soils with gleyed B and C horizons the profile morphology shows marked similarities to that of the gley soils. The profile contrasts with that of the freely drained Clanery series. The A horizon has a low chroma, with distinct fine mottling often present along root channels. Grey colours with distinct mottling predominate in the Bg horizon. Grey parent materials readily acquire strong gley morphology in contradistinction to brown or red materials which are not greatly changed. Although the upper soil layers are of moderately coarse texture and permeable to moisture, induration and massive structure in the B_3g/Cg horizon largely prevents water movement downwards.

Land use

The areas of this series on the moderately gentle slopes near Spittal are generally maintained as grassland but are occasionally cultivated for root or grain crops. The principal restrictions on land use are the impeded natural drainage, the highly stony nature of the soil, and the climate of the district. This has been characterized as *warm rather wet lowland, moderately exposed.* An efficient system of under-drainage, whether tile or some other form, is necessary to allow cultivation and the maintenance of good grassland on this soil.

FALBAE SERIES

Falbae series is one of the less extensive in the area covering only 1·0 square kilometres or 6·8 percent of the association. The profile is classified as a peaty podzol. While aeration and conditions of natural drainage seem to be good in the B horizon, the organic and A_2g soil horizons apparently remain wet or very moist for long periods. Like the Clanery series, the Falbae series occurs on both morainic mounds of moderately coarse-textured material south of the Graddoch Burn and on shallower stony drifts on steep hillsides near Upper Rusko. The parent materials are derived mainly from greywacke with a significant admixture of granite. The vegetation is generally a form of wet heath moor or flying bent (*Molinia*) grassland.

Profile Description

Slope:	14°
Vegetation:	*Calluna valgaris, Molinia caerulea, Agrostis canina, Festuca ovina, Campylopus flexuosus*
Drainage:	free below the iron pan

Horizon	*Depth*	
H	17–0 cm	Black (N2/0) slightly fibrous peat; weak subangular blocky; non-sticky; roots many; wet. Sharp change over 2 cm into
A_2g	0–5 cm	Very dark grey (5YR3/1) sandy loam; weak subangular blocky; friable to slightly firm; organic matter moderate; roots frequent; no mottles; moist. Very sharp change over undulating boundary into
B_1	5 cm	Iron pan—dark reddish brown (5YR2/2). Very sharp change into
B_2	5–17 cm	Strong brown (7.5YR5/6) gritty sandy loam; very weak medium subangular blocky; friable; organic matter low; roots few; stones, greywackes and granites, frequent; no mottles; moist. Gradual change over 10 cm into

Horizon	*Depth*	
B_3	17–45 cm	Yellowish brown (10YR5/4) gritty sandy loam; weak blocky; slightly friable; organic matter low; roots few; stones frequent, some large; no mottles; moist. Gradual change over 10 cm into
C	45+ cm	Light yellowish brown (10YR6/4) gritty sandy loam; massive; slightly indurated; no organic matter; no roots; stones frequent; no mottles; moist.

The peaty surface layer is well developed and generally more than 15 cm thick while the L and F horizons are often absent, destroyed by the practice of muirburn. It would seem that organic matter from the peaty layer has been washed into the grey A_2g horizon where, analyses indicate, it is present in moderate to high amounts. The distribution of the organic material, however, seems to be uneven, with concentrations in cracks and above the iron pan, and the mineral and organic materials appear to be in a loose association rather than in an intimate organo-mineral complex.

The iron pan is usually strongly developed and prevents both root and moisture penetration, but sometimes the pan is weak or intermittent or distinguished only by the very sharp irregular boundary between the A_2g and B_2 horizons. Below the pan the colour of the B horizon is generally uniform and of high chroma, but some profiles have been encountered where patches with pale colours and lower chroma, and patches with redder colours, occur directly beneath the B_1 horizon. Such patches suggest incipient gleying consequent on increased wetness of the surface layers or a breakdown of the iron pan. Structure in the B horizon is often weak but the layer is friable and easily penetrated by roots once the pan is ruptured.

The parent material appears to be little altered by processes of soil formation and is generally compact or indurated, thus preventing root penetration below the B horizon.

Land Use

This soil is used as unenclosed rough grazing for hill sheep and cattle. The climate is classed as *fairly warm rather wet lowland and foothill, moderately exposed.* The main restrictions on land use include wetness, low fertility and high acidity associated with the peaty layer, together with the unfavourable climate responsible for the development of these conditions.

GREENBURN SERIES

A non-calcareous gley soil, the Greenburn series covers 4·6 kilometres, or 31·3 percent of the association. The soil occurs in two topographic situations; around Greenburn and Glenquicken it occupies gently sloping depressional sites, whereas in the Skyreburn Valley it is commonly found on steeper concave slopes. The natural drainage has been classified as poor, but there are small local occurrences of non-calcareous gley soils with very poor drainage; these have not been delineated separately. The parent material is generally a sandy loam and induration of the Bg or Cg horizons is uncommon. The moderately coarse texture of the soil and general absence of a pan allows the ready percolation of moisture down the profile with the result that waterlogging is usually of the ground water type. On steeper slopes, however, the soil may be associated with spring lines and telluric water. A few small areas of the soil have been cultivated, but the vegetation is generally a form of sharp-flowered rush (*Juncus acutiflorus*) pasture.

Profile Description

Slope:		1°
Vegetation:		*Juncus acutiflorus, Molinia caerulea, Ranunculus acris, Hylocomium splendens, Thuidium tamariscinum*
Drainage:		poor
Horizon	*Depth*	
A_1g	0–15 cm	Very dark greyish brown (10YR3/2) loam; weak medium subangular blocky; slightly plastic; organic matter high; roots many; stones frequent; no mottles; wet. Clear change over 3 cm into
A_2g	15–23 cm	Greyish brown (10YR5/2) loam to sandy loam; weak blocky to massive; slightly plastic; organic matter low; roots frequent; stones frequent; a few fine faint yellowish brown (10YR5/4) mottles; wet. Clear change over 5 cm into
B_2g	23–37 cm	Greenish grey (5GY6/1) sandy loam; massive; slightly plastic; organic matter low; dead roots frequent; stones frequent; small weathering greywackes, some granites; frequent coarse prominent strong brown (7.5YR5/6) mottles; wet. Clear change over 5 cm into
B_3g	37—60 cm	Greenish grey (5GY6/1) sandy loam; massive; slightly plastic; no organic matter; dead roots frequent; stones frequent; frequent medium faint olive-brown (2.5Y5/4) mottles; wet. Gradual change over 10 cm into
B_3g/Cg	60+ cm	Greenish grey (5G5/1) sandy loam; massive; firm to slightly plastic; no organic matter; roots few; stones frequent; frequent fine prominent yellowish red (5YR4/6) mottles along old root channels; moist to wet.

Under conditions of relatively high acidity (pH 4·5–5·0), a surface layer of raw or mor humus up to 5 cm accumulates, but more usually the organic and mineral matter are intimately mixed. The organic accumulation is mainly in the top 15 cm of soil, the A_1g horizon, with relatively low amounts in the next 10 cm, the A_2g horizon. This layer is a very pale grey and is strongly leached of readily extractable iron compounds, although there are a few fine ochreous mottles. Occasionally pale colours in the Bg and Cg horizons reflect the strongly gleying conditions, but ochreous segregations of hydrous iron oxides are common, indicating that eluviation is less intense than in the immediate subsurface layers.

Soil structure is generally weak throughout the profile, apart from the surface organo-mineral layer where development of blocky or subangular blocky structure can be moderate. The predominance of weak structure in the profile is caused by the low contents of clay and organic matter in the subsurface layers and the absence of any accumulations of hydrous compounds of ferric iron. Since the soil is readily permeable, yet strongly gleyed into the Cg horizon, it is considered to be a ground water gley. Some profiles, however, were encountered in which the Cg horizons, while not compact or indurated, were markedly less wet or moist than the overlying layers. The soil is stony, and in the upper soil layers large stones are common and boulders are occasionally found.

Land use

Much of this series is utilized for rough grazing, but a few areas have been drained and are maintained as improved grassland with occasional arable crops. The area is *warm* or *fairly warm, rather wet lowland and hill* and is *moderately exposed.* Soil wetness associated with the poor drainage is the main restriction on land use and it is compounded to some extent by the high rainfall and moist climate.

CREETOWN SERIES

A peaty gley, the Creetown series occupies 3·2 square kilometres or 22·1 percent of the association. The soil is developed on a stony sandy loam till or drift derived from greywacke and granite material, and generally occurs on gently sloping land or in depressional sites. The natural drainage has been classed as very poor and the soil mapped as small scattered patches throughout the association area. As with other soils of the association the stone content is high and large stones are common in the A horizon immediately below the peaty layer. The vegetation is generally a form of wet heather moor or the subassociation with *Molinia caerulea* of blanket bog.

Profile Description

Slope:		4°
Vegetation:		*Calluna vulgaris, Molinia caerulea, Trichophorum cespitosum, Sphagnum* spp., *Hypnum cupressiforme*
Drainage:		very poor
Horizon	*Depth*	
H	17–0 cm	Very dark brown (10YR2/2) fibrous peat; weak crumb to subangular blocky; roots many; wet. Gradual change over 10 cm into
A_2g	0–12 cm	Grey (N/6) loam to sandy loam; weak blocky; slightly plastic; organic matter low; roots frequent; stones frequent; a few fine prominent strong brown (7·5YR5/8) mottles; wet. Clear change over 5 cm into
Bg	12–62 cm	Dark greyish brown (2·5Y4/2) loam; massive to weak blocky; slightly plastic; organic matter low; dead roots frequent; stones frequent, some large boulders; a few fine faint ochreous mottles; wet. Gradual change over 7 cm into
Bg/Cg	62+ cm	Greenish grey (5GY5/1) loam; massive; firm; no organic matter; roots few; stones frequent; a few fine faint ochreous mottles; moist.

The principal features of the profile are the well developed peaty surface layer and the grey, strongly eluviated mineral horizons. The peaty layer is generally 15–30 cm thick and commonly contains 40–60 percent mineral matter, often associated with water moving laterally downhill. The very few mottles that occur in the mineral soil horizons are mainly associated with weathering stones or old root channels. Eluviation of sesquioxides, probably under the influence of organic solutions, seems to be strongest in the pale grey A_2g horizon immediately below the iron pan. Grey and greenish grey colours persist down into the parent material. Soil structure is very weak throughout the profile, but because of the moderately coarse texture and absence of pan layers the soil is highly permeable to moisture and waterlogging apparently is commonly of the ground water type, with telluric and flush waters affecting soils on steeper slopes.

Land use

The entire area of the series is utilized as rough grazing for sheep and cattle, and opportunities for significant improvement are limited. The climate is classed as *fairly warm lowland and foothill, exposed* to *moderately exposed.* The main restrictions on land use are associated with the peaty surface horizons, principally the soil and climatic wetness which has led to the formation of the layers, together with high acidity and low fertility. When considering the improvement of acid peaty gley soils in areas of high rainfall, an important factor is the very high cost involved when only a limited degree of improvement can be maintained under the prevailing conditions of high rainfall and persistent soil wetness.

Dalbeattie Association

The Dalbeattie Association is the third most extensive in the area of which it occupies 52·0 square kilometres or 3·6 percent. Soils of the association were first recognized near Dalbeattie (Soil Survey of Great Britain, 1958) and subsequently near Carsphairn (Grant, in preparation). The association is extensive in Carrick (Bown, 1973); there it is found on and near the outcrops of the granites of Loch Doon–Loch Dee, of Cairnsmore of Carsphairn and of the north-western part of Cairnsmore of Fleet. The southern extension of the outcrop of Cairnsmore of Fleet is the site of the main occurrence of the association in the area under consideration. Inextensive areas of the association have also ben mapped in a few other small patches. As in Carrick, the soils occur mainly in remote and rugged situations where there are numerous rock outcrops and extensive spreads of peat. Almost all the soils have raw humus peaty surface horizons and occur in patterns which have given rise to soil complexes.

Formerly most of the association was utilized for grazing by hill and sheep cattle, but in recent years extensive areas have been afforested. Red deer and wild goats are found in significant numbers in the area covered by this association.

DISTRIBUTION

The major part of the association as described in this memoir lies in the north-eastern corner of the area in Kirkcudbrightshire. It covers the south-western part of the Cairnsmore of Fleet granite outcrop, extending northwards from the Clints of Dromore to Loch Grannoch and eastwards from the west-facing slopes of Cairnsmore of Fleet and the headwaters of the Palnure Burn to the eastern boundary of the area. Soils of the association mapped in other localities, principally on Culvennan Fell, Barncorkrie Moor and near Glenluce, occupy only very limited areas.

PARENT MATERIAL

The parent materials of the soils in the association are the Galloway granites and the materials derived from them. The rocks comprise true granites together with some associated less quartz-rich rocks such as tonalites and quartz-diorites. In this area the granite rocks generally form areas of high ground which have been eroded by ice, so that deposits of till or drift are either absent or very shallow. Areas of rock outcrop and slabs of bare rock are frequent and soil formation is often restricted to the accumulation of raw humus or peat on rock surfaces or on shallow highly leached rock debris in hollows between outcrops. Coarse-textured moraines which occur as mounds, up to 5–10 metres high as at Dromore Farm, comprise some of the few areas with relatively deep drift.

The detritus derived from granite is generally gritty, having many angular crystals of quartz and feldspar, and is of coarse or moderately coarse texture. Although analyses of the rock indicate a moderate content of bases, particularly of sodium and potassium, these are found mainly in the relatively stable minerals, such as feldspar and muscovite, and are only slowly released by weathering. Soils developed on these materials therefore are generally highly acid.

SOILS

Four soil series, eight complexes and some areas of skeletal soils have been mapped in the Dalbeattie Association. Three soil series and seven soil complexes have been described previously (Bown, 1973); the Mulltaggart series, mapped for the first time in this area, has been described in the Carrick area (Bown, op. cit.) as part of the Cairnsmore complex, while the Loch Fleet complex is a newly established map unit.

The predominance of rugged and uneven topography is reflected in the mapping of 90 percent of the association as soil complexes and only 10 percent as soil series. Under the high annual rainfall conditions, ranging up to 2250 mm per annum, in the association area peat has developed extensively and almost all the soils have a thick peaty surface layer. The brown forest soil, Dalbeattie series, occupies only 0·3 percent of the association as a mapped series, and as a component of a soil complex it occurs only in the inextensive Dinnins complex. Abundant rock outcrops characterize map units over about 50 percent of the association, while hummocky moraine accounts for over 16 percent. Significant areas are occupied by the peaty podzol, Carsphairn series, and the peaty gley, Eglin series. Carsphairn series occurs on steep hillsides where detritus is sufficiently thick to cover underlying rock, and also, as at Cullendoch, on some larger moraines. Eglin series has been mapped on some moderately steep middle and footslope areas, as well as on some concave upper slopes at the heads of valleys.

Except in recently afforested areas, all the soils carry semi-natural vegetation; only a few acres around Dromore Farm have been cultivated.

DALBEATTIE SERIES

The Dalbeattie series is one of the least extensive, occupying only 16 hectares or 0·3 percent of the association. The profile is classified as a brown forest soil and the drainage as free. The soil is developed on stony, frost-shattered granitic debris, generally on short steep hillsides. The vegetation is usually a form of bent-fescue grassland, often with abundant bracken (*Pteridium aquilinum*).

Profile Description

Slope: 16°

Vegetation: *Pteridium aquilinum, Poa pratensis, Galium saxatile, Potentilla erecta, Festuca ovina, Agrostis* spp.

Drainage: free

Horizon	*Depth*	
H/A_1	0–2 cm	Black (5YR2/1) humose loam; moderate medium crumb; friable; organic matter very high; roots many; stones few; no mottles; moist. Clear change over 3 cm into
A_1	2–30 cm	Dark brown (10YR4/3) sandy loam to loam; moderate fine crumb to subangular blocky; friable; organic matter moderate; roots many; stones many, including some large boulders; no mottles; moist. Clear change over 5 cm into
B_2	30–50 cm	Yellowish red (5YR4/6) gritty sandy loam; weak medium blocky; friable; organic matter low; roots few; stones many, including boulders; no mottles; moist. Gradual change over 7 cm into
B_3	50–65 cm	Strong brown (7·5YR5/6) gritty sandy loam to loamy sand; massive; indurated; organic matter low to moderate; no roots; stones many, including large boulders; no mottles; moist. Diffuse change into
C/D	65+ cm	Very large boulders or solid rock.

In the natural or semi-natural state this soil is generally strongly acid and there is some development of a thin layer of raw humus, an H horizon. Usually less than 3 cm thick, this layer varies in character from a slight increase in organic content in the upper few centimetres of the A_1 horizon to a thin but distinct organic layer. Where such surface organic accumulation is thin, it generally overlies a brown organo-mineral layer with the organic matter in the mull form and with no evidence of eluviation of sesquioxides, other than some bleaching of sand grains, and the soil is classified as a brown forest soil. Increased development and thickness of the raw humus layer generally leads to podzolization and formation of a grey A_2 horizon leached of sesquioxides. In Galloway, intergrade soils of transitional character between the brown forest soils and podzols are relatively uncommon, and it seems that where conditions favour the accumulation of raw humus beyond a shallow incipiently developed layer then the build-up to a 15–20 cm thickness is relatively rapid and the material takes on the character of a shallow peat layer.

The brown organo-mineral A_1 horizon generally has a moderate organic content with a well developed friable crumb or subangular blocky structure. On the steep or irregular slopes, common in this area, there is a considerable range of thickness of this horizon. The reddish brown hues observed in the B_2 horizon in Dalbeattie series soils in Carrick (Bown, 1973) are also found in the soils in this area. Although values for chroma seldom exceed 6, the horizon is generally well developed and apparently rich in sesquioxides. The content of organic matter found in this layer is often relatively high for the B horizon of a brown forest soil, and while the high values could be associated with eluviation of organic material from surface layers, there is also the possibility of some root or bracken-rhizome material having been incorporated in the samples analysed. Consistence in the B horizon is usually friable but blocky structure may be weakly developed. The subdivision of the B_2 layer observed in some profiles in Carrick is less common in this area.

The lower layers of the profile vary considerably depending on the depth and nature of the parent material. An indurated B_3 horizon is generally present, but may be absent where the soil is shallow, so that the friable B_2 horizon passes directly down into frost-shattered rock debris. The colour of the B_3 is usually a pale brown but higher chromas, suggesting some sesquioxide accumulation, have also been found.

Like the parent material the soil is generally of moderately coarse texture and stony, often with some large boulders. The profile is an important component of the Dinnins complex.

Land use

The land covered by this series is utilized as rough grazing for cattle and sheep, or has been afforested. The areas around the Cairnsmore of Fleet granite are classed as *warm, wet* or *fairly wet lowland and foothill,* and are *exposed.* Near Barncorkrie on the Rhins of Galloway conditions are characterized as *warm moist lowland.* The main restrictions on land improvement are the steep slopes and the stony, bouldery nature of the soil.

CARSPHAIRN SERIES

Although occupying only 2·2 square kilometres, 4·3 percent of the association, Carsphairn is the most extensive series, occurring mainly around Cairnsmore of Fleet and Cullendoch. The profile is classified as a peaty podzol and the natural drainage is generally free below the iron pan, although some examples have been encountered with incipient gleying in the sesquioxide-rich B horizon. The upper horizons tend to remain wet for long periods, and in these layers the natural drainage is imperfect or poor. The parent material is a stony sandy loam or loamy sand hillside drift or moraine derived from granitic rocks, while the topography is generally of moundy moraines or steep hillsides with convex slopes.

The soil is also a component of several soil complexes and in hillslope situations areas sufficiently extensive to be mapped as the series are generally found only where the drift cover is fairly thick and there are no rock outcrops. The vegetation is usually of wet heather moor although dry Atlantic heather moor has been encountered where the soil occurs as a component of a complex.

Profile Description

Slope:		5°
Vegetation:		Sitka spruce/lodgepole pine plantation—10 or more years old. *Calluna vulgaris, Molinia caerulea, Erica tetralix*
Drainage:		free below the iron pan
Horizon	*Depth*	
H	25–0 cm	Dark reddish brown (5YR2/2) slightly fibrous peat; weak fine subangular blocky; non-plastic; many roots; wet. Clear change over 2 cm into
A_2g	0–12 cm	Pinkish grey (7·5YR6/2) gritty sandy loam; massive to very weak blocky; firm; organic matter low; roots frequent; many stones; no mottles; moist. Sharp change over 1 cm into
B_1	12 cm	Very weak iron pan.
B_2	12–35 cm	Yellowish red (5YR5/8) gritty sandy loam; weak blocky to massive; slightly firm to friable; organic matter low; roots few and concentrated in festoons down occasional cracks; many stones; no mottles; moist. Gradual change over 7 cm into
B_3	35–52 cm	Yellowish brown (10YR5/4) gritty sandy loam; massive; firm; no organic matter; no roots; many stones; no mottles. Gradual change over 7 cm into
C	52+ cm	Light greyish brown (10YR7/2–6/3) gritty sandy loam to loamy sand; massive; indurated; no organic matter; no roots; many stones; no mottles; moist.

The peaty surface horizon is well developed, generally 15–30 cm thick, has a high waterholding capacity and remains wet for long periods. The wet peaty layer tends to maintain gleying conditions in the underlying mineral soil horizon, the A_2g horizon, which has a firm consistence and when dry is grey with some staining and streaks of organic matter, apparently washed in from the overlying peaty layer. When the soil of the A_2g is moist or wet the organic staining can largely obscure the grey colour, making the layer difficult to discern.

The iron pan is variable in character, particularly where the soil is on steep slopes under conditions of high rainfall, and over distances of a metre or so can change from a hard strong pan impenetrable to roots and moisture to a mere line of demarcation between the A_2g and the B horizon. The iron pan generally lies within 5–15 cm of the mineral soil surface but under very wet conditions it can be found at 50–100 cm depth. The B_2 horizon, as in the Dalbeattie series, is relatively red in hue while the chroma shows the high values typical of horizons probably affected by illuviation and rich in amorphous sesquioxides. Sometimes the layer seems weakly cemented and firm or compact rather than friable. Where the soil is developed on morainic materials the parent material is generally indurated throughout, but stony hillside drifts or tills are less uniform and although generally indurated or compact are not invariably so.

Around the Cairnsmore of Fleet a number of weakly developed iron pans have been encountered below which the B horizon has a variegated appearance. Colours of high chroma characteristic of sesquioxide-rich B horizons predominate, but paler olive and greyish brown colours also occur, particularly in the upper part of the layer, giving the impression that a formerly aerobic podzolic B horizon has become gleyed. If this is indeed so, the most probable explanation would seem to be increased soil wetness but whether caused by higher rainfall or by degree of development of the B horizon is unclear.

In the Twachtan complex a few areas are found where the raw humus layer is shallow (5–10 cm), the A_2 appears sandy and freely drained and the B horizon is organic-rich and sesquioxidic. These profiles in the Twachtan complex are the only examples so far encountered in south-west Scotland of humus-iron podzols developed on granitic materials.

Land use

The natural vegetation carried by the Cairsphairn series is used as rough pasture for sheep and cattle at low stocking densities. Several areas have been recently planted to forestry. The areas, characterized as *cool wet foothills and upland, exposed* or *very exposed,* are relatively unfavourable to improved forms of agriculture. The main soil limitations are the peaty surface layer and wetness above the iron pan.

EGLIN SERIES

Only a small area, 1·7 square kilometres or 3·2 percent of the association has been mapped as the Eglin series but it occurs also as a component in several soil complexes. Mainly found on gentle and moderately steep slopes with a cover of drift or till and no outcropping rock, the soil has also been mapped on a few fairly steep concave slopes at the heads of valleys. In the area considered in this memoir it is restricted to the locality around Cairnsmore of Fleet. The profile is classified as a peaty gley and the natural drainage as poor, although some patches with very poor drainage, too small to be significant, have also been included. The parent material is a moderately coarse-textured pale brown gritty sandy loam in which coarse sand particles of quartz and feldspar are prominent. Flying bent (*Molinia*) grassland and wet heather moor are the main vegetation types, but on concave slopes there is often considerable variation, with some form of sharp-flowered rush pasture present.

Profile Description

Slope:	7°
Vegetation:	*Molinia caerulea, Calluna vulgaris, Agrostis canina, Erica tetralix*
Drainage:	poor

Horizon	*Depth*	
H	30–0 cm	Black (5YR2/1) slightly fibrous peat; weak subangular blocky; non-sticky; many roots; wet. Clear change over 5 cm into
A_2g	0–25 cm	Light grey (10YR7/1) gritty sandy loam; very weak blocky; slightly friable; organic matter low; roots few; stones frequent; no mottles; moist. Gradual change over 10 cm into
B_2g	25–60 cm	Light brownish grey (10YR6/2–7/2) gritty sandy loam; massive to very weak blocky; sticky; no organic matter; roots few; stones frequent; a few fine faint ochreous mottles; wet. Gradual change over 7 cm into
Bg/Cg	60+ cm	Pale brown (10YR6/3) gritty sandy loam; massive; indurated; no organic matter; no roots; stones frequent; a few fine faint ochreous mottles; moist.

The black peaty surface layer contrasts with the strongly gleyed A and B layers that overlie the pale brown indurated parent material. The peaty H layer is generally thick and slightly less thick than the 30–35 cm in areas mapped as peat. On footslopes and on concave slopes hill wash has sometimes resulted in the incorporation of considerable amounts of mineral matter with the peat. The mineral layers overlying the parent material are grey, but the A_2g horizon immediately below the peaty layer is paler than the underlying B_2g horizon and resembles the A_2g of the peaty podzol Carsphairn series; leaching of sesquioxides in this horizon is intense in both series. Sesquioxides have also been strongly removed from the B_2g horizon which is grey or greyish brown, occasional fine mottles being the only trace of the oxidized forms of iron. Structure in both A and B horizons is extremely weak and textures are generally gritty sandy loam.

The parent material is also grey or greyish brown in colour but is generally indurated, and while there is some ochreous mottling the soil appears less altered by gleying than the overlying layers. Conditions in the deeper layers of this series are, however, somewhat variable and where induration is absent or the drift shallow, gleying can extend downwards for considerable depths or even to bedrock.

Land use

The vegetation is of a relatively low yielding semi-natural type and is utilized as unenclosed rough grazing for hill sheep and cattle. Some areas have been afforested. The area has been characterized as *cool wet foothill and upland* and as *exposed* or *very exposed.* Restrictions on the use of this soil are severe and improvements are not as a rule feasible. The wet conditions associated with the peaty surface and upper horizons of the soil profile make any improvement difficult and extremely expensive, while the unfavourable climatic factors restrict the degree to which improvement can be effected.

MULLTAGGART SERIES

Mulltaggart series is of very limited occurrence in this area, being found only on the summit of Cairnsmore of Fleet at an elevation over 550 m (1800 feet), where it totals 1·3 square kilometres, 2·5 percent of the association. Although not designated as a series, the soil was described in the Carrick area as the main component of the Cairnsmore complex, a complex also found to a limited extent in this area. The soil is classified as a sub-alpine soil and the natural drainage is generally free, but slight gleying and incipient waterlogging which have not been separately delineated can also occur. The parent material is generally very shallow, extremely stony, frost-shattered rock debris derived from granite. The pale brown fine sandy loam fine material occurring in the comparable Merrick series in Carrick has not been encountered in this series in this area. Stone stripes, large solifluction terraces and 'ploughing boulders' are often associated with soils of this series and frost appears to be an important influence on their formation. The vegetation of the Mulltaggart series is generally brown bent-woolly fringe moss heath with mountain heath rush moor in areas affected by snow-banks or somewhat impeded drainage. *Salix herbacea* also occurs characteristically on soils of this sub-group.

Profile Description

Slope:	2°
Vegetation:	*Vaccinium vitis-idaea, Vaccinium myrtillus, Salix herbacea, Carex bigelowii, Rhacomitrium lanuginosum*
Drainage:	free

Horizon	*Depth*	
H/A	0–3 cm	Black (N2/0) humose loam; very weak subangular blocky; slightly plastic; organic matter very high; many roots; stones frequent; no mottles; wet. Clear change over 3 cm into
H/A_2	3–10 cm	Very dark grey (5YR3/1) gritty humose loam; weak subangular blocky; non-sticky; organic matter very high; many roots; many large granite stones; many bleached sand grains appear prominently; no mottles; wet. Clear change over 5 cm into
H/B	10–26 cm	Dark reddish brown (5YR3/2) gritty humose sandy loam; weak subangular blocky; non-sticky; organic matter moderate to high; frequent roots; many large granite stones; all mineral grains with black humus coatings; no mottles; wet. Sharp change over 2 cm into
C	26–28 cm	Brown (10YR5/3) sandy loam; massive; sticky; organic matter low; no roots; many large granite stones; no mottles; wet. Merging change into
D	28+ cm	Solid granite rock.

As mentioned above the soils of this series on Cairnsmore of Fleet are very shallow, with the brown sandy loam C horizon very thin or absent. The most striking feature of the profile is the very loose open nature of the organo-mineral layers which despite their high stone content are easily dug. It is thought this feature is largely due to winter frost-heave which affects the fine material and also causes movement of stones. All the layers above the C or D horizons appear black and humose, with a very high content of organic matter. With its black colour and greasy nature the organic matter resembles raw or mor humus, but because the material occurs in intimate association with mineral matter its exact nature is not clear, and this uncertainty is reflected in the use of the horizon symbols H/A and H/B. The proportion of organic matter in the organo-mineral layers apparently decreases gradually with depth in contrast to the trend in the podzol soils occurring at lower altitudes where the content of organic matter is generally a minimum in the grey eluviated A_2 horizon. In some respects the distribution of organic matter in these sub-alpine soils resembles that in the A horizons of the brown forest soils rather than that in the upper layers of podzols. The absence of earthworms and the relatively low biological activity makes the comparison with the brown forest soils unproductive, except in so far as it leads to the consideration of whether the incorporation of organic matter into the organo-mineral layer is achieved by natural processes other than translocation by, and redistribution from, true colloidal solution. The distinction is important here for if processes of solution and redistribution, characteristic of the formation of podzols, are not involved, the profile should probably be considered a type of ranker. The presence of high amounts of readily extractable organic matter and sesquioxides characteristic of spodic horizons (Soil Survey Staff, 1960) is inconclusive as any horizon with a high organic content will probably yield high values for readily extractable organic matter. Information of this type is very useful in characterizing horizons which are clearly B horizons, but cannot be regarded as a deciding factor in determining whether a layer is an A horizon with primary organic matter or a B horizon containing translocated organic material.

Despite the uncertainty as to the nature of much of the organic matter in the organo-mineral layer, the absence of coatings on the stones and sand grains in the upper part of the layer and the presence of well formed black humose coatings on particles in the lower part of the horizon, suggest that there is at least some translocation and redistribution of organic matter within the black surface layers. Whether this is differentiation within an A horizon where the bulk of the organic matter has been formed *in situ* and incorporated by the normal processes leading to the development of an A horizon, or whether the organic matter in the lower part of the layer is predominantly of illuvial origin and therefore a result of podzolic processes, is not clear.

Land use

The sparse wind-pruned vegetation provides meagre grazing for hill sheep for a few months in summer. The area is characterized as *cold wet upland* and *very exposed.* The climate restricts any improvement in the agricultural use of the land and afforestation is not possible.

TWACHTAN COMPLEX

Twachtan complex, first mapped around Loch Twachtan in Carrick, here occupies 8·6 square kilometres or 16·6 percent of the association. It occurs generally in the valley floors or on broad gently inclined footslopes as at Cullendoch, Dromore and north of Falbae, where hummocky moraines have been deposited in an irregular pattern. The moraines comprise very stony, coarse-textured, loamy sand material derived from granite and they are generally strongly indurated. The soil pattern is predominantly peaty podzols, similar to the Carsphairn series, developed on the morainic mounds with areas of peat or peaty gley soils in the intervening hollows. In the area south of Dromore the moraines are crowded together with very few flat or gently sloping inter-moraine hollows and consequently there is a relatively low proportion of peat or peaty gley soils in the complex. On the steep sides of the moraines some patches of brown forest soils have been encountered alongside some profiles which are humus-iron podzols. The vegetation is generally a form of wet heather moor, with some areas of dry heath except on the brown forest soils where it is a form of bent-fescue grassland with bracken.

Land use

The productivity of the moorland vegetation communities is low and the land is suitable only for forestry or for rough grazing for sheep or cattle.

The area is characterized as *fairly warm wet lowland and foothill* and is *exposed.* The possibilities for improvement are limited, the main restrictions being associated with the soil pattern, the topography and the peaty surface layers.

GALA COMPLEX

The Gala complex occupies 6·9 square kilometres, 13·3 percent of the association, and, as in the area to the north, has been mapped along gentle and moderately inclined lower hillslopes. The terrain is generally somewhat uneven but there is very little outcropping rock and the parent material, a sandy loam or loam till derived from granite rocks, is usually moderately thick. The areas are relatively wet, and the predominating soils are poor and very poorly drained peaty gley soils similar to the Eglin series, with some patches of peaty podzol soils of the Carsphairn series occurring on mounds or other convex sites. Areas of peat occur where the peaty surface layers have developed to a thickness of more than 35 cm. The complex is characterized by the peaty surface horizons of all the component soils and by the absence, or sparse occurrence, of outcropping rock. The vegetation is extremely variable, but is generally flying bent grassland or wet heathei moor.

Land use

All the areas of this complex are utilized as unenclosed rough grazing for sheep or cattle or have been recently afforested. Their climate is characterized as *cool wet foothill and upland* and *exposed.* The high rainfall, the wetness of the soils, the character of the peaty surface layers, the uneven topography and the remote situation of most areas of the complex severely restrict the possibility of significant improvement.

DINNINS COMPLEX

The Dinnins complex, first mapped in the Carrick area (Bown, 1973), ranges widely in character and is of limited extent. In the present area it occupies 1·1 square kilometres or 2·1 percent of the association, with small patches mapped on the outcrops of the granitic intrusions at Barncorkrie, near Glenluce, on Culvennan Fell, and near Dromore Farm. The complex is encountered at moderate or low elevations, generally on moderately or steeply inclined footslopes where drift is thin or absent. There is a well developed micro-topography, with some hollows, gentle slopes and steep areas, often below rock outcrops. The parent material is either the granitic rock itself, or shallow frost-shattered rock debris or locally derived drift from granitic rocks.

Apart from a small proportion of the Twachtan complex the Dinnins complex is the only map unit in which brown forest soils occur, and it is the presence of these soils which characterizes the unit. Although related to those described as series of the association, most of the soils in the complex are not typically developed and are often very shallow, with poorly differentiated horizons, or unusually stony. The soil pattern generally comprises brown forest soils similar to the Dalbeattie series on local steep slopes, and soils with peaty surface horizons (peaty podzols, peaty gleys or peats) on the gentle slopes, together with areas of non-calcareous gley soils and some rock outcrops which can range widely in number. It is emphasized that there is considerable variation in character of this unit, and there is little consistency in the proportions of the constituent soils. The vegetation is very varied, but the brown forest soils usually carry bracken-dominated bent-fescue grassland.

Land use

This complex provides rough grazing for hill sheep and cattle and the value of the herbage depends largely on the proportion of freely drained brown forest soil in the unit. Because of the topography and outcropping rock improvements are generally impracticable, unless the situation is particularly favourable. The areas mapped vary from *warm rather dry lowland* to *fairly warm rather wet lowland and foothill* and are generally *exposed.*

RIECAWR COMPLEX

In the Loch Doon area of Carrick the Riecawr complex is moderately extensive and comprises a well characterized soil pattern on a typical form of micro-topography. In the area described in this memoir, however, it occupies only 56 hectares comprising two small patches near the headwaters of the Little Water of Fleet. The topography is generally of level or gentle slopes with a well developed micro-topography of isolated rock knolls, often in the form of roche moutonnées. Peat of varied thickness, but with depths of about a metre common, is developed over most of the area while shallow peaty ranker soils occur on most of the rock knolls. On the peat the vegetation is often flying bent grassland but on the rock knolls Atlantic heather moor is most common.

Land use

Part of the area of the complex has been recently afforested and the remainder forms rough grazing for hill sheep and cattle. The area is classed as *fairly warm wet foothill and lowland* and is *exposed.* The high rainfall, the wetness of the peaty soils, and the difficulties of cultivation caused by the rock outcrops severely reduces the possibility of significant agricultural improvements.

GARRARY COMPLEX

The Garrary complex, previously encounted in the Carrick area, is by far the most extensive unit in the association, occupying 21·3 square kilometres or 41 percent. The main area of the association, around Cairnsmore of Fleet and Loch Grannoch, has a very rugged appearance with an abundance of rock outcrops on many hillsides and summits, topography characteristic of the Garrary complex. Till is generally absent or very shallow in such areas and soil parent materials are very stony moderately coarse sandy loam rock debris derived from granite. The soils are characterized by peaty surface horizons and have profiles grouped for the most part as peaty podzols or peaty gleys together with some areas of peat. The development of horizons, however, tends to be poor and many intergrade profiles difficult to classify also occur. The natural drainage varies widely in any area of the complex but is generally poor to very poor. The main features of the unit are an abundance of outcropping granite rock and peaty surface horizons to the soils. Somewhat similar areas with very little outcropping rock, generally in the form of bare granite slabs, and a heterogeneous group of soils developed on very shallow rock debris have been distinguished as the Loch Fleet complex. The character of the vegetation is even more varied than the soils and examples of most moorland plant communities are to be found.

Land use

This complex is suitable only as rough grazing for hill sheep or cattle, for afforestation or for sporting and other recreational uses. The climate of the area is characterized as *cool wet foothill and upland* or *fairly warm wet foothill* and is *exposed* or *very exposed.* The abundance of rock outcrops, the wet and peaty nature of the soils and the poor climate make significant improvements impracticable.

LOCH FLEET COMPLEX

The Loch Fleet complex has been mapped on generally smooth or slightly undulating hillsides around Cairnsmore of Fleet and Loch Grannoch where it occupies 4·7 square kilometres or 9·1 percent of the association. The soil parent material is the grey or greyish brown stony sandy loam rock debris or drift common in the association and is very shallow, generally less than one metre and often less than 50 cm over solid granite rock. Some rock outcrops, usually slabs of bare granite, occur in the complex but much less prominently than in the Garrary complex. The soils are characterized by peaty surface layers and the profiles encountered in the complex can usually be grouped as peaty gleys, peaty rankers or peaty podzols, with the peaty gleys predominating. The natural drainage in much of the area of the complex is poor or very poor, and there is considerable downslope water movement through the soil layers. The vegetation varies greatly in composition but is usually wet heather moor.

Land use

Much of this complex is utilized as rough grazing for hill sheep and cattle, and forestry plantations have recently been established on some areas. The areas of the complex are classed as *cool wet foothill and upland* or *fairly warm wet foothill, exposed* or *very exposed.*

The wetness of the climate and of the peaty soils, the presence of areas of rock outcrop and the shallowness of the soils are the main factors restricting land use and making improvements not feasible. These factors are also of importance to tree growth, in particular to the stability of forest plantations as tree height increases.

MULLWHARCHAR COMPLEX

The Mullwharchar complex has been already described by Bown (1973). In this area it has been mapped on Craignelder and Cairnsmore of Fleet. The complex is not extensive and occupies only 1·3 square kilometres or 2·5 percent of the association. Rock outcrops, generally slabs of bare granite, occur abundantly, while the soils have a peaty surface horizon and are mainly very shallow. Above 550 m (1800 feet) this unit generally gives way to the Cairnsmore complex. The vegetation is diverse but is commonly a form of heather moor.

Land use

The areas of this complex provide sparse grazing for hill sheep but they have some value for sport and other recreational pursuits. The areas are described as *cold wet upland* and are *exposed.* Improvements are not feasible, the principal limitations being the climate and outcropping rock. The establishment of forestry plantations is seldom possible because of the shallowness of the soils and the high degree of exposure.

CAIRNSMORE COMPLEX

First encountered on Cairnsmore of Carsphairn in the Carrick area (Bown, 1973) this complex, which occupies 56 hectares or 1·1 percent of the association, has been mapped in the area presently under consideration on the rounded gently sloping dome-like tops of Cairnsmore of Fleet and Craignelder. These granite hills have, above 550 m (1800 feet) elevation, rock outcrops or large boulders in association with soils of the sub-alpine major soil sub-groups similar to those of the Mulltaggart series. The vegetation is similar to that on the Mulltaggart series and is generally brown bent-woolly fringe moss heath with mountain heath rush moor in some areas.

Land use

These areas provide sparse grazing for hill sheep for a few months in summer, their main agricultural use; they are also of some value for recreational pursuits such as hill walking. The areas are classed climatically as *cold wet upland* and *very exposed.* Consequently neither improvement to the agricultural value of the land nor afforestation is possible.

SKELETAL SOILS

These soils occur mainly in the neighbourhood of the Cairnsmore of Fleet granite outcrop, on the head walls of corrie features and on some other steep rocky hillsides. In all they cover 1·5 square kilometres, 2·9 percent of the association. Although rock outcrops and areas of bare rock are important components of several of the soil complexes previously described, in none do they cover such a large proportion of the unit as they do in the areas mapped as carrying skeletal soils. Vegetative cover is sparse and bare rock accounts for 25–50 percent of the unit. Soil formation in areas between the rock outcrops is mainly restricted to humus accumulation, and under the high rainfall (about 2000 mm per annum) prevailing, this is commonly of the mor type. The profile generally consists of up to 15–20 cm of peaty material, overlying a rock pavement or a shallow layer of raw humus on a thin horizon of mixed mineral matter and black mor-type humus. This unit is well seen on Craignelder Hill.

These areas have little or no value for agriculture or forestry, but they contribute to the amenities of the locality.

Darleith Association

Soils of the Darleith Association were first mapped by Mitchell and Jarvis (1956) in north Ayrshire, where they are extensive, and they have also been delineated subsequently in central and south Ayrshire and in south-east Scotland. Only one map unit, the Bennane complex, has been encountered here.

BENNANE COMPLEX

The Bennane complex covers only about 28 hectares in two small areas, one near Auchengaillie on the Machars and the other at Mains of Dhuloch in the northern part of the Rhins Peninsula. The relief is generally of moderate slopes with an undulating micro-relief occasioned by frequent outcrops of rock or by knolls where rock is near the surface.

The parent rocks, porphyrite sills or dykes, are probably somewhat acid but the soils have been placed in the Darleith Association because of the character of the soil pattern which closely resembles that of the Bennane complex as previously described in the Carrick area (Bown, 1973). The soils are mainly freely drained brown forest soils and are similar in general features to the Darleith series but with a wide range in depth, and a very high stone content. They are developed mainly on stony frost-shattered rock-debris, but some locally derived drift also occurs. Rock outcrops at intervals through the complex and the uneven nature of the underlying rock surface gives rise to the wide range in soil depth, the stoniness and other features of the profile. A few areas of imperfectly or poorly drained soils occur locally in hollows. The vegetation is mostly a type of improved grassland but under semi-natural conditions a form of bent-fescue grassland prevails.

Land use

Where slopes are moderate, grassland can generally be improved by the use of lime and fertilizers, and occasional cultivation may be possible where outcropping rock is less than normal. The areas of the complex are classed as *warm moist lowland* and are *exposed.*

Ettrick Association

The Ettrick Association was first mapped at the eastern end of the Southern Uplands by Muir (1956) and later by Ragg (1960) and Ragg and Futty (1967). In south-west Scotland the association has been mapped in central Ayrshire (Grant, in preparation) and in Carrick (Bown, 1973). In the area described in this memoir the association is the most extensive group of soils encountered, covering 585 square kilometres or 40·9 percent of the area. The soils are developed on Ordovician and Silurian greywacke and shale and drifts derived from them. Agriculturally the soils range from the relatively fertile brown forest soils at low and moderate altitudes to skeletal soils on drift-free hills with abundant outcropping rock suitable only for rough grazing. As in Carrick, extensive areas of rugged and uneven topography have given rise to extensive areas of soil complexes. In the Moors and Machars regions of Wigtownshire extensive areas of peat are common throughout the general area of the association.

DISTRIBUTION

Soils of the Ettrick Association are found throughout the areas described in this memoir, except on the lowlands of the Stranraer Isthmus and on the Fleet Hills. The association extends over almost all of the Moors and the northern part of the Machars of Wigtownshire, with the exception of the Cree–Bladnoch Lowlands and areas with a cover of peat. In the southern part of the Machars the association is mainly restricted to areas of the Achie complex, which is characterized as relatively drift-free with knolls of outcropping rock, and occurs extensively amongst the soils of the Rhins Association developed on red tills. Soils of the association also predominate in the area of western Kirkcudbrightshire described (Chapter 1) as the Eastern Foothills. The topography here is generally extremely rugged and soil complexes are the main map units. On the Rhins Peninsula areas of the association are also found, but are restricted to small drift-free patches of the Achie complex.

PARENT MATERIAL

The soils of the Ettrick Association are developed on material derived from the Ordovician and Silurian rocks which underlie most of the area. The rocks, described in Chapter 3, are interbedded greywackes and shales and are generally grey or bluish grey in colour, although red strata have been encountered in a few minor localities. Some areas of black, organic-rich, fossil bearing shales also occur, but are not extensive, and conglomerate beds crop out locally, as at Corsewall. The composition of the rock varies considerably as indicated in the analyses given in Appendix V. The silica content ranges from that of an acid igneous rock such as granite to that of an intermediate rock such as andesite.

Differences in rock composition are probably of greatest significance in the fairly extensive areas free of drift or till where soils are developed on frost-shattered rock debris either weakened *in situ* or transported only short distances downslope. These materials are of loamy sand or sandy loam texture with a large content of angular stones and are the predominant parent material in a number of soil complexes, as well as being the parent material of the Linhope series.

Moraines, thought to be deposited by valley glaciers, occur locally in the area. They are hummocky mounds of coarse or moderately coarse-textured materials with a high content of angular and subangular stones and boulders. The deposits are mainly restricted to the valley of the Penkiln Burn and are much less extensive than around the Merrick and Kells Hills to the north.

In Wigtownshire much of the till derived from greywackes and shales takes the form of drumlins or drumlinoid ridges left by ice which had travelled a considerable distance. The drumlins are generally widely scattered amongst extensive peat areas on the moors to the north and on relatively drift-free often rocky areas at lower elevation in the south. Shallower tills occur along the middle and lower slopes of hills, mainly the Fleet Hills, along the Moors Scarp east of Stranraer and in areas north of Port William and near Glenluce. The tills are generally moderately stony with subangular to subrounded greywacke stones. In the Carrick area (Bown, 1973) similar deposits were separated into a group of more stony material generally with loamy textures and a less stony till with mainly clay loam textures. These tills formed the parent material of soils which were classified as different series. In this area tills of intermediate character also occur fairly extensively and classification of some of the soils developed on such materials as separate series is difficult. In general, however, soils formed on the more stony, less fine-textured tills and drifts with less than 25–27 percent clay in the middle and upper horizons and a tendency towards induration have been separated from those on the less stony more fine-textured tills which generally have a firm or plastic consistence.

On the Machars of Wigtownshire where both the grey tills of the Ettrick Association and the red or reddish brown tills of the Rhins Association occur, the character of the till changes very gradually over a wide zone from the one to the other. The change appears to take place along an irregular belt between Port William and Baldoon. The soils close to this line are generally intermediate in character between the modal types of the two associations, indicated on the soil map by the symbol I.

SOILS

The Ettrick Association, most extensive of the area, has also most mapping units—seven series, eleven soil complexes, and skeletal soils.

Four soils of the series have been reported previously in south-east Scotland (Muir, 1956; Ragg, 1960; Ragg and Futty, 1967) and subsequently in south-west Scotland; all the other map units, with the exception of the Corsewall and Ervie complexes, have been described in the Girvan and Carrick area (Bown, 1973).

Approximately 35 percent of the association has been mapped as soil series, the Linhope series, a freely drained brown forest soil, being the most extensive. This series takes in much of the arable land in the Machars, the lower slopes of the Luce Valley and along the Kirkcudbrightshire coast, as well as occurring in scattered patches, generally on drumlins, throughout the moorland area. The imperfectly drained brown forest soils with gleyed B and C horizons, the Kedslie and Altimeg series, are much less extensive and consist of many small patches, mainly at low altitudes, on gentle or moderate slopes.

The peaty podzol, Dod series, and the peaty gley, Dochroyle series, are the main soil series in the moorlands of northern Wigtownshire and the foothills of Kirkcudbrightshire, although peat and soil complexes are the predominant mapping units in these areas. Some concave slopes and areas receiving flush waters in the hill and moorland districts carry the non-calcareous gleys, Littleshalloch or Ettrick series, which are also found in the lowlands, mainly in depressions.

Soil complexes occupy about 65 percent of the association and are almost equally distributed between the moorland and lowland zones. The Achie complex is very extensive at low altitudes, particularly on the Machars; the Trool and Finlas complexes are widespread on the generally flatter areas of the moorlands, particularly around the Castle and Mochrum Lochs; the Darnaw complex occupies most rocky hilltops such as Artfield Fell; and the Glenlee complex occurs on rocky lower slopes. The Stroan and Minnoch complexes, established in moraine areas in Carrick, are inextensive in this area. Bush complex predominates along the middle slopes of the Penkiln Valley and is widespread on hill and moorland areas around Newton Stewart, while the closely related Largmore complex is mainly restricted to flush sites.

LINHOPE SERIES

The Linhope series is the most extensive, occupying 137 square kilometres or 23·4 percent of the association. It is also a major component of the widespread Achie complex. The soil is classified as a brown forest soil of low base status and where a few areas have been encountered with a vegetation and profile morphology typical of more base rich soils, no instances have been found of values for the base saturation of unlimed soils exceeding 50 percent. The natural drainage is free. Throughout the area of the association the soil is widespread at low and moderate elevations, generally less than 160 m (500 feet), but under favourable conditions of slope and climate it occurs up to 230 m (750 feet).

The soils are developed on a range of parent materials derived from greywackes and shales, but despite this varied origin all the materials are stony, of loam or sandy loam texture and grey in colour. The Linhope series is predominant on the thick till deposits, occurring as widely scattered drumlins at low and moderate elevations. In the north-east of Wigtownshire the Linhope soils generally form the whole drumlin, but around Glenluce, Barlae and Torhouse they are restricted to the steep sides of the drumlins, while soils with imperfect drainage occupy small areas on the gently sloping tops. The areas around the drumlins are generally free of till, and are characterized by rock outcrops, but there are also extensive areas of smoother topography with a shallow cover of stony drift or frost-shattered debris and these also carry soils of the Linhope series. At higher elevations the soil is generally restricted to steep hill slopes and the parent material is a shallow till or soliflucted stony hillside drift.

Under semi-natural conditions the vegetation is generally a form of acid bent-fescue grassland, often with abundant bracken. A number of different woodland communities have been recorded (Chapter 7), although the total wooded area is small.

Profile Description

Slope:		19°
Vegetation:		*Pteridium aquilinum, Agrostis tenuis, Festuca ovina, Trifolium repens, Anthoxanthum odoratum, Rhytidiadelphus squarrosus*
Drainage:		free
Horizon	*Depth*	
L and F	0–2 cm	Litter and fermentation layer—mainly old bracken fronds in various stages of decomposition.
A	2–25 cm	Brown (10YR4/3–5/3) loam; weak medium subangular blocky; friable; organic matter moderate to high; many roots; frequent stones; no mottles; moist. Gradual change over 7 cm into
B_2	25–50 cm	Strong brown (7·5YR5/8) loam; weak medium subangular blocky; friable; organic matter low; frequent roots; frequent stones; no mottles; moist. Gradual change over 10 cm into
B_2	50–70 cm	Light yellowish brown (2·5Y6/4) loam to sandy loam; weak blocky; slightly firm; organic matter low; a few roots; frequent stones; no mottles; moist. Clear change over 5 cm into
C	70+ cm	Grey (5Y5/1) loam to sandy loam; massive; indurated; no organic matter; no roots; frequent stones; no mottles; moist.

The organo-mineral A horizon under semi-natural conditions generally shows a moder humus form, with the upper 5–10 cm having a darker colour, higher humus content and stronger structure than the rest. At elevations above 160 m (500 feet) a layer of raw or mor humus 1–3 cm thick generally develops, and there is some incipient podzolization, as indicated by a tendency to paler colours and bleaching in the upper parts of the horizon. At low or moderate elevations where liming or occasional cultivations are carried out, and also on some steep slopes, the horizon shows a mull humus form which ranges considerably in thickness from 15 to 40 cm, the deeper layers generally occurring on steep slopes at low elevations. The effect of slope is well seen on some drumlins where the steep sides carry soils with mull or mull-like moder humus while towards the crest and top as the slope decreases an H horizon or raw humus develops. Where conditions are favourable, the H layer becomes relatively thick and the soil is then classed as a member of the Dod series, a peaty podzol.

The ochreous, sesquioxide-rich B_2 horizon is well developed, generally with hues of 7·5YR, although 5YR and 10YR are also encountered. The horizon is generally friable, but the strength of the structure depends on the soil moisture state, tending to be weak under highly moist conditions and moderately strong when the soil is slightly moist. The bulk density of the horizon is moderate and roots penetrate readily. In some woodland, and other locations at low altitude, the B horizons have lower chromas and are darker than is typical for the series; base saturation values for such profiles are about 40 percent but do not usually exceed 50 percent. These soils are regarded as intergrades to the brown earths of high base status, but have not been separated in this area because their extent is so limited.

The B_3 horizon is paler, and generally has a 2·5Y hue. The blocky structure is weakly developed and the consistence is slightly firm or firm. Soil profiles tend to be shallow on strongly convex slopes, such as the upper slopes of drumlins, and on slopes where cultivation has been fairly frequent and downslope movement of soil in the plough layers has occurred. The effects are particularly noticeable in the B horizons which are often only 5–10 cm thick, the upper parts of the layer having been gradually incorporated in the 'A horizon' as erosion progressed.

Where the parent material is till or moraine the boundary between B and C horizons tends to be quite clear with a sharp change from the B horizon into the indurated till. Where the soil is developed on frost shattered rock debris, C horizon material is often not clearly identifiable, the B horizon merging downwards into the solid rock. The colour of the parent till or moraine is generally grey but in some areas can be greyish brown.

Where the association borders the Rhins Association, pinkish grey colours in the upper till layers often became pale reddish brown colours at depths of 75–100 cm. The pale reddish brown material is generally nearer the surface in imperfectly drained brown forest soils even where they occur in close association with their freely drained counterparts as, for instance, on the same drumlin feature. The reasons for this are not clear, but are probably connected with the deposition of the till rather than with soil-forming processes.

Land use

This series varies greatly in stoniness and depth and occurs under widely varying conditions of slope and climate. Consequently the productivity and pattern of land use of the soils also differ a great deal. Arable agriculture with fairly frequent cultivation for barley, turnips or potatoes and relatively short breaks in grass is practised around Whauphill, in the valley of the River Bladnoch and in a few areas south of Newton Stewart. Cultivation is less intense in the areas north of Port William, on the lower slopes of the Luce Valley and around Kirkcowan. Cropping is similar but there are longer periods in grass. In the moorland areas where the Linhope soils often occur as patches amongst peat and peaty soils, accessibility to machinery is a major factor influencing utilization. Where access is reasonable the land is generally utilized as 'in bye', carrying cultivated grass and occasional root and grain crops. The soil is often suitable for more intensive cropping, but the farming system is that appropriate to the extensive areas of surrounding peat and moorland.

Where access for machinery is difficult the land is usually utilized far below its intrinsic capability, as rough grazing.

The areas have generally a *warm moist* or *rather wet lowland* climate and, except in the valley of the Bladnoch and around Newton Stewart where there is shelter, are *exposed.* The main factors limiting use of the series are the high content of stones, which tends to increase with elevation, and steepness of slope and climate. The types of land differ, depending on the degree of severity and the combination of these factors. Where cultivation is possible the free draining nature of the soils generally allows some flexibility in the timing of operations, though harvesting difficulties can be caused by the moist atmospheric conditions. The series carries healthy grazing and can generally be stocked for long periods of the year without excessive damage from poaching. Grassland is capable of high productivity but the level achieved depends greatly on management and fertilization. The natural acidity of the soil makes liming important.

ALTIMEG SERIES

Developed on the more compact tills derived from greywackes and shales, and with only moderate clay content, the Altimeg series has been classified as a brown forest soil with gleyed B and C horizons. It is relatively inextensive, totalling 7·8 square kilometres or 1·3 percent of the association, but it occurs in small patches widely throughout the association area. The natural drainage is imperfect, with impedance to water movement often occasioned by compaction or induration in the subsoil layers. The series occurs on gentle slopes, principally on the tops of drumlins which have the freely drained Linhope series on the more steeply sloping sides. The soils are mainly restricted to the lowland zone where they have been treated with lime and fertilizer and cultivated. Under semi-natural conditions the vegetation is usually a form of meadow grass-bent grassland in which rush species are more or less common.

Profile Description

Slope:		3°
Vegetation:		*Agrostis tenuis, Poa trivialis, Holcus lanatus, Trifolium repens, Juncus effusus*
Drainage:		imperfect
Horizon	*Depth*	
Ap	0–25 cm	Dark greyish brown (10YR4/2) loam; moderate medium subangular blocky; friable; organic matter moderate; many roots; frequent stones; a few fine distinct ochreous mottles along some root channels; moist. Sharp change over 2 cm into
B_2g	25–52 cm	Greyish brown (2·5Y5/2–5/1) loam; weak coarse blocky; firm to compact; organic matter absent; no roots; frequent stones; a few medium distinct yellowish brown (10YR5/6) mottles; moist. Gradual change over 10 cm into
Bg/Cg	52+ cm	Greyish brown to brown (10YR4/2–7·5YR4/2) loam to clay loam; massive; indurated; no organic matter; no roots; frequent stones; a few coarse streaks of prominent yellowish red (5YR5/6) mottles, often bordering light grey (5Y7/1) material in vertical streaks; moist.

The brown colours in the A horizons are generally paler than in the freely drained Linhope series and where cultivation is infrequent fine reddish brown mottles occur along root channels. Some dark coloured organo-mineral surface horizons occur where reclamation and cultivation has led to the incorporation of shallow peaty layers. The underlying horizons are predominantly grey in colour, stony, with subangular to subrounded greywacke stones, and dense and hard when dry or slightly moist although often firm or compact when moist. The texture of the upper 50–70 cm varies considerably from one area of the series to another; loams tending to predominate, and clay contents are normally less than 25–27 percent. Some soils with higher clay contents but with compaction in the upper part of the profile or high stone content have also been placed in this series.

Induration is usually present in the lower layers of the profile, and in some soils can affect the horizon immediately below the topsoil. Gleying is mainly caused by surface waterlogging with drainage impedance partly occasioned by the massive structure and induration of the lower soil layers.

The colour of the parent material is generally grey or greyish brown and often differs only slightly from that of the Bg horizon but on close examination the raw, little-altered nature of the C horizon is apparent; care in the interpretation of grey colours is necessary. Brownish colours are sometimes encountered in the C horizons, being probably more common in the area to the east. On the Machars, where the association borders the Rhins Association, the deeper soil layers are generally brown or reddish brown but the upper layers are grey or greyish brown and more nearly resemble the mode for the series. Areas where such soils are common are indicated by the symbol I on the soil map.

Land use

Occurring as small patches in more extensive areas of the Linhope series, the land use of the Altimeg series generally conforms to the land use pattern of the surrounding area. A system of long ley grassland with short breaks in grain and roots is normal in localities where mineral soils predominate. The Altimeg series tends to be wet in winter and early spring and this can delay cultivation of naturally freely drained soils in the same field. Where peat and peaty soils are extensive and farming is based on rough grazing by sheep and cattle the Altimeg series, like the Linhope series, often forms areas of 'in bye' with productive improved grassland and occasional cultivation. As with the Linhope series, however, soils of this series in the moorland area are often only accessible to machinery with difficulty because of surrounding peat and consequently they are utilized together with the peat as rough grazing.

The areas are classed as *warm, moist* or *rather wet lowland* and are *exposed.* Wetness of the soils is the main limitation on land use and is generally compounded by the moist climatic conditions.

KEDSLIE SERIES

The Kedslie series occupies lower gentle or moderate slopes, where till deposits are generally thick. The series also occurs on the gently sloping tops of drumlins. The main areas are near the coast north of Port William, around Glenluce and on the slopes below the 'Moors Scarp' east of Stranraer. In all, the Kedslie series occupies 10·4 square kilometres or 1·8 percent of the association. The parent material is a greyish brown or grey clay loam till derived from greywacke and shale with a clay content, in this area, between 25 and 33 percent. The soil is classified as a brown forest soil with gleyed B and C horizons and the natural drainage is imperfect. Much of the series has been cultivated, if only infrequently, and carries improved grassland; under semi-natural conditions the vegetation is a form of meadow grass-bent grassland with rush species or rye grass-crested dog's tail pasture.

Profile Description

Slope:	6°
Vegetation:	long ley grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–25 cm	Dark greyish brown (10YR4/2) loam; moderate medium subangular blocky breaking to fine crumb; friable; organic matter moderate; many roots; frequent stones; a few faint ochreous mottles along root channels; moist. Clear change over 3 cm into
A_2g	25–42 cm	Pale brown (10YR4/3) clay loam; weak coarse blocky; firm; organic matter low; roots few; frequent stones; frequent coarse prominent strong brown (7·5YR5/6) mottles and many medium light grey (10YR6/1) mottles; moist. Gradual change over 7 cm into
B_2g	42–70 cm	Light greyish brown (2·5Y6/2) clay loam; coarse prismatic; firm; organic matter absent; no roots; frequent stones; many coarse prominent strong brown (7·5YR5/8) mottles; moist. Gradual change over 7 cm into
B_3g/Cg	70+ cm	Light brownish grey (2·5Y6/2) clay loam; massive; very firm; no organic matter; no roots; frequent stones; frequent coarse distinct dark yellowish brown (10YR4/4) mottles; frequent dark manganiferous staining; moist.

The low chroma of the A horizon reflects the impeded drainage conditions. Under cultivation the structure of the organo-mineral surface layer is only moderately stable, although under semi-natural conditions the upper 5–10 cm may be somewhat humose with better structural development. The pattern of gleying, and therefore waterlogging, is most intense in the A_2g horizon. Prismatic structure is usually well developed in the B_2g layer but commonly the units are coarse. Coarse pores allowing easy moisture movement in the soil are usually absent from the structural units and confined to interfaces between units. Permeability in the Cg layer is generally low because of the massive structure and moderately fine texture, and alteration of the soil by waterlogging and the development of gley character decreases with depth. Where the colour of the parent material itself is grey, as in much of the area, recognition of the gley pattern can be difficult, but the shades characteristic of altered and unaltered material can generally be recognized.

The main features distinguishing this series from the Altimeg series are the somewhat higher clay content of the B and C horizons and the absence of compact or indurated soil layers, together with the moderate development of prismatic structure and plastic consistence when wet, a somewhat lower stone content and a higher degree of base saturation, particularly in the subsoil layers. Some soils mapped as Kedslie and Altimeg series do not have the distinctive features of either soil well developed; such soils are assigned to one or other series according to the properties thought to be predominant.

In the area north of Port William and where till deposits occur north-eastwards towards Wigtown, the parent material is brown or pale reddish brown indicating that it contains some of the red material of the Rhins Association. The soils on this deposit are intergrades between Kedslie and Rhins series and the main areas of their occurrence are indicated on the map by the use of the symbol I.

Land use

In the areas north of Port William and south-east of Glenluce, a rotation of grain and roots with some years in grassland is fairly regularly followed. In other areas cultivation is less frequent, though fertilizers are generally applied and grazing is controlled. The series occurs less commonly than the Altimeg in the moorlands or marginal areas but in these situations management is less intense and controlled.

Although old shallow stone drains appear to be working efficiently in some areas, most of the series requires under-drainage to allow cultivation or the proper utilization of herbage. The soil is only moderately acid and below the plough layer total phosphorus is low to moderate with low values for readily soluble phosphorus.

The areas of the series are classed as *warm, moist* or *rather wet lowland* and *exposed.* The main limitations on land use are the wetness of the soil, which even with under-drainage necessitates careful management, and the moist climatic conditions which make worse the effects of soil wetness. The soil is somewhat stony and the rooting depth is moderate, with penetration below the Ap horizon generally restricted by soil wetness and high bulk density.

DOD SERIES

The Dod series is developed mainly on scattered drumlins and banks of till in the high-lying north-western part of the moorland between Loch Ryan and Urral Fell and on shallow drifts on steep slopes around Cambret Moor and Cairnharrow east of Creetown. The series occupies 13·8 square kilometres or 2·4 percent of the association and is classified as a peaty podzol with free natural drainage below the iron pan. Above the pan the drainage class varies from imperfect to poor to very poor. The parent materials, derived from greywackes and shales, have been described in Chapter 3 and are generally a grey, fine loamy, moderately stony till in the drumlins and till ridges and a slightly more sandy, stony soliflucted shallow hillside drift on steeper slopes. Soils of the creep phase of the series mentioned in the account of the Carrick area (Bown,

1973) normally occur in association with hills higher than 600 m (1800 feet) and have not been encountered in this area. Only small areas of reclaimed soil have been mapped in this series and the semi-natural vegetation is generally a form of wet heather moor or flying bent grassland with some Atlantic heather moor on the drier sites such as Cairnharrow Hill.

The Dod series is also a component of several soil complexes but, except in the Minnoch complex, the depth, stoniness and horizon differentiation in these map units show great variation over short distances.

Profile Description

Slope:		8°
Vegetation:		*Calluna vulgaris, Trichophorum cespitosum, Molinia caerulea, Nardus stricta, Potentilla erecta*
Drainage:		free below the iron pan
Horizon	*Depth*	
H	25–0 cm	Black (5YR2/1) slightly fibrous peat; weak subangular blocky; slightly plastic; many roots; wet. Sharp change over 1 cm into
A_2g	0–17 cm	Greyish brown (10YR5/2) loam; weak blocky; firm; organic matter moderate to high, mainly staining along cracks and as washed-in material; frequent roots; frequent stones; no mottles; moist. Sharp change over 1 cm with irregular boundary into
B_1	17 cm	Strong iron pan
B_2	17–37 cm	Strong brown (7·5YR5/8) loam; weak blocky; friable; organic matter moderate to low; a few roots; frequent stones; no mottles; moist. Gradual change over 7 cm into
B_3	37–55 cm	Brownish yellow (10YR5/6) loam; weak blocky; friable; organic matter low; no roots; frequent stones; no mottles; moist. Merging change over 7 cm into
C	55+ cm	Grey to greyish brown (10YR5/1–5/2) loam to sandy loam; massive; indurated; no organic matter; no roots; frequent stones; no mottles; moist.

As with most podzol profiles the differentiation of horizons in this soil is striking, the grey of the A_2g layer when dry contrasting strongly with the ochreous colour of the B horizon and with the black H layer. Under the high rainfall the peaty surface layer is well developed and rarely less than 20 cm in thickness. A considerable proportion of the series occurs in areas with extensive deposits of peat. On shedding sites podzol profiles have been encountered under depths of peat up to 60 cm but where the H layer is more than 35–40 cm thick the soil is mapped as peat.

The A_2g horizon occurs immediately below the peaty surface layer and analysis generally shows a moderate or high organic matter content. In a newly exposed wet profile the A_2g horizon is often dark in colour and its appearance is masked by the organic matter, but when the horizon dries the grey colours generally become prominent with the black organic matter irregularly distributed. The organic matter gives the impression of having been physically washed into the layer, particularly into structural cracks from the overlying peat, but without becoming part of any intimate association such as would produce a well developed organo-mineral complex. Mottling is absent from the horizon but the firm consistence and the frequently wet state of the layer indicates that it is gleyed

PLATE 3/Cults Loch in the foreground and the Black Loch in the middle distance occupy depressions in the sands and gravels, the parent materials of the Yarrow Association, of the Stranraer Lowlands. The Scarp which separates the lowlands from the Cree-Luce Moors can be seen to the right.

By courtesy of Aerofilms and Aero Pictorial Ltd.

PLATE 4/Gravels in the Stranraer Lowlands, the parent material of the Yarrow Association soils, seen in section.

PLATE 1/Stone Circle at Tourhouskie: evidence of the presence of early man. Soils of the freely draining Linhope series of the Ettrick Association occur in the surrounding area.

PLATE 2/The ruins of the former Glenluce Abbey in the valley of the Water of the Luce. On the slopes behind East Boreland Farm the soils belong to the Linhope and Kedslie series of the Ettrick Association.

as well as eluviated. The appearance and consistence of the horizon contrast with the sandiness of the A_2 horizons of the freely drained iron podzols.

The A_2g horizon is normally less than 10 cm thick and is underlain by an iron pan, usually continuous and well developed, which forms a barrier to penetration by moisture and roots; the latter commonly form a mat on the upper side of the pan. The character of the pan shows some variation; in some localities it is weak and discontinuous and in others appears absent, its position being indicated by a sharp line of demarcation between the A_2g and the B_2 horizons. Where the iron pan is weak and conditions of fairly intense wetness obtain in the overlying layers, there can be some waterlogging, and consequently weak gleying, in the upper part of the B_2 horizon. Gleying in these circumstances is generally expressed as a variegation in the ochreous hues of the horizon; as conditions become more extreme some grey colours develop.

In some soils the A_2g horizon is much thicker than normal and the iron pan is at a depth of 30–60 cm or more below the mineral surface. The sesquioxidic B horizon is generally much less thick and well developed below the deeper iron pans. Soils where the A_2g layer is thick and the iron pan deep appear to intergrade with the peaty gley Dochroyle series and possibly some have been mapped with that series because the depth of the pan made separation difficult. More commonly, however, oxidizing conditions prevail in the B_2 horizon and its colour is uniform and of high chroma.

Structure in the B horizon is generally irregularly blocky and somewhat weakly developed. The consistence is friable and when moisture content is high the horizon has the silty or soapy feel associated with a high content of amorphous sesquioxides. The content of readily extractable sesquioxides is clear from the appearance of the horizon, but there is some doubt whether this sesquioxidic material results from weathering of minerals *in situ* and a relative enrichment in sesquioxides by the more rapid eluviation of cations and silica or whether much of it is of illuvial origin. The relative proportions of readily extractable sesquioxides in the B and C horizons are varied and in some profiles meet the requirements of a spodic horizon (Soil Survey Staff, 1960).

The C horizon is a loam or sandy loam, massive, indurated or very compact and generally grey.

Land use

The coarse grasses and ericoid species which predominate on this series are suitable only for rough grazing by hill sheep or cattle. Some areas where the peaty surface layer was relatively weakly developed have been reclaimed in the past, but no areas of recent improvement have been encountered. The areas are classified as *fairly warm rather wet lowland and foothill* and the land is *exposed.*

The wetness, low bearing strength, strong acidity and low natural fertility of the peaty surface layer, together with climatic wetness, make major improvements and reclamation both difficult and expensive. The degree to which improvement can be effected is limited.

In some localities areas of this series, together with the other surrounding moorland soils, are being planted to trees, generally Sitka spruce or lodgepole pine. Pre-planting cultivation is essential and tines are used to disrupt the iron pan and improve drainage.

LITTLESHALLOCH SERIES

The Littleshalloch series is a non-calcareous gley with poor natural drainage. Occupying 14·3 square kilometres or 2·4 percent of the association, the series occurs mainly in hill areas below about 230 m (750 feet) on uneven valley slopes, where, under the influence of topography, run-off, local seepage or spring water is concentrated in flushes. The parent material varies considerably but is usually a hillside drift or soliflucted frost-shattered material, both of which may overlie indurated till, or pass down into rock at depth. The material (described in Chapter 3) is derived from greywackes and shales, is stony and of loam texture. The vegetation is a form of wet pasture in which rush (*Juncus*) species and tufted hair grass (*Deschampsia cespitosa*) commonly occur.

Profile Description

Slope: 4°

Vegetation: *Juncus effusus, Holcus lanatus, Ranunculus acris, Trifolium repens, Lotus corniculatus*

Drainage: poor

Horizon	*Depth*	
A_1g	0–15 cm	Very dark grey (10YR3/1) to dark greyish brown (2·5Y4/2) loam; weak medium subangular blocky; slightly firm to slightly plastic; organic matter very high; many roots; frequent stones; a few fine distinct ochreous mottles along root channels; moist to wet. Clear change over 5 cm into
A_2g	15–30 cm	Grey (5Y5/1) loam; weak medium blocky; slightly firm; organic matter low; frequent roots; frequent stones; some boulders; a few distinct yellowish brown (10YR5/6) mottles; moist. Clear change over 5 cm into
B_2g	30–45 cm	Grey (5Y6/1) loam; weak blocky; sticky to slightly plastic; no organic matter; a few roots; frequent stones; frequent medium prominent strong brown (7·5YR5/6) mottles; wet. Clear change over 5 cm into
B_3g	45–77 cm	Light greenish grey (5BG7/1) loam; massive; indurated; no organic matter; no roots; many stones; frequent yellowish red (5YR5/6) mottles, mainly in wavy lines around areas of grey material; moist. Gradual change over 10 cm into
Cg	77+ cm	Greenish grey (5BG6/1) loam to clay loam; massive; slightly indurated; no organic matter; no roots; frequent stones; some dark brown (7·5YR4/4) mottles in lines along occasional vertical grey areas.

The character of the organo-mineral surface layers shows considerable variation, ranging from a greyish brown predominantly mineral layer with a moderate organic matter content to a dark grey somewhat humose horizon with a high content of well decomposed organic matter in close association with the mineral material. Separation is not generally possible at the present scale of mapping, however, as the soils occur in close association in the landscape. At the higher elevations of the series the paler-coloured, less-organic type of A horizon can carry a shallow, 2–5 cm, surface layer of black humus showing an intergradation to the peaty gley, Dochroyle series.

Occurring immediately below the A_1g, the A_2g horizon is generally a very pale grey with a comparatively low amount of ochreous mottling. The layer appears both intensely gleyed and strongly eluviated by solutions percolating from the A_1g horizon. In some profiles the layer is darker because of the accumulation of old dead and decaying roots. Structure in this horizon is generally weakly developed.

There is a considerable range in the degree of mottling in the B_2g horizon reflecting, in part, variation in the amount of waterlogging with changes in topography, as well as small differences in permeability resulting from the effect on moisture movement and intensity of leaching of variations in texture, structure and compaction. Mottling tends to be least in the more sandy soils, where it is associated with weathering stones, and becomes more pronounced where textures are finer and profiles are intergrading to the related Ettrick series.

The lower soil layers, the Cg and in some instances the B_3g horizon, are commonly indurated, massive and less permeable than the overlying horizons. In some profiles water has been seen to move through the profile in the layer immediately above the induration. The Cg horizon is grey, possibly a partial reflection of the natural parent material colour, although this is not easily distinguishable from the effects of gleying. In some profiles orange or reddish brown mottles occur as narrow vertical streaks, suggesting the presence of coarse prismatic structure; water probably moves through the slightly greyer material between peds. The material in these layers, however, is very weakly structured and few ped faces can be positively identified.

Induration or compaction are not invariably present in the lower layers, particularly where the soil is developed on stony frost-shattered debris *in situ* or transported only a short distance downslope. The stone content is often high in soils on hillslopes at the higher elevations of the series, and in some areas there is a concentration of small boulders just below the A_1 horizon.

Waterlogging is generally caused by water movement downslope through the soil and occasionally by the collection of water in depressional situations. It is difficult to categorize the soil wetness as either surface or ground waterlogging and the effects of seepage or telluric water are perhaps best considered separately.

Land use

Where the series lies at elevations near the upper limit of its altitudinal range it is generally utilized as rough grazing for sheep and cattle. The productivity and palatability of the herbage are generally better than on peaty moorland or hill soils and it may be that some improvements such as draining with open ditches have sometimes been carried out.

At lower elevations the series generally takes the form of small patches or channels in fields with other soil types. Under-drainage systems have usually been installed in such locations and the land is utilized as improved grassland or as long leys with short arable breaks. Some unimproved areas are found at low and moderate elevations and these are managed differently from the surrounding land.

The areas of the series are classified as *warm moist lowland* to *fairly warm rather wet lowland and foothill* and are generally *exposed.* The main restriction on land use is the wetness of the soil, allied to high rainfall and unfavourable climatic conditions. For any form of improved agriculture the installation of efficient under-drains is essential, and the system should be designed in close relation to the soil pattern. Soil permeability in the upper horizons is generally good.

In hill or moorland areas the fertility of the soil for forest production is relatively high and good rates of tree growth can be expected. Careful attention to drainage is necessary, however, and consideration must be given to the effects of waterlogging and gleying on tree stability.

ETTRICK SERIES

The Ettrick series is the least extensive of the association in this area, occupying only 2·3 square kilometres or 0·4 percent of the association. The soil is classified as a non-calcareous gley and the natural drainage is poor with waterlogging mainly of the surface water type. The series occurs in a few small areas north of Port William near Glenluce and south of Glen App, generally on deep till deposits and on gentle or moderate slopes. The parent material, described in Chapter 3, is generally grey or greyish brown, moderately fine textured—clay loam or heavy loam—and moderately stony. Much of the series carries improved pasture but under semi-natural conditions the vegetation is generally a form of sharp-flowered rush pasture.

Profile Description

Slope:	5°
Vegetation:	improved grassland with *Lolium perenne, Poa trivialis, Trifolium repens, Ranunculus repens*
Drainage:	poor

Horizon	*Depth*	
Ap	0–25 cm	Greyish brown (2·5Y5/2) loam; moderate medium blocky; organic matter moderate; many roots; frequent stones; a few fine faint ochreous mottles along root channels; moist. Clear change over 5 cm into
A_2g	25–35 cm	Greyish brown (10YR5/2) loam; very weak medium blocky; slightly firm; organic matter low; frequent roots; frequent stones; a few fine prominent yellowish red (5YR5/6) mottles; moist. Clear change over 5 cm into
B_2g	35–82 cm	Light greenish grey (5G7/1) clay loam to loam; coarse prismatic; very firm; no organic matter; a few roots; frequent stones; many medium prominent yellowish brown (10YR5/6) mottles and frequent dark manganiferous staining; moist. Gradual change over 10 cm into
Bg/Cg	82+ cm	Greenish grey (5GY6/1) clay loam; massive; very firm; no organic matter; no roots; frequent stones; frequent medium distinct strong brown (7·5YR5/6) mottles, with some manganiferous staining; moist.

The content of organic matter in the A horizon is generally moderate: humose horizons as encountered in the Littleshalloch series occur infrequently.

Grey colours predominate throughout the profile, but are most prominent in the A_2g horizon where ochreous mottling is less than in the lower layers and eluviation is at a maximum. The B_2g horizon, the zone of maximum waterlogging, is generally characterized by prominent distinct mottling, much more extensive than in the related Littleshalloch series. Prismatic structure is well developed in this layer with clearly formed smooth structure faces, sometimes extending up into the A_2g horizon and down into the Cg layer. The peds are generally relatively coarse and without internal coarse pores so that water movement is largely restricted to structural cracks. When the soil moisture content is high the consistence is usually plastic. When the soil is only slightly moist or dry the material of the B horizon and lower layer seems to be close packed with a high bulk density that is unfavourable to root growth.

The Bg horizon merges only gradually into the Cg horizon with depth. Mottling extends below the depth of most profile pits but as a rule becomes less frequent and less prominent with depth so that the brownish grey colours of the parent tills can become apparent. Structures tend to be massive or very coarse prismatic with only occasional structural faces but induration is uncommon, although the till seems comparatively compact and dense.

Land use

This series generally occurs as small areas in fields with other soil types and is managed in the same way as the predominant soil. Most areas of the series have an effective system of under-drainage, even if in some instances this is mainly old stone drains. The land is generally kept for long periods in grass, and provided fertilization is adequate and precautions are taken against poaching, the level of production is good. The areas are classed as *warm, moist* or *rather wet lowland* and are *exposed.* The main restrictions on the utilization of the land are associated with the wetness of the soil, compounded in some areas by relatively high rainfall.

DOCHROYLE SERIES

The Dochroyle series, occupying 20·7 square kilometres or 3·5 percent of the association, is one of the more extensive series. The soil is a peaty gley and its natural drainage class is very poor. Possibly some soils with an iron pan deeper than the range of observation during normal field investigation have also been mapped with the series. The series occurs mainly in the moorland area between the Moors Scarp and the Tarf Water, where it is developed on the gentle and moderate slopes of drumlins and drumlinoid ridges, and also around the edges of peat areas where the peat thins out. A few areas are also found along the Carsluith Burn near Creetown. The parent material is generally the grey medium-textured loam till described in Chapter 3.

The soils of the series generally carry semi-natural vegetation ranging from blanket bog to wet heather moor and flying bent grassland.

Profile Description

Slope:	8°
Vegetation:	*Vaccinium myrtillus, Molinia caerulea, Juncus squarrosus, Sphagnum recurvum, Odontoschisma sphagni*
Drainage:	very poor

Horizon	*Depth*	
L and F	17–12 cm	Litter and fermentation layers.
H	12–0 cm	Dark reddish brown (5YR2/2) well humified peat; moderate medium subangular blocky; roots many; moist. Sharp change over 2 cm into
A_2g	0–17 cm	Dark greyish brown (10YR4/2) loam; very weak blocky; firm; organic matter high with much localized staining; frequent roots with many dead; frequent stones; no mottles; moist. Gradual change over 7 cm into
B_2g	17–45 cm	Grey (5Y5/1) gritty loam; massive; firm; organic matter low; frequent dead roots; frequent stones; a few fine distinct strong brown (7·5YR5/6) mottles; moist. Clear change over 4 cm into
Cg	45+ cm	Grey (5Y6/1) loam; massive; indurated; no organic matter; no roots; frequent stones; a few fine distinct brown (7·5YR5/4) mottles or staining; moist.

Occurring around peat margins and locally on moderately steep slopes within extensive areas of peat, the Dochroyle series is characterized by a thick well developed peaty surface layer. This tends to act as a sponge maintaining wet or very moist conditions in the profile throughout the greater part of the year, even on shedding sites with moderately good run-off characteristics. Consequently, gleying is intense in the mineral soil layers and grey colours predominate throughout these horizons. The A_2g horizon is generally a greyish brown colour, in this closely resembling the A_2g horizon of the related peaty podzol Dod series, and it has a moderately high content of organic matter which, as in Dod series, is unevenly distributed and appears to have been washed in from the overlying peat rather than formed *in situ*. In some profiles an abundance of dead roots also contributes to the organic content of this layer. Ochreous mottling is absent from the A_2g horizon which appears to have been strongly leached of sesquioxides.

The colour of the B_2g horizon is grey or greenish grey and does not usually show any red or brown hues. Its organic content, probably mainly composed of dead root material, is low. The absence, or infrequent occurrence, of mottles in this layer reflects both the intensity of gleying and the leaching of sesquioxides. Where textures are medium loamy the degree of base saturation is generally low and the soils are strongly acid throughout the profile, particularly in horizons above the C horizon. Where slightly higher contents of clay occur, however, the degree of base saturation and the pH value can be rather higher while more ochreous mottling is present than is typical of this series. Soils in flush sites are also significantly less acid than the average for the series. The texture of the parent material is generally slightly finer than that of the overlying layers, the structure is massive and there is well developed compaction or induration.

Because of the profile morphology the soil has been classed hydrologically as very poorly drained. This grouping is perhaps not altogether satisfactory when the series occurs on moderate convex slopes where moisture is derived mainly from precipitation. It is possible that in some soils of this series the gley morphology is a less than satisfactory guide to the degree of waterlogging. The grey colours and inextensiveness of ochreous mottling are to a considerable extent occasioned by the intensely acid conditions and the degree of eluviation. It is perhaps significant that profiles with slightly more than average amounts of ochreous mottling in the subsoil are likely to have somewhat higher pH values.

Land use

This series is utilized mainly as rough grazing for hill sheep and cattle. Productivity of the natural vegetation is poor, particularly in spring, and the carrying capacity of the land is low. Around the moorland edge a few areas of the series have in the past been improved but little work of this type has been done in recent years.

As mentioned above the areas are classed as *fairly warm rather wet lowland and foothill* and are *exposed.* Restrictions on land use are associated with the nature of the peaty layer, particularly the wetness of the soils and the climate, and with strong acidity and low soil fertility. When improvements are under consideration, areas where the peaty layer is relatively shallow present the least difficulty.

A number of areas have recently been afforested after extensive drainage with open ditches. The species planted is mainly Sitka spruce with some lodgepole pine. The growth rate of the trees is expected to be moderate, but as tree height increases consideration will have to be given to the effects of the very poor natural drainage on stability.

STROAN COMPLEX

The Stroan complex which was first mapped in the area to the north (Bown, 1973) covers 4·1 square kilometres or 0·7 percent of the association. The main area of the complex occurs in the lower part of the valley of the Penkiln Burn, with a few inextensive areas on the moors between Newton Stewart and Glenluce. The topography is generally level or gently sloping with scattered hummocks of moraine. The moraine comprises material derived from greywackes and shales and is generally of coarse texture with a high content of stones and large subangular boulders somewhat less rounded than those found in till. West of Newton Stewart some of the hummocks are of gravel with rounded stones.

The soil pattern consists of brown forest soils belonging to the Linhope series on the morainic mounds with some areas of valley peat or peaty gley soils on the intervening flat areas. The Linhope soils, which are generally typical of the series, are strongly acid and can have a thin raw humus surface layer, while the parent material is somewhat coarser than normal and is very strongly indurated. The occasional mounds of gravel give rise to soils of the Yarrow series but their pattern of occurrence and the smallness of the areas involved do not justify the separation of a distinctive map unit. The peat areas receive flush water to some extent and are fairly typical of the valley peats, while the peaty gley soils are generally very stony. The vegetation on the brown forest soils is bent-fescue acid grassland with abundant bracken (*Pteridium aquilinum*) while the peaty areas usually carry flying bent grassland often with bog myrtle (*Myrica gale*).

Land use

A considerable proportion of the complex forms part of a deer park, while much of the remainder has been afforested. Japanese or hybrid larch have been planted on the brown forest soils, and Norway and Sitka spruce on the peats and peaty gleys.

The areas of the complex have been classified as *warm rather wet lowland* and are *moderately exposed*. The main restrictions on land use are the intricacy of pattern of the soils and the high degree of wetness associated with the peat areas.

MINNOCH COMPLEX

The Minnoch complex is extensive in the valleys around the Merrick and Kells Hills (Bown, 1973), but in the area under consideration occupies only 24 hectares, or less than 0·1 percent of the association. It occurs in a few small patches on the moors near Killgallioch where mounds of moraine stand up from the surrounding peat. As in the Stroan complex the moraine is coarse-textured, loamy sand to sandy loam, with a high content of boulders. The soil pattern consists of peaty podzol soils belonging to the Dod series on the moraines, with peat occupying the intervening hollows. The areas of peat carry flying bent grassland or blanket bog, while the Dod series carries wet heather moor.

Land use

This complex is utilized as rough grazing for hill sheep and cattle, but some areas are likely to become afforested. The areas of the complex are classed as *fairly warm rather wet lowland and foothill* and are *exposed*. Land-use-capability is restricted mainly by factors associated with the well developed peat and peaty surface layers, in particular wetness, low fertility and low bearing strength.

TROOL COMPLEX

The Trool complex, first mapped in the valley west of Loch Trool, is extensive at low or moderate elevations and occupies 45·3 square kilometres or 7·7 percent of the association. The complex occurs in the moorland tracts and is widespread in the area between Mochrum and the Bladnoch River and around Penninghame. Strong erosion during the glacial period has given rise, on gentle or moderate slopes, to a pronounced micro-topography of rock knolls or roche moutonnées. The rock knolls are of greywackes and usually have a thin discontinuous cover of frost-shattered rock debris on which shallow very stony brown forest soils of the Linhope series have formed. Also found are some brown skeletal soils with no B horizon and a brown organo-mineral very stony A horizon overlying rock at 20–30 cm, and a few soils with profiles belonging to the iron podzols, which have a shallow raw humus layer over a bleached sandy grey layer and an ochreous B horizon. The areas between the knolls are occupied by peat deposits which are generally rather deep, about 1 metre or so.

In areas where the general slopes are somewhat steeper than normal and the rock knolls are low or only slightly raised, the Trool complex merges with the Bush complex described below. The vegetation on the rock knolls is usually a form of bent-fescue acid grassland with abundant bracken, while the peat areas generally carry flying bent grassland or bog myrtle moor.

Land use

Agriculturally, the complex is utilized solely for rough grazing by sheep and cattle. The stocking capacity and possibility of improvement are low, but the rock knolls provide some shelter and dry lying for the livestock. Around Penninghame some areas have been afforested; larch are often planted on the brown forest soils of the knolls and Sitka spruce, lodgepole pine and some Norway spruce on the peats. The areas of the complex have been characterized as *warm rather wet lowland* and they are *moderately exposed.* The rocky topography and the wetness associated with the peaty areas very much restrict the possibilities for improvement.

FINLAS COMPLEX

The Finlas complex is extensive, occurring throughout much of the moorland tract of Wigtownshire. It covers 38·1 square kilometres and accounts for 6·5 percent of the association. The complex is widespread around the Castle and Mochrum Lochs and on Glenhapple Moor. The topography is similar to that of the Trool complex and comprises level or gently sloping areas, heavily eroded during glaciation, with a strongly developed micro-topography of rock knolls or roche moutonnées. The rocky knolls carry thin peat on bare rock or thin peat over a shallow layer of grey, eluviated stony rock-debris. Some very stony peaty podzol soils similar in sequence of horizons to the Dod series are also found, but they are much shallower than the normal soils of the series. The areas between rock outcrops are occupied by peat deposits which are generally more than 1 metre deep. Flying bent grassland and blanket bog are the principal plant communities on the peaty areas, with wet and dry heather moor occurring on the rock knolls.

Land use

Rough grazing for hill sheep and cattle is the main form of land use. The productivity of the herbage is low but the rocky knolls afford some shelter to stock. A few areas of this complex have been afforested and the species chosen and the ground preparation are much the same as for peat, apart from some inconvenience in the use of machinery caused by the rock knolls. Only occasionally is the depth of soil in the rocky areas sufficient to allow them to be planted. The areas of the complex are classed as *warm,* or *fairly warm, rather wet lowland and foothill* and are *exposed.* The wetness, low fertility and cultivation difficulties caused by outcropping rock are the main factors preventing significant improvement.

ACHIE COMPLEX

In the area under consideration, the Achie complex is the most extensive unit of the Ettrick Association, occupying 157·1 square kilometres or 26·8 percent of the association. The unit was first mapped in the East Border area as the Ettrick complex (Muir, 1956). Later, in the Carrick area (Bown, 1973) a number of other complexes were distinguished in the association and the soil pattern was renamed the Achie complex to conform to the treatment of these additional units. The complex occurs here throughout most of the lowland areas of the association at elevations of less than about 180 m (600 feet) and also in districts where soils of the Rhins Association predominate. It is particularly widespread on the Machars, around Burrow Head, Monreith and north of Whithorn, while good examples can be seen around Upper Barr, south of Newton Stewart, and on the Rhins of Galloway around Glenstockadale. Slopes generally range from gentle to moderately steep and severe erosion during glaciation has given rise to a micro-topography of rocky knolls, which is generally pronounced but in a few areas is subdued.

The soils are developed mainly on very stony frost-shattered rock debris, but occasionally on shallow till. The materials have mostly accumulated by solifluction and other creep processes in hollows between rock outcrops, and soil depths range widely over short distances. The soils are mainly freely drained and belong to the Linhope series although they are more stony than usual and often have deep colluvial topsoils. Around rock outcrops the soils are often a type of brown ranker with a shallow brown organo-mineral horizon resting directly on rock. In some depressional sites the natural drainage can be imperfect and then the soils resemble those of the Altimeg series.

Where significant areas resembling this complex in micro-topography occur in depressions, the natural drainage of the soils around the rock outcrops is usually poor and the soil pattern grades into that of the Ervie complex described below. The Achie complex is characterized mainly by the predominance of freely drained brown forest soils and by scattered rock outcrops. The pattern of outcropping rock, however, differs greatly from one area to another and in some areas the uneven surface of the underlying rock and the varying depth of soil is indicated only by a slightly undulating ground surface. In such areas the soil pattern is intergradational between that of the Achie complex and the Linhope series. Where rock outcrops are very close together, especially on steep hillsides, the soil pattern merges into that of the Glenlee complex described below.

Much of the complex is managed as improved grassland, but under semi-natural conditions the vegetation is generally a form of bent-fescue acid grassland, often with gorse (*Ulex europaeus*), or bracken (*Pteridium aquilinum*), while soft rush pasture can occur in the wet hollows.

Land use

The frequency of outcropping rock is the principal factor affecting land use on this complex. Where outcrops are quite widely spaced, slopes are gentle or moderate and the elevation is fairly low, cultivated grass leys are generally maintained, with fairly regular breaks for grain and root crops. More commonly, however, conditions of slope, altitude or frequency of outcropping rock are less favourable and allow only occasional cultivation, although machinery may be regularly used for the surface treatment and maintenance of good quality grassland. Grassland maintained under these conditions is usually grazed by dairy cattle.

In more remote situations or where slopes are steeper or rock outcrops are frequent some lime and fertilizers can often still be applied but the balance between cost and return is not so favourable. Under the most difficult conditions rough grazing by sheep and cattle is the general form of utilization.

The areas of the complex are classed as *warm dry* to *warm rather wet lowland* and are *exposed* or *moderately exposed.* The main restriction on land use is the pattern of rock outcrops on which depends the intensity of cultivation and degree of improvement possible.

ERVIE COMPLEX

The Ervie complex is moderately extensive, occupying 7·9 square kilometres or 1·3 percent of the association. The complex has been recognized for the first time in this area and is well developed in the Ervie district of the northern part of the Rhins. It has been mapped where glaciated and strongly eroded rock knolls occur in depressional situations. The soil pattern consists of very shallow skeletal or brown ranker-like soils on the rock outcrops, and, in the intervening hollows, very stony, poorly drained, non-calcareous gley soils on the stony rock debris of loamy texture. The surface horizon of soils in this complex is generally a mineral layer but sometimes a humose surface layer is found in soils in wet hollows and a raw humus layer in the freely drained soils. The vegetation on this unit is generally semi-natural, with sharp-flowered pasture in the wet hollows and a form of bent-fescue acid grassland on the dry areas. The complex is similar to the Achie complex but occurs in depressional, poorly draining sites, instead of the free-draining areas occupied by the Achie complex.

Land use

Most of the land is utilized as unimproved rough grazing for sheep and cattle. The productivity of the herbage is relatively good for this type of pasture, but because of its wetness, the land unlike the related Achie complex is not well suited to the outwintering of stock. Most of the areas are characterized as *warm moist lowland* and are *exposed.* The main factors restricting land use are the amount of outcropping rock and the wetness of much of the soil. The underlying rock and its unevenness make drainage very difficult and not normally worthwhile in relation to the degree of improvement likely to be effected.

BUSH COMPLEX

The Bush complex has been mapped over 26·2 square kilometres, or 4·5 percent of the association, and is extensive at elevations below 230 m (750 feet) on moderate slopes along the valley of the Penkiln Burn and the eastern side of the Cree Valley. It also occurs in scattered patches throughout much of the northern part of the moorland area. The complex has been previously described for the Carrick area (Bown, 1973). The topography is generally moderate hill slopes or valley sides with a slight hummocky micro-relief. The soil pattern is closely related to relief and consists of peat or very poorly drained peaty gley soils over most of the area. The peaty gley soils belong to the Dochroyle series, and are developed on shallow drift or frost-shattered rock debris. Shallow stony freely drained brown forest soils belonging to the Linhope series are developed as scattered patches on the slightly raised areas which are generally underlain by greywacke rock. The vegetation pattern is well developed and of striking appearance. Flying bent grassland or bog myrtle moor is generally carried on the peat and peaty gley areas and bent-fescue pasture with patches of dense bracken, *Pteridium aquilinum,* on the brown forest soils.

Land use

Rough grazing for hill sheep and cattle is the main form of land use on this complex, but some areas have been recently planted with trees. The stocking capacity is usually low, because apart from the flush of growth in June and July the productivity of the flying bent grass is poor throughout the year. The areas of free-draining soils, however, do afford some dry lying for stock.

The areas of the complex are classed as *warm rather wet lowland* and are *exposed* or *moderately exposed.* Features associated with the soil pattern and the peaty nature of many of the soils are the main factors restricting the type of land use and the possibilities of improvement. The areas of brown forest soil can be reclaimed for improved grassland but this is not generally worthwhile because of the small size of the individual areas. The peaty areas are extremely wet and the micro-relief makes drainage difficult.

GLENLEE COMPLEX

The Glenlee complex, first mapped in the valley of that name in the Carrick area (Bown, 1973), occupies 32·8 square kilometres or 5·6 percent of the association. The complex occurs at moderate and low altitudes throughout the association and in some areas where soils of the Rhins Association predominate. It occurs mainly on steep or moderately steep rocky hillslopes such as those of Barraer or Culvennan Fells, but has also been mapped on some gently sloping areas where outcropping greywacke and shale rocks appear to predominate, such as between Glasserton and Monreith Bay. The soils are either very stony freely drained brown forest soils, resembling Linhope series, or skeletal soils. With increasing altitude soils with a shallow raw humus surface layer become common and the soil pattern passes into that of the Darnaw complex. Although outcropping rock gives the impression that it is predominant in the unit, it does not usually make up more that about 15 percent of any area of the complex. The vegetation is a form of bent-fescue grassland, often with bracken, *Pteridium aquilinum,* on the deeper soils.

Land use

This unit is entirely utilized for sheep and cattle as rough grazing, and its productivity at low altitude can be moderate. The areas of the complex are classed from *warm dry* to *warm rather wet lowland* and are *moderately* to *very exposed.* Improvements are not feasible on the steep slopes and excessive number of rock outcrops on this unit.

CORWALL COMPLEX

The Corwall complex has been mapped for the first time in this area. The unit is not extensive, occupying only 2·3 square kilometres or 0·4 percent of the association, and is restricted in occurrence to a few steep hillsides, mainly on the lower slopes of the Eastern Foothills in Kirkcudbrightshire. The slopes are generally relatively smooth with little micro-relief or rock outcrops, but large and medium-sized boulders often occur on the surface. The soils are very shallow and stony and generally similar to the Linhope series but with a significant proportion of profiles of the shallow brown ranker type. The vegetation is a form of bent-fescue grassland often with abundant bracken (*Pteridium aquilinum*). All the soils are freely drained.

Land use

The areas mapped as this complex are utilized as rough grazing, mainly by sheep as some slopes are excessively steep for cattle. They are classed as *fairly warm rather wet lowland and foothill* and are *exposed.* Improvements in these areas are not feasible on account of the steepness of the slopes, the shallowness of the soils and the presence of boulders.

DARNAW COMPLEX

Less extensive than in the area around the Carrick Hills where it was first recognized, the Darnaw complex nevertheless is widely scattered throughout the hill and moorland tracts of the area and occupies 32·6 square kilometres or 5·6 percent of the association. The complex is well developed on the hilltops of the Machars Fells, as at Craignarget Fell, and on similar features in the Moors, as at Artfield Fell. In the Eastern

Foothills the complex has been mapped on Pibble Hill and also around Ben John. The areas of this complex are generally rugged hillsides or summits with an uneven micro-relief of rock outcrops. Their elevation is usually greater than 200 m (650 feet) but some occur at lower altitudes. The soils do not show any particular pattern and the complex is characterized largely by the presence of greywacke rock outcrops and soils having peaty surface layers. On shedding sites around outcropping rock the soils are formed on very shallow stony rock debris and resemble the Dod series, a peaty podzol, although, as with many soils in this and other complex mapping units, the development and differentiation of horizons are less clearly defined than where the soils occur in areas large enough to be mapped as series. Some very shallow peat ranker profiles also occur. The drainage class of both types is generally free or imperfect. In the hollows and depressions between outcrops the drainage is usually impeded and deeper peaty gley profiles have developed on the stony colluvial rock debris or shallow drift which is found there. The character of the soil reflects the considerable variation in local conditions, and in deeper and wetter hollows the peaty surface layer is more than 35–40 cm thick and is considered peat.

The rock outcrops generally have a prominent appearance and seem to predominate in the soil pattern although normally they form no more than about 15 percent of any area of the complex. The proportions of peaty podzolic, peaty gley and peat soils vary widely in different areas and any one can be absent; peat, particularly, is sometimes absent on the more rocky hills. Around Ben John rock outcrop is rather less than in most areas of the complex and the soils are predominantly freely or imperfectly drained.

Like the soils, the plant communities differ widely in character and include white bent (*Nardus*) grassland, wet heather moor and blanket bog.

Land use

This complex is utilized almost entirely as rough grazing for sheep and cattle; the productivity of the vegetation is generally poor and except in areas where climate is especially favourable, the stock carrying capacity is low. A few areas of the complex have been afforested, but ground preparation is difficult and tree growth is uneven because of the variation in conditions. The areas of the complex range widely from *warm rather wet lowland* to *cool wet foothill and upland* and are *exposed.* Significant improvements are not possible because of the difficulties associated with the rock outcrops and the nature of the peaty surface layers.

LARGMORE COMPLEX

The Largmore complex has been mapped at elevations below 250 m (800 feet) on moderately steep hillsides with slightly undulating micro-topography. The complex is not extensive, occupying only 4·7 square kilometres or 0·8 percent of the association, and occurs as small scattered patches throughout the association area, generally in mid- and footslope positions on valley sides. The parent material is mainly shallow stony drift or rock debris derived from greywacke and shale, although in a few areas similar patterns of soils included with this unit occur on deeper till deposits with an uneven surface. The complex consists of a number of small scattered areas of the freely drained brown forest soil Linhope series, which is generally shallow with rock fairly near the surface, surrounded by a network of the poorly drained non-calcareous gley soil, Littleshalloch series. The wetness is caused by run-off, generally from higher slopes, passing over the surface of the rock or indurated drift and down through the upper horizons of the soil profile, and it is the influence of local micro-relief on this moisture movement that produces the pattern of freely and poorly drained soils. Some soils with imperfect natural drainage, belonging to the Altimeg series, also occur. In some areas a significant proportion of gley soils have developed humose surface layers and the soil pattern is intergrading to that of the Bush complex. The vegetation is generally a form of bent-fescue grassland with abundant bracken (*Pteridium aquilinum*) on the freely draining soils and sharp-flowered rush pasture on the gley soils.

Land use

Most of the area is utilized as rough grazing for sheep and cattle. The productivity is relatively good, however, and the herbage, which is almost entirely of soft grasses, is highly palatable. Generally some improvement of the drainage conditions has been effected by the ploughing of open drains. Few areas of the complex have been afforested, but good growth from Sitka and Norway spruce can be expected. The areas of the complex are classed as *warm* or *fairly warm rather wet lowland and foothill* and are generally *exposed.*

Factors associated with the network of gley soils, and to some extent with the micro-relief, are the main restriction to improvement in these areas. The installation of effective under-drains on which improvement depends is possible in some areas, although it is generally difficult because of the proximity of rock to the surface, the bouldery nature of the drift and the occurrence of springs and seepage. The degree of improvement to be expected is from good rough grazing to moderately improved grassland. Improvements are probably most worth undertaking where the proportion of freely drained soils is high.

BROCHLOCH COMPLEX

The Brochloch complex is most extensive in the Eastern Foothills in Kirkcudbrightshire but also occurs scattered throughout the moorland areas of the association. In all the complex occupies 27·5 square kilometres or 4·7 percent of the association. It generally occurs on upper hill slopes or hill summits at moderate or high elevations, from 230–600 m (750–2000 feet), where the micro-relief is fairly well defined with no, or very little, outcropping bare rock. The parent materials are thin stony drifts and rock debris derived from greywackes and shales and the soils are characterized by their well developed peaty surface horizons. The soil profiles which make up this map unit can be grouped as peaty podzols, peaty gleys or peats, together with some peaty skeletal soils and peat rankers. In form and development, however, most soil horizons vary considerably from the modal types in the related soil series. The relative proportions of the constituent soils also vary widely with change in local conditions. On Cairnharrow and Scar Hills the relatively dry climatic conditions and the absence of pronounced hollows is reflected in the predominantly freely and imperfectly drained podzol rankers and peaty podzol soils, with only a few peats and peaty gleys. In other areas of the complex conditions are generally wetter and the peat and peaty gley components are more extensive. The great variation in drainage and soil conditions is responsible for the wide variety of vegetation and plant communities.

Land use

Most of this complex is utilized as rough grazing for sheep and cattle, but between Palnure and Penkiln Burns a few areas have been planted with trees. The areas of the complex are classed as *fairly warm rather wet lowland and foothill* or *cool wet foothill and upland* and are *exposed.* Significant improvement is not feasible because of factors associated with the topography and difficulty of drainage.

SKELETAL SOILS

Skeletal soils occupy only 28 hectares or less than 0·1 percent of the association. The two areas of this unit mapped are near Talnoltry where steep faces of almost bare greywacke rock rise above narrow bands of sparsely vegetated scree.

Land use

Both areas occur in forest plantations, and some planting of the screes with pine has been attempted; tree growth, however, is extremely poor. Areas of this type are of value only for amenity purposes.

Fleet Association

The Fleet Association is one of the less extensive soil groupings, occupying 2·4 square kilometres or 0·2 percent of the area. The soils are freely drained and are developed on small isolated patches of gravel.

DISTRIBUTION

The association is confined to the eastern part of the area where it occurs along the valleys leading out from the Fleet Hills. Some of the more significant areas mapped lie along the Little Water of Fleet, near Anwoth and at the mouth of the Skyre Burn. Minor patches occur along other water courses and also on mounds near Glenquicken.

PARENT MATERIAL

The soils of the Fleet Association are developed on gravels of mixed

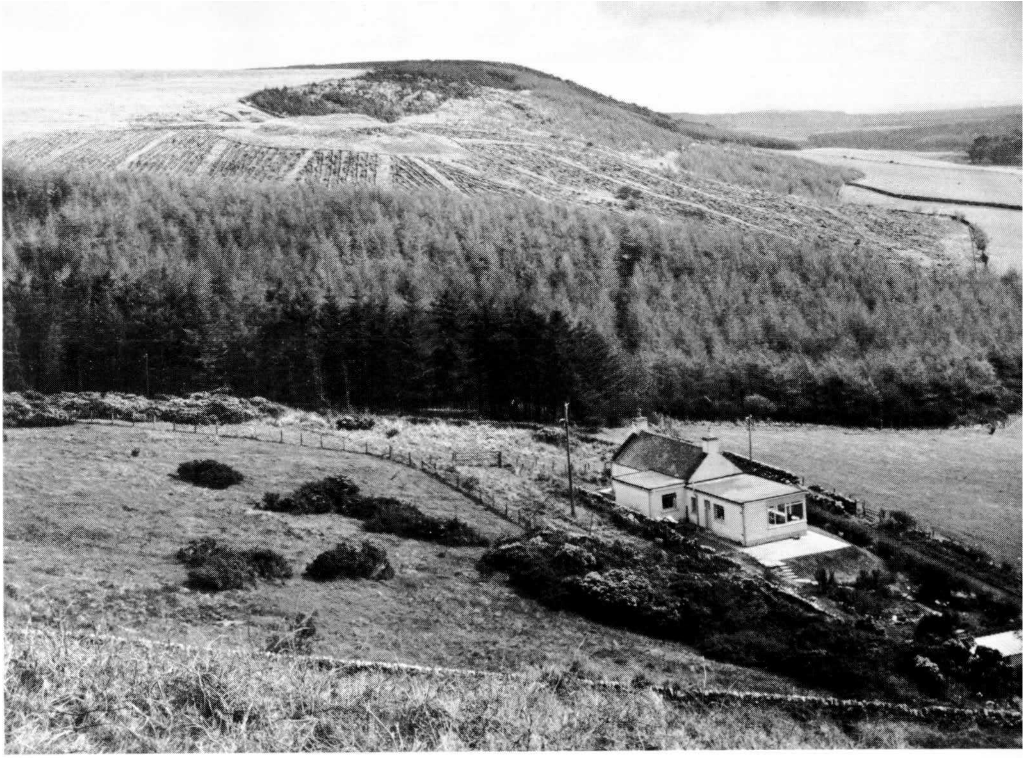


PLATE 5/The Moors Scarp above Craigcaffie, looking south-eastwards. On the steep slope conifer plantations are in course of establishment on the soils of the Linhope series of the Ettrick Association.

PLATE 6/The Clints of Dromore, granite cliffs to the north of an area of hummocky moraines mapped as the Twachtan complex in the Dalbeattie Association.

PLATE 7/Cutcloy Farm, photographed from the air, surrounded by a wide expanse of soils of the Achie complex in the Ettrick Association.
By courtesy of Aerofilms and Aero Pictorial Ltd.

PLATE 8/The Mull of Galloway, the southernmost land in Scotland. Soils of the Mull series, a humus-iron podzol, of the Rhins Association are developed on the thin stony drift covering the area in the foreground.
By courtesy of Aerofilms and Aero Pictorial Ltd.

origin comprising material derived both from granites and from greywackes and shales. There is considerable variation in the relative proportions of these materials, with the amount of granitic material generally decreasing as distance from the Cairnsmore of Fleet outcrop increases. The gravels differ greatly in their mode of origin. Along the Little Water of Fleet they occur as river terraces and on Glenquicken Moor as mounds of glaciofluvial morainic outwash, while in coastal sites they may have been reworked by the sea on a former beach level.

SOILS

Two series only have been distinguished in this association. The freely drained brown forest soil, Fleet series, is the more extensive, the peaty podzol, Glenquicken series, occupying only about 8 hectares.

FLEET SERIES

Although the Fleet series occupies only 2·4 square kilometres it accounts for 96·7 percent of the association. It occurs mainly on river terraces along water courses flowing away from the Cairnsmore of Fleet granite, and there are some small areas on the Moor near Glenquicken. The parent materials are gravels of mixed origin containing detritus from both granite and greywacke. The profile is classified as a brown forest soil and the natural drainage is free. Much of the series has been cultivated, if only occasionally, but the semi-natural vegetation is a form of bent-fescue grassland.

Profile Description

Slope:	0°
Vegetation:	Arable grassland—*Dactylis glomerata, Cynosurus cristatus, Trifolium repens, Ranunculus repens, Lotus corniculatus*
Drainage:	free

Horizon	*Depth*	
Ap	0–22 cm	Very dark brown (7·5YR2/2) gritty sandy loam; moderate medium blocky; friable; organic matter moderate; many roots; frequent stones; no mottles; moist. Clear change over 3 cm into
B_2	22–35 cm	Dark reddish brown (5YR3/4) sandy loam to loamy sand; weak blocky; friable; organic matter low; frequent roots; many stones; no mottles; moist. Gradual change over 7 cm into
B_3	35–70 cm	Brownish yellow (10YR6/6) gritty loamy coarse sand; very weak blocky to single grain; friable; organic matter low; a few roots; many stones; no mottles; moist. Gradual change over 12 cm into
C	70+ cm	Pale brown (10YR6/3) coarse sand and gravel; single grain; loose; no organic matter; a few roots; many rounded stones; no mottles; slightly moist.

The brown organo-mineral surface layer generally contains bleached sand grains and some soils may possibly be reclaimed from podzols. There is no clear morphological evidence for such changes, however, and at the low altitudes where the series occurs in the valley floors the surrounding soils are not generally podzols. The colour in the upper part of the B horizon is often a rather dark reddish brown somewhat similar to that of some Dalbeattie series soils developed on granitic materials and may reflect the influence of the granite debris in the parent material. Structure in the B horizon is generally weak and consistence friable, but in a few profiles where cementation is present the structure is massive and there is weak induration. The C horizon is the loose, single grain, unaltered sand and gravel, with the colour that of the constituent particles. While the content of medium-sized rounded stones is high throughout the profile, it is rather less in the surface horizon than in the deeper soil layers.

Land use

Occurring as it does as a number of small scattered patches this series is utilized in accordance with the nature of the surrounding soils and the system of farming practised on them. Near Anwoth cultivation for the growth of barley or root crops can be quite frequent, but elsewhere the soil is generally maintained in improved grassland. The areas of the series are *warm rather wet lowland* and are *exposed* to *sheltered* depending on local land-form factors. Apart from the smallness of the areas in which this series generally occurs, the main restrictions on the use of the soils are the high stone content, the low clay content and low waterholding capacity. Yields are liable to be reduced by drought.

GLENQUICKEN SERIES

Glenquicken series occupies only about 8 hectares, in one small area near Glenquicken Farm. Although this area seems to have been affected by earlier reclamation the podzolic character of the profile is still apparent and the soil is classified as a peaty podzol. The natural drainage is free in the lower soil horizons and only very occasionally does waterlogging occur in the A_2g layer. The grassland vegetation is very different from what would be expected under semi-natural conditions.

Profile Description

Slope:	1½°
Vegetation:	arable grassland, *Holcus lanatus, Festuca* spp., *Agrostis* spp., *Deschampsia cespitosa, Trifolium repens, Cirsium* sp.
Drainage:	free

Horizon	*Depth*	
Ap/H	0–15 cm	Very dark greyish brown (10YR3/2) sandy loam; weak blocky; friable; organic matter high; many roots; frequent stones; no mottles; many bleached sand grains; moist. Sharp change over 2 cm into
A_2g	15–27 cm	Light grey (10YR6/1) sandy loam; weak blocky; friable; organic matter low; frequent roots; stones few; moist. Sharp change over 2 cm and very irregular boundary into
B_2	27–52 cm	Strong brown (7·5YR5/8) sandy loam; weak blocky; friable; organic matter low; roots few; frequent stones; occasional patches of Ap material, probably in old burrows; no mottles; moist. Gradual change over 10 cm into
B_3	52–80 cm	Light yellowish brown (2·5Y6/4) sandy loam; massive; slightly firm; no organic matter; a few roots; stones few; no mottles; moist. Clear change over 5 cm into
B/C	80+ cm	Dark reddish brown (5YR2/2) coarse sand and gravel stained with iron and manganese compounds.

Probably much of the former raw humus or peaty layer has been removed and only a shallow remnant, incorporated with the upper part of the A_2g horizon to form the existing Ap/H horizon, remains. The layer is characterized by the dark colour of organic matter and the abundance of bleached sand grains. The lower unaltered part of the A_2g layer is prominent and is rather sandy. The undulating boundary and sharp transition into the B horizon suggest the presence of an iron pan, although none could be detected. The ochreous colours of the B horizon are indicative of a high content of sesquioxides and are typical of this class of profile. The staining with iron and manganese compounds in the lower part of the profile described is not typical of peaty podzol soils and very likely reflects a zone of seepage through the subsoil, possibly under the influence of underlying rock. The parent material is not well sorted and is probably morainic in origin.

Land use

The small area of this soil is utilized as somewhat improved grazing by sheep and cattle. It is classified as *fairly warm rather wet lowland and foothill* and is *exposed.* The main restrictions on the utilization of this series are the unfavourable climatic conditions, poor waterholding capacity and low natural fertility occasioned by strong podzolization.

Kirkcolm Association

The Kirkcolm Association has been mapped on the coarse-textured deposits of the Post Glacial raised beach, formerly termed the lower or '25 foot' raised beach. The soils have not been previously distinguished and although having a close resemblance to soils of the Dreghorn Association at Girvan (Bown, 1973) they are coarser in texture. The association occupies 10·5 square kilometres, about 0·7 percent of the area, occurring, as would be expected, in narrow discontinuous strips along the coast. The soils are younger than most others in the area and the degree of horizon differentiation is low. In some areas they provide much of the land for the valuable early potato crop.

DISTRIBUTION

As mentioned above the association is restricted to narrow tracts bordering the long coastline of the area. Much of the coast, especially along the west side of the Rhins Peninsula and around Burrow Head, consists of steep rocky cliffs, and the few raised beach deposits are restricted to sheltered situations. More extensive areas of these soils occur near Kirkcolm, and to the west of Glenluce and near Ardwell. In a few areas the beach deposits have been covered by sand dunes.

PARENT MATERIALS

The parent materials of the association are all of coarse texture—sands or sands and gravels. Soils developed on fine-textured materials deposited contemporaneously, generally in estuarine locations, have been distinguished either as the Stirling Association or as the Carbrook. The nature of the former coastline and the greywacke and shale rock which outcrop along most of its length was such that gravels formed the major proportion of the beach materials, with sands relatively restricted in extent. Both sands and gravels appear to be derived predominantly from greywackes and shales, but the gravels show a considerable range in the proportion and size of their constituent stones. On some former storm beaches the stone content is very high and soils appear to be developed on former shingle banks, while on other, similar beaches the shingle character of the deposits is less pronounced but the rounded cobbles are large and the proportion of sandy material is low. In a few localities where the deposits contain shell fragments the soils have been placed in the Kirranrae series.

SOILS

Six soil series and one soil complex have been mapped in the Association. About 90 percent of the association area is occupied by soils classified as freely drained, and of these the Kirkcolm series developed on gravels is the most extensive, accounting for 73·1 percent of the association. Less extensive are the Clachan series developed on sands and the Kirranrae series formed on calcareous parent materials. Soils with impeded natural drainage are found in only small areas, generally in hollows and on shallow beach deposits affected by seepage from higher ground. The Corsewall complex occurs inextensively south of Corsewall Point.

KIRKCOLM SERIES

The Kirkcolm series covers 7·8 square kilometres or 73·1 percent of the association. The soils, developed on Post Glacial raised beach gravels, are significantly younger than most other soils in the area and soil formation is less advanced. Profile development, however, is considered sufficient to allow the soils to be classed with the brown forest soils and the natural drainage is free. The series, like the other soils of the association, is confined to coastal locations and the slopes on the former beaches are level or gentle. Few areas with semi-natural vegetation have been encountered as most of the series has been cultivated, but one area of sycamore—elm woodland has been recorded.

Profile Description

Slope:		0°
Vegetation:		*Acer pseudoplatanus, Pinus sylvestris, Fraxinus excelsior, Silene dioica, Poa trivialis, Dryopteris dilatata*
Drainage:		free
Horizon	*Depth*	
L & F	2—0 cm	Leaf litter partially decomposed.
A	0—17 cm	Very dark greyish brown (10YR3/2) sandy loam; strong fine crumb; very friable; organic matter high; many roots; many rounded stones; no mottles; sand grains bleached; moist. Sharp change over 2 cm into

Horizon	*Depth*	
B	17–67 cm	Brown (10YR4/3) loamy coarse sand to coarse sand; single grain; friable; organic matter low; frequent roots; many rounded stones; no mottles; moist. Gradual change over 10 cm into
C	67+ cm	Coarse sand and gravel with the colour that of the constituent particles, derived largely from greywackes.

The surface horizon is generally moderately coarse-textured and stony although the amount and size of the stones varies considerably, with some soils having an exceptionally high content of large rounded cobbles. There is also a wide range in the organic matter content of the A horizon, probably at least explained by differences in land use in the past. The B horizon is generally poorly developed with colours of moderate or low chroma indicating fairly weak weathering. Textures are coarse with a very high content of stones. The C horizon is generally raw gravel and sand. In some areas the gravels have the character of shingle with insufficient fine material to fill the interstices between the rounded stones and, in a few areas, with stones which are largely discoid in shape.

Land use

Much of the land producing the valuable early potato crop is on this series, the main areas being around Loch Ryan and along the eastern shore of Luce Bay. The equable, relatively frost-free climate is the major factor in making these soils suitable for the growth of this specialized crop, but the very free drainage and the moderately coarse textures of the surface layers are also important, facilitating cultivation in the early months of the year. In some areas the stony nature of the soils could be an obstacle to full mechanical harvesting of the crop, and indeed the stone content is sometimes such as to make any type of arable agriculture difficult. They are farmed in the same manner as the adjacent inland soils.

The areas of the series have been classified as *warm rather dry* or *warm moist lowland* and are *exposed* or *very exposed,* but the variations caused by the operation of specific local factors are possibly of greater significance in the narrow coastal strips mentioned above. The main restrictions on land use are the low waterholding capacity of the soils and their high stone content; in some areas exposure can be significant.

CLACHAN SERIES

Occupying only 76 hectares or 7·1 percent of the association, the Clachan series is nevertheless second in extent. It occurs as very small scattered patches around the coast, mainly in protected bays along the western shore of the Rhins Peninsula. The parent materials are coarse-textured sands on the Post Glacial raised beach which is either level or very gently sloping. Like the Kirkcolm series the soils are relatively young and horizons are less clearly developed than in most other soils in the area. The series has nevertheless been grouped with the brown forest soils and its drainage class is free. Much of the series has been affected by cultivation, but the natural vegetation is probably some form of maritime grassland.

Profile Description

Slope:	0°
Vegetation:	newly ploughed area
Drainage:	free

Horizon	*Depth*	
Ap	0–27 cm	Brown (10YR4/3) loamy sand; weak fine subangular blocky; friable; organic matter low; frequent roots; no stones; no mottles; many bleached sand grains; moist. Clear change over 3 cm into
B/C	27–54 cm	Brown (7·5YR5/5) sand; single grain; friable; no organic matter; a few roots; no stones; no mottles; moist. Gradual change over 10 cm into
C	54+ cm	Light yellowish brown (10YR6/4) sand; single grain; friable; no organic matter; no roots; no stones; a few coarse distinct strong brown (7·5YR5/6) mottles; moist.

Coarse textures predominate throughout the profile and the organic content of the A horizon is generally low to moderate. The B horizon is only weakly differentiated from the parent material, having colours of moderate chroma. Weathering appears to be relatively slight with only low amounts of free sesquioxides. The C horizon consists of a raw little-altered sand, its colour being mainly that of the individual sand grains, although in some areas mottling occurs in the deeper layers, the effect of occasional high ground water levels.

Land use

The major factor controlling the agricultural use of this soil is the smallness of the areas of occurrence, the usual outcome being that the series is farmed in a manner similar to that of the surrounding area. On the Rhins most areas carry some form of arable grassland while near Garlieston arable farming with barley and root crops is practised.

The areas of the series have been classified as *warm rather dry* or *warm moist lowland* and are *exposed* but in these small coastal areas the effect of local variations is likely to be significant. The main restrictions on land use, apart from the size of the areas mapped, are the poor waterholding capacity of the soils and the effects of exposure.

KIRRANRAE SERIES

The Kirranrae series is inextensive, occupying only 68 hectares, but it forms 6·3 percent of the association. It has been mapped in two coastal areas—at Kirkcolm and south of Creetown. The parent materials are Post Glacial raised beach deposits ranging from sands to gravels with a variable but significant content of sea shells. The soils are classified as brown calcareous soils but because they are of such limited extent they have been included in the appendices in the same table, and in the soil key in the same column, as the brown forest soils. There are no areas of semi-natural vegetation, the soil being either under arable crops or carrying improved grassland.

Profile Description

Slope:	0°
Vegetation:	ley grassland
Drainage:	free

Horizon	*Depth*	
Ap	0–22 cm	Very dark greyish brown (10YR3/2) gritty loam; moderate medium blocky; friable; organic matter high; many roots; stones few; no mottles; many white shell fragments; moist. Clear change over 5 cm into
B/C	22–65 cm	Greyish brown (10YR5/2) gritty loamy sand; very weak blocky; friable; no organic matter; roots few; stones few; no mottles; many white shell fragments; moist. Gradual change over 7 cm into
C	65+ cm	Gritty coarse sand with greywackes and granite material and abundant shell fragments; single grain; loose; no organic matter; no roots; stones few; no mottles; moist.

The soils mapped in this series show a wide range in stone content and amount of shell material. The organic matter content of the A horizon is generally moderate to low and structural development is relatively weak. Shell fragments are generally present in the surface layer but are less frequently found near Kirkcolm than near Creetown. Weathering in the B/C horizon appears slight with brown colours of moderate or low chroma predominating.

Land use

At Kirkcolm the series is utilized for arable agriculture and the growing of early potatoes while at Bagbie improved grassland is established. The two areas are classed as *warm moist lowland* and are *moderately exposed.* The restrictions on agriculture are a consequence of the poor waterholding capacity of the soil. It should not be necessary to apply lime to these soils.

DALLY BAY SERIES

The Dally Bay series is very inextensive, covering only 36 hectares or 3·4 percent of the association. It occurs in three small widely separated patches along the coast—near Garlieston, near Stranraer and south of Corsewall Point. The soils are developed on sands, with some gravels, deposited on the Post Glacial raised beach where fluctuations of the ground watertable are such as to give rise to mottling of moderate intensity in the upper parts of the profile. The series is classified as a brown forest soil with gleyed B and C horizons although, as in other soils of the association, horizon differentiation is only moderate. The natural drainage is imperfect and the vegetation in uncultivated areas is a form of maritime grassland.

Profile Description

Slope:	0°
Vegetation:	newly ploughed area
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–35 cm	Dark greyish brown (10YR4/2) loamy sand; weak subangular blocky; friable; organic matter low; frequent roots; no stones; a few fine distinct reddish brown (5YR5/4) mottles; moist. Clear change over 3 cm into
B/Cg	35–70 cm	Greyish brown (10YR5/2) sand; single grain; friable; no organic matter; a few roots; no stones; frequent medium distinct yellowish brown (10YR5/6) mottles; moist. Gradual change over 10 cm into

Horizon	*Depth*	
Cg	70+ cm	Greyish brown (10YR5/1–5/2) sand; single grain; non-sticky; no organic matter; no roots; no stones; a few medium prominent strong brown (7·5YR5/6) mottles; wet.

The principal features of this soil are the coarse sandy textures throughout the profile, the low to moderate organic matter content in the surface horizon and the pattern of gleying. The mottling, incipient in the A horizon and moderate in the B layer, is characteristic of the fluctuating ground watertable which is only occasionally near the surface. In the area at Dally Bay there is a significant content of small gravel stones in the profile.

Land use

Land use on this series varies widely. Arable agriculture with frequent cultivation is common near Garlieston while long ley grassland is maintained at Stranraer and permanent pasture in the area south of Corsewall Point. The areas are characterized as *warm moist lowland* and are *moderately exposed* but as with other soils in the association locally operative factors are likely to be important. The main restrictions on arable agriculture are occasioned by the poor waterholding capacity of the soil, which can cause drought conditions in summer, and by the watertable which is sometimes high enough to hinder winter cultivation.

DRUMMORE SERIES

A non-calcareous gley soil with high natural ground watertable, Drummore series is very inextensive, occupying only 20 hectares or 1·9 percent of the association. The series has been mapped in two small areas at Garlieston and also near Drumbreddan. The parent materials are gravels which are part of the Post Glacial raised beach. The high watertable is due to springs or seepage from higher ground and the vegetation is a form of park woodland.

Profile Description

Slope:	0°
Vegetation:	*Agrostis* spp., *Festuca* spp., *Ranunculus* spp., *Juncus* spp.
Drainage:	poor

Horizon	*Depth*	
Apg/H	0–27 cm	Very dark brown (10YR2/2) humose sandy loam; moderate medium subangular blocky; non-plastic; organic matter very high; many roots; frequent stones; no mottles; wet. Clear change over 5 cm into
Bg/Cg	27–67 cm	Greenish grey (5GY6/1) and very dark grey (10YR3/1) sandy loam; single grain to massive; non-plastic; organic matter moderate to high; many dead roots; small rounded stones abundant; no mottles; wet. Gradual change over 10 cm into
Cg	67+ cm	Grey (5Y5/1) loamy sand; massive to single grain; non-sticky; organic matter low; a few dead roots; small rounded stones common; no mottles; wet.

The surface layer is generally humose with a high content of well humified organic matter thoroughly incorporated with the mineral material. A moderate organic matter content is also sometimes found in the Bg/Cg layer, largely because of dead roots. Gleying in the subsoil layers is severe, with intense reduction and eluviation of iron compounds and absence of ochreous mottles or localized concentrations of oxidized sesquioxides. Coarse textures throughout the profile reflect the nature of the soil parent material.

Land use

Most of the area of this series is at present used as park land. It is classified as *warm rather dry lowland* and is *exposed.* Intense water-logging and poor natural drainage are the main factors restricting agricultural use.

PORTLONG BAY SERIES

The Portlong Bay series occurs as scattered small patches near the coast and totals only 64 hectares or 6·0 percent of the association. The soil is developed on sands of the Post Glacial raised beach where a slight depression or seepage from higher surrounding areas gives rise locally to a high ground watertable. The natural drainage is poor with some small areas with very poor drainage being also included. The soil is classified as a non-calcareous gley. Some areas have been drained and carry arable grassland while under semi-natural conditions the vegetation shows considerable variation.

Profile Description

Slope:	0°
Vegetation:	cultivated grassland
Drainage:	poor

Horizon	*Depth*	
Ap	0–20 cm	Very dark brown (10YR2/2) sandy loam; moderate to weak subangular blocky; friable; organic matter high; many roots; no stones; a few faint ochreous mottles along root channels; moist. Sharp change over 1 cm into
B_2g	20–30 cm	Dark brown (10YR4/3) sandy loam; massive; slightly firm; organic matter low; no stones; a few fine dark reddish brown (5YR 2/2) mottles along old root channels; moist. Clear change over 4 cm into
B_3g	30–72 cm	Dark greyish brown (10YR4/2) loamy sand; massive to single grain; slightly firm; organic matter low; frequent old dead roots; no stones; medium distinct dark reddish brown (5YR3/4) mottles frequent at base of horizon; wet. Sharp change over 1 cm and irregular boundary into
Cg	72+ cm	Grey (N5) loamy sand; massive; slightly firm; organic matter low; a few old dead roots; no stones; frequent coarse distinct yellowish red (5YR4/6) mottles and a few light grey mottles; some strong iron tubes along old root channels; wet.

The surface horizon is frequently humose, reflecting the accumulation of organic material under waterlogged conditions, and it has a high content of well-humified organic matter intimately mixed with the mineral material. Textures are coarse throughout the soil which has a high permeability, allowing moisture to percolate readily to the ground watertable, and through the subsoil layers. Indurated or other impervious horizons are normally absent. Gleying is intense below the surface layers, although sometimes overall brownish colours can result from an accumulation of dead roots. Iron tubules probably indicate that roots of specialized plants such as *Equisetum* spp. were once present.

Land use

In areas where under-drains have been installed this series generally carries improved grassland, but as the soil occurs in low-lying depressional sites or in areas subject to seepage drainage is often difficult. Unless local conditions are especially favourable, cultivation can be difficult and consequently grassland is the predominant form of land use. The areas of this series are classified as *warm rather dry* or *warm moist lowland* and are *exposed.* The major restriction on arable agriculture is a high degree of waterlogging which because of associated land form and other factors can only to a limited extent be overcome by drainage.

CORSEWALL COMPLEX

The Corsewall complex occurs in only one small area, on the coast just south-west of Corsewall Point; it occupies 24 hectares or 2·2 percent of the association. The complex is formed on sand and gravel materials of the Post Glacial raised beach where there are abundant knolls of outcropping greywacke rock. The soil pattern comprises wet, strongly gleyed soils belonging to the Portlong Bay and Drummore series interrupted by outcrops of rock. The soils of the complex are uncultivated and carry semi-natural vegetation with species characteristic of wet maritime situations predominating.

Land use

The area of this complex is utilized only as rough grazing. It has been characterized as *warm rather dry lowland* and is *exposed.* The abundance of outcropping rock combined with the poor drainage of the soils severely restricts the agricultural use of the land.

Rhins Association

The Rhins Association has been established and mapped for the first time in this area. The soils are developed on reddish brown clay loam tills containing greywacke stones, which are predominant throughout the Rhins Peninsula, from which the association takes its name; they also occur on till deposits in the southern part of the Machars of Wigtownshire. The association is next in extent to the Ettrick Association occupying 215 square kilometres or 15·0 percent of the area. Soils of the association occur only at low and moderate altitudes, less than 180 m (600 feet), and the topography is strongly drumlinoid. A very high proportion of the association has been cultivated, or is suitable for cultivation, and the soils are mainly brown forest soils with gleyed B and C horizons having imperfect natural drainage; freely and poorly drained soils are much less extensive. The association ranges from *warm rather dry lowland* to *warm rather moist lowland*, and is generally *exposed*. Dairy farming is the main form of agriculture.

DISTRIBUTION

The association has been mapped in two separate localities, on the Rhins of Galloway and on the southern part of the Machars of Wigtownshire. Soils of the association occur throughout the Rhins from the Mull of Galloway to Milleur Point, occupying the major proportion of the peninsula where some soils of the Yarrow Association and the Achie complex also occur as scattered patches, together with a small area of the Barncorkrie Association and some inextensive areas of peat.

On the southern half of the Machars the association is restricted to the area south and east of a line passing from Mochrum north-east to Whauphill and thence north to Torhouse and east along the River Bladnoch to the coast. In this area the soils are developed on drumlinoid till deposits scattered through areas of eroded rock or shallow drift carrying soils of the Ettrick Association. The symbol I has been used on the soil map with many soils of the association near the northern limit of their extent to indicate that they are intergrading in character to soils of the Ettrick Association.

A few small areas of the association have also been mapped on the higher parts of the Stranraer-Luce Bay Lowlands where reddish brown till deposits appear above the surrounding sands and gravels.

PARENT MATERIALS

As already mentioned the parent material of the association is a reddish brown clay loam till containing predominantly greywacke stones. The reddish brown colour of the till is thought to be derived from soft readily comminuted sediments underlying the sea bed of Loch Ryan, the Firth of Clyde and Wigtown Bay. As stated in Chapter 3 only small amounts of red material are needed to strongly colour otherwise pale brown or grey materials and probably ice passing over Loch Ryan or Luce Bay on to the Rhins or across Wigtown Bay on to the Machars transported red fine material, accounting for the observed colours of the tills. But as few stone fragments identifiable as originating from red sedimentary rocks have been encountered, the possibility that some of the red colour of the till originates from red-stained greywacke rocks cannot be entirely dismissed, although very few of these rocks outcrop in the area.

On the Rhins Peninsula the surface layers in much of the till appear to be partially water-sorted, particularly in low lying areas or on the lower slopes of drumlinoid features. The clay content in the apparently modified layers is significantly, and often markedly, less than in the underlying till or in other unmodified materials. The cause of the alteration has not been fully established but is thought to be related to the effect of meltwaters temporarily impounded or running through the surface till layers in Late Glacial times, possibly above a permafrost layer.

In some areas the till is shallow over rock, generally loam or sandy loam and more stony than usual. Symbols are used on the soil maps to indicate that rock occurs near the surface in these areas—G in areas of greywacke and shale and P for Permian conglomerate.

SOILS

The soils in this association can be considered in two groups—soils developed on the unaltered parent tills and soils on modified or shallow stony tills. In all, nine soil series and one soil complex have been mapped, and of these three series occur on the unmodified clay loam till and six on modified or shallow materials. The brown forest soils are extensive, occupying approximately 75 percent of the association, almost 90 percent if soils of the Buyoch complex, mainly of the brown forest type, are included. The imperfectly drained Rhins and Portpatrick series are the most extensive, with the freely drained Portencalzie series occupying a somewhat smaller area. The association occurs almost entirely at elevations below 170 m (550 feet) and soils with raw humus or peaty surface horizons—the humus-iron podzol Mull series, the peaty podzol Auchleach series, and the peaty gleys Glenstockadale and Lochnaw series—are of very limited extent. The poorly drained non-calcareous gley mineral soils, Ardwell and Balscalloch series, are somewhat more extensive but are mainly confined to inter-drumlin hollows and other depressional sites.

PORTENCALZIE SERIES

The Portencalzie series, occupying 42·5 square kilometres or 19·8 percent of the association, is one of the more extensive soils in the area. Classified as a brown forest soil with free natural drainage, it has been mapped throughout the association area but occurs mainly at relatively low altitudes, below about 70 m (250 feet). There is a considerable range of properties in the series, related mainly to changes in the parent material, and the three different variants recognized are indicated on the soil map.

The dominant soil type of this series is developed on deposits of modified till. The till, the main parent material of the association, is a reddish brown clay loam with greywacke stones as described above and is generally laid down in the form of drumlinoid hills. The upper layers of the modified till above about 40 cm are generally sandy loam or loam but can be loamy sand where alteration of the till has been particularly deep and intense. The freely drained soils of the Portencalzie series formed on this material generally occur on steeply sloping drumlin sides but at low altitudes can extend over the moderately sloping drumlin crests.

The variation in the Rhins till along the boundary with the till of the Ettrick Association between Port William and Bladnoch has already been mentioned and the soils developed on these materials are indicated by the symbol I on the soil map. The main features of these soils are the paler, less red colours of the upper layers of many of the tills and the occurrence of freely drained soils where the modified character of the till, as described for the modal parent material, is less clearly marked.

The other two variants of this series which have been distinguished occur in areas where the parent drifts or tills are shallow. These materials are generally of loam or sandy loam texture, have a higher than usual stone content and pass down with depth into rock rather than into the clay loam till. The symbol G on the map indicates that the underlying rocks are greywacke and shales and the letter P that they are of Permian age.

Areas of semi-natural vegetation occur rarely on these soils which, although extensive, are generally arable or maintained in good quality grassland. Profile descriptions of examples of each soil type included in this series are given below as follows:

1. Modal soil developed on modified deep till.
2. Soil intergrade with Linhope series.
3. Soil developed on thin drift overlying greywacke.
4. Soil developed on thin drift overlying Permian rocks.

Profile Description: 1, Modal Profile

Slope:	4°
Vegetation:	arable grassland
Drainage:	free

Horizon	*Depth*	
Ap	0–27 cm	Reddish brown (5YR4/3) loam; moderate medium to coarse subangular blocky, breaking to fine crumb; friable; organic matter moderate; many roots; frequent stones; no mottles; moist. Clear change over 3 cm into
B_2	27–42 cm	Red (2·5YR5/6) loam to sandy loam; weak coarse subangular blocky; friable; a few to frequent roots; organic matter low; frequent stones; no mottles; moist. Clear change over 4 cm into
B_3/C	42+ cm	Weak red (2·5YR4/2) sandy loam; massive; strongly indurated; no organic matter; no roots; frequent stones; no mottles; moist; no change with depth to 1 metre.

Profile Description: 2, Intergrade to Linhope series

Slope:	10°
Vegetation:	arable grassland
Drainage:	free

Horizon	*Depth*	
Ap	0–15 cm	Brown (7·5YR4/3) loam; medium subangular blocky, breaking to fine crumb; friable; organic matter moderate; many roots; frequent stones; no mottles; moist. Clear change over 3 cm into
B_2	15–32 cm	Strong brown (7·5YR5/8) loam; weak medium blocky; friable; organic matter low; frequent roots; frequent stones; no mottles; slightly moist. Gradual change over 7 cm into
B_3/C	32–57 cm	Brown (7·5YR5/4) loam; coarse prismatic to massive; hard to indurated; no organic matter; no roots; frequent stones; some large greywacke boulders; no mottles; slightly moist to dry. Gradual change over 7 cm and irregular boundary into
C	57+ cm	Reddish brown (5YR5/3) loam; coarse prismatic to massive; hard to indurated; no organic matter; no roots; frequent stones; a few coarse grey mottles down widely spaced structural cracks; slightly moist to dry.

Profile Description: 3, Profile developed on thin drift over greywacke

Slope: 1°
Vegetation: long ley grassland
Drainage: free

Horizon	*Depth*	
Ap	0–15 cm	Dark reddish grey (5YR4/2) loam; moderate medium subangular blocky; friable; organic matter moderate; many roots; frequent stones; no mottles; moist. Sharp change over 1 cm into
B_2	15–35 cm	Yellowish red (5YR6/6) loam; weak medium subangular blocky; slightly friable; organic matter low; frequent roots; frequent stones; no mottles; moist. Clear change over 4 cm into
B_3/C	35–47 cm	Reddish brown (5YR5/3—2·5YR5/3) loam to sandy loam; massive; indurated; no organic matter; no roots; frequent stones; no mottles; slightly moist. Diffuse change over 12 cm into
C	47+ cm	Reddish brown to red (2·5YR5/4 to 10R5/3) loam to sandy loam; massive; compact to slightly indurated; no organic matter; no roots; frequent stones; moist. Passing down into greywacke rock at 100 cm.

Profile Description: 4, Profile developed on thin drift over Permian rocks

Slope: 5°
Vegetation: long ley grassland
Drainage: free

Horizon	*Depth*	
Ap	0–37 cm	Dark reddish brown (5YR3/3) loam; moderate medium subangular blocky; friable; organic matter moderate; many roots; frequent stones; moist. Gradual change over 7 cm into
B_2	37–67 cm	Yellowish red (5YR4/5) sandy loam; weak blocky; slightly friable; organic matter low; roots few to frequent; frequent stones, mainly greywacke; moist. Gradual change over 7 cm into
B_3/C	67+ cm	Brown (7·5YR5/2) sandy loam; massive; indurated; no organic matter; no roots; frequent stones; no mottles; moist. Merging at 100 cm into breccia rock.

In these soils the depth of the surface layer, the A or Ap horizons, varies considerably depending on the local topography and the effects of erosion, particularly under the influence of cultivation. Colours are generally characterized by reddish brown hues except in the intergrade soils where the surface horizon is more commonly brown. Textures are mainly loamy and organic matter content is moderate. The B horizons are generally well developed with high chromas characteristic of layers rich in sesquioxides and reddish brown or yellowish red hues reflecting the influence of the red parent materials; although in the intergrade soils, strong brown and yellowish brown colours predominate. Textures of the B horizons are mainly sandy loam or loam and the B_3 or B_3/C layers generally show compaction or induration, less well developed in some of the intergrade soils which appear hard when dry or slightly moist but can be firm when moist. Soils developed where the rock occurs relatively near the surface, at 100–200 cm, are generally more stony than the soils formed on the deeper tills and in some areas, as in the north of the Rhins Peninsula, the content of large stones can be quite high. It is in the C horizons that the differences associated with the soils represented on the map by separate symbols are most clearly shown; these have already been discussed.

Land use

Many of the soils are amongst those most suitable for arable cultivation in the area but in some instances the frequency of cultivation is restricted by the steep slopes on some drumlinoid features and the rather high stone content where rock is close to the surface. In addition the predominance of the imperfectly drained soils of the Rhins Association in areas where the Portencalzie series occurs, further influences the utilization of this series, so that arable cropping is rather less frequent than might be expected. Nevertheless the series forms some of the most frequently cropped land in the area. The free drainage and the loam to sandy loam textures in the upper layers ensure a satisfactory waterholding capacity and as a rule easy cultivation. The main crops are barley, wheat, potatoes and turnips.

Much of the series is classified as *warm rather dry* or *warm moist lowland.* Conditions are, however, *exposed.*

RHINS SERIES

The Rhins series is the most extensive soil in the association, occupying 72·3 square kilometres or 33·7 percent of the association. The series occurs throughout the association area on both the Rhins Peninsula and the south-eastern part of the Machars, and like the other soils of the association lies largely below 170 m (550 feet) elevation. Drumlinoid hills and ridges, the main topographic features, are responsible for a wide range and frequent changes of slope. The characteristic parent material of the association is a thick reddish brown clay loam till with greywacke stones. A few areas, mainly around Garlieston, where the till is shallow and underlain by greywacke rock are indicated on the soil map by the symbol G, and soils of the Rhins series in the region between Port William and Bladnoch, where the till is modified by an admixture of the till of the Ettrick Association, are indicated by the symbol I. The permeability of the till is moderate, and the natural drainage is imperfect and the soils are classified as brown forest soils with gleyed B and C horizons. Areas of semi-natural vegetation rarely occur on soils of this series, which generally carry ley grassland, or, occasionally, arable crops.

Profile descriptions typical of the modal and the intergrade soils of the series are given below.

Profile Description: 1, Modal Profile

Slope:	6°
Vegetation:	long ley grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–25 cm	Very dark greyish brown (10YR3/2–4/2) loam; moderate medium blocky breaking to fine crumb; friable; organic matter moderate; many roots; a few to frequent stones; no mottles; moist. Clear change over 3 cm into
B_2g	25–40 cm	Reddish brown (5YR5/3) clay loam; coarse prismatic; firm; organic matter low; a few roots; frequent stones; frequent fine diffuse yellowish red (7·5YR6/8) mottles; moist. Clear change over 4 cm into

Horizon	*Depth*	
B_3g	40—65 cm	Reddish brown (2·5YR4/4) clay loam; coarse prismatic to massive; very firm; no organic matter; no roots; frequent stones; a few fine faint strong brown (7·5YR5/6) mottles and a few coarse light brown (7·5YR6/4) mottles, particularly around stones which have coatings of fine material; much dark manganiferous staining; moist. Diffuse change over 15 cm into
C	65+ cm	Reddish brown (2·5YR4/4) clay loam; massive; very firm; no organic matter; no roots; frequent stones; no mottles; frequent dark manganiferous staining; moist.

Profile Description: 2, Intergrade Profile

Slope: 1°
Vegetation: arable grassland
Drainage: imperfect

Horizon	*Depth*	
Ap	0—17 cm	Brown (10YR4/3) loam; moderate medium subangular blocky breaking to fine crumb; friable; organic matter moderate; many roots; frequent stones; no mottles; moist. Sharp change over 1 cm into
B_2g	17—60 cm	Reddish brown (5YR5/5) loam; coarse prismatic to massive; very firm; organic matter low; roots rare; frequent stones; frequent fine faint strong brown (7·5YR5/6) mottles and a few grey streaks down widely spaced structural cracks; moist. Diffuse change over wide boundary into
B_2g/C	60+ cm	Brown (7·5YR5/2—3) loam; massive to coarse prismatic; very firm; no organic matter; no roots; frequent stones; a few faint mottles and some dark manganiferous staining; moist.

The brown organo-mineral plough layer occasionally shows fine ochreous mottling along root channels and it has a moderate organic matter content. The horizon is generally moderately deep, about 25 cm, but is sometimes shallow on the upper slopes of drumlins or on other sharp convex slopes, the result of erosion or soil creep induced by cultivation. The change into the underlying B_2g horizon is generally sharp. Below the plough layer the till appears to be relatively little altered by pedological processes, the main effects being the development of coarse prismatic peds and mottling. Structure formation seemingly does little to improve the subsoil layers as a medium for root growth which is restricted by the high bulk density and compact nature of the almost unaltered till. The small content of haematite, which mainly accounts for the reddish brown colour of the till, is resistant to the effects of waterlogging and gleying and thus mottling is subdued, the ochreous mottles tending to be fine and relatively faint and pale pink colours developed on the smooth faces of the peds. Some development of manganiferous staining and concretions also occurs, but mottling decreases with depth and the till becomes massive. The subsoil is slowly permeable and comprehensive systems of under-drainage are necesssary if the soils are to be used to the best advantage agriculturally.

The soils, which are intergrading to soils of the Ettrick Association and in particular to the Kedslie series, are similar to the modal soils in most respects but the colours in the upper till-layers are generally brown, with hues which are either less red than is usual or pale with lower chromas and higher values than are generally encountered. Further, in

PLATE 9/Drumlins in Kirkcolm Parish carrying soils of the Rhins and Portpatrick series, brown forest soils with gleyed B and C horizons, of the Rhins Association.

PLATE 10/Drumlins near Knocknain consisting of thick reddish brown clay till, the parent material of soils of the Rhins Association. An area of alluvial soils is in the foreground.

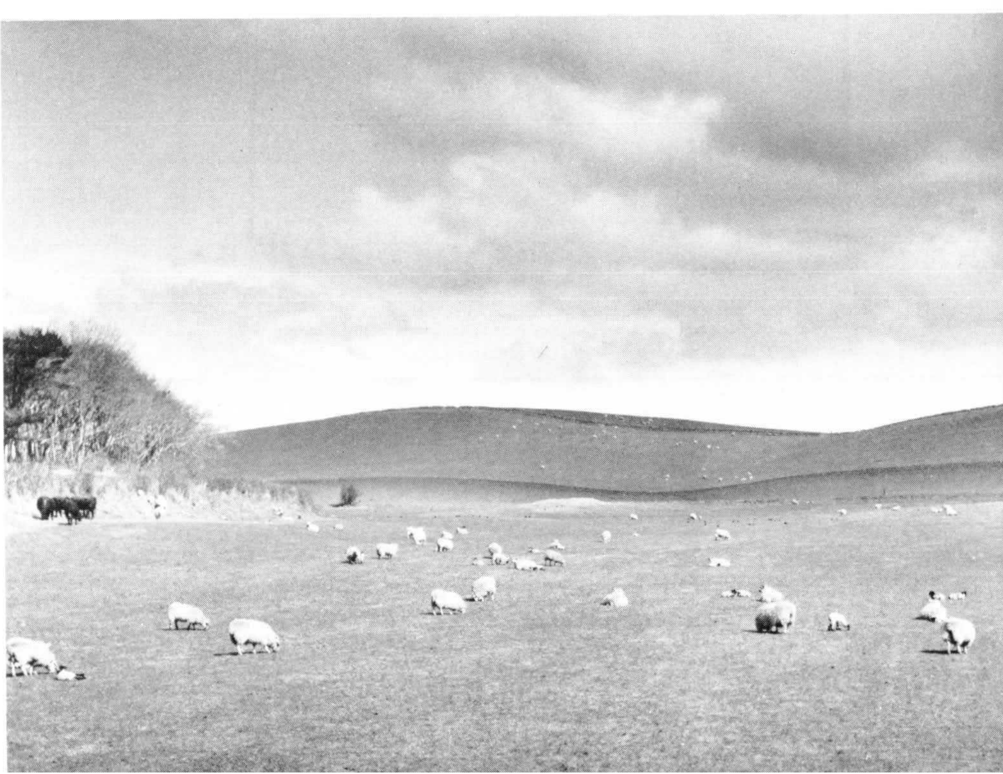


PLATE 11/Cairngarroch Farm with soils of the Yarrow Association and poorly drained alluvial soils. Beyond the farm is the undulating ground underlain by thick till which typifies the area south-west of Drummore.

By courtesy of Aerofilms and Aero Pictorial Ltd.

PLATE 12/The undulating till plain north-east of Port William. The soils are brown forest soils with gleyed B and C horizons of the Ettrick and Rhins Associations in the foreground and background respectively.

areas with intergrading soil profiles the proportion of freely drained soils developed on till is higher than is normal for the association and the relationship of these soils and their drainage characteristics to the topography resembles that obtaining in the Ettrick Association.

Land use

As the most widespread soil on the Rhins Peninsula, the Rhins series, together with the closely related Portpatrick series, has a considerable influence on the system of farming practised there. The summer climate here in the south-west of the country, where the series occurs at low and moderate elevations, is characterized as *warm moist lowland, warm rather wet lowland* and in some areas as *warm rather dry lowland.* The average annual rainfall is in the range 1000–1250 mm and the growing season is over 250 days, 300 days at the Mull of Galloway—one of the longest seasons in Scotland. This combination of warm moist climate and moderately clayey soils with good waterholding capacity is favourable to the growth of grass and therefore to systems of farming based on leys. Although cultivation is also possible throughout much of the area of the series and association, the land is not altogether satisfactory for arable cropping, especially on a large scale, because of the impeded natural drainage, the moist climate and the prevalence of moderate or steep slopes. On the other hand dairy farming, traditional in the area and based on long ley grassland, is ideally suited to the climate and the predominating soil conditions. In the southern part of the Machars the series is less prevalent than on the Rhins Peninsula but the system of farming is similar.

Arable crops are mainly turnips, barley and oats, grown to provide winter feed for the dairy herds. Cropping is generally limited to short breaks between periods of ley grass and to areas at lower elevations. In the relatively lower lying and drier area between Sandhead and Port Logan cropping is rather more intense with some wheat and potatoes grown as cash crops.

PORTPATRICK SERIES

The Portpatrick series, like the closely related Rhins series, is one of the more extensive soils in the area, occupying 48·6 square kilometres or 22·6 percent of the association. The series occurs mainly on the Rhins Peninsula at low and moderate altitudes, generally on lower slopes at less than 100 m (350 feet). The natural drainage is imperfect and the soil is classified as a brown forest soil with gleyed B and C horizons.

The parent material, the reddish brown clay loam till with greywacke stones, which characterizes the association has been discussed in Chapter 3. The upper till layers are partially water-sorted, generally sandier than the deeper till and with a lower content of clay. The watersorting is possibly the result of the action of temporarily impounded glacial meltwaters, which might also account for the fact that this series and the related Portencalzie series occur at relatively low altitudes and are absent from the higher areas.

Only small areas of the series occur in the Port William area, on tills, indicated with the symbol I on the soil map, which are intergrading in character with those of the Ettrick Associations.

Almost all the area of this soil has been cultivated and carries grassland or arable crops. Profile descriptions given below are for a modal soil and an intergrade.

Profile Description: Modal Soil

Slope:	6°
Vegetation:	arable grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–25 cm	Reddish brown (5YR4/3) loam; moderate medium subangular blocky breaking to fine crumb; friable; organic matter moderate; frequent stones; many roots; no mottles; many bleached sand grains; moist. Clear change over 4 cm into
A_1/B_2g	25–47 cm	Light reddish brown (5YR6/3) loam to sandy loam; weak coarse subangular blocky; frequent small vesicular pores; frequent worm channels; organic matter low; a few roots; frequent stones; frequent fine distinct yellowish red (5YR6/8) mottles; moist. Gradual change over 10 cm into
B_2g	47–72 cm	Reddish brown (5YR5/3) gritty sandy loam; massive; firm; organic matter low; a few roots; frequent stones; frequent medium distinct yellowish red (5YR5/4) mottles; moist. Gradual change over 7 cm into
B_3g/Cg	72+ cm	Reddish brown (5YR4/3) gritty sandy loam; massive; indurated; no organic matter; no roots; frequent stones; a few fine ochreous mottles and frequent dark manganiferous staining; moist.

Profile Description: Intergrade Soil

Slope:	5°
Vegetation:	arable grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–25 cm	Very dark greyish brown (10YR3/2) loam; moderate medium subangular blocky; friable; organic matter moderate; many roots; frequent stones; no mottles; moist. Gradual change over 7 cm into
B_2g	25–65 cm	Brown (7·5YR5/2) sandy loam to loam; weak coarse blocky; slightly friable; organic matter low; a few roots; frequent stones; frequent medium distinct yellowish red (7·5YR5/6) mottles; moist. Gradual change over 7 cm into
B_3g	65–105+ cm	Brown (7·5YR5/4) sandy loam; massive; slightly firm; organic matter low; no roots; frequent stones; frequent fine distinct strong brown (7·5YR6/2) mottles along large cracks; moist.

The plough layer is generally of loam texture, with a moderate organic matter content and a moderately stable blocky or crumb structure. Developed on the modified till, the underlying B_2g horizon is commonly weakly developed with colours generally less red than in the unmodified till of the Rhins series. The horizon also tends to develop ochreous mottling and become gleyed more readily than the clay loam materials of the Rhins soil. Bulk density and degree of compaction in the upper horizons are also less in soils formed on modified materials than in soils formed at similar depths from till. Root development is also somewhat greater in the Portpatrick series than in the Rhins. In the modified till medium or sandy textures generally extend to depths of more than

45–50 cm but in some areas these textures are found at greater depths and the unmodified till is not reached in a normal profile pit. Soils developed on the more strongly modified tills are often indurated in the deeper soil layers, but not invariably. Where the unmodified clay loam till is encountered at some depth in the profile it is generally designated a C or Cg horizon, but the processes responsible for the differentiation of the overlying layers are probably geological.

Land use

In general terms the agricultural utilization of this series is similar to that for the Rhins series discussed above. The good waterholding capacity of the soil and the warm humid climatic conditions favour the growth of grass and the traditional system of farming based on dairying. In the drier rather lower lying area between Sandhead and Port Logan cultivation is more frequent than in other areas and some cash cropping is undertaken. The layers with sandy loam texture give greater permeability than in the Rhins series and moisture percolates more readily into the deeper soil layers and to field drains. Deep ploughing can be more easily carried out and the subsoil material is more easily incorporated into the topsoil. Root development in the subsoil layers is also likely to be greater in the less dense and less compact materials.

These factors tend to make the Portpatrick series more suitable for arable agriculture than the Rhins series, but under similar conditions of climate and topography the total effect is not significant and does not lead to any difference in the land-use-capability designations of the two series. The areas of the series have been classified as *warm moist lowland* and *warm dry lowland* with some areas *warm wet lowland* and all are *exposed*. The main restrictions on arable agriculture are the impeded natural drainage and the moist climate.

MULL SERIES

The Mull series, mapped only on a small promontory, the Mull of Galloway, in the south of the Rhins Peninsula, occupies 44 hectares, or 0·2 percent of the association. The soil has been classified as a humus-iron podzol with free natural drainage and is developed on shallow reddish brown stony drift overlying greywacke and shale rocks. The area has been reclaimed by liming, ploughing and reseeding.

Profile Description

Slope:	4°
Vegetation:	Pasture with *Agrostis* spp., *Festuca* spp., *Holcus lanatus, Anthoxanthum odoratum, Cynosurus cristatus, Nardus stricta, Trifolium repens, Juncus squarrosus, Potentilla erecta*
Drainage:	free

Horizon	*Depth*	
H/Ap	0–15 cm	Very dark grey (5YR3/1) humose sandy loam; moderate medium subangular blocky to crumb; friable; organic matter high; many roots; a few stones; no mottles; moist. Sharp change over 1 cm into

Horizon	*Depth*	
A_2	15–22 cm	Brown (7·5YR5/2) sandy loam; weak blocky; friable; organic matter low; many roots; frequent stones; no mottles; moist. Sharp change over 2 cm into
B_{21}	22–35 cm	Black (5YR2/1) humose loam; massive; firm; organic matter high; a few roots; frequent stones; no mottles; moist. Gradual change into
B_{22}	35–47 cm	Dark reddish grey (5YR4/2) loam; massive; weakly cemented; organic matter moderate; a few roots; frequent stones; a few strong brown patches associated with weathering stones; moist. Clear change over 4 cm into
B_3	47–62 cm	Reddish brown (5YR4/4) loamy sand to sandy loam; massive; weakly indurated; no organic matter; no roots; frequent stones; no mottles; earthworms present; moist. Gradual change over 7 cm into
B_3/C	62+ cm	Brown (7·5YR4/2) sandy loam to loamy sand; massive; strongly indurated; no organic matter; no roots; frequent stones; no mottles; earthworms present; moist.

The humose surface layer appears to have been formed by the ploughing and mixing of a former shallow raw humus layer with the upper part of the mineral A_2 horizon. The greyish brown A_2 mineral horizon remaining below the plough layer is sandy and friable and apparently unaltered by cultivation. The organic matter content in the upper part of the B horizon is high, and is well humified and thoroughly mixed with the mineral matter. The content of extractable sesquioxides, low in this layer, rises with depth and the B_{22} horizon has a rather lower organic matter content and somewhat more reddish colours, probably indicating higher amounts of extractable sesquioxides which reach a maximum in the underlying horizon. Textures are sandy loam to loamy sand throughout the profile and the stone content increases from moderate near the surface to abundant in the deeper soil layers. The presence of earthworms probably reflects the effects of earlier liming and cultivation.

Land use

Probably reclaimed by cultivation from former moorland, the series now carries moderately good grassland which is utilized mainly for grazing by sheep. It is said locally that the area was once used for growing wheat. The areas of the series are placed in the class of *warm rather dry lowland* but they are *very exposed.* The main restrictions on arable agriculture are the stone content and depth of soil, together with a low natural fertility and high degree of exposure.

AUCHLEACH SERIES

Like the Mull series, the Auchleach series is inextensive, occupying only 1·4 square kilometres or 0·6 percent of the association. The series occurs mainly on a few drumlin crests and other shedding sites on the moors between Knock and Maize and Knockquhassen, with other small areas near Milleur Point and south of Barncorkrie.

The drainage in the B horizon is generally free and the profile is classified as a peaty podzol. The parent material is either a shallow till of loamy texture or the reddish brown till, characteristic of the association, with partially water-sorted surface layers. Attempts have been made in several areas to reclaim this soil, but the semi-natural vegetation is generally a form of wet heather moor.

Profile Description

Slope:	10°
Vegetation:	arable grassland
Drainage:	free below the iron pan

Horizon	*Depth*	
Ap/H	0–22 cm	Black (10YR2/1) peaty loam; strong medium subangular blocky; friable; organic matter very high; many roots; frequent stones; no mottles; moist. Clear change into
B_1	22 cm	Weak discontinuous iron pan.
B_2	22–37 cm	Yellowish red (5YR4/5) loam; weak subangular blocky; slightly friable; organic matter low; frequent roots; frequent stones; no mottles; moist. Gradual change over 6 cm into
B_3	35–57 cm	Reddish brown (5YR5/3) loam; weak coarse subangular blocky; very firm; no organic matter; a few roots; frequent stones; a few medium distinct yellowish red (5YR5/6) mottles; moist. Gradual change over 7 cm into
B_3/Cg	57+ cm	Reddish brown (2·5YR4/3) loam to clay loam; coarse prismatic; indurated; no organic matter; no roots; frequent stones; a few medium distinct yellowish red (5YR5/6) mottles and widely spaced large cracks containing light brownish grey (10YR6/2) material; moist.

The modal form of this soil is not well defined as it has been mapped on relatively few sites. The profile described above differs from that of a typical peaty podzol in that the surface peaty layer and the A_2g horizon have been mixed by cultivation, while some incipient mottling in the B_3 horizon indicates a slight tendency for waterlogging to occur in this layer. The iron pan is weak and discontinuous and the clay content, as estimated by field texturing but not fully confirmed by laboratory analysis, is rather higher than is normal for this major soil group. The cracks with brownish grey infillings in the B_3/Cg layer probably represent the effects of former frost action such as ice wedge formation.

Land use

Several areas of this soil have been reclaimed by cultivation and are maintained in moderate or poor quality grassland which is utilized as grazing for hill sheep and breeding or store cattle; unreclaimed areas provide rough grazing. The areas of the series have been classified as *warm rather wet lowland* and are *very exposed.* The main factors restricting the use of this land are the character of the peaty surface layer, the wetness of the upper soil layers and the wet climate.

ARDWELL SERIES

A non-calcareous gley soil with poor natural drainage, the Ardwell series occurs in the inter-drumlin hollows and other depressional sites and is developed where the reddish brown clay loam till characteristic of the association is unmodified by processes affecting the clay content of the surface layers. The series is of moderate extent, occupying 5·7 square kilometres or 2·6 percent of the association, and most areas have been drained and are maintained in cultivated grassland.

Profile Description

Slope:		0°
Vegetation:		long ley grassland
Drainage:		poor
Horizon	*Depth*	
Ap	0–22 cm	Brown (10YR5/3) loam; weak medium subangular blocky; slightly friable; organic matter moderate; many roots; a few stones; a few fine prominent yellowish red (5YR5/6) mottles; moist. Clear change over 3 cm into
A_2g	22–45 cm	Light brownish grey (2·5Y6/2) clay loam; weak coarse prismatic; firm; no organic matter; a few roots; a few stones, mainly weathering greywackes; frequent medium distinct olive-yellow (2·5Y6/5) mottles; moist. Gradual change over 7 cm into
B_2g	45–72 cm	Reddish brown (2·5YR5/3) clay loam; very coarse prismatic; very firm; no organic matter; no roots; frequent stones; frequent coarse distinct strong brown (7·5YR5/6) and a few pinkish grey (7·5YR6/2) mottles; moist. Diffuse change over 15 cm into
Cg	72+ cm	Reddish brown (2·5YR5/4) clay loam; firm; massive; no organic matter; no roots; frequent stones; a few medium faint brown (7·5 YR 5/4) and a few pinkish grey (7·5YR6/2) mottles; moist.

The organic content of the plough layer is generally low or moderate and the blocky or subangular blocky structure is relatively weakly developed and unstable. Mottling is generally present in this layer but is fine and restricted to root channels. The eluviated and strongly gleyed A_2g horizon is generally well developed and predominantly grey in colour, but it varies in depth and is often shallow. Root growth in this horizon is poor as a result of the high bulk density of this and the deeper till layers and of the intense gleying and unfavourable hydrological conditions. Below the A_2g horizon the reddish brown colour of the parent material predominates and reflects the resistance of this material to gleying and the effects of waterlogging. The B_2g horizon is differentiated from the Cg horizon mainly by the greater amount of mottling and the better defined structure. Areas where the tills intergrade to those of the Ettrick Association are indicated on the soil map by the symbol I.

Land use

This series has been mapped mainly in small wet patches often in sinuous hollows and depressions alongside soils with less impeded drainage. The system of farming is the same as for the predominating imperfectly drained brown forest soils with gleyed B and C horizons. Efficient underdrainage is essential to the best utilization of both imperfectly and poorly drained soils, but in the poorly drained areas care must be taken to adapt the drainage system to the local topography and run-off patterns.

Most areas have been tile-drained previously and carry improved or cultivated grassland which is grazed by dairy cows. Generally areas with poorly drained soils are only infrequently cultivated for renewal of the sward, and arable crops are less common than on the better drained soils of the association.

The areas of the series are classified as *warm rather moist* to *warm wet lowland* and the topographic situation of the soils is such that exposure is rather less than in the surrounding areas. The main factors restricting arable agriculture on these soils are poor natural drainage and the moist climatic conditions.

BALSCALLOCH SERIES

The Balscalloch series occupies 13·6 square kilometres or 6·3 percent of the association and is classified as a non-calcareous soil with poor natural drainage. Like the related Ardwell series it occurs mainly in inter-drumlin hollows and depressions alongside water courses or drainage channels. The parent material is the reddish brown clay loam till characteristic of the association in which the surface layers appear to have been modified and are more sandy than the deeper till. Most of the series has been tile-drained and carries improved or cultivated grassland, with sharp-flowered rush (*Juncus acutiflorus*) occurring in some areas.

Profile Description

Slope:	0°
Vegetation:	long ley grassland
Drainage:	poor

Horizon	*Depth*	
Ap	0–27 cm	Dark greyish brown (10YR4/2) loam; weak medium blocky; slightly friable; organic matter moderate; frequent roots; a few stones; a few fine distinct reddish brown (5YR5/4) mottles along root channels; moist. Clear change over 3 cm into
A_2g	27–45 cm	Light brownish grey (10YR6/2) sandy loam; weak blocky to prismatic; firm; organic matter low; a few roots; a few stones; some Ap material along worm channels; frequent medium distinct yellowish brown (10YR5/4) mottles; moist. Gradual change over 10 cm into
B_2g	45–75 cm	Reddish grey (5YR5/2) loam; weak coarse prismatic; firm; no organic matter; a few dead roots; frequent stones; frequent coarse diffuse yellowish brown (10YR5/4) and some pinkish grey (7·5YR 6/2) mottles; moist. Gradual change over 10 cm into
B_3g/Cg	75+ cm	Reddish grey (5YR5/2) clay loam; massive; firm; no organic matter; occasional large dead roots; frequent stones; a few fine to medium very diffuse brown (7·5YR5/4) and pinkish grey (7·5YR 6/1) mottles along root channels; moist.

This soil tends to remain for long periods in pasture and significant amounts of reddish brown mottling develop along fine root channels in the A horizon. The development and stability of structure in the surface horizon is relatively weak. The A_2g horizon is strongly gleyed, but the degree of ochreous mottling suggests that eluviation of sesquioxides is less intense in the profiles of moderate acidity than in the more strongly acid soils. The modified till layers are less red than the unaltered tills and are more readily affected by gleying, as indicated by the degree of ochreous mottling in the B_2g horizon. Structural development in the A_2g and B_2g layers varies considerably; it is generally weak blocky where the till has been highly modified and is sandy loam, and prismatic in the less altered tills. The C horizon is generally massive and has the reddish brown colour of the unaltered till.

Land use

Like the Ardwell series, this soil occurs in hollows and depressions amongst soils with less strongly impeded drainage. Most areas have been tile-drained previously and are maintained in improved or cultivated grassland utilized mainly as grazing for dairy cattle. The sward is generally broken for renewal only at infrequent intervals and the amount of arable cropping is small.

The areas of the series are classed as *warm rather dry lowland* to *warm wet lowland* and because of their topographic position are *moderately exposed.* The main factor restricting arable agriculture is the impeded soil drainage, the effect being generally more severe where the climate is wetter.

GLENSTOCKADALE SERIES

The Glenstockadale series is found mainly on drumlinoid till ridges in the moorland area around Broad Moor on the elevated crest of the Rhins Peninsula between Portpatrick and Stranraer. In all, the series covers 3·4 square kilometres or 1·6 percent of the association. The parent till is unmodified and has the reddish brown colour and clay loam texture characteristic of the association. The soil is classified as a peaty gley, and the natural drainage on the predominantly shedding sites which it occupies is poor. The natural vegetation has been modified in a few areas where attempts to reclaim the soil have been made, but under semi-natural conditions is normally a form of wet heather moor or flying bent grassland.

Profile Description

Slope:		5°
Vegetation:		*Molinia caerulea, Festuca ovina, Carex nigra, Plagiothecium undulatum, Lophocolea bidentata*
Drainage:		poor
Horizon	*Depth*	
H	27–0 cm	Dark reddish brown (5YR2/2) well humified peat; weak subangular blocky; many roots; wet. Clear change over 3 cm into
A_2g	0–12 cm	Greyish brown (10YR5/2) to dark reddish brown (5YR4/2) loam; massive to very coarse blocky; firm; organic matter high; frequent roots; frequent stones; no mottles; moist. Clear change over 5 cm into
B_2g	12–30 cm	Grey (5Y5/1) loam; weak coarse to medium subangular blocky; firm; organic matter low; a few dead roots; frequent stones; many coarse faint light olive-brown (2·5Y5/4) mottles; moist. Gradual change over 7 cm into
B_3g	30–47 cm	Greenish grey (5BG6/1) clay loam; weak coarse blocky to prismatic; firm; no organic matter; a few dead roots; frequent stones; a few medium distinct yellowish brown (10YR5/6) mottles and a few medium distinct light reddish brown (5YR6/3) patches; moist. Clear change over 5 cm into
Cg	47+ cm	Brown (7·5YR4/3) clay loam; massive; very firm; no organic matter; no roots; frequent stones; frequent fine prominent light greenish grey (5BG7/1) mottles; moist.

The peaty surface layer is well developed and generally between 15 and 30 cm thick. Considerable amounts of organic matter occur in the A_2g horizon, much of it apparently washed into cracks from the overlying peat horizon, but some also well incorporated with the mineral matter, imparting a somewhat brown coloration to the horizon. Ochreous mottles are generally absent from the layer, which appears to be both strongly gleyed and eluviated. Gleying is also intense in the Bg horizon where pale grey and greenish hues are typical of reddish brown haematitic materials which, although normally resistant to gleying, show a marked colour change when periodic waterlogging is severe. Ochreous mottles are also present. The brown or reddish brown colours of the parent till predominate in the Cg horizon and mottling is mainly greenish grey along the root channels of specialized deep rooting plants such as horsetails (*Equisetum* spp.). Waterlogging is mainly in the surface layers and is occasioned by the low permeability of the till, although on shedding sites it is probably partly caused also by the water-absorbent peaty surface layer.

Land use

Most of this series is utilized as rough grazing for hill sheep and cattle although attempts at reclamation have been made in a few areas, with herbage consisting mainly of fine grasses being maintained in place of the native moorland species. The areas of the series have been characterized as *fairly warm rather wet lowland and foothill* and are *very exposed*. The principal factors restricting the agricultural use of this series are the poor natural drainage, the nature of the peaty surface layer, the wet climate and the strong exposure.

LOCHNAW SERIES

The Lochnaw series is one of the less extensive soils of the association occupying only 0·4 percent or 76 hectares. The series has been mapped mainly on Larbrax Moor, with small areas south of Barncorkrie and near Knockglass, west of Stranraer. Like the related Glenstockadale series the soil is developed mainly on the shedding convex slopes of drumlinoid till ridges. The parent material is the reddish brown clay loam till, characteristic of the association, in which the upper layers are modified and more sandy than the unaltered material. In part of the area the soil occurs on thin stony medium-textured drift with greywacke rock at a shallow depth, this being indicated on the soil map by the symbol G. The natural drainage is poor and the series is classified as a peaty gley; the semi-natural vegetation is generally a form of wet heather moor.

Profile Description

Slope:	3°
Vegetation:	*Calluna vulgaris, Erica tetralix, Trichophorum cespitosum, Pohlia nutans*
Drainage:	poor

Horizon	*Depth*	
H	30–0 cm	Dark reddish brown (5YR2/2) fibrous peat; weak blocky; many roots; wet. Gradual change over 7 cm into

Horizon	*Depth*	
A_2g	0–10 cm	Very dark greyish (10YR3/2) loam; weak subangular blocky; firm; organic matter moderate; frequent roots; frequent stones; no mottles; moist. Clear change over 5 cm into
B_2g	10–25 cm	Brown (7·5YR5/4) loam; weak subangular blocky; slightly firm; no organic matter; frequent dead roots; frequent stones; frequent coarse distinct reddish yellow (7·5YR6/8) and frequent fine distinct brownish grey (10YR6/2) mottles; moist. Gradual change over 10 cm into
B_3g	25–45 cm	Light reddish brown (5YR6/3) loam; weak subangular blocky to massive; firm; no organic matter; a few dead roots; frequent stones; frequent to few medium distinct strong brown (7·5YR5/6) mottles; moist. Gradual change over 7 cm into
Cg	45+ cm	Light reddish brown (2·5YR6/4) clay loam; massive; very firm; no organic matter; no roots; frequent dark manganiferous mottles; frequent medium distinct greyish brown mottles and a few distinct ochreous mottles; moist.

In many properties the Lochnaw series closely resembles the related Glenstockadale series, but textures in the upper mineral layers are not so fine. The peaty H horizon is generally thick, 20–30 cm, and, in a few inextensive areas, has apparently become drier, possibly under the influence of colonizing bracken (*Pteridium aquilinum*), and has developed prismatic structure, most prominent at the base of the layer. Structures in the upper mineral horizons are generally blocky and tend to be only weakly developed. In colour the A_2g horizon is dark, although generally the content of organic matter is moderate with local concentrations often occurring in streaks. The degree of gleying in the B_2g horizon varies according to local conditions, but brown colours commonly predominate with a moderate degree of ochreous and grey mottling reflecting an intensity of gleying and waterlogging relatively mild for a peaty gley soil. The reddish brown clay loam till, which has some grey mottling indicating gleying, occurs at a depth of from 50 to 100 cm and is massive. Where the drift is shallow and overlies greywacke rock, textures are mainly loam.

Land use

Most of this series is utilized as rough grazing of moderate quality for sheep and cattle. It is classified as *warm moist lowland* or *warm rather wet lowland* and is *exposed*. The main restriction on arable agriculture is the poor soil drainage together with the nature of the peaty surface layer and the moist climatic conditions.

BUYOCH COMPLEX

The Buyoch complex is extensive, occupying 26·3 square kilometres or 12·3 percent of the association. Mapped in scattered patches throughout the association area, it is well seen at Buyoch Farm near the Isle of Whithorn. The complex, resembling the Achie complex of the Ettrick Association, has been mapped at moderate and low altitudes on an ice-eroded landscape of scattered outcrops of rock interspersed with shallow deposits of reddish brown till of the Rhins Association. The soil pattern consists of brown forest soils with free or imperfect drainage and differing widely in depth and stone content and are interspersed with rock outcrops. The amount of outcropping rock varies considerably and the complex has been mapped on both gentle and steep slopes. A number of the less rocky areas have been cultivated and some well fertilized grassland is maintained on them but the semi-natural vegetation is usually a form of bent-fescue grassland with gorse (*Ulex europaeus*) in a few areas.

Land use

Land use on this complex is dependant on the frequency and pattern of outcropping rocks. In a few local areas where the outcropping rocks are less than is usual, there is some cultivation and growth of arable crops such as barley or turnips in a rotation with long ley grass. In many areas good quality grassland is maintained by the use of lime and fertilizers with surface cultivation. The least favourable areas, on steep slopes or where frequency of rock outcrops is high, generally carry rough grazing. The quality of this grazing, however, is relatively good, and productivity is much greater than on the peaty moorland soils. The areas vary from *warm rather dry lowland* to *warm wet lowland* and are *exposed*. Outcropping rock and variable soil depth are the main restrictions to arable agriculture.

Yarrow Association

Soils of the Yarrow Association have been mapped previously in south-east Scotland by Ragg (1960) and Ragg and Futty (1967); small areas have also been found in Carrick (Bown, 1973).

The Association is extensive in the present area, occupying 89·0 square kilometres or 6·2 percent of the area, and a number of series not previously mapped have been distinguished. The soils occur mainly in the lowland areas, particularly the Stranraer Lowlands, under relatively favourable climatic conditions, and although the topography is most often level or gently sloping, moundy areas also occur. The parent materials are sands and gravels deposited as glacial outwash or Late Glacial raised beaches, and as they are highly permeable freely drained soils make up about 90 percent of the association. The soils have generally been cultivated and carry either improved grassland or arable crops.

DISTRIBUTION

The largest single area of the association occurs between Loch Ryan and Luce Bay on the Stranraer Lowlands, and from this area the soils extend northwards along the east and west shores of Loch Ryan and south along the west coast of Luce Bay through Ardwell to lowlands between Terally and Port Logan. Soils of the association are also found around Galdenoch Moor, to the north of Portpatrick, around Corsewall Point and at Cailliness Point south of Drummore. Other small areas occur scattered throughout the Rhins Peninsula, along the valleys of the Luce

Water and the Rivers Bladnoch and Cree and as narrow strips along the coastline of the Machars.

PARENT MATERIALS

In south-east Scotland soils of the Yarrow Association have been mapped on gravel deposits, generally fluvioglacial outwash derived from greywackes and shales. Soils on such deposits are, however, much more extensive in the Stranraer–Wigtownshire area where they occur together with soils developed on sands. Because of their close association and occurrence on similar landforms the soils formed on sands and those on gravels have been grouped together in the one association, but are mapped as separate soil series.

The materials are all very coarse-textured and highly permeable, and while the sands are almost stone-free there is a wide range in size and amount of stone in the gravels which are, however, derived almost entirely from greywacke and shale materials. The deposits are generally Late Glacial in age and comprise material possibly of morainic origin, fluvioglacial outwash and Late Glacial raised beach material. Soils developed on sands or gravels laid down more recently by rivers or on the Post Glacial raised beach show somewhat different profile characteristics and have been placed in other soil groups.

SOILS

Of the nine soil series and one soil complex mapped in this association, only the Yarrow series has been previously described. The freely drained brown forest soils, Yarrow and Cairnside series, are the most extensive, accounting for about 90 percent of the association. The humus-iron podzols, Knockarod and Larbrax series, are of minor extent and mainly restricted to the area around Galdenoch Moor. The poorly drained non-calcareous gleys, Innermessan and Dinduff series, occur only in small localized hollows, and are often just of sufficient extent to be represented at a scale of 1: 63,360. Soils with imperfect drainage are difficult to distinguish when developed on highly permeable materials such as sands and gravels, but a few areas of brown forest soils with gleyed B and C horizons have been mapped, as the Carsnaw, Galdenoch and Cailliness series.

YARROW SERIES

The Yarrow series is one of the more extensive soils in the area, occupying 59·5 square kilometres or 66·8 percent of the association. The series is classified as a brown forest soil with very free natural drainage, but some areas of former podzols in which the upper horizons have been destroyed by ploughing have also been mapped with this series. The series is found throughout the association area, generally at low and moderate altitudes, and the main occurrences are the Stranraer–Luce Bay Lowlands, on Galdenoch Moor and as scattered areas around the coast and along river valleys. The parent materials are gravels derived from greywackes and shales and deposited in morainic forms as fluvioglacial outwash or on the Late Glacial raised beach. The soils have mainly been cultivated and semi-natural vegetation is restricted to a very few areas. It is generally a form of bent-fescue grassland, but some areas of woodland also occur.

Profile Description

Slope: 0°

Vegetation: *Fagus sylvatica, Quercus robur, Acer pseudoplatanus, Holcus mollis, Oxalis acetosella*

Drainage: free

Horizon	*Depth*	
L and F	3–0 cm	Leaf litter and fermentation layers
A_1/H	0–5 cm	Dark brown (7·5YR3/2) humose sandy loam; moderate fine crumb; friable; organic matter very high; many roots; frequent stones; many bleached sand grains; no mottles; moist. Clear change over 3 cm into
A_1	5–30 cm	Brown (7·5YR4/4) sandy loam; weak fine subangular blocky; friable; organic matter moderate; many roots; many stones; no mottles; moist. Gradual change over 7 cm into
B_2	30–57 cm	Strong brown (7·5YR5/8) sandy loam; weak subangular blocky; friable; organic matter low; frequent roots; many stones; moist. Gradual change over 5 cm into
C	57+ cm	Dark brown (7·5YR3/2) coarse sand and gravel; single grain; loose; no organic matter; no roots; many stones; no mottles; slightly moist.

Under semi-natural or woodland conditions, a thin layer of partially decomposed litter generally overlies the A horizon. The upper organo-mineral layer is thin, generally about 5 cm thick, is dark and has a high organic matter content, many bleached sand grains and a strong structure. The form of the organic matter generally resembles a silicate moder but in some areas intergrades to raw or mor humus. In the underlying brown organo-mineral A horizon the organic matter content and structure development are moderate. Cultivation leads to the destruction of the litter layer and the organic-rich surface horizon and their incorporation into a plough layer, generally brown in colour with moderate organic matter content and structure. The H and A_2 horizons of some podzols have also probably been destroyed by cultivation, so that the soils now resemble the Yarrow series with which they have been mapped. In suspected former podzols, however, the surface layers are often darker or blacker than in true brown forest soils, and in some areas, remnants of a former A horizon or evidence of an iron pan may be found. The B_2 horizon has a high chroma and is apparently rich in extracted or weakly crystalline sesquioxides. The structure is weak, consistence is friable with occasional profiles showing cementation. Below the B horizon the parent material or C horizon is a raw sand and gravel apparently unaltered by weathering or pedological processes and only rarely indurated. Textures throughout the profile are coarse or moderately coarse sandy loam to loamy sand. The amount and size of the rounded stones present varies greatly.

Land use

Much of the land in this series, which occurs at low and moderate elevations, has moderate or gentle slopes, although there are also areas with hummocky topography and short steep slopes. Generally, therefore, the soils have been cultivated and are farmed in a rotation of ley grassland and arable crops, mainly barley, potatoes or turnips. Dairy farming, which predominates in the lowland tracts of the areas as a whole, is the main system of farming followed on this series, although in dry seasons the low waterholding capacity of the soils may retard the growth of grass. Nevertheless, on most farms these soils with their very free drainage and sandy textures provide some of the most easily cultivated land and periods in grass are shorter than for most other soils.

The areas of this widespread series are classed as *warm rather dry lowland* to *warm rather wet lowland* and are *exposed* or *moderately exposed.* Although cultivation is easy, yields are restricted on account of the low waterholding capacity of these soils. The high stone contents also affect the use of some machinery and restricts the range of crops grown.

CAIRNSIDE SERIES

The Cairnside series is moderately extensive, occupying 19·4 square kilometres or 21·8 percent of the association. It occurs mainly on the Stranraer–Luce Bay Lowlands and on Galdenoch Moor, with smaller areas forming scattered patches near the coasts. The soil is classified as a brown forest soil with very free natural drainage and is developed on sands generally deposited as fluvioglacial outwash or as part of the Late Glacial raised beach. Also mapped with this series are some former podzol soils, in which the upper horizons have been mixed and incorporated into the plough layer by cultivation. Most of the series has been cultivated and semi-natural vegetation, generally a form of bent-fescue grassland, occurs in small areas.

Profile Description

Slope:	2°
Vegetation:	arable grassland
Drainage:	free

Horizon	*Depth*	
Ap	0–25 cm	Dark brown (10YR3/3) sandy loam; weak to moderate fine crumb; many roots; organic matter moderate; no stones; no mottles; moist. Sharp change over 1 cm into
B_2	25–35 cm	Yellowish red (5YR4/6) loamy sand; single grain to weak blocky; friable; organic matter low; a few roots; no stones; no mottles; moist. Clear change over 4 cm into
B_3	35–67 cm	Strong brown (7·5YR4/6) loamy sand to sand; friable; no organic matter; a few roots; no stones; no mottles; moist. Gradual change over 10 cm into
C	67+ cm	Brown (7·5YR5/5–10YR5/3) sand to loamy sand; single grain; friable; no organic matter; no roots; no stones; no mottles; moist.

The Ap horizon is generally brown with a chroma of three or more, but in some soils derived from former podzols by cultivation the colour is darker brown or black and the chroma is low. These soils also have a high content of bleached sand grains in the Ap horizons. Under cultivation, the content of organic matter in the Ap horizon is reduced to low levels but sometimes high values are found in the A_1 horizons of semi-natural soils or after long periods in grassland. The B horizons are well developed with colours of high chroma and a significant content of extractable sesquioxides. In a few instances the occurrence of an iron pan indicates the soils were once podzols. Except in the A_1 horizon of uncultivated soils, the horizons are weakly structured. The parent material is normally brown or the colour of the raw unweathered sand grains which are generally unaggregated. A few of the parent materials are indurated.

Land use

The land use on the Cairnside series is very similar to that on the Yarrow series. Milk production is the predominant form of farming, probably under the influence of established local tradition. A rotation of grass, grain and root crops is generally followed, as in other lowland parts of the area, but the periods in grass are usually shorter. Cultivation is generally relatively easy because of the very free drainage and the coarse texture of the soils and a tilth can be readily obtained. The low contents of clay and organic matter in the soil mean, however, that waterholding capacity is poor and consequently there is a danger of drought. In dry years yields are reduced.

Areas of this series are classed as *warm rather dry lowland* to *warm rather wet lowland* and are *exposed* or *moderately exposed.* Arable cropping is mainly restricted by the very sandy nature and low waterholding capacity of the soil, characteristics which govern the choice of crop and affect reliability of yield.

CARSNAW SERIES

Carnsaw series has been mapped in only one small area, near Newton Stewart, and occupies 16 hectares or 0·2 percent of the association. The soil is classified as a brown forest soil with gleyed B and C horizons and the natural drainage is imperfect. The parent material is a shallow deposit of gravel associated with fluvioglacial outwash. The soil carries good quality improved grassland.

Profile Description

Slope:	0°
Vegetation:	long ley grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–25 cm	Dark reddish brown (5YR3/2) loam; moderate medium subangular blocky; friable; organic matter high; many roots; many stones; no mottles; moist. Clear change over 4 cm into
Bg	25–70 cm	Greyish brown (10YR5/2) coarse sand and gravel; single grain; friable; no organic matter; a few roots; many stones; a few medium distinct yellowish brown (10YR5/6) mottles; moist. Gradual change over 10 cm into
Cg	70+ cm	Brown (7·5YR5/2) coarse sand and gravel; single grain; friable; no organic matter; no roots; many stones; a few faint yellowish brown mottles; moist.

In this soil the intensity of gleying and conditions of wetness are both moderate, and markedly less than in the poor and very poorly drained profiles. The profile morphology and drainage relationships suggest that the soil overlies an impervious layer at a shallow depth and is affected by a ground watertable rising near the surface for relatively short periods during the year. The organic matter content of the surface layer is high, possibly reflecting a former thin peaty layer. Textures are coarse and sandy throughout the profile and there is a high content of rounded stones.

Land use

The series carries long ley grassland which is grazed by dairy cows. The area is *warm rather wet lowland* and is *moderately exposed.* The main restriction on arable agriculture is the liability to wetness.

GALDENOCH SERIES

The Galdenoch series is inextensive, occupying only 2·7 square kilometres or 3·0 percent of the association. The soils are developed on sands deposited on the Late Glacial raised beach or by fluvioglacial meltwaters. Classified as a brown forest soil with gleyed B and C horizons, the series has been mapped in low-lying flat or slightly depressional areas where the watertable is generally moderately high and shows considerable seasonal fluctuation. Gley morphology is moderately developed and the natural drainage is imperfect. The series generally carries cultivated grassland.

Profile Description

Slope:	0°
Vegetation:	long ley grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–30 cm	Black (5YR2/1) sandy loam; weak medium subangular blocky; friable; organic matter high; many roots; no stones; no mottles; moist. Sharp change over 1 cm into
B_2g	30–47 cm	Dark greyish brown (10YR4/2) and black (10YR2/1) loamy sand; very weak blocky; friable; organic matter moderate to low; frequent roots; no stones; a few to frequent medium yellowish red (5YR4/6) mottles and ochreous tubules along old root channels; moist. Clear change over 4 cm into
B_3g	47–90 cm	Dark greyish brown (10YR4/2) sand; single grain; friable; no organic matter; roots rare; occasional small rounded stones; frequent medium prominent dark reddish brown (2·5YR3/4) and strong brown (7·5YR5/6) mottles; moist. Clear change over 4 cm into
Cg	90+ cm	Brown to greyish brown (10YR5/3–5/2) coarse sand; single grain; non-plastic; no organic matter; no roots; a few small rounded stones; no mottles; wet.

The black colour of the surface horizon probably reflects a former thin raw humus or peaty layer incorporated by ploughing into the mineral soil. In some areas deep topsoils were encountered. Sandy textures with a low clay content occur throughout the profile, and the soil is highly

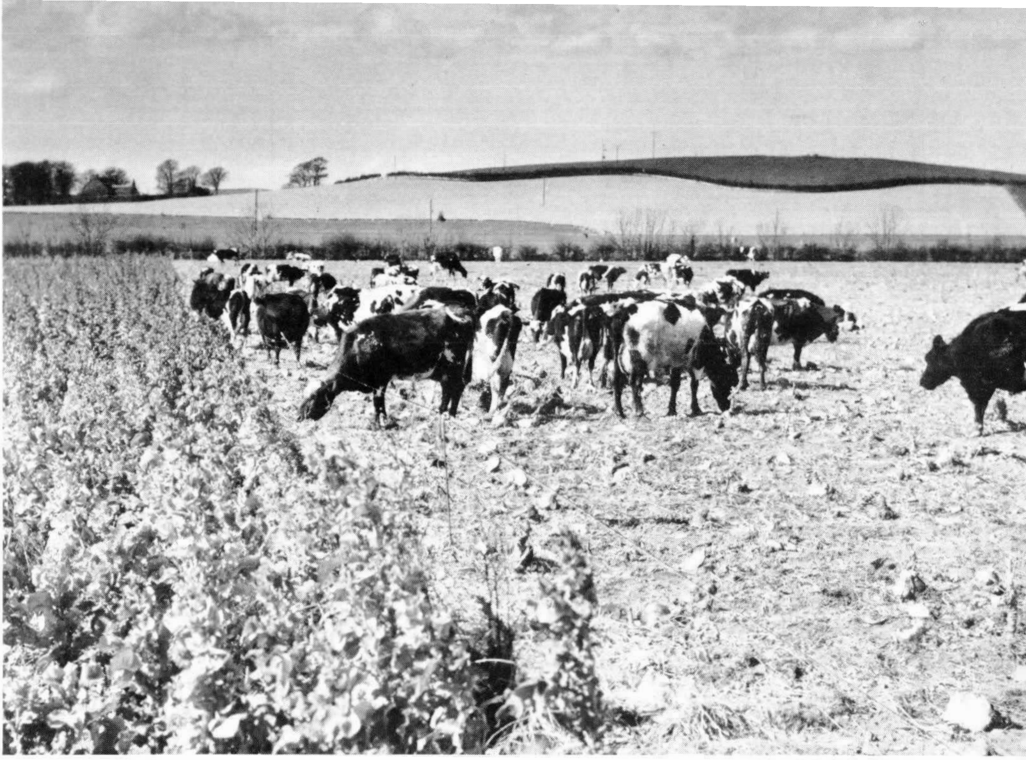


PLATE 13/Herd of Ayrshire dairy cows grazing turnips on alluvial soils near Garlieston.

PLATE 14/Seed-bed preparation on soils of the Stirling series of the Stirling Association near Carsnestock. Cairnsmore of Fleet is in the background.

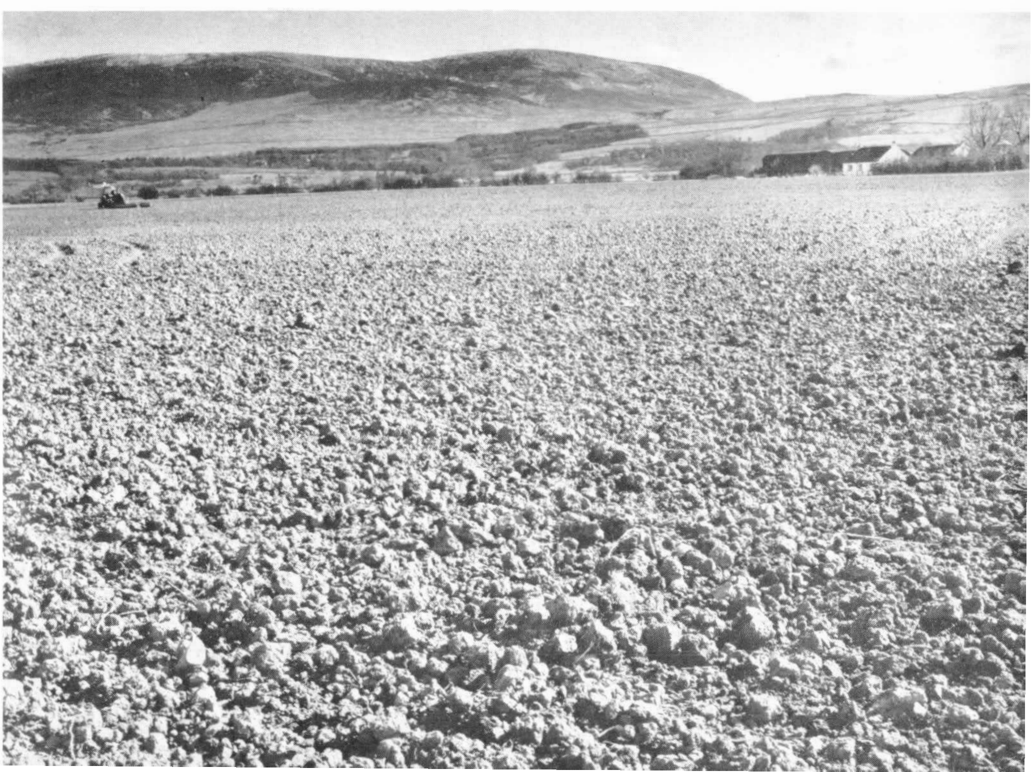


PLATE 15/Cloddy tilth on soil of the Stirling series in the Stirling Association.

PLATE 16/Killantrae Farm near Port William, with soils belonging to the Kedslie series of the Ettrick Association.

permeable with moisture penetrating readily to the ground watertable. Although the permanent watertable is usually at about 80–100 cm depth in the profile, moderate or weak mottling and gley morphology in the B_2g horizon shows that the upper soil layers are waterlogged only occasionally. Structural development in these soils is generally weak, but because of the coarse texture a tilth is readily obtained. Bulk densities seem to be relatively low throughout the profile and conditions favour good root development particularly where artificial drainage has improved aeration.

Land use

The soils of this series are generally maintained for long periods in grass which is utilized as grazing for dairy cows. Cropping for grain and roots is carried out between the periods under grass, but the suitability of the land for arable agriculture depends on the effectiveness of the tile-drainage system. The areas of the series are classified as *warm rather dry lowland* or *warm moist lowland* and are generally *exposed*. The main restrictions on arable agriculture are the liability of the soil to periods of waterlogging and the low waterholding capacity.

CAILLINESS SERIES

The Cailliness series has been mapped in only one small area, near Cailliness Point south of Drummore, where it occupies 28 hectares or 0·3 percent of the association. The soil is classified as a brown forest soil with gleyed B and C horizons and the natural drainage is imperfect. The parent material, a poorly sorted sandy loam or fine sandy loam, is part of the Late Glacial raised beach. No examples of semi-natural vegetation have been found on this series, all of which has been cultivated.

Profile Description

Slope:	3°
Vegetation:	arable grassland
Drainage:	imperfect

Horizon	*Depth*	
Ap	0–35 cm	Very dark greyish brown (10YR3/2) sandy loam; weak subangular blocky to crumb; friable; organic matter moderate to low; many roots; stones few; moist. Clear change over 3 cm into
B_2g	35–62 cm	Brown (7·5YR5/4) sandy loam to loam; massive; slightly firm; organic matter low; roots few; stones few; frequent medium faint strong brown (7·5YR5/6) mottles; some Ap material along worm channels; moist. Clear change over 5 cm into
B_3g/C	62+ cm	Reddish brown (2·5YR5/4) loam; massive; indurated; no organic matter; no roots; stones few; a few fine faint yellowish red (5YR5/6) mottles; moist.

The textures in this soil are generally moderately coarse, but because of stratifications of the parent material they are somewhat variable although the textures in the deeper layers are always the less coarse. The profile is moderately gleyed, with the zone of maximum gleying in the B_2g horizon. It is not certain whether drainage impedance is caused by the massive structure and induration of the B_3g/C horizon or by an impermeable layer of more clayey material occurring at somewhat greater depth; the reddish brown colours at the base of the profile suggest the soil is underlain by till.

Land use

This soil is farmed in a rotation which consists of grass utilized for dairy cows, and arable crops. The period in grass is rather shorter and the frequency of cropping rather greater than in most areas of south-west Scotland. The area, classified as *warm rather dry lowland* and *exposed,* is favourable to arable agriculture. The somewhat impeded natural drainage is the main limitation on the agricultural use of this soil.

KNOCKAROD SERIES

A freely drained humus-iron podzol, the Knockarod series has been mapped in a few small areas, 1·0 square kilometres or 1·2 percent of the association, at relatively low elevations around Galdenoch Moor. The parent materials are fluvioglacial outwash gravels derived mainly from greywacke and shale and the vegetation is a form of dry heather moor with gorse (*Ulex europaeus* and *U. gallii*) in some areas.

Profile Description

Slope:	6°
Vegetation:	*Calluna vulgaris, Erica cinerea, Festuca ovina, Ulex gallii*
Drainage:	free

Horizon	*Depth*	
H	12–0 cm	Black (5YR2/1) well humified peaty organic matter; weak blocky; friable; many roots; some bleached sand grains; moist. Clear change over 3 cm into
A_2/H	0–7 cm	Very dark grey (5YR3/1) humose sandy loam; weak subangular blocky; friable; organic matter very high; many roots; many small rounded stones; no mottles; moist. Gradual change into
B_{21}	7–12 cm	Black (5YR2/1) humose sandy loam; massive; compact; organic matter very high; frequent roots; frequent stones; no mottles; moist. Sharp change over 1 cm with irregular boundary into
B_{22}	12–57 cm	Dark reddish brown (5YR3/3) sandy loam; weak blocky to massive; compact; slightly indurated; organic matter low; a few roots; many stones; no mottles; moist. Gradual change over 7 cm into
C	57+ cm	Reddish brown (5YR4/3) coarse sand and gravel; single grain; loose; no organic matter; no roots; many stones; no mottles; moist.

The H horizon is typically thin and rather dry and friable with the boundary between the H and A_2 layers less well defined than in the peaty podzol soils. Although its eluviated character is clearly shown by the grey, bleached mineral matter, the A_2/H layer has a high organic matter content, much of it apparently washed in from the surface organic layer. The organic matter is, however, distributed in patches and is not as intimately mixed with the mineral matter as in the underlying B_{21} horizon. The organic matter content of the profile, apart from the H horizon, is at a maximum in the B_{21} layer where the uniform black colour and coating of most of the particles shows the close association of the organic and mineral materials. At the boundary with the lower part of the B_2 horizon a thin iron pan sometimes forms, but this is usually weak and discontinuous. In the lower B_2 horizons colours have a fairly high chroma and there is apparently a high content of extractable sesquioxides, while in the C horizon colours are generally those of the brown unweathered, uncoated sand grains. The B horizons in this soil are commonly massive in structure and are either compact or weakly cemented.

Land use

The small areas of this soil are utilized mainly as rough grazing for Blackface sheep or Galloway cattle. The ericaceous vegetation tends to be of low productivity but conditions are relatively dry. Some cultivated soils were probably of this type prior to cultivation but they have been altered sufficiently to have been mapped with the Yarrow series. The area is characterized as *warm moist lowland* and is *exposed.* The barriers to arable agriculture on this series are the poor waterholding capacity, stoniness and low natural fertility of the soil, and the expense and difficulty of reclamation.

LARBRAX SERIES

The Larbrax series closely resembles the related Knockarod series and occurs at relatively low elevations in the same general area, around Galdenoch Moor where it occupies 68 hectares or 0·8 percent of the association. The soil is classified as a humus-iron podzol with free natural drainage and is developed on sands of fluvioglacial origin. The vegetation is generally dry Atlantic heath.

Profile Description

Slope:	8°
Vegetation:	*Calluna vulgaris, Festuca ovina, Pohlia nutans*
Drainage:	free

Horizon	*Depth*	
H	7–0 cm	Dark reddish brown (5YR2/2) raw humus; weak subangular blocky; slightly friable; many roots; occasional bleached sand grains; moist. Clear change over 4 cm into
A_2/H	0–5 cm	Very dark grey (10YR3/1) humose sandy loam; weak blocky; firm; organic matter very high; many roots; moist. Clear change over 4 cm into
B_{21}	5–15 cm	Dark reddish brown (5YR2/2) humose sandy loam; weak blocky; firm; organic matter very high; frequent roots; no stones; no mottles; sand grains coated with humus; moist. Sharp change over 1 cm into
B_1	15 cm	Weak iron pan, very irregular boundary. Sharp change over 1 cm into
B_{22}	15–30 cm	Dark reddish brown (5YR3/2) loamy sand; massive; compact or weakly cemented; organic matter moderate; a few roots; no stones; no mottles; moist. Gradual change over 10 cm with irregular boundary into

Horizon	*Depth*	
B_{23}	30—40 cm	Reddish brown (5YR4/4—/5) loamy sand; massive; compact or weakly cemented; no organic matter; no roots; no stones; no mottles; moist. Gradual change over 7 cm into
C	40+ cm	Brown (7·5YR4/4) sand; massive; indurated; no organic matter; no roots; a few small rounded stones; no mottles; moist.

Apart from the difference in parent material, sands rather than gravels, this soil closely resembles the Knockarod series in association with which it occurs in the landscape. The raw-humus surface layer is typically shallow and well humified. Considerable amounts of organic matter appear to have been washed into the A_2 horizon where they are distributed patchily in streaks and local concentrations. The eluviated character of the horizon is well shown by the grey colours of the mineral material. In the upper part of the B_2 horizon the organic matter is well incorporated and evenly distributed, coating the mineral grains and making them dark brown or black. Coatings of iron oxide, however, seem to be absent in this layer, and although illuvial with respect to organic matter, the horizon appears eluviated of mineral oxides, an inference supported by the nature of the sharp irregular boundary with the underlying iron-oxide-rich horizon. In the profile described above, a thin discontinuous iron pan is formed at the boundary. The iron-oxide-rich B_{22} horizon is a dark reddish brown, with a chroma which is relatively low, possibly because of the masking effect of associated organic matter. In the deeper layers colours are somewhat brighter with high chromas. The iron-oxide-rich horizons in this soil are typically cemented and indurated, as is the C horizon, but this is not invariably the case and soils which are friable or firm in the deeper layers also occur. Textures are coarse throughout the profile which is generally stone-free, although occasionally a few small rounded gravel stones occur in some layers.

Land use

The series is utilized mainly as rough grazing for Blackface sheep and Galloway cattle, but in a few areas attempts at reclamation have been made by ploughing and the application of lime and fertilizers. The areas of the series are classified as *warm moist lowland* and are *exposed.* The main restrictions on arable agriculture are the low waterholding capacity of the soil together with its poor natural fertility and high cost of reclamation.

INNERMESSAN SERIES

Although in total Innermessan series occupies only a small area, 1·8 square kilometres or 2·1 percent of the association, it is widely scattered in small patches throughout the association area. The series is a non-calcareous gley soil, classified as poorly drained under natural conditions. Some areas with very poor drainage have been included with this unit as they are of very limited extent. The soil, developed on gravels deposited on the Late Glacial raised beach or as fluvioglacial outwash, is restricted to small hollows where the ground watertable is locally high. The vegetation varies widely, but is generally a form of sharp-flowered rush pasture.

Profile Description

Slope:	0°
Vegetation:	long ley grassland
Drainage:	poor

Horizon	*Depth*	
Ap/H	0–20 cm	Very dark grey (5YR5/1) humose sandy loam; weak blocky; friable; organic matter very high; many roots; frequent stones; many bleached sand grains; a few fine ochreous mottles along root channels; moist. Clear change over 3 cm into
A_2g	20–25 cm	Grey (5YR5/1) loamy sand; single grain; friable; organic matter moderate, mainly patches of staining; a few to frequent roots; many stones; no mottles; moist. Clear change over 5 cm into
B_2g	25–42 cm	Brown (7·5YR4/2) loamy sand; massive; slightly firm; organic matter low; a few roots; frequent stones; no mottles; moist. Gradual change over 7 cm into
B_3g	42–62 cm	Very dusky red (2·5YR2/2) loamy sand; massive; non-sticky; organic matter low; no roots; many stones; no mottles but dark colours associated with sesquioxidic materials deposited at the watertable; wet. Gradual change over 7 cm into
Cg	62+ cm	Brown (10YR5/3) loamy sand; massive; non-sticky; no organic matter; no roots; many stones; wet.

Where soils of this series have been drained and cultivated, former highly organic surface layers have been mixed with the mineral material to form the plough layer. Weak or absent in the subsurface layers, structure is massive where the particles cohere and single grain where they are non-coherent. The pale-grey eluviated A_2g horizon is typical of poorly drained soils influenced by surface organic layers and in the upper part of the Bg horizon colours of low chroma also reflect gleying conditions. Even after artificial drainage the watertable tends to remain high; the level at which the water generally remains being marked by a layer of orange-coloured hydrated oxides of iron, possibly in association with manganese and other minerals. This series is often difficult to drain as suitable outfalls from the depressional situations in which the soil occurs are not readily obtained.

Land use

Where tile-drainage has been installed this soil is maintained in long ley or permanent grass of moderate quality. To prevent serious damage to the sward the grazing period is restricted to the drier parts of the year. Occasionally where it occurs as a small area in a generally freely drained field, the series is cultivated, but yields from the poorly drained area are poor. If drainage is not feasible the soils generally remain in natural pasture and are grazed as conditions allow. The areas of the series range from *warm rather dry lowland* to *warm moist lowland* and are *exposed.* The difficulty of satisfactorily controlling the watertable is the principal barrier to arable agriculture on these soils.

DINDUFF SERIES

The Dinduff series is restricted to small hollows and although widely distributed throughout the association area occupies only 3·2 square kilometres or 3·6 percent of it. Classified as a non-calcareous gley, the soil has predominantly naturally poor drainage; some very small areas of very poorly drained soils have, however, been included in this unit as they are of insignificant extent. The parent materials are sands deposited on the Late Glacial raised beach or by glacial meltwaters. Under semi-natural conditions the vegetation is generally a form of sharp-flowered rush pasture, often with abundant tufted hair grass (*Deschampsia cespitosa*).

Profile Description

Slope:	0°
Vegetation:	long ley grassland
Drainage:	poor

Horizon	*Depth*	
Ap	0–30 cm	Very dark grey (5YR3/1) sandy loam; weak blocky; friable; organic matter high; many roots; no stones; no mottles; moist. Clear change over 4 cm into
A_2g	30–42 cm	Grey (5Y6/1) loamy sand; single grain; slightly friable; organic matter low; a few roots; a few small rounded stones; no mottles; moist to wet. Clear change over 5 cm into
Bg/Cg	42+ cm	Dark grey (10YR4/1) sand; single grain; non-plastic; no organic matter; no roots; a few small rounded stones; a few fine faint ochreous mottles; wet.

Some soils mapped with this series have shallow surface horizons rich in organic matter and where drainage and cultivation is carried out these horizons are incorporated in the plough layer. Colours are generally grey throughout the profile, reflecting the strongly gleying conditions. Mottling tends to be absent from the Ap and A_2g horizons which are strongly eluviated of sesquioxides. The ground watertable is high and a reddish brown ochreous layer with hydrated iron oxides normally occurs at the level at which water generally stands. Textures are sandy and low in clay throughout the profile, with structure formation weak or absent. The soil is readily permeable and moisture percolates easily to the watertable.

Land use

Drainage of the low lying depressional sites in which this soil commonly occurs is seldom easy because of the difficulty of obtaining a satisfactory outfall, but where it has been possible, long ley or permanent grassland is usually maintained. Where it occurs as small patches in the same field as more freely drained soils, the series is sometimes cultivated. Yields, however, are generally low. Undrained areas generally carry poor quality grassland which is grazed as conditions allow. The areas range from *warm rather dry lowland* to *warm moist lowland* and are *exposed*. The difficulty of satisfactorily controlling the watertable is the principal restriction to arable agriculture on these soils.

LOGAN COMPLEX

The Logan complex has been mapped in only one small area, near Logan Mains in the southern part of the Rhins Peninsula, where it occupies 16 hectares or 0·2 percent of the association. The area is low lying, in a depressional site with small mounds of gravel, probably of fluvioglacial origin, and the soil pattern consists of humus-iron podzol soils similar to Knockarod series on the gravel mounds with peat in the intervening flat areas. The vegetation has been much altered by earlier attempts at drainage and reclamation.

Land use

The earlier attempts at drainage and cultivation appear to have been followed by considerable reversion, so that the area now carries moderate or poor quality grassland utilized, as conditions of wetness allow, as grazing for dairy or store cattle. The site is classed as *warm rather dry lowland* and is *exposed*. The main restrictions on arable agriculture are associated with the wetness of the peaty soils and the low natural fertility of the podzols.

Stirling Association

Soils of the Stirling Association were first mapped in the Forth Valley on the Carse of Stirling (Shipley, in preparation); they have also been described by Ragg and Futty (1967) in the northern part of East Lothian and by Laing (1976) in the Earn and Tay Valleys. In south-west Scotland the association accounts for 21·3 square kilometres or 1·5 percent of the area. The soils are developed on silty or silty clay estuarine alluvium of Post Glacial raised beach age and are gley soils with poor natural drainage. The well known peat moss, the Moss of Cree, which occurs within the general area of the association is underlain by similar sediments. The land is level and carries good quality grass and occasionally arable crops.

DISTRIBUTION

The association is mainly located in the valley of the River Cree below Newton Stewart, where it occupies the flat land on each side of the river, but it also extends south of Wigtown where it has been mapped around the mouth of the River Bladnoch.

PARENT MATERIAL

The grey clays and silts which form the parent material of the association are described in Chapter 3. The materials were laid down under estuarine conditions during the period of the formation of the Post Glacial raised beach. Depositional conditions were rather variable and this accounts for the textural differences observed in the sediments which range from clays and silty clays to fine sandy silts. Generally the content of clay is greater and the proportion of fine sand less in the sediments farthest from the river banks or coast. The less clayey, fine sandy silt loam materials, which may include some recently formed alluvium, are those nearest to water courses. The materials are uniformly stone-free and grey or, at depth, blue-grey in colour. As there is generally a ground watertable these hues reflect gleying and pedological conditions as well as the natural appearance of the deposits.

In some instances shells occur in the sediments, and probably account for the small percentage of calcium carbonate in the subsoils. The symbol S is used on the soil map to indicate localities where these shells are more than usually abundant.

SOILS

Four soil series have been distinguished and mapped in the association in this area—the Stirling, Fordel and Poldar series have been recognized previously, and the Newton Stewart series reported for the first time. The soils are all poorly drained and strongly gleyed. The Poldar series which occupies a very small area, is a peaty gley. Separation of the different gley soils is based mainly on variation in texture, the more extensive Stirling series having the highest proportion of clay and the less extensive Newton Stewart and Fordel series having relatively greater amounts of silt and fine sand.

STIRLING SERIES

Closely resembling the soils in the Carse of Stirling, the Stirling series is the most extensive of the association, covering 12·0 square kilometres or 56·1 percent of the association. The series underlies most of the flat land around the mouths of the Rivers Cree and Bladnoch where it is developed on grey fine-textured estuarine silty clays deposited during the period of the Post Glacial raised beach. The textures of the sediments are somewhat more variable than is general in the Stirling area and probably reflect different depositional conditions. The pale grey colours are typical of soils of the association in this area and are indicative of the poor natural drainage status of the soil which is classified as a non-calcareous gley, although in some areas free calcium carbonate derived from shell fragments has been encountered in the lower soil horizons. Most of the series has been cultivated and generally carries highly productive grassland.

Profile Description

Slope:	0°
Vegetation:	arable grassland
Drainage:	poor

Horizon	*Depth*	
Ap	0–15 cm	Dark greyish brown (10YR4/2) silty clay loam; moderate medium subangular blocky; firm; organic matter low to moderate; many roots; no stones; frequent fine distinct yellowish brown (10YR4/5) mottles mainly along root channels; moist. Clear change over 4 cm into

Horizon	*Depth*	
A_2g	15–27 cm	Light brownish grey (2·5Y6/2) silty clay loam to silty clay; strong coarse prismatic; firm; no organic matter; frequent roots; frequent medium distinct yellowish brown (10YR5/5) mottles; moist. Gradual change over 6 cm into
B_2g	27–42 cm	Greenish grey (5BG5/1) silty clay; strong coarse prismatic; firm to plastic; no organic matter; roots few; no stones; frequent medium distinct yellowish brown (10YR5/5) mottles; moist. Gradual change over 6 cm into
B_3g/Cg	42+ cm	Greyish brown (10YR5/2) silty clay; massive; firm; no organic matter; no roots; no stones; frequent medium distinct strong brown (7·5YR5/6) and frequent medium greenish grey (5BG6/1) mottles; moist.

Typically the plough layer, pale greyish brown in colour, is thin and has a low organic matter content which, together with the high proportion of silt, accounts, at least in part, for the relatively poor development of structure. Under the action of rain or weathering the soil slakes rather easily and as it dries a thin surface cap or crust is likely to form. Although prismatic structure is well developed in the subsoil layers and smooth structure faces can readily be seen, particularly during the drier summer months, surface crack development is much less than reported (Ragg and Futty, 1967) for the rather less-gleyed Cauldside series occurring under the drier climatic conditions of East Lothian. Mottles are common in the Bg horizon, typically yellowish brown but occasionally strong brown. Deep cores taken in this soil have generally revealed a ground watertable at depths of 1 to 2 metres. Stone-free throughout the profile, the soil becomes highly plastic when wet so that it is important for the preservation and maintenance of soil structure that cultivations be restricted to periods when the soil moisture state is suitable.

Land use

The series occurs on flat estuarine areas which permit cultivation of the entire series, provided drainage is improved. In the past, efficient under-drains were installed throughout most of the series and good quality highly productive grass has been established and maintained. In a few areas deterioration of the drainage system has led to invasion by rushes (*Juncus* spp.) and a consequent decrease in sward quality. The soil is slowly permeable and in some areas rotations with short breaks for arable cropping are followed, the crops generally grown being spring-sown barley and wheat. Grass leys are generally highly productive on these soils, but care is necessary because the sward is easily damaged by poaching. Cultivation is possible only when the moisture state is suitable. If the soil is worked under wet conditions, when it is strongly plastic, the structure is liable to be badly damaged. A tilth is then difficult to obtain, especially if the soil has been allowed to dry out and hard clods to form. The areas of the series are classified as *warm moist lowland* or *warm rather wet lowland* and are *moderately exposed.* The main factors restricting arable agriculture are associated with the poor natural drainage, the relatively weak structure in the surface layers and the limited range of moisture conditions under which cultivation is possible.

NEWTON STEWART

The Newton Stewart series closely resembles the Stirling series and both soils occur on the tracts of flat land near the mouths of the Cree and Bladnoch Rivers. The series is only moderately extensive, occupying 4·3 square kilometres or 20·1 percent of the association; it is developed on grey or greyish brown estuarine sediments of silty clay loam to silt loam texture. Although a few shells sometimes occur at depth, the content of free calcium carbonate is small and sporadically distributed and the soil is classified as a non-calcareous gley with poor natural drainage. The symbol s is used on the soil map to indicate areas where shell content is greater than usual. Like the other series in the association the soil is generally maintained in good quality grassland with occasional arable cropping, mainly of spring grain.

Profile Description

Slope:		0°
Vegetation:		arable grassland
Drainage:		poor
Horizon	*Depth*	
Apg	0—17 cm	Dark greyish brown (10YR4/2) silt loam; weak prismatic to angular blocky; firm; low organic matter; many roots; no stones; frequent fine distinct strong brown mottles; moist. Clear change over 4 cm into
A_2g/Bg	17—35 cm	Brown (10YR4/3) silt loam; moderate prismatic; firm; low organic matter; a few roots; no stones; frequent medium distinct strong brown (7·5YR5/8) mottles with light brownish grey (10YR6/2) mottles on ped faces; moist. Clear change over 4 cm into
B_2g	35—50 cm	Brown (7·5YR5/3) silt loam to silty clay loam; moderate prismatic; firm; organic matter low; a few roots; no stones; many medium prominent strong brown (7·5YR5/6) mottles with pinkish grey (7·5YR6/2) mottles on ped faces; moist. Gradual change over 7 cm into
Cg	50 – 105 + cm	Light greyish brown (10YR6/2) silt loam; massive; plastic; no organic matter; no roots; no stones; occasional manganiferous staining and frequent medium distinct yellowish brown (10YR5/6) mottles; wet.

As with most soils developed on extensive alluvial materials the surface horizon is typically shallow, greyish brown and weakly structured. The shallowness of the plough layer is probably partly due to rooting of the natural vegetation near the surface prior to drainage improvement, and not just to the relatively high power required for deep ploughing before the advent of tractors and the intractable nature of the subsoil when brought to the surface. In the Bg horizons, prismatic structure is well developed but is generally coarse and, together with the fine soil texture, is responsible for a low degree of permeability.

The soil is strongly gleyed with grey and ochreous mottles well developed. The ochreous mottling is yellowish brown, strong brown or, occasionally, yellowish red. Although soil textures show some variation with depth because of slight differences in depositional conditions, materials are generally well sorted with a high silt content and an absence of coarse or medium sand; they are entirely stone-free.

Land use

Occurring on flat topography and at an elevation less than 10 m (35 feet), this series, like the other soils of the association, is well suited to productive agriculture once an efficient under-drainage system has been installed. The entire area of the series has been drained in the past and is now maintained in good quality pasture or, occasionally, cultivated for grain crops. The high content of silt and low content of organic matter in the surface layers give rise to relatively weak unstable soil structures which tend to break down if bare ground is exposed to heavy rain and cause capping. Where cultivation is undertaken, operations have to be very carefully timed to avoid the destruction of structure and obtain the best conditions for crop growth.

The areas have been classified as *warm moist lowland* or *warm rather wet lowland* and are *moderately exposed.* The main factors limiting arable agriculture are the poor natural drainage and slow permeability of the soil and the weak structure of the plough layer.

FORDEL SERIES

The Fordel series occurs on narrow flat tracts of land along the River Cree and the west coast of Wigtown Bay, occupying 4·1 square kilometres or 19·3 percent of the association. Classified as a non-calcareous gley soil with poor natural drainage, the series is developed on estuarine alluvial materials deposited as part of the Post Glacial raised beach. In some areas free calcium carbonate derived from shells is present in the lower horizons. The sediments are well sorted, have a high content of silt and fine sand, and typically have a lower clay content than the related Newton Stewart and Stirling series. The soils are cultivated for the production of grass or, occasionally, of arable crops.

Profile Description

Slope:	0°
Vegetation:	arable grassland
Drainage:	poor

Horizon	*Depth*	
Apg	0–20 cm	Dark greyish brown (10YR4/2) fine sandy silt loam; weak angular blocky breaking to crumb; slightly friable; organic matter low; many roots; no stones; frequent fine distinct strong brown (7·5YR5/8) mottles; moist. Sharp change over 1 cm into
Bg	20–55 cm	Greyish brown (10YR5/2) fine sandy silt loam; weak coarse prismatic; slightly firm to friable; no organic matter; a few roots; no stones; many medium distinct yellowish brown (10YR5/6) mottles and a few manganiferous stains; moist. Gradual change over 10 cm into
Cg	55+ cm	Grey (5Y5/1) fine sandy silt loam; massive; firm; no organic matter; a few dead roots; no stones; frequent medium distinct brown (7·5YR5/4) mottles; moist.

The Apg horizon shows the grey colours, shallow depth and poor structural development typical of soils in this association. The organic matter content of the plough layer is low and this together with the high proportion of silt and fine sand makes the soil especially liable to structural breakdown, when exposed without a crop cover to the action of rain, and to the formation of a surface cap or crust on drying. Prismatic structure in the Bg horizon is rather less strongly developed than in the more clayey soils of the association but gleying is well developed. There is no formation of an eluviated A_2g horizon as observed in most gley soils with more highly acid reactions. Stones are entirely absent.

Land use

These soils have generally been drained in the past, but in a few areas drainage has deteriorated and the sward has been invaded by rushes. Although they are kept for long periods in grass, cultivation for the production of grain crops is occasionally carried out in a few areas. Grass leys on this series are generally highly productive but must be utilized with care as they are highly liable to damage by poaching. Some areas along the River Cree are liable to flooding during exceptionally high tides and are protected by artificial banks.

The climatic region to which the series belongs is *warm moist lowland* or *warm rather wet lowland, moderately exposed.* The main features limiting arable agriculture are the poor natural drainage, the very weak structure and the liability of the soil to surface capping.

POLDAR SERIES

The Poldar series occurs around the edges of the peat mosses on the flat tracts of estuarine alluvial deposits of the lower Cree Valley; it covers only 1·0 square kilometres or 4·5 percent of the association. A peaty gley soil with poor natural drainage, the series has been mapped where surface horizons of 5–30 cm of peaty organic matter occur, occasionally as remnants of deeper peats which have been partially removed. The parent materials are generally silty clays and are stone-free. Human activity has left no areas of semi-natural vegetation and much of the series is maintained in improved grassland.

Profile Description

Slope:	0°
Vegetation:	arable grassland
Drainage:	poor

Horizon	*Depth*	
H/Ap	0–20 cm	Dark reddish brown (5YR2/2) peaty loam; strong granular structure; friable; many roots; no stones; no mottles; moist. Clear change over 3 cm into
A_2g	20–45 cm	Dark greyish brown (2·5Y4/2) silty clay; weak coarse prismatic; firm to plastic; organic matter low; frequent roots; no stones; frequent medium distinct yellowish red (5YR5/6) mottles; moist. Gradual change over 10 cm into
B_2g	45–65 cm	Grey (5YR5/1) silty clay; very weak prismatic; firm to plastic; no organic matter; a few roots; no stones; frequent fine distinct yellowish brown (10YR5/6) mottles; moist. Gradual change over 7 cm into

Horizon	*Depth*	
Cg	65 + cm	Grey (10YR5/1) silty clay; massive; plastic; no organic matter; a few dead roots; no stones; frequent medium faint yellowish brown (10YR5/4) mottles; wet.

The peaty horizons have considerably better structure than the surface horizons of the mineral soils of the association, but under the wet conditions frequently encountered they have a low bearing strength. The subsoil layers are fine-textured with poor structure development and are very slowly permeable. Gleying is intense throughout the profile and there is some eluviation of the A_2g layer under the influence of organic substances leached from the peaty surface horizon. The ochreous mottling, which is strong throughout the profile, tends to become paler with depth. The subsoil layers are stone-free and when wet strongly plastic.

Land use

Efficient under-drainage is necessary for the productive utilization of this soil and where it has been installed good leys can be maintained. Careful management of grazing is necessary, however, as in wet conditions the sward is easily damaged by poaching. Where the drains are ineffective the land lies wet for long periods and is not very productive. Arable cropping is not generally undertaken on this soil.

The area has been classified as *warm rather wet lowland* and is *moderately exposed.* The main restrictions on arable agriculture are the slow permeability and poor natural drainage of the soil and the poor bearing-strength of the surface horizon.

Links and Dune Sand

At the head of Luce Bay, between Sandhead and the Piltanton Burn, deposits of wind-blown sand occupy about 11 square kilometres; much less extensive deposits occur along the coast, usually at the heads of secluded bays as at Port Logan and Ardwell Bay on the Rhins and Airds Bay near Gatehouse of Fleet, bringing the total to 13·2 square kilometres or 0·9 percent of the area.

The sands are pale brown, quartzose and generally lacking in shelly material although a few shell fragments have been observed in some areas. The proportion of sand is very high, generally 96–98 percent, with only 2–3 percent of clay and less than 1 percent of silt. Four soils have been distinguished, according to their water relationships and degree of gleying, one soil complex and some areas of bare dunes. Soils with impeded drainage are restricted to hollows and dune slack areas and are differentiated mainly according to the height of the watertable.

Soils unaffected by waterlogging are the most extensive of those grouped as Links and are generally excessively freely drained. The vegetation is often a form of acid grassland, mainly bent (*Agrostis*) and fescue (*Festuca* spp.) with bracken (*Pteridium aquilinum*) present in some areas. In the Luce Bay area, the surface has been considerably disturbed by various forms of human activity and the sands are less stable with a considerable proportion of marram grass (*Ammophila arenaria*) in the vegetation and some areas of bare dune sand. The soils are very immature and profile development is mainly restricted to the accumulation of varying amounts of organic matter in the surface layer. Where soils have been stabilized for a longer period than usual, a degree of weathering of the subsurface layers has produced colour differentiation and the initial stages of formation of a B horizon.

Profile Description

Slope		3°
Vegetation:		*Festuca rubra, Agrostis tenuis, Veronica chamaedrys, Hylocomium splendens, Pseudoscleropodium purum*
Drainage:		free to excessive
Horizon	*Depth*	
A	0–12 cm	Pale brown (10YR6/3) sand; weak fine crumb; friable; organic matter low, but slightly greater accumulation in the surface 3 cm; frequent roots; no stones; no mottles, but many sand grains bleached; slightly moist. Clear change over 3 cm into
A/C	12–42 cm	Brown (10YR4/3) sand; single grain; friable; no organic matter; frequent fine roots; no stones; no mottles; moist. Gradual change over 10 cm into
C	42+ cm	Brown (10YR5/3) sand; single grain; friable; no organic matter; no stones; no mottles; moist.

There is little organic matter in the A horizon, probably as a result of the comparatively short period of soil formation. Formation of a significant organo-mineral complex is discouraged by the low organic accumulation and by the very low clay contents in the A horizon. The soil is leached, has a low degree of base saturation and is moderately strongly acid (pH 5 to 5·5). Sand grains bleached under the influence of organic matter are common in the A horizon but there are seldom enough to form even a rudimentary bleached A_2 horizon. Below the A horizon the only indication of soil formation is the colour changes associated with weathering; these are generally slight but in a few soils are sufficiently intense to indicate the presence of a B horizon. In the deeper layers the sand appears unaltered. There is no aggregation of soil particles other than the formation of weak fine structure in the surface layers. Quarry faces and other exposures generally reveal one or more buried soils, some showing more mature profile development than the soil on the present land surface.

In some low lying areas, soils are affected by waterlogging, and several small patches, totalling 32 hectares, where the watertable is relatively deep and gley characters only moderately developed, have been placed in the imperfectly drained category. The vegetation is generally grassland with rushes (*Juncus* spp.) and silverweed (*Potentilla anserina*).

Profile Description

Slope:		1°
Vegetation:		*Juncus acutiflorus, Agrostis* spp., *Poa* spp., *Potentilla anserina*
Drainage:		imperfect
Horizon	*Depth*	
A	0–27 cm	Dark brown (10YR3/3) loamy sand; weak fine crumb; friable; organic matter low; many roots; no stones; no mottles; moist. Clear change over 3 cm into

Horizon	*Depth*	
Ag	27–40 cm	Greyish brown (10YR5/2) and brown (10YR4/3) sand; single grain; friable; organic matter very low; roots few; no stones; a few medium distinct ochreous mottles; moist. Gradual change over 7 cm into
B/Cg	40–67 cm	Greyish brown (10YR5/2) sand; single grain; friable; no organic matter; no roots; no stones; a few coarse distinct dark yellowish brown (10YR3/4) mottles; moist. Gradual change over 10 cm into
Cg	67+ cm	Greyish brown (10YR5/2) sand; single grain; friable; no organic matter; no roots; no stones; frequent medium distinct dark yellowish brown (10YR3/5) and yellowish red (5YR4/6) mottles; moist.

Profile development is mainly restricted to accumulation of organic matter in the surface and development of gley morphology in the subsoil. Despite the dark colour of the surface layer, the organic matter content is low. Conditions in the A horizon are aerobic and there is no indication of gleying or waterlogging. In the subsoil, however, greyish brown or grey colours predominate and ochreous mottling becomes more intense with depth. For much of the year a ground watertable is present, but is generally at some depth, rising into the upper soil layers only for short periods.

The poorly drained Links soils have been mapped on flat low-lying inter-dune areas where a strongly developed gley morphology indicates that the ground watertable is within the upper metre of the solum for considerable periods of the year. Sedges (*Carex* spp.) and rushes (*Juncus* spp.) predominate in the vegetation.

Profile Description

Slope:	0°
Vegetation:	*Carex nigra, Carex* spp., *Agrostis canina, Hydrocotyle vulgaris, Rhytidiadelphus squarrosus*
Drainage:	poor

Horizon	*Depth*	
Ag	0–20 cm	Dark greyish brown (10YR4/2) loamy sand; weak fine blocky; friable; organic matter moderate; many roots; no stones; frequent ochreous mottles along root channels; moist. Clear change over 5 cm into
A/Cg	20–40 cm	Greyish brown (10YR5/2) sand; single grain; friable; organic matter low; frequent old coarse roots; no stones; frequent medium distinct yellowish red (5YR5/6) mottles; moist. Gradual change over 10 cm into
Cg	40+ cm	Grey (5Y6/1) sand; single grain; non-sticky; no organic matter; a few dead roots; no stones; a few yellowish red (5YR5/6) mottles along old root channels; wet.

As in other Links soils, only limited horizon differentiation and profile development are apparent. Because of the high ground watertable accumulation of organic matter is greater than in the freely and imperfectly drained soils. Gleying, prominent throughout the profile, is intense in the deeper soil layers, which are below the watertable for long periods and iron compounds are in the reduced state and highly mobile. The clay and silt contents are very low throughout the solum and there is no aggregation of soil particles other than the formation of some weak fine blocky structure in the surface horizon.

In two areas at the head of Luce Bay, within 100 metres or so of the coast, the watertable is at or very near the soil surface for the greater part of the year. These areas, which together amount to 2·1 square kilometres, have been mapped as very poorly drained. Associated with these soils are some small areas of peat and humose soils, not mapped separately at the present scale. The vegetation is variable but frequently includes rushes (*Juncus* spp.) and creeping willow (*Salix repens*).

Profile Description

Slope:	0°
Vegetation:	*Salix repens, Juncus articulatus, Riccardia* spp.
Drainage:	very poor

Horizon	*Depth*	
Ag	0–4 cm	Very dark grey (10YR3/1) loamy sand; single grain; non-sticky; organic matter low but a thin surface deposit of dried algal remains present; many roots; no stones; a few medium yellowish brown (10YR5/4) ochreous mottles; wet. Sharp change over 1 cm into
A/Cg	4–30 cm	Greenish grey (5G6/1) sand; single grain; non-sticky; no organic matter; a few to frequent roots; no stones; frequent medium prominent yellowish red (5YR5/6) mottles; wet. Gradual change over 10 cm into
Cg	30+ cm	Greenish grey (5G6/1) sand; single grain; non-sticky; no organic matter; no roots; no stones; a few faint ochreous mottles; wet.

The surface Ag horizon ranges widely in both organic matter content and thickness. Below the Ag horizon the greenish or bluish colours of intense gleying predominate, some of the prominent ochreous mottling being associated with plant roots. Aggregation of soil particles is generally absent and the structure is single grain throughout the profile.

Near Torrs Warren a small area has been mapped as Links complex as free, poorly and very poorly drained Links soils occur in a pattern too intricate for the elements to be delineated at the 1: 63,360 scale of mapping.

Wind-blown sands relatively bare of vegetation and piled into the form of dunes have been mapped as Dune sand. They cover 60 hectares, the main area being at Torrs Warren.

Land use

The low clay and organic matter contents of these soils are associated with very low waterholding capacity, poor soil structure and low fertility. Where the sands are well stabilized and the topography is favourable, swards of improved grassland can be maintained by the use of fertilizers. More undulating areas are fit only for rough grazing or forestry, and areas where the sands are only partially stabilized are of little other than amenity value.

Before the strongly gleyed Links soil can be utilized agriculturally comprehensive under-drainage is required and this is not easily achieved because of their situation.

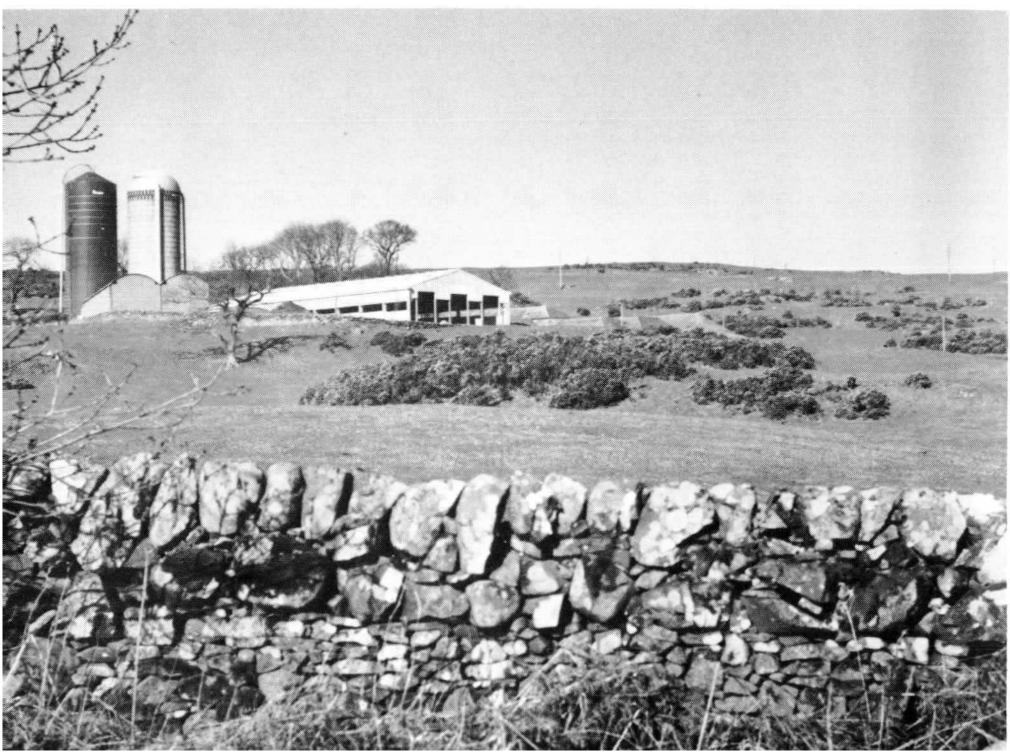
The areas of Links have been classified as *warm rather dry lowland* and are *exposed* or *moderately exposed.* The main factors restricting

PLATE 17/The eroded rocky slopes of Cairnsmore of Fleet from the valley of the Palnure Burn.

PLATE 18/Barraer, a sheep and stock rearing farm near Newton Stewart, on soils of the Ettrick Association. Lamachan and Curlywee Hills are in the background.

PLATE 19/Pasture on estuarine alluvial soils of the Stirling series of the Stirling Association at Nether Barr in the Cree Valley.

PLATE 20/Upper Barr Farm with soils of the Achie complex in the Ettrick Association.



agricultural utilization are low waterholding capacity and liability to erosion in the freely drained soils and poor natural drainage in the gley soils.

Alluvium

Undifferentiated alluvial soils have been mapped over 78·6 square kilometres or 5·5 percent of the area. They occur predominantly along water courses and burns and are distributed throughout the area. The more extensive units are found along the Piltanton Burn and along the River Bladnoch between Mochrum Park and the confluence with the Water of Malzie. Other significant tracts occur along the Water of Luce, along the River Cree above Newton Stewart and along the Kilfillan and Powton Burns at Garlieston. Areas where shallow peat deposits have developed on the alluvial materials or are interbedded with them have been mapped as Peat–Alluvium.

Alluvium is an unconsolidated water-laid sedimentary deposit which can be divided into types according to the environmental conditions under which it was laid down. In this area the alluvium was laid down during the Post Glacial period. Undifferentiated alluvial soils have been mapped mainly along water courses with a few on lacustrine deposits occupying the sites of former lakes. In the valley of the River Cree below Newton Stewart, extensive deposits laid down under estuarine conditions during the period of the Flandrian transgression, have been separately distinguished as the parent materials of the Stirling Association, while Saltings have been mapped on the active estuarine alluvial tracts fixed by vegetation and lying below the level of the highest spring tides. In contrast to till and moraine laid down by ice, water-laid deposits are sorted according to particle size. The degree of sorting varies considerably, but is generally sufficient to achieve a significant separation of coarse and fine material. Banded or interbedded layers of varying texture arising from change in depositional conditions are often found. Textural variations can also occur in rapid succession over a deposit surface and within a short distance it is possible to pass from sandy material to clay and back to sand. In this area, alluvial tracts along rivers are generally coarse-texturerd, with gravel or boulder beds. Less coarse-textured, stone-free deposits are commonly the result of the reworking of fluvioglacial sands or estuarine silts.

Alluvial soils range in profile development according to their age, the activity of soil-forming processes and the deposition of fresh sediment. In the hill and high-lying areas where in periods of heavy rain streams rise in spate and overflow their banks, alluvium is still being deposited, and in soils formed on such young active alluvium profile development is only weak and confined to humus accumulation in the surface, with some mottling if the internal drainage is impeded. The profile description given below is of a freely drained soil with a coarse gravelly subsoil developed on alluvium along the upper reaches of the Penkiln Burn. Flooding and deposition of silt are probably still active.

Profile Description

Slope:	0°
Vegetation:	*Poa pratensis, Anthoxanthum odoratum, Cynosurus cristatus, Trifolium repens, Cerastium holosteoides*
Drainage:	free

Horizon	*Depth*	
A_1	0–25 cm	Brown (10YR4/3) loam; moderate medium subangular blocky to crumb; friable; organic matter moderate; many roots; many stones; no mottles; moist. Gradual change over 7 cm into
A_1/C	25–45 cm	Dark greyish brown (10YR4/2) loamy sand; weak subangular blocky; friable; organic matter low; frequent roots; frequent to many stones; no mottles; moist. Gradual change over 7 cm into
C	45+ cm	Coarse sand and gravel; colour that of greywacke and granitic debris; single grain; loose; no organic matter; a few roots; many stones with some large rounded boulders; no mottles; moist.

As in most alluvial soils in the area the texture is less coarse in the surface layers than in the subsoil layers. The brown colours in the A_1 and A_1/C layers are mainly associated with organic matter accumulation, and there is little evidence of acid weathering of minerals or release of significant amounts of sesquioxides. Soil aggregation is largely confined to the layer of organic matter accumulation. The drainage class of the soil described is very free, but in general the hydrologic conditions of alluvial soils differ widely depending on the relative levels of the neighbouring land and the local watertable.

Alluvium associated with courses of slow-moving rivers and streams, which are mainly restricted to low altitudes, is generally less stony and of finer texture than alluvium associated with vigorously flowing water and its internal drainage is more frequently impeded. The alluvium beside the Piltanton Burn west of Genoch Mains is poorly drained, stone-free, silt loam or silty clay in the upper layers, with considerable accumulation of organic matter in the surface horizon. The profile description which follows is of a soil from this area.

Profile Description

Slope:	0°
Vegetation:	arable grassland
Drainage:	poor

Horizon	*Depth*	
Ap	0–30 cm	Very dark brown (10YR2/2) silt loam; moderate medium blocky; firm; organic matter high; many roots; no stones; frequent fine prominent yellowish red (5YR4/8) mottles along root channels; moist. Sharp change over 1 cm into
A_2g	30–40 cm	Grey (5Y5/1) silty clay; weak coarse prismatic; plastic; organic matter low; a few roots; no stones; a few fine prominent yellowish red (5YR4/8) mottles; wet. Clear change over 4 cm into
(B)g	40–52 cm	Dark greyish brown (10YR4/2) loamy sand; massive; slightly sticky; organic matter low; a few roots; no stones; frequent medium prominent yellowish red (5YR4/6) mottles and tubules, tubules show light greenish grey (5BG7/1) linings; wet. Clear change over 3 cm into
Cg	52+ cm	Dark greenish grey (5GY4/1) loamy sand; massive; non-sticky; organic matter low; a few decomposed roots; no stones; frequent grey (5Y5/1) mottles with a few yellowish red (5YR4/6) tubules in upper 15 cms; wet.

This soil is characterized by high organic matter accumulation in the surface and strongly developed gley features, with a marked textural change at 40 cm indicating a change in the conditions of deposition of material. Profile development is further evidenced by the formation of prismatic structure below the Ap horizon and the colour differentiation of the A_2g and Bg horizons.

Land use

Alluvial soils are generally fertile, occur on level ground and where the internal drainage is free or imperfect they are readily cultivated. Some of the more important areas of alluvial soils used for growing crops, mainly turnips, barley and oats, are situated along the Water of Luce and at Garthland. Many alluvial areas are too small to be effectively managed separately from the surrounding land; such areas are kept for long periods under grassland, particularly in upland and marginal areas.

On alluvial soils with poor internal drainage, cultivation or the maintenance of good quality grassland is possible only where an efficient system of under-drainage is installed, and this is often made difficult because there is no suitable outlet. Consequently many areas remain for long periods in grassland, with rushes (*Juncus* spp.) prominent.

These soils are very widely distributed and accordingly the climate under which they occur varies, although most areas are *warm moist* or *wet lowland* and *moderately exposed.*

Peat–Alluvium

Complexes of peat and alluvium have been mapped over 35·4 square kilometres or 2·5 percent of the area. They generally occur along water courses and are common in the long channels through the sands and gravels of the Stranraer Lowlands and along the moorland reaches of streams. There are other, rather broader, areas in low-lying situations, many between drumlins in the Machars Lowlands, where some possibly occupy sites of former lochs. All these soils are situated in depressed sites where the watertable is high, drainage difficult and flooding a hazard. The peat can be interbedded with alluvial sediments or intermingled with alluvium on the surface. The agricultural value of these soils is low, unless circumstances are especially favourable or drainage has been improved.

Saltings

Saltings are found along the tidal reaches of the River Cree, on both sides of the Cree estuary. In all they occupy 9·8 square kilometres or 0·7 percent of the area. The soils are periodically submerged by the tide, being developed on estuarine alluvium which extends from below the high water mark of spring tides almost to the reach of neap tides. The sediments are generally of silty texture, silt loams or fine sandy silt loams, with some silty clay loam in the higher lying areas and fine sandy loams at the lowest levels. Some shell fragments are also generally present in the sediments.

The vegetation consists of halophytic species with thrift (*Armeria maritima*), sea plantain (*Plantago maritima*), sea aster (*Aster tripolium*), sea arrowgrass (*Triglochin maritima*) and scurvy grass (*Cochlearia officinalis)* predominating and, depending on the frequency and depth of inundation, giving rise to several different plant communities (Chapter 7). The ground surface is dissected by numerous channels from 30 cm to 2 m deep formed during the retreat of tidal waters after periods of inundation.

Profile Description

Slope:		0°
Vegetation:		*Festuca rubra, Juncus gerardii, Plantago maritima, Aster tripolium, Agrostis stolonifera*
Drainage:		very poor
Horizon	*Depth*	
Ag	0–17 cm	Very dark grey (10YR3/1) silt loam; coarse prismatic and weak blocky; slightly plastic; organic matter low; many roots; no stones; many fine prominent dark reddish brown (2·5YR3/4) mottles, particularly on ped faces; wet. Gradual change over 7 cm into
A/C_1g	17–45 cm	Grey (10YR5/1) silt loam; coarse prismatic; organic matter low; frequent roots; no stones; frequent very fine distinct reddish brown (5YR5/4) mottles; wet. Clear change over 5 cm into
C_2g	45–62 cm	Grey (10YR5/1) fine sandy loam; massive; sticky; organic matter low; frequent dead roots; no stones; frequent fine distinct brown (7·5YR4/4) mottles; a few shell fragments; wet. Gradual change over 7 cm into
C_3g	62+ cm	Grey (5Y5/1) fine sandy loam; massive; sticky; no organic matter; no roots; no stones; occasional black (N3/0) patches; wet.

There is little evidence of profile development apart from some accumulation of organic matter, usually present in moderate or small amounts but often well distributed through the upper 50–70 cm of soil. Gley colours are well developed and some formation of prismatic structure is apparent in the upper layers.

Land use

Without earthworks to keep out the sea there is no possibility of improving these soils, but they provide very healthy grazing for stock and are thus valued by farmers who have access to them. Care in management is necessary, however, if losses of stock during periods of inundation are to be avoided.

Mixed Bottom Land

Mixed bottom land is the cartographic unit used to represent soil complexes occurring along narrow stream channels. The unit comprises narrow tracts of alluvial soils, too small to be shown individually, and soils, often skeletal, on the banks which sometimes border water courses. The soils are very varied in profile morphology, age and parent material. This unit has been mapped over 27·1 square kilometres or 1·9 percent of the area.

Peat

Peat, which is the most extensive soil in the area, has been mapped over 254·9 square kilometres or 17·8 percent of the area and is also a frequent and extensive component of soil complexes. It consist of accumulations, on the mineral surface, of organic matter more than 25–30 cm thick. Similar accumulations, but less than 25–30 cm thickness, also occur and form the surface horizons of soils classified in the peaty podzol or peaty gley major soil sub-groups. The mode of formation, the composition and the properties of peat are described in Chapter 6.

Land use

The areas of peat which carry semi-natural plant communities (Chapter 7) of low productivity are mainly used for sheep and cattle grazing on the extensive pattern. The peat is waterlogged for the greater part of the year. The difficulty of drainage and the large amounts of fertilizer needed for improvement of the sward make reclamation expensive and it is only occasionally undertaken. In recent years, however, the Forestry Commission have established coniferous forests in several areas.

6 | Peat

In moist, well-aerated soils of temperate regions, a balance is struck between the deposition of plant debris on the one hand and decomposition and mineralization on the other, equilibrium being reached when the soil organic fraction is around 5–10 percent of the dry weight of the soil. The rate at which decomposition takes place depends not only on prevailing environmental conditions but also on the nature of the organic residues involved. Where conditions for decomposition are less favourable, oxidation of plant remains proceeds more slowly and vegetable matter accumulates at the soil surface. This build-up of organic residues is usually associated with poorly-drained soils in which aeration is seasonally restricted.

Peat is defined in general terms as an accumulation of partly decomposed plant remains formed on waterlogged sites where excess moisture at the soil surface has inhibited the normal aerobic process of decomposition. Other conditions conducive to the formation of peat are low average temperature, high acidity and nutrient deficiency, all of which depress microbiological activity. The most important factors that influence peat development are therefore functions of climate, topography and geology. These also control the nature and abundance of vegetation which in turn largely determines the type of peat formed. Plant communities associated with soils and water relatively rich in plant nutrients (eutrophic) give rise to types of peat quite distinct from those formed where conditions are acid and base-deficient (oligotrophic). The chemical and physical properties of the peat are further influenced by the nature and amount of water present during peat formation. Although peat differs from other soils in that it is almost entirely or very largely organic, no exact line of demarcation can be logically or consistently drawn. In this account, soils with a surface organic layer greater than 0·3 m thick and containing more than 60 percent organic matter are classified as peat.

In the area under review, peat covers some 25,000 hectares or about 18 percent of the land surface. Assuming an average depth of 2 m, reserves are estimated to exceed 100 million tons air dry peat. Before the nineteenth century, little attempt was made to improve such land for agricultural use but in the New Statistical Account of Scotland Vol. IV (1845) frequent mention is made of peatland reclamation, paring, burning and drainage being cited as the principal techniques employed. However towards the end of the century, incentive for such schemes gradually declined as imports of cheap food from abroad increased.

Although extensive tracts of the deep peat have now been drained and planted by the Forestry Commission, much of the peatland within the area still comprises rough grazing of variable quality and, apart from drainage and rotational burning, little has been done in recent years to upgrade the pasture. A notable exception is the reclamation carried out by Mr Alexander Allan of Muirfad Farm, Newton Stewart who, in the early sixties, successfully pioneered and demonstrated surface seeding techniques for pasture improvement on deep peat.

For centuries, probably even before Roman times, peat has been cut and dried by traditional methods to provide a low-grade fuel for local domestic use. Obviously the more accessible deposits on the low ground near centres of population attracted most attention and many of these have been completely cut over. Elsewhere, cutting has been largely confined to the perimeters of the more extensive peatland areas. Historical accounts frequently refer to the time and energy expended in cutting, drying, transporting and stacking the year's supply. Despite the fact that peat winning is a seasonal operation, occurring at a time when labour requirements for other work are at a premium, air-dry sod peat remained an important domestic fuel until well into the nineteenth century. However, by the middle of the century, coal was increasingly being burnt in towns and in areas without a good local supply of peat. Since the end of the nineteenth century peat burning has markedly declined in the face of competition from coal, oil, gas and electricity. In the 1950s however, a number of deposits were surveyed in the area concerned as part of a national plan to utilize Scottish peat resources. These consisted of the Moss of Cree lying south of Newton Stewart at the mouth of the River Cree, and a group of peatlands contained within a roughly rectangular area which extends from Dergoals Moss across the A75 as far south as Mindork Moss near Craigeach Fell and which is bounded by the River Tarf to the north-east and a line joining Lochs Castle and Dervaird to the south-west. It is estimated that these deposits alone contain the equivalent of some 12 million tons of air-dry peat.

Within the area surveyed, three main types of deposit are distinguished—namely, confined (basin) mire, unconfined (blanket) mire and partly-confined (intermediate) mire. The term mire is used to define all peatland types (bog, moss, moor, fen, etc.) irrespective of their topographical, hydrological, or phytosociological relationships.

Confined mires form locally under the influence of ground water (soligenous mires) and are typically located within poorly drained hollows or basins. Initial stages of development are often represented by peat derived from aquatic or semi-aquatic vegetation. As deposition continues, the mire surface may ultimately rise above the level of inflow and therefore climate, though not of primary importance, will largely determine the nature of the peat and the rate at which it develops. This fundamental change in hydrological conditions is accompanied by an equally important change in nutrient source from ground water (minerotrophic) to rainwater (ombrotrophic). Typically, a fully-developed confined raised mire has a convex or dome-shaped configuration and shows, in section, several quite distinct horizons which reflect the changing environmental conditions from the minerotrophic 'low moor' stage, represented by lake mud and grass and sedge peat, to ombrotrophic raised bog or moss in which the main components are *Sphagnum,* cotton grass and ericaceous plants.

Unlike confined mires, unconfined mires develop on different landforms under conditions of high rainfall, low mean annual temperature and high relative humidity. Such deposits are generally oligotrophic and their nature and development are further influenced by geology and climate which, in many areas, interact to produce base-deficient soils supporting plants such as *Sphagnum* and associated moorland species whose structural adaptations and growth form help to hold water at the soil surface and intensify the wet conditions. Stratigraphically, unconfined mires tend to show little variation in botanical composition or degree of decomposition with depth.

Partly-confined mires are located in valleys, on terraces or between drumlins etc. and exhibit characteristics intermediate between those of confined and unconfined mires. Some of these mires have clearly originated in topographic depressions but have since developed beyond their original confines. When several partly-confined mires are located close together and encroach upon each other, they can form an almost continuous peat cover akin to unconfined mire.

The area under discussion can be conveniently divided into seven main regions (Fig. 14), each with distinctive peatland as well as topographic features. These regions and the landform regions described in Chapter 1 (Fig. 3) are similarly distributed. Landform regions 1, 2, 4 and 5

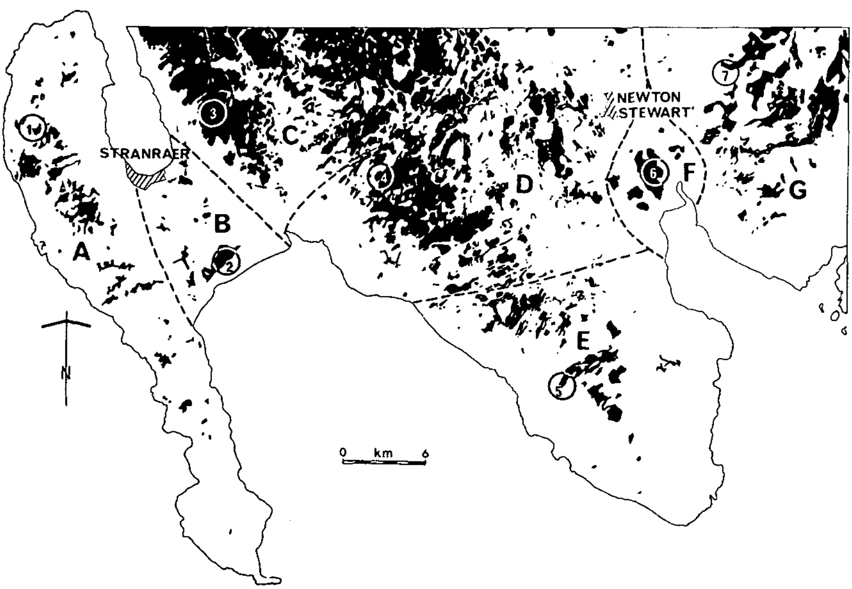


FIG. 14 Distribution of Peat and Location of Main Sites Surveyed 1—Glengyre; 2—West Freugh; 3—Braid Fell; 4—Flow of Dergoals; 5—Drummoddie; 6—Cree; 7—Louran Rig

correspond to peatland regions A, B, F and G, respectively. However, because of its topographic variation and the diversity of peatland types present, landform region 3 has been divided into three peatland regions, C, D and E. The major river valleys, which comprise landform region 6, have been included with the peatland regions in which they occur.

Based on altitude, the peatland regions fall into three broad groups—low, moderate and high. Most of the ground within regions B and F lies below 15 m (50 feet) O.D. and peat covers approximately 6 percent and 20 percent of the land surface respectively. Much of the peat of region F overlies relatively level or slightly undulating estuarine sediments, whereas in region B it is generally situated within topographic depressions in the fluvioglacial and raised beach deposits.

Regions A, D and E are characterized by ground of moderate height, most of which lies below 122 m (400 feet). As peat covers only about 5 and 8 percent of regions A and E, respectively, and as most of the hills are relatively low, the areas are predominantly agricultural in character, the mires being largely contained within basins and valleys, except for some small tracts of blanket mire in region A. In contrast, approximately 30 percent of region D is covered with peat, and large tracts of very wet peatland (flows) abound. These flows, which are partly confined (Ratcliffe, 1964), are interspersed with numerous drumlins and rock ridges.

Although both regions C and G are largely composed of high ground, the similarity ends there. The hills in region C rise to 213–259 m (700–850 feet) and are relatively subdued and rolling with few rock exposures. In contrast, region G is characterized by more rugged relief; most of the hills rise to over 305 m (1000 feet) and one peak, the Cairnsmore of Fleet, exceeds 700 m (2300 feet). In consequence, most of region C is blanketed with deep peat whereas in region G the peat is mainly restricted to the gentler slopes and valleys, and is usually less than 1 m deep. In the eastern half of region C some of the mires associated with drumlins and rock ridges on relatively level ground are similar to the flows of region D. Peat cover for regions C and G is approximately 45 and 20 percent, respectively.

In each region, a number of mires were investigated, one of which, representative of the predominant type, was selected for more detailed study. Procedure depended on the size and complexity of the area, and varied from close grid (100–200 m) survey to multiple or even single-line traverse. Depth soundings and surface levels were recorded at the intersection of grid lines and at least every 200 m along the traverse lines. A series of complete cores was extracted from each area and sampled at 0·5 m intervals of depth. Gross botanical composition and degree of humification (H) or decomposition, determined by the method of von Post (von Post and Granlund, 1926), were recorded for each sample in the field; sealed sub-samples were taken for laboratory determination of ash and moisture contents and for more detailed botanical assessment by optical techniques. Specially selected cores, usually from the deeper parts of the mire, were also sampled for determination of major and minor elements, pollen analysis and detailed stratigraphical examination of sub-fossil plant components on a semi-quantitative basis. The composition of the vegetation and the general morphological and hydrological features at each site were also recorded. Botanical nomenclature follows Clapham, Tutin and Warburg (1962), Warburg (1963), Paton (1965), James (1965) and Dickson (1973). Common names of vascular plants are given in brackets where the species is first mentioned.

PEATLAND REGION A

Glengyre Moss (NW 984645, Fig. 14), representative of the partly-confined mires of the Rhins Peninsula, lies some 10 km north-west of Stranraer in a valley alongside the unclassified road between Little Galdenoch and Glengyre. It comprises 20 hectares of deep and shallow peat and ranges in altitude from 71 m (233 feet) to 76 m (250 feet) O.D. Peat depths of 0·8 m to 6·8 m, with a mean of 3·3 m, were recorded. Much of the mire has been extensively cut-over as illustrated in Fig. 15, which shows a section passing through shallow cut-over peat and uncut bog.

The mire vegetation can be divided into two major categories which correspond to the cut-over areas and the uncut remnants of the former raised bog surface. Due to the effect of drainage, *Calluna* (heather) is dominant on the uncut areas and grows in abundance with *Eriophorum vaginatum* (hare's-tail) and *Campylopus flexuosus,* together with the occasional plant of *Pteridium* (bracken) and *Ulex europaeus* (gorse). As *Sphagnum* species (bog mosses) are unable to flourish in relatively dry habitats, they occur here only infrequently.

Although *Juncus effusus* (soft rush) and *Salix* sp. (sallow willow) have locally encroached on to the cut-over areas, elsewhere a more typical oligotrophic peatland community has become re-established, healing many of the scars produced by peat cutting. This community is characterized by an abundance of species favouring wet conditions, e.g. *Sphagnum* species (*S. papillosum, S. cuspidatum, S. capillaceum**), *Narthecium ossifragum* (bog asphodel) and *Drosera rotundifolia* (sundew). *Calluna, Erica tetralix* (cross-leaved heath) and *Eriophorum vaginatum* are less abundant than on the drier intact areas. Other species characteristic of this oligotrophic community and its dried out phase include *Eriophorum angustifolium* (common cotton-grass), *Trichophorum cespitosum* (deer-grass), *Aulacomnium palustre, Hypnum cupressiforme, Pleurozium schreberi, Odontoschisma sphagni* and *Cladonia impexa.*

Similar features were observed at a number of mires within region A. Most have been affected by cutting—as at Balgown Moss (NX 005686), a partly confined mire, where the remaining peat banks are dominated by dense *Calluna*. However, at this site the better drained areas of cut-over mire support a dense stand of *Pteridium* with few associated species, while areas enriched by ground water support abundant *J. effusus* in

* *Sphagnum capillaceum* includes *S. rubellum* in accordance with Hill (1976).

association with *Galium palustre* (marsh bedstraw), *Carum verticillatum* (whorled caraway), *Hydrocotyle vulgaris* (pennywort) and *Epilobium palustre* (marsh willow-herb). At Broad Moor (NX 023587), a relatively small oligotrophic unconfined mire, the vegetation is similar to that recorded on regenerating cut-over areas at Glengyre. Disturbance by peat cutting and sheep grazing is indicated by the presence of *J. effusus*, *Deschampsia flexuosa* (wavy hair-grass) and possibly by *Vaccinium myrtillus* (bilberry). Some of the mires in this region have been

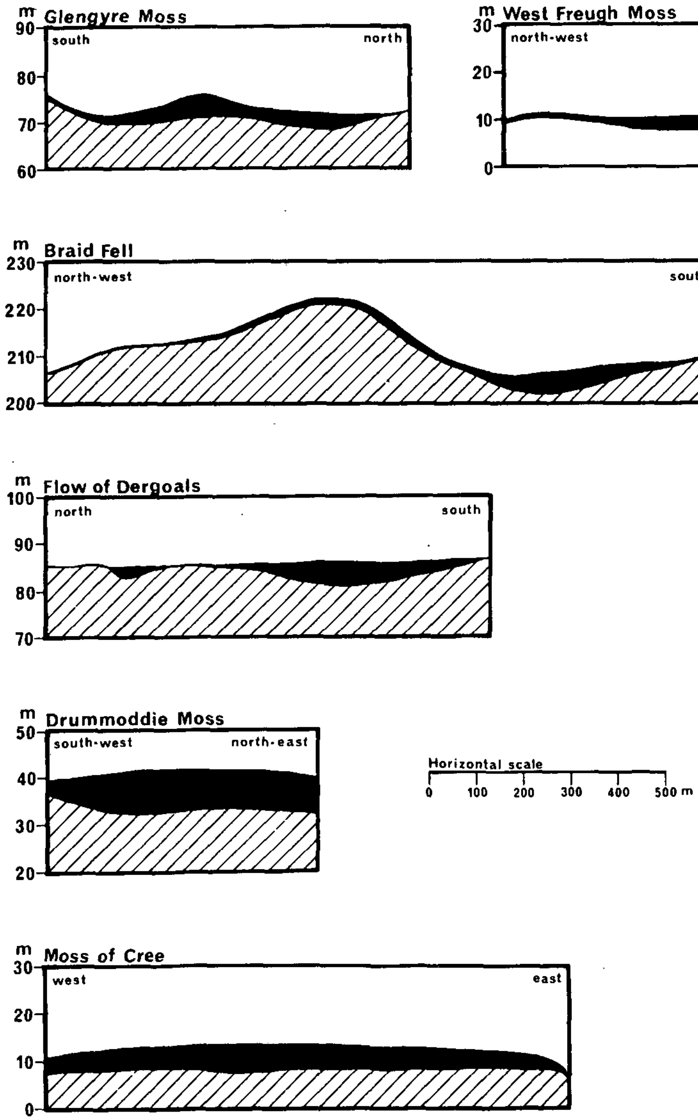


FIG. 15 Sections showing Topographical Relationship of Main Mire Types

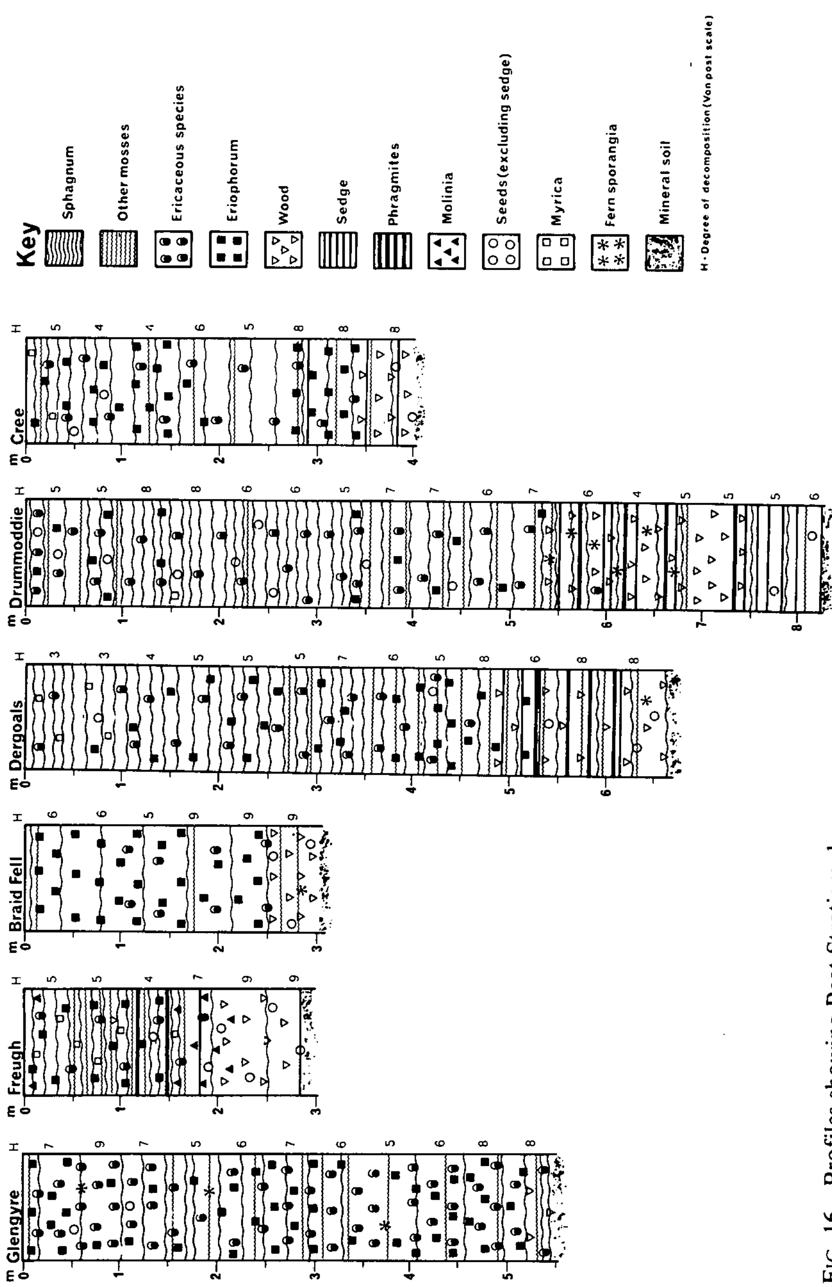


FIG. 16 Profiles showing Peat Stratigraphy

reclaimed—for example, Logan Moss (NX 090437) part of which is pasture and part *Betula—Salix* (birch-willow) carr. The carr supports a herb and ground layer largely composed of *Dryopteris carthusiana* (narrow buckler-fern), *Pteridium, J. effusus* and a number of mosses including *Sphagnum squarrosum, S. fimbriatum* and *Plagiothecium undulatum.*

To investigate the stratigraphy of Glengyre Moss, four complete cores were extracted, one of which, from the mire centre, was transported to the laboratory for detailed botanical analysis. Four horizons were identified (Fig. 16) and their botanical components give some indication of the conditions prevalent at the time of deposition and of the plant communities from which the peat was derived.

Although the lowest horizon, 5·5–5·2 m, is highly decomposed, a number of plant remains were identified; these include wood (probably *Betula*), *Sphagnum palustre, Hypnum cupressiforme* and ericaceous twigs. This terrestrial assemblage is indicative of no more than slight nutrient enrichment during early peat accumulation. Between 5·2 and

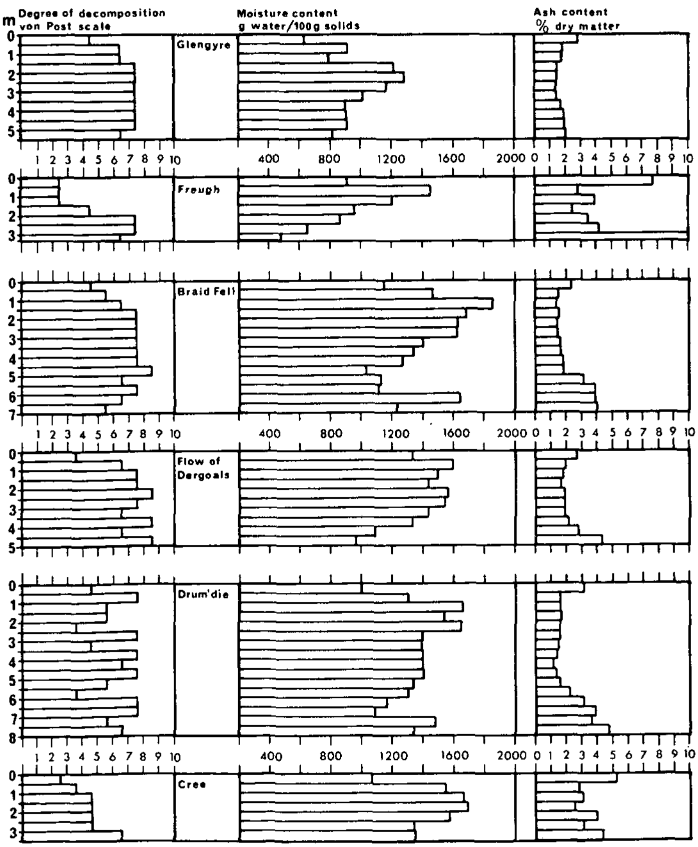


FIG. 17 Variation of Degree of Decomposition, Moisture Content and percent Ash with Depth

4·0 m, the sub-fossil assemblage is characterized by abundant *Eriophorum vaginatum* and ericaceous remains associated with *Sphagnum* sect. Acutifolia, *Aulacomnium palustre* and *H. cupressiforme*. This assemblage marks the onset of oligotrophic conditions which prevailed through to the present time. From 4·0 to 3·0 m, a dry phase is suggested by a relatively sparse assemblage of twigs and carbonized leaves of ericaceous plants and by the apparent absence, except at 3·3 m, of *Sphagnum* remains, *Sphagnum* occurs throughout the top 3·0 m and is generally poorly preserved. However, remains of *S. capillaceum*, *S. cuspidatum* and *S. imbricatum* were recognized and these, together with scattered seeds of *Rhyncospora alba* (white beak-sedge) and rhizomes of *Eriophorum angustifolium*, suggest that the top 3·0 m of the core accumulated under wetter conditions than the lower 2·5 m.

Two other cores from the centre of the mire, each 5·5 m deep, were examined in the field. These also showed an initial peat horizon containing wood overlain by oligotrophic peat. Another core, 1·5 m deep, extracted from a cut-over area at the north-east of the mire, has 1·0 m of woody peat overlain by 0·5 m of amorphous peat and is thus similar to the lower portion of the other cores.

The degree of decomposition of the peat is generally moderate (H4) to high (H9), the mean value for all samples being H7. On a fresh weight basis, the field moisture contents ranged from 86·6 percent to 92·8 percent, the lowest values occurring at the top and bottom of the profile. Ash contents, 1·3–3·7 percent, are typical of acid oligotrophic peat and support the view that there was little or no flow of ground water on to the mire throughout most of its development. Variation in the degree of decomposition, moisture content and ash content with depth for a selected profile are shown in Figure 17. Here, for convenience, the moisture contents are expressed on a dry weight basis.

PEATLAND REGION B

The name West Freugh Moss (NX 122589) was adopted for the mire covering 105 hectares between West Freugh Airfield and Torrs Warren sand dune system at the head of Luce Bay (Fig. 14). The deposit occupies a gently shelving basin and exhibits no marked variation in depth (Fig. 15). The mire, surveyed on a 100 m grid, lies between 8 m (26 feet) and 13 m (43 feet) O.D. Most of the surface is relatively level and until recently ploughed for forestry was little disturbed despite some earlier attempts at drainage. The most severe disturbance has been in the south-west section where the peat has apparently been cut over. Peat cutting for fuel on the Freugh Estate is mentioned in the *'New Statistical Account of Scotland'* (Anderson, 1845).

Prior to ploughing, *Calluna, Erica tetralix, Eriophorum vaginatum, Myrica gale* (bog myrtle) and locally *Molinia* (purple moor-grass) were abundant on the little-disturbed or virgin peat. Associated *Sphagnum* species (mainly *S. capillaceum* and *S. recurvum*) though not very abundant occurred throughout the virgin area. The above species and less frequently occurring *E. angustifolium, Narthecium ossifragum, Vaccinium oxycoccus* (cranberry), *Pleurozium schreberi, Hypnum cupressiforme* and *Odontoschisma sphagni* constituted an oligotrophic peatland community unaffected by water from the surrounding mineral ground. In the cut-over section to the south-west *Juncus effusus* is frequent and grows in association with a variety of plants including *Holcus mollis* (creeping soft-grass) *Agrostis canina* (brown bent-grass), *Ranunculus acris* (meadow buttercup), *Galium palustre, Hydrocotyle vulgaris, Cirsium palustre* (marsh thistle) and *Cratoneuron filicinum,* all species characteristic of a mesotrophic community.

In contrast to West Freugh Moss all of Aird Moss (NX 095605), a confined soligenous mire in the north of region B, supports vegetation indicative of nutrient enrichment. The drained western part is characterized by pasture grasses and patches of *J. effusus*. Elsewhere the mire is undrained and the vegetation forms a mosaic of communities, each dominated by a single species, predominantly *J. effusus*. Other community dominants include *Typha latifolia* (great reedmace), *Carex rostrata* (bottle sedge) and *Eleocharis palustris* (common spike-rush).

Peat stratigraphy was examined at seven sites on Freugh Moss, all within the oligotrophic virgin area from the centre of which a core was taken for detailed botanical analyis (Fig. 16). The lowest horizon (2·8 to 2·0 m) is largely composed of highly-decomposed amorphous peat with some *Betula* wood and *Juncus* seeds, and a little *Sphagnum* sect. Acutifolia at 2·5 m. This assemblage, since it overlies and even penetrates clay, represents a pioneer community of birch-rush carr. Above this there is a moderately to highly decomposed horizon (2·0 to 1·6 m) in which *Molinia* and sedge remains dominate the sub-fossil assemblage. These remains are associated with a large number of taxa which includes seeds of *Potentilla erecta* (common tormentil) and *Juncus,* some ericaceous twigs and frequently-occurring *Sphagnum* sect. Acutifolia leaves. At the time of deposition of this horizon the site had become somewhat impoverished in nutrients and was probably a poor fen.

From 1·6 m to the surface, the sub-fossil assemblage is characteristic of acid oligotrophic conditions with abundant remains of *Sphagnum papillosum, S. cuspidatum* and *Sphagnum* sect. Acutifolia. Some remains of *Phragmites* (reed) occur between 1·5 and 1·2 m and are possibly relic plants from the preceding nutrient-enriched communities. Most of the cores examined in the field have the general stratigraphic sequence described above.

Decomposition values are generally low to moderate in the oligotrophic horizons and moderate to high in the underlying horizons. The overall mean is H6 and the range is H3 to H9. Moisture contents, 83 to 94 percent with a mean of 88 percent, seem rather low and are probably influenced by the high mineral content. The ash content of the peat is in the range 2·6–26·5 percent with a mean of 7·6 percent, which is rather high for this type of deposit. Whilst carrying out the botanical analysis of the peat, fine quartz sand grains were found at nearly all levels. These were probably blown from the adjacent sand dunes and are responsible for the unusually high ash values. Variations with depth in decomposition and in moisture and ash contents are shown in Figure 17.

PEATLAND REGION C

Braid Fell (NX 112666), situated approximately 8 km north-east of Stranraer (Fig. 14), forms part of an extensive tract of unconfined mire representative of the major peatland type in region C. The hill road from Craigcaffie forms its western boundary, the rest of its outline being arbitrarily defined. The surveyed area lies between 198 m (650 feet) and 234 m (769 feet) O.D. and covers 310 hectares. Surface levels and peat depths were recorded on a 100 m grid and the results used to construct contour maps of both the surface and bottom of the deposit (Fig. 18). Depths of around 2 m are common on the hill which gave the mire its name but increase markedly on the shelf in the south-west corner to between 4 and 6 m; the maximum depth recorded, 7·7 m, occurred in an isolated pocket. This information together with the contour map and the cross section in Figure 15 serves to illustrate how peat formation alters and modifies topographic features, changing the landscape, filling hollows and ultimately producing a relatively even surface with less severe gradients.

In addition to the area described above, five other sites were examined by means of traverse lines ranging from 600 to 1300 m. Peat depths taken at 100 m intervals varied from 0·5 to 6·0 m, means being in the 1·4–2·8 m range. In short, the results closely reflect those obtained from the main survey at Braid Fell.

The vegetation of Braid Fell is fairly typical of oligotrophic unconfined mire. However, the peatland and vegetation have been subjected to modifying pressures such as grazing, muirburn, minor attempts at improvement by drainage and some peat cutting for fuel.

Over most of the area, the oligotrophic bog vegetation is characterized by *Calluna, Erica tetralix, Eriophorum* spp. and *Sphagnum* spp. (principally *S. papillosum* and *S. capillaceum*). *Molinia, Trichophorum* and *Vaccinium oxycoccus* are also widely distributed and locally abundant. On shallower and possibly better drained peat, *V. myrtillus* grows in association with oligotrophic species, *Deschampsia flexuosa* and *Festuca rubra* (red fescue), constituting a community characteristic of grazed, relatively shallow, upland unconfined mire.

The abundance of certain species has probably been affected by land use. For instance, burning may cause a temporary increase in the abundance of *Erica tetralix*, a species that recovers quickly after fire; drainage reduces the abundance of *Sphagnum* species and promotes the growth of *Calluna*. Where shallow, widely-spaced drains have been laid out, the effect of drainage is probably not very great, but where peat has been cut for fuel vigorous growth of *Calluna* is characteristic of the relatively freely-drained peat banks. With time, abandoned cuttings become recolonized, mainly by acid bog vegetation.

PLATE 21/Fluvioglacial gravels at New Luce in the Water of Luce Valley. The soils belong to the Yarrow series of the Yarrow Association.

PLATE 22/The River Bladnoch embanked to protect the alluvial soils from flooding.

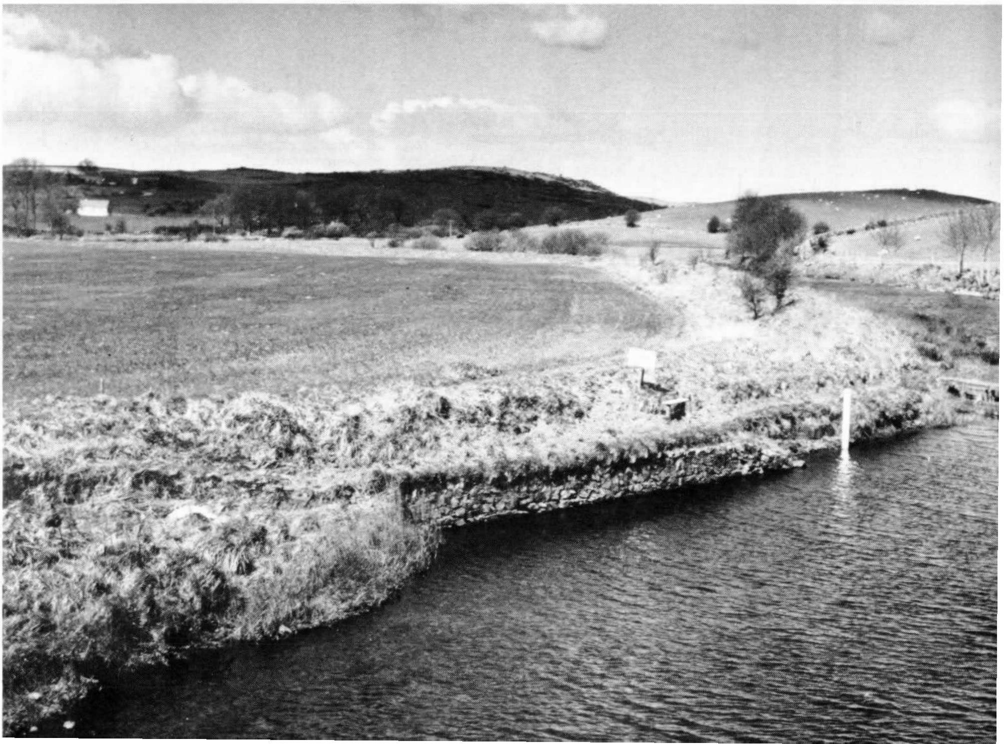


PLATE 23/View south-eastwards from Knock Fell. The moorland consists mainly of deep peat deposits, in part afforested, and soils of the Finlas complex of the Ettrick Association.

PLATE 24/View across the Cree–Luce Moors between Dalhabboch and Craigcaffie. Soils belong mainly to the Dod and Dochroyle series of the Ettrick Association, together with extensive areas of peat.

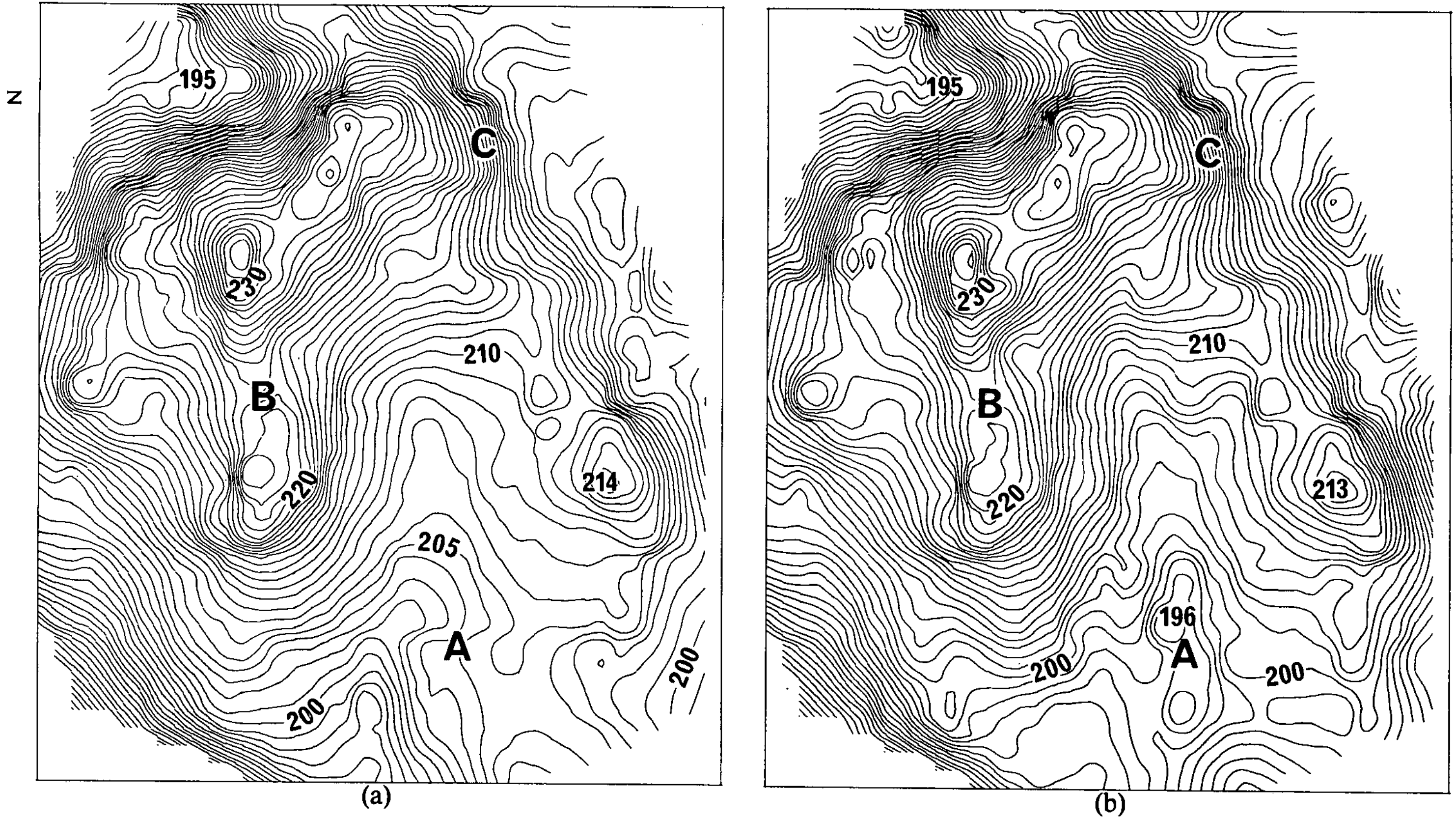


FIG. 18 Relationship between Surface (a) and Bottom (b) Contours following Peat Formation at Braid Fell (contours at 1 m intervals)

Typical oligotrophic bog vegetation was also recorded at High Eldrig (NX 201686), Balmurie (NX 227656) and Drumadryland (NX 120685) and the upland bog community with *V. myrtillus,* at Drumadryland and Stab Hill (NX 149719). The communities and pressures described above are repeated throughout most of the peatland of region C.

In comparison with sites described previously, the peat stratigraphy of Braid Fell proved to be less complex. In the core taken for detailed examination (Fig. 16), two horizons were distinguished, a lower woody horizon from 3·0 to 2·5 m and an upper oligotrophic horizon between 2·5 m and the surface. *Betula* and *Alnus* wood and *Juncus* seeds are the main recognizable components in the highly-decomposed peat (H8 to H9) of the lower horizon. The upper horizon, largely composed of *Eriophorum vaginatum* and *Sphagnum* sect. Acutifolia with *S. papillosum* and *S. cuspidatum,* can be divided into two sub-horizons based on degree of decomposition. From 2·5 to 1·5 m, the peat is highly decomposed (H8 to H9), whereas above 1·5 m decomposition is moderate, ranging from H4 to H7. Most of the cores examined in the field have a similar botanical sequence in which woody (*Betula*) peat is overlain by *E. vaginatum* and *Sphagnum* peat; in the relatively shallow cores, however, few identifiable remains could be detected. In some of the deeper pockets of peat, sedge remains were found below the oligotrophic horizons.

The physical characteristics of the peat are typical of unconfined bog. Overall, decomposition values range from H3 to H9, with a mean of H7, while the moisture content varies from 82·7 ro 94·9 percent with a mean of 90·4 percent. Moisture values are somewhat low, possibly because of the high incidence of shallow peat and attempts to drain the site. Ash values, in the range 0·9–15·7 percent (mean 2·9 percent) are typically higher in the peat immediately overlying the mineral soil. Trends in decomposition, moisture content and ash content with depth are illustrated in Figure 17.

PEATLAND REGION D

During the 1950s the former Scottish Peat Committee, in collaboration with the Macaulay Institute, initiated a survey programme to locate and evaluate the major Scottish peat reserves and to assess their potential as a source of fuel for the production of electricity (Scottish Home Department, 1954). As part of this programme, eight mire complexes were surveyed in south-west Scotland (Department of Agriculture and Fisheries for Scotland, 1964). Six of these are located within peatland region D (Table J) and constitute an almost continuous expanse of deep blanket mire totalling approximately 2000 hectares. Peat depths generally ranged from 3 to 4 m and reserves were estimated to be in the region of 5·6 million tons peat solids.

The Flow of Dergoals (NX 236584, Figs. 14/15), a typical example of the mires of the region, lies to the south of the Newton Stewart–Stranraer road (A75), approximately 5 km to the east of

Table J. Main Characteristics of Mires Surveyed in Peatland Region D

Mire	Area (ha)	Mean depth (metres)	Mean degree of decomposition (H)	Mean ash content (percent)	Mean moisture content (percent)	Peat solids (million tons)
Blairderry Moss	542	4·3	7	3·8	92·5	1·53
Dirskelpin Moss	372	3·0	7	2·8	91·5	0·96
Knock Moss	180	3·6	6	4·6	92·0	0·43
Mindork Moss	182	3·5	6	5·5	92·9	0·45
Flow of Dergoals	276	3·7	6	4·0	92·5	0·77
Annabaglish Moss	567	3·5	6	4·3	92·4	1·5

Glenluce village. The area investigated encompasses the adjacent Dirneal Moss and as previously surveyed was divided into three sub-areas. Sub-areas I and III are relatively level and are characterized by an almost continuous cover of deep peat. In sub-area II, the peat has developed on the relatively steep slopes of the adjoining Dergoals Burn and is consequently much shallower.

Within sub-areas I and III *Trichophorum cespitosum* is dominant over large tracts of mire. In addition *Calluna, Sphagnum* species, *Erica tetralix* and *Eriophorum angustifolium* also grow as community dominants. Locally, plants such as *Myrica gale, Vaccinium oxycoccus, Narthecium ossifragum, Eriophorum angustifolium* and *Cladonia* species are abundant. Where the surface is soft and wet, *Sphagnum* species are dominant, *S. magellanicum* being abundant in this type of situation throughout peatland region D. In some of the better drained parts of the mire, as in sub-area III, *Molinia* is dominant.

Much of the mire, especially sub-areas II and III, has been ditched and many of the ditches have become infilled with *S. cuspidatum* and *Rhyncospora alba,* species also encountered in the wetter parts of the mire. Relatively good and improved drainage on steeper slopes and in ditched areas, together with grazing by sheep and nutrient enrichment around mineral outcrops and alongside streams, is responsible for localized occurrences of *Phragmites communis, Juncus effusus, Carex* species, *V. myrtillus* and *Pteridium.*

The other mires in region D surveyed for the Scottish Peat Committee support a similar flora, *Trichophorum* being the most frequent dominant. *Sphagnum* species and *Trichophorum* generally dominate the wetter areas of these mires; for example part of Mindork Moss (NX 308570) supports a community largely composed of *Trichophorum, S. capillaceum, S. magellanicum* and *Calluna.* Many of the relatively dry edges of the mires, e.g. Blairderry (NX 270615), carry dense stands of *Calluna* and are transitional to heathland.

Where the mires are flushed by nutrient enriched water around rock outcrops and drumlins, *Molinia* is frequently dominant and species such as *Polytrichum commune, Filipendula ulmaria* (meadow-sweet), *Pedicularis palustris* (red-rattle), *Succisa pratense* (Devil's-bit scabious) and rarely *Schoenus nigricans* (bog-rush) are present. Examples of flushed communities in which *Sphagnum papillosum, Molinia, Myrica* and *Eriophorum angustifolium* are the most abundant species occur on Knocketie Moss (NX 291588). Here the main associates are species of *Carex,* including *C. rostrata* and *C. echinata* (star sedge), *Trichophorum, S. capillaceum, Erica tetralix, Menyanthes trifoliata* (bogbean), *Narthecium ossifragum* and *Agrostis canina.* This assemblage of acid bog species and species which require a degree of nutrient enrichment is indicative of diffuse flushing. Nearby, within well-defined linear flushes or soaks, often only 1–2 m wide, the flora is characterized by an abundance of *Potamogeton polygonifolius* (bog pondweed), *Juncus acutiflorus* (sharp-flowered rush) and *Carex* species together with other plants indicative of nutrient enrichment, including *Equisetum fluviatile* (water horsetail), *Ranunculus flammula* (lesser spearwort), *Potentilla palustris* (marsh cinquefoil) and *Carum verticillatum*.

A detailed characterization of the peat horizons was carried out on a core from the Flow of Dergoals (Fig. 16). *Betula* wood occurs in the mineral ground beneath the mire and throughout most of the lowest peat horizon (6·6–4·8 m); the other major plant components are *Phragmites* and mosses—*Polytrichum commune, Thuidium tamariscinum* and *Hylocomium splendens*. Remains of *Sphagnum* species (*S. imbricatum, S. palustre, S. magellanicum* and sect. Acutifolia) occur in small quantities throughout the horizon, indicating that the peat was formed by a poor fen-carr vegetation.

From 4·8 to 3·5 m, the principal recognizable plant components are ericaceous remains, *Eriophorum vaginatum*, and the mosses *Polytrichum* sect. Juniperina, *Dicranum* sect. Scoparia, *Aulacomnium palustre, Sphagnum* sect. Acutifolia, *S. imbricatum, Pleurozium schreberi* and *Hypnum cupressiforme*. Between 3·5 and 2·1 m, the peat is largely composed of *S. imbricatum* associated with small quantities of *Eriophorum* species, ericaceous remains and *Sphagnum* sect. Acutifolia. Above 2·1 m the peat is again largely composed of *Sphagnum*, but *S. imbricatum* is replaced by *S. papillosum*. *Eriophorum angustifolium* and ericaceous remains are frequent and wood of *Myrica*, a species found in a variety of habitats, occurs in the top 0·8 m.

All the stratigraphic investigations previously carried out on the mires of this region (Department of Agriculture and Fisheries for Scotland, 1964) show features similar to those described above, *Sphagnum* peat generally overlying sedge (mainly *Carex*) peat. Much of the sedge peat contains varying amounts of wood and occasionally *Menyanthes* seeds. Plant remains most frequently associated with the *Sphagnum* peat are of *Eriophorum* species, *Trichophorum* and *Calluna*.

Most of these mires are characterized by pockets of deep peat which originated in isolated basins; later the peat spread over the intervening ground to form a more or less continuous cover. Hence many of the mires are partly-confined, being intermediate between raised basin and blanket mire. The bulk of the peat in the basin is derived from sedge species which flourished as long as there was a supply of nutrient-enriched ground water from the surrounding land. As the peat increased in depth, the greater portion of the surface of each mire eventually ceased to be affected by ground-water run-off and *Sphagnum* peat, indicative of nutrient-poor or oligotrophic conditions, was formed. The influence of ground water varied at different sites; for example the sedge peat horizons of Dergoals Moss (NX 255603) are thin compared with those of the overlying *Sphagnum* peat whereas at Knock Moss (NX 265570) they are relatively thick and locally extend to the surface of the mire.

In general, the degree of decomposition of the peat is moderate to high, low values being mainly associated with the upper horizons; means of H6 and H7 were recorded for the six mires surveyed (Table J). Mean moisture contents (91·5–93·3 percent) and mean ash contents (2·8–5·5 percent) are in accord with those expected for predominantly oligotrophic peat. The ash content tends to be higher in the lower minerotrophic sedge horizons. Variations in the degree of decomposition, moisture content and ash content with depth for a typical profile from Dergoals Moss are shown in Figure 17.

Table K. Late and Post Glacial Chronology

Years before present	Climatic period	Zone	Era
	Sub-Atlantic	VIII	
2500			
	Sub-Boreal	VIIb	
5000			
	Atlantic	VIIa	Post Glacial or Flandrian
7500			
	Boreal	VI	
9000			
	Early Boreal	V	
9600			
	Pre-Boreal	IV	
10,300			
	Upper Dryas	III	
10,800			Late Glacial or Late Devensian
	Allerod	II	
12,000			
	Lower Dryas	I	
			Glacial

PEATLAND REGION E

As previously mentioned, the mires of peatland region E are relatively few and are situated mainly in troughs or valleys amongst gently rolling hills. Drummoddie Moss (NX 393460, Figs. 14/15), 5 km north-west of Port William, forms part of a complex which occupies adjoining valleys and is typical of most of the deposits in this region. Survey was confined to that part of the moss which lies between the unclassified road connecting the B7021 and the A714, and a track running from North Drummoddie over the north-eastern part of the mire. Typically, the mire surface supports vegetation indicative of oligotrophic conditions, *Calluna, Trichophorum, Eriophorum vaginatum, Erica tetralix* and *Myrica* being the most abundant species. *Sphagnum* species are subordinate to the above plants and only locally constitute a major component of the flora. Since the mire was surveyed, part of it has been ploughed for afforestation.

Approximately 2 km south of Drummoddie at Auchness Moss (NX 394438), a similar type of oligotrophic flora was recorded, the major difference being a high abundance of *S. capillaceum*. Much of this site has also been ploughed and afforested. Where the peat has been cut-over, *Molinia* grows in dense tussocks amongst which few other species are able to survive. Those that do are relatively sparse and include *Potentilla erecta, Calluna, Erica tetralix* and *Eriophorum angustifolium.*

Airies Moss (NX 408487), a mire situated within a basin 4 km to the north of Drummoddie Moss, is largely afforested, except for the eastern part which has been cut over and supports a flora dominated by *Juncus effusus.* Associated plants suggest that this part of the mire is affected by minerotrophic water; they include *Ranunculus acris, Holcus lanatus* (Yorkshire fog), *Cardamine pratensis* (lady's smock), *Epilobium palustre, Galium palustre, Carex disticha* (brown sedge), *C. echinata* and *Equisetum fluviatile.* This community has a marked similarity to the vegetation of the cut-over area of Freugh Moss in region B.

The stratigraphy of two cores of peat, 8·0 and 8·3 m deep respectively, from the centre of Drummoddie Moss was investigated in the field. At a depth of approximately 5 m, a major change in the nature of the peat was recorded. Above 5 m the horizons are mainly composed of oligotrophic *Sphagnum* peat whereas below this level wood and sedge remains predominate. In the core investigated in the laboratory (Fig. 16), the major change occurred at 5·4 m. Three main horizons were identified, one above and two below this depth. The lowest horizon (8·3–7·6 m) is composed of peat and gyttja containing abundant *Cladium mariscus* (fen sedge) seeds, and the occasional *Betula* seed, *Scorpidium scorpioides* shoot and *Sphagnum* sect. Cuspidata leaf. The discovery of *Cladium* is of interest because, although sub-fossils of the plant are abundant in some English and Irish mires, they have rarely been reported from Scottish mires.

The *Cladium* peat is overlain by a horizon (7·6–5·4 m) characterized by *Betula, Carex paniculata* (panicled sedge), *Phragmites* and fern sporangia together with traces of a number of *Sphagnum* species including *S. palustre* and *S. imbricatum.* This assemblage is probably derived from an open, poor fen-carr in which birch trees or bushes interspersed with more open stretches of *Phragmites* afforded shady conditions for the growth of ferns and *C. paniculata.*

Between 5·4 and 3·5 m the peat is derived mainly from ericaceous plants, *Eriophorum vaginatum, Sphagnum* sect. Acutifolia and *Aulacomnium palustre.* Traces of *Polytrichum* sect. Juniperina, *Dicranum* sect. Scoparia and *Hypnum cupressiforme* were also recorded. Since the *Betula* seeds found between 4·1 and 3·5 m were not accompanied by wood remains it is impossible to say whether they originated from birch growing on or around the mire. Above this horizon, at 3·5–1·7 m, *S. imbricatum* and ericaceous remains are the main components, the only other recognizable sub-fossils found in quantity being seeds of *Rhyncospora alba,* a plant of relatively wet acid peatland. In the top horizon (above 1·7 m), *Sphagnum* sect. Acutifolia, *S. papillosum,* ericaceous remains, *Hypnum cupressiforme, R. alba* seeds and *Eriophorum vaginatum* rhizomes form the bulk of the recognizable remains in the peat. Small quantities of *Rhacomitrium lanuginosum, Myrica* and *E. angustifolium* also occur.

In general, the peat at Drummoddie Moss has a moderate degree of decomposition, H values ranging from H2 near the surface to H8 at depth (mean H6). Moisture contents, in the range 90·8–94·3 percent (mean 93·1 percent), are high and fairly characteristic of this type of mire. Ash contents (mean 2·3 percent) are low and the narrow range (1·1–4·7 percent) suggests that at the mire centre there was little inwash of mineral matter throughout the minerotrophic stage of development. Variations in H values, moisture content and ash content with depth for a single profile are shown in Figure 17.

PEATLAND REGION F

Several references to the peatland of region F, and in particular to the Moss of Cree, are made both in Sinclair's *Statistical Account of Scotland* (Boyd, 1792; Duncan, 1795) and in the *New Statistical Account of Scotland* (Richardson, 1845; Young, 1845). According to these accounts it would seem that these mires were once much more extensive and that during the eighteenth and nineteenth centuries they were greatly reduced in area by cutting for fuel and reclamation for agriculture.

The Moss of Cree (NX 440600), situated on the west side of the River Cree, 5 km south of Newton Stewart and 4·5 km north of Wigtown, covers approximately 520 hectares and is the largest mire in the region (Fig. 14). When surveyed on a 100 m grid interval in 1960 (Department of Agriculture and Fisheries for Scotland, 1964), it was found that, apart from some attempt at drainage, the greater part of the mire was in a relatively undisturbed state. It was also recorded that 'the bog is remarkable in the way in which it comes to a sudden stop at almost all points on its perimeter' (Fig. 15). This feature is probably a result of peat cutting and reclamation around the edge of the mire and is shared by the other mires of the region. In recent years much of the western half of the moss has been planted with conifers by the Forestry Commission.

The vegetation of the relatively undisturbed eastern half exhibits a distinct zonation. The central area is dominated by *Sphagnum* species and contains wet hollows in which *S. cuspidatum* abounds. *S. magellanicum, S. papillosum, S. capillaceum, S. tenellum* and *S. recurvum* occur with *Trichophorum, Eriophorum* species, *Calluna, Erica tetralix, Myrica, Vaccinium oxycoccus,* and other vascular plants typically found on oligotrophic mires. Passing from the centre to the edge of the mire, vascular plants (in particular *Eriophorum vaginatum* and *Molinia*) become more abundant and *Sphagnum* species decrease. Around the drier edge, *Molinia* and *Betula* are dominant either singly or together.

Some of the other mires in the region, for example Carsegown Moss (NX 428580) and the western half of Borrow Moss (NX 432580), have similar vegetation communities. The eastern half of Borrow Moss has been tile-drained, resulting in a lowering of the surface by shrinkage and the development of vegetation dominated by *Juncus effusus*. Muirfad Flow (NX 455623) on the east bank of the Cree has been ditched at 8 m intervals and now supports a relatively good sward of pasture grasses.

On the Moss of Cree, according to the earlier peat survey report (Department of Agriculture and Fisheries for Scotland, 1964), the main constituent of the peat is *Sphagnum* together with small quantities of *Calluna* twigs and *Eriophorum* fibres. At or near the base of the deposit, *Betula* wood was found in most boreholes and *Carex* remains occurred less frequently. The vegetation sequence suggested is of birch carr and a few restricted areas of fen, growing on poorly drained, gently undulating clay, being soon overwhelmed by oligotrophic bog vegetation.

A more detailed stratigraphic analysis of a core from the centre of the unplanted area of the mire is represented in Figure 16. Between 4·0 and 3·4 m the peat contains *Betula* wood and some remains of *Sphagnum* (including *S. imbricatum*), *Aulacomnium palustre* and sedge. *Juncus effusus*-type seeds are abundant in the lowest 0·2 m. This oligotrophic open fen-carr peat is overlain by oligotrophic *Sphagnum* peat in which *S. imbricatum* is the most abundant species and *S. papillosum, S. magellanicum, S. cuspidatum, S. subsecundum* and sect. Acutifolia occur in varying amounts. Also present are remains of ericaceous plants, *Eriophorum vaginatum* and *Myrica* together with occasional seeds of *Rhyncospora alba* and shoots of *Aulacomnium palustre, Pohlia nutans, Polytrichum* sect. Juniperina and *Hypnum cupressiforme.* A core was also examined from the centre of Carsewalloch Moss (NX 460617) less than 2 km to the east of Moss of Cree. Here 0·5 m of woody peat is overlain by 3·0 m of *Sphagnum* and *Eriophorum* peat.

Peat samples taken from the Moss of Cree show, on average, a low to moderate degree of decomposition. Values range from H2 near the surface to H8 in the deeper horizons. Ash contents are relatively low except in the lower layers where the values of up to 27 percent indicate a certain degree of contamination with mineral soil. Moisture contents range from 88 percent to over 95 percent and are characteristic of wet, virgin mire. Variations in degree of decomposition and moisture and ash contents with depth are illustrated in Figure 17.

PEATLAND REGION G

The high-level unconfined mire of region G was examined around Louran Rig (Fig. 14) on the northern extension of Cairnsmore of Fleet, between 305 m (1000 feet) and 457 m (1500 feet) O.D. Here the peat is relatively shallow, seldom exceeding 1·5 m in depth. Since access was difficult, survey was confined to random sampling to determine general characteristics.

Well-drained sites, especially on relatively steep slopes, support dense stands of *Calluna* in which the main and sometimes virtually the only associates are *Sphagnum capillaceum* and *Hypnum cupressiforme.* Sites influenced by surface water flowing from acid rock and soil are characterized by a greater variety of oligotrophic species. *Sphagnum papillosum* and *Trichophorum* are community dominants and *S. subsecundum inundatum, S. compactum* and *Juncus effusus* are indicators of flushing. This pattern of *Calluna*-dominated vegetation on the drier, unflushed sites and *Sphagnum* communities on the wetter, flushed sites is repeated throughout much of peatland region G.

On Blair's Hill (NX 482628), 5 km south of Louran Rig, at approximately 180 m (590 feet) O.D., peat occurs in pockets interspersed by mineral and shallow peaty soil. Here the vegetation has been influenced by the combined effects of flushing and heavy grazing. *Molinia* dominates much of the area and on the peat grows in association with *Anthoxanthum odoratum* (sweet vernal grass), *Sphagnum capillaceum, Myrica, Calluna, S. papillosum* and flush community plants, including *Viola palustris* (marsh violet) and *Myosotis caespitosa* (water forget-me-not).

Peat stratigraphy of two cores, 1·4 and 1·5 m deep, was examined at Louran Rig. The peat from both cores shows a high degree of decomposition (H8), which increases slightly in the bottom half metre of the deeper core. In general the peat is composed of apparently amorphous or structureless material in which remains of *Calluna* and *Eriophorum angustifolium* are recognizable towards the top of the profile and remains of wood occur near the base. Moisture and ash contents are relatively low, maximum values recorded being 90·2 and 2·6 percent, respectively.

VEGETATIONAL HISTORY

Reconstruction of the vegetational history of the area is based on the pollen analysis of four basin mires, namely Moss of Cree, Blairderry Moss, Drummoddie Moss and Glengyre Moss.

The technique of pollen analysis depends on the fact that pollen grains and spores are normally preserved for many thousands of years in anaerobic deposits such as peat and lake sediments. Identification and quantitative assessment of the grains isolated from the preserving matrix yields a continuous record of the vegetation that grew on and around the site and of the major environmental changes that have occurred. Graphic representation of this vegetational record is achieved in 'pollen diagrams' (Fig. 19) which can be interpreted in terms of the series of northern European climatic periods identified by Blytt (1876) and Sernander (1908); these can be correlated with the sequence of pollen zones devised by Godwin (1975), which is applicable to most of Britain outwith the Highlands of Scotland (Table K).

1. Moss of Cree

Peat formation started in the Atlantic period at a time when woodland containing a high proportion of alder and some birch was probably abundant (Fig. 19). Subsequently, in the sub-Boreal, the proportion of tree pollen (especially alder) was greatly reduced because of a very marked increase of hazel-type pollen which rose from almost zero to high percentages. Since pollen grains of hazel (*Corylus avellana*) and bog myrtle (*Myrica gale*) are virtually indistinguishable in routine pollen analysis, the 'coryloid' pollen total probably includes a substantial

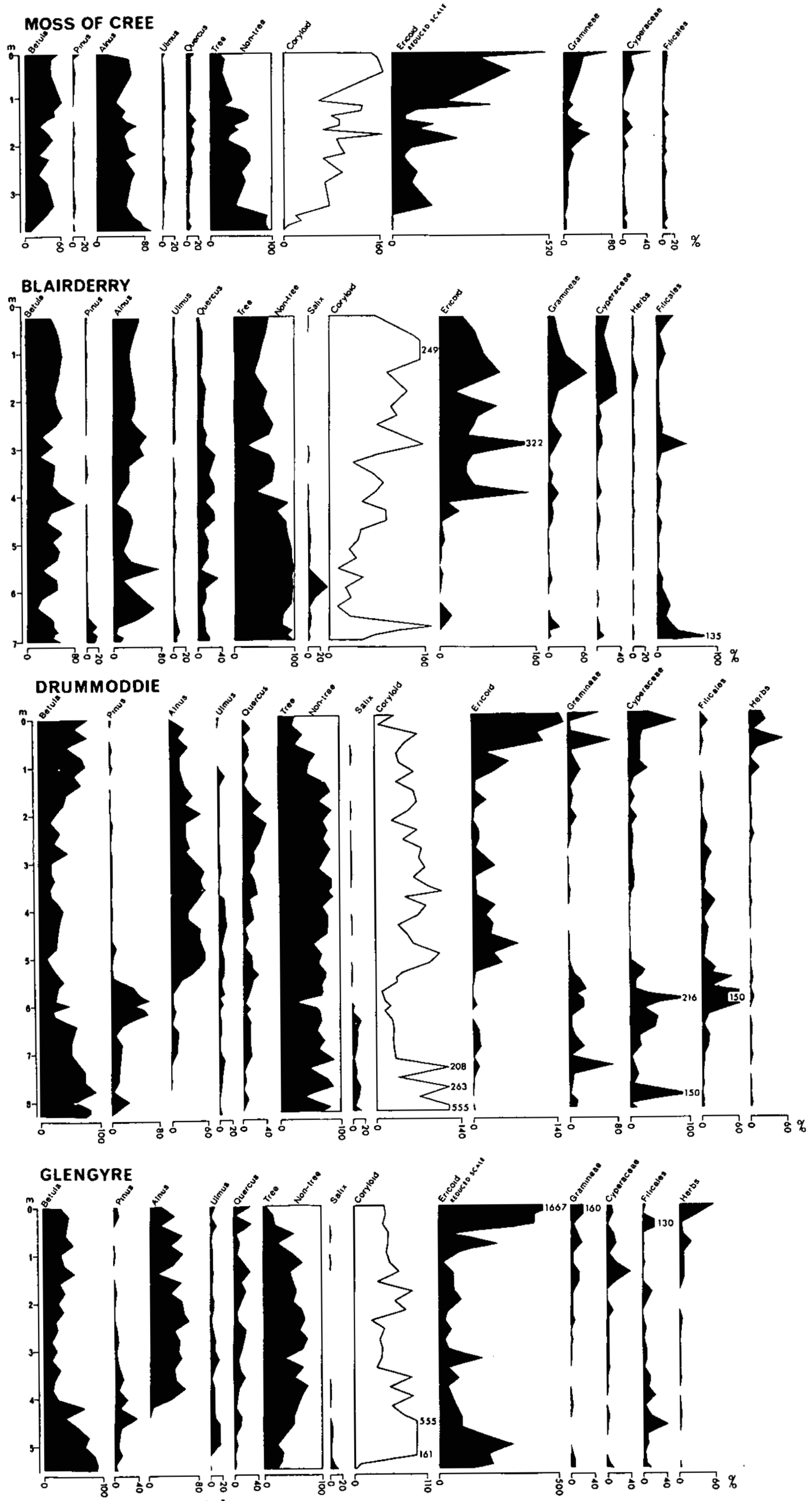


FIG. 19 Pollen Diagrams

proportion of *Myrica,* a plant at present well established on this and on many other bogs in western districts of Scotland. Elm is poorly represented throughout and pine is virtually absent. On the other hand, oak is relatively well represented in the sub-Boreal but thereafter declines leaving birch as the only tree, apart from alder, to attain abundance in the sub-Atlantic. In the light of the above evidence, it is considered that the area around the Moss of Cree first supported arboreal vegetation, dominated mainly by alder; later, in the sub-Boreal period, this was succeeded by mixed alder and birch woodland. Trees of mixed deciduous woodland never reached a high degree of frequency, but a shrub element of the coryloid type was clearly a factor of increasing importance as the vegetation developed.

In the non-arboreal portion of the diagram, it is noticeable that the ericoid pollen rises to high values in the most recent period, the sub-Atlantic. Similarly, grass and sedge pollen tends to increase towards the top of the profile.

2. Blairderry Moss

This pollen diagram can be dated in the initial stage to the late Boreal period. There is a clearly defined Boreal–Atlantic Transition at 6·2 m (Fig. 19), but the close of the Atlantic period is obscure and no boundary appears in the diagram, although it could occur about 5·4 m where there is a definite falling away of alder from its highest frequency. At 3·0 m the change from sub-Boreal to sub-Atlantic is indicated by a number of fluctuations which signify the onset of wetter conditions—e.g. rising of the alder pollen count, decline of oak and a falling of the tree pollen in general. Other noteworthy features of this pollen record are the:

(i) very high combined arboreal pollen totals (especially from the base to the end of the sub-Boreal period);
(ii) high proportion of oak during the sub-Boreal;
(iii) nearly reciprocal values for birch and alder;
(iv) virtual absence of pine pollen after the earliest stage.

There is here strong indication of almost complete dominance of the vegetation before the sub-Atlantic period by birch-alder-oak woodland. After the beginning of the sub-Atlantic oak declined somewhat and although elm increased slightly, there can be little doubt that the woodland became increasingly dominated by birch and alder. This, however, was a woodland reduced in area by the expansion of heathland as evidenced by the substantial increase of non-arboreal, particularly ericoid, pollen. Near the top of the profile, coryloid percentages rise to a very high level and it is suggested that, as at Moss of Cree, this may well be due to a major contribution of the pollen of *Myrica*—a plant which at present flourishes on Blairderry Moss.

3. Drummoddie Moss

The pollen diagram from this moss lends itself well to zonation according to the Godwin scheme (Fig. 19). Prior to the Boreal–Atlantic Transition at 5·5 m, pine and birch in varying proportions dominate the tree pollen. Near the end of the Boreal period, pine becomes the most abundant tree, the pollen count reaching 60 percent of the arboreal pollen. At the Boreal–Atlantic Transition, pine is reduced to very low values which continue to the end of the sub-Atlantic period. Alder rises at the Boreal–Atlantic Transition and maintains its dominant position until the close of the sub-Boreal period (1·5 m). Oak, a relatively low producer of pollen, is fairly frequent, especially in the sub-Boreal when it probably reached co-dominance with birch and alder. Elm is rather less well represented but shows the characteristic decline marking the termination of the Atlantic period at 3·8 m. Tree pollen as a whole is very abundant and constitutes over 70 percent of the total pollen count for most of the time before the sub-Atlantic period—indicating that this part of the country was very well wooded from early Boreal times to approximately 2500 years B.P.

The non-tree section of the pollen record reveals very high values for coryloid pollen in the Boreal period but normal values in the later periods, there being no increase suggestive of a contribution from *Myrica* as at Moss of Cree and Blairderry Moss. The ericoid group displays trends very like those of a typical Scottish pollen diagram, increasing in abundance in the latest period, the sub-Atlantic, when woodlands were reduced and heather moor expanded.

4. Glengyre Moss

Although less deep than Drummoddie, Glengyre Moss covers roughly the same time-span, from the Boreal to the sub-Atlantic periods. The Boreal–Atlantic Transition is at 4·0 m (Fig. 19) and the pine curve repeats the trends seen in the Drummoddie pollen diagram, indeed many of the comments on the Drummoddie data apply to those from Glengyre but there are differences in aspects of tree pollen frequency. Thus, in the Boreal period, percentages of total tree pollen are lower at Glengyre than at Drummoddie whereas elm is slightly more abundant and shows less of a disparity with oak; ericoid values are relatively higher at Glengyre and this, together with abundant coryloid pollen, accounts for the rather low proportion of arboreal pollen. The reconstruction of vegetation at Glengyre indicates that birch together with pine and hazel was succeeded by an abundance of alder with birch and mixed oakwood which continued until the general reduction of forest cover due to climatic change and human activities.

Evidence of early agriculture rests on the identification of certain types of herbaceous pollen—particularly plantain (*Plantago* sp.) which has been recorded in the upper peat horizons at Cree, Drummoddie and Glengyre.

5. Summary

Despite the occasional presence of pine stumps in hill peat in parts of south-west Scotland, pine was virtually absent from the woodland of

Wigtownshire in post-Boreal times. Birch and alder, the pollen count of the latter occasionally reaching values as high as any recorded in Scotland, emerge as the species which generally shared arboreal dominance. Oak was abundant during periods of optimal climatic conditions, i.e. the Atlantic and the sub-Boreal. There is evidence that bog myrtle (*Myrica gale*) strongly influenced the shrub flora in the sub-Atlantic period at some sites. Development and expansion of moorland occurred in the sub-Atlantic period—a trend repeated throughout Scotland.

ANALYTICAL RESULTS

Results of analyses of peat samples taken from five selected sites (Appendix VI, Tables 27–31) generally reflect the conditions under which the peat originated and subsequently developed; however, some trends are inconsistent and difficult to interpret.

The ash content was measured by igniting a 2 g sample of oven-dry milled peat at 500°–550°C. From a solution of the ash in dilute hydrochloric acid, total calcium, sodium, potassium and magnesium were determined spectrochemically. Total phosphorus and total nitrogen were determined in an acid digest by colorimetric methods. The pH value was measured in a 1 : 2 suspension in water using a glass electrode.

Ash contents, in the range 1·3–6·5 percent, are generally very low except for samples taken near the peat-mineral soil interface or from mires that have been influenced during development by mineral matter brought in by wind or surface water. The above-average values obtained for samples from West Freugh Moss (Table 28) reflect the minerotrophic conditions that prevailed at this site and, particularly near the surface, the influence of wind-blown sand. At Glengyre Moss (Table 27) and Drummoddie Moss (Table 30), on the other hand, ash contents are very low throughout almost the whole profile, suggesting that inflow of ground water played little or no part in mire development. The relatively high ash content in the surface horizon at Moss of Cree (Table 31) probably results from heather burning.

The pH values are low, ranging from 3·3 to 4·4, and at some sites, notably Glengyre (Table 27) and Moss of Cree (Table 31), show a remarkable consistency with depth. Values from Flow of Dergoals (Table 29) and Drummoddie Moss (Table 30) are more variable, but at West Freugh Moss (Table 28) there is a distinct tendency for the pH to increase towards the base of the profile.

Values for calcium, 0·067–1·26 percent, exhibit a general tendency to increase with depth. Results from Drummoddie Moss (Table 30) clearly indicate the boundary at 5·5 m between the underlying wood-grass-sedge and the overlying oligotrophic *Sphagnum* peat (Fig. 16). At Flow of Dergoals, the calcium contents show considerable variation down the profile whereas at Glengyre (Table 27) the values are considerably lower and are characteristic of peat formed under ombrotrophic conditions.

Values for sodium, 0·017–0·093 percent, are low and generally show neither marked differences nor consistent trends. Results for potassium are similar, ranging from 0·009 to 0·045 percent, those from Flow of Dergoals (Table 29) and Drummoddie Moss (Table 30) being particularly low and almost invariable with depth. The amount of magnesium, overall 0·068–0·795 percent, in some mires tends to increase with depth to a maximum about half or two-thirds of the way down the profile.

Total phosphorus is very low, being in the 0·012–0·040 percent region; in general, values in the upper 0·5 m are somewhat higher than those in the underlying horizons. Results for nitrogen range from 0·69 to 1·76 percent but trends are inconsistent in that some mires (e.g. Glengyre Table 27) show a tendency for nitrogen to decrease with depth whereas others (e.g. Drummoddie, Table 30) display a distinct tendency for the nitrogen content to increase towards the surface and basal horizons.

The low ash content and the moderate to high degree of decomposition of the peat in these deposits are consistent with a relatively high calorific value and indicate the suitability of the peat for fuel and related purposes. Furthermore, the low phosphorus and calcium contents might favour utilization for other industrial processes. Only the Moss of Cree contains substantial amounts of peat of a low degree of decomposition, widely regarded as the type most suitable for general horticultural use; however, the recent afforestation of this mire will largely preclude such use in the foreseeable future. On the other hand, other mires, including Drummoddie Moss, contain considerable reserves of peat of a moderate degree of decomposition which could be utilized for horticultural purposes and general soil improvement. Because the winning and harvesting of peat are largely dependent on climatic conditions, it is likely that, in this area of moderate to high rainfall, production of peat for horticulture would be a more viable proposition than the production of air-dry sod or milled peat for industrial use.

7 | Vegetation

INTRODUCTION

As regards vegetation and the vast expanses of peat, the Moors of Galloway resemble Caithness in the extreme north-east of the country. There is no counterpart in Caithness, however, for the more fertile Rhins and part of the Machars, and eastwards into the Stewartry of Kirkcudbright the relief is less subdued and the exposure less severe.

The climates of Galloway and Caithness are similar too, both falling, in part, within the hyperoceanic sub-sector, but in thermal zonation the two areas differ greatly. Lowland Galloway is in the northern temperate sub-zone, and southern species such as *Euphorbia paralias* and *E. portlandica* are found there; in Caithness, on the other hand, the lowland region falls partly in the hemiboreal sub-zone but mainly in the southern boreal sub-zone, and arctic alpine species such as *Salix herbacea* and *Arctous alpinus* are found there on extremely exposed hill crests. Thus in Galloway the variety of vegetation is richer, extending from the salt-marshes of Wigtown to the oroarctic communities on the summit of the nearby Cairnsmore of Fleet.

METHODS

Recording of the vegetation in the field was based on the methods laid down by Poore (1955). The Domin scale was used as a measure of the cover/abundance of individual plant species.

Construction and analysis of the plant community tables were carried out according to the methods of the Zürich–Montpellier School of phytosociologists (Braun-Blanquet, 1932, Ellenberg, 1956, and Küchler, 1967). Relevés (vegetation sample areas) were grouped into tables on the basis of the character species of class, order and alliance, together with the physiognomy and general species composition of the individual relevés. The groups of relevés were then subdivided by character and differential species into plant associations, or into provisional communities where inadequacy of data did not justify setting up associations. Some of the larger associations were then further subdivided into subassociations, based on groups of differential species.

In naming the plant communities so set up, the latinized form (-etum) was used for associations and one or two botanical species names for provisional communities. In the text below these forms are followed by the common English name and a brief description. Each community is placed in the appropriate class, order and alliance and the plant lists for

PLATE 25/Knock Fell, an eroded rocky hill, one of the Machars Fells.

PLATE 26/Soils of the Finlas complex in the Ettrick Association beside Fell Loch.

PLATE 27/The Garrary complex at Loch Grannoch.

PLATE 28/Borrow Moss, photographed from the air, surrounded by soils of the Stirling series of the Stirling Association. The northern part of the moss differs from the rest in appearance because of former attempts at drainage and improvement.

the relevés recorded in Galloway are given in Tables 32–47 (Appendix VII). More detailed descriptions of the plant communities can be found in the monograph 'Plant Communities and Soils of the Lowland and Southern Upland Regions of Scotland' (Birse and Robertson, 1976).

PLANT COMMUNITIES

A few records of the sand-dune vegetation were collected but were rejected from the general tables of the Scottish vegetation as imperfect samples. The maritime dune vegetation can, however, be placed tentatively into the appropriate associations.

Mertensio-Atriplicetum laciniatae (Nordhagen 1940) Tx. 1967
Frosted orache strand-line

This is the vegetation on the drift line along the shore. Species present are *Cakile maritima, Atriplex laciniata* and *Salsola kali*. The character species, *Mertensia maritima,* is rare although it is recorded locally. The climate of this association in the area, and of the three associations next discussed, is hyperoceanic humid northern temperate. The soil is a skeletal soil on sand which is being constantly moved by storm action, and contains layers of seaweed and other debris. No records of this vegetation were made.

Elymo-Agropyretum boreo-atlanticum Tx. (1937) 1967
Northern sea couch-grass dune

One relevé of this vegetation was recorded but was omitted from the table because it contained a large element of strand-line vegetation. The primary dunes are mainly fixed by *Agropyron junceiforme* and in the sample recorded *Honkenya peploides* was present. This would place the vegetation in the subassociation with *Honkenya peploides*.

Because of the recorded presence of *Euphorbia paralias* on the Galloway coast (Perring and Walters, 1962), it is possible that the vegetation is part of the southern association, Euphorbio-Agropyretum junceiformis Tx. (1945) 1952, but further sampling is needed to establish this.

The soil is skeletal on an aeolian sand which is very low in organic matter and repeatedly subject to movement by wind.

Elymo-Ammophiletum Br.-Bl. et De L. 1936.
Northern marram grass dune

As with that of the primary dunes, the vegetation of the main building phase of the dunes is perhaps at the transition between the northern association and the southern, Euphorbio-Ammophiletum Tx. (1945) 1952, association. The samples recorded were transitional to Koelerion albescentis vegetation and are omitted from the tables.

The soils are skeletal on aeolian quartz sand with occasional shell fragments. The humus content is low, but former surfaces covered by later sand blow are marked by a small yet visible increase in organic matter.

Euphrasio-Festucetum Géhu et Tx. (MS.)
Eyebright–red fescue dune

A few records of this type of vegetation were made but they contained rather a large element of Thero-Airion species and consequently were dropped from the tables. *Viola tricolor* spp. *curtisii* was present in the relevés but the other differential species of the association, *Gentianella campestris, Bellis perennis,* and *Ranunculus acris,* were not recorded. At the same time, *Astragalus danicus* and *Festuca ovina,* differential species of the east coast association, Astragalo-Festucetum arenariae Westhoff et Tx., were absent, thus confirming the placing of the fixed dune vegetation in the hyperoceanic association.

The soils are still skeletal but the initial stages of profile development can often be seen.

Puccinellietum maritimae (Warming 1890) Christiansen 1927
Sea poa salt-marsh
(Table 32)

Only one record of this community was taken, although it is fairly extensive in the Wigtown area. *Puccinellia maritima* is the only grass in the relevé, but cover values for *Plantago maritima* and *Armeria maritima* are rather high for this early stage of the salt marsh.

The climate is euoceanic humid northern temperate, but the occurrence of the community is independent of climate. The soil is a poorly drained coastal saline gley with a surface horizon pH of 7·3 and an exchange complex with a high content of both calcium and sodium ions.

Juncetum gerardii Warming 1906
Mud rush salt-marsh
(Table 33)

This is the main community of the salt-marshes and covers many acres of the flat land bordering the Wigtown and Baldoon Sands. *Juncus gerardii* is often absent from the vegetation, but can be abundant, and the grasses *Festuca rubra* and *Agrostis stolonifera* are often the dominant species. The grassy sward is grazed by sheep and cattle.

The climate is again euoceanic humid northern temperate, but within Scotland climate has no significant influence on the distribution of the community. The soils are coastal saline gleys, poorly or very poorly drained. The content of exchangeable sodium is high and, towards the lower boundary of the community, where it is in contact with Puccinellietum, sodium is the dominant ion in the exchange complex.

Carex dioica–Eleocharis quinqueflora community Birse et Robertson 1976
Few-flowered spike-rush mire
(Table 34)

Small sedge mires are not uncommon in the area, but their total extent is not significant and only one record was made. It is a good example of the community, with abundant *Eleocharis quinqueflora* and *Carex hostiana* and frequent *Eriophorum latifolium*, a species which is rather local in its occurrence in Scotland.

The climate is euoceanic very humid at the boundary between the northern temperate and oroboreal sub-zones. The soil is a peaty gley of high base status, with a pH of 6·1 and a base saturation of 90 percent in the surface horizon. Exchangeable calcium and magnesium contents are high and the carbon:nitrogen ratio is a little over 15.

Potentillo-Juncetum acutiflori Birse et Robertson 1976
Sharp-flowered rush pasture
(Table 35)

This is one of the characteristic communities of south-west Scotland and attains here its finest degree of expression. *Juncus acutiflorus* is the dominant and *Carum verticillatum*, the second character species, is common throughout much of the vegetation. The two subassociations occur in the area. The first, with *Poa trivialis*, is the more closely related to the richer Calthion vegetation, the second, with *Festuca ovina*, having a strong element of Nardo-Callunetea species.

The community is mainly a lowland one, occurring in the northern temperate sub-zone, but does extend into the orohemiboreal and lower oroboreal sub-zones, especially the second subassociation. The soils are non-calcareous gleys, peaty gleys and basin peat. The *Poa trivialis* subassociation is generally on moderate to high base status soils and the *Festuca ovina* subassociation is equally divided between soils of low base status and those with moderate to high base status.

Ranunculus repens–Juncus effusus community Birse et Robertson 1976
Soft rush pasture
(Table 36)

This wet pasture community, which is usually associated with arable land, has been placed in the Calthion alliance. The vegetation is often grazed during the pastoral period of an arable rotation and rested from grazing during the cereal and root-crop stages. Only one relevé of the community was recorded—from Reoch, north-east of Stranraer, on land abandoned from agriculture. The soil is a very poorly drained soil of the Dochroyle series which has, characteristically for the community, a surface horizon of low base status.

Juncus effusus–Sphagnum recurvum community Birse et Robertson 1976
Bog moss water track
(Table 37)

This second community with abundant *Juncus effusus* has also been provisionally placed in the Calthion alliance. Its status is not very clear, however, as the index of similarity with the *Ranunculus repens–Juncus effusus* community is only moderate (Birse and Robertson, 1974) and with all other communities is rather low or less.

The community is usually associated with blanket peat, along the margins of streams draining from the peat. The soil of the relevé from near Braid Hill is black amorphous peat with local washes of mineral material. Base status is low and the peat is acid and affected by 'flush' water.

Lolio-Cynosuretum (Br.-Bl. et DeL 1936) Tx. 1937
Rye-grass–crested dog's tail pasture
(Table 38)

This is the second characteristic pasture community of the area and is more closely associated with dairying than the other, Potentillo-Juncetum acutiflori, which is usually a component of the rough grazings. The two subassociations of the community, although differing slightly from their continental counterparts in species composition, are nevertheless still recognizable as the same units. The subassociation with *Luzula campestris* has as differential species *Luzula campestris, Lotus corniculatus, Rhytidiadelphus squarrosus* and *Ranunculus bulbosus*. It is the vegetation of permanent pasture and of ley pasture which has been laid down for a considerable number of years. *Festuca rubra* and *Agrostis tenuis* are usually the most abundant grasses and *Lolium perenne* is absent or of low cover. *Trifolium repens* is abundant, but there is a tendency for species of Nardo-Callunetea and other indicators of less fertile conditions to be present.

Four of the relevés recorded are from the euoceanic very humid northern temperate sub-region and the fifth is from the hyper-oceanic humid northern temperate sub-region on the Rhins Peninsula. With one exception the soils are of low base status in the Linhope and Kirkcolm series, but the mean pH of the surface horizon is 5·4 and the carbon : nitrogen ratio is less than 15, indicating fairly fertile conditions.

The typical subassociation is the vegetation of ley pastures and is thus the most important element in the landscape of the dairying area. Abundant creeping buttercup, *Ranunculus repens,* and frequent annual meadow-grass, *Poa annua,* differentiate it from most relevés of the first subassociation, but there is a transition between the two subassociations and these species encroach into the first. *Phleum pratense* and *Rumex obtusifolius* are truer differentials, occurring only in the typical subassociation. *Lolium perenne* is abundant, partly as a sown-out species, and white clover, *Trifolium repens,* is often very abundant. The greater degree of treading associated with the high intensity of grazing on this fertile pasture is indicated by the presence of *Poa annua,* but even more so by the occurrence of *Plantago major.*

With one exception, which is at the boundary between the northern temperate and the hemiboreal sub-zones, all the relevés are from the northern temperate sub-zone in the lowland region. Moisture conditions vary from humid to very humid in both the hyperoceanic and euoceanic sub-sectors. The soils range from freely drained brown forest soils of the Portencalzie series to non-calcareous gleys of the Ardwell, Balscalloch, Ettrick and Stirling series. In all the soils, except the Portencalzie series at Culscadden north of Garlieston and the Altimeg series at Bents near Newton Stewart, the surface horizon is moderately to well saturated with bases. The carbon : nitrogen ratio in the surface horizon is less than 15 in all except the cultivated peaty gley of the Glenstockadale series on the Rhins Peninsula.

Achilleo-Festucetum tenuifoliae Birse et Robertson 1976
Bent–fescue grassland
(Table 39)

This is the vegetation of the better hill grazing. It is fairly common in Galloway but more extensive in the lower rainfall areas farther east. The two relevés in Table 39 are the subassociation with *Thymus drucei* and the subassociation with *Holcus mollis.* Actually, both relevés are intermediate between the two subassociations and have been assigned to their respective subassociations on the basis of some of the class character and companion species. The first relevé, placed in the *Thymus drucei* subassociation, contains *Sieglingia decumbens, Calluna vulgaris* and *Erica cinerea* and no *Holcus mollis,* indicating open conditions with little affinity to woodland other than the presence of bracken, *Pteridium aquilinum,* and the second contains *Holcus mollis* and also *Conopodium majus* and *Artichum undulatum,* indicating affinity to woodland, and has been placed in the *Holcus mollis* subassociation.

Both records are from the lowland region, the first from the boundary between the northern temperate and the orohemiboreal sub-zone and the second from the northern temperate sub-zone. The soils are freely drained brown forest soils of low base status of the Linhope series. Exchangeable calcium is low for one and moderate for the other and in both exchangeable magnesium in the A horizon is moderate. The carbon: nitrogen ratio of this horizon under the *Thymus drucei* subassociation is 11, indicating a satisfactory level of nitrification, and under the *Holcus mollis* subassociation it is just under 20, indicating microbiological conditions less favourable to nitrification.

Junco squarrosi–Festucetum tenuifoliae Birse et Robertson 1976
Heath rush–fescue grassland
(Table 40)

Subassociation with *Molinia caerulea*

Flying bent (*Molinia*) grassland

Although the typical subassociation (*Nardus* grassland) of the community is found locally, this second subassociation is by far the more common. *Molinia caerulea* is abundant throughout the vegetation and lends its characteristic colours through the changing seasons of the year—bluish to purplish green in summer through the gold of autumn to the pale straw of the flying bent of winter and spring.

The two relevés recorded lack the second differential species, *Trichophorum cespitosum*, but in one there is *Carex nigra* and *Eriophorum angustifolium* and in the other *Sphagnum capillaceum* and *Calypogeia* spp., which confirms their placing in the *Molinia caerulea* subassociation. The first relevé is from Knock and Maize on the Rhins Peninsula and the second is from Dalhabboch beside Penwhirn Reservoir. Both are from the very humid orohemiboreal climatic sub-region, but the former is from the hyperoceanic sub-sector and the latter from the euoceanic, although still very close to the hyperoceanic. Cattle and sheep graze the vegetation and hold in check the dwarf shrubs occurring in it. The soils under the relevés are both peaty gleys, of the Glenstockadale and Dochroyle series. The surface peaty horizons are very acid, pH 3·6 and pH 3·5, and base saturation is low. Exchangeable calcium and magnesium have, respectively, the anomalous medium and high values associated with the high base exchange capacity of peaty organic matter. The carbon : nitrogen ratio is over 15 but less than 20, indicating more satisfactory nitrifying conditions than under the neighbouring dwarf shrub moorland.

Carex bigelowii–Juncus squarrosus **community Birse et Robertson 1976**
Mountain heath rush moor
(Table 41)

This community occurs on the summit of the Cairnsmore of Fleet in association with *Nardus* grassland. It is dominated by *Juncus squarrosus,* heath rush, and has a high index of similarity with the widespread mountain community, the *Agrostis montana–Rhacomitrium lanuginosum* community. Its index of similarity with *Nardus* grassland in the same alliance is moderate.

The climate is euoceanic perhumid lower oroarctic on the summit of the Cairnsmore of Fleet and the soil under the relevé recorded is a subalpine soil with peaty surface horizon (oroarctic peaty humus podzol), part of the Mulltaggart series. The contents of exchangeable calcium and magnesium are moderate in the organic surface horizon, but to a great extent this reflects the organic matter content as the pH is 3·7 and the base saturation 22·9 percent.

Carici binervis–Ericetum cinereae Br.-Bl. et Tx. (1950) 1952
Atlantic heather moor
(Table 42)

The initial phase of this community occurs on the older dunes in the hinterland of Luce Sands. *Ammophila arenaria* and *Carex arenaria* are still frequent in the vegetation and the soil is skeletal on sand. Vegetation is more mature in the typical and *Molinia caerulea* subassociations of the community. Relevés of the typical subassociation have been recorded at High Auchenlarie, west of Gatehouse of Fleet, and at Galdenoch on the west side of the Rhins. In the latter *Ulex gallii* is quite abundant; so far this is the only record to include this species and it links the community with vegetation to the south. The High Auchenlarie relevé is from the very humid orohemiboreal sub-region in the euoceanic sub-sector and the Galdenoch relevé from the drier and warmer humid northern temperate sub-region in the hyperoceanic sub-sector. Both soils are humus-iron podzols, with some drainage impedance in the former.

The subassociation with *Molinia caerulea,* moist Atlantic heather moor, is much more extensive than the typical and eight relevés have been recorded in Galloway on soils ranging from humus-iron podzols to acid peaty gleys. As in the typical subassociation the dominant plant is *Calluna vulgaris,* but a number of variants have been provisionally distinguished subdividing this part of the association. The first is differentiated by *Hylocomium splendens* and *Plagiothecium undulatum* and is the form with plagiotropic mosses dominating the ground layer. It is usually northern in its distribution and is a late stage in recovery after fire. The variant with *Cladonia floerkeana* is often a fairly early stage after burning. The typical variant is distinguished by the presence of orthotrophic mosses, *Pohlia nutans, Leptodontium flexifolium* and *Campylopus* spp. in the ground layer, and is an early stage after fire. The fourth variant, differentiated by *Leucobryum glaucum,* has been recorded in Scotland only from the south-west and is very similar to the form of the subassociation recorded by Braun-Blanquet and Tüxen (1952) in Ireland.

The range in climate is from the hyperoceanic humid northern temperate sub-region on the Rhins to the euoceanic very humid orohemiboreal sub-region in the east of the area. These are not the climatic limits of the subassociation, but merely a measure of the types of climate under which it most commonly occurs. There is a wide range in the drainage of the soils from freely drained Larbrax series to very poorly drained Creetown series. Base saturation and pH of the surface horizon are low and the carbon: nitrogen ratio is greater than 15, and for most of the soils greater than 20.

Campylopo-Ericetum tetralicis Birse et Robertson 1976
Bog heather moor
(Table 43)

This community borders on the blanket bog vegetation and is often the transition between it and moist heather moor. It is less extensive than the moist heather moor and only one relevé was recorded. *Calluna vulgaris* is the most abundant flowering plant, but *Erica tetralix* and *Trichophorum cespitosum* also give high cover values. The character species *Sphagnum compactum* is abundant and the liverwort *Odontoschisma sphagni* has a very high cover value.

The site of the record is near the base of Artfield Fell at the upper limit of the lowland region. The soil is a peaty podzol of the Dod series. The A_2 horizon is gleyed above a thin iron pan. The peaty surface horizon has a pH value of 3·7 and base saturation of 12 percent; the contents of exchangeable calcium and magnesium are moderate, but the high base exchange capacity of organic matter has to be taken into account in assessing these values.

Erico-Sphagnetum magellanici J. J. Moore (1964) 1968
Blanket and raised bog
(Table 44)

The blanket bog, basin bogs and raised bogs of Galloway carry this general Western European community. *Andromeda polifolia* is sometimes present, distinguishing the vegetation from that north of the Midland Valley. The liverwort *Pleurozia purpurea* has been recorded as far east as Eldrig Moss near Newton Stewart, linking the vegetation there with that of the hyperoceanic strip of land along the west coast.

The three subassociations of the community have been recorded in this region, although the first is of limited extent. One relevé of the subassociation with *Cladonia uncialis* has been described from the raised bog of Eldrig Moss. This subassociation is commonly found in the more northern and upland regions and its presence here in the lowland region is probably due to the more severe conditions of desiccation occasionally prevailing on the dome of the raised moss. The relevé is not a strongly expressed example of the subassociation as *Rhacomitrium lanuginosum* was not recorded and *Cladonia uncialis* has a very low cover value. The peat under the relevé is variable in nature, being dark reddish brown amorphous material with layers of *Sphagnum* which are only slightly decomposed. The pH just below the surface is 3·7 and the carbon: nitrogen ratio is greater than 30.

The second subassociation, with *Molinia caerulea,* is perhaps the most widespread of the three in this region. It usually occurs where there is a slight degree of flushing, so that it is often extensive in the high rainfall areas of the west and in depressional sites elsewhere. Two of the four relevés recorded have abundant *Myrica gale* and the subassociation can be equated with McVean and Ratcliffe's (1962) 'Western blanket bog'. The relevés have been recorded from level basin peat in the lowland region. The peat itself varies in constitution from dark reddish brown amorphous material, sometimes with wood remains, to material with lenses of slightly decomposed *Sphagnum* and *Eriophorum* shoot bases in some of the deeper deposits. The pH of the layer below the surface mat of raw *Sphagnum* is around 4·0. Under two of the relevés there appears to be abnormal microbiological activity, as the carbon: nitrogen ratio is 15 or less. Normally the value is over 20.

Two relevés of the typical subassociation have been recorded, at Galdenoch on the Rhins peninsula and at Challochglass south-west of Kirkcowan. Both belong to the variant with *Myrica gale* and are thus linked with the *Molinia caerulea* subassociation. The peat at Challochglass is at an early stage in the formation of a raised moss and at both sites the carbon : nitrogen ratio in the surface layer is over 30, indicating a lower level of nitrification than is found under the *Molinia caerulea* subassociation.

Agrostis montana–Rhacomitrium lanuginosum community Birse et Robertson 1976
Brown bent–woolly fringe-moss heath
(Table 45)

Vegetation of this type is found in the area only on the summit of the Cairnsmore of Fleet. The relevés are low in number of character species, but species such as *Carex bigelowii, Cetraria islandica* and *Cornicularia aculeata* differentiate the community from heath vegetation of the forest zone. The sub-community with *Salix herbacea* is of limited extent and occurs on sites which are blown clear of snow in winter.

The climate is lower oroarctic and, because of the open position in the path of rain-bearing winds from the Atlantic, the upper slopes of the Cairnsmore are in the perhumid division. The soils are mapped as sub-alpine soils of Mulltaggart series, but the upper members of this series could be included with oroarctic podzols and podzolic rankers (Birse and Robertson, 1976). The pH of the surface humus is low, although more than 4·0 and the base saturation is low. The microbiological conditions in these soils, however, seem more favourable than in most forest zone podzols, as the carbon : nitrogen ratio just exceeds 15.

Galio saxatilis–Quercetum Birse et Robertson 1976
Oakwood
(Table 46)

Oakwood exists now as remnants in the vicinity of some mansion houses or as the derived community of secondary birchwood. Other areas are planted with conifers. The two relevés under *Quercus petraea* canopy, in Cardoness Wood and near Cairnsmore House, are fine examples of the subassociation with *Endymion non-scriptus*. The third relevé, from secondary birch woodland near Newton Stewart, belongs to the same subassociation, but shows affinities with the typical subassociation.

All three relevés are from the lowland region in a euoceanic very humid northern temperate climate. The soils are freely drained brown forest soils of low base status in the Linhope and Clanery series. The carbon : nitrogen ratio in the A horizon of these soils is around 15, indicating a reasonably good level of nitrification.

Aceri-Ulmetum glabrae Birse et Robertson 1976
Sycamore–elmwood
(Table 47)

Although woodland of this community on the more fertile soils occurs in even smaller patches than acid oakwood, it is much more widespread, because suitable niches for its survival are to be found along many stream-courses and in the policies of mansion houses. The canopy layer is not natural, as many of the trees are planted, and it includes the alien species *Acer pseudoplatanus.* The dominant trees are *A. pseudoplatanus, Fraxinus excelsior* and *Ulmus glabra,* and where the upper canopy layer has been reduced or destroyed the dominant can be *Corylus avellana.*

In the field layer there is often a uniform cover of *Mercurialis perennis* or abundant *Circaea lutetiana* and *Endymion non-scriptus* along with it. Tall ferns, species of *Dryopteris* and *Athyrium filix-femina,* are also common and the characteristic moss of the ground layer is *Eurhynchium striatum.*

All the relevés are from the northern temperate sub-zone which on the Rhins is in the hyperoceanic sub-sector, but to the east of there is in the euoceanic sub-sector. The soils are all of rather low base status in the A horizon and include brown forest soils of the Linhope and Portencalzie series and a non-calcareous gley of the Ardwell series. The vegetation of this woodland indicates fertile conditions and this is borne out by the carbon : nitrogen ratio which, with one exception, is less than 15. The base saturation, however, is abnormally low for this type of woodland, but this appears to be a soil feature associated with the highly oceanic climate. The action of the often continuously moist and rather cool climate is to produce a low saturation of bases in the A horizon while general conditions for plant and soil fauna nutrition still remain good.

RELATIONSHIP BETWEEN MAJOR SOIL SUB-GROUP AND PLANT COMMUNITIES

The occurrence of the more extensive natural and semi-natural communities on each major sub-group has been established. The rather artificial vegetation of ley pasture is included in these communities, but the even less natural vegetation of arable fields has yet to be described. The major soil sub-groups are, where it applies, considered to be of low base status (dystric) or moderate to high base status (eutric). These two categories cannot be readily differentiated when mapping soils at a scale of 1 : 25,000, but are of considerable significance when the soils of individual stands of vegetation are being described.

Skeletal Soils
(Table 48)

The only extensive soils within the area are on the aeolian sands of the maritime zone. Since the relevés on the dunes were rejected as unrepresentative of the communities being set up, with the exception of that of the initial phase of Carici binervis–Ericetum cinereae, the soil of this relevé is the only one to appear in the tables. It is an immature soil showing the initial stages of profile development. The developing A horizon has a pH value of 4·7 and low base saturation, indicating a dystric regosol of the European classification (Dudal 1968, am. 1969, 1971, 1973). No exchangeable calcium is detectable in this horizon but there is a moderate amount of exchangeable magnesium. The carbon: nitrogen ratio is over 20, characteristic of heath vegetation, and the total phosphorus is low.

Brown Forest Soils
(Table 49)

Only one of the brown forest soils has a base saturation value in the A horizon greater than 50 percent (eutric cambisol). The soil is a member of the Portencalzie series and the vegetation on it is the typical subassociation of Lolio-Cynosuretum. The level of exchangeable calcium in the A horizon is moderate, total phosphorus is moderate and the carbon: nitrogen ratio is 11.

The remainder of the brown forest soils have base saturation levels in the A horizon of less than 50 percent (dystric cambisols). Despite these low values some carry plant communities normally associated with high nutrient levels. The main series is the Linhope, which carries the full range of vegetation to be found on these soils, but relevés have also been recorded on the Portencalzie, Kirkcolm and Clanery series.

The mean pH of the A horizon is 5·1 and the mean base saturation is 25 percent. The levels of exchangeable calcium (mean 3·4 me per 100 gm) and exchangeable magnesium (mean 1·2 me per 100 gm) are medium. There is a medium amount of phosphorus and, except in three of the soils, the carbon : nitrogen ratio is less than 15. The exceptions are soils under the *Holcus mollis* subassociation of Achilleo-Festucetum tenuifoliae, the *Endymion non-scriptus* subassociation of Galio saxatilis-Quercetum and the typical subassociation of Aceri-Ulmetum glabrae.

In addition to these vegetation types, both the typical and the *Luzula campestris* subassociations of Lolio-Cynosuretum and the *Thymus drucei* subassociation of Achilleo-Festucetum tenuifoliae are found on the dystric brown soils. The occurrences of the typical subassociation of Lolio-Cynosuretum and of Aceri-Ulmetum glabrae seem somewhat anomalous. The presence of the Lolio-Cynosuretum is possibly attributable to the rapid turnover of nutrients associated with heavy grazing. The occurrence on the dystric soils of Aceri-Ulmetum glabrae, woodland normally on base-rich soils, is possibly accounted for by the conjunction of its topographic position along watercourses and in depressions, and the oceanic climate.

One of the acid soils is a shallow lithic phase of Linhope series on Silurian shale. It has a highly organic A horizon and qualifies as a humic cambisol. The vegetation occurring on it is the typical subassociation of Aceri-Ulmetum glabrae.

Brown Forest Soils with Gleying
(Table 50)

Brown forest soils with gleying are extensive on the Rhins Peninsula and on the Machars. The dominant vegetation on these is Lolio-Cynosuretum.

Four of the five relevés sampled are on soils of moderate to high base status (eutric gleyic cambisols). These soils are under a regime of fairly intensive agriculture and their base status may have been upgraded by the application of lime and fertilizers. All the relevés are from the euoceanic northern temperate sub-region, mainly in the very humid sub-division, with the exception of one from the humid sub-division. The soil series are the Kedslie in the Ettrick Association and the Rhins in the Rhins Association.

The mean pH of the surface horizon is 6·2 and the base saturation 67 percent. Exchangeable calcium content is medium to high and the content of exchangeable magnesium is moderate. Total phosphorus is medium to high and the carbon : nitrogen ratio is less than 15.

Both the *Luzula campestris* and the typical subassociation of Lolio-Cynosuretum are in the relevés, but the intensively used typical subassociation is the more extensive. This is the only community recorded on these soils, although the primitive vegetation was probably a form of Ulmetum glabrae or Galio saxatilis-Quercetum.

The fifth relevé is on the Altimeg series, on a low base status soil, the base saturation of the surface horizon being 25 percent. It is in the euoceanic very humid northern temperate sub-region, immediately to the north-east of Newton Stewart. Exchangeable calcium is low in the surface horizon, but total phosphorus is high and the carbon : nitrogen ratio is less than 15. The vegetation is the typical subassociation of Lolio-Cynosuretum.

Humus-Iron Podzols
(Table 51)

Humus-iron podzols (orthic podzols) are not extensive as mappable soils but often form a component of the soil complexes. Four relevés have been recorded, two on the Rhins Peninsula in the hyperoceanic humid northern temperate sub-region and two from the euoceanic very humid hemiboreal sub-region near Gatehouse of Fleet.

The mean pH of the surface humus horizon is 4·2 and the base saturation 16 percent. In the A_1/A_2 horizon immediately below, the mean base saturation is 5 percent and exchangeable calcium is not detectable or low. Total phosphorus in the surface humus is low to moderate and the mean carbon : nitrogen ratio is 26.

Carici binervis-Ericetum cinereae is the only community recorded on the humus-iron podzols. Careful search might reveal fragments of woodland, and certainly plantations are now being established on this type of soil. The typical subassociation of the Atlantic heather moor is described on the Larbrax series at Galdenoch on the Rhins and on

Minchmoor series in the Darnaw complex at High Auchenlarie. The subassociation with *Molinia caerulea* is recorded on the Larbrax series at Galdenoch and on a humus-iron podzol in the Twachtan complex near the Fleet Viaduct, but both relevés are somewhat transitional to the typical association and the differential species of the *Molinia caerulea* subassociation are poorly represented.

A further relevé of this subassociation has been recorded from within the Darnaw complex at Auchenlarie, west of Gatehouse of Fleet. The soils within this complex range widely in character, but the profile below the relevé recorded closely resembles the typical humus-iron podzols, apart from some signs of drainage impedance. The pH, base saturation and contents of exchangeable bases are comparable with the values for the freely drained soils. The relevé is from the very humid orohemiboreal in the euoceanic sub-sector.

Peaty Podzols
(Table 53)

Peaty podzols (histic podzols), like the humus-iron podzols, do not usually form large areas of soils mappable as soil series, but are often a component of the soil complexes in hilly country. The soils recorded are three uncultivated soils in the euoceanic sub-sector and one cultivated soil on the Rhins in the hyperoceanic sub-sector. Two of the soils in the euoceanic sub-sector are in the very humid orohemiboreal sub-region and the third is in the very humid north temperate sub-region. The soil on the Rhins is in the humid northern temperate sub-region.

In the three uncultivated soils the mean pH of the peaty surface horizon is 3·8 and the base saturation 11 percent. Exchangeable calcium and exchangeable magnesium contents are moderate, but values are affected by the high exchange capacity of peaty organic matter. Phosphorus content is low to medium and the average carbon : nitrogen ratio is 18 percent. The cultivated soil has, clearly, been treated with lime and fertilizers as the pH of the surface horizon is 6·4 and the base saturation is 70 percent. The ameliorative effect of cultivation is evident in the value of the carbon : nitrogen ratio, which is 14.

Plant communities on the uncultivated soils are the *Molinia caerulea* subassociation of Carici binervis-Ericetum cinereae and the bog heather moor, Campylopo-Ericetum tetralicis. The soil series recorded are the Falbae and the Dod series. The cultivated peaty podzol at Marsclaugh in the north of the Rhins is on Auchleach series and the vegetation there is the typical subassociation of Lolio-Cynosuretum.

Saltings Soils
(Table 54)

These rather immature soils in estuaries and on flats by the shore have been named coastal saline gleys (saline phase of gleyic fluvisols) by Birse and Robertson (1976). Because of their location near MHWS (mean high water springs) they are, in the southern half of Scotland, in the northern temperate sub-zone. The relevés recorded are from the saltings of the River Cree estuary near Wigtown, in the euoceanic humid sub-region of the climate.

At their lowest level these soils are daily flooded with sea-water and at their highest they are flooded only by the high spring tide. In the soils sampled the mean pH of the surface horizon is 7·4 and the horizon is well to completely saturated with bases. Sodium is often the dominant cation in the exchange complex at the lowest level of the salt-marsh and the content is high even at the upper limits. In the surface horizon of the soils near Wigtown exchangeable calcium content is high and the content of exchangeable magnesium is medium to high. Total phosphorus is low to medium and the carbon : nitrogen ratio varies from below 15 to a little above.

The vegetation of the lowest level recorded is Puccinellietum maritimae and the greatest expanse of salt-marsh carries Juncetum gerardii.

Non-calcareous Gleys
(Table 55)

Non-calcareous gleys are considered in two groups, namely, medium to high base status soils (eutric gleysols) and low base status soils (dystric gleysols). In Galloway they are fairly common in the lowland region. Climatically they are predominatly in the northern temperate sub-zone, although also present in the orohemiboreal. They occur in both the hyperoceanic and euoceanic sub-sectors and on the full range of moisture balance found in these sub-sectors.

The mean pH in the surface horizons of the eutric group is 5·8 and the base saturation has a mean value of 69 percent. The content of exchangeable calcium is generally high and of exchangeable magnesium moderate. The phosphorus content is moderate and the carbon : nitrogen ratio is less than 15, except in two anomalous soils with a high organic matter content in the A horizon where the value is greater than 15.

Soils of all the non-calcareous gley series derived from glacial boulder clay in the area are included in the relevés described. Stirling series and Newton Stewart series, on estuarine raised beach deposits, are also included. Two communities have been recorded on these soils, Potentillo-Juncetum acutiflori and Lolio-Cynosuretum. Three of the four relevés of the sharp-flowered rush pasture are of the *Poa trivialis* subassociation and one is of the *Festuca ovina* subassociation. The relevés of the Lolio-Cynosuretum are all from the typical subassociation.

Only two relevés have been recorded on the low base status gleys, one from the euoceanic very humid northern temperate sub-region at Dervaird, east of Glenluce, and the other from the hyperoceanic very humid northern temperate sub-region at Dunskey House near Portpatrick. The mean pH of the surface horizon of both soils is 4·9 and the base saturation is 14 percent. The content of exchangeable calcium is low and of exchangeable magnesium medium, but the carbon : nitrogen ratio is less than 15, showing a satisfactory level of microbiological activity.

The *Festuca ovina* subassociation of Potentillo-Juncetum acutiflori is recorded in the first relevé and the typical subassociation of Aceri-Ulmetum glabrae in the relevé at Dunskey House.

Peaty Gleys
(Table 56)

The peaty gleys are also considered as two groups—a moderate to high base status category (humo-eutric gleysols) and a low base status category (histo-dystric gleysols). These soils, because of their poorer drainage or because they often occur in less favourable climatic conditions, are less likely to be modified by agricultural practices than the non-calcareous gleys. The dystric soils are thus more extensive than the eutric members. The sub-group as a whole has been recorded from the very humid northern temperate to orohemiboreal sub-region in both the hyperoceanic and euoceanic sub-sectors. The majority of the relevés are from the cooler hemiboreal sub-zone.

Only one relevé is on a soil of the eutric type. It is a member of the Creetown series with pH 6·1 and base saturation 90 percent in the surface horizon. Contents of exchangeable calcium and magnesium are high and the carbon : nitrogen ratio is just over 15. The vegetation is the *Carex dioica–Eleocharis quinqueflora* community.

Relevés on the more extensive dystric soils are from the Glenstockadale and Lochnaw series on the Rhins Peninsula and from the Dochroyle and Creetown series in the area to the east of it. In the peaty surface horizon the pH has a mean value of 4·0 and the base saturation is 21 percent. Because of the high base exchange capacity, contents of exchangeable calcium and magnesium range from low to high values. The mean carbon : nitrogen ratio is 21, but this includes an anomalous value of 13.

The soil with the low value for the carbon : nitrogen ratio occurs under a stand of the *Poa trivialis* subassociation of Potentillo-Juncetum acutiflori. This is the subassociation of the more fertile soils and therefore it is the base saturation that is anomalously low and not the carbon : nitrogen ratio. Other pasture communities on the acid peaty gleys are the *Ranunculus repens–Juncus effusus* community and flying bent (*Molinia*) grassland, the *Molinia caerulea* subassociation of Junco squarrosi-Festucetum tenuifoliae. Moorland vegetation recorded on these gleys is the moist Atlantic heather moor, the *Molinia caerulea* subassociation of Carici binervis-Ericetum cinereae.

Sub-alpine Soils
(Table 57)

These soils are termed sub-alpine in this memoir, but in the Grampian Mountains and other high mountains of Scotland they extend into the full alpine zone. Birse and Robertson (1976), describing the vegetation over a wider area of Scotland, include these soils with the oroarctic podzolic group. In the European classification they are ferri-humic podzols and humic podzols to which the qualifying term 'cryic' could be added to distinguish them from forest zone podzols.

The four relevés sampled are from the summit area of the Cairnsmore of Fleet in the euoceanic perhumid lower oroarctic sub-region. In the surface humus horizon of the soils the mean pH is 4·2 and the base saturation has a mean value of 16 percent. Exchangeable calcium content is low or moderate and the content of exchangeable magnesium is medium. The phosphorus content is medium or high and the mean value of the carbon : nitrogen ratio is 17.

The soils are all members of the Mulltaggart series, although the soil with a peaty surface layer is perhaps a variant [cryo-(histo-)humic podzol]. The vegetation on this soil is mountain heath rush moor, the *Carex bigelowii–Juncus squarrosus* community, whereas the other three relevés are of the *Agrostis montana–Rhacomitrium lanuginosum* community. The first of these, on the cryo-ferri-humic podzol, is part of the sub-community with *Salix herbacea* which occurs on eminences usually blown clear of snow and the other two, on cryo-humic podzols, are part of the typical sub-community.

Peat
(Table 58)

Peat is one of the most extensive soils in Galloway, occurring either as a separate mappable entity or as a component in some of the soil complexes. The moderate to high base status (eutric histosol) is of very limited extent and it is the low base status peat (dystric histosol) which dominates so much of the landscape. Relevés on the deposit have been recorded from both the hyperoceanic and euoceanic sub-sectors in the very humid sub-division. Most of the samples are from the northern temperate sub-zone, but two are from the hemiboreal.

One relevé was recorded on a small area of eutric peat at Boreland, north of Newton Stewart. The pH of the surface peat is 5·4 and the base saturation is 64 percent. The carbon : nitrogen ratio is 18, which is in accord with the vegetation at the site—the *Poa trivialis* subassociation of Potentillo-Juncetum acutiflori.

The dystric peat, which varies from dark reddish brown amorphous material to paler fibrous material of *Sphagnum* and *Eriophorum,* has a pH of around 4·0 and a base saturation of 19 percent in the surface layer. The content of exchangeable calcium ranges from medium to high, but this reflects the high base exchange capacity of peat and not a high nutrient level. The carbon : nitrogen ratio is somewhat variable and falls into two distinct groups; in the first the value is around 15 and must indicate local conditions of flushing or faunal activity, while in the second the value is around 30.

Two communities have been recorded on the low base status peat. The first is the bog moss water track, the *Juncus effusus–Sphagnum recurvum* community, at the edge of peat mosses or alongside streams drain-

PLATE 29/Saltings near Wigtown.

PLATE 30/Bareagle Forest Nursery established on Links soils.

PLATE 31/Coniferous forest plantation established on Links soils at Luce sands.

PLATE 32/Aerial view of Dalreagle Farm. Drumlins consisting of thick till carry soils of the Linhope and Altimeg series of the Ettrick Association. The surrounding low lying areas are occupied mainly by alluvial soils.

ing out of blanket peat. Under the relevé recorded the peat is partly redistributed and contains washes of mineral material. The carbon : nitrogen ratio has the extremely low value of 12·5, but this may be a true indication of the greater nitrification in the peat under this flushed community. The second community is Erico-Sphagnetum magellanici, the vegetation on the blanket bogs and raised bogs of Western Europe. One relevé is on the raised bog at Eldrig Moss and is of the *Cladonia uncialis* subassociation of the community. The other relevés, apart from one which is on blanket peat and belongs to the typical variant of the *Molinia caerulea* subassociation, are all on basin peat and the vegetation includes the typical variant and the *Myrica gale* variant of the *Molinia caerulea* subassociation and the *Myrica gale* variant of the typical subassociation.

8 | Agriculture

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AGRICULTURAL DEVELOPMENT

Man probably came to Wigtownshire around 6000 B.C. and lived for several thousand years by fishing and hunting. Grazing of domesticated animals began about 2500 B.C., but crops were not grown until Celtic tribes used bronze implements around 1000 B.C. Wheeled carts and better tools were employed by Iron Age people who established themselves mainly on the raised beaches, but frequent wars made fortified villages necessary for the safety of man and livestock. Peace returned under the Romans, but their departure was followed by a period of invasion and warfare. Galloway landowners were reluctant to accept the feudal system, well established in Scotland in the late eleventh century, and war led to the neglect and impoverishment of land.

During the thirteenth and fourteenth centuries, improvements were again made. Much woodland was cleared, producing humus-rich soil for cultivation and cropping. Ploughing was done by teams of oxen. A spade was used where ploughing was impracticable. Good crops of oats, barley, wheat, peas and beans were grown and this gave incentive for industrious people to cultivate inaccessible places. The benefits of fallowing after two or three crops in succession were realized and agricultural practices in general became better understood. Horses were reared for sale, but cattle and sheep only for the sale of wool and hides; meat was seldom sold and was thus relatively plentiful for home consumption. However, land drainage or fencing had yet to be introduced, winter feeding of stock was a problem, tenure was on a year-to-year basis, and the living conditions of a peasant were still very primitive.

The fifteenth, sixteenth and seventeenth centuries saw very little agricultural development. Much cutting of woodland almost depleted the countryside of trees. This was rectified in 1535 by an Act of Parliament ordering landowners to plant three acres of trees for every £100-worth of land owned.

Farming was so depressed in the mid-seventeenth century that sufficient food to meet the needs of the local inhabitants could not be produced. In years when crops were poor there was famine. Horse, cattle and sheep numbers were very low and their condition was poor. Scarcity of winter keep meant that large numbers of animals had to be slaughtered at Martinmas. Crop yields were considered good if they were three times the seed sown. Farms were still operated on the 'run-rig' system. Land was over-cropped and, with little animal manure and no artificial fertilizers, very impoverished.

The Union of the Parliaments in 1707 opened a new market for beef cattle. Landowners and progressive-minded farmers became aware that if the land was enclosed with dykes to form fields grazing stock could be tended more easily and grazing methods improved. Sir David Dunbar of Baldoon, who began the improvements in the rearing and management of cattle, had a field of 4 km by over 2 km in which he accommodated about a thousand animals annually, either reared or bought, which he then sold to drovers. Stock in enclosures no longer required peasants to keep them off arable land when at summer grazing. Landowners soon found that they could get much higher rents for land enclosed into fields and so more and more land was enclosed; small tenants and cotters were dispossessed.

Hardship for small farmers coincided with agricultural progress. In addition to the enclosure of land, lime application was started, potatoes were introduced, grassland was improved, and some landlords started building new farmhouses and steadings. Metal roads were laid, enabling goods to be transported by cart instead of on pack horses. The introduction of turnips and the inclusion of red clover in grass leys meant that many more cattle could be wintered and their condition much improved. Towards the end of the eighteenth century about 20,000 head of cattle from Galloway, plus a further 11,000 Irish cattle imported into Portpatrick, were driven annually to the English markets by dealing drovers.

The nineteenth century saw revolutionary changes in farming. Underground drainage was extensively practised; bone meal, then guano and nitrate of soda, were used as fertilizers; improved varieties of grain were introduced, also threshing mills, reaping machines and other new implements. Improved cropping methods were combined with better animal husbandry. The first system of dairy farming was started. Old farmhouses were replaced by houses and steadings built of whinstone with slated roofs. Leases were extended to 19 years. The health of the working classes improved with the addition of potatoes, vegetables, milk, butter and meat to the basic oatmeal diet.

Oil cakes, which were imported duty-free, were mixed with bruised oats, bean meal and sometimes cut turnips, draff, etc., giving a good quality, cheap winter feed for bullocks and cows, and thus enabling more stock to be carried and quality to be improved. More and better farmyard manure, needed for the increased acreage of turnips, was also produced. Less cereals and more grass improved fertility. Crop yields were improved by the use of fertilizers and improvement was further encouraged by the introduction in 1842 of the first government aid to agriculture, a drainage grant.

Unlike north Ayrshire, the main centre of dairy farming, Wigtownshire had no centres of large population near at hand and, with a very limited market for liquid milk, was compelled to base its dairy industry on cheese and butter making. Cheese could be made only on farms with relatively large dairy herds, and thus it was only with the establishment of Dunragit Creamery in 1880, and others soon after, that the smaller farms were able to turn profitably to dairying. The good grass-growing ability of the area made summer milk production very profitable and soon Cheddar cheese became the most important product of the county.

The late nineteenth/early twentieth century was a difficult period for farming, but it was also a period of tremendous advancement. The development of large dairy herds led to the building of large steadings and farmhouses. Small farms were amalgamated to save building and labour costs. Manuring and drainage may have been neglected on some farms but the introduction of basic slag and Cockle Park-type grass seed mixtures resulted in a great increase in both summer grazing and hay for winter. The nitrogen fixed by wild white clover enriched the soil and improved arable crops.

The 1914–18 War brought a period of prosperity which lasted only until 1921 when farmers suddenly found themselves again in very depressed conditions. World cheese and butter prices were so low that Wigtownshire producers were often getting no more than 3d per gallon of milk. In 1933, however, the Scottish Milk Marketing Board was formed and this was the salvation of Wigtownshire dairy farming. Every producer was given the same price for his milk; this favoured the manufacturing milk producers of Wigtownshire but naturally met strong opposition from the producer retailers near the centres of population.

During the Second World War farmers had an assured market and a guaranteed price which enabled them to plan for long term production. Despite very strict rationing of imported feeding stuffs, scarcity of certain fertilizers and a reduction in the labour force, considerably more milk and arable crops were being produced at the end of the war than in the pre-war years.

Post-war farming in the forties and fifties continued to be very profitable. Those years saw the greatest revolution ever seen in farming. Mechanization developed at a rate beyond all expectation. Science was more closely linked to practice. Farm workers, drawn by higher wages in other industries, left the land at a rate never before experienced, but because of the rapid introduction of mechanization, this had no detrimental effect on the development of the industry.

The sixties again brought change to the farming scene. Costs rose rapidly and subsidies and grants were reduced; produce prices, however, did not increase and in some cases fell. Wigtownshire farmers were able to maintain a satisfactory profit by increasing output by grassland intensification, bigger dairy herds and more beef and barley.

Fears that over-production would glut the home market were growing, when, in the early seventies, a world beef and grain scarcity developed; at the same time there was a change in demand from man-made fibres to wool. Scarcity of dairy labour and the attraction of beef cattle making over £20 per 50 kg liveweight, plus a calf subsidy and perhaps a hill cow subsidy and winter keep supplement, induced a number of farmers to move out of dairying. This slowed down the increase in milk production and reduced the number of farmers sharing its proceeds.

Beef, sheep, and grain producing farmers entered 1973 with better prospects than they had experienced for some time. Dairying, which had led the field of profitability for a number of years, was now facing more uncertainty; nevertheless it is likely to remain the most important farming enterprise in Wigtownshire. Changes in farming in the seventies will probably be influenced by the effects of joining the E.E.C. No doubt there will be increased beef production, perhaps an extension of the cereal area, and possibly increased importance of grass in milk and other forms of grazing-animal production. Wigtownshire farmers are well equipped to compete in the production of milk and other pastoral farming products.

AGRICULTURAL ESTATES

Agricultural estates have played a major role in the development of agriculture in Wigtownshire. They were first formed in the early twelfth century on the introduction of the feudal system, and by the eighteenth century had become commercial enterprises with rents paid in money and not in kind. Methods of crop and stock husbandry improved, and landlords became interested in maintaining their land in a fertile state. When it was realized that liming or marling did not permanently renew fertility, some estates stipulated that not more than three successive grain crops were to be taken after its application, and that grassland was not to be broken until it had lain for perhaps 6–9 years. Some landlords also required that turnips be included in the rotation. As these conditions involved ploughing most of the farm, grass production came mainly from temporary leys rather than from permanent pasture. This was the start of ley farming.

Although stock and crop husbandry methods improved in the eighteenth century, nothing was done to provide farm buildings or to improve the tenants' turf and mud hovels. The early nineteenth century, however, saw the establishment of the large two-storey farmhouse with a steading to suit the size of the farm, and cottages for workers. The granting of nineteen year leases gave tenants greater security, and for the good ones this was sufficient incentive to improve their home and farm.

It took many centuries to develop the agricultural estates but it has taken only one for many to be completely broken up or considerably reduced in size. There are two reasons for this. The main cause of the breakdown of Wigtownshire estates has been the tax on heritable estates, which was first introduced by Gladstone and has increased ever since. On the death of a landowner, an area of the estate generally has to be sold to raise capital to pay death duty. Owner-occupiers of even moderate sized farms may soon be faced with a very similar situation, as taxes on rapidly rising land values could put a strain on their capital resources. The second reason is the security of tenure given in the 1947 Agricultural Act, which has resulted in some landowners selling farms when a tenant quits. The number of tenanted farms in Wigtownshire has dropped from 966 in 1939 to 359 in 1972.

Most Wigtownshire estates are progressive in their outlook. To meet present day requirements on low-staffed farms, they are pursuing a policy of building modernization, incorporating many up-to-date features which typify sound management.

LIVESTOCK

Cattle breeding, rearing, fattening and milking have for many years been the main farming enterprises of Wigtownshire. From very early times farmers have been skilled at selecting from their own stock cows and bulls best suited for a specific purpose, at first for hides, then for beef and more recently for milk production.

Wigtownshire cattle breeders are probably best known for the part they played in developing 'the Galloway', which was one of the first fixed breeds of cattle in Scotland. The Galloway is reputed to have originated by crossing the small local cows with polled bulls of an unknown breed from Cumberland. Then through selection a uniform breed of bigger animals of good quality was evolved.

More than 200 years ago these cattle realized more on the Smithfield market than best quality English beef. As they were hardy and, being polled, less harmful when fed loose in straw yards, English graziers were also prepared to pay more for them as stores. In more recent years the Ayrshire breed, which was evolved through selection by breeders in north Ayrshire, was introduced to Wigtownshire, and local breeders founded and developed some of the finest herds of the breed.

Along with cattle breeding and rearing, there developed from early in the eighteenth century a very necessary trade in cattle dealing. At first droving dealers bought cattle locally on credit and took them to English markets, but later dealers also bought and sold locally.

Modern organized marketing has taken much of the gamble out of selling; the role of the Galloway has changed; and the native Ayrshire is now being challenged by the Friesian.

Dairying

Towards the end of the eighteenth century cattle began to be used for commercial milk production. At first the native Galloway was used. Later, Ayrshire cattle were brought to many Wigtownshire farms, and their introduction proved so profitable that before long there were dairies on farms in every parish.

The nineteenth century brought many developments in dairy farming, including the imposition of sanitary standards for dairy byres and milk handling premises, the introduction of coolers and the establishment of a minimum standard of 3 percent butter fat for milk sold liquid. The first suction milking machine was patented in 1889 and the pulsator invented six years later, but it was only when J. & R. Wallace of Castle Douglas marketed a machine in 1907 that the milking machine became commercially recognized. The machine was a great boon to Wigtownshire with its large dairy herds and by the late 1920s was widely adopted.

From the inception of the Milk Marketing Board in 1933, the number of cows in Wigtownshire consistently increased, reaching a peak in the late sixties with about 33,000 cows, comprising cows and heifers in milk and cows in calf but not in milk. In the early seventies this fell slightly to about 32,000. The 1972 Scottish Dairy Farm Census indicates, however, that a further increase can be expected. Increased cow population has come from an increase in the size rather than in the number of herds. The number of herds reached a peak of almost 700 in the mid forties, but has dropped back to 447 in 1972. This meant that by 1972 average herd size was 73·2 cows; 21·5 percent of herds had over 100 cows and only 19 percent had less than 40 cows. Increased herd size, combined with higher milk yield per cow, has almost trebled the average production per herd in the past thirty years.

In recent years, there has been a big change in the breed structure. As recently as 1965, the native Ayrshire breed still accounted for 94 percent of the Wigtownshire dairy herds but by 1972 this had dropped to 78 percent. During the same period Friesian and Friesian Ayrshire Cross increased from 5 to 22 percent and now they account for a third of dairy followers and Ayrshires for only two-thirds; the swing to Friesians will probably continue.

Whereas cow numbers have increased since the Second World War, the number of bulls kept for service has dropped from almost 2000 in the early post-war years to less than 800 in 1972. During this time the use of artificial insemination had considerably increased: 1309 inseminations were carried out in 1952, the numbers increasing annually to reach 11,475 inseminations in 1972. In 1972, 11·5 percent of milk-producing herds in the county used only A.I. for breeding, 50·8 percent used some A.I. and only 37·7 percent did not use A.I. Two Friesian inseminations are now used for each Ayrshire, compared with eleven Ayrshire for each Friesian in 1963.

Milk recording is now the responsibility of the Scottish Milk Marketing Board who are introducing new methods to eliminate the need for recorders to stay overnight at farms and to obviate farm testing of butter fat. This, combined with centralized preparation of records by computer, is changing milk recording from a very simple to a highly sophisticated aid to stock management and breeding. In 1972, 38 percent of Wigtownshire herds were officially recorded.

During the past two decades there have been many developments in cow housing, milking systems and milk handling. The first refrigerated bulk milk tank was installed in a Wigtownshire farm in 1956. Now there are 451 bulk tanks and only 26 farms still use cans. The first round-the-byre milking pipeline taking milk direct from the udder to the tank was installed about 1959. By 1972 there were 268 pipelines in use; individual cow yields can be measured by flow meter.

The most revolutionary change, however, was from byre to the cubicle loose housing developed in Northern Ireland and Cheshire in the early fifties. Other changes were self-feed silage, mechanically-fed silage from towers and many easy-feed systems, parlour milking, and the handling of cow wastes as slurry. The number of cubicle-housed units has considerably increased in recent years, and the rate of installation is accelerating. The proportion of units with parlour milking has risen from 9·5 percent in 1969 to 20·3 percent in 1972. Herring-bone is the most popular unit, but at the same time of writing three rotary units are being installed.

Well-run dairy units have for a long time been among the most profitable farming enterprises. Rising wages and a relatively high labour requirement, however, together with the much increased prices for grain, beef and other cattle, are reducing the advantage of dairying over other production systems.

In 1971/72 the average gross margin per hectare for a group of farms in Wigtownshire was £237, £54 higher than in 1970/71. Although the average milk yield was only 14 litres per cow higher, gross output was up by £23 because of an increase in the value of cast cows and calves, and an increase in milk price. Variable costs, excluding concentrates, increased by £3·3 per cow, but this was more than offset by a saving of £6·8 per cow on concentrates and a slight increase in the stocking rate.

To ensure a supply of good quality replacement heifers it is generally necessary to rear them at home. The gross margin return from rearing young dairy stock is generally much less than the gross margin obtainable from dairying, and consequently most intensive dairy farmers now aim to rear only enough dairy heifers for replacement.

Beef production

During the past two decades, beef production has considerably increased in importance in the farming economy. There were 61,457 head of beef cattle in 1972, six times the number in the immediate post-war years. The drive for beef from the dairy herd in the fifties increased the number of steers in the county from about 5500 in the mid to late forties to over 9000 by 1955 and to over 13,500 by 1960, but the tremendous increase in the beef suckling herd did not take place until recent years. Between 1950 and 1960 the mean annual increase in the herd was 419 cows, between 1960 and 1970 1039 cows and between 1970 and 1972 1722 cows. The growth has been due to a combination of factors, including higher subsidies for suckling cows, the increased sale price of suckled calves, a reduction in the number of milk producers, and a decline in the profitability of sheep. With store beef cattle at around £20 per 50 kg and generous subsidies for suckling cows and beef calves, the efficient production of suckled calves is now almost as profitable per unit area as dairying.

The profitability of cattle fattening has also considerably increased, but is still very dependent on skilful buying and selling. Where cattle are bought dear or sold on a weak market the gross output can be very low and even very skilful stock husbandry leaves little scope for an acceptable profit margin.

Animal Health

Improvements in husbandry methods have produced a continual improvement in animal health. Two diseases which can be transmitted from animals to humans, tuberculosis and brucellosis, have received close attention. First, bovine tuberculosis was tackled and in 1953 the county was completely freed from the disease. In more recent years a great effort has been made to clear Wigtownshire of stock carrying brucellosis and by the end of 1972, 243 dairy herds and 107 suckling herds were accredited free. By March 1973, 52 percent of all herds were fully accredited and a further 26 percent in process of becoming so.

Sheep

In the early nineteenth century sheep were used to control ragweed. The benefit of their droppings to herbage was realized, but their close grazing habit was considered detrimental to cattle pasture.

The number of breeding ewes in Wigtownshire in 1972, 67,156 is almost the same as it was in 1939. Total sheep numbers are slightly higher, owing to an almost 20 percent increase in lambing percentage. Stock improvement has largely been carried out by flockmasters through careful drafting of ewe lambs and careful selection of rams. Improved dips and vaccines have largely controlled insect and disease pests.

Sheep farming has seldom experienced long periods of prosperity, and thus owners have been reluctant to invest the large amount of capital necessary for the fencing and improvement of pasture required to increase productivity over a long period.

Horses

The early Wigtownshire horse, the Galloway pony, was a hardy, active surefooted animal, reputed to have been developed from or improved by Spanish horses which escaped from a wrecked ship of the Armada. These ponies were much sought after for riding to wars. Stallions brought from Ayrshire and England increased the size and produced the Clydesdale draft horse.

At one time, the breeding of draft horses was very profitable, but the little now carried out is mainly a hobby for showing. In 1939 there were about 3000 farm work horses in Wigtownshire but by 1960, with the general adoption of the farm tractor, there were little more than 300, and now no work horses are used.

Pigs

Pigs are mentioned in reports of the twelfth century, but it was not until the eighteenth century that domesticated pigs were kept by individual families to provide household meat. In the early nineteenth century, when potato growing became popular, their numbers increased considerably. They were fed mainly on potatoes in winter and grass in summer. Few were housed, and to stop them digging they were either 'rung' or had the two strong tendons of the snout cut above the nose. Little attention was given to their breeding, so that animals were slow-maturing and of poor conformation.

Farm cheese-making resulted in commercial pig production being started on many farms to utilize the whey. In the early twentieth century practically every farm had some pigs, but when farm cheese-making stopped so did many pig enterprises. The rationing of concentrates during the Second World War caused a further decline in the county's pig population.

Pig-keeping in Wigtownshire is now concentrated on a small number of large specialized units. Many of the sows are housed in stalls in modern environment-controlled houses. Fattening pigs are kept in well insulated houses with slatted dunging passages, so that labour requirement is low. The total number of pigs has consistently increased from a little over 2000 in 1945 to over 18,000 in 1972.

Poultry

Poultry, like pigs, were at first kept only for family needs, and it was not until the 1930s that poultry-keeping increased in popularity. The appointment in 1935 of a West of Scotland Agricultural College poultry instructress improved husbandry methods, giving healthier and more productive flocks.

In the fifties, when poultry-keeping was profitable, the deep litter system was introduced and soon almost every farm had an old building converted to house a few hundred hens. The sixties brought a decline in the profitability of commercial egg production. Nearly all the small deep litter units went out of production, leaving only a number of battery units, mainly on dairy farms employing family labour. With no large towns there is little retail egg market, and practically all eggs must be marketed through packing stations.

The decline in profitability of egg production has brought a change from a large number of small units to a small number of large units. Now some of the large units are closing down altogether. The number of pullets and hens kept for egg production in Wigtownshire in 1972 was less than the very reduced numbers kept during the war years, and less than half the number kept in the early sixties. The reduction in the national poultry flock could, however, bring higher egg prices; indeed they are rising at the time of writing.

A number of large intensive breeding flocks for broiler chick production have been established. In 1972 there were nearly 138,000 broilers and other table birds in Wigtownshire, outnumbering poultry kept for commercial egg production by 5 to 1. Several large broiler units are in operation.

GRASS

That the mild, moist climate was ideally suited for grass growing, was recognized from very early times, and thus the farming economy of Wigtownshire has always been based on a system of grazing livestock. Grass growth normally starts in very early spring and it is quite common for dairy cows to be at pasture in early April. A cold, dry east wind in early spring is, however, not uncommon and can delay spring growth. Occasionally there are dry spells in summer which retard growth and scorch the grass, but, surprisingly, in these years milk production and stock condition are generally above normal; the late Mr John Ramsay, Low Drummore, an excellent practical farmer, said he liked to see his grass fields burned at least once every year. Grass continues growing and retains its freshness well into winter, and dairy cows are seldom housed before November.

The formation of enclosures in the late eighteenth century was probably the start of grass being regarded as a crop, but it was given little attention until in the nineteenth century land drainage was started and lime, marl and sea shells used as stimulating manures. It was, however, not until the twentieth century that the potential of grassland as a crop was exploited. Improved grass seed mixtures, which included white clover, and the regular use of basic slag and ground mineral phosphate greatly increased the stock carrying capacity of pastures, and was the basis of successful grassland farming until after the Second World War.

In the early post-First World War years, a very successful Wigtownshire farming family, the Ramsays, developed a very productive pasture by sowing seed mixtures containing much red and white clover and using generous dressings of phosphate, potash and lime. Their rotation was turnips followed by two crops of oats, and then four or five years pasture. In the last year in grass, 1250 kg basic slag and 625 kg potash salts per hectare were applied; farmyard manure was applied to the sow-out crop, and followed with lime; basic slag or mineral phosphate was again applied to second year grass. Early spring grazing further encouraged clover growth and produced wonderful summer pasture which was ideal for the spring-calving dairy herds.

In the years between the wars farmers became aware that the use of heavy dressings of fertilizer nitrogen combined with a rotational grazing system could greatly increase grass yields. Depressed milk prices, however, discouraged farmers from attempting new methods that involved additional expenditure, even if they did result in increasing output. It was not until after the Second World War that farmers started to apply fertilizer nitrogen to grass generously. By the sixties, most farmers were practising a rotational grazing system, and application of 250 kg N per hectare annually to dairy cow grazing was common.

The 1972 Dairy Farm Census revealed that during the 1971 grazing season 61 percent of Wigtownshire dairy farmers practised strip or paddock grazing. Many of the remaining 39 percent practised a less intensive rotational system, such as field rotation. During this period also, greater reliance was placed on grass for the supply of winter feeding. By the early seventies the area of turnips, kale, and other arable forage crops had dropped to half that cropped in 1939, whereas the area of grass conserved for winter feed had doubled, two-thirds were conserved as hay and one-third as silage; in 1955, more than four-fifths of the conserved grass was cut for hay.

Because of this improvement in the manuring and management of grassland the county's almost doubled cattle numbers could be carried on a reduced grassland area and a much smaller area of arable forage crops. The level of stocking intensity per forage unit area has a very great effect on farm profit. During the sixties and early seventies, farm fixed costs rose consistently at a relatively high rate. To offset this, it has been necessary to increase farm gross margin per unit area.

In grazing livestock enterprises, high gross margin per unit area is generally linked to high stocking rate. Efficient grassland management to provide adequate stock nutrient requirements at a high stocking rate is one of the most important factors in profitable stock farming today. It is being keenly sought by Wigtownshire farmers, who have achieved the greatest cow stocking density for any county in Scotland.

Hill Grazings

In the forties and fifties there were very high subsidy rates for lime and fertilizers, and grants were given for the improvement of upland and hill grazings. Some farmers used these benefits to carry out large-scale improvements. At that time, however, hill farming was not in a very prosperous state and full advantage could not be taken of the incentives offered. Land improvement carried out under a comprehensive farm policy was limited and did little to increase the long-term productivity of hill farms in the county. Unless nearly all of a hill grazing is improved, stock grazing has to be controlled by enclosing the improved land. Where this is not done, stock leave the unimproved part, which further deteriorates because of under-grazing, and concentrate on the improved land which quickly deteriorates because of over-grazing. Hill land improvement is associated with many problems, including fencing, increased stocking and winter feeding whereas the old system of under-stocking combined with some spring burning is relatively problem free.

CEREALS

For many generations locally grown oats provided the staple diet for the people, and locally grown barley or bere was brewed to provide ale. In the eighteenth century wheat was re-introduced, providing luxury foods made from wheaten flour. Under the 'run-rig' system of farming the area of cereals was restricted by the amount of farmyard manure that could be made in winter. To increase the area, grazing stock were often enclosed at night in summer to manure ground for cropping the following year.

In the early nineteenth century, yields were greatly increased by the application of shell marl, introduced by someone who had seen this done in Ireland, and continuous cereal cropping was practised. When yields again began to drop farmers were surprised that further applications of this new manure did not result in a return to high yields.

The replacement of the 'run-rig' system with a whole farm rotational system, followed by the introduction of fertilizers made it possible to grow large acreages of cereals. The cereal area in Wigtownshire was greater at the beginning of the nineteenth century than in 1939 or 1972.

Oats and Barley

Oats was the main cereal grown in Wigtownshire until the 1960s. The 1809 area of 7810 ha increased to 13,686 ha in 1945 and then consistently dropped to an all time low of 1410 ha in 1972.

Barley, however, fell from the 1809 area of 1372 ha to 14 ha in 1939, the fall being caused initially by the cessation of liming when fertilizers were first used; this effect was not seen on the acid-tolerant oats, potato and turnip crops. A combination of factors caused a tremendous increase in acreage in the sixties: by 1965, 5222 ha were grown, rising more slowly to 5976 ha in 1972. New short-strawed varieties were introduced, which had a much higher yield potential than oats. Regular liming in the post-war years raised the pH of most soils to over 6 making them ideally suited for barley. This coincided with combine harvesters coming into general use, and it was soon found that the short-strawed barley crops were much more easily handled than oats.

In the late sixties and early seventies new oat varieties were introduced, which had a yield potential equal to that of barley. Because oats is a better grass seed nurse crop than barley, many farmers considered returning to oats for their sow-out crop. The expected increase has not occurred.

Wheat

Wheat was the only cereal grown in Wigtownshire until the Bronze Age when it was superseded by oats and barley. In 1809, 538 ha of wheat were grown in the county but in 1939 only 38 ha; since about 1960 the area has been 150–300 ha. The wheat is grown mainly near Garlieston and Whithorn. Although not an important crop in the county, wheat yields well under good husbandry.

Cereal yields and gross margins returns for about twenty farms are shown in Table L. Few grew oats, so that the sample for this crop is small. With the exception of the 1970 oat crops, which had very low yields, there is remarkably little difference in the average gross margins. There is, however, a wide range in margins for the barley and wheat crops and between the highest levels of each of the three cereals. The tremendous potential of wheat is clearly shown. Barley and oats, however, are likely to give better returns where soil conditions are poor or husbandry skills are below average. A big increase in cereal prices from late 1972 should raise considerably the gross margin returns for that year's crop.

OTHER CROPS

Potatoes

Potatoes were brought from Ireland and were first grown in Wigtownshire in lazy beds in 1722, but it was not until the late eighteenth century that they were accepted generally and widely grown. By 1809 the area in potatoes was 1270 ha, which was similar to the acreage during the Second World War, and much more than the 300–350 ha now grown.

In the mid-nineteenth century, potato growing had a severe set-back when 'potato disease' destroyed many crops. The shaws were first to die, the tubers rotting prior to lifting or in storage. A few years later the sets rotted shortly after planting, and many fields had to be replanted or sown with turnips.

Table L. Crop Yields and Gross Margins for Farms in Wigtownshire

Crop	Gross margin level	Yield tonnes/ha	Gross margin £/ha
1970 Barley	Highest	5·36	122·8
	Lowest	2·32	42·0
	Average	3·85	76·4
1971 Barley	Highest	4·89	121·8
	Lowest	3·88	61·5
	Average	4·05	93·4
1970 Wheat	Highest	6·27	157·4
	Lowest	1·75	12·4
	Average	4·03	77·8
1971 Wheat	Highest	5·26	143·1
	Lowest	3·51	43·2
	Average	4·29	98·1
1970 Oats	Highest	2·51	57·6
	Lowest	2·38	44·7
	Average	2·41	52·1
1971 Oats	Highest	3·76	88·5
	Lowest	3·13	82·8
	Average	3·45	85·5

In the 1880s Ayrshire farmers started boxing potatoes to promote earlier growth. The Wigtownshire farmers soon followed, and early potatoes were grown in sheltered coastal areas around Loch Ryan, Luce Bay, Isle of Whithorn and elsewhere. This is now a highly developed, very specialized industry. Nearly 900 ha of early potatoes were grown in the post-war years, but the area is now only around 250 ha. The numerous reasons for the decline include the much more highly specialized and mechanized nature of the industry, labour scarcity and a need for better living accommodation for lifting squads, variable levels of profit, and a few boom years on account of technical development followed by a few years of reduced returns once the industry as a whole had caught up and over-produced.

Under favourable conditions early potato growing can be very profitable. During 1970 and 1971 the highest gross margin level per hectare averaged £274 from yields of 21 tonnes. Growing costs, however, are high; variable costs alone generally exceeding £250 per hectare and under favourable conditions gross output may not be much higher. Commercial early potato growing is now carried out by a small number of growers with relatively large acreages. In 1963 there were 150 growers but by 1973 only 60. Maincrop potatoes are grown only for local consumption and commercially grown by only a very few farmers.

Turnips, Kale, etc.

One of the greatest difficulties of medieval farming—the supplying of winter feed for cattle—was overcome in the eighteenth century by the introduction of turnips and their eventual acceptance as a cattle feed. The Earls of Galloway and Stair became aware of a second advantage in this new crop: its inclusion in a rotation resulted in a long term improvement of the land. By the end of the century new leases carried stipulations designed to prevent over-cropping and soil exhaustion; not more than three cereal crops could be grown and were to be followed by a green crop with farmyard manure, then a sow-out crop and not less than five years in grass.

These two advantages rapidly increased the turnip acreage. After the Second World War, however, scarcity of labour and higher wages made singling, hoeing and snedding more difficult and more costly, the introduction of chemical herbicides for use in cereal and grass reduced the need for cleaning with a green-crop, and there were developments in the making of silage and easy feeding methods. All these factors caused a rapid decline in the turnip and swede acreage. It was thought that the introduction of pre- and post-emergence turnip herbicides, precision sowing and mechanical harvesting would stop the decline, but this has not happened. After falling from its peak of 4225 ha in 1945 to 1316 ha in 1970, the acreage declined further to 1171 ha in 1972.

The introduction of direct drilling of kale seed into grass swards treated with Paraquat, and strip grazing of the resulting crop, has increased the acreage of kale, but it is still less than a quarter that of the turnips and swedes. Rape for cow grazing and sheep fattening extends to about 320 ha and mangolds to about 70 ha. The 1972 total forage area at 1860 ha areas is 47 percent of the 1939 acreage, and 35 percent of the 1945 area.

AGRICULTURAL EDUCATION

Young Farmers' Clubs in Wigtownshire have done much to provide prospective farmers with technical and business knowledge of farming. In 1960 a group of farmers in the county formed an Agricultural Discussion Group and in 1962 dairymen founded a Stockman's Club. A number of small groups of farmers hold regular meetings at members' farms.

The formation of the Agricultural Training Board in 1966 meant that trained instructors were available for short courses. In 1969, Wigtownshire Education Authority started day release classes, with a course curriculum designed to City & Guilds Examination Standards. The West of Scotland Agricultural College undertakes systematic teaching for ordinary and higher National Diplomas at Auchincruive near Ayr; it also provides short vocational courses. Advisory work on agriculture is done through trained staff at Area Offices, supported by the scientific resources of the College.

Not only are farmers now better informed on technical aspects of agriculture, but the great majority now have a much better understanding of its business aspects. Wigtownshire was one of the few counties in Scotland selected in 1967 to pioneer the Government-aided Farm Business Recording Scheme. Over 100 farmers participated by keeping suitable records, having them analysed to detect technical and management weakness, and then endeavouring to overcome the shortcomings and make their farming more profitable. In the same year about fifty farmers formed a co-operative Group, Galloway Farm Secretarial Services Ltd. A full secretarial service is provided and records kept, not only for tax assessment but also as a means of detecting weaknesses and strengths in management. On most co-operating farms, enterprise gross margins are calculated as well as the whole farm fixed cost structure.

The National Farmers' Union has for a considerable time looked after the interests of the farming community. It has been responsible for the introduction, fostering and development of many farming improvements, and has done much to encourage agricultural education.

FARM STAFF

In 1972 the Wigtownshire farm labour force, at 1374 full-time and 261 casual workers, was less than half its 1945–50 size. Wages have risen to £30 per week, but are still not as high as those of industrial workers with similar responsibility, and it is expected that they will rise considerably in the next few years. Added to this is the possibility that farm workers will become even scarcer. Obviously it is becoming essential to employ labour to the best advantage, and to this end organization of work is being improved and the use of machinery increased on all types of farm, particularly on dairy farms which have a high labour requirement.

Many of Wigtownshire's dairymen are paid by contract. The dairyman provides all labour, and in return receives a payment per cow, a proportion of the milk cheque or a combination of the two. A bonus is also generally paid on each calf reared. Most contracts now require the farmer to provide relief staff when dairy staff are on holiday.

9 | Forestry

by J. D. MacNab BSc and D. A. Thompson BSc

Forestry Commission (Scotland)

Prior to 1930, woodlands in the area were confined mainly to woods in the more sheltered positions and to policy woodlands planted for amenity round mansion houses. In some instances—e.g. Stair, Glasserton, Monreith, Mertonhall and Shennanton estates—belts of trees were established against the prevailing wind to shelter agricultural lands. These woodlands were generally of broad-leaved species, with sycamore, elm, oak, beech and ash planted on moderately fertile mineral soils, although on Stair estate these species had gradually been replaced by conifers, the most favoured species being Japanese larch and Corsican pine. Even today it is possible to walk for miles on the northern moors of Wigtownshire without seeing trees other than the odd clump beside a farm-house.

Before the Second World War only two Forestry Commission forests had been established in the region—at Kirroughtree in 1931 and at Kilsture in 1935. Even here the first plantings were made mainly on areas that had previously carried a tree crop. It was not until the post-war years that major expansion of State forests took place, made possible by the introduction of heavy crawler tractors which facilitated the drainage and deep ploughing of the poorer soils and made them a successful medium for tree growth. Such sites would previously have been classed as unplantable. Most of this expansion took place from 1950 onwards, two new forests being created at Bareagle and Penninghame, and Kilsture, Kirroughtree and Fleet forests being extended.

NURSERIES

Partly because severe winters seldom occur in the region two forest-tree nurseries have been established by the Forestry Commission—at Bareagle near Stranraer, and at Kirroughtree near Newton Stewart. A third Commission nursery at Fleet forest lies just outside the south-eastern boundary of the area. The milder climate of the south-west gives a longer growing season and healthy planting stock can be raised from seed and utilized more quickly than if these nurseries had been established further east where the climate is harsher. These three nurseries meet the needs of the Forestry Commission in the South Scotland Conservancy besides leaving some surplus for export to other parts of the country. At Bareagle there are two sections of nursery, one on old agricultural land on freely drained sand mapped as the Cairnside series, the other, the heathland section, on stabilized freely drained dune sand near Luce Bay. The nursery at Kirroughtree is on alluvium.

MODERN PRACTICE AND TECHNIQUE

At the present day, wherever possible, all land is ploughed prior to planting. Peaty gleys and peat are treated by deep single-furrow ploughing and by draining the area of all excess ground water. Peaty podzols are tine-ploughed to break any pan or indurated layer, and so provide vertical drainage. Roots can penetrate to a greater depth after such treatment.

Planting is usually carried out on the side of the upturned furrow so that the young plant has the advantage of freedom from competing vegetation for the first year at least, is on a well drained medium, and benefits from the decaying vegetation in the sandwich layer between turf and soil. As most of the soils have insufficient phosphate for healthy tree growth, ground mineral phosphate, or GAFSA—crude rock phosphate, is applied at the time of planting at the rate of 40–60 g per plant. A more recent development in technique is to spray this fertilizer from the air, by either fixed-wing aircraft or helicopter, at the rate of 375 kg per hectare. This saves manpower and large areas can be covered in a relatively short time.

When planting started, trees were put in at a density of 4000–4200 per hectare but this has been gradually reduced to the present level of about 2500 per hectare, i.e. an increase in spacing between plants from 1·5×1·5 m to 2×2 m. The advantages of this wider spacing are threefold: firstly, there is a saving in planting stock; secondly, first thinnings are delayed from approximately 18–20 years to 23–25 years when the trees will be of greater size and more easily sold for pulping, chipboard etc; and thirdly, there is greater tree stability. The main outlets for the first thinnings are the pulp and chipboard mills. Thereafter thinning is carried out twice or three times at 4–6 year intervals and then at less frequent intervals as the trees become fewer. According to the site and the species grown, the final cut is made when the trees are between 60 and 80 years old.

Between planting and thinning the tree crop, depending on site and species, is weeded for up to five years after planting, and after 5–6 years the drains are cleaned out or deepened as necessary. Between 8 and 10 years, again depending on species and site conditions, tree crops usually start to close canopy, and thus to kill out competing ground vegetation, and at this stage drains may require further attention.

Ground skidding is the normal method of extracting timber in the area. Organic soils are easily broken up by the constant passage of heavy extraction equipment and timber, and so successful ground skidding demands mineral soil near to the surface. On brown forest soils, podzols, some peaty gleys and most mineral-soil complexes ground skidding is feasible. It is also sometimes possible on organic complexes containing moundy morainic deposits or on hills with rocky micro-relief, depending on the distribution of moraine or rock through the organic soils. On the other organic complexes, however, some form of extended winch extraction is preferable.

PRIVATE WOODLANDS

With the exception of the Stair estate, little expansion has taken place on private estates and in many cases the area under woodland has remained static or even decreased. As yet there are no private forestry enterprises in the area although there are some operating in neighbouring regions where they carry out quite extensive afforestation programmes similar to those of the Forestry Commission.

Fifteen estates in the region have woodland managed under the Dedicated Woodland Schemes. These comprise most of the larger blocks of privately-owned woods, some 1900 hectares, and vary in size from 20 to 700 hectares. In addition there are some 500 hectares of smaller blocks of privately-owned woodlands on estates that are neither Dedicated nor worked to an Approved Plan. A further 200 hectares consist of very small clumps under 0·5 hectares or very narrow shelter strips under 20 metres wide, mostly on owner-occupied farmlands.

These private woodlands consist almost entirely of old broadleaved species, in some cases with an admixture of conifers, or coniferous woods up to 40 years old; very few are pure crops of older conifers. Slightly more than half the woodland area is under broadleaved crops.

Most of the private woodlands lie within a 5 kilometre band of the coast, are seldom at elevations above 90 m (300 feet), and are established on the brown forest soils of the Rhins and Ettrick Associations, mainly the Rhins and Linhope series. On the Stair estate, however, many of the woodland blocks on the lower flat land between Loch Ryan and Luce Bay are on the Yarrow series of that association, and as elevations rise up the scarp to the north-east the crops are on Ettrick Association soils, first the Linhope and then the Dochroyle series, and finally on peat on the rolling moorland above.

STATE FORESTS

State forests in the area are mainly on soils of the Ettrick, Dalbeattie and Rhins Associations. The crops are composed mostly of young coniferous species; only one-tenth of the plantations are over 20 years old, the oldest, 100 hectares at Kirroughtree having been planted some 40 years ago. On a 200 hectare block established on an old woodland site at Kilsture between 1935 and 1958 half the crop is composed of broadleaved species, mainly oak with some ash in the moisture-holding hollows. The principal conifer is Sitka spruce which grows well on all soils from brown forest soils to moorland peats, provided there is enough moisture, and occupies over half the area planted. Lodgepole pine, Japanese and hybrid larches, Corsican pine, Scots pine and Norway spruce are the other conifers frequently present. Small areas of Douglas fir, Western hemlock, noble and grand firs and Lawson's cypress have also been planted.

Prior to 1946 little was done in the way of mechanical preparation of ground for planting. On sloping and better drained mineral soils the young trees were notched into the ground using an 'L' or 'T' notch. On the wetter hollows and flats, drains were dug by hand, and the young trees notched into turfs cut from the excavated material spread out between the drains at normal planting spacing. Since then ground preparation by ploughing has been used increasingly and today practically all ground is ploughed and drained prior to planting. On the sand dunes adjoining Luce Bay, however, it has been found that cultivation is not advantageous, as it causes movement of sand and excessive weed growth.

Cultivation and drainage have widened the range of soils on which Sitka spruce can be grown successfully, this species being the most adaptable and economic provided available moisture is adequate. Japanese and hybrid larches grow well on shallow, freely drained mineral soils with a ground vegetation of heather (*Calluna vulgaris*) or heather and bracken (*Pteridium aquilinum*). Scots pine is a tree of the drier, eastern side of Scotland, and does not grow well in the wetter south-west except on sheltered sites on the more freely drained mineral soils below 250 m (800 feet).

Sitka spruce grows fast on the richer, deeper and more moisture-retaining mineral soils and on organic-mineral complexes where there is a ground cover of grasses, herbs and bracken. It still grows well on the organic complexes where there is a lush growth of flying bent (*Molinia caerulea*) but is generally replaced by lodgepole pine on the peat areas with a ground vegetation of heather, cross-leaved heather (*Erica tetralix*), deer grass (*Trichophorum cespitosum*), cotton grass (*Eriophorum* spp.) and bog moss (*Sphagnum* spp.). Mixtures of Sitka spruce and lodgepole pine have been planted on the organic complexes and peats where flying bent and bog myrtle (*Myrica gale*) are present to only a limited extent. It was hoped that the pine would smother out the heather and shelter and nurse the Sitka spruce, which would become the final crop after removal of the pine in the thinnings. In present practice, however, these mixtures have been largely discontinued and the soil range of pure Sitka spruce planting is being extended with the help of fertilizers and chemical control of heather. Besides the underlying soil conditions, exposure and altitude are most important in determining which species will grow successfully. Here again Sitka spruce is the tree that stands up best to blast at higher altitudes.

Corsican pine has been planted on the coastal freely drained stabilized dunes and on soils of the Yarrow Association close to Luce Bay, and is growing well. It has been found that this species, although a slow starter, is less affected by salt-laden winds from the sea than any other, and grows best on deep sandy soils.

Bareagle Forest

Planting began in 1951 and very little ground remains unforested; the planted area is 1937 ha. Soils of the Ettrick Association predominate but there are areas of Rhins and Yarrow Associations in the western parts of the forest.

In the east the forest consists of isolated blocks of varying size mainly lying on peat or on an organic soil complex. The Finlas, Darnaw and Bush complexes are the most common. There are also small areas of the Linhope and Dod series at Craigenveoch. The pattern is very much the same in the Glenwhan section, with the addition of a substantial area of the Glenlee mineral soil complex. The Lochnaw section has a great variety of soils in a small area, one being the Rhins series, an imperfectly drained brown forest soil. Finally, a significant area of forest has been established on the freely drained stabilized sand dunes on the north shore of Luce Bay.

Kilsture Forest

Planting began in 1935 with broadleaved species. Of a total area of 1557 ha, 1335 ha have now been planted. The main section, parts of the Corsemalzie and Auchleand sections, and the Barnbarroch section, are on either the Achie or the Glenlee mineral soil complex, depending on the amount of rock outcrop. Numerous small plantations, such as those on the Moss of Cree, are on peat and organic soils are an important component of the remaining soil complexes in the forest.

Penninghame Forest

Planting began in 1951 in the main block. The total area of the forest is 5212 ha of which 2629 ha have been planted. Part of the forest lies outside the area and is covered by the memoir for the area to the north (Bown, 1973).

Brown forest soils of the Linhope series occur commonly in the Loch Ronald section and also occasionally in the main block. A substantial area is on the Trool complex which consists of organic and mineral soils. In places, mineral soils predominate and the Achie or Glenlee complexes have been mapped; in others less well drained, organic soils of the Finlas complex are found and peat is mapped, especially in the Tannylaggie section. The Bush, an organic and mineral-soil complex, also occurs.

Kirroughtree Forest

Planting began in 1931 and 4169 ha out of a total area of 6354 ha are now covered. The soils in this forest belong to the Ettrick and Dalbeattie Associations. With the exception of mappable areas of Linhope series, brown forest soils, in the Warren and Cassencarie sections, the Ettrick Association consists of complexes varying from the organic soils of the Finlas complex to the mineral soils of the Corwall complex. The Dalbeattie Association consists almost entirely of the organic soils of the Garrary complex with small areas of peat and the Loch Fleet complex.

Fleet Forest

The total area of Fleet Forest covered by this memoir is 3060 ha of which 1340 ha are afforested; planting began in 1956. Throughout the forest there are considerable areas of peat which merge into various organic soil complexes, the Garrary and Twactan complexes being most common. In the Dromore section, small areas of peaty podzols and peaty gleys have been identified as the Carsphairn and Eglin series respectively.

Small areas of Clatteringshaws and Bennan forests lie within the area, their soils being similar to those in the adjoining Fleet Forest.

CROP YIELDS

Sitka spruce is one of the most productive of the species planted and will continue to be so in the foreseeable future. Yields vary considerably, depending on frost conditions and weed competition, but broadly two classes can be distinguished. On peat and the organic-soil complexes of the Ettrick Association a mean annual yield of 10 m^3 gross/ha or a total yield over 60 years of 600 m^3 gross/ha is expected. For the mineral soils and mineral-soil complexes of the Ettrick Association and the organic soil complexes of the Dalbeattie Association the yields expected are 12 m^3 gross/ha annually or 720 m^3 gross/ha over 60 years.

Obviously these are average yields showing wide variations determined by individual site conditions. Furthermore, techniques are rapidly improving and areas afforested in the last few years should give much higher yields than similar areas afforested twenty years ago. Widespread top dressing with phosphate, potash, and possibly nitrogen, together with suppression of heather competition by chemical control, will do much to advance the trend towards higher average yields.

10 | Discussion of Analytical Data

Profiles representative of the soil series present in this area have been sampled during the survey. Each sample has been analysed for loss on ignition, soil separates, exchangeable cations, percentage base saturation, pH, carbon, nitrogen and readily soluble and total phosphorus, and some profiles of particular interest have been subjected to more detailed investigation. The clay mineral composition has been determined by X-ray and differential thermal methods; the X-ray amorphous, poorly-ordered, siliceous and sesquioxidic materials have been determined by chemical techniques; and the trace element content has been obtained by spectrochemical methods.

The data from the standard analyses are given in Appendix II, each profile having a number by which it is readily identified when referred to in this chapter; the other data are grouped in Appendices III–V. Following a summary of the general significance of theses analyses, a detailed discussion of the chemical characteristics of the soils is given below. For the four major associations data are considered under the heading of the individual soil series, for another two associations under major soil sub-groups, and for the less widespread associations under associations.

It is important to note that for any one soil series chemical data can vary widely, and that in general only mean values are discussed, although the range of values is also considered, if apparently well established.

Loss on Ignition

Loss on ignition measures the weight loss due chiefly to the oxidation of organic matter to carbon dioxide and the elimination of water combined with clays and other soil material, and, in calcareous soils, to the loss of carbon dioxide from the calcium carbonate. In non-calcareous soils of moderate clay content the value for loss on ignition in the surface horizon gives a rough estimate of the organic matter content (Ball, 1964).

Soil Separates

The soil separates—sand, silt and clay—are determined by mechanical analyses. The relative proportion of these fractions present is referred to as texture, an important physical property of soil which greatly influences moisture retention and drainage, tillage properties and liability to 'poaching' by stock and machinery, as well as the type of soil structure and base exchange properties of the soil.

Cation Exchange Capacity

The cation exchange capacity is a quantitative expression of the ability of a soil to take up, release, and exchange one cation for another. Many of these cations are plant nutrients and the amount and nature of exchangeable bases gives some indication of the presence of easily available nutrients.

The exchangeable ions are held primarily on the organic matter and clay fractions of the soil. Soils with high organic and clay contents have high exchange capacities. Thus in most soils the exchange capacity decreases with depth in the profile, reflecting the fall in organic matter content, while the non-organic horizons of soils with a high clay content generally have higher exchange capacities than those of sandy soils. The base exchange capacities of many very coarse-textured parent materials are extremely low (5 me/100 g soil).

Percentage Base Saturation and pH

The total of exchangeable bases expressed as a percentage of the exchange capacity of the soil is termed the percentage base saturation. The part of the exchange complex not carrying basic ions is assumed to be occupied by hydrogen ions.

The pH is a measure of the hydrogen ion concentration in the soil. An acid soil has a low pH, 4·0 to 5·0, a neutral or near neutral soil has a pH of 6·0 to 7·0, and an alkaline soil a pH greater than 7·0.

Acid soils generally have a low percentage base saturation, while in neutral and near neutral soils the exchange complex is completely saturated. A soil with a low percentage base saturation but a high exchange capacity can, however, have a greater content of total exchangeable bases than a soil with a higher percentage base saturation but a lower exchange capacity.

A number of important soil properties and processes are correlated with and affected by the soil pH. Earthworm and other biotic activity is reduced under acid conditions and the natural plant communities are strongly influenced by the soil reaction. In addition the availability of some plant nutrients, e.g. manganese and boron, is markedly affected by pH, as is the liability of plants to attack by certain diseases.

Carbon and Nitrogen

The carbon content of a soil is closely correlated with the amount of organic matter present, which is usually calculated by multiplying the value for soil carbon by the factor 1·72.

The organic matter in the soil is generally concentrated in the surface horizon and decreases down the profile, although the B horizons of some podzols are exceptional in having a local concentration of organic matter at some depth. The amount and nature of the organic matter in a soil has a major role in influencing the type and stability of soil structure; it also forms a reserve source of plant nutrients, and is the seat of much of the soil base exchange activity.

An important characteristic of soil horizons with a humus content greater than 25 percent is their low bulk density (Birse, priv. com.). As a consequence of this, such soils have relatively lower amounts of nutrients or other elements per unit volume as compared with mineral horizons, although they may have a high content as judged per unit weight of soil. In this area most humic horizons are strongly acid with only a low proportion of exchange sites carrying bases. These factors, together with the assumption that there is a limit to the volume of soil which any one plant is able to exploit, helps to explain why the raw humus horizons of podzols, peaty podzols and peaty gleys are poor media for plant growth when they often have high contents of exchangeable bases and of phosphate per unit weight of soil.

The amount of soil nitrogen is used to compute the carbon to nitrogen ratio of the organic matter. A carbon : nitrogen ratio of about 8–13 indicates organic matter existing under conditions of fairly rapid humification and high biotic activity, while a high carbon : nitrogen ratio in the range 15–25 is typical of peats and mor humus where the rate of decomposition is slow.

The soil organic fraction is also a major source of nitrogen, an important plant nutrient.

Phosphorus

The soils have been analysed for their total content of phosphorus, expressed as units of phosphorus pentoxide, and for readily soluble phosphorus, which is an indication of the phosphate fraction readily available as a plant nutrient.

Barncorkrie Association

The parent material of the Barncorkrie series of this association, an unmodified reddish brown till, has a clay content in the range 20–25 percent and textures of clay loam or sandy clay loam with occasional loams. The Portencorkrie series is underlain by a similar till but the upper layers have been partially water-sorted (cf. Chapter 5), so that at depths of from 40 cms to 1 metre the clay content is 12–15 percent, and sand 60–70 percent.

In both series, the base exchange capacity in the A horizon is in the lower part of the moderate range, 17–25 me/100 g soil, and decreases with depth to a very low value, 3–7 me/100 g soil, in the parent material; the degree of base saturation shows an opposite trend, rising with depth from a moderate or moderately low value, 15–35 percent, near the surface to a high value, 80–90 percent, in the parent material. The soil is acid or moderately acid, pH 5·0–6·0 in the surface and pH 5·8–6·4 in the parent material. Under cultivation the amount of exchangeable bases is generally moderate at the surface. Values for exchangeable calcium decline with depth to low. In the imperfectly drained Barncorkrie series the content of exchangeable magnesium rises with depth, though the value remains in the moderate range, while in the freely drained

Portencorkrie series there is no very pronounced general trend in the value with depth and the content in the subsoil horizons is in the lower part of the moderate range. The value for exchangeable sodium is moderate throughout the profile, but for exchangeable potassium it is low in all horizons except some plough layers where fertilizers have been recently applied.

In both series the organic matter content of the A horizon ranges from moderate to high, 8–15 percent, with low values for the carbon : nitrogen ratio.

The total phosphorus status in the plough layer is to a large extent dependent on agricultural history but is generally moderate; in the subsoil horizons it is low. Readily soluble phosphorus is low to moderate, although sometimes there is a high content in the plough layer.

Carbrook Association

In this area, the Carbrook and Harviestoun series are developed on red fluviatile deposits and have clay contents of about 50 percent in all horizons below the plough layer. In both series the base exchange capacity, 15–25 me/100 g soil, is in the lower part of the medium range and declines slightly or changes irregularly with depth, while the degree of base saturation is more than 50 percent in the surface and rises with depth to complete or almost complete saturation. The soil is acid, pH 5·5–6·0, in the surface and moderately acid or neutral in the subsoil; some values for base saturation of 100 percent and slightly alkaline reactions, pH 7·0–7·5, are probably accounted for by shell fragments in the parent material. The exchangeable calcium value is medium or high throughout the profile and varies irregularly with depth while exchangeable magnesium shows a similar trend being moderate in the surface and increasing in the subsoil to high or nearly so. Exchangeable sodium is high or moderately high in the surface and with depth either shows little change or rises. The value for exchangeable potassium is moderate throughout the profile in both series.

In the plough layer of soils developed on these clayey materials the organic matter content is generally low, less than eight percent organic matter, and so is the carbon : nitrogen ratio. The total phosphorus status is generally moderate, but sometimes low in the subsoil, while the value for readily soluble phosphorus ranges widely from low to very high.

Creetown Association

CLANERY SERIES

Developed on stony drifts and rock rubble the Clanery series has a low clay content, 5–10 percent, in all horizons below the A, while the value for sand is in the range 50–70 percent.

The base exchange capacity, which is moderate in the surface, decreases abruptly below the A horizon to low in the parent material.

Under semi-natural conditions the base saturation is moderate to low, 10–25 percent in the surface, but in some areas lime application has raised it to over 60 percent. In the lower horizons saturation decreases and the amounts of the bases reach very low values, less than 7 percent, in the parent material. In the absence of liming, acid conditions prevail throughout the profile, pH ranging from 4·5–5·5 in the surface and increasing slightly with depth. Values for all the exchangeable bases are low, or occasionally moderate, in the organo-mineral A horizon, reflecting biological accumulation, and fall sharply below this layer to very low values in the B and C horizons. Liming produces high values for exchangeable calcium in the surface layer but has little effect below 30 cms.

The content of organic matter in the A horizon is moderate, 8–13 percent, but the carbon : nitrogen ratio, reflecting the acid conditions, is only moderately low, 13–15. Occasionally there is a very thin, 2–3 cms, H horizon.

The total phosphorus status is moderate in the surface, but is commonly low in the subsoil; the amount of readily soluble phosphorus ranges widely, being mainly low but occasionally very high.

ARKLAND SERIES

Analytical data for the imperfectly drained Arkland series resembles closely that of the related Clanery series. The clay content throughout the profile is about 10 percent. The base exchange capacity is moderately low in the surface, decreasing to very low in the subsoil, and the base saturation is moderately low, 17–40 percent, in all horizons. The soil is acid or moderately acid and there is no significant or regular change with depth. Values for exchangeable bases, which are low to moderate in the surface, decrease with depth.

The organic matter content is moderate to low, and the carbon : nitrogen ratio is low. The total phosphorus content is moderate in the surface horizon and mainly low in the subsoil, while because of the somewhat impeded drainage the value for the readily soluble phosphorus is moderate throughout.

GREENBURN SERIES

As in other soils of the Creetown Association, the content of clay throughout the profiles of the Greenburn series is relatively low, 7–11 percent, and is unlikely to cause very low permeability. The conditions of wetness and strong gleying in these soils are mainly associated with spring lines and seepage.

The base exchange capacity in the Ag horizon is generally moderate, 16–25 me/100 g soil, and declines to low in the subsoil, with less than 5 me/100 g soil in the Cg horizon. The degree of base saturation of the exchange complex is moderate to high, generally in the range 30–90 percent, and although in some profiles there is a tendency for saturation to increase with depth, in general the trend is not regular. The level of acidity is only moderate, pH 5·5–6·5 in the surface—less acid than other soils of the association—and there is little change with depth although the pH does tend to rise slightly. In the surface the content of exchangeable calcium is high, and of exchangeable magnesium moderate, and the values for exchangeable sodium and potassium range from high to low; in the subsoil horizons, despite the degree of base saturation, the content of exchangeable bases is low, mainly because of the low exchange capacity of these layers.

The soil generally has a high organic matter content in the surface with a moderate carbon : nitrogen ratio, 13–16, but where under-drainage has been installed and cultivation and liming carried out, the content of organic matter is moderate and the carbon : nitrogen ratio lower, 10–12.

As a result of biological accumulation the content of total phosphorus in the surface layer is moderate, but in the subsoil the value is generally low, although a high proportion of the phosphorus is readily soluble and available to plants.

FALBAE SERIES

As in other soils of the association the content of clay in the mineral horizons throughout the profile is generally in the range 6–12 percent.

The value for base exchange capacity is very high, greater than 100 me/100 g soil in the peaty surface horizon, and moderate in the A_2g horizon where the content of organic matter is moderate to high, but in the deeper layers the value is generally low, although in the B horizon which has a high content of X-ray amorphous sesquioxides and associated organic matter the value is higher, 10–18 me/100 g soil. Throughout the profile the soil is strongly acid, the pH value rising with depth from 3·7 to 4·0 in the surface, to 4·7–5·0 in the parent material. In keeping with the soil acidity the base saturation is very low, generally less than 5 percent in the mineral horizons and only about 10 percent in the peaty surface horizon. Nevertheless, because of the extremely high base exchange capacity of the peaty horizon moderate or high amounts of the exchangeable cations, calcium, magnesium, sodium and potassium are present, but the strongly acid conditions and very low base saturation probably give a truer indication of the status of the soil as a medium for plant growth. In the mineral horizons the content of exchangeable bases is low.

The carbon : nitrogen ratio is high, both in the organic peaty surface layer and in the A_2g mineral soil horizon, which generally also has a moderate content of organic matter.

Both total and readily soluble phosphorus are low in the mineral soil horizons, with the exception of the parent material where a high amount of readily soluble phosphorus can occur at about 1 metre depth. In the peaty surface horizon the amount of total phosphorus is moderate and the readily soluble phosphorus level is high.

CREETOWN SERIES

A clay content in the range 6–11 percent is characteristic of profiles in this series and other soils of the association, but a clay content of 15–18 percent has been found in the Bg horizon.

The value for the base exchange capacity is high or very high in the surface organic layer and is generally proportionally related to the amount of organic matter in the horizon. The exchange capacity of the A_2g horizon is in the range 10–18 me/100 g soil and declines to less than 5 me/100 g soil in the parent material. Throughout the profile the exchange complex shows a very low degree of saturation with bases, generally less than 10 percent and commonly less than 5 percent, but values of 20 percent can occur where the surface layer is affected by mineral-rich seepage waters. Conditions are strongly acid throughout the profile, with pH ranging from 3·7–4·0 in the organic layer to 5·0 in the parent material, but in soils affected by flush water the reaction is higher, pH 4·7–5·0 in the surface, and rises only slightly with depth.

The content of exchangeable bases is very low in all mineral horizons, and while it is higher in the organic surface layer the very low degree of saturation of the exchange complex more accurately reflects the status of the soil as a medium for plant nutrition.

The value for total phosphorus is generally low throughout the profile and is moderate only in the organic surface horizon in some parent materials; the content of readily soluble phosphorus, despite the strongly gleying conditions, is also low, except for an occasional high value in the Cg horizon.

Dalbeattie Association

DALBEATTIE SERIES

Developed on stony drifts and frost-shattered rock debris, the Dalbeattie series generally has a clay content of less than 10 percent and a high sand content, most of which is coarse sand, consisting mainly of raw feldspars and quartz particles from disintegrating granite. Base saturation is low, less than 5 percent, throughout the profile and the soil is strongly acid, pH 4·5 in the surface rising to pH 5·0 in the parent material; the base exchange capacity is high or moderately high in the very shallow raw humus H layer, and moderately low or low in the B horizon. The content of exchangeable bases under semi-natural conditions is very low throughout the profile, except in the shallow H layer where moderate or high values for exchangeable sodium and potassium reflect biotic accumulation. Apart from the organic H layer, there is a moderate organic matter content in both A and B_2 horizons and the carbon : nitrogen ratio throughout the profile is moderately high, 15–20.

The contents of total phosphorus and of readily soluble phosphorus are in the moderate range throughout the profile.

Weathering and soil formation under the conditions of strong leaching and high acidity have led to the release and accumulation in the profile of large amounts of X-ray amorphous or poorly-ordered materials. Values for material released by the carbonate extractant are 1·9 percent Al_2O_3 and 0·08 percent SiO_2 from the A horizon and 6·0 percent Al_2O_3 and 0·32 percent SiO_2 from the B_3 horizon. The amounts of carbon, aluminium and iron released by the potassium pyrophosphate extractant are relatively high throughout the profile, but show a marked peak in the B_2 horizon where some of the criteria of a spodic horizon (Soil Survey Staff, 1975) are satisfied. Associated with the high amount of extractable sesquioxides in the B horizon is a high value for hydroxyl activity, 147 me/100 g soil, as determined by treatment with sodium fluoride.

CARSPHAIRN SERIES

Like other soils of the association the Carsphairn series, a peaty podzol, has a low content of clay, 5–10 percent, and a high amount of sand, 60–90 percent, in all mineral horizons. The base exchange capacity is generally very high in the surface peaty layer, but can be only moderately high where the horizon is thin or has a high mineral content. In the underlying mineral horizons the value for the exchange capacity is moderate in the A_2g horizon, where the organic matter content is high, but declines with depth to very low. Where the B horizon has a high illuvial organic matter content the exchange capacity is also moderately high. The degree of base saturation, however, is low, less than 5 percent in mineral horizons, and throughout the profile acidity is high, pH 4·0–4·5 in the surface and pH 5·0 in the parent material. The content of all exchangeable bases is low in the mineral horizons and sometimes in the peaty layer. Biological accumulation, however, gives rise to moderate or high amounts of exchangeable calcium, magnesium, sodium and potassium in the surface organic horizon of many soils, particularly in the litter layer, but low base saturation of the exchange complex shows a better correlation with the plant nutrient-supplying status of these organic layers than the content of bases.

Below the organic layer the organic matter content is moderate or high only in the Ag horizon, or occasionally in a B horizon having a dark colour, while the carbon : nitrogen ratio is wide, 15–25. The value for total phosphorus is generally low except in the peaty layer and sometimes in the B horizon, while the content of readily soluble phosphorus is low throughout the profile, although the H horizon occasionally has a moderate or high value.

In the field the B horizons of this soil appear rich in sesquioxides, but this is not confirmed by the analytical data from the one profile analysed. The carbonate removed a large amount of aluminium, 9·1 percent Al_2O_3, from the B horizon, while the amount of siliceous material removed from this horizon, 0·24 percent SiO_2, contrasts strongly with the amount from the A_2g horizon, less than 0·01 percent SiO_2. Although the potassium pyrophosphate extractant removed only a very small amount of iron, 0·06 percent Fe, from the B horizon, this is not considered representative of the series, and possibly the sesquioxidic nature of the B horizon is to some extent confirmed by the high value, 322 me/100 g soil, for the hydroxyl activity as measured by treatment with sodium fluoride.

EGLIN SERIES

The stony drifts and shallow tills which give rise to the Eglin series generally have a clay content in the range 5–10 percent and a high sand content, 60–80 percent. The soil horizons have similar contents. The base exchange capacity of the peaty surface horizon is very high, 100 me/100 g soil, but the value can be lower where the horizon has a high content of mineral matter. The degree of base saturation is very low, less than 10 percent and generally less than 5 percent, and the level of acidity is high, pH 4·8 to 5·2, where the soil is affected by seepage with water of moderate mineral content; in the absence of flushing the reaction can be even more acid. In the mineral horizons the content of exchangeable bases is very low, and although in the organic horizon magnesium, sodium and potassium are present in moderate amounts, calcium is very low.

The peaty layer obviously has a very high organic matter content, but where flushing or hill wash occurs mineral matter can be incorporated to the extent of 60–80 percent. Where a soil is affected by seepage the carbon : nitrogen ratio is only moderately high, 14–18, but the value can be higher where the soil is developed on shedding sites.

The contents of total and readily soluble phosphorus are low in the mineral soil, but can be medium in the surface organic layer.

Weathering in the mineral soil horizons is strongly affected by leaching with acid organic solutions percolating from the peaty surface horizon. Extraction with carbonate removed only a very small amount of siliceous material, 0·04 percent SiO_2, and a moderately low amount of amorphous or poorly-ordered aluminous material, 0·80 percent Al_2O_3. The amount of aluminous material extracted is, however, rather higher than in other peaty gley soils, as appears also to be the case with soils in other major sub-groups developed on granitic parent materials. The amount of iron extracted by potassium pyrophosphate is also low throughout the profile and reflects the high rate of leaching relative to the intensity of weathering. The hydroxyl activity, as measured by reaction with sodium fluoride, is moderate in the mineral horizons and approximately proportionate to the extractable, poorly-ordered aluminous material.

MULLTAGGART SERIES

The clay content in the upper horizons of the Mulltaggart series is in the range 5–10 percent, but these layers have a high organic matter content which is of overriding importance in determining the nature of the soil. The profiles of this series, which have been sampled, rest almost directly on rock.

The thin surface H horizon has a base exchange capacity in the range 30–60 me/100 g soil, varying according to the proportion of organic matter in the layer. In the underlying H/A_2 and H/B layers the organic matter content is less and the base exchange capacity is in the range 10–30 me/100 g soil. The soil is strongly acid, pH 4·1 to 4·6, and strongly eluviated, with a very low degree of base saturation, 0–10 percent. The contents of exchangeable magnesium, potassium and sodium are medium in the thin surface layer, due to biotic accumulation, but low in underlying layers, and the level of exchangeable calcium is very low throughout the profile. The value for calcium, however, can be high in soils affected by seepage from winter snow banks. The organic matter content is high in all layers of this soil, but below the upper 3–5 cms is generally less than 20 percent, while the carbon : nitrogen ratio is only moderately high, 15 to 18, in all horizons. Below the surface layer, total phosphorus is moderate and readily soluble phosphorus is low.

Treatment with the carbonate extractant removed only a small amount of amorphous or poorly-ordered siliceous material, 0·07 percent SiO_2, but a relatively large amount of aluminous material, 2·3 percent Al_2O_3, from the H/B horizon as compared with a moderate amount, 0·54 percent Al_2O_3, from the H/A_2 horizon. High amounts of sesquioxidic material, 1·55 percent Al and 0·46 percent Fe, were also removed from the H/B horizon by treatment with pyrophosphate, as was a high amount of organic matter, 2·94 percent carbon. The H/B horizon, therefore, clearly satisfies some of the criteria for a spodic horizon.

Ettrick Association

LINHOPE SERIES

The parent material of the Linhope series is generally loam or sandy loam, with the clay content ranging from 18 to 26 percent for tills deposited as drumlins and from 12 to 26 percent for hillside drifts and frost-shattered rock debris with values of 12 to 22 percent most frequent. The proportion of loamy materials is higher and the average clay content greater in this area than in Carrick to the north where morainic and other relatively coarse-textured materials are more common. The base exchange capacity in the organo-mineral A horizon is generally moderate, in the range 15–25 me/100 g soil, but higher values, 25–40 me/100 g soil and 80–120 me/100 g soil respectively, are associated with the organic-rich upper 5–7 cms of the A horizon sometimes found under semi-natural conditions, and with the thin H horizon, which is sometimes present. The value for exchange capacity decreases to low, less than 10 me/100 g soil, in the parent material. Agricultural management and liming history markedly affect the degree of base saturation in the A horizon or plough layer. Under semi-natural grassland and some woodland conditions base saturation in the surface is very low, 8–12 percent, while in profiles sampled under cultivated and improved grassland it is moderately high, 45–60 percent; a few soils under deciduous woodland communities are relatively base-rich with 40 percent saturation. With depth, however, the base saturation declines in all soils, generally to a very low value, less than 5 percent saturation. Soil acidity is affected by the same factors as base saturation, and limed and improved soils have a reaction of pH 5·5–6·0 in the surface changing irregularly, or decreasing slightly with depth to pH 5·0–5·5. Under semi-natural conditions the pH value is generally 4·5–5·0, with some lower values in the range pH 4·0–4·5, and with depth the acidity decreases somewhat. Moderate amounts of exchangeable cations—magnesium, sodium and potassium—are present in the A horizon of all Linhope soils sampled, although the value for sodium is sometimes high in thin surface layers with high organic matter content. The exchangeable calcium value in the surface horizon is generally low in semi-natural soils and high where liming has been regular, but in both cases the value decreases with depth to very low. Where cultivation is fairly frequent or infrequent the organic matter content is medium to high, but it can be very high in thin surface H horizons or in shallow surface subdivisions of the A horizon. The carbon : nitrogen ratio of the organic matter shows a wide range, but the higher ratios, 15 to 25, are associated with highly organic horizons.

Although generally slightly higher in the topsoil than the subsoil, the total phosphorus content is usually moderate throughout the profile and, except where fertilizer has been recently applied, the content of readily soluble phosphorous is low.

Soil formation and weathering under relatively acid conditions have led to the release and accumulation in the B horizon of amorphous or poorly-ordered sesquioxides. Extraction with the carbonate solution released moderately high amounts of aluminous material, 1–1·5 percent Al_2O_3, with the peak in the B_2 horizon. The amount of associated siliceous material is, however, moderately low. Extraction with potassium pyrophosphate removes high amounts of aluminium and iron compounds, 0·97 percent Al and 0·65 percent Fe respectively from the B_2 horizon and confirms that the B horizon is rich in sesquioxides. Following the trend in sesquioxide content, the hydroxyl activity also reaches a peak in the B_2 horizon where values are moderate, but there is no clear evidence of eluviation and illuviation in the profile and the data do not satisfy entirely the accepted criteria for a spodic horizon.

ALTIMEG SERIES

The Altimeg series is developed on parent materials with a textural range similar to that of the Linhope series. The clay content varies considerably but generally lies between 10 and 25 percent. The proportion of fine clay ($<0{\cdot}5\mu$) of the total clay is fairly constant, about 40 percent in all horizons, indicating that translocation of clay has not taken place in this soil. The base exchange capacity of the A or Ag horizon is generally moderate, 15 to 25 me/100 g soil, but the value can be higher where there is an unusually high level of organic matter and is occasionally low where contents of organic matter and clay are both low. In the subsoil horizons exchange capacity is very low. The percentage base saturation ranges widely in the topsoils because some of them have had applications of lime, but in the subsoil horizons values are moderate, 20–60 percent. The reaction of the soils is generally moderately acid, in the range pH 5·0 to 6·0, throughout the profile with no clearly defined trend associated with depth. The exchangeable bases, magnesium, sodium and potassium are present in the topsoil in moderate amounts which decline with depth, while in the absence of liming, calcium is generally low throughout the profile, tending to decline with depth. There is a wide range in the content of organic matter in the A and Ag horizons, but the carbon : nitrogen ratio is moderately low, 11–15. Values for total phosphorus are generally moderate throughout the profile, except from those topsoils affected by recent fertilizer application. Readily soluble phosphorus is generally moderate to high.

Weathering and soil formation under the conditions of moderate acidity and periods of waterlogging operating in these soils have not produced significant amounts of amorphous or poorly-ordered sesquioxidic or siliceous materials in the profile. Extraction with potassium pyrophosphate removed only very low amounts of aluminous and ferrous materials, whereas treatment with the carbonate solution removed moderate amounts of both siliceous and aluminous materials, 0·23 percent SiO_2 and 1·0 percent Al_2O_3 from the Bg horizon.

KEDSLIE SERIES

In western Scotland the clay content in the lower horizons and parent material of the Kedslie series is generally 25–35 percent, while sand is in the range 40–50 percent.

The proportion of fine clay ($<0{\cdot}5\,\mu$) within each horizon is a fairly constant percentage of the total clay, indicating that there has probably been little or no translocation of clay within the profile. The base exchange capacity of A and Ag horizons having low or moderate amounts of organic matter is generally moderate, 15–23 me/100 g soil, but in more organic-rich soils the value can be higher; 30 me/100 g soil. In the subsoil layers the exchange capacity is generally in the range 5 to 10 me/100 g soil. The degree of saturation of the exchange capacity is high or moderate, and apart from those soils with topsoils affected by liming, tends to increase gradually with depth. Soil acidity throughout the profile is generally moderate, in the range pH 5·5 to 6·5. Of the exchangeable bases, sodium and potassium are generally moderate in the topsoil and decrease in the subsoil—potassium to low values. Exchangeable magnesium consistently rises with depth from a moderately low value, 0·5–1·0 me/100 g soil in the surface to a high level, 4·0 to 7·0 me/100 g soil, in the parent material, although application of magnesian limestone can affect the value in the A horizon. Liming has resulted in a high value for exchangeable calcium in many plough layers, but there is a marked decline in the subsoil. The organic matter content is medium or low, with the carbon : nitrogen ratio moderately low, 11–15, as would be expected under the mildly acid conditions. Total phosphorous is low or moderate in the subsoil layers, but in the topsoil it is often high tending to reflect past fertilizer treatment; readily soluble phosphorus varies widely but is generally low in the subsoil.

The content of amorphous and poorly-ordered siliceous and sesquioxidic weathering products is very low in the one soil profile of this series analysed, and no accumulation of these weathering products has taken place under the conditions of relatively mild acidity and weak weathering. The value for hydroxyl activity generally tends to correlate with the amount of extractable iron and aluminium, but profile No. 39 shows an anomalously high value of 72 me [OH]/100 g soil in the B_2g horizon.

DOD SERIES

The morainic materials widespread in Carrick are much less extensive in this area where the parent materials of the Dod series, like those of the Linhope series, are stony sandy loam or loam drifts and tills with a clay content generally in the range 10–20 percent. There is considerable variation in the base exchange capacity values for the different horizons, reflecting, in the main, the variation in the organic matter content of the layers. In the peaty horizon the exchange capacity is extremely high, 90 to 120 me/100 g soil, and is still high or very high, 25–60 me/100 g soil, in the underlying A_2g horizon where a moderate or high amount of organic matter washed in from the peaty layer is present. The sesquioxide-rich B_2 horizon underlying the iron pan also shows a moderate value, 15–25 me/100 g soil for exchange capacity, but it is not clear whether this is associated with organic matter bound up with the illuvial sesquioxides or whether these amorphous or poorly-ordered materials themselves contribute to the exchange capacity. In the parent material the value for exchange capacity is low. The degree of saturation of the exchange complex is very low, 6–15 percent in the peaty layer and less than 5 percent in the mineral horizons. Conditions, therefore, are strongly acid, pH 4·0 or less at the surface and become only slightly less acid with depth—pH 5·0 in the parent material. The contents of exchangeable magnesium, sodium and potassium are high in the surface, but the very low base saturation probably gives a better indication of the nutrient-supplying-power of the soil; the surface layer is generally very low in exchangeable calcium while the mineral horizons are extremely impoverished in all exchangeable bases.

All the soils have a well developed peaty surface horizon and considerable illuviation of organic material into the upper mineral layer, the A_2g horizon, appears to have occurred, for the organic matter content here is generally high, as is the value for the carbon : nitrogen ratio, 15–30. The content of total phosphorus is generally moderate, but is sometimes high in the peaty layer, while with depth the value generally shows a minimum in the A_2g horizon and a maximum in the B_2 horizon—a pattern which parallels and is possibly linked with the eluviation and illuviation of sesquioxides. The value for readily soluble phosphorus is low in all mineral soil horizons.

Treatment with the pyrophosphate extractant has confirmed the sesquioxidic nature of the B_2 horizon as inferred from its morphology; large amounts of iron, 2·0–2·3 percent and aluminium, 1·3–1·7 percent, being removed, together with associated organic matter, 2·5 percent. These values constitute strong maxima when compared with other layers in the soil and satisfy some of the criteria for a spodic horizon. Treatment with the carbonate extractant also removed large amounts of amorphous or poorly-ordered aluminous material from the

B_2 and B_3 horizons in the profile, and correlated with these high amounts of extractable sesquioxides are high values for hydroxyl activity, 173 me[OH]/100 g soil.

LITTLESHALLOCH SERIES

The parent materials of this series include thick tills and stony hillside drifts with a clay content normally in the range 15 to 25 percent, although the value can be lower where the soil is shallow. The percentage of fine clay ($<0{\cdot}5\mu$) as a proportion of the total clay shows a slight maximum in the B_2g horizon and could result from the more active weathering of the parent material in this zone than in other layers or from the translocation of clay within the profile. The proportion of sand varies widely but is commonly between 50 and 70 percent.

The value for the base exchange capacity is generally moderately high, 25–40 me/100 g soil, and is associated in the A_2g horizon with a high amount of organic matter. Where the organic matter content of the surface horizon is moderate or low the value for the base exchange capacity is less, 20 me/100 g soil, and below the A_2g horizon the value for the base exchange capacity decreases markedly and is low, 3–12 me/100 g soil in the parent material. The degree of base saturation is moderate, 20–50 percent, or high, 50–90 percent, the higher values being usually associated with flush conditions and more mineral-rich waters. The level of soil acidity is naturally moderate, the reaction ranging from pH 5·0 in the surface to pH 6·0 in the Cg horizon, or, under flush conditions, from pH 6·0 in the surface to pH 6·5 in the parent material. In the A_2g horizon the content of exchangeable sodium is generally high and the potassium content moderate, while for both bases the value decreases with depth to very low in the parent material. The content of exchangeable magnesium is also moderate in the surface, but the trend with depth is unusual for a gley soil in that the value declines to very low in the parent material instead of rising to moderate or high. Exchangeable calcium is also high or very high in the surface organo-mineral horizon, but falls sharply in the A_2g horizon and, with depth, decreases further to very low values. In this series the organic matter content of the surface horizons is often high and some horizons are humose, particularly in areas of seepage in the uplands; soils with only a moderate organic matter content, however, also occur. The carbon : nitrogen ratio of the organic material is moderate, 12–18. The value for total phosphorus in the surface soil varies widely, but is generally moderate, while in the subsoil very low values are common. Readily soluble phosphorus is generally moderate or low.

The profile of this series, No. 67, treated with extractants for the determination of amorphous and poorly-ordered siliceous and sesquioxidic materials was almost certainly anomalous with respect to these elements. The potassium pyrophosphate solution removed large amounts of carbon, aluminium and iron from the Bg horizon and the carbonate solution removed large amounts of aluminous and siliceous materials. Correlated with the high amount of extractable aluminous material was a high value for hydroxyl activity. These results are characteristic of a freely drained soil—a brown forest soil or a podzol—rather than of a gley. An explanation can possibly be deduced from the morphological appearance of the profile analysed; although it has dull greyish colours throughout the subsoil it has a somewhat yellowish hue and this, taken with the analytical results, suggests that possibly the profile was formed by the strong gleying of a former freely drained brown forest soil consequent on a marked change in hydrologic conditions which, however, did not greatly affect the weathering products.

ETTRICK SERIES

Field textures in the subsoil and parent material of this series are clay loam or loam and the clay content is normally 25–35 percent although some lower values have also been found.

The percentage of fine clay ($<0{\cdot}5\mu$) as a proportion of the total clay shows a slight maximum in the B_2g horizon and could result from the more active weathering of the parent material in this zone than in other layers or from the translocation of clay within the profile. The base exchange capacity in the organo-mineral surface horizon is moderate, 14–25 me/100 g soil, and decreases with depth to low, usually 6–10 me/100 g soil, in the subsoil and parent material. The degree of base saturation in the A horizon is dependent on liming history, but in the subsoil it is moderate and rises with depth, generally to a high value in the parent material. The soil reaction varies with the base saturation but is generally moderately acid, pH 5·0 to 6·0, tending to change irregularly or to rise with depth. Except where liming has given rise to a high value for calcium, the content of exchangeable bases in the surface layer is moderate. In the subsoil the value for exchangeable calcium, after a marked decrease in the A_2g horizon, rises gradually with depth, while the magnesium decreases slightly immediately below the plough layer and thereafter increases consistently with depth. The organic matter content of the A_1g horizon is generally moderate but low and high values are also found; the carbon : nitrogen ratio is moderately low, 12–18. The A_1g horizon also has a moderate content of total phosphorus, but the value is often low in the subsoil where readily soluble phosphorus is low to moderate.

The strong gleying conditions in the subsoil preclude the build up of ferruginous weathering products and extraction with the potassium pyrophosphate solution removed only very small amounts of amorphous or poorly-ordered ferruginous and aluminous materials. The amount of aluminous material removed with the carbonate extractant was also small, but the solution removed a moderate amount of readily soluble siliceous material. In the profile examined (No. 71), despite the small amounts of poorly-ordered weathering products, the hydroxyl activity is moderate except in the B_2g horizon where it is high.

DOCHROYLE SERIES

In the loamy tills on which most of the soils of this series are developed the clay content is 17–27 percent, but it is rather lower in some soils developed on stony drifts. The silt (U.S.D.A.) content is usually between 20 and 30 percent. The variation in base exchange capacity with depth is closely related to the organic matter content of the horizons and the value is generally very high, 90–120 me/100 g soil in the peaty layer, although it can be lower where the horizon has an appreciable mineral content. The value for exchange capacity is generally high, 30–50 me/100 g soil in the upper mineral layer, the A_2g horizon, and is largely associated with high amounts of washed-in peaty organic matter; in the deeper soil horizons the value is generally low, less than 10 me/100 g soil. Saturation of the exchange capacity with bases is usually low throughout the profile, with values commonly 10–20 percent in the surface peaty layer and less than ten percent in the subsoil. Under strong flush conditions, however, the level of base saturation can be greater than 50 percent. The soils are strongly acid, a reaction of pH 3·6–4·0 in the surface rising with depth to pH 5·0, and where strong flush conditions exist the value can be pH 4·7–5·0 in the surface rising to pH 6·0 in the parent material. Of the exchangeable bases, sodium and potassium are generally high in the surface and calcium and magnesium are moderate to high. The low level of saturation of the exchange complex, however, is probably a better index of the status of these soils for the supply of plant nutrients. In the mineral soil horizons exchangeable bases are usually very low, although the levels of calcium and magnesium can be moderate under flush conditions. The carbon : nitrogen ratio of the peaty organic layer is usually moderately high, 15–25, although values outside this range do occur. Total phosphorus is moderate in the peat layer but low in the subsoil, as is the readily soluble phosphorus. Extraction with the pyrophosphate and carbonate solution has indicated that under the conditions of intense gleying and strong eluviation there is no accumulation of poorly-ordered weathering products, although in the A_2g horizon about 1 percent Al_2O_3 was extracted by the carbonate solution. Hydroxyl activity in this layer as determined with sodium fluoride is, however, relatively low, but is moderate in the deeper layers.

Fleet Association

In the sands and gravels which are the parent materials of the Fleet and Glenquicken series of this association the clay content is very low, usually less than 5 percent, but it can be slightly higher where gravels are poorly sorted or morainic. The sand content is generally in the range 85–95 percent. The base exchange capacity in the surface varies considerably, ranging from 15 to 30 me/100 g soil, and is likely to be higher in the organic layer of the Glenquicken series. In the subsoil the value decreases with depth, and is commonly very low, less than 5 me/100 g soil, in the parent material. Liming probably accounts for the moderately high base saturation, 30–60 percent in the surface, and with depth the value falls gradually to less than 5 percent saturation in the subsoil. The level of soil acidity is moderate, pH 5·5–6·0, and in the profile examined almost certainly shows the effects of past liming. Of the exchangeable bases, sodium and potassium are moderate or low in the surface layer and calcium and magnesium moderate and moderate or low, respectively; in the parent material values for all bases are very low. Differences in agricultural practice account in part for the range of organic content in the A horizon in the Fleet series, while the Glenquicken series profile sampled was taken from an area recently reclaimed. Total phosphorus is generally moderate in the surface horizon, but can be moderate or low in the subsoil; the level of readily soluble phosphorus is usually low throughout the profile.

Kirkcolm Association

All the soils in this association are developed on coarse-textured materials on the Post Glacial raised beach and the clay content is usually less than 5 percent, but can be higher under conditions of impeded drainage. The sand content is usually 85–90 percent in the parent material and is considerably less in the upper horizons.

The base exchange capacity is closely related to the organic content of the soils. Where the organic matter content is high the exchange capacity is moderate, 24–40 me/100 g soil, but where the organic matter content is less than 5 percent it is low, 5–10 me/100 g soil. Most areas of this association have been cultivated and treated with lime and fertilizer and accordingly both the freely and poorly drained soils have a high level of base saturation, 60–90 percent in the surface horizons, while in the subsoil the level varies widely. Under semi-natural conditions the base saturation of the A horizon is generally in the range 20–30 percent. A number of profiles of both freely and poorly drained soils, occurring as narrow strips of land along the coast, have a very high value for exchangeable sodium in the A horizon; low values also occur, but are associated with areas somewhat more distant from the shore or with some poorly drained areas. Levels of exchangeable magnesium and potassium are usually moderate and calcium ranges widely from very low to very high. In the subsoil horizons values for all bases tend to decrease with depth to low in the parent material. Calcium carbonate occurs as shell fragments in the Kirranrae series. Under the prevailing conditions the soils are moderately acid, pH 5·0–6·4, apart from the Kirranrae series which can be alkaline. The levels of organic matter have already been discussed and the carbon : nitrogen ratio is usually low or moderately low, 10–14, although some high values are associated with organic matter accumulation in some poorly drained profiles. Total phosphorus is generally moderate, although both high and low values occur, and the level of readily soluble phosphorus has a wide range.

Rhins Association

PORTENCALZIE SERIES

In Chapter 5 reference is made to the different conditions under which the Portencalzie series occurs and some of these have relevance to the discussion here. Soils developed on the normal thick till of the Rhins Association have a clay content in the range 12–22 percent in the upper 45 cms; below this, the unmodified till with a clay content of 25–33 percent usually lies at depths between 50 to 150 cms. Where the soils are developed on shallow tills or drifts underlain by Permian strata or greywacke, the clay content is similar to that of the soils resting on deep till, generally in the range 10–22 percent throughout the middle and lower horizons, but the sand content is possibly somewhat greater, 50–80 percent. A number of the soils sampled were taken from areas mapped as intergrades between Portencalzie and Linhope series. These are usually developed on thick till deposits and indications of modification are found only in the B horizon; the till of the deeper layers has a clay content in the range 26–33 percent and between 20 and 30 percent silt (U.S.D.A.).

The base exchange capacity in the organo-mineral A horizon of these soils is moderate, usually in the range 15–25 me/100 g soil, although the value can be high in shallow highly organic surface layers occurring under woodland or other semi-natural vegetation. With depth the value decreases regularly to below 10 me/100 g soil, commonly to less than 5 me/100 g soil. Agricultural practice has strongly influenced the degree of base saturation in the surface and consequently the level is higher than it would be under semi-natural conditions; there is, therefore, a tendency to a minimum value in the B horizon, increasing to high in the parent material. Under the prevailing agricultural conditions the soils are only moderately acid, pH 5·5–6·5 in the surface, and there is either little change or no systematic change in acidity with depth. Reflecting the effects of liming, exchangeable calcium is usually high in the plough layer and decreases regularly with depth to low or moderately low in the parent material, while exchangeable magnesium and potassium are generally moderate in the surface and decrease with depth, occasionally to very low.

It has already been stated that the level of organic matter in these soils is moderate or low and the carbon : nitrogen ratio is also moderate to low, 10–15. Like so many other features of these soils, the total phosphorus status of the plough layer has been greatly affected by fertilizer application and the level is often high, whereas in subsoil horizons the value is moderate. The readily soluble phosphorus status varies widely and changes with depth are irregular.

In the field the B horizon—and also to some extent the A horizon—appears to be rich in sesquioxides, and this has been confirmed by analyses, as has the accumulation of weathering products in these soils. The pyrophosphate removed moderate amounts of aluminous and ferruginous materials from the A horizons, moderate to high amounts from the B horizon and very low amounts from the parent material. Cold carbonate solution removed 2·5 percent Al_2O_3 and 0·26 percent SiO_2 from the B horizon. Values for extractable weathering products, while showing a marked peak in the B horizon, do not satisfy the criteria for a spodic horizon, nor is there evidence of podzolization. The dithionite extractant removed large amounts of ferruginous material from most horizons of the soils in the Rhins Association, but probably as the result of attack on the red haematitic coatings of the mineral grains acquired through geological processes, and consequently values for ferruginous material extracted by this reagent cannot be taken as reflecting soil weathering or any other pedological process.

RHINS SERIES

The soils of the Rhins series are developed on the unmodified reddish brown clay loam till which characterizes both the series and the association. Below the plough layer textures are relatively uniform down the profile and the clay content is usually in the range 24–34 percent, although soils with higher or lower levels do occur. The proportion of silt (U.S.D.A.) is generally between 20–30 percent, but in some soils ranges up to 35 percent.

Soils typical of the Rhins series have moderate base exchange capacity, 14–25 me/100 g soil in the plough layer, but in profiles intergrading to those of the Ettrick Association (Chapter 5) the base exchange capacity tends to be moderately low, 10–14 me/100 g soil. With depth the exchange capacity decreases to low, 10 me/100 g soil, but no very low values, less than 5 me/100 g soil, have been found. The degree of base saturation is usually high and tends to increase somewhat with depth, while the soil is only mildly acid, pH 6·0–6·5 in the surface, and in many profiles approaches neutrality with depth. The level of calcium on the exchange complex is generally high in the A horizon, having been raised by liming, and with depth there is either a regular decrease to low or moderate in the subsoil or a minimum value in the Bg horizon followed by some increase in the underlying parent material. The value for exchangeable magnesium is in the lower part of the moderate range, 0·3–2·0 me/100 g soil, in the surface layer, declines somewhat in the B_2g horizon and then rises with depth to the middle or upper part of the moderate range, 2·0–5·0 me/100 g soil. Sodium and potassium on the exchange complex vary considerably but are commonly moderate or moderate to high in the surface and either change irregularly or fall with depth in the subsoil.

Most soils of the series are cultivated and have a moderate to low content of organic matter with a carbon:nitrogen ratio in the range 10–17, the higher ratios being somewhat unexpected in an arable soil of moderate organic content and acidity. Fertilizer application has also raised the level of total phosphorus in the plough layer, but in the subsoil values for both readily soluble and total phosphorus are generally low or moderate.

There is apparently no significant accumulation of amorphous or poorly-ordered weathering products in these soils. Extraction by the pyrophosphate solution removed only very low amounts of aluminous and ferruginous material from the subsoil layers and treatment with the carbonate solution yielded low amounts of extractable aluminous material, which is in keeping with the moderately low values for hydroxyl activity. Like other series in the association, however, the soil is characterized by relatively high amounts of ferruginous material, 1·0–1·5 percent Fe, extractable by treatment with sodium dithionite, much of which is probably derived from the red haematitic coatings on the mineral particles.

PORTPATRICK SERIES

In the upper soil horizon, derived from modified till material, the clay content is generally in the range 10–22 percent; in the deeper unmodified till layer the level can be somewhat higher. Like the Rhins series, the Portpatrick series has a moderate or moderately low value, 12–22 me/100 g soil, for base exchange capacity in the surface layer, and this decreases with depth to low, 3·0–10·0 me/100 g soil in the subsoil. The degree of saturation of the exchange complex is moderately high, 50–80 percent, in the surface, decreases slightly in the B_2 horizon, and rises to high in the parent material. The soil is only moderately acid, pH 5·8–6·5, in the surface and there is no regular trend in acidity change with depth: a few soils with a slightly higher degree of acidity have been encountered. The exchangeable calcium level is high or moderate in the plough layer, affected to some extent by liming, and decreases with depth to low in the parent material; in some profiles there is a minimum in the B_2g horizon. The other important exchangeable bases, magnesium, sodium and potassium, are generally present in moderate amounts in the surface horizon, but whereas the magnesium content generally increases with depth after a minimum in the B_2g horizon, sodium and potassium values change irregularly or fall with depth. Most soils in this series are cultivated and the organic matter content of the plough layer is moderate or low with the carbon: nitrogen ratio in the range 10–19, the higher of these values being somewhat unexpected in cultivated soils of only moderate acidity. The contents of total and readily soluble phosphorus in the plough layer have been greatly modified by fertilizer application, but in the subsoil are generally low, although the level of readily soluble phosphorus in some B_3g and Cg horizons can be very high.

Because of the conditions of moderate acidity, base saturation and impeded drainage there has been little or no accumulation of amorphous or poorly-ordered weathering products in these soils. The pyrophosphate solution removed some aluminous and ferruginous materials from the plough layer, and very low amounts from the subsoil. Extraction with the carbonate solution removed siliceous and aluminous material in only low or moderate amounts, although in the profile examined (No. 47), the lower part of the plough layer had an anomalously high value for aluminous material which did not correlate, as might have been expected, with the level for hydroxyl activity, which is moderate throughout the profile.

MULL SERIES

Developed on shallow, stony, frost-shattered rock rubble or drift, this soil has a clay content generally between 5 and 10 percent. The base exchange capacity is correlated with the content of organic matter and is moderately high in the H/Ap and B_{21} horizons but low, less than 10 me/100 g soil, in other horizons. The degree of base saturation is moderately high, 50 percent in most horizons, with a minimum value in the B_{22} horizon; the higher levels in the overlying horizons almost certainly reflect the effects of past liming. The reaction is moderate throughout the profile, rising from pH 5·0 in the surface to pH 5·7 in the parent material. The contents of all the main exchangeable bases are moderate or high in the surface layer but decrease to low below the B_{22} horizon. The organic matter content is high in the surface horizon and moderately high in the B_{21} layer but very low in the A_2 horizon, while a history of liming is probably partly responsible for the moderate value, 15, for the carbon : nitrogen ratio. The content of total phosphorus is low throughout the profile but the value for readily soluble phosphorus in the H/Ap horizon is very high and probably reflects fertilizer usage.

The podzolic nature of this profile is well shown by chemical extraction techniques. Large amounts, 4·1 percent, of organic carbon were removed by the pyrophosphate solution from the B_{21} horizon but the amounts of aluminous and ferruginous materials extracted from the B_{21} and B_{22} horizons, though only moderate, were higher than the very low amounts found in the surface H/Ap and A_2 horizons. Only the B_{21} horizon satisfies some of the requirements for a spodic horizon. Although only moderate amounts of amorphous or poorly-ordered aluminous material were extracted by the pyrophosphate solution, amounts removed from the B_{21} horizon by treatment with the carbonate solution were fairly large, 1·8 percent Al_2O_3. The hydroxyl activity in this layer, however, is only moderately high and in other B horizons the value is lower.

AUCHLEACH SERIES

This inextensive soil is developed on loamy till or drift parent materials, the Auchleach series has a uniform clay content, 16–19 percent, in the one profile analysed. The exchange capacity is moderately high, 43 me/100 g soil in the organic H/Ap horizon, moderate in the A_2g horizon and very low in the B horizon and the parent material. The soil is acid throughout the profile, pH 4·8 to 5·1, and although base saturation is low in the A_2g and B_2 horizons it is moderately high in the H/Ap and C horizons. The level of exchangeable calcium is high in the H/Ap horizon, probably reflecting past efforts at improvement by liming. The levels of exchangeable magnesium, sodium and potassium are moderate in this horizon, but decrease markedly in the subsoil horizons. The organic matter content is very high in the H/Ap horizon where the carbon: nitrogen ratio is also high. A moderate content of total phosphorus is associated with the organic layer but the amount in the mineral horizons is low.

Although the soil is classified as a peaty podzol, some mixing of the upper horizons has resulted from earlier attempts at reclamation and cultivation. In the profile analysed, results from extraction with the pyrophosphate solution do not clearly indicate that the soil is podzolic, only moderate amounts of aluminous and ferruginous materials being removed from the B horizon; in addition, these values tend to decrease gradually with depth instead of reaching a peak in that horizon. Apart from the iron pan the criteria for a spodic horizon are not satisfied in this profile. Extraction with the carbonate solution did, however, remove relatively large amounts of amorphous or poorly-ordered aluminous material, 1·5 percent Al_2O_3, from the B_2 horizon, although this is associated with only a moderately high level of hydroxyl activity.

ARDWELL SERIES AND BALSCALLOCH SERIES

The Ardwell and Balscalloch series are of the same drainage status and developed on similar parent materials, apart from some textural modification of the upper layers of till in the Balscalloch series. They are also closely related in chemical characteristics and are accordingly here considered together. The clay content in the middle and lower horizons of the Ardwell series is generally in the range 25–35 percent, although higher values are found near Marsclaugh, while in the Balscalloch series the clay content in these horizons is usually less than 25 percent. The Ag horizon has a moderate base exchange capacity, 17–26 me/100 g soil, related to some extent to the amount of organic matter and generally decreasing with depth to low, 5–12 me/100 g soil, in the parent material. The degree of base saturation is high throughout the profile and commonly reaches 100 percent in the parent material, while in the surface the soil is moderately acid, pH 5·5–6·5, having been modified by lime application, and in the subsoil the reaction ranges from weakly acid to slightly alkaline pH 6·0–8·0. Calcium is by a large margin the predominant base on the exchange complex in the surface horizons and is present in high amount, 14–22 me/100 g soil, decreasing to moderate or low in the Bg horizon, and sometimes also in the underlying Cg horizon, although a small amount of free calcium carbonate is found in the parent material of some soils. Of the other exchangeable cations, magnesium is moderate to low in the surface and tends to rise with depth in the subsoil, while sodium and potassium are moderate or high in the surface and decrease irregularly in the lower horizons. Many of these soils have been cultivated and have a moderate or low organic matter content, with carbon : nitrogen ratio ranging from 10–22: the higher ratios are somewhat unusual in view of the relatively high base status. The phosphorus status of the surface horizon has no doubt been considerably modified by fertilizers. In the subsoil, however, the level of total phosphorus is generally low or moderate, while readily soluble phosphorus is generally high, although low values do occur. Treatment of selected soils with the carbonate and pyrophosphate extractants has shown that there is little or no accumulation of amorphous or poorly-ordered weathering products in any layer below the Ag horizon.

GLENSTOCKADALE AND LOCHNAW SERIES

The Glenstockadale and the Lochnaw series are both peaty gley soils and their chemical characteristics are very similar. The main difference between the series is that the upper layers of till on which the Lochnaw series is developed have been partially re-sorted, whereas the Glenstockadale series is formed on unmodified till. The clay content in the A_2g and Bg horizons tends to be somewhat lower in the Lochnaw series than in the Glenstockadale series.

Base exchange capacity is very high, 150–250 me/100 g soil, in the peaty surface layer, moderate to high, 25–80 me/100 g soil, in the A_2g horizon, mainly because of washed in organic matter, and low in the parent till. The soils are strongly acid, pH 3·6–4·0, in the organic layer, but the reaction increases consistently with depth to pH 5·2 to 5·6 in the Cg horizon. Despite the very high level of exchangeable hydrogen in the H layer, which gives rise to the strongly acid reaction, the degree of base saturation in this horizon is moderate, 30–40 percent saturation with bases. In the underlying mineral soil the base saturation falls abruptly to very low, rising somewhat in the Bg horizon and markedly in the parent material to moderately high, 40–60 percent. In comparison with mineral soils, the content of all the nutrient cations on the exchange complex of the peat layer is high, but the high level of acidity probably correlates more accurately with the status of the soil as a plant nutrient medium. In the A_2g and Bg horizons the amount of exchangeable nutrient bases is low, but in the parent till the value for these bases is moderate.

As expected in the strongly acid conditions of the surface horizon the carbon : ratio of the organic matter is high or very high, 20 to 30. The organic layer also shows marked accumulation of total phosphorus, a high proportion of which is readily soluble, but in the mineral horizons the content of both fractions is low. Treatment of a profile (No. 91) of the Glenstockadale series with the pyrophosphate solution removed fairly low amounts of iron and aluminium from the mineral soil horizons; except in the A_2g horizon from which almost 1·0 percent Al was extracted. The carbonate solution also removed from this layer a considerable amount, >1·0 percent, of amorphous or poorly-ordered aluminous material. It is possible that part of the aluminous material removed by both extractants is associated with the exchange complex. The levels of hydroxyl activity are moderate throughout the profile.

Stirling Association

The series of the Stirling Association are closely related and accordingly are discussed together. One of the principal differences between the constituent series of the association is their texture: the Stirling and Poldar series are the finest textured, with clay contents in the upper subsoil layers of 35–45 percent and sand, 11–15 percent, almost entirely fine sand. In contrast, Fordel series has a high proportion of silt, 40–60 percent, and fine sand, 30–40 percent. In the Newton Stewart series particle size distribution is intermediate between these two.

In the Stirling series the percentage of fine clay ($< 0\cdot 5\mu$) as a proportion of the total clay is at a maximum in the B_2g horizon. It is notable that in profile No. 82 the fine clay is 54 and 46 percent of the total clay in the surface and Cg horizons respectively, but is 63 percent in the B_2g horizon. It cannot be concluded on this basis that the fine clay maximum in the B_2g horizon is due to pedogenic factors alone, since local variations within the parent material, of recent sedimentary origin, are to be expected. Although the precise reason for this effect cannot be fully established, the result is none the less of considerable practical significance.

The exchange complex in soils of this association is highly saturated in the A horizon, 70–90 percent, and becomes fully saturated in the subsoil; in the peaty horizon of Poldar series saturation can be somewhat less than in the mineral soils. The base exchange capacity of the Ag horizon is generally moderate or moderately low, 12–21 me/100 g soil, in association with low amounts, less than 8·0 percent, of organic matter, but where the organic matter content is high, values for exchange capacity can be higher, 35–45 me/100 g soil, and in the peaty horizon of the Poldar series they are very high.

The subsoil horizons generally have a small content of calcium carbonate, probably associated with occasional shell fragments. The soils are only mildy acid or near neutral in the surface horizon, pH 6·0–6·5, although the organic horizon of the Poldar series is somewhat more acid, pH 5·5. The subsoil horizons are generally neutral, but some are weakly alkaline. Calcium is the predominant base on the exchange complex throughout the profile and levels of magnesium, sodium and potassium are moderate; in about 50 percent of the profiles sampled the exchangeable magnesium increases with depth to high values. The generally low and occasional high values for the content of organic matter in the A horizon of the mineral soils has already been mentioned. The carbon : nitrogen ratio of the original material is generally low to moderate, 10–13, but can be higher, 14–18, and in the peaty layer of the Poldar series is very high. Below the A horizon, which has been modified by fertilizer application, the content of total phosphorus is generally low, but values for readily soluble phosphorus range from low to high, with high values fairly common.

That the content of amorphous and poorly-ordered aluminous or ferruginous weathering products in these soils is extremely low has been determined by extraction with the pyrophosphate solution. Treatment with the carbonate solution confirmed that amounts of poorly-ordered aluminous material in these soils is low, but removed amounts of siliceous material which are moderate or relatively high in comparison with other soils in the area. The levels of hydroxyl activity, while they vary considerably, are in moderate range and are presumably associated with soil clays and not with amorphous or poorly-ordered materials.

Yarrow Association

In this area the Yarrow Association comprises soils developed on coarse-textured water-laid deposits—sands and gravels—with the differences between series of the same major soil sub-group mainly in physical properties, stoniness being one of the more easily recognized. In discussing the chemical properties of soils in this association, therefore, series in the same major soil sub-group are considered together.

YARROW AND CAIRNSIDE SERIES

The parent material of both Yarrow and Cairnside series is very coarse-textured, sand content being 85–95 percent and silt and clay each about 5 percent or less. In the upper horizons of some soils, however, there is a greater proportion of finer sized fractions. In both series most soils have been cultivated and have a low or moderate amount of organic matter and, in the A horizon, a moderate to low base exchange capacity, 8–15 me/100 g soil, the value decreasing with depth to very low, less than 5 me/100 g soil. Soils under semi-natural conditions with a high amount of organic matter in the surface layer can show a moderate to high exchange capacity. The degree of base saturation and levels of soil acidity in the surface soils have been markedly altered by application of lime. Base saturation, however, is generally in the range 30 to 70 percent in the surface, with the value usually decreasing to very low, less than 5 percent in the parent material, although in a few subsoils with low exchange capacity, small amounts of bases give rise to a high level of base saturation. Under semi-natural conditions the soils are strongly acid, pH 4·5–5·0, but agricultural improvments have generally somewhat reduced the acidity of the surface layer, pH 5·5–6·0, with some soils having a near neutral reaction. In the C horizons the reaction is usually in the range pH 5·5–6·0. Of the bases on the exchange complex calcium is usually high in the A horizon, reflecting a history of lime application, with occasional moderate or low values. Exchangeable magnesium is in the range 0·2–1·0 me/100 g soil, while sodium and potassium values have a wide range but are most commonly low. The subsoil layers, particularly the C horizon, are extremely low in all nutrient bases. As already mentioned, the organic matter content of these soils has been affected by cultivation and liming and is low or moderate, while the carbon : nitrogen ratio is generally low, 10 to 13, although higher ratios do occur. Total and readily soluble phosphorus in the A horizon are largely a reflection of the agricultural management of the soils, while in the B and C horizons the phosphorus status is usually low.

The profiles examined showed a considerable range in amounts of readily extractable amorphous or poorly-ordered weathering products. A profile (No. 25) of the Yarrow series sampled from beech and oak woodland gave levels of iron and aluminium, extracted by the pyrophosphate solution, with strongly marked peak values in the B horizon which satisfy some of the criteria for a spodic horizon. These high amounts of weathering products have been confirmed by the extraction with the carbonate solution which removed 2·5 and 3·0 percent

Al_2O_3 from the B horizon and, as determined by treatment with sodium fluoride, the high levels of amorphous and poorly-ordered materials are associated with the high levels of hydroxyl activity, 160 and 190 me/100 g soil.

The results for a profile of Cairnside series (No. 28) treated with similar extractants are very different from those for the Yarrow profile. Only moderate amounts of iron and aluminium were removed by the pyrophosphate solution and show no marked peak in any layer. The moderate content of amorphous and poorly-ordered material in this profile has been confirmed by extraction with the carbonate solution, which removed little aluminous or siliceous material, and by the moderate levels for hydroxyl activity. The behaviour of all the horizons of this profile with these extractants closely resembles that of immature soils and of the parent materials of free draining soils.

CARSNAW, GALDENOCH AND CAILLINESS SERIES

The sand and gravel parent materials which carry the Galdenoch and Carsnaw series generally contain less than 5 percent clay and similarly low amounts of silt. The parent material of the Cailliness series is of finer texture, with clay and sand contents in the range 15 to 25 percent.

The base exchange capacity in the surface horizon is closely related to the amount of organic matter and ranges from moderately low to moderately high, 13–30 me/100 g soil, while in the subsoil it is low or very low. The degree of base saturation is moderate to high throughout the profile, but in the surface is much affected by liming as is the level of soil acidity which is usually moderate in all horizons. Calcium is the predominant base on the exchange complex and is high in the surface layer, but is low or moderate in the subsoil. Magnesium is moderately low, 0·3 to 1 me/100 g soil in the surface and falls with depth, while sodium and potassium are moderate in the surface and low in the deeper layers.

The amount of organic matter ranges from low to high, with a moderate or low carbon : nitrogen ratio. The phosphorus status of the plough layer reflects the former fertilizer practice, but in the subsoil the value is generally low.

KNOCKAROD AND LARBRAX SERIES

As in other soils of the association the parent materials of these series have a very high sand content, approximately 90 percent, about 5 percent clay and low amounts of silt. Base exchange capacity is extremely high in the raw humus surface horizon and is also high in the A_2 and B_{21} horizons, in association with high amounts of organic matter. Except in the surface layer, where there is some biological accumulation, the degree of base saturation is very low throughout the profile, and the level of acidity is very high, pH 3·8–4·5 in the surface and decreases with depth to pH 5·0–5·5 in the parent material. Although the amounts of the exchangeable bases, calcium, magnesium, sodium and potassium in the raw humus horizons are high the exchangeable hydrogen is very much greater and probably gives a more accurate indication of the nature of the soils as media for plant growth. In the deeper subsoil layers the content of all bases is low. Except in the surface horizon where there is accumulation of organic matter in the surface, total phosphorus is low or moderate and the amount of readily extractable phosphorus is very low in all horizons.

The results of extraction with the pyrophosphate and carbonate solutions clearly confirm the classification of these soils as podzols. The values of iron, aluminium and organic carbon removed by the pyrophosphate solution are high and reach a peak in the B horizon, and also fulfil some of the criteria of a spodic horizon. The carbonate solution extracted 1·0–1·5 percent Al_2O_3, amorphous or poorly-ordered material, from the B horizon, but a higher amount was removed from the C horizon which also showed the highest level of hydroxyl activity.

DINDUFF AND INNERMESSAN SERIES

Gleying in these soils is the result of high ground water rather than impermeability of the subsoils which have the very high sand content, about 90 percent, and low amounts of clay and silt characteristic of the association. The base exchange capacity in the surface layer varies widely with some high values associated with organic matter accumulation, but in the subsoil values are low and relatively uniform. The degree of base saturation is generally moderate or high in the surface where it is possibly affected by liming, and low or moderate at depth. Similarly, soil acidity is moderate, pH 5·5–6·0, in the surface and changes irregularly or increases slightly with depth in the profile. High levels of exchangeable calcium occur in the surface horizon but decrease sharply on passing down into the subsoil, although the extremely low values common in the C horizons of the freely drained soils are not encountered. Except in some organic rich horizons, exchangeable magnesium in the surface layers is low or moderately low, 0·3 to 1·0 me/100 g soil, and decreases with depth. Sodium and potassium are also moderate or low, decreasing with depth to very low, but surface layers with high contents of organic matter can show high values. The organic matter content of the upper horizons ranges widely as does the carbon : nitrogen ratio. Total phosphorus is very low in the subsoil but biological accumulation and fertilizer application give moderate levels in the Ag horizon and the generally moderate amounts of readily soluble phosphorus are sometimes very high in the surface horizon.

Links

Links soils are immature and profile development is restricted to the accumulation of some organic matter in the surface. The parent material, aeolian sand, is 97 percent sand with about 2 percent clay. Except in the A horizon where some occur in association with the organic matter the soil is extremely low in all exchangeable bases. The accumulated organic matter is also largely responsible for much of the exchange capacity of the soil which generally is very low throughout the profile, although in the surface it can range up to 8 me/100 g soil. The degree of base saturation ranges widely but because of the very low exchange capacity the values have little significance. The soil reaction is acid throughout the profile, generally in the range pH 4·7–5·5. The accumulation of organic matter ranges from 1 percent to 4 percent, with some high values occurring under poor and very poor drainage conditions. The total phosphorus status is low, but moderate amounts of readily soluble phosphorus are sometimes found. The chemical features of soils in the Links group apparently vary little with changing drainage conditions, apart possibly from the organic matter accumulation in some poorly drained soils. Gley features are, however, strongly developed under conditions of waterlogging and elements capable of several oxidation states are probably in the reduced form.

Saltings

The estuarine alluvium which forms the parent materials of these immature saline gley soils is characterized by very high, 40–55 percent, silt (U.S.D.A.) content. The amounts of clay range widely from 5 to 33 percent, with the higher values occurring in surface horizons of soils located near the high water mark of ordinary spring tides and the lowest values restricted to soils near the low water mark of ordinary spring tides or to the deeper horizons of other soils.

The soil is regularly inundated by the sea and has a high content of water-soluble chloride, 10–25 me/100 g soil, associated with sodium and other cations. Free calcium carbonate is present as shell fragments below 40 cm. The soil reaction is generally alkaline, pH 7·0–8·2.

The amount of organic matter accumulated in the surface horizon of these young soils is usually low, between 2 and 6 percent, but in some soils near the high water level the value can be higher. The steady deposition of sediment has led to the incorporation of small amounts of organic matter throughout these soils. Carbon : nitrogen ratios are low, in the range 10–13, but values of 13 to 16 occasionally occur. The total phosphorus status is low or moderate and the amounts of readily soluble phosphorus are moderate, 3·0–8·0 mg P_2O_5/100 g soil.

Alluvium

Alluvial soils occur under a wide range of conditions and show considerable variation from one location to another. Most commonly in the middle and upper reaches of water courses the amount of clay in the surface layer is moderate, 14–22 percent, declining to less than 10 percent in the more coarse-textured subsoils. In the broader alluvial tracts at low elevations the amount of clay in the surface is greater, 20–33 percent, but also decreases with depth. The base exchange capacity varies considerably according to the extent of clay and organic matter accumulation but is generally in the range 15–30 me/100 g soil and decreases in the more coarse-textured subsoils to low values. The degree of base saturation ranges considerably but is usually moderate, about 50 percent saturation, although some areas along the lower reaches of the Rivers Cree and Bladnoch are completely saturated with bases and the extremely high levels of exchangeable sodium suggest the soils have been reclaimed from saltings. Except in these somewhat exceptional areas, soil acidity is generally moderate, pH 5·0–6·0, throughout the profile.

In most soils the amounts of exchangeable bases are moderate in the surface and decrease to low with depth, but there are notable exceptions, such as those soils taken in from former saltings, where the content of exchangeable bases is very high, and the broad alluvial area along the Piltanton Burn where, apart from a high amount of calcium in the surface, the content of exchangeable bases is very low. The accumulation of organic matter in alluvial soils varies widely, but is generally from 5 to 20 percent. Total phosphorus is generally medium to low throughout the profile, but high amounts were found in one profile, while readily soluble phosphorus can be high in the surface, but is moderate or low in the subsoil.

Peat

Peat occurs extensively throughout the area, in situations ranging from depressional to upland. The peats are generally very strongly acid, pH 3·7 to 4·2, varying little with depth. In some areas affected by flush waters and in very depressional sites the degree of acidity is less, pH 4·5–5·5, sometimes decreasing with depth. The cation exchange capacity is naturally very high, 80–200 me/100 g soil, throughout. In the most acid peats the amount of exchangeable calcium is moderate or low and is exceeded by the value for exchangeable magnesium which is high. The less acid peats affected by flush waters or occurring in very depressional sites show a high or extremely high, 10–55 me/100 g soil value for exchangeable calcium which greatly exceeds the moderate to high level of exchangeable magnesium. The amount of exchangeable sodium is generally high, 0·3–2·0 me/100 g soil, and changes little with depth, while the value for potassium is most commonly moderate and with depth shows a decreasing trend.

The peats generally contain a low amount of total phosphorus but the value can be high in flushed or in some low lying sites, while the level of readily soluble phosphorus is usually low.

MAJOR SOIL SUB-GROUPS: SUMMARY OF ANALYTICAL DATA

Brown Forest Soils, Freely Drained

The brown forest soils are developed on parent materials ranging in texture from coarse to medium. The coarse-textured materials are mainly sands and gravels with less than 5 percent clay, while the more extensive materials are sandy loam and loam drifts and tills having 10–20 percent clay; in a few finer textured tills, the amount of clay is 20–27 percent.

In the mineral A and Ap horizons the cation exchange capacity is generally in the moderate range, 15–30 me/100 g soil, and is strongly influenced by the content of clay and organic matter. Soils under semi-natural conditions commonly have a high amount of organic matter in the upper 5–10 cms of the A horizon and, on occasion, a weakly developed thin H horizon or raw humus; in these horizons, base exchange capacity can be high, 30–50 me/100 g soil. With depth, in parallel with the decline in the content of organic matter, the exchange capacity decreases to low, less than 10 me/100 g soil, and in coarse-textured materials to less than 5 me/100 g soil. The degree of saturation of the exchange complex has been much modified by agricultural practices and especially lime applications, and in enclosed cultivated areas can range in the A and Ap horizons from moderate to high, 30–90 percent saturation. In semi-natural grassland soils the proportion of bases on the exchange complex of the A horizon is low to moderate, 8–25 percent, but can be higher in organic L, F, and H horizons. With depth in the profile the degree of base saturation usually tends to decrease markedly to very low or low values, less than 5 or 10 percent saturation, but occasional moderate values, 30–60 percent are encountered, and in the Portencalzie series the base saturation shows no marked trend with depth and is generally high, more than 50 percent, in the parent material. Soil acidity in the A horizon is of course also much modified by liming and where improvements have been carried out is usually moderate, pH 5·5–6·0, although it is higher, pH 5·5–6·6, in the Portencalzie series. Semi-natural soils show considerably greater acidity, usually in the range pH 4·5 to 5·5. In soils with acid or intermediate parent materials, the soil reaction tends to rise with depth.

The content of exchangeable bases is varied, particularly in agriculturally improved areas, but under semi-natural conditions the values for exchangeable calcium and magnesium are low or moderate in the A horizon and decrease with depth to very low. In some thin surface layers the content of bases can be higher, with exchangeable sodium and potassium moderate or high in contrast to the lower amounts in cultivated soils.

The organic matter content of the surface mineral horizon is generally high, 13–20 percent, under semi-natural conditions but falls to moderate, 8–13 percent, where cultivation is common and can be low on some sandy soils. The carbon : nitrogen ratio is usually moderate, 12–15, but sometimes higher or lower if associated with unusually high or low amounts of organic matter. Total phosphorus is generally moderate in the surface horizon with some high contents in cultivated soils. Values for total phosphorus show a declining trend with depth. Readily soluble phosphorus is usually low throughout the profile but some higher values occur in shallow H layers as a result of fertilizer usage.

Extraction of the soils with the pyrophosphate solution removed iron and aluminium from amorphous and poorly-ordered weathering products; the amounts of these appear to be moderate in the A horizon with high peak values in the B horizons. The criteria for a spodic horizon appear to be partially satisfied in some soils but not in others. Some relatively young sandy soils give only low values. Treatment with the carbonate solution also removed moderate to high amounts of amorphous and poorly-ordered aluminous materials, 6–10 m moles Al_2O_3/100 g soil from the B horizon: these values are correlated with moderate and very high levels of hydroxyl activity in the A and B horizons respectively. These soils appear to have relatively high amounts of amorphous or poorly-ordered sesquioxidic weathering products in the A and B horizons with peak values in the latter but the extent of eluviation and illuviation, if any, is uncertain.

Brown Forest Soils with Gleyed B and C horizons

The tills of firm consistence and apparently high bulk density which form the parent materials of most of the brown forest soils with imperfect drainage in this area have a clay content in the range 20–33 percent; occasionally higher values are found in lacustrine materials and, more commonly, lower values of 10–20 percent are encountered in some stony drifts and modified tills. A few brown forest soils with gleyed B and C horizons developed on coarse-textured materials, have less than 10 percent clay in the C horizon.

The base exchange capacity is generally in the range 15–30 me/100 g soil in the surface, declining with depth to low, 5–10 me/100 g soil in the parent material; in some stony drift materials it can be very low, less than 5 me/100 g soil. As these soils form a major part of the cultivated land in this area and have been extensively limed, the base saturation in the surface horizons is usually high, 40–80 percent, with lower values found only occasionally and restricted to less intensively farmed areas. With depth the level of base saturation shows a rising trend. Under the moderately impeded drainage conditions leaching is less intense than in the freely drained brown forest soils and soil acidity is moderate, pH 5·5–6·5, in the surface, and frequently declines somewhat with depth.

The content of exchangeable calcium is generally moderate to high in the A horizon and falls with depth, commonly to low values. The value for exchangeable magnesium is generally in the lower part of the medium range in the surface, 0·3–1·5 me/100 g soil, and rises with depth to medium or high, except in the Altimeg and Arkland series where there is usually little change. Exchangeable sodium and potassium both vary greatly in amount and the trend with depth tends to be irregular.

The organic matter content ranges from low to high, 6–16 percent, with the carbon : nitrogen ratio usually between 10 and 15, although a few values up to 18 occur. Total phosphorus, which is moderate in the A horizon, can fall to low in the subsoil whereas readily soluble phosphorus, which is low in the surface, usually rises in the subsoil. Cultivation and fertilizer usage can significantly influence this pattern.

The soils appear to contain only small amounts of amorphous and poorly-ordered weathering products in the layers below the surface A horizon. The amounts of siliceous and aluminous materials extracted with the carbonate solution show a range of moderate to low values with little discernible pattern, while the values for sesquioxidic materials extracted by the pyrophosphate solution are low. As would be expected from these findings, the hydroxyl activity value tends to be moderate or low in all horizons.

Humus-iron Podzols

Humus-iron podzols, relatively inextensive in this area, are developed on coarse-textured parent materials with 10 percent or less of clay and high or very high amounts of sand. The value for base exchange capacity in the surface raw humus layer is very high and tends to vary directly with the content of organic matter. In the mineral horizons the exchange capacity decreases with depth but is high in the A_2 and B_{21} horizons because of washed in and illuviated organic matter: the value is very low, less than 5 me/100 g soil, in the parent material. Saturation of the exchange complex with bases is low to moderate, 15–30 percent in the surface horizon under natural conditions and is very low in the subsoil layers; the value can be higher where base exchange capacity is extremely low, less than 1 me/100 g soil. The soils are extremely acid, pH 3·8–4·5 in the H layer, the acidity decreasing with depth to pH 5·0–5·5 in the parent material. The content of exchangeable bases in the H layer is high but the low level of base saturation probably more accurately reflects the nutrient supplying power of the soil. In the subsoil horizons the amount of nutrient bases is very low.

The H horizon is, of course, largely organic and relatively high amounts of black organic matter appear to have been washed in and disseminated through the eluvial A_2 horizon and the upper part of the B horizon. The carbon:nitrogen ratio is high, in the range 20–30, but can be lower where lime has been applied in the past.

Nutrient turnover and biological accumulation tend to give a moderate amount of total phosphorus and a high level of readily soluble phosphorus in the raw humus horizon, but in the mineral horizons the content of both forms of phosphorus is low.

Amorphous and poorly-ordered weathering products are low in the H and A_2 horizons but in the B horizon show high peak values which satisfy some of the criteria for a spodic horizon.

Peaty Podzols

The peaty podzol soils in this area are developed mainly on stony drifts with 10 percent or less of clay, but the Dod and Auchleach series also occur on tills with 15–20 percent clay. The cation exchange capacity is extremely high, 70–130 me/100 g soil, in the peaty surface horizon, although attempts at agricultural improvement generally result in a reduced content of organic matter and a lower base exchange capacity. Although markedly less than in the H horizon, the value is also high, 20–40 me/100 g soil, in the upper mineral horizon, the A_2g. In deeper horizons the exchange capacity falls to very low, less than 5 me/100 g soil, in the parent material. The degree of saturation of the exchange complex is low, 5–15 percent, in the peaty layer, and in the underlying mineral horizon it is extremely low, generally less than 5 percent, with 1 percent common. An exception is the Auchleach series (No. 60), with saturation values of 15 percent in the B horizon and 57 percent in the parent material. Except in occasional areas where improvement has been attempted, the soils have an extremely acid reaction, pH 3·8–4·4, in the surface, with acidity decreasing regularly with depth to pH 4·8–5·2 in the parent material. In the subsoil layers the value for exchangeable bases in the organic horizons is extremely low in keeping with the very high content of exchangeable hydrogen and low degree of base saturation. The content of exchangeable magnesium, sodium and potassium is moderate to high, and the value for calcium ranges widely from extremely low to high, 0·06 to 12·0 me/100 g soil. The organic matter content of the peaty layer usually ranges from 60–90 percent, with lower amounts sometimes found where cultivation has been attempted. The carbon:nitrogen ratio is high, usually between 20 and 30, with some values between 15–20 where horizons are shallow or have been disturbed. Total phosphorus is moderate in the surface layer and generally declines with depth, often to low values in the subsoil horizons, although a maximum for total phosphorus sometimes occurs in the B horizon, possibly accumulated or stabilized by sesquioxidic weathering products. Readily soluble phosphorus ranges from low to high in the organic layer but is generally low in the subsoil.

Profiles treated with the pyrophosphate and carbonate extractants show a well defined trend in the distribution of amorphous and poorly-ordered weathering products. Only small amounts of ferruginous materials are removed by the pyrophosphate solution, but rather higher, moderate amounts of aluminous materials, 0·5 to 0·8 percent Al, are removed from the A_2g horizon and relatively large amounts of sesquioxidic materials, 1·4–1·8 percent Al and 2·0–2·3 percent Fe, from the B horizon and moderate to low amounts from the parent material. These values correlate well with soil morphology and those for the B horizon appear to satisfy some of the criteria for a spodic horizon. In the profiles of the Auchleach and Carsphairn series that have been analysed and in which peaty podzol morphology is only moderately well developed, trends are much less pronounced than in those examined of the Dod series. The results for extraction with the carbonate solution show a similar pattern for amorphous or poorly-ordered aluminous materials which are moderate or low in the A_2g horizon but very high, greater than 9 m moles Al_2O_3/100 g soil, in the B horizon, with a maximum in the B_3 horizon or the upper layer of the parent material. Correlated with these high values for extractable aluminous materials are extremely high values for hydroxyl activity, 170–300 me/100 g soil.

Non-calcareous Gleys

In this area these soils are developed on parent materials with a wide textural range but are most common on loam or clay loam tills with 20–30 percent clay. In hill and upland areas non-calcareous gleys in flush sites occur on stony drifts with 7–16 percent clay, and in sand and gravel areas gleys, which occur in occasional hollows, have less than 5 percent clay.

Base exchange capacity is generally in the range 15–30 me/100 g soil in the surface horizon but higher values occur in humose layers. With depth the exchange capacity decreases, usually to less than 10 me/100 g soil in the parent material. Saturation of the exchange complex with bases is generally in the range 40 to 80 percent in the surface, with higher values where lime application has been heavy and lower values in soils in unflushed upland situations. With depth base saturation tends to increase, usually to 60–100 percent, but on very coarse-textured materials there may be a decrease to 15–30 percent. In the surface horizon soil acidity is moderate, pH 5·0–6·0, although in soils of the Stirling Association conditions are only weakly acid to neutral, pH 6·0–7·0. With depth the soil reaction tends to become less acid. Exchangeable calcium is generally high in the surface, 8–20 me/100 g soil, and falls with depth, except in soils of the Stirling Association where calcium carbonate can be present. Exchangeable magnesium, sodium and potassium generally show moderate values in the A horizon, with magnesium commonly increasing markedly with depth in loamy soils, but changing irregularly where textures are coarser, and sodium and potassium changing irregularly or decreasing.

Both the organic matter content and the carbon:nitrogen ratio vary widely in this group of soils, the higher values for the carbon:nitrogen ratio being associated with the higher contents of organic matter. Total phosphorus is moderate in the surface and decreases with depth, often to low values, while readily soluble phosphorus tends to rise with depth and high values are commonly found in the subsoil.

Only very low amounts of amorphous and poorly-ordered weathering products are extracted from these soils by the pyrophosphate and carbonate solutions, although one profile (No. 69) of the Littleshalloch series having moderately high amounts, differs markedly from other soils of the major soil sub-group.

Peaty gleys

These soils are generally developed on loam or clay loam tills or drifts with clay contents in the range 20–33 percent but they can also occur on stony drifts of coarser texture with 5 to 10 percent of clay. The base exchange capacity in the peaty surface horizon is very high, generally in the range 60–120 me/100 g soil, with some higher or lower values associated with unusually high or low amounts of organic matter. In the A_2g horizon the exchange capacity is varied and is affected by the amount of washed in organic matter but is usually between 15 and 30 me/100 g soil; in the Bg and Cg horizons it decreases to low, less than 10 me/100 g soil, or very low, less than 5 me/100 g soil. Saturation of the exchange complex with cations is usually low, 5–15 percent in the peaty layer, and very low, less than 5 percent, in the subsoil, although the Poldar series (No. 93) shows very high base saturation in the subsoil and moderate exchange capacity. The soils are commonly very strongly acid, pH 3·8–4·4 in the peaty surface horizon, but where flushing or seepage occurs conditions can be less acid, pH 4·7–5·3. With depth acidity declines somewhat and is usually one pH unit higher in the Cg horizon than in the H or A_2g horizons. In the surface exchangeable calcium ranges widely from very low to very high where flushing occurs or improvements have been attempted, but in the subsoil layers it is consistently very low. Exchangeable magnesium, sodium and potassium also are present in moderate or high amounts in the organic layer but are generally low in the subsoil with occasional moderate values.

The organic matter content of the peaty layer is in the range 50–70 percent, with occasional values outside this range, but in the A_2g horizon the range is very wide, from 6–50 percent. The carbon : nitrogen ratio is generally between 15 and 20, with a few very high values.

Total phosphorus is moderate in the organic horizon and low in the mineral horizons, while readily soluble phosphorus is generally low in all layers, except for an occasional high value in the surface or in the Cg horizon.

The amounts of extractable amorphous or poorly-ordered weathering products in soils of this sub-group are low. The pyrophosphate solution removed from all horizons only small amounts of iron but moderate amounts of aluminium, particularly from the A_2g layers. It is possible, however, that much of this aluminium is exchangeable under the strongly acid conditions. The carbonate solution removed a moderate amount of aluminium, 6–10 m moles Al_2O_3/100 g soil, from the A_2g horizon but there is no association with high hydroxyl activity as in the freely drained soils.

Sub-alpine Soils

Occurring at altitudes above 630 metres, sub-alpine soils in this area consist of soil horizons rich in organic matter lying directly on solid or coarsely shattered granite rock. Only one series belonging to this sub-group has been mapped.

Base exchange capacity is fairly high in the humose horizon, generally in the range 20–50 me/100 g soil, but tends to be lower in the H/A_2 horizons because of the lower organic matter content. The soils are strongly leached, and saturation of the exchange capacity by bases is generally less than 10 percent in the surface and less than 5 percent in the lower horizons, although in one profile (No. 94), the degree of base saturation is considerably greater, 18–30 percent saturation. This is probably caused by seepage of meltwaters from winter snow banks. Soil acidity is high, pH 4·0–4·5 in the surface and pH 4·5–4·8 in the H /B horizon. Exchangeable bases are low throughout the profile, although magnesium and sodium can be moderate and potassium high in the 2–3 cm thick surface layer. In soils affected by seepage from snow banks exchangeable calcium can be moderate or high.

The organic matter content of the humose horizons is at a maximum, 40–55 percent, in the surface 2–3 cm, and at a minimum, 8–18 percent, in the H/A_2, while in the H/B_2 layers it is 13–30 percent. Despite the very strongly acid conditions the carbon:nitrogen ratio, 15 to 20, is only moderately high. The content of total phosphorus is generally related to the organic content of the soil and is greatest, moderate or high, in the surface 2 to 3 cms and least, low or moderate, in the H/A_2 horizon. Readily soluble phosphorus is generally low, except in the surface horizons, rich in organic matter, where it can be high.

Only a small amount of amorphous or poorly-ordered siliceous material, 0·07 percent SiO_2, was removed by the carbonate solution, but the amount of aluminous material, 2·3 percent Al_2O_3, removed from the H/B horizon is relatively large, compared with the moderate amount, 0·54 percent Al_2O_3, from the H/A_2 horizon. Treatment with the pyrophosphate solution also removed high amounts of sesquioxidic material from the H/B horizon, 1·55 percent Al and 0·46 percent Fe, together with a high amount of organic matter, 2·94 percent carbon. The H/B horizon, therefore, clearly satisfies some of the criteria for a spodic horizon.

MINERALOGY OF THE CLAY FRACTIONS

According to the International System of mechanical analysis the clay fraction of soil is defined as that consisting of particles with effective diameter less than 2μ. This fraction of the soil contains a distinct group of crystalline minerals with specific properties. Clay minerals are basically hydrated silicates of aluminium, often containing significant amounts of iron, magnesium and potassium etc. Since many of them occur in the form of thin flake-like crystals they are termed, in general, layer silicates. The clay fraction is, however, rarely made up entirely of crystalline clay minerals; oxides and hydroxides of iron and aluminium, for example, goethite (αFeOOH –), hematite (αFe_2O_3) and gibbsite ($\gamma Al(OH)_3$), are commonly present, as are X-ray amorphous or poorly-ordered forms of these compounds and aluminosilicate gels. These accessory materials may occur as discrete entities or as coatings on the surface of crystalline minerals exerting an influence on the properties of the clay fraction disproportionate to the amounts actually present. Varying amounts of colloidal organic matter are also present in the clay fraction and may form complexes with the inorganic components.

Mineralogical analyses have been carried out on a selection of profiles typical of the principal soil series of the area (Appendix V, Table 25). X-ray diffraction and differential thermal analysis, established instrumental techniques, were employed. Selective chemical dissolution methods designed to characterize and quantify, (a) free ferric oxides (Bascomb, 1968, Mitchell *et al.*, 1971) and (b) poorly ordered aluminosilicates (Follett *et al.*, 1965, Perrott *et al.*, 1976) in soils have been dealt with earlier in this chapter under the appropriate soil association.

The assemblages of crystalline clay minerals can be correlated, in general, with the mineralogy of the parent materials and in most instances where these correlations obtain they are a result of direct inheritance from the parent rocks with no structural alteration of mineral structure, pedogenic processes serving in the main to produce simply variations in properties. The occurrence of X-ray amorphous or poorly-ordered inorganic material in the clay fraction of soil, is, on the other hand, most probably an effect arising principally from pedogenic weathering.

The clays from the upper horizons of the brown forest soil of the Dalbeattie Association (No. 5) contain appreciable amounts of X-ray amorphous aluminosilicate. X-ray diffraction patterns of C horizon clay, however, show some very weak reflections which could be attributed to kaolin and mica minerals. There is no evidence of either crystalline ferric oxides or of gibbsite in any of the horizons.

A brown forest soil (No. 6), a brown forest soil with gleyed B and C horizons (No. 39), and a non-calcareous gley (No. 67) of the Ettrick Association were examined. In the clay fraction, the predominant clay minerals are chlorite and mica and undoubtedly these minerals are inherited from the greywackes and shales—the rocks from which the parent materials of this association are derived. The mica mineral becomes more vermiculitic in the upper soil horizons, whereas the amount of chlorite is constant throughout the profile. There is a tendency for goethite and poorly-ordered aluminosilicate to occur in the surface horizons and this may be taken as an indication of some mineral decomposition. Kaolinite is usually present in minor amounts throughout the profiles as are quartz and feldspars. Few differences in mineralogy were observed which could be attributed directly to differing internal soil-water relations between the profiles.

The clays from a brown forest soil (No. 15) of the Kirkcolm Association developed on raised beach sands and gravels contain mainly mica and vermiculite with subordinate kaolinite and minor chlorite. Quartz and feldspars are also present. No accessory minerals were, however, observed. The clay mineralogy of this profile is remarkably uniform and the lack of differentiation can probably be accounted for in terms of the immaturity of the profile.

The clay mineralogy of three major soil groups of the Rhins Association, as reflected by a brown forest soil (No. 18), a brown forest soil with gleyed B and C horizons (No. 42) and a non-calcareous gley (No. 75), has been determined. This association is developed on a clay loam till containing greywacke stones and, as might be expected, there are similarities in the clay mineralogy with the soils of the Ettrick Association. Vermiculite is present in the clay fraction of the surface horizons of the brown forest soil and the non-calcareous gley and is most probably derived from the weathering mica. Chlorite and mica are the dominant clay minerals in almost all of the horizons of the three profiles. The only noteworthy points of difference with the Ettrick Association is that there is hematite in the imperfectly drained brown forest soil profile and a trace of smectite in the non-calcareous gley.

Only the poorly drained series of the Stirling Association developed on raised beach silts and clays was examined. The clay fraction of all the horizons (No. 81) consists essentially of mica and vermiculite with subordinate amounts of kaolinite and chlorite. The profile is unusual in being the only one of the area in which montmorillonite occurs in significant amount (<25 percent) in every horizon. Gypsum was recorded in the clay fraction of the basal horizon and may be due to the shelly material noted in this soil. Calcium carbonate was observed in the fine sand fraction of the C horizon but there is no evidence of carbonate in the clay fraction, an obvious indication of the coarse particle size of this constituent.

A brown forest soil (No. 25) of the Yarrow Association developed on gravels, derived from Ordovician and Silurian greywackes and shales, while morphologically typical of the soil series, has a somewhat unusual mineralogy. The clay fraction from the surface horizon contains a large amount of crystalline material, principally kaolin and vermiculite with some quartz and feldspar. However, the sub-surface and basal horizons contain very large quantities of poorly-ordered aluminosilicate gel material. There is little evidence of crystalline clay minerals and accessory iron and aluminium oxides are absent. No satisfactory explanation can be offered to account for this somewhat unusual phenomenon.

TRACE ELEMENTS

The trace element contents of samples from forty representative profiles have been determined spectrochemically using the methods described by Mitchell (1964). For the purposes of this report, the trace element level in a profile is indicated by the total contents of these elements in the mineral B and C horizons. This level is hereafter referred to as the total content unless otherwise stated. The overlying A horizons, comprising Ap, A_1, A_2 etc., may be modified by ploughing in cultivated profiles or by the accumulation of organic matter in uncultivated profiles. The contents of trace elements extractable by 0·5 M acetic acid (cobalt, nickel, lead, and vanadium), 0·05 M EDTA (copper, manganese and zinc), or neutral M ammonium acetate (molybdenum), especially from the upper horizons (0–25 cm), provide an indication of the plant-available portion and can be used for assessing the likelihood of problems arising from deficiencies or excesses.

More than half of the area is covered by soils mapped as complexes and mapping units other than soil series. Of the total area about one fifth is covered by peat. Soils of the Ettrick, Rhins and Yarrow Associations and their complexes which are derived from Ordovician and Silurian greywacke material, are predominant and cover over 60 percent of the total area. The soils are thus derived largely from rocks of sedimentary origin. The trace element distribution is therefore that normally found in argillaceous sediments, which generally contain levels of most trace elements near the mean content of the range found in igneous rocks. These soils, therefore, display trace element abnormalities only in exceptional circumstances. Because of the nature of their parent materials, soils of the Dalbeattie Association, derived from granitic rocks, and those of the Kirkcolm Association, derived from sands and gravels, might be expected to be low in such biologically important trace elements as cobalt and copper. Soils of these associations, however, cover relatively small areas representing 3·6 and 0·8 percent of the total respectively.

In the following accounts of the values obtained for the various associations, figures in parenthesis refer to the profiles listed in Appendix II.

Ettrick Association

The parent materials of the soils are drifts derived from Ordovician and Silurian greywackes and shales. Ten profiles of the association were examined representing the freely drained Linhope (Nos. 6, 7 and 13) and Dod (No. 58) series; the imperfectly drained Altimeg (Nos. 36 and 37) and Kedslie (No. 39) series; the poorly drained Littleshalloch (No. 67) and Ettrick (No. 71) series; and the very poorly drained Dochroyle (No. 88) series.

Total *cobalt* contents are all within the narrow range of 10 to 25 mg/kg, mean 17 mg/kg, which is in the middle of the range of 1 to 40 mg/kg commonly found in soils. Total cobalt in thirteen A horizon samples, six of which were cultivated, were rather lower at 2 to 15, mean 10, mg/kg. Although the extractable cobalt in the plough layers of five of the cultivated profiles are moderately high, in one profile (No. 36) of the Altimeg series, the level is borderline which suggests that the possibility of cobalt deficiency affecting stock cannot be ruled out.

Total *nickel* contents range from 40 to 100, mean 70, mg/kg, which is close to the average nickel content of the earth's crust (75 mg/kg) and typical for a shale. Total nickel contents of the A horizons are generally lower at 12 to 60, mean 35, mg/kg. Extractable nickel contents range from 0·12 to 1·6 mg/kg, levels which are not high enough to indicate a risk of nickel toxicity affecting vegetation.

Total *copper* contents range from 15 to 40, mean 27, mg/kg, and in the A horizons from 3 to 30, mean 21, mg/kg. Five of the ten profiles have litter humus horizons rich in organic matter, which contain from 6 to 30, mean 19, mg/kg. Total copper contents generally show little change with increase in depth and little variability between the profiles. Extractable copper contents show much greater variation ranging from <0·3 to 8·9 mg/kg, highest values being in profile No. 88 of the very poorly drained Dochroyle series. Extractable values in the upper horizons of all of the profiles are moderately high and in the plough layers of the six cultivated profiles are around 2 ppm or above, which suggests that problems of copper deficiency affecting cereal growth are unlikely.

Total *manganese* contents range from 300 to 1000, mean 590 mg/kg, while the mean content of the A horizon soils is 720 mg/kg. Extractable manganese contents generally decrease with increase in depth and range widely from <0·5 to 150 mg/kg. In one profile No. 71, of the Ettrick series, extractable manganese increases in the B horizons to 120 mg/kg, due probably to impeded drainage conditions. The ploughed layers of the six cultivated profiles have extractable manganese contents of 21 to 150, mean 75, mg/kg, and pH values ranging from 5·0 to 6·4, so problems of manganese deficiency affecting crops are unlikely.

Total *molybdenum* contents of the samples varied between 1 and 8 mg/kg and nearly all profiles included horizons containing 3 mg/kg or more. Extractable molybdenum in the cultivated upper horizons of profiles (Nos. 36 and 37) of the Altimeg series were at the top or slightly above the normal range at 0·05 and 0·08 mg/kg, suggesting the possibility of molybdenum excess in pasture herbage growing on the imperfectly or poorly drained soils of this association, a problem that could be aggravated by liming.

Total *lead* contents ranged from 4 to 80 mg/kg, mean, 17 mg/kg, which is close to the crustal abundance figure for lead of 13 mg/kg. Higher values of up to 200 mg/kg were found in the A horizons and organic surface horizons. Extractable lead figures varied from <0·08 to 3·6 mg/kg, and in any one profile, the highest values were generally in the upper horizon. Extractable *zinc* levels were of the order of 0·5 mg/kg or less in the B and C horizons of the profiles but, in the upper horizons of cultivated profiles, ranged from 0·44 to 6·0 mg/kg.

Rhins Association

The parent materials of the soils are either red-brown clay loam drifts containing mainly greywacke stones, or red-brown clay loam drifts having partially modified surface layers and other similar drifts of loamy texture. The soil parent material resembles that of soils of the Ettrick Association and total trace element contents might be anticipated to be similar. Thirteen profiles of the association were examined representing the freely drained Portencalzie (No. 18, 19 and 24), Mull (No. 52) and Auchleach (No. 62) series; the imperfectly drained Rhins (No. 41 and 42) and Portpatrick (No. 47 and 48) series; and the poorly drained Ardwell (No. 75), Ballscalloch (No. 77), Glenstockadale (No. 91) and Lochnaw (No. 92) series. All the profiles except the poorly drained peaty gleys (No. 91 and 92) have been ploughed or cultivated to some extent.

The total *cobalt* contents range from 4 to 30, mean 16, mg/kg, which is very similar to that for corresponding soils of the Ettrick Association. In the twenty-four A horizons total cobalt contents are <2 to 15, mean about 8, mg/kg. Extractable cobalt in all the samples varies widely from 0·03 to 4·2 mg/kg. In the B and C horizons of freely drained soils, extractable cobalt does not exceed 0·66 mg/kg, while those of all imperfectly and poorly drained profiles have horizons with more than 1·1 mg/kg and in one case (No. 92) up to 4·2 mg/kg. Extractable cobalt in the upper horizons of all the profiles is generally around 0·5 mg/kg or greater. In two profiles No. 52 and 92 however, extractable cobalt levels are low enough at 0·10 and 0·34 mg/kg respectively to suggest the possibility of cobalt deficiency affecting animal health.

Total *nickel* contents range from 30 to 100, mean 60, mg/kg, while those of A horizon samples range from 8 to 60, mean 33, mg/kg.

Extractable nickel contents vary widely from 0·13 to 3·3 mg/kg but are in no case high enough to cause nickel toxicity in vegetation.

Total *copper* contents are 6 to 60, mean 22, mg/kg, while the contents of A horizon samples range from 3 to 40, mean 17, mg/kg. The effect of impeded drainage on the mobilization of copper in soils of this association is clearly evident. Extractable copper in the B and C horizons of the five freely drained profiles of the Portencalzie, Mull and Auchleach series range from <0·05 to 1·6, mean 0·66, mg/kg, while in corresponding horizons of the four poorly drained profiles of the Ardwell, Ballscalloch, Glenstockadale and Lochnaw series it ranges from 1·3 to 5·9, mean 2·9, mg/kg. Extractable copper levels in the cultivated A horizon samples are moderately high and generally well above 1·5 mg/kg. In two profiles (No. 52 and 62), however, of the Mull and Auchleach series, extractable copper in the plough layers is low enough to suggest the possibility of copper deficiency in cereals arising on some freely drained soils of this association.

Total *manganese* contents range widely from 150 to 1500, mean 610, mg/kg, while those of the A horizons range from 50 to 2000, mean 650, mg/kg. Extractable manganese in the upper horizons of ten of the cultivated profiles are moderately high (24 to 170 mg/kg) and in most cases are above 50 mg/kg. These high extractable levels, coupled with soil pH values ranging from 5·1 to 6·5, suggest that manganese deficiency in crops is unlikely. In one profile (No. 52), however, extractable manganese values were very low at < 0·1 mg/kg in both A and B horizons, these low values being related to their low total contents.

Total *molybdenum* contents range from 1 to 4 mg/kg, mean 2, mg/kg, while the A horizons contain 1 to 6 mg/kg, with a mean of about 3 mg/kg. Extractable molybdenum levels in the upper horizons of the eleven cultivated profiles range between 0·02 and 0·15, mean 0·06, mg/kg. In two of these (No. 52 and 42), the levels are 0·1 mg/kg or above, suggesting the possibility that copper deficiency in cattle could be induced by high molybdenum in pasture herbage growing on these soils. Total *vanadium* contents in the sixty-seven A, B and C horizon samples of this association range from 30 to 150, mean 80, mg/kg, while the corresponding forty-seven samples from the Ettrick Association range from 50 to 150, mean 83, mg/kg, thus illustrating the close similarity in trace element content of the soils of the Rhins and Ettrick Associations.

Total *lead* contents vary between <3 and 20, mean about 10, mg/kg, while A horizon sample contents are greater and range from 15 to 60, mean 30, mg/kg. Highest levels for total and extractable lead are nearly always in the uppermost horizon of the profiles. Extractable *zinc* levels in the upper horizons of the eleven cultivated profiles vary between 1 and 12 mg/kg though seven of the values are in the range 1 to 2 mg/kg.

Dalbeattie Association

The parent materials of the soils are granitic rocks and their derived drifts, and soils of this association cover about 3·6 percent of the map area, mainly in the region to the east of Newton Stewart. Four profiles of the association were examined representing the freely drained Dalbeattie (No. 5), Carsphairn (No. 56) and Mulltaggart (No. 94) series and the poorly drained Eglin (No. 87) series. All four profiles were uncultivated and had peaty surface horizons. The soils were also highly acid with pH values of 4·1 to 5·2.

Total *cobalt* contents are 3 mg/kg or less, this being characteristic of a granite parent material. Extractable cobalt is very low throughout three of the profiles, suggesting that cobalt deficiency could arise in stock grazing herbage growing on soils of this association. In one profile (No. 5) the upper horizons have total cobalt contents of 8 and 10 mg/kg and extractable contents of 3·4 and 1·8 mg/kg respectively, both of which suggest that cobalt has been added to this soil.

Total *nickel* contents are 10 mg/kg or less throughout all four profiles. Extractable values are highest in the upper horizon of each profile but in no case exceed 0·9 mg/kg.

Total *copper* contents are also generally low at 10 mg/kg or less. The peaty topsoil horizon of each profile has rather higher total copper levels of 15, 12, 25 and 40 mg/kg, with extractable levels of 7·4, 7·1, 14 and 3·5 mg/kg respectively, which are near the top end of the normal range (0·3 to 10 mg/kg) of extractable copper in Scottish soils. If these soils were to be brought into arable cultivation, however, they might well carry plants with low copper contents, as the subsoils, particularly of profiles (No. 56 and 87), have low extractable copper levels.

Total *manganese* contents are at the low end of the normal range at 100 to 300 mg/kg while the A horizons of three of the profiles contain 60 to 100 mg/kg. The A horizons of profile No. 5 contain much greater amounts of manganese, 2000 and 1500 mg/kg, of which 650 and 120 mg/kg respectively are extractable. This is exceptional, and cannot be explained readily for this uncultivated profile, unless colluvial material high in manganese has been carried downslope or manganese has been inadvertently added to this soil. Extractable manganese levels in the upper horizons of the other three profiles are 10 to 20 mg/kg and in the B and C horizons about 1 mg/kg or less.

Total *molybdenum* contents in the upper horizons of the four profiles are 5, 2, 3 and 3 mg/kg respectively, while the B and C horizon samples contain 1 mg/kg or less. Extractable molybdenum levels are within the normal range for soils and not high enough to suggest that problems with animal health are likely to arise. Total *vanadium* contents are low, ranging from 5 to 25, mean 18, mg/kg, in the samples from all four profiles as might be anticipated in soils derived from granite.

Total *lead* contents are fairly high, consistent with the nature of the parent material, ranging from 10 to 60 mg/kg. All four profiles show strong surface enrichment of lead, the organic matter-rich upper horizons containing 150, 80, 400 and 300 mg/kg lead respectively. Extractable lead levels decrease with increase in depth in each profile and in the upper horizons are relatively high at 9·3, 4·5, 23 and 2·0 mg/kg. Extractable *zinc* levels are also moderately high at 8·2, 13, 16 and 7·9 mg/kg in the surface horizons of the four profiles and decrease sharply with increase in depth.

Stirling Association

The parent materials of the soils are estuarine Low Raised Beach silts and clays, silty clay loams and silt loams or silty fine sands. These soils cover about 2 percent of the total map area and occur mainly in the river valley between Newton Stewart and Wigtown and on low-lying land around the mouth of the river Cree. Four profiles of this association were examined, representing the Fordel (No. 79), Newton Stewart (No. 81), Stirling (No. 82) and Poldar (No. 93) series. All four profiles had high or very high silt or clay contents, were gleyed throughout their A, B and C horizons and supported a cultivated grass sward.

There is little variation in the total *cobalt* contents between profiles and values range between 6 and 20, mean 13, mg/kg. Extractable cobalt contents are moderately high throughout all four profiles ranging between 0·45 and 2·6, mean 1·0 mg/kg. The increased extractability of cobalt in soils with poor drainage is observed in the lower horizons of all four profiles, from which as much as 10 to 15 percent of the total cobalt is extractable. Extractable cobalt contents in the cultivated upper horizons are all greater than 0·8 mg/kg, thus no problems of cobalt deficiency in stock would be anticipated.

Total *nickel* contents vary between 20 and 60, mean 40, mg/kg. Extractable nickel levels are normal throughout the profiles and show little change with increase in depth. They range between 0·33 and 3·2, mean 1·6, mg/kg, at which levels problems due to nickel toxicity affecting crops would not be anticipated.

The four profiles have total *copper* contents ranging from 4 to 10, mean 8 mg/kg, and show little variation with increase in depth. Extractable copper levels are moderately high throughout the profiles ranging from 0·71 to 3·6, mean 1·9, mg/kg, and the percentage extractability of copper is generally high (mean 23 percent) being over 30 percent in the B and C horizons of profile (No. 93) of the Poldar series. No problems due to deficiency of copper in cereals would be expected.

Total *manganese* contents in all four profiles are around 600 mg/kg. Total manganese contents in all A, B and C horizon samples, with only two exceptions, range between 150 and 800, mean 480, mg/kg. The exceptions are the two C_1g horizons of the profile (No. 81) of the Newton Stewart series, described as having dark manganese oxide staining, which have total manganese contents of 2000 and 1500 mg/kg respectively. Extractable manganese levels are generally high but show considerable variation with increase in depth in each profile. Values range from 4·4 to 250 mg/kg but in each of the four profiles a B or C horizon sample is present containing at least 160 mg/kg.

Total *molybdenum* contents range from <1 to 4 mg/kg and extractable levels in the cultivated surface horizons of the four profiles are 0·02 to 0·06 mg/kg. Total *vanadium* contents show little change with increase in depth ranging from 60 to 100, mean 80, mg/kg while extractable vanadium varies widely from <0·02 to 2·7 mg/kg.

Total *lead* contents range from 10 to 30, mean 20, mg/kg. With increase in depth both the total and extractable contents show a tendency to decrease slightly, the latter ranging from 0·15 to 1·8 mg/kg. Extractable *zinc* in the cultivated surface horizons of three of the profiles are 3 to 5 mg/kg, but in profile (No. 93) of the Poldar series is greater at 30 mg/kg.

Kirkcolm Association

The parent materials of this association are beach sands and gravels and two profiles were examined representing the freely drained Kirkcolm (No. 15) and Clachan (No. 16) series. Both profiles were taken on land which had been recently ploughed.

Total and extractable *cobalt* contents throughout both profiles are 3 to 15, mean 7, mg/kg, and 0·10 to 0·86, mean 0·53, mg/kg, respectively. Extractable cobalt levels decrease with increase in depth in each profile as normally occurs in cultivated freely drained soils; in the cultivated surface horizons of both profiles, however, the levels appear to be adequate.

Total *nickel* contents change little with increase in depth throughout both profiles, ranging from 25 to 30 mg/kg, while extractable values range from 0·12 to 1·3 mg/kg.

Total *copper* contents in the C horizons of both profiles are rather low at 6 and 3 mg/kg respectively, but in the upper horizons there is a considerable difference, 25 and 6 mg/kg, which cannot be accounted for by the presence of organic matter. The clay contents, however, are much greater in the upper horizons of profile No. 15, which is a sandy loam rather than a sand in texture, and this may account for their higher copper contents. There are also large differences in extractable copper which, in the plough layers of profile No. 15 of the Kirkcolm series, are moderately high at 5·8 and 6·0 mg/kg, whereas throughout profile No. 16 of the Clachan series the values are less than 1 mg/kg. This suggests that copper may have been added to profile No. 15 and that cereals may respond to addition of copper if grown on soils of the Clachan series.

Total and extractable *manganese* contents are much greater in the cultivated horizons of profile No. 15, at around 2000 and 230 mg/kg respectively, than in those of profile No. 16 at about 300 and 30 mg/kg. These differences, as suggested above for copper, may be due to the higher clay content of soils of the Kirkcolm series or possibly to the addition of manganese to this soil.

Total *molybdenum* contents are moderately high at about 4 mg/kg throughout each profile. Extractable molybdenum in the upper cultivated horizon of the profile (No. 15) of the Kirkcolm series is also moderately high at 0·09 mg/kg whereas in the corresponding horizon of profile No. 16 it is about normal at 0·02 mg/kg. Total *vanadium* contents are similar throughout both profiles at 40 to 60 mg/kg.

Total *lead* contents in the C horizons of both profiles are 8 mg/kg, but are considerably greater in the cultivated A horizons at 30 and 100 mg/kg. Extractable lead values are also greatest in the cultivated A horizons at 0·35 to 0·77 mg/kg. Extractable *zinc* values in these same horizons are within the normal range at 3·6 to 7·2 mg/kg.

Yarrow Association

The parent materials of this association are fluvioglacial and Upper Beach sands and gravels derived largely from Ordovician and Silurian greywackes. The soils occur most extensively across the isthmus south-east of Stranraer, along the coastal fringes, and also along the valleys of the rivers Luce and Cree. Seven profiles of the association were examined representing the freely drained Yarrow (No. 25 and 26), Cairnside (No. 28), Knockarod (No. 53) and Larbrax (No. 54) series; the imperfectly drained Galdenoch (No. 51) series; and the poorly drained Dinduff (No. 84) series.

Total *cobalt* contents are similar to those of the Ettrick and Rhins Association soils, ranging from 3 to 25, mean 12, mg/kg. Cobalt contents of the ten samples of A horizons are generally slightly lower at <3 to 20, mean 8, mg/kg. Extractable cobalt contents vary widely from 0·10 to 1·5 mg/kg but levels in the cultivated surface horizons of profiles (No. 26, 28, 51 and 84) are adequate.

Total *nickel* contents are 20 to 100, mean 66, mg/kg, and in the A horizon samples 15 to 80, mean 39, mg/kg. Extractable contents vary widely from 0·19 to 4·5 mg/kg, the latter value being in the poorly drained profile (No. 84) of the Dinduff series where nickel has been mobilized by impeded drainage conditions. This amount, however, should not cause toxicity problems in the growth of vegetation.

Total *copper* contents range from 4 to 25, mean 13, mg/kg, while those of the corresponding A horizons range from 4 to 30, mean 15, mg/kg. Extractable copper varies widely from 0·32 to 29 mg/kg, the very high value being in the litter horizon of the uncultivated profile (No. 25) of the Yarrow series. Extractable copper levels in the upper horizons of the four cultivated profiles are between 1·7 and 2·7 mg/kg, suggesting that no copper deficiency problems should arise in the growth of cereals.

Total *manganese* contents range from 150 to 1000, mean 500 mg/kg, while those of the corresponding A horizons range from 100 to 1200, mean 510 mg/kg. Extractable manganese contents vary widely from < 0·5 to 340 mg/kg, the very high value being in the litter horizon of profile No. 25. In the four cultivated surface horizons levels are 20 to 40 mg/kg.

Total *molybdenum* contents range from 2 to 8, mean 4·3, mg/kg, while those of the corresponding A horizons range from 2 to 10, mean 4, mg/kg. Although some of these total figures are above normal, the extractable molybdenum values of 0·02 to 0·06 mg/kg in the surface horizons of the four cultivated profiles do not suggest that animal health problems are likely to occur unless molybdenum uptake by pasture herbage is increased by liming. Total *vanadium* contents range from 40 to 100, mean 70, mg/kg. Extractable vanadium ranges between <0·02 and 3·7 mg/kg, the highest levels being in samples from the poorly drained profile (No. 84) of the Dinduff series.

Total *lead* contents range from 10 to 60, mean 17, mg/kg, while in the corresponding ten A horizon samples they vary from 15 to 200, mean 60, mg/kg. Extractable lead values are about 0·5 to 1·5 mg/kg in the upper horizons of all seven profiles. Extractable *zinc* levels are around 30 mg/kg in the organic H horizons of the three uncultivated profiles, but much lower at between 2 and 3 mg/kg in the cultivated upper horizons of profiles No. 28, 51 and 84.

Soils of the Ettrick, Rhins and Yarrow Associations are developed on greywacke parent materials derived from the same geological formations and their total trace element contents might therefore be anticipated to be similar. This was found to be the case for total cobalt, copper, manganese, molybdenum, nickel, lead and vanadium, the levels of these elements also being similar to those found in soils of the Ettrick Association from adjacent areas covered by Sheets 7 and 8. The results indicate that few problems of deficiency of copper and manganese in crops are likely to be encountered in this area. Deficiencies of cobalt affecting ruminant animals could occur in soils of the Dalbeattie Association and, although unlikely, cannot be entirely ruled out on some freely drained soils of the other associations. Molybdenum levels are moderately high in some of the soils derived from greywacke parent material, particularly those of the Rhins Association, and it appears possible that this could give rise to induced copper deficiency problems in animals especially after liming of the soils. Toxicity problems arising from excess nickel, lead or zinc are unlikely to occur.

SUMMARY OF ANALYTICAL METHODS

1. Soil separates (sand, silt and clay) were determined by a modification of the hydrometer method (Bouyoucos, 1927a, 1927b)
2. The exchangeable cations were determined in a neutral normal ammonium acetate leachate, calcium, sodium and potassium being determined by flame photometry (Ure, 1954) and magnesium by direct photometry (Scott and Ure, 1958)
3. Exchangeable hydrogen was determined by electrometric titration of a neutral normal barium acetate leachate (Parker, 1929). pH was determined in aqueous suspension by means of the glass electrode
4. Total carbon was determined by a wet combustion method using standard potassium dichromate solution (Walkley and Black, 1934)
5. Total nitrogen was determined by a semi-micro- Kjaldahl method (Markham, 1942)
6. Total phosphorus was determined by a colourimetric method using hydrazine sulphate, after fusing the soil with sodium carbonate (Muir, 1952)
7. Readily soluble phosphorus was determined colourimetrically in a 2·5 percent acetic acid extract (Williams and Stewart, 1941)
8. The distribution of pyrophosphate-extractable iron and organic carbon in organo-mineral soil samples was assessed using the method of Bascomb (1968)
9. Free ferric oxide associated with the inorganic fraction of the soil was determined by the dithionite method of Mitchell *et al.* (1971)

10. The "active fraction" of aluminosilicates, that is, the silica and alumina extracted by very mild alkali treatment was determined by the method of Follett *et al.* (1965)
11. The action of sodium fluoride solution on poorly-ordered inorganic gel systems in soils was determined by the method of Perrott *et al.* (1976)
12. Particle size distribution within the clay fraction was determined using a centrifugal particle size analyzer and a modified procedure of Slater and Cohen (1962)
13. The trace element determinations were made spectrochemically according to the methods described by Mitchell (1964)
14. The mineralogy of the clay fractions was determined by differential thermal analysis and X-ray diffraction. Differential thermal curves were determined according to the methods described by Mitchell and Mackenzie (1959). Diffraction patterns of the soil clays were obtained on film with a Raymax 60 X-ray generator.

11 | Land-Use-Capability

The object of a land-use-capability classification is to arrange areas of land into groups according to their characteristics and potential for the growth of agricultural crops and, to some extent, of trees. The crops considered in classifying land in Scotland are the arable crops common in Britain and maps are produced showing the classified land areas.

The system of land-use-capability classification (Bibby and Mackney, 1968) is a modification of that used by the Soil Survey of the U.S.A. (Klingebiel and Montgomery, 1961). In general principles it is the same as that used in compiling the map for the Girvan and Carrick district (Bown, 1969, in Bown, 1973) to the north of the present area, but since then a classification for climatic factors (Birse and Dry, 1970) has been developed and this, together with the extension of the range of crops considered from those confined to a region within Scotland to those for Britain as a whole, has brought about some changes in the detailed application of the system. The arrangement of the map key has also been modified to conform with that adopted generally in Scotland.

The classification is based on the principle that land capable of the whole range of uses common in Britain is placed in the first or highest class. When the character of the soil or conditions of site impose burdens of special cultivation practices or restrict the range of crops or the forms of land utilization possible, land is placed in progressively lower categories according to the severity of the limitations. Arable cropping requires more fertile soils and more favourable conditions of climate and slope than improved grassland, while rough grazing and forestry are possible on all sites except those where conditions for plant growth are so poor that the land can only be used for amenity purposes.

For the purpose of this classification the factors which affect crop growth are grouped under the following heads—rooting zone or soil conditions, soil wetness or moisture conditions, climate, gradient (including soil pattern effects), and liability to erosion. In addition, land use is affected by many human factors. Where land is placed in other than the highest land-use-capability class (Class 1), it means that one or more of these factors has been identified as significantly unfavourable to crop growth; such factors are termed the limiting factors. The nature and effects of these features have been described previously (Bibby and Mackney, 1969) and their agronomic significance is only briefly commented on below.

Human Factors and Underlying Assumptions and Qualifications of the Classification

On individual farms the use to which land is put can be greatly affected by the individual farmer, his wishes and skill, and the amount of working capital available. The practicability of improvement may also be influenced by the system of land ownership. Lack of a good network of roads can make the use of agricultural machinery and the removal of harvests difficult, while proximity to a large urban area giving a ready market for the produce may affect the choice of crops. These factors are short term in the context of land classification and they are not taken into account.

Land, however, must be managed to some level and in this classification it is assessed on its capability under a moderately high level of management (Bibby and Mackney, op. cit.).

Another assumption underlying the classification system is that such improvements as can be undertaken at reasonable cost by individual farmers acting alone have been effected. Improvements requiring to be carried out on a regional scale are not taken into account, however, and if effected later may change the classification.

It should be emphasized that the system is not a soil suitability classification for specific crops or use, a qualification of particular importance in the present area. Early potatoes are a high value crop grown in south-west Scotland under specialized conditions of climate and soil, and the early-potato land is some of the most valuable in the area, yet the freedom from early frosts which characterizes this land is not of comparable advantage to other crops and thus has little effect on the general land capability rating. The difficulty of indicating specially advantageous factors and the areas in which they operate, is a feature of the structure of the classification. The main early potato areas in this region have been indicated on the map by use of an additional symbol.

Wetness

Unfavourable hydrologic conditions in the soil can be the result of either an excess or a deficiency of soil moisture. Inadequate water supply is usually associated with climate or with soil characters causing low waterholding capacity, and the resultant limitations in land use are considered under these heads.

Excess soil water can restrict opportunities for cultivation, delay sowing of spring crops, cause denitrification, late germination and spring growth, lead to puddling of surface soils and formation of cultivation pans, and reduce rooting depth and drought resistance. Use of harvesting machines can be difficult on wet land and this may restrict the choice of crop, particularly in regard to late-maturing roots; crops for winter feed for consumption on the land may also be inadvisable. Wet land also demands expenditure on the installation and maintenance of drains.

Wetness of land has many causes, including, for instance, slow permeability occasioned by fine texture, induration or other pans, high ground watertable and flooding. High rainfall and low temperatures can also produce wet and unfavourable soil conditions, generally by inducing the formation of peat layers, the high waterholding capacity of which intensifies conditions of excessive moisture. Peat formed in this manner and associated with poor climatic conditions is also unfavourable to improved forms of agriculture because of its high acidity, low nutrient content and low bearing strength when wet for machines and stock.

Soil Conditions or Root Zone Characters

Unfavourable soil characters are shallowness, stoniness, poor soil texture and inherent low fertility.

Shallowness. The meaning of soil depth differs in pedologic and agronomic contexts, but for land-use-capability studies it is taken as the depth to which plants can root easily. Restriction of the normal rooting depth is generally due to the occurrence near the surface of bedrock, an indurated layer or an iron pan. Other soil layers or material, though not generally accepted as indurated, may have high bulk density values and while not entirely preventing root penetration may, nevertheless, be very poor rooting media. Rooting depth is also restricted in waterlogged soils, but in this case wetness is taken to be the limiting factor.

The detrimental effects of shallow soils are generally the result of low waterholding capacity and reduction in nutrient uptake because of the restricted volume of soil available to plants.

Stoniness. Stones influence crop production, mainly through their effect on the use of farm machinery. Small stones interfere with cultivation and with mechanized harvesting, particularly of root crops. Large stones and boulders may preclude mechanized cultivation. Stones also affect growth directly by restricting the soil volume available for waterholding and nutrient supply.

Soil Texture and Structure. Unfavourable cropping conditions are associated with both sandy and clayey soils. Sandy soils have a low waterholding capacity and can have a somewhat low content of plant nutrients. Fine-textured soils are likely to be slowly permeable and to have coarse cloddy structures which, over a wide range of moisture contents, can be easily damaged. Where soil organic matter is low these unfavourable effects are intensified, particularly in the case of the poor structure associated with fine sandy silt soils. These soils become massive and dense under the action of rainfall and as they dry cappings form which both hinder plant emergence and damage seedlings.

Soil Fertility. Inadequate nutrient-supplying power in soils can usually be corrected, or at least greatly ameliorated, by suitable manuring.

Gradient and Soil Pattern Effects

The agricultural significance of gradient is usually expressed in terms of the effect of slope on the use of farm machinery, operations becoming progressively more difficult and restricted as gradient becomes more severe. In the slope classification (Bibby and Mackney, 1969) given below, an attempt is made to identify gradients necessitating significant changes in farming practice.

Gently sloping 0–3°	presents no obstacles to agriculture
Moderately sloping 3–7°	operation of specialized row root crop machines may be difficult
Strongly sloping 7–11°	use of the combine harvester and two way ploughing becomes difficult
Moderately steeply sloping 11–15°	movement of loads becomes difficult
Steeply sloping 15–25°	normal rotations are not usually practised and grassland predominates. Ploughing is difficult on slopes over 20°.
Very steeply sloping 25° +	mechanized operations are possible only with specialized machines and pastures are usually rough.

Although slope range in the present area is wide, much of the steeper land is in hill regions with other conditions such as climate and wetness also unfavourable to arable conditions.

Limitations arising from the soil patterns of the complex mapping units are also extensive. The rock outcrops which characterize a number of mapping units considerably impede arable agriculture and in more extreme cases may preclude the use of machinery. Other limitations are caused by the intermingling of areas of freely and poorly draining soils associated with complex run-off patterns of drainage water from hillsides.

Liability to Erosion

Liability of soils to erosion is generally associated with the action of wind or water. Coastal dunes or light sandy or peaty soils are liable to movement when exposed in a dry condition to wind, certain coastal localities are subject to marine erosion, and gullying may take place on steep hillsides where the vegetation cover has been weakened by a bad grazing policy or other practices. Movement can also occur on more gentle slopes after storms or under long-continued cultivation.

Climate

As already stated in Chapter 4, climate is an important soil-forming factor and its nature is to some extent reflected in the soil profile. In the choice of crops and land use, however, its direct effect on plant growth is more critical than its influence through the soil.

Little precise knowledge is available for the effects of climate on crop growth, but the principal factors are thought to be temperature and moisture, together with incidence of frost and degree of exposure or amount of wind. For consideration of its effect on land-use-capability in

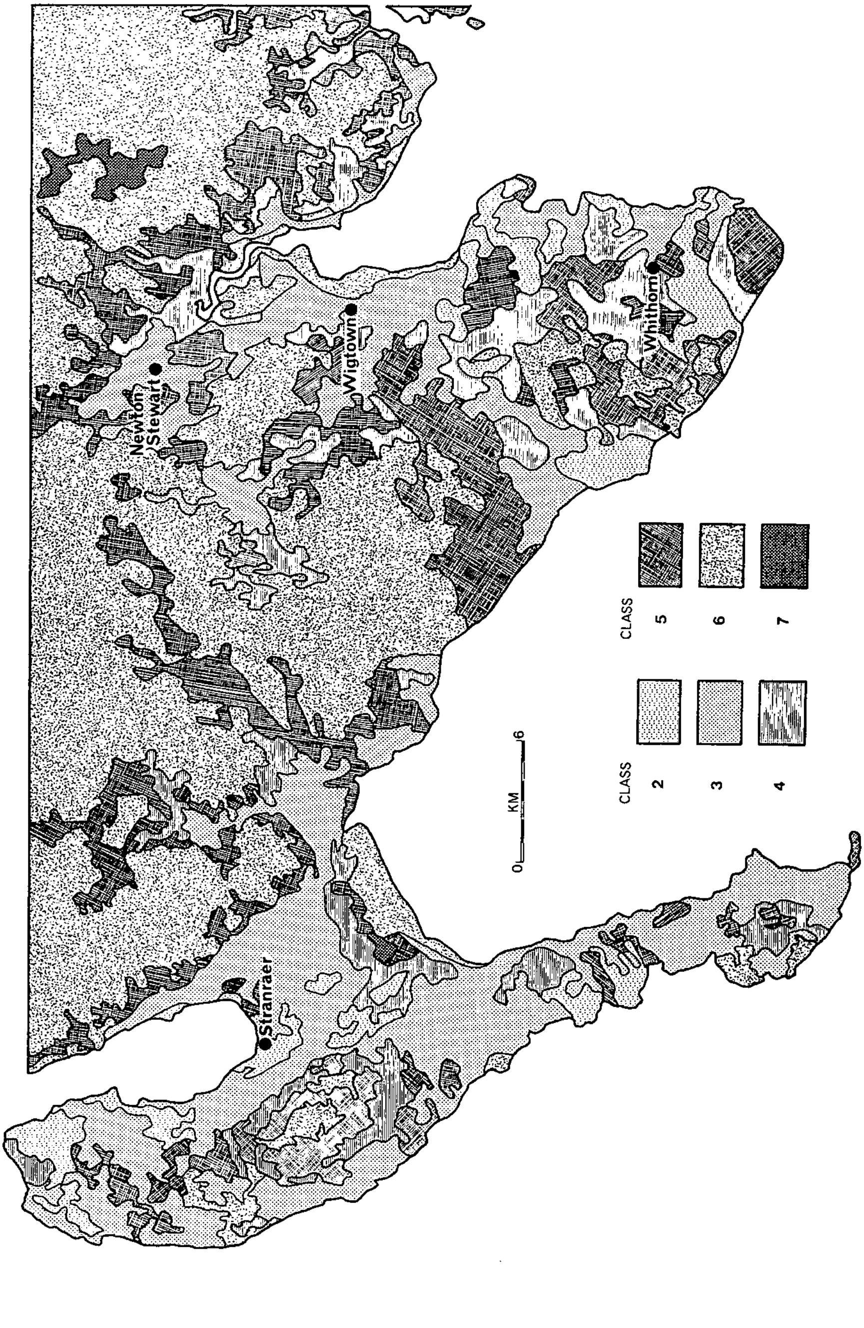

FIG. 20 Distribution of Land-Use-Capability Classes

this area the climate has been categorized according to the system of Birse and Dry (1970) and Birse and Robertson (1970) which is based mainly on temperature and moisture conditions in summer, the period of active plant growth. The appreciation of temperature is by the integrated total of day degrees Celsius above the base level of 5·6°C, taken as the threshold of significant plant growth. The moisture status of the climate is assessed by taking for each month the difference between potential evapotranspiration and rainfall and obtaining the total of those months when evapotranspiration exceeds rainfall. The resulting value is a measure of the tendency of the soil to dry out or to remain near field capacity. The map (Birse and Dry, op. cit.) of summer climatic conditions obtained by delineating regions based on a combination of these temperatures and wetness parameters compares well on an empirical basis with the general distribution of different forms of agriculture. The correlation is improved when account is taken of the effects of exposure as shown on the map (Birse and Robertson, op. cit.) compiled from published measurements of wind speed and supplemented by observations of natural vegetation.

The better arable lands usually have accumulated temperatures of more than 1375 day degrees C in the summer period and potential water deficits of more than 50 mm and are sheltered or only moderately exposed with average wind speeds of less than 4·4 metres per second. Potential for arable agriculture decreases as conditions become cooler, more moist or more exposed and cultivation is not generally possible in areas where accumulated temperatures are less than 1000 day degrees C or where there is no month with a potential water deficit. When the accumulated temperature is less than 1000 day degrees C and there is no development of a moisture deficit, areas of improved pasture are small and the land is mainly in rough grazing. The cold wet mountain tops with accumulated temperatures of less than 550 day degrees C and no moisture deficit have very little potential for agriculture or forestry and their value is mainly for amenity purposes.

The effect of exposure on land-use-capability rating is most apparent in areas where the temperature and moisture regime are, in general, favourable to arable agriculture, that is, mainly in lowland regions, and particularly along coasts. Land classed as exposed, with wind speeds in excess of 4·4 metres per second, is not generally placed in the highest category and land capability is further restricted where average wind speeds exceed 6·2 metres per second. Much of the present area is exposed, particularly to winds from the west and south-west, and as well as high ground some coastal zones are very exposed. The mountain and hill areas, already limited to low capability categories by temperature and moisture regimes, are not generally further restricted by exposure.

LAND-USE-CAPABILITY CLASSIFICATION

The system of land-use-capability classification (Bibby and Mackney, 1969) is an attempt to place areas of land into groups according to their use-capability by interpreting the information on the soils of the area acquired during the course of soil survey and integrating this with the knowledge of climate and topography.

The classification system has three categories; the highest, the land-use-capability class, groups land according to the degree of limitation on its use for growing the common arable crops of Britain. The factors which limit arable agriculture—soil condition, wetness, land gradient, liability to erosion and climate—have already been discussed and each forms the basis of a land-use-capability sub-class, the second category. In the lowest category, the land-use-capability unit, land is grouped according to its response to management and improvement practices and to the approximate yields obtainable. Such information is not always generally available over large areas, and land in the area under consideration has not been classified at this level.

In the highest category there are seven land-use-capability classes. Land in Class 1 is well adapted, under normal management, to intensive arable agriculture and should give good yields of any of the normal British arable crops. In the present area, however, no land has been placed in Class 1 because the climate is such that the narrow coastal areas which do have a favourable temperature and moisture regime suffer a significant degree of exposure. Class 2 land, land well suited to arable agriculture but with some minor limitations affecting the choice of crops or cultivations, is not extensive in this area. Parts of the Rhins and Machars do enjoy a favourable climate, but other limitations such as drainage impedance and rock outcrops are frequent. Arable agriculture is possible on land in Classes 3 and 4 but either the choice of crops is restricted, good yields obtainable only in favourable years, or management practices have to be adapted to overcome the limitations to which the soils are subject. Much of the land in the lowland parts of the area has been placed in these classes because of restrictions associated with wetness or climate.

Land in Class 5 is not suitable for arable agriculture, but with the use of normal improvement techniques moderate to good quality grassland can be maintained; tree growth is also likely to be moderate to good. Where mechanized improvements are not feasible capability is restricted to rough grazing, moorland, or forestry and the land is placed in Class 6. In areas where limitations, generally of slope or climate, are so severe that grazing is of low value and afforestation impossible, land is placed in Class 7, as being only suitable for amenity purposes including various sporting activities, walking and climbing.

On land in Classes 1 and 2, therefore, arable agriculture can be intensively practised; on land in Classes 3 and 4 more difficulty is encountered, risks are greater and yields are lower; on land in Classes 5, 6 and 7 arable agriculture is not possible. Livestock farming based mainly on grazing is carried out principally on land in Classes 3, 4, 5 and 6, with the more intensive forms of utilization, dairying in this area, concentrated on Class 3 and 4 land and the less intensive, such as suckler cows and sheep, on Class 5 and 6 land.

Forestry is possible on all types of land except Class 7, but under the conditions prevailing in Scotland growth of hardwood species is such that their cultivation is only rarely justified in economic terms. On land in Classes 5 and 6 coniferous trees compete with agriculture because of their ability to survive and grow under the relatively unfavourable conditions which characterize this type of land. When the value of the product as compared with that of arable crops and the financial effect of the long period between planting and harvest are considered, it is clear that from an economic standpoint woodland can seldom compete with agriculture on land in Classes 1, 2, 3 or 4.

The land-use-capability sub-classes which comprise the second category of the classification are sub-divisions of the land-use-capability classes and place areas of land into sub-groups according to the nature of the limitation, very broadly defined, on their use. The limiting factors are grouped under the heads of wetness, root zone characters, gradient, liability to erosion and climate. These may characterize land-use-capability sub-classes either individually, where only one factor is the main restriction on agriculture, or in combination, where two factors, or more in exceptional cases, interact or are equally instrumental in limiting the potential uses of land. As indicated in the discussion given above, some of these factors comprise such a number of diverse elements that their use without qualification on the land-use-capability map leads to considerable heterogeneity in the units delineated. The degree of variability permissible on any particular map must depend on the exigencies of scale, the purpose of the map, and the information available.

The attempts to integrate knowledge of soils, site and climate, to formulate the significance of these characteristics for agriculture and to represent the evaluation in the form of a map are intended to provide information for a variety of users that will be valid over a considerable period of time. Klingebiel and Montgomery (1961) consider that the purpose of a capability classification is as an aid to agriculture, while Bibby and Mackney (1969), although agreeing that this is the primary intention, mention government planners as well.

Although an accurate representation of the agricultural potential of land is required by both types of user, there is some difference in the amount of detail demanded. The interest of government planners at national or local level is likely to be concentrated on the general agricultural potential of different areas of land proposed for development. Information of this type is carried at the highest categoric level of the classification, the land-use-capability class, and is clearly indicated by the colours used on the map. To be useful for planning purposes the maps must meet the approval of the farming community and the more adequately the maps show the relationship of areas which are agriculturally similar and distinguish those which differ, the more likely it is that this will be given.

Agriculturalists and their advisers require to have land grouped and characterized according to similarity of features important to farming. Groupings of this type are made in the third category of the classification, the land-use-capability unit. Land-use-capability units as defined in the American Classification (Klingebiel and Montgomery, 1961) demand data on crop yields and performance not generally available in Britain. For Britain, Bibby and Mackney (1969) describe land-use-capability units which 'respond in a similar way to management and improvement practices' and are 'to be described in terms of their physical and chemical characteristics, their suitability for cropping and their management problems'. The physical properties of soils are, as mentioned earlier, a predominant influence on farm management and land improvement practices, and classification based on these features establishes groups where management requirements are largely the same. Land-use-capability units, however, are not generally shown on maps at less than the 1:25,000 scale, and the land-use-capability classification of the present area, represented at the 1:63,360 scale, is at the capability class and sub-class levels only. The capability classes are represented on the map by colours and the sub-classes by symbols.

LAND-USE-CAPABILITY MAPPING UNITS

The land-use-capability classes and sub-classes delineated in the present area are shown in Table M, together with the soils included in each. A brief description of the land-use-capability sub-classes is given below, and where a sub-class comprises several different types of land, because of the diverse nature of some limiting factors, attention is drawn to the principal characters of each.

Table M. Land-Use-Capability Classification of the Soil Units

Capability class	Capability sub-class	Soil mapping units
2	2s	Portencalzie, Linhope, Kirkcolm and Kirranrae series
	2w	Portpatrick, Rhins, Barncorkrie, Altimeg, Kedslie and Harviestoun series
	2cs	Portencorkrie, Linhope and Portencalzie series
3	3s	Cairnside, Clachan, Yarrow, Kirkcolm, Fleet, Kirranrae, Linhope and Portencalzie series
	3sw	Cailliness series
	3w	Ardwell, Balscalloch, Carbrook and Littleshalloch series and alluvial soils
	3ws	Stirling, Newton Stewart and Fordel series
	3g	Portencalzie, Portpatrick, Rhins, Portencorkrie, Linhope, and Kedslie series
	3cs	Portencalzie, Portencorkrie, Linhope, Clanery and Dalbeattie series and alluvial soils
	3cw	Portpatrick, Rhins, Barncorkrie, Altimeg, Kedslie, Arkland and Harviestoun series
4	4s	Larbrax, Knockarod, Portencalzie, Dally Bay and Kirkcolm series
	4w	Carsnaw and Galdenoch series and alluvial soils
	4ws	Stirling, Newton Stewart and Fordel series
	4g	Portencalzie, Portpatrick, Rhins, Linhope and Kedslie series and Buyoch and Achie complexes
	4cs	Portencalzie, Portencorkrie, Linhope, Clanery, Fleet and Yarrow series
	4cw	Portpatrick, Rhins, Ardwell, Balscalloch, Altimeg, Kedslie, Ettrick, Arkland, Littleshalloch and Greenburn series

Table M (*contd.*)

Capability class	Capability sub-class	Soil mapping units
5	5s	Mull series and Links soils
	5w	Innermessan, Dinduff, Drummore, Portlong Bay, Creetown, Dod, Dochroyle, Glenstockadale, Lochnaw, and Auchleach series, Logan complex, Peat, Peat-alluvium and alluvial soils
	5wg	Largmore and Ervie complexes
	5g	Portencalzie, Linhope and Yarrow series, Bennane, Buyoch, and Achie complexes
	5cs	Linhope, Clanery, Dalbeattie, Fleet and Yarrow series
	5cw	Littleshalloch, Greenburn, Portpatrick, Rhins, Ardwell, Balscalloch, Altimeg, Kedslie, Ettrick, and Arkland series and alluvial soils
6	6se	Links soils
	6w	Glenquicken, Carsphairn, Eglin, Creetown, Falbae, Dochroyle, Dod, Lochnaw, Glenstockadale, and Auchleach series, Minnoch, Brochloch, Twachtan and Gala complexes, Peat, Peat-alluvium, Saltings and alluvial soils
	6ws	Links soils
	6wg	Ervie, Corsewall, Largmore, Finlas, Trool, Riecawr, Loch Fleet, Stroan, Bush and Dinnins complexes
	6g	Portpatrick, Linhope, Clanery, Fleet, Yarrow, Littleshalloch and Dalbeattie series, Glenlee and Corwall complexes and mixed bottom land
	6gw	Darnaw and Garrary complexes
7	7g	Mullwharchar complex and skeletal soils
	7e	Dune sands
	7c	Eglin, Carsphairn and Mulltaggart series, Cairnsmore, Garrary and Loch Fleet complexes and Peat

Class 2

SUB-CLASS 2s

Land in this capability sub-class is not extensive and is restricted to coastal localities where the more sheltered areas of the Kirkcolm and Kirranrae series occur. The soils, which belong to the brown forest soil major soil sub-group, are generally of average or greater depth and are naturally free draining. The coarse texture of the subsoils render the land liable to drought in dry years, while the stone content, though variable, is considerable and can cause difficulties with some of the more sophisticated harvesting machinery. The land is level and is particularly valuable because of its suitability for growing early potatoes. The heavy fertilization usually practised with this crop has built up good levels of fertility, but under natural conditions leaching is significant, calling for liming on the Kirkcolm series. The Kirranrae series has a significant content of shells and is less likely to develop harmful levels of acidity.

SUB-CLASS 2w

In this sub-class are the imperfectly drained brown forest soils with gleyed B and C horizons which occur on gentle and moderately sloping land in the climatically more favourable parts of the area. The summer climate is classified as *warm rather dry lowland* and winters are *exposed* and *extremely mild.* The surface soils are loams, generally with a moderate stone content. The subsoils, which are clay loam or loam with coarse prismatic structure, seem hard and compact when dry, but soften and become plastic when wet. Waterlogging occurs in the upper soil layers mainly in winter and early spring, caused by the slow permeability of the subsoils, and this is the main factor restricting agricultural operations, although some deeper rooting crops can be limited in their root development by the stiff poorly-structured subsoils. Efficient tile or plastic under-drainage systems are essential to good arable agriculture and in certain circumstances subsoiling should give additional benefits. Care has to be taken in the timing of cultivations, but a wide range of crops can be grown and yields are generally good. Leaching is not usually severe and the natural level of fertility is average and can readily be raised by fertilizer application.

SUB-CLASS 2cs

Land in this sub-class is restricted to the warm and moderately dry lowlands which are moderately exposed and some warm and rather moist areas which are more sheltered. In both situations the slightly unfavourable features of the climate significantly restrict agriculture and prevent land being placed in Class 1. The soils are freely draining brown forest soils with loamy textures, of average depth and with appreciable stone content. The degree of stoniness constitutes the main soil limitation. The land is generally level or moderately sloping, and under natural conditions leaching is often appreciable and acidity fairly high. Waterlogging is not a problem and under-drainage need not be considered, but regular applications of lime and phosphate are usually necessary for good crop growth. Good yields are obtainable with a wide range of crops, but as land in this sub-class occurs as small areas amongst less highly rated land utilized for dairying, cropping must fit in with the overall farming system.

Class 3

SUB-CLASS 3s

This sub-class mainly comprises the free draining brown forest soils developed on coarse-textured parent materials, together with some very stony brown forest soils of loamy textures occurring under favourable climatic conditions. Much of the land lies between Loch Ryan and Luce Bay and is generally level or gently sloping, but can be more strongly sloping where there are morainic landforms and fluvioglacial deposits. In the soils developed on sands and gravels low waterholding capacity is the principal limiting factor because it leads to lowered yields in dry seasons and severe reductions in the occasional drought years. Under natural conditions these soils are strongly leached and liming and fertilizer requirements are high. A considerable range of arable crops can be grown but the land is not ideal for intensive arable agriculture. Many of the gravel soils also have a high stone content, causing additional difficulty with some crops. A few areas of this land in sheltered locations near the sea are suitable for the valuable early potato crop and the more extensive of these are indicated by an asterisk.

In some of the brown forest soils included in this sub-class the loamy texture gives a better waterholding capacity and lessens liability to drought. Climate conditions are *warm* and either *rather dry* or *slightly moist,* and the main limitation to arable agriculture is the content of moderately large stones.

SUB-CLASS 3sw

The small area of the imperfectly drained Cailliness series developed on fine sands and silts has been placed in this sub-class. The soil has a high ground watertable in winter and suffers some waterlogging at this season, but the low waterholding capacity makes the land subject to drought in summer.

SUB-CLASS 3w

The poorly drained non-calcareous gleys occurring in the more favourable climatic areas have been placed in this sub-class, together with a few alluvial tracts liable to occasional flooding. Textures in the surface soils are loams and in the subsoils clay loams or loams. The soils, on moderate slopes, are generally moderately stony. Waterlogging of the surface water type, caused by slow permeability in the subsoil, occurs in soils formed on tills of the Rhins Association, often in interdrumlin hollows, and also in soils on the clays of the Carbrook Association. In the Ettrick Association poor permeability in the upper layers is not generally the cause of wetness in the Littleshalloch series in which waterlogging is associated with induration in the deeper subsoils or flushing. Efficient under-drainage is essential for arable cropping on both groups of soils; systems where drains are relatively closely spaced at shallow depth are likely to be most suitable in conditions of surface waterlogging, while on the soils of the Littleshalloch series particular attention will probably have to be given to field ditches in 'up slope' situations and to outfalls. The soils are placed in Class 3 only where *warm dry* or *slightly moist lowland* climates favour early drying of the land.

The limitations on agriculture are those generally associated with waterlogging—the difficulties associated with cultivation in winter and spring and the use of heavy harvesting machinery in autumn, and the late commencement of growth in spring.

Some small alluvial tracts with liability to flooding are also placed in this unit. The soils are varied but are generally loams in the surface and coarse-textured at depth, usually with free or imperfect drainage. Although flooding does not always occur it is, nevertheless, frequent enough to be a hazard to autumn sown crops, and in hill or moorland areas summer floods following thunderstorms occasionally cause serious damage.

SUB-CLASS 3ws

The sub-class comprises the poorly drained gley soils of the Stirling Association developed on estuarine alluvium. The soils are stone-free and textures in the surface are silty clay loams to fine sandy silt loams, the range in the subsoil being similar with some finer silty clay layers. The climate is generally *warm moist lowland* and the land only *moderately exposed.* The land is level or only gently sloping, and although the soils are only slowly permeable there is a permanent watertable and gleying increases with depth. The organic content in the surface is moderate or low and this together with the high silt or clay contents and weakly weathered or raw state of the soils gives rise to weakly developed structure which is easily damaged. The soils are naturally nearly neutral or only slightly acid and are generally fairly fertile. Efficient under-drainage is essential for arable agriculture on these soils. Although cropping is generally restricted to spring-sown grain crops and grass leys, yields are often very good. Great skill and care is required in the timing and execution of cultivations and good tilths are difficult to obtain. The more clayey soils of the Stirling series tend to be hard and cloddy, while the silty Fordel series soils tend to 'cap' under the action of rain. The land is not considered suitable for root crops.

SUB-CLASS 3g

Strongly sloping land, often on drumlinoid hills, in the Rhins and Machars which has no other major limitations has been placed in this class. The land is classed as *warm rather dry* or *moist lowland* and is *moderately exposed.* Both freely and imperfectly draining brown forest soils have been included in the unit, and while surface soils are moderately stony and generally loamy, clay loams and loams occur in the subsoil. Under natural conditions the free-draining soils tend to be acid and regular dressings of lime and phosphate are important. The soils with impeded drainage show some variation but are generally moderately acid and rather less leached. Although wetness is not a major limiting factor on this land, under-drainage is necessary for arable agriculture on soils with gleying in the B and C horizons. While it may not be possible to use some of the more sophisticated root harvesting machinery, most normal farming operations are carried out on this land, though with greater difficulty and consumption of power. Choice of crops is not especially restricted, but land such as this does not generally remain under the plough for long periods and in this area it is managed to fit in with the predominant pastoral or mixed farming of the region.

SUB-CLASS 3cs

This sub-class comprises most of the free-draining brown forest soils, other than those developed on coarse fluviatile deposits, which occur in *warm rather wet lowland* or in the more *exposed* areas of *warm moist lowland* where rainfall is less than 1270 mm (50 inches) per annum. The surface soils are generally loams of average depth and their moderately stony nature is the main soil limitation. The subsoils are also mainly stony loams, but some tills are clay loam. Under natural conditions the soils are strongly acid and are readily leached. Moderate but frequent applications of lime are necessary for arable farming. In this area it is particularly difficult to distinguish the effects of climate on arable agriculture, because the high moisture levels which make the management of large areas of arable land difficult are, under the prevailing warm conditions, especially favourable to good pastoral farming which predominates throughout much of the area. The severity of the moist and exposed conditions is, however, considered sufficient to make intensive systems of arable agriculture impractical.

SUB-CLASS 3cw

The brown forest soils with imperfect natural drainage occurring in the *warm rather wet lowlands* and the more *exposed* parts of the *warm moist lowlands* have been placed in this sub-class. The surface soils are generally moderately stony loams of average depth and the subsoils generally clay loam or loam tills with coarse or massive structures, hard when dry and plastic when wet. Some soils show induration. Drainage impedance is mainly due to the slow permeability of the subsoils, and although in this major soil sub-group waterlogging of such soils is not generally severe, the effects in this region are compounded by the moistness of the climate. Efficient under-drainage is necessary to allow cultivation for arable cropping and for the maintenance and utilization of good grassland. Difficulties in the timing of cultivations and of harvesting make intensive arable systems of farming impractical. With most common arable crops average yields are possible, but with late-sown crops or under poor harvest conditions yields can be much reduced.

Class 4

SUB-CLASS 4s

Soils in this sub-class occupy only a small area and are of diverse nature. A few patches of Portencalzie series, a freely drained brown forest soil, occurring near the northern end of the Rhins Peninsula have been included because of their content of moderately large stones which interferes considerably with cultivation.

In the Kirkcolm Association some areas, probably old storm beaches, are particularly stony and have many large rounded cobbles. Cultivation of these soils is difficult and only occasionally carried out. In addition to limitations imposed by stoniness the soils have the disadvantage of being very coarse-textured in the subsoils.

The humus-iron podzol soils of the Yarrow Association have also been placed in this sub-class. They are coarse-textured, have very weak soil structure and are strongly leached and impoverished of plant nutrients. Expenditure on reclamation is necessary and continuing large inputs of lime and fertilizer are essential. Although arable cropping is possible, choice of crops is restricted and yields are likely to be moderate or low for a considerable time.

SUB-CLASS 4w

The imperfectly drained soils in the Yarrow Association, which cover only small areas, have been placed in this sub-class. Textures are generally sandy loams or gravelly sandy loams overlying sand or gravel. Relatively impermeable tills or other materials at shallow depth, together with the low lying sites, cause considerable waterlogging of these soils in winter through high watertables. Thus the soils are difficult to drain and liable to become saturated after heavy rain. Autumn sown crops are not a suitable choice and difficulties are likely with late-harvested root crops. Yields are generally only moderate.

Some alluvial tracts where flooding is judged a significant hazard are also included in this unit. The soils show considerable variation.

SUB-CLASS 4ws

Land in this sub-class comprises those areas of soils in the Stirling Association which occur as *warm rather wet lowland.* The land is level or gently sloping. The soils are the same series as those in sub-class 3ws and the limitations on their use are similar, although the effects of both poor drainage and weak structure are greater under the wetter climatic condition. Efficient under-drainage is essential for any cultivation of the land and great care is necessary in the timing of the operations. Conditions are not suitable for growing root crops and spring-sown grain is generally grown.

SUB-CLASS 4g

The sub-class comprises two types of land, one where the main limitation is steepness of slope and the other where cultivation is hindered by rock outcrops. Both freely and imperfectly drained brown forest soils on moderately steep slopes in the lowland and foothill areas are included in this unit. Climatic conditions are relatively good and the soils are moderately stony loams which in some places are shallower than average. The steep gradient makes arable agriculture difficult. The use of combine harvesters is not possible and some operations can be performed in only one direction. A fairly wide range of crops can be grown and moderate to good yields can be expected but it is impossible to employ sophisticated planting and harvesting machinery.

The Buyoch and Achie complexes are characterized by rock outcrops of variable frequency and are only recorded on the soil map in general terms. Consequently assessing land-use-capability on this unit is particularly difficult and this is noted on the land capability map.

The soils between rock outcrops are mainly free-draining brown forest soils with stony loam textures, although some areas with imperfect drainage may occur, generally underlain by shallow clay loam till. The areas are moderately or strongly sloping and are classed as *warm lowland* with a range of moisture conditions. Where outcropping rock occurs it is generally the main factor restricting arable agriculture. This limiting factor affects agriculture principally through its effect on the use of machinery. Large machines are awkward to handle and much time can be taken working small areas and avoiding outcrops; breakages are also likely to be high. A fairly wide range of crops grow well, but on a field basis yields are likely to be low because of the uncultivated areas around rocks.

SUB-CLASS 4cs

Most of the land in this sub-class occurs in foothill situations and in areas marginal to moorlands. The climate is the principal limiting factor and the areas are classed as *warm wet lowland* and *exposed*. There are generally no periods of potential water deficit, but some land in drier areas with an annual rainfall of more than 1270 mm (50 inches) has been included. The soils are free-draining brown forest soils, mainly developed on stony drifts of medium texture but in a few small areas are formed on gravels. Slopes vary widely but are often strongly sloping. The surface soils on the shallower stony drifts tend to be more stony than normal for the particular series and this stoniness is the main soil limiting factor, but in some areas it is the shallowness of the soil. Despite the free-draining nature of the soil the prevailing wet conditions are the main limitation on arable agriculture. In the absence of any significant soil water deficit ripening of grain crops is delayed so that harvests are often late and harvesting made more difficult by the high rainfall. Weed control and harvesting root crops are also likely to be troublesome. Much of this land remains for long periods in grass, and when it is cultivated crops are generally oats or roots for fodder.

SUB-CLASS 4cw

This sub-class comprises soils with impeded drainage that occur under wet climatic conditions. In the *warm wet lowlands* and areas with more than 1270 mm (50 inches) of annual rainfall, soils in the imperfectly drained group are placed in this class, as are poorly drained soils with climates slightly less wet. The surface soils are usually loams underlain by clay loam or loam tills or somewhat more stony loamy drifts. Waterlogging on the till soils is predominantly of the surface water type. Conditions can be ameliorated without undue difficulty by normal forms of under-drainage which are essential if this land is to be used for arable agriculture or improved grassland. Drainage is equally necessary on the poorly drained soils on stony drifts where waterlogging is mainly due to the effects of a combination of ground water and flushing.

Limitations on agriculture are caused by wetness, both soil and climate. Cultivations are difficult and sowing of crops may be late and harvests are often risky. The land will support moderate to good grassland and is usually under pasture for long periods.

Class 5

SUB-CLASS 5s

Land in this sub-class occupies only a small area and comprises soils with severe root zone restrictions. They occur in lowland situations with favourable climates. The Mull series, a humus-iron podzol, is shallow and in addition to being strongly leached and impoverished is locally very stony. The land is not generally suitable for arable agriculture, but improved grassland can be maintained, although the mineral status of the herbage sometimes necessitates care for the health of grazing animals.

SUB-CLASS 5se

The more stabilized areas of links soils have been placed in this sub-class. The soils are extremely sandy with low waterholding capacity and very low natural fertility. They are classed as *warm rather dry lowland.* Maintenance of moderate to poor quality grassland is possible, though in some years drought is severe and if the surface turf becomes broken care has to be taken to prevent the spread of patches of erosion.

SUB-CLASS 5w

A number of small areas of lowland peat and peaty alluvium soils which have been drained in the past or border drained areas have been placed in this sub-class, together with a few areas highly liable to flooding, and some small patches of coarse-textured soils with high ground watertable.

These areas are classed as *warm rather dry* or *moist lowland,* and occur generally as small local hollows or narrow tracts along water courses. The peaty areas usually have high ground watertables and because of their topographic situation drainage can be difficult, and the areas remain wet at some season even after improvements have been carried out. Arable agriculture is generally impracticable and grassland has to be carefully managed to prevent undue damage to the sward when the ground is soft.

Peaty alluvial and alluvial areas liable to flooding can to some extent be protected by river embankments, but land in this sub-class is at high risk and generally only partial improvement is possible. Some soils in this group are naturally poorly drained, making under-drainage an essential preliminary to sward improvement, but soils with free and only slightly impeded natural drainage also occur. Free-draining alluvial soils are less liable to damage by poaching than the peaty soils, but the danger of flooding is a hazard to livestock, particularly to young animals, and grazing has to be carefully controlled.

The coarse-textured mineral soils with high ground watertable generally occupy very small hollows in areas of sands and gravels. Drainage is necessary for any form of improved agriculture, but adequate outfall is not easily obtained, making installation and maintenance difficult. Even after drainage wetness is likely to be a severe and continuing limitation on land use, and consequently these areas are usually maintained in grassland.

SUB-CLASS 5wg

Only a few small areas of two soil complexes have been included in this mapping unit. Strongly gleyed soils which have a persistent high watertable or are affected by flush waters are a major proportion of each complex and wetness is the main limiting factor. In one of the soil complexes the nature of the limitation is also affected by the soil pattern; although patches of freely drained soils occur throughout the unit, the network of poorly drained soils makes improvement difficult. In other areas, predominantly of poorly drained soils, outcropping rock constitutes an additional limitation. The soil pattern in these units, together with their topographic situation, makes drainage difficult, and even where drainage has been carried out cultivation is not feasible. Improved grassland is the most productive form of land use in these areas.

SUB-CLASS 5g

This sub-class comprises land of two types: areas where slope is near the limit for the use of wheeled tractors and areas where outcropping rock makes arable cropping impractical. On the steeply sloping land the soils are free-draining brown forest soils developed on stony drifts or gravels, and have surface textures that are loams or sandy loams. There is a wide range of climate but very severe conditions do not occur. The steep slopes make the use of wheeled tractors difficult and though mechanical operations are possible they are usually restricted to the reseeding of pasture and the distribution of fertilizer.

Soil complexes characterized by outcropping rock and mainly free-draining brown forest soils form the greater part of this sub-class. Slopes are generally moderate or gentle and elevations intermediate. The areas vary from *warm rather dry lowland* to *cool rather wet foothill.* Soils are loamy and very stony and over short distances vary greatly in depth from shallow to deep. Much of the land has very shallow soils and outcrops of rock, and consequently if cropping is attempted there is a high proportion of waste land. In any case the pattern of outcrops is such that farm operations are difficult and are generally restricted to the distribution of fertilizer and occasional reseeding of the sward.

SUB-CLASS 5cs

The soils occurring in this sub-class are free-draining brown forest soils developed on drifts of medium texture or on gravels. Climatic wetness, however, constitutes the main limitation on land capability. In the *cool wet foothills* and *warm wet lowlands* there is generally no month in which evapotranspiration exceeds precipitation, which is usually greater than 1270 mm (50 inches) per annum and can be 1520 mm (60 inches). Land in this sub-class occurs under these conditions, mainly along the edges of moorland and hills, often in small patches and with a wide range (up to steeply sloping) of slope. There may be some surface boulders and large stones are frequently a significant impediment to cultivation. On these free-draining soils the high rainfall which makes harvesting hazardous is favourable to the growth of grass, which with good management can be productive. The soils are, however, highly leached and acid, requiring considerable applications of lime and fertilizers. Where land of this sub-class occurs as small patches within the area of the peaty moorland soils it is generally farmed on the same extensive system, but where fencing costs can be justified, it is capable of considerable improvement.

SUB-CLASS 5cw

All the soils on this sub-class suffer from drainage impedance, but the effects of soil wetness are compounded by unfavourable climatic factors, particularly the low evapotranspiration relative to rainfall. Land with gley soils classified under natural conditions as poorly drained has been placed in this sub-class when it occurs in *warm rather wet* climate where rainfall exceeds 1270 mm (50 inches) per annum, while the areas of naturally imperfectly drained brown forest soils with gleyed B and C horizons have been placed in this sub-class only in the slightly wetter *warm wet lowland* climate characterized by having no month in the year when evapotranspiration exceeds precipitation.

The soils are mainly loams in the surface layers and loam or clay loam in the subsoils, though in some alluvial soils textures may be coarser. The slowly permeable loam and clay loam till subsoils cause widespread surface waterlogging, while in the less extensive and more permeable coarser stony loamy drift subsoils high ground water or flushing is responsible for excess soil water.

Under-drainage is essential to the best use of land in this sub-class and in the areas affected by surface waterlogging can generally be achieved by normal drainage layouts. In areas affected by ground water or flushing, however, precautions must be taken to establish the source of excess water and to keep ditches and surface drains clear. The wet climate prevailing in the area of this sub-class generally prevents the conditions being sufficiently improved to allow arable cropping and grassland to be the predominant form of land use. Although such grassland can be productive, it has to be utilized with care to prevent severe poaching damage to swards.

Class 6

SUB-CLASS 6se

The sub-class comprises the area of partially stable sand dunes of Luce Sands, at present being used as a military range. The limitations on land use are the extremely sandy nature and low waterholding capacity of the soils and their high liability to wind erosion.

SUB-CLASS 6w

Much of the area of peat and peaty soils of the moorland is placed in this sub-class, together with the coastal tracts of saltings. These two types of land are very different in their nature and limitations. Utilization of the areas of saltings is limited by frequent flooding, while in the areas of peaty soils land use is limited by several interrelated factors.

The areas of saltings provide useful and healthy grazing for considerable periods of the year, but in most months the land is liable to inundation by the sea at high tide. Improvements could only be achieved on construction of defences against the sea, an obvious impossibility on a farm scale.

Peats and peaty soils are some of the most extensive soils in the area and almost all have been placed in this sub-class. A few areas improved in the past have been placed in sub-class 5w and some small areas with very unfavourable climatic conditions at high altitude have been placed in sub-class 7c. Some small areas of peaty soils have been reclaimed in the past by drainage and other measures, but little improvement has taken place recently and there seems little likelihood of any in the near future. The limiting factors restricting the use of peat and peaty soils to rough grazing are complex and only partly understood. The peaty layers impart a distinctive overall appearance to the land, which differs from areas with mineral soils both in its general features and in its behaviour as a medium for agriculture and for plant growth.

In the uplands peat has developed under the influence of the cool wet conditions and the climate is a continuing limitation on the degree of improvement in land-use-capability that can be effected by drainage or other measures. Over much of the moorland area climatic conditions are such as to restrict the land-use-capability even of good soils on moderate slopes to Classes 4 or 5, so that the utmost benefit that can be obtained by reclamation measures is an advance from rough grazing or forestry to improved pasture or poor arable land. Measures which would be considered justified if the land-use-capability could be raised to Class 1 or 2 are less likely to be acceptable where the limit of improvement is to Class 4 or 5.

Under more favourable climatic conditions peats generally occur as large basin bogs and improvement is only possible after extensive drainage on a regional scale; such schemes are outside the scope of individual farmers and are not therefore considered under the present system of land capability.

The waterholding capacity of peat is considerable, and under the conditions of high rainfall peaty soils remain waterlogged for the greater part of the year. Such soils differ from mineral soils in many respects; they have a low bulk density and bearing strength, and when they are wet damage to crops or grass swards by machinery or the treading of animals is very common. In particular, unlike most mineral soils, the structure of peats reforms naturally when it dries. In the area under discussion the peats are generally very acid and poor in plant nutrients and a high base exchange capacity gives rise to high lime requirement.

Methods of surface seeding are available for the up-grading of swards on this land, but without artificial drainage the degree of improvement is limited. Intensive artificial drainage, large additions of lime and fertilizer, tillage and reseeding are all feasible on these soils, but circumstances are such that in the foreseeable future only a very small proportion of this land is likely to be improved. The principal limitation of this sub-class is wetness, while difficulty of consolidation and low fertility are both associated with nature of the peaty surface horizon. The soils occupy much of the moorland areas of the region and because of the severity of their limitations are regarded as suitable only for poor quality rough grazing and for forestry.

SUB-CLASS 6ws

A few small areas of wet very sandy soil of the Links type have been placed in this sub-class. The soils have a very high ground watertable, and their topographic position generally makes drainage very difficult. Because of the low natural fertility associated with the very sandy nature of these soils, improvement measures are rarely justified.

SUB-CLASS 6wg

This sub-class is extensive in the hill and moorland areas where it includes many of the soil complexes in the area. The range of soils is not wide and the most frequent pattern is peats and peaty soils with rock outcrops or moraine. A few units occur in which poorly drained mineral soils are combined with rock outcrops or freely drained brown forest soils. The map units generally occur in areas of unfavourable climate and the limitations on improvement are intensified by topographic features. Many of the soil map units placed in this sub-class are characterized by frequent rock outcrops, while in other areas the complex soil pattern is the outcome of the undulating ground surface, in which, however, outcropping rock does not occur.

Land use in all these areas is restricted to rough grazing and forestry. The fertility of the land with mineral soils and ground waterlogging will usually be significantly higher and the pasture more productive than land where wetness is associated with peaty soils.

SUB-CLASS 6g

Several types of land are grouped in this sub-class in which the limiting factor is some aspect of topography. Much of the land is too steep for the use of wheeled tractors and improvement is therefore difficult. The soils are generally free-draining brown forest soils of loamy texture developed on very stony drifts, though a few soils on very steep gravel banks are also included. The herbage is generally a form of acid grassland such as bent-sheep's fescue pasture which provides rough grazing of relatively good quality.

Other land in this sub-class belongs to mapping units with frequent outcropping rock. The soils are generally brown forest soils, shallow and extremely stony, and improvement measures are hardly ever practicable.

Mixed bottom land delineated along stream channels is also placed in this sub-class, as the main limitation on its use is associated with the small areas of occurrence.

SUB-CLASS 6gẇ

The areas of soil complexes placed in this sub-class have outcropping rock as a dominant feature and the soils have a peaty surface layer. Their use is restricted to rough grazing and forestry and very little improvement of any sort is possible.

Class 7

SUB-CLASS 7e

A few small areas of unstabilized dune sands have been placed in this sub-class. The land provides no grazing and is only capable of use for amenity and other non-agricultural purposes, although with special treatments it may be possible to establish trees.

SUB-CLASS 7g

The skeletal soils and the soil complex which make up this sub-class have very little value. Much of the land comprises the steep rock cliffs at the heads of corries and affords little rooting depth for trees or grazing for animals. The land may have a value for rock climbing or other amenity purposes.

SUB-CLASS 7c

The climate is the main limiting factor on the capability of land in this sub-class, which in this region comprises the *very cold wet uplands and mountains* and part of the *cold wet upland* which is *very exposed* and has *rather cold winters* (Birse and Dry 1970, and Birse and Robertson 1970). In general terms this sub-class is restricted to the area around Cairnsmore of Fleet above about 520 m (1700 feet). In making the land-use-capability map this altitude was chosen because it approximates both to the upper limit of afforestation and to the elevation above which grazing, though it retains some value, has a very low productivity and is available for only a short period of the year. The land on these mountain tops is mainly used for amenity and sporting purposes, although it has also a slight rough grazing value; afforestation is not possible.

CONCLUSION

There is a wide range in the use-capability of land in south-west Scotland; of the seven land-use-capability classes, six are represented in this area. Only small areas of land have been classed as suitable for intensive arable agriculture with a wide range of crops and no land has been placed in Class 1. This is partly because of limitations associated with the relatively high degree of exposure obtaining on most of the land at moderate and low elevations and partly because of the stony nature of many of the soils. Land in Class 2 is restricted to some areas of freely and imperfectly drained soils in the more sheltered, warmer and less humid coastal areas.

Dairying is the main agricultural activity outside the hill and moorland tracts and this is reflected in the predominance of land in Class 3 on the Rhins Peninsula and in the Machars. The conditions of high climatic and soil moisture, which together with the degree of exposure restrict the suitability of the land for large scale intensive agriculture, are favourable to the growth of grass and the maintenance of swards in good condition for long periods. Land in Class 4 is rather less extensive than that in Class 3 and occurs along the more elevated parts of the Rhins Peninsula, around the fringes of the Kirkcudbrightshire hills and along the edges of, or as patches within, the areas of the moors. The utilization of land in this class is strongly influenced by the capability of the surrounding areas. On the Rhins and in other localities where it occurs in association with Class 3 and Class 5 land, land in this class is farmed in a similar manner, generally for dairying. On the moors and around their peripheries, however, Class 4 and 5 land is associated with large areas of Class 6 land and it is the last which determines the land use, namely rough grazing for sheep and cattle raising. The intensity of utilization varies according to the proportion of land with a capability for arable cropping or improved grassland; where significant areas of such land occur as a unit, grain or root crops can be grown for stock feed and grazing is usually controlled and well managed. When land suitable for cultivation occurs in small units, management is not as a rule intensive.

Class 6 land is very extensive and incorporates most of the moor and hill land in the north and east of the area. The only practical forms of agriculture are sheep and cattle grazing on the extensive pattern. Only small areas have been placed in Class 7 as being restricted in capability to use for amenity purposes.

Forestry in the region is based largely on plantations of conifers and although tree growth has not been directly considered in this land-use-capability interpretation, it is apparent that most post-war afforestation has taken place on Class 6 land where it is competitive with extensive livestock enterprises. The upper elevation limit of Class 6 land has been taken to more or less coincide with the probable upper limit of land suitable for tree planting. On Class 5 and the better classes of land good or very good tree growth can generally be obtained, but forestry production does not increase in value on the better classes of land to the same degree as agriculture. Thus afforestation, although possibly justifiable on economic grounds on some land in Class 5, is only rarely likely to be more profitable than agriculture on land with a capability for arable agriculture.

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APPENDIX I

Profile Description

The standard terms used in profile description are:

a. Terms relating to the site:
   Relief and Slope, Vegetation, Aspect and Altitude
b. Terms relating to the profile as a whole:
   Horizon Notation and Drainage Class
c. Terms describing horizon properties:
   Colour, Texture, Structure, Consistence, Induration, Organic Matter Content, Stoniness, Mottling and Horizon Boundaries.

Relief and Slope Class

Single slope classes (U.S.D.A. 1951) are defined by a range of angles of slope, while the relief class describes the frequency of undulation of the landscape which is dependent on and defines lengths of slope.

Class A	*Single Slope Class*	*Relief Class*
Limits		
Lower 0 percent (0°)	Level	Depressional to flat
Upper 1–3 percent (½–1½°)		Very gently undulating
Class B		
Limits		
Lower 1–3 percent (½–1½°)	Gentle	Gently rolling slopes of low frequency
Upper 5–8 percent (3–4½°)		Undulating slopes of higher frequency
Class C		
Limits		
Lower 5–8 percent (3–4½°)	Moderate	Rolling slopes of low frequency
Upper 10–16 percent (6–9°)		Strongly undulating slopes of high frequency Moundy slopes of very high frequency
Class D		
Limits		
Lower 10–16 percent (6–9°)	Moderately steep	Strongly rolling to hilly
Upper 20–30 percent (12–17°)		

Class E
Limits

Lower 20–30 percent (12–17°) Upper 45–65 percent (24–33°)	Steep	Steeply hilly or dissected

Class F
Limits

Lower 45–65 percent (24–33°) Upper none (90°)	Very steep	

Horizon Notation

Soil horizons are referred to by letter symbols as follows:

- L a superficial layer of relatively undecomposed plant litter generally of the preceding year.
- F a superficial layer of partially decomposed litter with recognizable plant remains.
- H a superficial layer of decomposed organic matter with few or no recognizable plant remains.
- A upper organo-mineral and mineral layers under natural or semi-natural conditions.
- B lower layers of the solum which have undergone pedological change.
- C the parent material from which the soil has developed.
- D rock from which C horizon has been formed, or layer underlying the solum not related to the parent material.
- g when following another horizon symbol indicates that the layer is strongly gleyed.
- (g) used when gley characters are only slightly expressed.
- p when following an A horizon symbol indicates a layer mixed by cultivation.

These symbols have more precise significance when applied to specified major soil groups as follows.

HORIZON NOTATION OF THE MAJOR SOIL GROUPS

Peaty Podzol (*with iron pan*)

- L undecomposed plant litter.
- F partially decomposed litter.
- H decomposed organic matter or black, raw humus, usually >5 cm thick.
- A_1 the uppermost mineral layer, dark organic matter mixed with mineral matter relatively rich in silica.

A_2	a layer immediately below the A_1 which is low in organic matter, pale grey in colour and rich in silica, and may show signs of gleying; it is designated either A_2(g) when gleying is slight or A_2g when gleying is strong. A concentration of roots may be present at the bottom of this layer and they may be partially decomposed.
B_1	a thin iron pan about 1·5 mm thick. Maximum enrichment of sesquioxides. May be continuous and impermeable to water and impenetrable to roots; then there is a strong tendency for gleying and for roots to concentrate immediately above in the A_2.
B_2	brighter in colour than the A or C horizons. Relative enrichment of free sesquioxides.
B_3	not so bright as B_2. Shows some relative enrichment of free sesquioxides and may show some degree of induration.
C	the relatively unweathered parent material.

Humus-Iron Podzols

L	undecomposed plant litter.
F	partially decomposed litter.
H	decomposed organic matter—dark brown or black raw humus, usually 10 cms.
A_1	the uppermost mineral layer, dark coloured organic matter mixed with mineral matter, relatively rich in silica.
A_2	a layer immediately below A_1 containing less organic matter, grey or grey-brown in colour and rich in silica.
B_{21}	darker than A_2, black or dark grey, relative enrichment with organic matter.
B_{22}	brighter than A or C horizons, relative enrichment with sesquioxides.
B_3	not so bright as B_{22}. Shows some relative enrichment of sesquioxides and may be indurated.
C	the relatively unweathered parent material.

Brown Forest Soil (low base status)

L	undecomposed plant litter.
F	partially decomposed plant litter.
H	trace of decomposed organic matter—may be absent.
A	brown colour with medium organic content, moder type; crumb structure. No differentiation into A_1 or A_2.
B_2	brighter brown colour than the A horizon. A relative enrichment of free sesquioxides.
B_3	less bright than the B_2 horizon and nearer to the colour of the parent material. May show some degree of induration.
C	the relatively unweathered parent material.

Brown Forest Soil with Gleyed B and C Horizons

L	undecomposed plant litter.
F	partially decomposed litter.

H	trace of decomposed organic matter.
A	mixed mineral and organic layer, moder type. No differentiation.
$B_2(g)$	well defined blocky or prismatic structure. Horizon of maximum gleying, mottles within and sometimes on peds. May have greater clay content than A or C horizons.
$B_3(g)$	less well defined blocky or prismatic structure. Mottling within and sometimes on peds.
C(g)	structure usually massive, less mottled than B horizons.

Peaty Gley

L	undecomposed plant litter.
F	partially decomposed litter.
H	raw humus usually >5 cm thick, black in colour.
A_1g	mixed organic and mineral layer. A little ochreous mottling along roots, weak structure.
A_2g	pale brown layer, humus stained, low in organic matter, weak structure.
B_2g	pale coloured with slight ochreous mottling and iron tubes surrounding root tracks, blocky structure.
B_3g	grey to bluish grey with distinct iron tubes, no mottling, massive structure.
Cg	bluish grey, no iron tubes, massive.

Non-calcareous Gley

L	undecomposed plant litter.
F	partially decomposed litter.
H	trace of decomposed organic matter—often absent.
A_1g	mixed mineral organic layer. Some ochreous mottling associated with roots. Weak structure.
A_2g	pale coloured mineral layer low in organic matter. Structure weak. May be some ochreous mottling.
B_2g	well defined blocky or prismatic structure. Peds coated with grey; ochreous and grey mottles within.
B_3g	less well defined blocky or prismatic structure. Peds coated with grey; ochreous and grey mottles within.
Cg	original colour of parent material more apparent. Structure more massive, although peds may still have grey coatings and ochreous and grey mottles within.

Sub-alpine Soil

L	undecomposed plant litter.
F	partially decomposed plant litter.
H/A_1	organo-mineral layer with black greasy humus.
H/A_2	organo-mineral layer with black greasy humus and bleached sand grains.
H/B_2	organo-mineral layer with black greasy humus and humus coated stones and coarse particles.
C	light brown sandy loam layer. May be very stony.

Drainage Class

Drainage class is assessed on, and defined according to the degree of gleying in the soil. The general characters of each class are given below. Precise descriptions are only possible with individual series.

DRAINAGE: EXCESSIVE

Soil horizons are shallower than is normal and B horizons are bright and uniform in colour. Profiles of this category are of small extent and are not shown on the soil map.

DRAINAGE: FREE

The B horizons are bright and uniformly coloured; soils with B horizons showing only slight dullness and only a small number of mottles are included in this class.

DRAINAGE: IMPERFECT

The B horizons are less bright than those of the well drained soils and have appreciable mottling.

DRAINAGE: POOR

The Bg horizons are dull and mottling is evident.

DRAINAGE: VERY POOR

The Bg horizons are dull and mottling is very evident.

Colour

Soil colours are defined by reference to the Munsell Soil Color Charts (Munsell Color Company Inc., 1954) and described according to their notation and nomenclature. The Munsell system describes colour in terms of hue, value, and chroma. Hue refers to the dominant spectral colour (red or yellow), value to the apparent lightness as compared with absolute white, and chroma refers to the purity of the hue or departure therefrom. Colours or groups of colours thus defined are given standard names, e.g. pale brown—10YR6/3 (hue 10YR, value 6 and chroma 3).

Texture

The texture of a soil refers to the relative proportions, according to size, of those primary particles of which it is composed which pass through a 2 mm sieve.

Particles larger than 2 mm are indicated by terms descriptive of their nature, such as stony, pebbly, gritty etc.

Particles less than 2 mm are grouped in separates according to their effective diameters when subjected to the techniques of mechanical analysis. The size ranges of the separates—sand, silt and clay—according to the U.S. Department of Agriculture and the International schemes, are given below.

U.S.D.A. scheme			International scheme		
Name of separate		Effective diameter (range) μm	Fraction		Effective diameter (range) μm
sand	very coarse sand	2000–1000			
	coarse sand	1000–500	sand	coarse sand I	2000–200
	medium sand	500–250		fine sand II	200–20
	fine sand	250–100			
	very fine sand	100–50			
	silt	50–2	silt III		20–2
	clay	< 2	clay IV		<2

The textural classes and their range of composition (U.S.D.A. scheme) are shown in the triangular diagram (Fig. 21). Soil textures are assigned

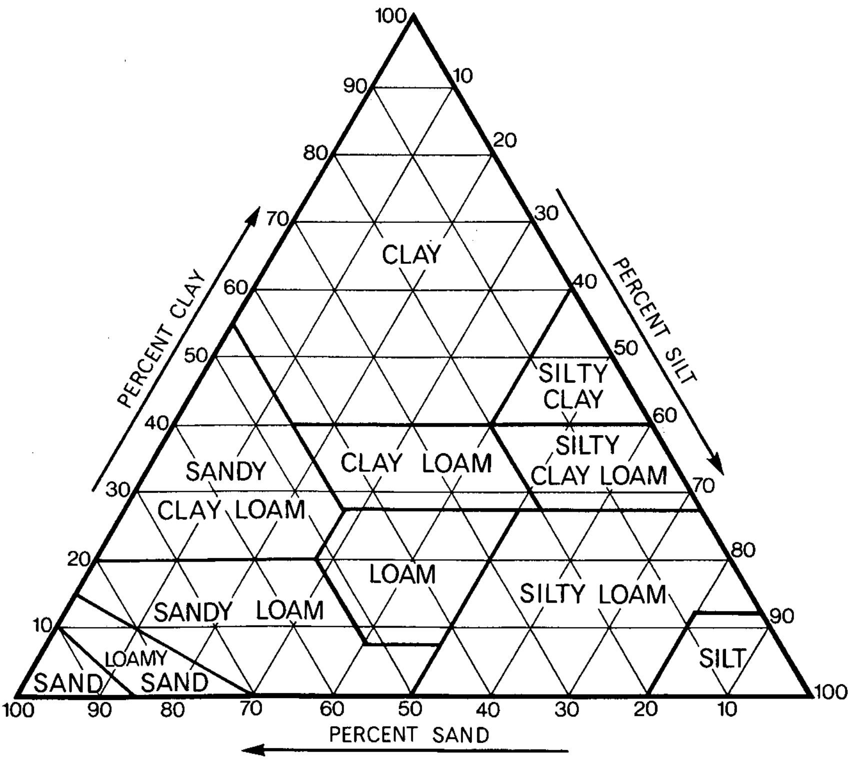

FIG. 21 The Percentage of Clay (<2μ), Silt (2-50μ) and Sand (50-2000μ) in the Basic Soil Textural Classes

by noting the area in which the size grade composition occurs when plotted on the diagram.

General terms referring to broad classes of soil texture are defined by grouping the basic textural classes (U.S.D.A., 1951) as shown below.

	General terms	Basic textural classes
sandy soils	coarse-textured soils	sands loamy sands
loamy soils	moderately coarse-textured soils	sandy loams
	medium-textured soils	loams silt loams silts
	moderately fine-textured soils	clay loams sandy clay loams silty clay loams
clayey soils	fine-textured soils	sandy clays silty clays clays

Structure

The structure of a soil is the aggregation of its primary particles into compound units, peds, which are largely independent of one another. Field descriptions of structure record these features of the peds:

i shape and arrangement
ii size
iii distinctness and durability.

PRIMARY TYPES OF STRUCTURE

I. Platy —with one dimension, the vertical, much less than the other two.

II. Prismlike —with the two horizontal dimensions much less than the vertical.

III. Blocklike —with three dimensions of the same order of magnitude, but having plane or curved surfaces that are casts of the moulds formed by the faces of the surrounding peds.

IV. Spheroidal—with three dimensions of the same order of magnitude, having plane or curved surfaces which have slight or no accommodation to the faces of the surrounding peds.

Class designates the size of the aggregates; five are recognized for each type. The terms used are very fine, fine, medium, coarse and very coarse. The types and classes of soil structure are given in Table 1.

Grade of structure is the degree of aggregation and expresses the differential between cohesion within aggregates and adhesion between aggregates, and in practice is determined mainly by observing the durability of the aggregates. Terms used for grade of structure are:

1. Weak — units barely observable *in situ*. When disturbed the soil material breaks into a mixture of a few unbroken units and many broken with much unaggregated material.
2. Moderate—well formed units but not distinct in undisturbed soil. When disturbed there are many unbroken units, some broken units and a little unaggregated material.
3. Strong —well formed units distinct in undisturbed soil; adhere only slightly to one another. When disturbed consist of entire units with few broken and very little unaggregated material.

Soils without structure are either:

a. Single grain—primary particles do not cohere.
b. Massive —primary particles cohere.

Consistence

Soil consistence is a quality of soil material which is expressed by the degree of cohesion or adhesion, and is measured by the resistance of soil material to deformation or rupture.

The following terms are used to describe consistence under various conditions of moisture (U.S.D.A., 1951).

CONSISTENCE WHEN WET

To evaluate, roll soil material between thumb and forefinger.

0. Non-plastic —no wire formable.
1. Slightly plastic—wire formable and soil mass easily deformed.
2. Plastic —wire formable and moderate pressure required to deform soil mass.
3. Very plastic —wire formable and much pressure required to deform soil mass.

CONSISTENCE WHEN MOIST

To evaluate, attempt to crush in the hand.

0. Loose —non-coherent.
1. Friable —soil material crushes under very gentle pressure but coheres when pressed together.
2. Firm —soil material crushes under very moderate pressure between thumb and forefinger but resistance distinctly noticeable.
3. Very firm—soil material crushes only under strong pressure; sometimes not crushable between thumb and forefinger.

CONSISTENCE WHEN DRY

To evaluate, break an air-dry mass in the hand.

0. Loose —non-coherent.
1. Soft —breaks to powder or individual grains under very slight pressure.
2. Hard —can be broken easily in the hand but only with difficulty between thumb and forefinger.
3. Very hard—can normally be broken in the hands but only with difficulty.

Induration

Induration of soil material refers to a handling property of the soil which unlike consistence appears not to be markedly affected by moisture content. Three terms are used to describe induration and they are defined below.

1. Weakly indurated — not usually detected when digging but presence shown by stabbing a knife into profile face. Breaks easily in the hand.
2. Moderately indurated—detected when digging. Breaks in the hand by using moderate pressure.
3. Strongly indurated —detected when digging and in fact causes difficulty. Not readily broken in the hand.

Organic Matter

Organic matter may be described quantitatively and qualitatively.

a. *Quantitatively*

i. Organic soil >20 percent organic matter
ii. High 13–20 percent
iii. Moderate 8–13 percent
iv. Low <8 percent

b. *Qualitatively*

i. Mull humus —an intimate mixture of mineral and organic matter in the A horizon with the constituent parts indistinguishable by a lens.
ii. Silicate moder —appears similar to mull but its organic and inorganic constituents may be distinguishable with a good lens.
iii. Raw humus (mor)—a distinct organic horizon less than 30 cm thick having little mineral material.

Stoniness

Few stones — <15 percent by volume
Frequent stones—15–50 percent by volume
Many stones — >50 percent by volume

Mottling

Mottling is described according to the abundance, size and colour of mottles and colour contrast between mottles and unmottled soil material.

1 Colour —Munsell color chart notation

2 Abundance
- few —mottles <2 percent of surface
- frequent —mottles 2–20 percent of surface
- many —mottles >20 percent of surface

3 Size
- fine — <5 mm
- medium —5–15 mm
- coarse — >15 mm

4 Contrast
- faint —hue and chroma of matrix closely related.
- distinct —matrix and mottles vary 1–2 units in hue and several units in value and chroma.
- prominent—matrix and mottles vary several units in hue, value and chroma.

Horizon Boundaries

Horizon Boundaries are described in terms of distinctness and regularity. The terms for distinctness are based on the width of the boundary and are given below.

1 Sharp —2·5 cm
2 Clear —2·5–6 cm
3 Gradual—6–12 cm
4 Diffuse —12 cm

TABLE 1. TYPES AND CLASSES OF SOIL STRUCTURE

Type (Shape and Arrangement of Peds)

Class (Size)	Platelike with one dimension (the vertical) limited and much less than the other two; arranged around a horizontal plane; faces mostly horizontal	Prismlike with two dimensions (the horizontal) considerably less than the vertical; arranged round a vertical line; vertical faces well defined; vertices angular.		Blocklike: polyhedronlike, or spheroidal, with 3 dimensions of the same order of magnitude; arranged round a point.			
				Blocklike: blocks or polyhedrons having plane or curved surfaces that are casts of the moulds formed by the faces of surrounding peds.		Spheroids or polyhedrons having plane or curved surfaces which have slight or no accommodation to the faces of surrounding peds.	
		Without rounded caps	With rounded caps	Faces flattened: most vertices sharply angular	Mixed rounded and flattened faces with many rounded vertices	Relatively non-porous peds	Porous peds
	Platy	Prismatic	Columnar	(Angular) Blocky	Subangular Blocky	Granular	Crumb
very fine	very fine platy <1 mm	very fine prismatic <10 mm	very fine columnar <10 mm	very fine angular blocky <5 mm	very fine subangular blocky <5 mm	very fine granular <1 mm	very fine crumb <1 mm
fine	fine platy 1–2 mm	fine prismatic 10–20 mm	fine columnar 10—20 mm	fine angular blocky 5–10 mm	fine subangular blocky 5–10 mm	fine granular 1–2 mm	fine crumb 1–2 mm
medium	medium platy 2–5 mm	medium prismatic 20–50 mm	medium columnar 20–50 mm	medium angular blocky 10–20 mm	medium subangular blocky 10–20 mm	medium granular 2–5 mm	medium crumb 2–5 mm
coarse	coarse platy 5–10 mm	coarse prismatic 50–100 mm	coarse columnar 50–100 mm	coarse angular blocky 20–50 mm	coarse subangular blocky 20–50 mm	coarse granular 5–10 mm	
very coarse	very coarse platy >10 mm	very coarse prismatic >100 mm	very coarse columnar >100 mm	very coarse angular blocky >50 mm	very coarse subangular blocky >50 mm	very coarse granular >10 mm	

Standard Analytical Data

TABLE 2 BROWN FOREST SOILS, FREELY DRAINED

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
1.	BARNCORKRIE ASSOCIATION; Portencorkrie Series. Knockencule, 209037 – 209042																			
Ap	5–15	10·9	59	22	70	11	14	8·8	1·2	0·3	0·08	6·5	61	6·0		4·5	0·43	271	39	Moderate clay throughout.
B_2	25–30	5·6	62	23	74	11	12	2·1	0·4	0·09	—	5·6	32	6·1		2·9	0·28	90	2	Exchangeable cations low below
B_3	35–40	3·6	67	19	76	9	14	1·2	0·3	0·07	—	3·3	32	5·6		1·9	0·16	76	4	plough layer, particularly
B_3/C	55–65	2·3	70	18	79	9	12	0·9	0·3	0·1	0·03	1·5	48	5·8				79	9	exchangeable K. Moderate acidity.
C	72–80	1·9	65	20	76	10	14	1·7	0·7	0·1	0·03	0·4	87	5·7				73	9	Low total P_2O_5 below plough layer
C	95–105	2·1	66	18	73	11	16	2·1	0·7	0·1	0·05	0·3	91	5·8				79	8	and moderate readily soluble P_2O_5.
2.	CREETOWN ASSOCIATION; Clanery Series. Clanery, 216814 – 216818																			
Ap	2–10	12·2	42	39	59	23	13	13·8	0·1	0·2	0·6	9·0	62	6·2		6·8	0·57	357	11	Low clay content in B and C
B_2	22–30	11·3	46	42	64	24	7	3·6	1·5	0·07	0·2	11·8	32	6·0		4·1	0·38	189	1	horizons. Very low exchangeable
B_3	35–45	5·5	55	36	69	23	6	1·4	—	—	—	6·7	18	5·8				132	6	cations in B_3 and C horizons and
C	65–72	3·1	53	39	67	25	8	—	—	—	—	4·2	1	5·7				131	23	very low percentage base saturation
C	87–95	3·0	69	25	79	15	6	—	—	—	—	4·2	2	5·6				115	13	in parent material. High readily
																				soluble P_2O_5 in C horizon.

n.d. Not determined — Less than lower limit of determination.

TABLE 2. Brown forest soils, freely drained—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
3.								CREETOWN ASSOCIATION; Clanery Series. Cuil, 216651 – 216655												
H/A	0–2	27·9	n.d.	n.d.	n.d.	n.d.	n.d.	4·8	1·8	0·9	0·6	73·1	10	4·0		15·4	1·18	217	2	Very low exchangeable Ca in mineral horizons. High exchangeable Na in C horizon. Low percentage base saturation throughout. High readily soluble P_2O_5 in parent material.
A	5–12	12·4	49	38	69	18	7	—	0·2	0·1	0·2	21·8	3	4·6		5·0	0·40	127	—	
B_2	30–40	12·3	60	29	76	13	5	—	0·1	0·1	0·08	23·2	1	4·9		5·0	0·33	137	1	
C	55–65	4·8	44	45	63	26	9	—	0·1	0·3	0·06	18·9	2	4·6				120	14	
C	99–105	2·6	48	42	65	25	10	—	0·1	0·4	0·06	9·8	5	4·5				97	24	
4.								CREETOWN ASSOCIATION; Clanery Series. Craig, 217649 – 217653												
Ap	2–10	13·2	43	38	61	20	12	3·9	0·8	0·2	0·2	15·0	25	5·5		5·9	0·38	197	4	Low clay below plough layer. Very low exchangeable bases below plough layer. Moderately strongly acid throughout. High readily soluble P_2O_5 in B and C horizons.
B_2	27–37	6·6	59	29	72	17	8	1·4	0·1	0·1	0·02	9·7	14	5·6		2·7	0·19	152	14	
B_3	47–55	4·9	60	30	72	19	7	0·8	—	0·1	—	6·8	14	5·7				117	42	
C	65–75	2·9	68	27	78	17	5	—	0·1	0·03	0·04	6·5	2	5·7				107	12	
C	85–92	2·4	68	25	77	17	7	—	—	0·04	0·04	6·5	1	5·7				86	12	

5. DALBEATTIE ASSOCIATION; Dalbeattie Series. Fleet Viaduct, 217641 – 217644

H/A_1	0–2	22·1	58	16	64	10	9	1·0	0·8	0·2	0·4	43·3	5	4·4	11·0	0·73	24·4	<1	Low clay and high sand in B horizons. Very low exchangeable bases throughout. Very low percentage base saturation. High acidity. High carbon content in B horizon.
A_1	5–12	11·8	67	18	74	10	10	—	0·1	0·2	0·2	16·6	3	4·9	6·1	0·40	197	1	
B_2	32–42	14·1	76	13	79	10	4	—	—	0·03	0·02	18·7	<1	5·2	6·0	0·28	198	4	
B_3	52–60	5·4	90	4	90	3	4	—	—	0·05	—	9·3	<1	5·0	2·0	0·13	108	2	

6. ETTRICK ASSOCIATION; Linhope Series. Dervaird, 215198 – 215202

A	2–10	19·5	50	19	59	10	16	3·8	0·8	0·3	0·9	23·7	20	5·0	8·6	0·44	202	<1	Moderate to high clay for Brown Forest soil. Moderate exchangeable bases in A horizon and very low in B and C horizons. Moderately high activity. Very low readily soluble P_2O_5 throughout.
A	15–25	15·3	54	20	62	12	18	3·4	0·6	0·2	0·9	18·8	22	5·1	6·3	0·55	187	<1	
B_2	32–40	11·2	59	18	66	10	18	1·9	0·3	0·1	0·3	15·0	15	5·1			167	—	
B_3	45–52	6·0	51	19	59	11	27	0·6	—	0·03	0·1	16·4	5	5·3			84	<1	
C	67–75	6·2	48	24	57	15	25	0·9	0·1	0·04	0·2	6·0	17	5·2			70	<1	

7. ETTRICK ASSOCIATION; Linhope Series. Newton, 217674 – 217680

A/H	0–2	49·7	n.d.	n.d.	n.d.	n.d.	n.d.	2·5	3·4	0·4	0·6	59·0	10	3·9	26·3	0·91	275	9	High clay in lower part of B horizon. Very low exchangeable cations and percentage base saturation throughout. High organic content in A/H. Low readily soluble P_2O_5 in mineral horizons.
A_1	5–12	13·8	30	40	42	27	24	0·6	0·5	0·1	0·1	22·3	6	4·2	6·8	0·45	192	<1	
B_2	20–22	11·7	36	37	45	28	21	0·6	0·5	0·1	0·2	17·7	7	4·3	5·5	0·28	176	<1	
B_2	40–45	8·1	43	35	51	28	22	—	0·1	0·1	0·1	10·5	3	4·6			122	<1	
B_2	57–62	7·1	32	36	39	29	32	—	0·2	0·1	0·03	8·8	4	4·7			117	<1	
B_2	77–85	6·1	33	35	40	28	32	—	0·1	0·06	0·02	9·1	2	4·7			113	<1	

n.d. Not determined — Less than lower limit of determination.

TABLE 2. Brown forest soils, freely drained—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
8.						ETTRICK ASSOCIATION; Linhope Series. Cardoness Wood, 217657 – 217659														
A_{11}	2–7	12·6	38	35	50	23	21	5·4	1·4	0·2	0·5	11·2	40	5·7		5·2	0·44	237	<1	Moderate exchangeable bases in A horizon. Relatively high percentage base saturation and pH for this series. Low readily soluble P_2O_5 throughout.
A_{12}	10–15	10·0	32	39	45	27	24	2·3	0·6	0·2	0·2	9·7	26	5·6		3·8	0·34	251	<1	
B	32–40	7·6	44	32	53	24	24	—	0·2	0·06	0·08	7·8	5	5·4				238	<1	
9.						ETTRICK ASSOCIATION; Linhope Series. Glenchamber, 215246 – 215249														
A	2–10	14·6	58	23	68	13	12	11·5	1·1	0·3	0·1	29·0	45	5·7		8·2	0·50	166	<1	Relatively high clay in B_3 and C horizons. High exchangeable Ca and moderate acidity in A horizon. Low total P_2O_5 in B_3 and C horizons and low readily soluble P_2O_5 throughout.
B_2	30–37	11·6	62	19	71	10	13	2·2	0·1	0·1	0·06	18·4	14	5·2		3·8	0·32	134	—	
B_3	42–47	4·6	45	27	58	14	25	0·9	—	—	0·02	7·6	12	5·1				78	2	
C	55–60	4·2	46	26	57	15	25	0·9	—	—	0·04	6·9	14	5·2				80	<1	
10.						ETTRICK ASSOCIATION; Linhope Series. Muil, 216607 – 216611														
Ap	2–10	13·4	40	29	51	18	25	1·3	0·4	0·2	0·2	12·9	14	5·0		6·1	0·43	219	<1	Relatively high clay in B_2 and B_3 horizons. Low exchangeable cations and percentage base saturation throughout. Moderately high acidity and uniform pH trend throughout. Very high total P_2O_5 in B_2 horizon.
B_2	32–42	10·6	37	33	48	22	27	0·8	0·05	0·4	0·1	11·5	8	4·8		4·0	0·28	769	<1	
B_2	60–67	8·5	47	33	57	23	20	0·3	—	0·2	0·08	9·1	6	4·9				651	<1	
B_3	92–100	6·0	49	25	57	17	27	0·3	—	0·1	0·06	6·5	7	4·9				432	<1	
C	110–120	3·5	58	24	66	15	18	0·3	—	0·01	0·04	2·8	11	5·0				77	4	

11. ETTRICK ASSOCIATION; Linhope Series. Artfield, 215217–215222

A	2–10	14·8	36	29	49	16	27	0·5	1·3	0·06	0·6	21·1	10	4·9	7·1	0·62	174	<1	Low exchangeable cations
A	20–27	11·6	50	26	61	15	18	—	0·07	0·04	0·3	15·4	3	4·8	4·7	0·46	162	<1	throughout. Low percentage base
B_2	32–37	8·9	53	25	61	16	18	—	0·05	0·03	0·2	11·5	2	5·0			184	<1	saturation throughout. Moderate
B_3	52–62	6·3	49	26	62	14	21	—	0·03	—	0·1	8·0	2	5·0			122	<1	total P_2O_5 and low readily soluble
C	82–90	3·6	49	27	60	16	24	—	0·1	—	0·1	3·5	7	5·2			81	<1	P_2O_5 throughout.

12. ETTRICK ASSOCIATION; Linhope Series. Challochglass, 215343–215347

A_{11}	2–5	26·2	n.d.	n.d.	n.d.	n.d.	n.d.	1·5	1·2	0·3	1·3	37·3	10	4·8	14·7	0·84	318	2	Very high organic content in surface
A_{12}	7–15	15·2	52	23	63	12	18	—	0·3	0·1	0·5	26·9	3	4·8	6·4	0·51	237	<1	5 cms. High exchangeable Na and K
B_2	30–40	10·0	53	27	65	15	15	—	0·06	0·05	0·07	14·2	1	5·0			103	<1	in surface. Exchangeable Ca low
B_2	60–70	9·2	55	27	66	16	14	—	0·07	0·02	0·08	12·5	1	5·0			159	2	throughout. Very low percentage
C	90–100	4·7	58	24	67	16	15	—	0·04	—	0·08	7·9	1	5·0			230	5	base saturation throughout.

13. ETTRICK ASSOCIATION; Linhope Series (intergrade variant). Kirvennie, 216714–216717

Ap	2–10	12·5	37	27	44	20	30	9·3	0·7	0·2	0·2	18·7	56	6·0	6·9	0·43	326	7	High clay throughout. Exchangeable
B_2	22–30	7·7	37	31	48	20	28	1·9	0·2	0·1	0·2	10·3	22	5·8	2·1	0·17	184	1	Ca and percentage base saturation
C	47–55	3·5	47	26	55	55	27	0·9	—	0·03	0·1	4·8	23	5·5			125	6	moderately high in surface. Acidity
C	75–80	3·2	51	27	59	59	22	0·9	0·03	0·03	0·1	2·4	47	5·7			108	11	moderate throughout.

n.d. Not determined — Less than lower limit of determination.

TABLE 2. Brown forest soils, freely drained—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
14								FLEET ASSOCIATION; Fleet Series. Culreoch, 217645–217648												
Ap	2–10	17·2	47	29	61	15	11	12·7	0·8	0·3	0·2	15·1	48	5·7		8·8	0·53	287	2	Low clay throughout. High exchangeable Ca in Ap. Exchangeable cations low in subsoil horizons. Acidity moderate throughout.
B_2	22–27	5·8	74	16	80	9	7	3·2	0·1	0·1	—	8·6	29	5·9		3·1	0·16	144	2	
B_3	37–45	2·9	89	7	92	4	4	0·9	0·04	0·06	—	6·7	13	5·9				102	2	
B_3/C	75–80	1·8	94	5	96	3	1	—	—	—	—	5·6	<1	6·0				96	2	
15.								KIRKCOLM ASSOCIATION; Kirkcolm Series. Cailliness, 209066–209069												
Ap	2–10	6·5	70	12	77	6	15	8·8	0·6	0·1	0·3	2·2	82	6·0	n.d.	2·2	0·14	375	60	Low clay below plough layer. Moderate exchangeable bases and acidity in surface. Low carbon in Ap. Very high readily soluble P_2O_5 throughout.
Ap	25–32	5·4	75	10	80	5	13	7·0	0·7	0·1	0·2	3·1	72	6·1	n.d.	1·8	0·14	243	43	
A/B	42–50	5·7	84	4	87	2	9	5·2	0·5	0·08	0·1	1·4	81	5·8	n.d.			215	15	
C	77–87	1·7	93	2	94	2	5	2·1	0·2	0·05	0·1	0·3	89	6·2	n.d.			87	10	
16.								KIRKCOLM ASSOCIATION; Clachan Series. Garlieston, 231822–231825												
Ap	2–10	3·3	93	4	95	2	3	5·3	0·9	0·1	0·2	3·2	67	6·2	6·1	1·9	0·16	173	n.d.	Low clay throughout. Moderate exchangeable bases and acidity in surface. Low carbon in Ap. Moderate P_2O_5 in Ap.
Ap	15–25	3·7	93	4	95	2	3	5·7	1·0	0·1	0·1	0·5	94	6·3	6·2	1·8	0·15	176	n.d.	
B/C	37–50	1·2	97	—	97	—	3	1·4	0·3	0·04	0·05	1·4	55	5·9	5·8			104	n.d.	
C	75–85	0·8	96	1	97	2	3	0·9	0·2	0·04	0·07	0·9	58	5·8	5·7			52	n.d.	

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	% $CaCO_3$	me/100 g Cation Exchange Capacity	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
17.								KIRKCOLM ASSOCIATION; Kirranrae Series. Bagbie, 217654–217656													
Ap	2–10	13·1	72	15	78	8	7	n.d.	0·7	0·3	0·1	—	100	7·3	9·0	9·5	4·5	0·43	205	54	Low clay content throughout. Free $CaCO_3$, complete base saturation and neutral to alkaline pH throughout. Low cation exchange capacity throughout.
B/C	32–45	8·8	83	12	88	7	5	n.d.	0·2	0·2	—	—	100	7·5	6·2	3·2	0·9	0·09	104	3	
C	67–75	13·6	89	8	93	4	3	n.d.	0·5	0·3	—	—	100	7·8	15·1	2·9			74	4	

n.d. Not determined — Less than lower limit of determination.

TABLE 2. Brown forest soils, freely drained—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
18.					RHINS ASSOCIATION; Portencalzie Series. Portencalzie, 200486–200490															
Ap	5–12	10·4	51	24	61	14	20	11·2	1·1	0·2	0·7	5·2	72	6·3		4·0	0·35	321	8	Moderate clay content throughout. High exchangeable calcium in plough layer. Percentage base saturation high in all layers except for minimum value in B horizon. High readily soluble P_2O_5 in B_3/C horizon.
Ap	17–25	8·8	51	23	59	16	21	12·2	0·7	0·2	0·3	5·1	72	6·5		3·3	0·22	264	—	
B	35–45	5·3	65	14	71	8	18	3·9	0·3	0·1	0·1	6·7	40	5·9				248	1	
B_3/C	57–67	2·5	62	20	69	14	18	4·3	0·9	0·4	0·1	1·2	83	5·8				105	17	
B_3/C	95–102	2·4	62	24	71	16	13	5·2	2·8	0·1	0·2	1·1	88	6·4				124	28	
19.					RHINS ASSOCIATION; Portencalzie Series (Permian variant). Corsewall House, 220045–220048															
Ap	2–10	11·0	49	23	59	13	23	5·5	0·3	0·2	0·2	5·2	54	5·5		4·9	0·45	242	4	Very low clay content in subsoil. Low exchangeable Ca and Mg throughout. Moderate percentage base saturation and acidity throughout.
Ap	15–25	7·1	51	20	57	14	25	2·0	0·1	0·07	0·1	6·1	27	5·2		3·7	0·38	199	2	
B_2	45–55	5·0	78	5	79	4	14	1·8	0·05	0·03	0·06	1·9	51	5·7				147	2	
B_3/C	70–75	3·3	85	3	87	2	11	1·7	0·1	0·01	0·04	0·9	67	6·0				140	5	

20. RHINS ASSOCIATION; Portencalzie Series. Drumbreddan, 200109—200113

Ap	5–15	11·3	51	32	68	15	11	17·4	9·0	0·4	0·01	7·1	79	6·6	5·9	0·46	662	109	Very high exchangeable Ca and Mg
Ap	20–27	5·8	56	33	67	22	8	12·7	2·3	0·2	—	4·0	79	6·7	3·3	0·26	304	45	in plough layer but very low
B_2	32–40	4·1	54	29	71	11	16	8·5	0·9	0·1	0·9	4·2	71	6·9			141	5	exchangeable K. High percentage
B_3/C	57–65	2·6	62	29	83	8	9	4·8	0·5	0·08	0·9	—	100	7·0			96	10	base saturation and pH. Very high
C	80–90	2·6	64	25	79	11	10	3·8	0·5	0·08	0·9	—	100	7·1			86	6	total and readily soluble P_2O_5 in Ap horizon.

21. RHINS ASSOCIATION; Portencalzie Series (Permian variant). Gallowhill, 219903—219908

Ap	2–10	12·4	45	34	61	19	15	16·4	0·5	0·2	0·04	5·2	77	6·3	5·5	0·46	295	12	Moderate clay content throughout.
Ap	12–22	11·4	47	34	61	20	13	17·3	0·5	0·2	0·03	4·5	80	6·5	5·2	0·35	273	10	Very high exchangeable Ca in Ap
B_2	22–30	7·9	51	29	62	18	16	7·6	0·5	0·1	—	4·5	65	6·5	2·9	0·23	192	2	horizon and very low exchangeable
B_3	47–55	3·5	56	26	66	15	19	1·7	0·1	0·02	—	1·7	52	6·1			105	20	K. High percentage base saturation
B_3	65–72	3·2	63	20	70	13	17	1·1	0·1	0·02	—	0·9	59	6·1			130	24	and moderately high pH throughout.
D	92–100	4·1	70	16	76	10	15	2·4	0·3	0·04	0·04	1·9	60	6·4			187	17	Very high readily soluble P_2O_5 throughout except in B_2.

22. RHINS ASSOCIATION; Portencalzie Series (Permian variant). Marsclaugh, 220029—220034

Ap	2–10	13·6	46	32	58	19	16	18·2	0·6	0·2	0·03	8·1	70	6·4	7·1	0·51	305	19	Very high exchangeable Ca in Ap
Ap	12–22	15·2	41	35	55	21	16	18·3	0·9	0·2	0·04	8·1	71	6·2	7·3	0·51	332	22	horizon. Exchangeable cations low in
B_2	27–35	8·4	56	29	64	21	11	2·0	0·05	0·1	0·03	8·1	21	5·5	2·7	0·26	210	2	B_2 and B_3/C horizons. Readily
B_3/C	45–52	4·9	19	15	76	9	13	0·7	0·03	0·1	0·03	2·8	24	5·5			134	3	soluble P_2O_5 *high in Ap and* B_3/C
B_3/C	70–77	3·3	84	8	88	4	8	0·5	—	0·02	—	1·9	20	5·2			117	9	horizons and low in B_2 horizon.
B_3/C	90–97	3·3	80	11	84	7	9	0·5	—	—	—	1·7	21	5·3			136	9	

n.d. Not determined — Less than lower limit of determination.

TABLE 2. Brown forest soils, freely drained—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
23.				RHINS ASSOCIATION; Portencalzie Series (Permian variant). Cruggleton, 214107–214111																
Ap	4–15	9·6	36	35	48	23	24	11·7	0·6	0·2	0·7	6·9	65	5·7		4·5	0·31	489	28	Moderately high clay content throughout. High exchangeable Ca in Ap horizon. Moderate acidity throughout. Very high readily soluble P_2O_5 in all horizons except in B_2 horizon.
B_2	25–32	5·9	43	30	55	18	24	6·7	0·4	0·1	0·06	3·3	69	6·6		1·6	0·15	278	4	
B_3	45–50	2·6	52	39	66	15	19	1·4	0·07	0·02	0·06	1·6	49	5·7				139	33	
B_3	60–70	2·6	52	26	62	15	23	1·4	0·2	—	0·1	1·6	51	5·8				124	33	
IIC	80–85	2·5	49	29	60	17	22	2·7	0·4	—	0·1	1·1	75	6·0				124	46	
24.				RHINS ASSOCIATION; Portencalzie Series (intergrade variant). Drumniel, 201245–201248																
A	5–12	12·2	41	32	56	19	21	6·1	0·6	0·1	0·4	5·5	57	5·6		5·8	0·42	372	16	Moderate clay content throughout. Exchangeable cations moderate in surface but low in B and C horizons. High total P_2O_5 in A horizon and high readily soluble P_2O_5 throughout.
B_2	25–30	7·9	42	31	57	16	24	1·5	0·08	0·08	0·1	4·6	28	5·7		3·5	0·18	155	6	
B_3/C	47–55	3·8	53	26	63	16	22	—	0·09	0·06	0·08	0·7	26	5·4				109	12	
C	65–70	3·1	49	27	61	15	24	—	0·05	0·07	0·1	0·8	23	5·4				105	12	

25. YARROW ASSOCIATION; Yarrow Series. Castle Kennedy, 215422–215426

L & F	2–0	58·7	n.d.	n.d.	n.d.	n.d.	n.d.	18·5	7·6	1·7	4·3	36·8	47	4·9	27·9	1·25	243	24	Low clay content throughout. Very high exchangeable bases in L and F horizons but low in A_1/H layer and very low in A_1, B_2 and C horizons. Acidity high throughout. Low readily soluble P_2O_5 in mineral horizons.
A_1/H	0–5	20·5	64	13	7	71	7	3·9	1·6	0·5	0·4	33·2	16	4·5	11·3	0·58	197	2	
A_1	15–25	10·0	63	18	12	70	13	0·5	0·3	0·2	0·1	17·1	6	4·5			119	1	
B_2	35–42	12·1	62	23	13	73	8	—	0·06	0·1	0·1	20·7	1	4·6			160	1	
C	62–75	6·6	88	4	3	89	5	—	0·02	—	—	10·6	<1	4·7			87	1	

26. YARROW ASSOCIATION; Yarrow Series. Ringuinea, 209070–209074

Ap	2–10	12·3	69	12	75	6	13	8·2	0·3	0·08	0·08	6·5	57	6·0	5·2	0·51	402	34	Low clay content in B and C horizons. Exchangeable Ca moderately high in Ap horizons but all exchangeable cations very low in B and C horizons. Total and readily soluble P_2O_5 high in Ap layer but very low in B and C horizons.
B_2	25–37	6·0	81	8	87	2	8	1·2	0·05	0·04	—	6·2	18	5·6	1·0	0·09	89	2	
B_3	45–52	2·6	94	2	95	1	4	—	0·04	0·02	—	1·4	4	5·5			41	1	
C	70–77	1·7	95	1	96	—	4	—	0·01	—	—	2·8	<1	5·4			60	2	
C	102–110	2·7	90	4	92	2	6	—	0·03	—	—	1·4	3	5·2			73	1	

27. YARROW ASSOCIATION; Yarrow Series. Cults, 200073–200076

Ap	5–15	6·1	84	6	87	3	7	4·9	0·2	0·1	0·4	7·5	74	5·6	2·5	0·12	144	10	Very high sand content throughout. Very low exchangeable cations throughout with exception of moderate exchangeable Ca in Ap horizon. Low total P_2O_5 in B and C horizons but moderate readily soluble P_2O_5.
B_2	25–35	2·1	95	2	95	2	3	0·8	0·1	0·05	0·06	4·1	23	5·8	0·4	0·04	89	5	
B_3	45–60	1·7	93	4	94	3	3	0·8	0·3	0·04	0·06	2·6	44	5·4			70	6	
C	65–75	0·8	95	2	97	<1	3	—	0·06	0·03	0·02	1·3	8	5·3			47	4	

n.d. Not determined — Less than lower limit of determination.

TABLE 2. Brown forest soils, freely drained—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
28.								YARROW ASSOCIATION; Cairnside Series. Inch Croft, 200054–200058												
Ap	7–17	4·6	82	7	86	3	9	1·1	0·07	0·05	0·03	7·3	14	5·4		2·4	0·14	150	5	Low clay content throughout. Very low exchangeable bases throughout, but acidity only moderate. Low total P_2O_5 but moderately high readily soluble P_2O_5 in B and C horizons.
B_2	25–35	2·5	91	3	92	2	7	1·1	0·09	0·01	—	4·3	21	5·6		1·3	0·09	91	2	
B_3	37–45	1·6	95	<1	95	<1	5	0·9	0·05	—	—	2·9	25	5·8				87	5	
B_3	52–60	1·0	95	4	95	3	2	0·8	—	—	—	2·0	28	5·9				102	9	
C	72–80	0·9	97	<1	97	<1	3	0·5	—	—	—	0·9	39	6·6				67	6	
29.								YARROW ASSOCIATION; Cairnside Series. Dunragit, 200068–200072												
Ap	5–12	9·4	72	12	78	6	11	5·4	0·4	0·1	0·09	10·5	37	5·0		5·1	0·40	167	19	Low clay content in B and C horizons. Exchangeable cations moderate to low in surface but low in all deeper layers. Acidity high, uniform with depth. Total and readily soluble P_2O_5 low in all layers below surface.
Ap	17–25	6·1	76	10	82	4	11	3·9	0·2	0·08	0·04	14·6	22	5·0		3·4	0·27	69	—	
B_2	35–45	3·0	89	3	91	1	8	0·5	0·03	0·05	0·03	6·3	8	5·1				68	2	
B_3	55–62	1·8	94	1	95	1	4	—	0·07	0·03	—	4·2	3	5·1				66	1	
C	65–77	0·9	94	3	97	<1	3	—	0·04	0·03	0·02	2·0	4	5·1				61	2	

TABLE 3. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

30.	BARNCORKRIE ASSOCIATION; Barncorkrie Series. Knockencule, 209043–209047																	
Ap	5–15	16·0	57	20	66	11	11	3·6	1·3	0·3	0·6	17·5	25	5·2	8·8	0·68	223	<1	Moderate exchangeable cations in Ap horizon, low exchangeable Ca in Bg and Cg horizons and high exchangeable Mg and Na in Cg. High percentage base saturation in Cg. Low total P_2O_5 in Bg and Cg horizons.
B_2g	30–37	7·4	61	18	69	11	16	1·4	0·6	0·1	0·1	10·8	17	5·3	4·2	0·28	98	<1	
IIB_3g	55–65	3·3	59	19	68	9	23	1·4	0·9	0·1	0·1	3·3	43	5·5			88	4	
IICg	77–85	2·8	57	21	66	12	22	2·0	2·3	0·3	0·1	1·5	76	5·8			69	1	
IICg	105–115	2·8	55	22	65	12	23	2·0	3·1	0·3	—	1·4	79	5·9			73	2	
31.	CARBROOK ASSOCIATION; Harviestoun Series. Culgroat, 200077–200080																	
Ap	7–15	7·2	50	24	50	23	27	6·9	1·2	0·2	0·1	6·2	58	5·5	3·0	0·29	157	6	Very high clay content in Bg and Cg horizons. High exchangeable Ca, Mg and Na in B_3g and Cg horizons and moderate exchangeable K. Very low total and readily soluble P_2O_5 in Bg horizon.
B_2g	25–32	4·4	16	33	23	27	51	6·7	3·6	0·3	0·2	5·3	67	5·5	0·7	0·07	35	<1	
B_3g	50–57	3·4	20	32	24	27	49	9·7	8·2	0·4	0·3	3·2	85	5·7			35	<1	
Cg	80–87	2·6	14	34	20	28	53	11·6	8·1	0·5	0·3	2·7	88	6·1			113	26	
32.	CREETOWN ASSOCIATION; Arkland Series. Spittal, 216828–216831																	
Apg	2–10	12·0	34	50	53	32	10	4·8	0·6	0·07	—	9·0	38	5·9	5·7	0·56	291	7	Moderately low clay content throughout. Low exchangeable bases in all horizons. Moderate to high readily soluble P_2O_5.
B_2g	35–45	4·4	56	32	67	21	10	0·9	0·1	0·04	—	5·2	18	5·7	1·1	0·08	102	6	
B_2g	60–70	4·4	59	29	71	17	10	0·9	0·09	0·04	0·06	3·8	22	5·8			111	9	
Bg/Cg	77–87	2·6	49	39	65	24	12	0·9	0·06	0·04	0·08	2·5	30	5·9			78	9	

n.d. Not determined — Less than lower limit of determination.

TABLE 3. Brown Forest Soils with Gleyed B and C Horizons—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
33.						ETTRICK ASSOCIATION; Altimeg Series. Barholm, 217756–217761														
A_1g	2–10	6·6	43	41	58	26	13	3·2	0·5	0·1	0·2	5·2	44	6·2		2·7	0·23	170	12	Low clay content in Bg horizons. Low exchangeable Ca throughout. Moderately low exchangeable Mg and low exchangeable Na and K in Bg horizons. Low total P_2O_5 and very high readily soluble P_2O_5 throughout.
A_2g/A_1g	25–32	3·4	53	34	65	22	13	1·5	0·3	0·08	0·06	2·5	44	6·1		1·1	0·07	83	5	
B_2g	40–50	1·6	58	33	70	22	9	1·1	0·3	—	0·04	1·8	45	6·1		0·5	0·05	57	21	
B_2g	57–62	1·8	58	34	70	22	8	0·5	0·3	—	0·03	1·8	29	6·1				76	33	
B_3g	72–80	1·6	43	47	58	32	9	1·5	0·4	0·02	0·05	1·1	65	6·0				94	42	
B_3g	97–105	1·7	45	45	59	31	10	2·4	0·6	0·01	0·06	0·9	77	6·1				96	39	
34.						ETTRICK ASSOCIATION; Altimeg Series. Glenchamber, 215243–215245														
Ap	2–10	22·2	57	21	69	8	6	1·9	0·6	0·3	0·6	26·6	11	4·8		11·9	0·98	175	1	Moderately low clay content in Ap and B_2g horizons. Very low values for exchangeable cations in B_2g horizon. Acidity high throughout. Low total and readily soluble P_2O_5 in B_2g and B_3g horizons.
B_2g	32–40	8·1	57	29	71	14	11	--	0·07	0·03	0·05	11·0	1	4·9		2·7	0·21	100	1	
B_3g	77–82	2·9	68	16	73	12	16	2·9	1·68	0·17	0·1	1·4	78	5·1				66	1	

35. ETTRICK ASSOCIATION; Altimeg Series. Millgrane, 216592–216595

Apg	2–10	14·5	63	21	72	13	8	12·9	0·8	0·2	1·1	8·4	64	6·3	6·5	0·44	319	6	Moderate clay content in upper 50 cms. High exchangeable Ca and K in Apg. All exchangeable cations low in Bg and Cg. Moderate total P_2O_5 and readily soluble P_2O_5 in Bg and Cg horizons.
Bg	30–35	4·5	63	21	68	16	16	0·8	0·06	—	0·4	5·1	19	5·6	0·5	0·05	100	5	
Cg	40–45	3·8	61	23	69	15	16	1·3	0·2	0·06	0·3	5·1	27	5·5			124	6	
Cg	75–80	3·5	47	26	54	19	27	1·8	0·5	0·06	0·2	5·1	33	5·2			135	11	

36. ETTRICK ASSOCIATION; Altimeg Series. Bents, 216738–216742

Ag	2–10	16·5	33	26	48	21	19	2·5	0·8	0·2	0·5	11·9	25	5·4	8·4	0·69	379	4	Unusually high clay content in Bg horizons. Moderate exchangeable K throughout and moderate exchangeable Mg and Na in Ag horizon. Exchangeable Ca low throughout. Acidity and percentage base saturation moderate. High readily soluble P_2O_5 in Bg and Cg horizons.
Bg	27–35	5·4	38	28	44	22	34	1·2	0·02	0·04	0·3	2·2	42	5·9	1·7	0·15	160	7	
Bg	42–50	4·3	34	30	43	22	36	0·9	—	0·05	0·3	1·7	43	5·9			180	12	
Bg	62–72	3·9	36	28	43	22	36	1·2	0·3	0·04	0·3	1·3	58	5·7			143	29	
Bg/Cg	82–90	3·1	43	27	49	31	30	0·9	0·3	0·04	0·2	1·3	53	5·8			198	29	

37. ETTRICK ASSOCIATION; Altimeg Series (intergrade variant). Kirvennie, 216709–216713

Ap	2–10	10·4	44	29	54	19	22	13·3	1·7	0·2	1·9	6·0	74	6·4	7·0	0·51	481	26	Unusually high clay content in Bg horizon. Exchangeable Ca high in Ap horizon but very low in Bg horizon. Readily soluble P_2O_5 high throughout.
Bg	25–30	1·5	59	16	65	10	25	0·9	0·1	0·03	0·6	4·4	28	5·6	0·8	0·09	145	12	
Bg	40–45	4·2	45	24	51	18	29	—	0·05	0·03	0·5	4·6	11	5·2			127	12	
Bg	60–67	4·0	45	25	54	15	29	—	0·10	0·02	0·5	4·9	11	5·1			130	11	
B/C	85–90	3·5	53	22	56	19	25	0·6	0·13	0·03	0·5	5·1	20	5·1			114	12	

n.d. Not determined — Less than lower limit of determination.

TABLE 3. Brown Forest Soils with Gleyed B and C Horizons—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
38.								ETTRICK ASSOCIATION; Kedslie Series. Drummuckloch, 200455–200459												
Ap	7–17	9·6	28	38	43	23	29	12·5	0·7	0·3	0·1	19·8	69	6·2		4·1	0·35	258	5	High clay content throughout. High exchangeable Ca in Ap horizon. High exchangeable Mg in Bg/Cg horizon. High percentage base saturation and weakly acid reaction throughout. Low readily soluble P_2O_5 in subsoil horizons.
A_2g	27–35	4·0	40	28	48	19	33	4·6	0·5	0·2	0·1	9·7	55	6·7		1·0	0·10	87	1	
B_2g	50–60	3·3	41	25	48	18	35	5·0	2·5	0·2	0·1	11·0	71	6·5				112	<1	
Bg/Cg	75–85	3·6	38	26	44	20	37	3·8	4·6	0·2	0·1	11·6	76	6·5				117	<1	
Bg/Cg	95–105	3·7	39	30	50	19	31	3·2	5·8	0·2	0·1	11·9	78	6·5				139	1	
39.								ETTRICK ASSOCIATION; Kedslie Series. Balker, 200538–200543												
A	5–15	9·8	34	36	46	24	25	7·3	2·6	0·3	0·5	7·0	60	6·1		5·2	0·34	93	1	Moderate exchangeable Ca in A horizon and low exchangeable Ca in Bg horizons. Moderate percentage base saturation and moderately acid reaction throughout. Low total and readily soluble P_2O_5 in upper 100 cms. High readily soluble P_2O_5 in Bg/Cg horizon.
B_2g	30–40	5·7	43	23	50	16	31	2·5	0·3	0·1	0·07	4·4	41	5·4		2·4	0·16	121	<1	
B_3g	47–55	3·4	51	24	63	12	25	1·4	0·3	0·1	0·06	3·1	37	5·3		1·4	0·14	71	1	
B_3g	60–67	3·3	47	28	58	18	25	1·2	0·3	0·08	0·05	2·4	40	5·4				73	2	
B_3g	87–95	4·1	43	30	56	17	27	1·2	0·3	0·08	0·05	1·7	51	5·4				79	4	
Bg/Cg	115–125	3·3	40	28	51	18	32	1·5	0·9	0·1	0·04	1·7	60	5·5				193	23	

40. ETTRICK ASSOCIATION; Kedslie Series (intergrade variant). Killantrae, 214142–214147

Ap	2–10	10·7	41	33	55	19	20	13·9	1·0	0·2	0·8	4·7	77	6·3	3·8	0·37	440	17	Uniform particle size fractions below Ap horizon. High exchangeable Ca in Ap horizon. Moderate exchangeable cations in Bg and Bg/Cg horizons. High percentage base saturation and moderately high reaction throughout. High total and *readily soluble* P_2O_5 *in surface.*
B_2g	15–25	9·4	42	31	52	21	22	14·8	0·9	0·07	0·7	3·8	81	6·3	3·9	0·32	374	27	
B_2g	35–42	4·8	43	26	53	16	29	5·3	0·5	0·01	0·7	2·3	74	6·4	0·7	0·07	143	3	
B_2g	47–55	3·8	49	24	58	15	27	7·0	0·9	0·04	0·4	2·3	78	6·7			138	1	
Bg/Cg	65–72	3·4	48	24	58	14	28	4·7	1·0	0·04	0·3	3·0	67	6·1			90	—	
Bg/Cg	85–92	3·3	48	24	58	14	28	4·7	1·6	0·04	0·2	2·8	70	6·1			138	—	

41. RHINS ASSOCIATION; Rhins Series. Low Ersock, 214081–214085

Ap	2–10	12·2	31	42	48	25	21	16·6	7·8	0·3	0·3	1·3	95	6·5	4·5	0·45	355	18	Uniform moderately high clay content in Bg and Cg horizons. High exchangeable Ca in Ap horizon and high exchangeable Mg in upper part of Ap horizon. High percentage base saturation and slightly acid reaction. High readily soluble P_2O_5 in Ap horizon but low total and readily soluble P_2O_5 in Bg horizons.
Ap	12–25	8·5	34	34	47	20	28	10·4	0·4	0·2	0·2	2·4	82	6·4	3·1	0·28	182	10	
Bg	40–50	4·1	40	27	50	17	31	3·8	0·3	0·1	0·1	—	100	6·6			81	1	
C	70–77	3·6	44	25	53	16	31	2·6	0·4	0·03	0·04	—	100	6·7			70	—	
C	92–100	3·4	42	27	51	18	32	7·1	1·5	0·1	0·1	—	100	6·8			114	12	

42. RHINS ASSOCIATION; Rhins Series. Balgown, 200491–200496

Ap	5–12	12·6	41	32	54	19	21	14·6	1·5	0·9	4·2	7·3	74	5·9	7·3	0·44	268	9	High exchangeable Ca and K in Ap horizon and high exchangeable Mg in C horizon. Moderate percentage base saturation and acidity throughout. Low total and readily soluble P_2O_5 in Bg and C horizons.
Ap	15–22	8·9	38	30	49	19	28	8·0	1·0	0·2	0·1	6·3	60	6·0	4·5	0·29	198	3	
B_2g	27–35	4·9	49	26	54	20	23	3·4	0·6	0·3	0·05	4·6	49	5·7	1·4	0·12	64	2	
B_3g	50–57	2·1	49	24	56	17	27	2·4	1·4	0·2	0·07	3·3	56	5·6			73	<1	
C	67–75	2·9	46	27	55	18	27	2·4	9·3	0·2	0·07	3·1	79	5·7			79	—	
C	95–105	2·8	52	23	59	16	24	2·9	5·9	0·2	0·07	1·2	89	6·6			104	2	

n.d. Not determined — Less than lower limit of determination.

TABLE 3. Brown Forest Soils with Gleyed B and C Horizons—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
43.																				RHINS ASSOCIATION; Rhins Series. Drumbreddan, 200105–200108
Ap	7–17	7·4	34	35	48	21	28	13·2	1·7	0·3	0·2	2·9	84	6·3		3·3	0·22	206	16	High clay content in Bg and C horizons. High exchangeable Mg and Na in Bg and C horizons. High percentage base saturation throughout. Low total and readily soluble P_2O_5 in Bg and C horizons.
B_2g	30–40	3·5	25	31	33	23	44	7·0	2·9	0·4	0·1	2·3	82	6·7		0·4	0·05	47	1	
B_3g	50–60	3·1	23	38	33	28	39	5·8	5·0	0·4	0·2	2·6	81	6·9				56	1	
C	80–90	3·1	24	36	34	26	40	4·4	5·2	0·7	0·1	—	100	7·1				78	1	
44.																				RHINS ASSOCIATION; Rhins Series. Gallowhill, 219898–219902
Ap	2–10	7·9	47	29	59	16	21	11·4	0·5	—	0·04	3·0	80	6·1		3·1	0·28	208	12	Lower clay content than usual in this series. Moderate exchangeable Ca and Mg in Bg and Cg horizons. High percentage base saturation and low acidity throughout. Low total and readily soluble P_2O_5 in Bg and C horizons.
Ap	15–25	6·1	49	25	59	15	23	8·2	0·5	0·1	—	1·9	82	6·2		2·2	0·19	170	6	
Bg	37–50	3·0	51	21	59	13	28	6·4	0·7	0·08	0·06	0·9	89	6·2				46	<1	
Cg	70–80	2·6	56	20	62	14	23	6·3	1·8	0·07	0·07	0·9	90	6·3				77	<1	
Cg	90–100	2·6	54	21	60	15	24	5·2	3·0	0·07	0·07	0·9	90	6·3				66	<1	

45. RHINS ASSOCIATION; Rhins Series (intergrade variant). Barvernochan, 201236–201240

Ap	5–15	13·1	41	37	53	24	16	8·3	0·6	0·2	0·3	4·6	67	5·9	6·7	0·44	419	3	Moderate clay content throughout.
B_2g	25–35	3·7	43	29	54	18	28	1·8	0·4	0·1	0·1	4·4	36	5·6	0·8	0·07	96	2	Low to moderate exchangeable Ca
B_2g	50–60	3·3	46	27	55	18	27	3·2	2·6	0·2	0·1	4·1	60	6·0			122	2	and moderate exchangeable Mg in Bg
Bg/Cg	65–75	3·5	44	27	54	17	29	3·8	3·5	0·2	0·1	3·3	70	6·4			117	2	and Bg/Cg horizons. High
Bg/Cg	92–100	3·5	46	26	54	18	28	3·8	3·4	0·2	0·1	2·1	78	6·6			150	< 1	percentage base saturation and
																			moderate acidity throughout.

46. RHINS ASSOCIATION; Portpatrick Series. Portencalzie, 200479–200485

Ap	2–10	7·3	55	19	63	11	23	6·1	1·0	0·7	0·1	4·8	62	5·6	2·6	0·24	181	4	Moderate to low clay content in Bg
Ap	15–20	6·1	55	19	62	12	23	5·7	0·8	0·6	0·08	5·0	59	5·8	2·3	0·20	154	3	and B/C horizons. Moderate
A/Bg	35–45	4·0	56	23	66	13	21	5·6	1·0	0·1	0·06	2·1	76	5·9	1·0	0·10	67	1	exchangeable Ca, Mg and Na in Bg
B_2g	55–65	2·9	58	29	71	16	13	4·7	1·2	0·1	0·05	0·8	88	6·2			49	4	and B/C horizons and low
B_3/C	82–90	2·6	66	23	74	14	12	4·7	2·3	0·1	0·05	0·7	91	6·4			96	18	exchangeable K. High percentage
B_3/C	100–107	2·3	66	24	76	14	10	4·3	2·5	0·1	0·08	0·2	97	6·4			96	19	base saturation and moderate to low
B_3/C	110–117	2·5	69	21	76	14	10	4·3	2·7	0·1	0·08	0·3	96	6·6			86	21	acidity throughout. Low total and
																			high readily soluble P_2O_5 in B_3/C.

47. RHINS ASSOCIATION; Portpatrick Series. Balgown, 200497–200502

Ap	5–12	15·9	48	28	57	19	16	13·0	1·1	0·2	0·1	10·1	59	6·0	8·3	0·44	304	14	High exchangeable Ca in Ap horizon
Ap	17–22	15·1	45	34	55	23	14	11·0	0·8	0·2	0·1	13·4	47	5·9	7·2	0·41	222	4	and low exchangeable Ca in Bg and
B_2g	35–45	5·4	51	28	61	18	19	2·5	0·2	0·08	0·01	6·2	31	5·9	2·0	0·11	87	1	B/C horizons. Moderate to high
B/C	55–62	3·4	53	23	61	14	25	2·4	1·7	0·1	0·05	3·3	56	5·5			43	—	percentage base saturation rising with
B/C	70–77	3·6	52	22	58	15	26	2·5	2·9	0·1	0·09	3·4	62	5·4			65	—	depth. Low total and readily soluble
B/C	90–100	2·9	48	27	60	16	25	3·4	6·4	0·2	0·07	1·5	87	6·2			88	5	P_2O_5 in Bg and B/C.

n.d. Not determined — Less than lower limit of determination.

TABLE 3. Brown Forest Soils with Gleyed B and C Horizons—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
48.								RHINS ASSOCIATION; Portpatrick Series. Drumbreddan, 200513–200519												
Ap	5–15	8·8	53	25	64	15	17	9·3	0·8	0·2	0·2	4·6	70	5·9		4·6	0·28	232	17	Uniform clay content with depth. Exchangeable Ca high in Ap horizon and low in Bg and Cg horizon. Exchangeable Mg, Na and K medium to low throughout but percentage base saturation high in all horizons. Total P_2O_5 low in Bg and Cg horizons.
Ap	20–27	7·0	49	28	63	14	19	9·2	0·7	0·2	0·1	2·9	78	6·1		3·6	0·24	207	13	
Ap	32–40	4·7	62	14	67	11	21	7·4	0·6	0·2	0·07	1·3	87	6·8		2·1	0·17	107	3	
B_2g	47–55	2·0	68	18	77	9	14	2·7	0·3	0·1	0·06	0·2	94	6·7				38	3	
B_3g	60–65	2·3	66	16	74	8	18	2·7	0·4	0·1	0·06	—	100	6·6				36	6	
B_3g	80–90	2·1	59	23	71	11	18	3·6	1·0	0·2	0·08	—	100	6·3				44	<1	
C(g)	100–110	1·7	62	19	70	11	19	2·7	2·0	0·2	0·1	—	100	6·1				45	<1	
49.								RHINS ASSOCIATION; Portpatrick Series. Cruggleton, 214102–214106												
Ap	2–10	11·8	44	37	62	18	13	17·5	0·7	0·2	0·7	3·7	84	6·5		6·7	0·63	351	31	Moderate uniform clay content throughout profile. High exchangeable Ca in Ap horizon. All exchangeable cations low to medium in Bg and B/Cg horizons. Percentage base saturation moderately high throughout. Low total P_2O_5 in Bg and B/Cg horizons.
Ap	15–22	9·6	44	36	62	19	15	12·5	0·5	0·1	0·6	4·6	75	6·2		4·0	0·32	193	7	
Bg	35–45	4·5	56	27	69	14	15	4·1	0·2	0·1	0·3	3·5	57	6·0				96	6	
B_3/C(g)	75–85	2·9	60	26	75	11	14	1·8	0·1	0·3	0·3	1·8	59	6·0				67	6	
B_3/C(g)	110–115	2·0	57	29	75	11	15	1·8	0·4	0·08	0·08	1·2	66	5·9				50	2	

50. KIRKCOLM ASSOCIATION; Dally Bay Series. Garlieston, 231826–231829

Ap	2–10	4·5	82	10	85	7	6	5·3	0·8	0·1	0·1	0·5	93	6·3	6·0	1·9	0·15	164		Low clay content throughout. Exchangeable Ca and Mg moderate in Ap horizon and low in B/Cg and Cg horizons. Percentage base saturation high in surface and moderate below 10 cms. Moderately acid reaction. Low total P_2O_5 in B/Cg and Cg horizons.
Ap	15–25	4·5	82	9	85	6	7	4·9	0·8	0·1	0·05	3·8	60	6·2	6·0	2·0	0·16	159		
B/Cg	50–60	1·1	96	1	97	—	3	0·9	0·2	0·06	—	1·4	47	6·1	5·9			48		
Cg	85–95	0·6	97	—	97	—	3	0·7	0·2	0·06	—	0·5	46	5·8	5·7			49		

51. YARROW ASSOCIATION; Galdenoch Series. Low Mye, 220099–220103

Ap	2–10	12·9	66	20	77	9	8	12·4	0·9	0·2	0·2	4·5	75	6·1		6·4	0·42	123	5	Low clay content throughout. High exchangeable Ca in Ap horizon. All exchangeable cations low below 50 cms. Low total P_2O_5 below 10 cms.
Ap	17–25	11·4	66	19	76	10	9	12·6	0·7	0·2	0·2	2·5	85	6·4		5·9	0·27	78	2	
Bg	35–45	7·7	75	13	81	7	8	6·0	0·7	0·1	0·03	4·5	60	6·3				41	1	
Bg	60–70	2·1	97	1	97	1	2	1·4	0·1	0·04	—	1·7	47	6·1				41	2	
Cg	97–105	2·4	92	4·1	93	3	4	1·1	0·2	0·03	—	1·7	43	6·3				81	9	

n.d. Not determined — Less than lower limit of determination.

TABLE 4. HUMUS-IRON PODZOLS

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
52.								RHINS ASSOCIATION; Mull Series. Mull, 209048–209054												
H/Ap	5–12	21·2	58	20	61	7	6	9·6	3·3	1·7	0·5	13·1	54	5·1		9·1	0·64	82	20	Clay content shows peaks in A_2 and $B_{2.1-2}$ horizons. High exchangeable Ca in B_{21} horizon. High exchangeable Na in H/Ap horizon. Exchangeable hydrogen high in B_{21} horizon. Organic matter high in B_{21} horizon. Low total P_2O_5 throughout but high readily soluble P_2O_5 in H/Ap and B_3/C horizons.
A_2	15–22	3·3	63	21	73	10	16	2·0	1·5	0·2	0·2	3·7	51	5·1		1·4	0·13	57	3	
B_{21}	25–32	14·2	66	20	76	10	7	10·2	2·6	0·6	0·2	22·4	38	5·6		6·7	0·44	117	1	
$B_{2.1-2}$	37–45	6·1	64	22	76	9	12	0·8	0·8	0·3	0·1	8·0	20	5·4		2·2	0·14	97	4	
B_{22}	50–57	3·3	73	20	89	4	6	—	0·3	0·2	0·03	3·3	13	5·8		1·1	0·06	85	1	
B_3/C	65–75	2·1	73	19	84	9	7	—	0·3	0·1	—	0·3	60	5·6				81	9	
B_3/C	80–87	1·8	80	15	89	6	5	—	0·2	0·1	—	0·3	52	5·7				72	14	
53.								YARROW ASSOCIATION; Knockarod Series. Galdenoch, 215292–215297												
H	10–2	67·7	n.d.	n.d.	n.d.	n.d.	n.d.	9·2	8·6	1·8	2·0	104·4	17	3·8		35·8	1·21	173	15	Low clay content throughout. High exchangeable bases in H horizon, but also very high exchangeable hydrogen and low percentage base saturation and pH. Exchangeable Ca and Mg in B and C horizons low. High organic matter in A_2/H and B_{21} as well as in H horizon.
A_2/H	2–7	19·1	58	23	72	8	5	1·7	1·8	0·6	0·7	47·4	9	4·1		10·7	0·42	125	2	
B_{21}	7–12	20·5	55	23	74	5	6	—	0·8	0·3	0·3	56·4	2	4·6		11·8	0·52	124	<1	
B_{22}	30–40	7·2	80	10	84	6	6	—	0·2	0·1	0·03	10·9	3	5·1		2·7	0·19	194	<1	
C	77–85	4·1	91	3	92	2	2	—	0·5	0·06	0·03	4·8	12	5·4		1·1	0·10	108	<1	

54. YARROW ASSOCIATION; Larbrax Series. Galdenoch, 215298–215303

H	7–0	47·1	n.d.	n.d.	n.d.	n.d.	n.d.	15·6	5·3	0·8	1·3	49·5	32	4·5	23·6	0·96	127	10	Low clay content throughout. Very high exchangeable Ca and hydrogen in H horizon. Very low exchangeable cations in mineral horizons. High acidity throughout. Total P_2O_5 low throughout. Readily soluble P_2O_5 low in B horizons.
A_2/H	0–5	16·1	67	16	78	4	5	—	0·2	0·1	0·3	26·4	2	4·4	8·6	0·33	75	<1	
B_{21}	7–12	10·5	69	18	79	7	8	1·4	1·3	0·4	0·6	21·8	14	4·8	4·6	0·22	65	<1	
$B_{2,1-2}$	17–25	5·5	74	11	80	5	12	—	—	—	0·07	14·4	1	4·7	1·5	0·14	69	<1	
B_{22}	32–40	1·9	91	2	92	2	6	—	0·02	0·02	—	5·5	1	5·1	0·6	0·06	87	5	
C	65–75	2·8	94	—	94	—	6	—	0·04	0·02	—	5·4	1	4·9	0·7	0·07	86	3	

n.d. Not determined — Less than lower limit of determination.

TABLE 5. PEATY PODZOLS

55. CREETOWN ASSOCIATION; Falbae Series. Clanery, 217622–217627

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
H	15–7	78·6	n.d.	n.d.	n.d.	n.d.	n.d.	7·7	5·1	0·8	0·6	101·8	12	3·7		44·1	1·7	219	21	Exchangeable cations and exchangeable hydrogen high in H horizon. Exchangeable cations low in all mineral horizons. Percentage base saturation very low throughout. Total P_2O_5 shows maximum in B_2 horizon and readily soluble P_2O_5 a minimum.
A_2g	2–7	14·4	76	33	58	22	14	—	0·3	0·07	0·2	28·3	2	4·2		8·3	0·42	97	2	
B_2	12–20	11·8	45	36	57	23	14	—	0·05	0·07	0·02	18·4	1	4·5		4·9	0·22	149	1	
B_3	30–37	6·9	55	34	68	22	8	—	—	—	—	8·8	—	4·6				111	2	
B/C	60–70	3·0	56	37	69	24	7	—	—	—	—	4·5	—	4·6				90	6	
B/C	77–87	2·2	61	34	75	20	5	—	—	—	—	3·6	—	4·7				110	15	

56. DALBEATTIE ASSOCIATION; Carsphairn Series. Gatehouse Station, 216764–216767

Horizon	Depth cm	% Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
H	5–0	31·7	n.d.	n.d.	n.d.	n.d.	n.d	—	0·3	—	0·5	30·8	3	4·4		16·2	0·64	157	5	Low clay content throughout. Very low exchangeable cations and percentage base saturation. Low total and readily soluble P_2O_5 in B horizon.
A_2	0–5	11·7	80	10	85	5	4	—	0·1	0·3	0·1	18·2	3	4·2		6·1	0·28	104	1	
B	10–20	5·8	90	3	90	3	4	—	—	—	0·03	10·4	<1	4·8				86	1	
C	30–40	1·9	81	11	85	7	8	—	—	—	0·02	2·5	<1	5·0				107	9	

57. DALBEATTIE ASSOCIATION; Carsphairn Series. Cullendoch, 217628–217632

H	27–17	68·1	n.d.	n.d.	n.d.	n.d.	n.d.	7·5	8·6	0·7	0·3	114·1	8	4·0	38·0	1·50	91	8
A_2g	0–10	6·3	68	19	75	12	11	—	0·2	0·03	—	16·6	1	4·4	3·0	0·13	41	1
B_2	15–25	6·9	73	14	78	8	10	—	—	—	—	11·2	—	4·9	2·5	0·10	114	1
B_3	37–47	3·2	68	22	76	13	12	—	—	0·07	—	3·3	2	4·8	0·9	0·05	58	1
C	60–70	1·3	74	17	79	12	9	—	—	—	—	2·3	—	4·9	0·3	0·02	63	1

Low exchangeable cations in all mineral horizons. Very low percentage base saturation throughout. Low total P_2O_5 throughout but maximum in B_2 horizon.

58. ETTRICK ASSOCIATION; Dod Series. Dalhabboch, 215275–215280

H	30–20	77·2	n.d.	n.d.	n.d.	n.d.	n.d.	—	4·8	0·8	0·4	121·2	5	3·7	38·9	2·85	162	4
A_2g	2–7	21·8	57	15	64	8	12	—	0·1	0·07	0·03	56·6	<1	4·0	12·4	0·55	87	—
B_2	12–20	15·5	65	16	70	10	12	—	—	0·06	0·02	28·2	<1	4·4	5·2	0·28	375	—
B_3	27–35	7·7	59	22	65	17	15	—	—	—	—	11·4	—	4·4			185	<1
C	47–57	4·9	52	27	62	17	18	—	—	—	—	5·8	—	4·6			137	11

Moderate clay content throughout. Very high exchangeable hydrogen in H, A_2g and B_2 horizons. Very low exchangeable Ca throughout, and low exchangeable cations in mineral horizons. High total and low readily soluble P_2O_5 in B_2 horizon.

59. ETTRICK ASSOCIATION; Dod Series. Artfield, 215223–215227

H	22–12	78·4	n.d.	n.d.	n.d.	n.d.	n.d.	5·1	6·5	1·0	1·8	103·7	12	3·7	42·1	3·13	190	9
A_2g	0–5	10·9	49	28	61	16	17	0·5	0·5	0·06	0·1	36·3	3	4·0	6·2	0·39	55	<1
B_2	10–20	11·7	69	18	79	8	7	—	0·07	—	—	26·7	<1	4·6			130	<1
B_3/C	30–40	9·3	63	24	75	12	9	—	0·03	—	—	16·6	<1	4·5			97	<1
C	50–55	4·5	56	27	68	5	15	—	0·4	—	0·02	6·0	7	4·7			122	8

Very high exchangeable hydrogen in H, A_2g and B horizons. High exchangeable Mg, Na and K in H horizon but low percentage base saturation. Low percentage base saturation and exchangeable cations in mineral horizons. Low readily soluble P_2O_5 in A_2g and B horizons.

n.d. Not determined — Less than lower limit of determination.

TABLE 5. Peaty Podzols—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
60.										**ETTRICK ASSOCIATION; Dod Series. Lagganmullan, 217767–217772**										
H	22–12	81·7	n.d.	n.d.	n.d.	n.d.	n.d.	2·6	6·4	0·9	1·4	94·4	11	4·0		44·7	2·07	283	16	Moderate clay content throughout. Exchangeable hydrogen high in H and A_2g horizons. Exchangeable Mg, Na and K high in the H horizon and percentage base saturation low. Very low exchangeable cations in mineral horizons. Acidity very high throughout.
A_2g	2–10	13·2	38	39	49	28	17	—	0·2	0·07	0·05	24·8	1	4·3		6·8	0·34	125	1	
B_2	20–30	7·9	36	43	47	32	17	—	0·06	0·02	0·01	10·4	1	4·9				125	1	
B_3	47–55	4·5	58	28	67	20	14	—	—	—	0·01	4·3	<1	4·9				101	4	
C	62–75	0·8	51	32	61	22	17	—	—	—	0·01	2·7	2	5·1				108	13	
61.										**FLEET ASSOCIATION; Glenquicken Series. Glenquicken, 216804–216808**										
Ap/H	2–10	14·7	58	25	71	11	10	4·5	0·7	0·08	0·2	13·9	28	5·4		8·2	0·62	120	—	Moderately low clay content throughout. Very low exchangeable cations in all horizons below 10 cms. Low percentage base saturation and moderately high acidity throughout. Low total and readily soluble P_2O_5 throughout.
A_2g	15–20	2·1	62	22	75	16	10	1·7	0·04	—	0·06	2·5	41	5·8		0·8	0·07	36	—	
B_2	30–40	6·1	64	23	71	16	10	1·4	0·03	—	0·06	8·8	14	5·5				67	—	
B_3	62–75	2·8	54	36	66	24	10	—	0·02	—	0·07	9·2	1	5·5				73	3	
B_4	82–90	3·6	91	6	92	5	3	0·8	—	—	0·07	6·5	11	5·5				54	1	

62. RHINS ASSOCIATION; Auchleach Series. Tunn Hill, 231813–231816

Ap	2–10	29·9	n.d.	n.d.	n.d.	n.d.	n.d.	13·9	2·1	0·3	0·7	26·2	39	5·1	4·6	16·9	0·84	206	Moderate clay content in mineral horizons. High exchangeable Ca in Ap horizon. Exchangeable cations low in B horizon. Acidity high throughout. Total P_2O_5 low in B_3 and B/C horizons.
B_2	25–35	10·0	49	29	56	20	18	1·9	0·5	0·07	0·2	16·9	14	4·9	4·3	3·5	0·21	122	
B_3	47–55	3·8	55	28	65	18	17	—	0·3	0·07	0·09	2·5	16	4·9	4·3			77	
B/Cg	67–75	3·4	54	27	63	18	19	0·8	0·6	0·1	0·03	1·1	57	4·8	4·1			65	

n.d. Not determined — Less than lower limit of determination.

TABLE 6. NON-CALCAREOUS GLEYS

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
63.								CARBROOK ASSOCIATION; Carbrook Series. Millisle, 214158–214162												
Ap	5–12	9·1	18	40	29	28	38	15·8	1·7	0·2	0·2	5·2	77	5·9		3·5	0·31	237	24	Very high clay content throughout. High exchangeable Ca and moderate exchangeable Mg, Na and K throughout. High percentage base saturation and weakly acid or neutral reaction throughout. Very high readily soluble P_2O_5 in Bg and Cg horizons.
A_2g	25–32	4·9	14	35	23	27	51	14·5	2·9	0·2	0·2	2·1	89	6·6		1·4	0·13	102	13	
Bg	52–60	3·8	15	37	23	29	48	10·8	3·9	0·2	0·2	—	100	7·1				180	84	
Bg	77–85	4·1	17	33	25	25	50	9·8	4·0	0·2	0·2	—	100	7·3				189	84	
Cg	102–110	4·1	17	29	22	24	54	12·3	4·6	0·2	0·4	—	100	7·4				179	73	
64.								CREETOWN ASSOCIATION; Greenburn Series. Lennie, 216819–216823												
Ap	2–10	12·5	54	30	56	29	9	12·4	1·7	0·2	0·06	4·2	78	6·5		6·2	0·50	294	17	Low clay content throughout. Exchangeable Ca high in surface but low in A_2g and Bg horizons. Exchangeable K very low in A_2g and Bg horizons. Acidity and percentage base saturation moderate throughout. Readily soluble P_2O_5 high or very high throughout.
A_2g	20–27	3·4	59	33	70	22	8	1·8	0·2	0·04	—	2·8	42	6·1		1·6	0·14	82	13	
B_2g	37–45	2·8	56	36	70	22	8	0·9	0·1	0·04	—	1·8	36	6·1				31	43	
B_2g	57–65	2·3	57	36	70	23	7	0·9	0·08	—	—	1·5	41	6·0				114	53	
B_3g	80–90	2·0	58	34	70	22	8	0·9	0·2	—	—	3·5	25	6·0				107	62	

65. CREETOWN ASSOCIATION; Greenburn Series. Cuil, 216663–216667

A_1g	2–10	21·9	54	24	66	12	6	9·3	1·5	0·4	0·4	14·9	44	5·5		9·8	0·76	127	2	High content silt (USDA) throughout. High exchangeable Na and Ca in A_1g. Moderate exchangeable cations in A_2g, Bg and Cg horizons. Moderate acidity throughout. High readily soluble P_2O_5 in Bg and Cg horizons.
A_2g	15–22	6·9	39	46	56	29	12	2·8	0·3	0·2	0·08	6·9	33	5·8		3·1	0·15	86	2	
B_2g	25–35	3·9	55	37	72	20	8	2·3	0·2	0·2	0·03	3·1	47	5·9				111	19	
B_3g	45–55	2·8	54	36	69	21	10	2·7	0·3	0·1	0·08	1·4	70	6·2				116	30	
Cg	77–90	1·7	62	29	72	18	10	2·3	0·2	0·1	0·2	0·3	89	6·5				111	28	

66. CREETOWN ASSOCIATION; Greenburn Series. Glen, 216771–216775

A_1g	2–10	17·1	55	27	70	11	5	8·1	2·2	0·1	0·3	6·1	64	5·7		9·0	0·58	120	2	Low clay and high silt (USDA) contents throughout. Low exchangeable Ca, Na and K in A_2g, Bg and Cg horizons. Moderate acidity and percentage base saturation throughout. Low total and high readily soluble P_2O_5 in Bg and Cg horizons.
A_2g	17–25	7·1	54	36	69	21	7	3·5	0·9	—	0·1	3·5	57	5·6		3·9	0·29	100	11	
B_2g	30–40	3·2	54	37	67	24	9	1·7	0·6	—	0·02	0·8	74	6·0				91	36	
B_3g	42–50	3·0	56	35	67	24	9	1·7	0·5	—	0·02	0·3	90	6·2				81	33	
B/Cg	82–90	2·5	70	21	78	13	9	1·7	0·6	—	0·02	2·5	48	6·1				82	36	

67. ETTRICK ASSOCIATION; Littleshalloch Series. Boreland, 216486–216489

A_1g	2–10	20·9	51	23	62	12	10	8·4	1·0	0·2	0·4	16·0	38	5·1		9·8	0·79	295	1	Moderate clay content throughout. Exchangeable cations moderate in A_1g horizon and low to moderate in A_2g, Bg and B/Cg horizons. Moderate acidity and moderately low percentage base saturation throughout. Low readily soluble P_2O_5 throughout.
A_2g	22–27	9·0	47	27	56	18	22	2·9	0·2	0·07	0·04	7·1	32	5·7		2·5	0·15	316	<1	
Bg	50–60	11·5	66	23	76	13	11	2·2	0·09	0·09	0·04	9·7	20	5·7				276	1	
B/Cg	85–95	7·7	62	24	70	16	14	2·2	0·1	0·05	0·02	5·2	31	5·9				202	<1	

n.d. Not determined — Less than lower limit of determination.

TABLE 6. Non-Calcareous Gleys—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
68.					ETTRICK ASSOCIATION; Littleshalloch Series. Barholm, 217752–217755															
A_1g	2–10	13·4	47	39	63	23	7	12·0	2·2	0·3	0·2	6·3	70	6·0		6·2	0·43	184	10	Low clay content throughout. High exchangeable Ca and Na in A_1g horizon and moderate exchangeable Mg. High percentage base saturation and low acidity for this series throughout. Low total and very high readily soluble P_2O_5 in A/Bg, B/Cg horizons.
A/Bg	35–42	1·9	71	23	79	14	7	2·0	0·7	—	0·05	2·1	56	6·6		0·4	0·04	84	33	
B/Cg	55–60	1·9	69	24	78	15	7	2·4	0·7	—	0·05	1·8	64	6·7				90	31	
B/Cg	82–90	1·7	73	22	83	12	5	2·4	0·8	—	0·05	1·8	65	6·7				89	40	
69.					ETTRICK ASSOCIATION; Littleshalloch Series. Boreland, 216492–216496															
H/A	0–5	41·8	n.d.	n.d.	n.d.	n.d.	n.d.	23·0	3·0	0·6	0·6	17·7	61	5·3		22·0	1·24	208	8	Moderate clay content throughout. High exchangeable Ca in H/A horizon. Moderate exchangeable cations in A_2g and B_2g horizons. Low to moderate percentage base saturation in A_2g, B_2g, Cg horizons. Low readily soluble P_2O_5 throughout.
A_2g	10–20	17·2	31	38	54	15	18	4·1	0·7	0·3	0·2	12·3	33	5·1		8·4	0·49	149	1	
B_2g	37–50	14·7	66	16	73	10	17	4·1	0·6	0·3	0·2	14·8	26	5·4				176	<1	
B_2g	57–65	13·6	74	12	78	8	14	3·4	0·5	0·2	0·1	12·2	26	5·5				121	1	
Cg	82–90	7·4	78	12	83	7	10	1·5	0·2	0·1	0·06	4·8	29	5·7				190	<1	

70. ETTRICK ASSOCIATION; Littleshalloch Series. Barlauchlin, 216700–216704

A_1g	2–10	24·6	52	22	62	12	8	10·1	4·6	0·3	0·4	25·8	37	4·9	14·2	0·96	198	3
A_2g	20–27	5·1	40	34	51	23	24	2·9	1·0	0·1	0·02	11·4	26	5·2	2·9	0·17	61	1
B_2g	37–42	2·0	54	24	62	17	21	0·9	0·3	0·03	—	8·8	13	5·7			54	2
B_3g	55–60	0·9	55	26	64	17	19	0·8	0·7	0·03	—	4·5	24	5·9			47	6
Cg	85–92	0·8	51	24	57	18	25	2·9	2·2	0·06	0·05	4·1	56	6·3			47	4

High exchangeable Ca and Na and moderate exchangeable Mg and K in A_1g horizon. Exchangeable cations low in A_2g, B_2g, and Cg horizons. Moderate to low percentage base saturation. Very low total P_2O_5 in A_2g, Bg and Cg horizons.

71. ETTRICK ASSOCIATION; Ettrick Series. Dirskelpin, 215334–215338

Ap	2–10	9·5	32	33	43	23	30	12·2	0·7	0·14	0·1	7·7	63	6·1	3·9	0·29	163	6
B_2g	27–37	3·9	53	25	63	15	22	0·8	0·1	0·05	0·8	6·2	14	5·4	0·6	0·05	90	6
B_2g	47–55	3·3	48	26	58	16	26	1·7	0·5	0·04	0·06	5·3	30	5·3			63	3
B_2g	67–75	3·5	48	22	56	14	30	3·8	3·5	0·1	0·1	4·7	62	5·6			99	2
B/Cg	90–95	3·1	51	22	57	16	27	4·3	7·2	0·1	0·1	3·8	75	6·4			117	10

Moderately high clay content in B_2g and B/Cg horizons. Exchangeable cations and percentage base saturation show minima between 27 and 55 cms. Acidity moderate throughout. Total P_2O_5 low in B_2g horizon.

72. ETTRICK ASSOCIATION; Ettrick Series. Balker, 200532–200537

A_1g	5–15	11·2	35	39	56	18	20	4·6	1·2	0·3	0·5	7·0	49	5·7	5·7	0·32	175	5
A_1g	20–27	6·5	40	33	56	17	24	3·4	0·8	0·2	0·1	4·3	51	5·7	3·5	0·24	106	3
A_2g	35–45	3·1	54	26	67	13	20	1·2	0·5	0·1	0·04	1·3	59	5·7	1·2	0·06	48	3
A_2g	55–62	2·6	64	24	74	14	12	1·2	0·6	0·09	0·04	0·8	70	5·7			50	7
B_2g	80–90	3·0	42	31	56	17	27	2·5	3·1	0·2	0·09	1·9	76	5·9			129	1
B/Cg	100–110	3·0	52	23	62	13	25	2·7	4·6	0·3	0·1	0·6	93	6·0			131	1

Low clay content 55–62 cms depth. Exchangeable cations moderate in A_1g horizon. High exchangeable Na and Mg in B/Cg horizon. Moderately high percentage base saturation and moderate acidity throughout. Low total P_2O_5 in A_2g horizon.

n.d. Not determined — Less than lower limit of determination.

TABLE 6. Non-Calcareous Gleys—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
73.			KIRKCOLM ASSOCIATION; Portlong Bay Series. Inch Croft, 200063–200067																	
Ap	5–15	17·2	63	16	71	8	8	6·5	0·6	0·04	0·06	23·2	24	5·7		8·8	0·33	116	2	Moderate to low clay content throughout and very low silt. Exchangeable Ca and Mg moderate in surface. Exchangeable cations in B_2g, B_3g and Cg very low. Low percentage base saturation throughout. Very high acidity in Cg horizon. Low total P_2O_5 throughout.
B_2g	20–29	3·6	77	14	87	3	10	1·8	0·1	—	—	9·2	17	5·7		1·7	0·17	21	1	
B_3g	35–45	2·4	85	7	89	3	9	1·1	0·04	0·02	—	6·2	15	5·6				40	5	
B_3g	55–65	2·1	84	8	89	3	9	0·9	0·1	0·06	0·04	5·3	18	5·2				30	1	
Cg	80–87	1·1	83	12	93	2	6	—	0·4	0·02	0·01	9·6	4	3·3				33	2	

74. KIRKCOLM ASSOCIATION; Drummore Series. South Cairnside, 220075–220078

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH H_2O	% $CaCO_3$	me/100 g Cation Exchange Capacity	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
H/ Apg	2–10	21·0	64	13	73	4	8	16·3	4·6	1·3	0·7	14·0	62	5·6	n.d.		10·3	0·88	230	14	Low clay and silt contents throughout. Exchangeable Ca high in H/Apg and Bg horizons and very high in Cg horizon. Exchangeable Mg high throughout. Acidity moderate and percentage base saturation moderate to moderately high throughout. Free $CaCO_3$ and acid pH in Cg horizon.
Bg	15–25	17·5	65	13	73	4	9	9·7	3·8	0·8	0·4	15·5	49	5·2	n.d.		9·0	0·63	120	3	
Bg	45–55	10·8	72	13	79	6	10	6·5	4·7	0·5	0·2	6·9	63	6·1	n.d.				147	13	
Cg	87–97	4·0	91	6	93	4	3	35·9	6·5	0·3	0·1	6·9	86	5·2	0·6				84	2	

n.d. Not determined — Less than lower limit of determination.

TABLE 6. Non-Calcareous Gleys—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	% $CaCO_3$	me/100 g Cation Exchange Capacity	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
75.						RHINS ASSOCIATION; Ardwell Series. Drumbreddan, 200100–200104															
Ap	5–12	12·6	51	25	61	14	18	14·8	0·4	0·6	0·7	10·2	62	5·4			6·0	0·28	274	27	Clay content moderately high in Bg and Cg horizons. Exchangeable Ca and Na high throughout and exchangeable Mg and K moderate. Acidity moderate and high percentage base saturation. High readily soluble P_2O_5 throughout.
Ap	25–32	10·0	50	24	61	13	22	11·8	0·2	0·4	0·4	8·3	61	5·5			4·8	0·32	140	12	
B_2g	45–55	3·0	37	30	46	20	34	6·9	1·7	0·3	0·4	3·1	74	5·8					100	27	
C	67–75	2·6	39	29	48	21	32	8·1	3·9	0·2	0·2	1·1	92	6·1					110	27	
C	82–90	3·0	40	28	48	20	33	29·9	1·4	0·2	0·1	—	100	6·3	<1				115	11	
76.						RHINS ASSOCIATION; Ardwell Series. Low Ersock, 214086–214090															
Ap	5–15	9·3	27	38	43	23	30	15·5	0·8	0·2	0·1	1·4	92	6·3			3·0	0·30	150	15	Moderately high clay content throughout. High exchangeable Ca in A_2g. Very high percentage base saturation throughout and neutral reaction in A_2g and B_2g horizons with alkaline reactions in Cg associated with free lime. Very high readily soluble P_2O_5 in A_2g and B_2g.
A_2g	30–37	3·9	36	36	54	18	28	10·4	1·3	0·1	0·07	—	100	6·9			0·6	0·50	112	57	
B_2g	52–62	3·5	42	26	52	16	32	7·3	1·1	0·1	0·08	—	100	6·9					179	63	
Cg	77–87	5·1	40	24	49	16	33	n.d.	2·8	0·05	0·1	—	100	8·1	6·1	5·2			186	2	
Cg	110–117	5·3	58	19	65	12	21	n.d.	3·0	0·06	0·1	—	100	7·8	7·3	3·5			159	<1	

Horizon	Depth cm	% Loss on Ignition	% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
77.								RHINS ASSOCIATION; Balscalloch Series. Cruggleton, 214096–214101												
Apg	2–10	12·7	32	40	50	23	21	22·0	1·2	0·2	0·9	1·1	96	6·3		5·4	0·44	505	78	Moderate clay content throughout. Very high exchangeable Ca in surface and moderate in A_2g and B_2 horizons. Exchangeable Mg and Na values show minimum in A_2g horizon. Very high percentage base saturation and moderately acid to neutral reaction in upper 70 cms. Very high readily soluble P_2O_5 throughout.
Apg	15–22	11·7	33	40	50	23	22	19·9	1·3	0·1	0·8	2·5	90	6·4		5·0	0·41	513	93	
A_2g	32–40	0·6	46	37	64	18	17	6·2	0·5	0·04	0·3	1·5	82	6·6		0·7	0·06	140	82	
B_2g	60–67	2·3	43	39	59	22	19	6·2	1·1	0·09	0·2	0·6	93	6·8				165	77	
B/Cg	85–95	3·3	45	36	65	16	19	7·1	3·4	0·1	0·2	—	100	7·8				159	57	
B/Cg	105–115	3·4	41	39	62	18	20	9·2	3·0	0·1	0·2	—	100	8·0				137	39	
78.								RHINS ASSOCIATION; Balscalloch Series. South Barsalloch, 214116–214121												
Ap	2–10	13·7	45	30	59	17	18	20·9	0·6	0·4	0·3	4·2	84	6·4		7·1	0·46	257	25	Moderate clay content rising with depth. Exchangeable cations low in A_2g horizon. Exchangeable Ca very high in surface, low in subsoil. High percentage base saturation throughout. Total P_2O_5 low in A_2g, B_2g and II B/Cg horizons. Readily soluble P_2O_5 high in Ap and A_2g horizons.
Ap	12–22	12·5	43	34	58	18	17	20·8	0·6	0·3	0·2	3·7	86	6·3		7·2	0·39	232	16	
A_2g	32–37	3·1	61	22	69	14	17	1·7	0·3	0·07	—	2·4	46	5·2		0·4	0·04	74	13	
B_2g	40–47	3·0	47	30	61	16	23	2·7	1·0	0·1	0·08	2·3	63	5·1				61	2	
II B/Cg	67–75	3·1	45	30	57	18	25	3·2	1·0	0·2	0·08	2·3	66	5·7				67	1	
II B/Cg	95–102	2·8	48	31	60	19	21	3·4	3·3	0·2	0·1	1·5	82	6·0				78	8	

n.d. Not determined — Less than lower limit of determination.

TABLE 6. Non-Calcareous Gleys—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	% $CaCO_3$	me/100 g Cation Exchange Capacity	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
79.								STIRLING ASSOCIATION; Fordel Series. Baldoon, 216459—216463													
Ag	2—10	6·8	26	49	47	27	23	13·8	2·2	3·6	0·8	4·6	82	6·0			2·5	0·21	101	6	Very high silt content throughout. High exchangeable Ca in Ag and Bg horizons. $CaCO_3$ in B/Cg horizon reflects presence of shells. Very high exchangeable Na throughout. Very high percentage base saturation throughout. Low total P_2O_5 throughout. High readily soluble P_2O_5 in Ag and Bg horizons.
Ag	17—25	4·4	29	44	47	26	25	9·2	2·1	0·9	0·1	2·5	83	5·8			1·4	0·90	82	15	
Bg	35—45	2·3	23	45	70	18	12	8·5	3·3	0·4	0·2	—	100	7·5					73	20	
B/Cg	65—75	5·0	45	40	63	22	12	n.d.	2·5	0·5	0·1	—	100	8·4	6·3	7·5			73	5	
B/Cg	90—100	3·4	68	29	94	4	2	n.d.	1·1	0·3	0·04	—	100	8·6	5·1	2·7			75	5	

AA

80. STIRLING ASSOCIATION; Fordel Series. Pálwhilly, 200123–200126

Ag	5–15	4·1	40	35	71	13	15	7·0	1·6	0·2	0·2	3·7	71	6·9			1·8	0·16	133	26	Low clay and high silt contents throughout. $CaCO_3$ in Cg on account of some shell fragments. High percentage base saturation. Low organic matter content in Ag horizon. Low total P_2O_5 in Bg and Cg horizons and high readily soluble P_2O_5 in Ag and Bg horizons.
Bg	25–35	1·7	41	51	73	19	9	4·7	1·5	0·2	0·1	—	100	7·2			0·9	0·08	94	33	
Cg	45–55	3·4	31	66	71	25	4	n.d.	2·0	0·3	0·1	—	100	7·1	4·1	6·8			73	5	
Cg	80–90	4·3	17	77	61	33	6	n.d.	2·2	0·4	0·2	—	100	7·2	4·4	7·2			93	5	

81. STIRLING ASSOCIATION; Newton Stewart Series. Grange, 200132–200140

Ag	5–12	4·9	24	61	52	33	15	6·5	1·1	0·08	0·2	3·4	70	6·5			1·9	0·12	166	10	Very high silt content throughout. Moderate total exchangeable cations throughout and high percentage base saturation. Low organic content. Low total P_2O_5 below 15 cms and high readily soluble P_2O_5.
A_2/Bg	20–27	3·6	22	58	42	37	21	6·5	1·1	0·08	0·2	—	100	6·7			0·8	0·07	86	9	
B_2g	35–45	1·9	16	58	40	34	26	7·9	1·7	0·1	0·3	0·3	97	6·7			0·5	0·06	77	13	
Cg	57–67	2·9	19	53	36	35	29	9·3	2·6	0·1	0·3	0·5	96	6·7			0·6	0·08	104	5	
C_1g	77–85	3·7	17	61	44	33	23	7·9	2·3	0·1	0·3	—	100	6·7					99	20	
C_2g	112–125	1·4	30	48	51	28	22	n.d.	2·9	0·2	0·3	—	100	6·7	4·8	7·1			99	25	
C_3g	145–157	1·4	52	38	63	27	11	n.d.	2·7	0·07	0·2	—	100	6·5	5·1	5·1			105	51	

n.d. Not determined — Less than lower limit of determination.

TABLE 6. Non-Calcareous Gleys—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	% $CaCO_3$	me/100 g Cation Exchange Capacity	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
82.								STIRLING ASSOCIATION; Stirling Series. Carslae, 200145—200149													
A_1g	5—12	16·0	10	51	20	41	27	36·9	1·8	0·2	0·7	2·9	93	5·9			8·6	0·31	324	38	Very high clay and silt contents. Very high exchangeable Ca throughout. High exchangeable Mg in Cg horizon. High percentage base saturation throughout. High readily soluble P_2O_5 except 22—30 cm depth.
A_1g	22—30	17·7	7	45	13	39	35	18·0	1·7	0·2	0·4	4·1	83	6·1			10·1	0·42	131	4	
A_2g	37—45	4·8	4	50	16	38	47	33·1	4·4	0·1	0·3	1·0	97	6·6					76	15	
B_2g	55—62	4·8	14	41	22	33	45	14·1	4·3	0·1	0·4	—	100	6·8					100	30	
Cg	77—85	6·1	15	49	28	36	36	23·2	7·0	0·1	0·4	—	100	7·8	<1				115	10	

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
83.																				
YARROW ASSOCIATION; Innermessan Series. Dalmannock, 215444–215448																				
Ap/H	2–10	29·5	n.d.	n.d.	n.d.	n.d.	n.d.	18·1	3·3	0·5	0·3	27·2	45	5·5		16·8	0·67	211	10	Low clay and silt contents throughout. High exchangeable Ca in Ap/H horizon. High exchangeable hydrogen in Ap/H and low percentage base saturation in Bg and Cg horizons. High organic content in Ap/H horizon. Low total P_2O_5 below 15 cm depth.
A_2g	20–25	8·0	71	13	76	8	11	6·1	0·8	0·08	0·05	13·2	35	5·0		4·0	0·15	42	4	
Bg	30–37	7·3	77	10	79	8	10	1·7	0·3	—	0·06	15·1	12	4·9				49	6	
Bg	45–52	7·3	85	4	87	2	7	1·4	0·3	—	0·07	11·4	14	5·1				95	8	
Cg	67–75	3·6	92	3	93	2	6	0·8	0·4	—	0·06	6·3	16	5·4				73	7	
84.																				
YARROW ASSOCIATION; Dinduff Series. East Galdenoch, 220060–220064																				
Ap	2–10	15·7	67	13	71	9	12	10·1	0·8	0·1	0·1	4·5	71	6·0		7·9	0·71	175	5	Low clay content throughout. High exchangeable Ca and percentage base saturation, and moderate acidity in Ap horizon. Low exchangeable cations in A_2g and B/Cg horizon. Very low total P_2O_5 below 30 cm depth.
Ap	17–27	12·0	71	12	75	8	10	10·9	1·0	0·07	0·1	4·5	73	6·2		6·6	0·65	162	8	
A_2g	32–40	2·5	86	6	88	4	8	2·6	0·4		0·05	4·4	41	5·7		0·7	0·07	17	1	
B/Cg	50–60	2·1	95	2	96	1	3	2·3	0·5		0·07	4·4	39	4·7				42	7	
B/Cg	85–95	1·6	97	1	98	—	2	1·4	0·4		—	2·7	39	4·2				44	1	

n.d. Not determined — Less than lower limit of determination.

TABLE 7. PEATY GLEYS

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
85.						CREETOWN ASSOCIATION; Creetown Series. Glen, 216781–216786														
H	15–5	65·5	n.d.	n.d.	n.d.	n.d.	n.d.	—	0·7	0·4	1·0	57·0	4	3·9		35·3	2·01	190	3	Moderate clay content in A_2g horizon. Very low exchangeable Ca throughout. Very low exchangeable cations below H horizon and high exchangeable hydrogen in H horizon. Very low percentage base saturation and high acidity throughout. Low total P_2O_5 in A_1g and A_2g horizons.
A_1g	2–10	15·4	40	45	58	27	7	—	0·08	—	0·05	17·0	1	4·0		8·2	0·53	84	2	
A_2g	15–22	7·1	31	48	44	35	18	—	0·04	0·04	—	10·5	1	4·3				48	<1	
A_2g	30–40	8·0	40	40	52	28	17	—	0·08	—	—	10·5	1	4·6				60	1	
B/Cg	52–60	1·9	58	31	68	21	11	—	0·2	—	0·02	1·4	10	4·8				111	18	
B/Cg	70–80	1·7	46	45	59	32	9	—	0·3	—	0·05	4·0	9	4·9				139	38	
86.						CREETOWN ASSOCIATION; Creetown Series. Clanery, 216809–216813														
H	25–12	54·4	n.d.	n.d.	n.d.	n.d.	n.d.	12·4	—	0·3	0·9	47·6	22	4·9		31·0	1·81	177	1	Moderate to low clay content. High exchangeable Ca and hydrogen in H horizon. Very low exchangeable cations in horizons below H horizon. Acidity high throughout. Low total and readily soluble P_2O_5 in all mineral horizons.
A_2g	2–10	7·9	43	44	60	27	9	1·2	0·1	0·07	0·06	9·9	13	5·1		3·8	0·26	60	1	
Bg	22–30	8·7	48	39	65	22	9	1·1	0·1	0·07	0·07	11·2	11	5·5				77	<1	
Bg	45–55	8·3	46	39	59	27	10	0·8	0·04	0·05	0·05	11·2	8	5·4				76	1	
B/Cg	72–82	2·9	78	18	86	10	4	—	0·1	0·07	0·05	4·2	5	5·1				57	2	

87. DALBEATTIE ASSOCIATION; Eglin Series. Cullendoch, 217637–217640

H	25–15	72·8	n.d.	n.d.	n.d.	n.d.	n.d.	—	0·6	0·2	0·6	99·2	2	4·8	38·9	2·42	253	—	Low clay content in mineral horizons. Very low exchangeable cations in all mineral horizons. Very low percentage base saturation and high acidity throughout. Low total and readily soluble P_2O_5 in A_2g and B/Cg horizons.
A_2g	5–15	3·7	63	28	81	10	9	—	0·1	—	0·02	10·8	1	4·7	2·1	0·15	65	2	
B/Cg	35–45	3·3	77	14	83	9	8	—	—	—	—	9·5	—	4·9			70	2	
B/Cg	70–80	4·5	73	16	82	7	8	—	0·2	0·03	—	10·8	2	5·0			83	<1	

88. ETTRICK ASSOCIATION; Dochroyle Series. Dalhabboch, 215265–215269

H	22–12	65·0	n.d.	n.d.	n.d.	n.d.	n.d.	7·6	3·3	0·9	1·1	78·9	14	3·7	32·2	2·38	316	2	Moderate clay content throughout. Exchangeable cations very low in all mineral horizons, and percentage base saturation low and acidity high throughout. Total and readily soluble P_2O_5 low in mineral horizons.
A_2g	2–10	15·1	54	22	64	11	17	—	0·2	0·1	0·04	37·1	1	4·2	8·3	0·44	96	<1	
Bg	37–40	4·0	57	26	67	16	17	—	—	—	—	3·0	1	4·8			70	1	
Cg	55–60	3·8	51	25	61	15	24	—	0·02	—	0·04	3·0	2	4·8			81	3	

89. ETTRICK ASSOCIATION; Dochroyle Series. Beoch, 215287–215292

H	15–5	69·0	n.d.	n.d.	n.d.	n.d.	n.d.	15·4	5·7	0·3	0·3	97·0	18	4·7	38·7	2·46	274	<1	Moderately high clay content in mineral horizons. High exchangeable cations in H and A/H horizons but low percentage base saturation and moderately strong acidity. Moderate exchangeable Ca, Mg and K in A_2g, B_2g and Cg horizons. Low total P_2O_5 in A_2g, Bg and Cg horizons. Profile shows effect of "flushing".
A/H	5–10	49·3	n.d.	n.d.	n.d.	n.d.	n.d.	19·9	6·6	0·3	0·03	47·9	37	5·2	26·3	1·08	145	—	
A_2g	20–25	12·0	40	29	52	17	26	8·6	3·6	0·07	0·03	10·9	53	5·9	5·7	0·22	61	—	
B_2g	30–37	7·9	49	22	55	15	26	6·4	3·3	—	0·03	7·2	58	6·0			48	<1	
Cg	45–52	4·2	43	28	51	20	27	2·9	1·7	—	0·04	1·1	81	6·1			60	12	
Cg	57–67	4·1	47	23	54	16	28	2·4	1·7	—	0·05	0·8	83	6·0			45	4	

n.d. Not determined — Less than lower limit of determination.

TABLE 7. Peaty Gleys—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
90.						ETTRICK ASSOCIATION; Dochroyle Series. Dalhabboch Bridge, 215281–215286														
H	20–10	82·5	n.d.	n.d.	n.d.	n.d.	n.d.	2·6	3·1	0·6	1·2	102·5	7	3·8		43·0	2·65	331	5	Moderate clay content in mineral horizons. Very low exchangeable cations in A_2g, B_2g, B_3g and Cg horizons. Very high exchangeable hydrogen in H horizons. Very low percentage base saturation and high acidity throughout. Low total and readily soluble P_2O_5 in mineral horizons.
A_2g	2–7	19·4	49	21	58	13	15	—	0·1	0·06	0·07	51·9	1	4·1		9·7	0·50	94	<1	
B_2g	12–20	12·9	47	26	58	15	21	—	—	0·2	0·02	32·0	1	4·5				96	<1	
B_3g	27–40	4·4	51	23	60	15	23	—	—	0·08	—	7·3	1	4·8				78	1	
Cg	60–67	4·1	40	26	48	17	33	—	—	—	0·05	6·5	1	4·6				117	1	
91.						RHINS ASSOCIATION; Glenstockadale Series. Knock and Maize, 215359–215363														
H	25–15	65·7	n.d.	n.d.	n.d.	n.d.	n.d.	9·5	11·2	1·9	1·4	143·5	14	3·6		36·9	2·03	262	22	High clay content in B_3g and Cg horizons. High exchangeable cations and high exchangeable hydrogen in H horizon. Low exchangeable Ca in A_2g, B_2g, Cg horizons. Low percentage base saturation and high acidity throughout. Low total and readily soluble P_2O_5 in B_2g, B_3g and Cg horizon.
A_2g	2–7	24·1	31	30	43	18	21	0·8	1·1	0·3	0·2	74·1	3	4·2		11·3	0·54	113	1	
B_2g	15–25	5·3	49	28	63	14	21	—	0·4	0·07	0·05	8·2	6	4·6				79	—	
B_3g	35–45	4·6	45	22	54	13	30	—	0·7	0·08	0·1	4·2	17	5·1				48	—	
Cg	52–60	4·3	45	22	53	14	31	1·2	2·5	0·08	0·1	3·1	56	5·6				92	—	

92. RHINS ASSOCIATION; Lochnaw Series. Larbrax, 215323–215327

H	15–5	75·9	n.d.	n.d.	n.d.	n.d.	n.d.	46·7	6·1	1·8	1·6	119·8	32	3·7	37·0	1·17	198	14	High clay content in B/Cg horizon. Very high exchangeable cations and very high exchangeable hydrogen in H horizon. Low exchangeable Ca and Mg in 0–50 cm depth. Low percentage base saturation and high acidity 0–50 cm depth. Low total P_2O_5 in mineral horizons.
A_2g	2–10	7·4	67	16	74	9	13	0·6	0·2	0·2	0·1	26·5	4	4·5	3·3	0·18	56	<1	
Bg	15–25	4·6	63	16	70	10	17	0·6	0·1	0·1	0·1	17·1	5	4·7			90	1	
B/Cg	45–52	4·6	48	22	56	15	27	0·6	0·4	0·1	0·2	7·6	15	4·8			69	6	
B/Cg	70–80	3·9	47	22	55	15	31	2·6	4·0	0·3	0·2	4·6	61	5·6			66	<1	

93. STIRLING ASSOCIATION, Poldar Series. Carslae, 200141–200144

H/Ap	5–15	68·7	n.d.	n.d.	n.d.	n.d.	n.d.	47·0	6·9	0·3	1·3	40·9	58	5·5	38·8	0·65	282	3	High clay content in A_2g and B_2g horizons. Very high exchangeable Ca, Mg, K and hydrogen in H/Ap horizon. High exchangeable cations in A_2g, B_2g and Cg horizons. High percentage base saturation throughout. Low total P_2O_5 in A_2g and B_2g horizons.
A_2g	25–35	5·9	12	41	17	36	48	9·8	6·4	0·2	0·6	4·3	80	5·9	2·2	0·17	57	4	
B_2g	50–60	5·1	13	46	21	38	41	9·8	7·0	0·1	0·5	0·9	95	6·4			74	19	
Cg	80–90	6·3	17	58	34	41	25	15·2	7·0	0·1	0·6	—	100	7·6			140	10	

n.d. Not determined — Less than lower limit of determination.

TABLE 8. SUB-ALPINE SOILS

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
94.			DALBEATTIE ASSOCIATION; Mulltaggart Series. Cairnsmore of Fleet, 216633–216635																	
H/A	0–2	41·2	n.d.	n.d.	n.d.	n.d.	n.d.	—	1·2	0·2	1·3	26·8	9	4·1		22·9	1·44	243	4	Low clay and silt content in H/A_2 and H/B horizons. Very low exchangeable Ca throughout. High exchangeable hydrogen in H/A and H/B horizons. Low percentage base saturation and high acidity throughout. High organic content throughout.
H/A_2	2–7	18·6	64	16	74	7	6	—	0·3	0·07	0·4	9·2	8	4·3		10·4	0·70	146	3	
H/B	12–17	12·0	69	15	75	9	10	—	0·07	0·03	0·07	26·9	1	4·6		6·8	0·43	153	1	

TABLE 9. MISCELLANEOUS SOILS

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH: H_2O	$CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
95.								ALLUVIUM; Genoch, 200094–200099												
Ap	5–10	13·5	45	25	53	18	23	12·3	0·1	0·03	0·02	10·5	54	5·4		7·8	0·37	239	8	Moderate to high clay content in 0–37 cm depth and low clay content below 40 cms. High exchangeable Ca in Ap horizon. Moderate percentage base saturation throughout. Acidity moderate 0–47 cms and very high below 60 cms. Low total P_2O_5 in A_2g, B_2g and Cg horizons.
Ap	12–20	11·9	46	22	51	17	26	8·4	0·1	0·1	0·06	11·0	44	5·5		6·2	0·29	117	3	
A_2g	30–37	4·2	33	33	54	12	35	7·3	0·1	0·1	0·1	5·2	59	5·5		0·7	0·07	30	1	
B_2g	40–47	1·8	85	7	90	3	7	2·3	0·1	0·04	—	2·5	49	5·6				47	3	
Cg	60–67	1·8	82	11	89	4	7	2·1	0·3	0·04	—	3·4	41	4·2				42	4	
Cg	77–85	1·7	86	7	90	3	6	1·8	0·3	0·03	—	4·0	35	3·7				47	3	
96.								ALLUVIUM; Auckinleck, 217779–217781												
A_1	2–10	9·1	64	17	71	10	14	6·3	0·9	0·1	0·1	7·6	50	6·1		3·9	0·29	260	27	Low clay content in C horizon. Exchangeable bases moderate in A horizon, low below 30 cm depth. Acidity moderate throughout. High readily soluble P_2O_5 in A horizon.
A/C	30–37	4·3	81	8	83	6	9	0·6	0·1	0·07	—	4·2	16	5·7		1·8	0·14	44	7	
C	65–75	3·7	91	5	93	3	4	0·6	0·1	0·06	—	4·2	15	5·7				94	4	

n.d. Not determined — Less than lower limit of determination.

TABLE 9. Miscellaneous Soils—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH H_2O	% $CaCO_3$	me/100 g water-soluble Cl	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
97.								SALTINGS; Martyrs' Stone, 216640–216644													
Ag	2–10	15·1	20	38	28	30	31	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	6·8	—	25·4	7·1	0·54	192	5	Clay content high in surface and low below 50 cm. Silt (U.S.D.A.) high throughout. Alkaline reaction below 15 cm. Free $CaCO_3$ present below 50 cm. Very high water-soluble Cl throughout. Low total P_2O_5 in Cg horizon.
A/Cg	27–35	7·7	27	41	42	25	33	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7·8	—	16·9	1·9	0·18	120	8	
Cg	50–57	5·7	38	50	38	50	12	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8·2	3	12·4	1·2	0·12	74	6	
Cg	67–77	5·6	46	48	78	16	6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8·2	3	11·8	1·2	0·094	69	3	
Cg	95–105	4·6	41	54	78	16	6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8·2	3	10·4	0·7	0·062	97	4	
98.								SALTINGS; Baldoon, 216450–216454													
Ag	2–10	10·6	23	55	50	28	17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7·3	—	24·3	3·4	0·27	116	3	Very high silt (U.S.D.A.) 0–85 cm depth. Alkaline reaction below 20 cm depth. Free $CaCO_3$ below 40 cm depth. Very high water-soluble Cl throughout.
B/Cg	20–30	9·6	13	53	36	30	29	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	7·8	—	20·7	2·9	0·23	136	4	
Cg	42–52	7·7	28	50	51	28	18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8·2	3	16·8			104	5	
Cg	72–82	5·7	42	48	73	16	8	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8·0	3	14·0			72	2	
Cg	100–110	4·3	72	22	90	4	4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8·2	3	8·9			70	7	

Horizon	Depth cm	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g: Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
99.																				**LINKS (Freely drained); Sandmill, 200081–200085**
A_1	7–15	3·7	91	3	93	1	6	0·5	0·3	0·1	0·09	7·4	12	4·9		2·0	0·11	54	2	Very high sand content throughout.
A/B	25–32	1·4	95	2	97	—	3	—	0·1	0·04	0·02	3·5	5	4·4		0·7	0·06	27	1	Very low exchangeable cations and
B/C	40–47	0·1	96	1	97	—	3	—	0·03	0·03	0·01	1·7	4	4·8				25	2	percentage base saturation. Low
C	60–67	0·5	97	—	97	—	3	—	0·06	0·02	0·01	1·2	7	5·0				25	3	organic matter content in A horizon
C	80–87	0·4	97	—	97	—	3	—	0·04	0·03	0·02	0·5	17	5·1				24	5	and very low total P_2O_5 throughout.
100.																				**LINKS (Imperfectly drained); Sandmill, 200086–200089**
A	10–17	3·7	85	5	87	3	10	4·1	0·5	0·09	0·04	3·9	55	5·5		1·8	0·16	155	39	Very high sand content throughout.
A_2g	30–35	0·7	95	4	96	3	1	0·9	0·09	0·03	—	0·8	55	5·7		0·4	0·04	24	8	Exchangeable cations low. Moderate
B/Cg	52–60	0·7	97	—	97	—	3	0·9	0·08	0·03	—	1·4	43	5·7				33	5	percentage base saturation and
Cg	80–87	0·3	98	—	98	—	2	0·5	0·07	0·02	—	0·2	77	5·7				38	3	acidity. Low organic matter in A
																				horizon. Very low total P_2O_5 below
																				30 cm depth.

n.d. Not determined — Less than lower limit of determination.

TABLE 9. Miscellaneous Soils—*continued*

Horizon	Depth cm	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations me/100 g Ca	Mg	Na	K	H	% Saturation	pH H_2O	pH $CaCl_2$	% Carbon	% Nitrogen	mg/100 g Total P_2O_5	mg/100 g Read. Sol. P_2O_5	Remarks
101.								LINKS (Poorly drained); Mid Torrs, 215394–215395												
Ag	2–7	11·2	84	6	87	3	5	0·9	1·5	—	—	6·0	29	4·9		5·1	0·30	84	5	High sand content throughout. Very low exchangeable cations and percentage base saturation. Acidity moderate to high throughout. Very low total P_2O_5 throughout.
A/Cg	25–35	0·9	96	1	97	—	3	—	0·04	—	—	1·6	3	5·6		0·2	0·02	34	3	
Cg	45–55	0·8	97	—	97	—	3	—	0·05	—	—	1·5	3	5·6				40	3	
102.								LINKS (Very poorly drained); Freugh, 215436–215439												
Ag	0–5	15·0	84	4	86	3	4	4·3	2·9	0·5	0·4	9·4	46	5·5		5·5	0·34	78	<1	High sand content throughout. Moderate exchangeable cations in 0–5 cm layer. Low exchangeable cations below 10 cm. Moderate percentage base saturation and acidity. Very low total P_2O_5.
Ag	10–15	1·6	96	1	97	1	2	0·5	0·2	0·03	0·06	1·2	40	5·6		0·6	0·03	24	<1	
Ag	17–37	1·0	94	2	95	1	3	0·5	0·3	—	0·04	1·7	31	5·5				20	<1	
Cg	47–57	0·6	97	1	97	1	1	0·3	0·2	—	0·03	1·0	34	5·7				30	3	

103. PEAT; Dervaird, 215213–215216

Pt	0–10	94·0	n.d.	n.d.	n.d.	n.d.	n.d.	13·3	8·7	1·4	1·1	106·4	19	3·9	49·9	1·71	151	11	High exchangeable Ca, Mg and Na throughout but extremely high exchangeable hydrogen. Low percentage base saturation and high acidity. Low total P_2O_5 below 25 cm depth.
Pt	27–37	72·8	n.d.	n.d.	n.d.	n.d.	n.d.	13·0	8·7	1·3	0·06	168·0	12	3·8	41·0	2·66	45	5	
Pt	50–60	76·5	n.d.	n.d.	n.d.	n.d.	n.d.	12·9	7·1	1·3	—	157·6	12	4·0			39	1	
Pt	67–77	72·0	n.d.	n.d.	n.d.	n.d.	n.d.	10·4	7·9	0·9	—	169·2	10	4·2			45	<1	

104. PEAT; Dirskelpin, 215339–215342

Pt	2–12	80·9	n.d.	n.d.	n.d.	n.d.	n.d.	4·4	7·6	1·5	0·9	122·5	11	3·6	42·6	1·2	103	9	Very high exchangeable hydrogen throughout. High exchangeable Mg and Na. Low percentage base saturation and very high acidity throughout. Low total P_2O_5 below 20 cm depth.
Pt	25–32	68·8	n.d.	n.d.	n.d.	n.d.	n.d.	1·7	8·1	1·4	0·4	147·1	7	3·6	32·5	1·70	63	5	
Pt	57–67	78·5	n.d.	n.d.	n.d.	n.d.	n.d.	4·4	9·6	1·5	0·1	159·8	9	3·8			32	1	
Pt	82–90	81·5	n.d.	n.d.	n.d.	n.d.	n.d.	4·4	10·2	1·6	0·1	151·7	10	4·0			23	1	

105. PEAT; Craigcaffie, 215262–215264

Pt	5–10	58·0	n.d.	n.d.	n.d.	n.d.	n.d.	10·2	5·8	0·9	0·3	95·9	18	4·4	31·8	2·54	316	1	Very high exchangeable hydrogen throughout, and high exchangeable Ca, Mg and Na. Moderate to low percentage base saturation and high acidity.
Pt	30–37	43·7	n.d.	n.d.	n.d.	n.d.	n.d.	7·7	6·6	0·2	—	54·0	27	5·1	21·8	1·10	98	<1	
Pt	65–75	56·6	n.d.	n.d.	n.d.	n.d.	n.d.	27·4	17·0	0·5	—	85·4	53	5·4			176	<1	

n.d. Not determined — Less than lower limit of determination.

Potassium Pyrophosphate Extractable Iron, Aluminium, and Carbon

TABLE 10. BROWN FOREST SOILS, FREELY DRAINED

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Dalbeattie	Dalbeattie	5	H/A_1	2·40	0·35	0·64	0·99	0·11	0·30	0·24	0·88
			A_1	1·63	0·60	0·73	1·33	0·13	0·23	0·24	0·97
			B_2	3·18	1·00	1·48	2·48	0·62	1·05	0·21	1·69
			B_3	1·29	0·55	0·39	0·94	0·24	0·46	0·16	0·55
Ettrick	Linhope	6	A	2·15	0·85	1·46	2·31	0·14	0·19	0·80	2·26
			A	2·03	1·00	1·54	2·54	0·14	0·19	0·79	2·33
			B_2	1·60	1·45	1·94	3·39	0·19	0·17	0·67	2·61
			B_3	0·66	0·48	0·10	0·58	0·02	0·04	0·37	0·47
			C	0·12	0·38	0·08	0·46	0·02	0·02	0·38	0·46
Ettrick	Linhope	7	A/H	5·23	0·27	0·76	1·03	—	—	0·71	1·47
			A_1	1·97	0·44	1·02	1·46	0·06	0·10	1·21	2·23
			B_2	1·69	0·44	0·92	1·36	0·06	0·10	1·30	2·22
			B_2	1·04	0·68	1·11	1·79	0·08	0·08	1·07	2·18
			B_2	0·68	0·65	1·23	1·88	0·06	0·04	1·06	2·29
			B_2	0·63	0·70	1·40	2·10	0·07	0·04	1·12	2·52
Ettrick	Linhope	8	A_{11}	0·97	0·44	0·58	1·02	0·05	0·07	0·78	1·36
			A_{12}	1·29	0·50	0·68	1·18	0·05	0·07	0·80	1·48
			B	0·97	0·58	0·74	1·32	0·06	0·06	0·71	1·45

Ettrick	Linhope	9	A	2·06	0·51	0·69	1·20	0·10	0·21	1·06	1·75
			B_2	1·74	0·97	0·65	1·62	0·12	0·21	0·71	1·36
			B_3	0·39	0·23	0·10	0·33	0·01	0·02	0·51	0·61
			C	0·29	0·16	0·05	0·21	0·01	0·02	0·71	0·76
Ettrick	Linhope (intergrade variant)	13	Ap	1·50	0·43	0·52	0·95	0·03	0·06	0·70	1·22
			B_2	1·11	0·64	0·45	1·09	0·04	0·06	0·45	0·90
			C	0·26	0·23	0·08	0·31	0·01	0·02	0·32	0·40
			C	0·08	0·19	0·03	0·21	0·01	0·01	0·35	0·38
Kirkcolm	Kirkcolm	15	Ap	0·79	0·19	0·38	0·57	0·04	0·07	0·59	0·97
			Ap	0·83	0·23	0·50	0·73	0·06	0·08	0·69	1·19
			A/B	0·75	0·19	0·43	0·62	0·07	0·10	0·59	1·02
			C	0·21	0·07	<0·01	0·07	0·01	0·06	0·25	0·25
Kirkcolm	Clachan	16	Ap	0·39	0·03	0·11	0·14	0·05	0·14	0·28	0·39
			Ap	0·38	0·05	0·10	0·15	0·05	0·14	0·25	0·35
			B/C	0·24	0·03	0·11	0·14	0·05	0·09	0·22	0·33
			C	0·13	0·01	0·07	0·08	0·03	0·05	0·14	0·21
Rhins	Portencalzie	18	Ap	0·98	0·33	0·39	0·72	0·04	0·07	0·83	1·22
			Ap	1·01	0·36	0·36	0·72	0·04	0·07	0·92	1·28
			B	0·71	0·78	0·75	1·53	0·08	0·08	0·73	1·46
			B_3/C	<0·05	0·07	0·02	0·09	—	—	0·92	0·94
			B_3/C	<0·05	<0·01	0·02	0·02	—	—	1·00	1·02
Yarrow	Yarrow	25	L & F	3·87	0·13	0·40	0·53	—	—	0·67	1·07
			A_1/H	2·56	0·33	0·85	1·18	0·17	0·41	0·86	1·71
			A_1	1·76	0·85	1·21	2·06	0·16	0·20	0·94	2·15
			B_2	2·07	1·60	1·81	3·41	0·43	0·46	0·80	2·61
			C	1·23	0·75	0·22	0·97	0·19	0·40	0·58	0·80
Yarrow	Cairnside	28	Ap	0·77	0·11	0·27	0·38	0·03	0·08	0·52	0·79
			B_2	0·25	0·24	0·38	0·62	0·06	0·04	0·55	0·93
			B_3	0·24	0·27	0·20	0·47	0·06	0·06	0·54	0·56
			B_3	0·25	0·28	0·16	0·44	0·11	0·13	0·55	0·71
			C	0·10	0·34	0·08	0·42	0·14	0·14	0·37	0·45

TABLE 11. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe+Al)	% (Fe+Al) / % Clay	% (C+Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Ettrick	Altimeg	36	Ag	1·92	0·35	0·14	0·49	0·03	0·08	0·33	0·47
			Bg	0·59	0·26	0·10	0·36	0·01	0·03	0·27	0·37
			Bg	<0·05	0·10	0·05	0·15	—	—	0·30	0·35
			Bg	<0·05	<0·01	0·04	0·04	—	—	0·30	0·34
			Bg/Cg	<0·05	<0·01	0·04	0·04	—	—	0·20	0·24
Ettrick	Kedslie	39	A	1·16	0·16	0·12	0·28	0·01	0·05	0·75	0·87
			B_2g	0·41	0·08	0·14	0·22	—	0·01	1·33	1·47
			B_3g	0·12	0·07	0·09	0·16	—	—	0·89	0·98
			B_3g	0·27	0·05	0·08	0·13	—	—	0·67	0·75
			B_3g	<0·05	0·02	0·06	0·08	—	—	0·66	0·72
			B/Cg	<0·05	<0·01	<0·06	0·06	—	—	0·90	0·96
Rhins	Rhins	41	Ap	1·05	0·20	0·23	0·43	0·20	0·06	0·96	1·19
			Ap	0·87	0·22	0·24	0·46	0·20	0·04	0·95	1·19
			Bg	0·04	0·12	0·04	0·16	—	—	1·42	1·46
			C	<0·01	0·08	<0·01	0·08	—	—	1·22	1·22
			C	<0·01	0·05	<0·01	0·05	—	—	1·46	1·46
Rhins	Portpatrick	47	Ap	2·27	0·35	0·40	0·75	0·05	0·16	0·62	1·02
			Ap	2·75	0·54	0·39	0·93	0·07	0·24	0·50	0·89
			B_2g	1·80	0·24	0·14	0·38	0·02	0·11	0·69	0·83
			B/C	0·14	0·09	0·03	0·12	—	—	1·43	1·46
			B/C	<0·01	0·07	0·01	0·08	—	—	1·10	1·20
			B/C	<0·01	0·05	0·03	0·08	—	—	1·20	1·23

TABLE 12. HUMUS-IRON PODZOLS

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Rhins	Mull	52	H/Ap	0·90	0·05	0·04	0·09	0·01	0·16	0·06	0·10
			A_2	0·68	0·08	0·02	0·10	0·01	0·05	0·03	0·05
			B_{21}	4·08	0·38	0·34	0·72	0·10	0·64	0·61	0·95
			$B_{2,\,1-2}$	1·29	0·29	0·10	0·39	0·03	0·13	0·57	0·67
			B_{22}	0·69	0·36	0·27	0·63	0·10	0·18	0·53	0·80
			B/C	0·69	0·27	0·16	0·43	0·06	0·14	0·41	0·57
			B/C	0·39	0·20	0·04	0·24	0·05	0·12	0·39	0·43
Yarrow	Knockarod	53	H	5·08	0·16	0·22	0·38	—	—	0·13	0·35
			A_2/H	3·74	0·30	0·26	0·56	0·11	0·81	0·28	0·54
			B_{21}	6·43	1·05	0·74	1·79	0·30	1·25	0·56	1·30
			B_{22}	0·68	0·49	0·30	0·79	0·13	0·20	0·74	1·04
			C	0·57	0·25	0·17	0·42	0·15	0·21	0·62	0·79
Yarrow	Larbrax	54	H	2·38	0·07	0·15	0·22	—	—	0·03	0·18
			A_2/H	2·63	0·05	0·48	0·50	0·10	0·54	0·03	0·51
			B_{21}	2·54	0·50	0·56	1·06	0·16	0·40	0·20	0·76
			$B_{2,\,1-2}$	1·28	0·55	0·89	1·44	0·12	0·15	0·50	1·39
			B_{22}	0·44	0·43	0·37	0·80	0·13	0·14	0·36	0·73
			C	0·28	0·39	0·15	0·54	0·09	0·11	0·37	0·52

TABLE 13. PEATY PODZOLS

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10)			% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
				% Carbon	% Aluminium	% Iron					
Dalbeattie	Carsphairn	56	H	3·24	0·50	0·46	0·96	—	—	0·10	0·56
			A_2	1·76	0·32	0·45	0·77	0·07	0·21	0·03	0·48
			B	0·89	0·48	0·06	0·54	0·18	0·46	0·02	0·08
			C	0·37	0·34	<0·01	0·34	0·04	0·06	0·03	0·03
Ettrick	Dod	58	H	6·53	0·15	0·21	0·36	—	—	0·05	0·26
			A_2g	5·75	0·79	0·12	0·91	0·08	0·54	0·04	0·16
			B_2	2·55	1·74	1·98	3·72	0·31	0·36	0·81	2·79
			B_3	0·99	0·62	0·42	1·04	0·07	0·14	0·47	0·89
			C	0·45	0·29	0·09	0·38	0·02	0·04	0·45	0·54
Ettrick	Dod	59	H	5·66	0·18	0·32	0·50	—	—	<0·01	0·32
			A_2g	2·76	0·50	0·25	0·75	0·04	0·19	0·08	0·33
			B_2	2·46	1·35	2·30	3·65	0·52	0·54	0·45	2·75
			B/C	1·89	0·58	0·34	0·92	0·10	0·27	0·36	0·70
			C	0·33	0·37	0·16	0·53	0·04	0·05	0·42	0·58
Rhins	Auchleach	62	Ap	3·97	0·46	0·27	0·73	—	—	0·03	0·30
			B_2	1·80	0·31	0·24	0·65	0·03	0·12	0·39	0·63
			B_3	0·19	0·14	0·11	0·25	0·01	0·02	0·94	1·05
			B/Cg	<0·01	0·06	0·06	0·12	0·01	—	0·86	0·92

TABLE 14. NON-CALCAREOUS GLEYS

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Ettrick	Littleshalloch	67	$A_{1}g$	2·06	0·48	0·46	0·94	0·09	0·25	0·56	1·02
			$A_{2}g$	0·86	0·49	0·42	0·91	0·04	0·06	0·58	1·00
			Bg	1·65	1·04	0·81	1·85	0·17	0·24	0·63	1·44
			B/Cg	0·71	0·63	0·08	0·71	0·05	0·10	0·31	0·39
Ettrick	Ettrick	71	Ap	0·87	0·04	0·07	0·11	—	0·03	0·62	0·69
			$B_{2}g$	0·50	0·09	0·10	0·19	—	0·03	0·59	0·69
			$B_{2}g$	<0·05	<0·01	0·07	0·07	—	—	0·60	0·67
			$B_{2}g$	<0·05	<0·01	0·04	0·04	—	—	0·83	0·87
			B/Cg	<0·05	<0·01	0·03	0·03	—	—	0·72	0·75
Rhins	Ardwell	75	Ap	2·44	0·41	0·66	1·07	0·06	0·16	0·37	1·03
			Ap	1·67	0·25	0·50	0·75	0·04	0·09	0·38	0·88
			$B_{2}g$	0·06	0·01	0·08	0·09	—	—	0·82	0·90
			C	<0·01	0·03	0·06	0·09	—	—	0·63	0·66
			C	<0·01	0·03	0·04	0·07	—	—	1·40	1·44
Rhins	Balscalloch	77	Apg	1·43	0·25	0·31	0·56	0·03	0·08	0·55	0·86
			Apg	1·46	0·26	0·31	0·57	0·03	0·08	0·44	0·75
			$A_{2}g$	0·01	0·07	<0·01	0·07	—	—	0·22	0·22
			$B_{2}g$	<0·01	0·05	0·03	0·08	—	—	0·64	0·67
			B/Cg	<0·01	0·05	0·04	0·09	—	—	0·63	0·67
			B/Cg	<0·01	0·05	<0·01	0·05	—	—	0·63	0·63

TABLE 14—*continued*

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Stirling	Fordel	79	Ag	0·58	0·07	0·25	0·32	0·01	0·03	0·40	0·65
			Ag	0·29	0·03	0·10	0·13	—	0·01	0·56	0·66
			Bg	<0·01	0·01	<0·01	0·01	—	—	0·63	0·63
			B/Cg	<0·01	0·01	0·10	0·11	—	—	0·62	0·72
			B/Cg	<0·01	<0·01	<0·01	0·01	—	—	0·38	0·39
Stirling	Newton Stewart	81	Ag	0·60	0·06	0·26	0·32	0·02	0·04	0·49	0·75
			A/Bg	<0·01	0·05	0·11	0·16	0·01	—	0·72	0·83
			B_2g	<0·01	0·03	0·07	0·10	—	—	1·06	1·13
			C_1g	0·14	0·03	0·03	0·06	—	—	1·50	1·53
			C_1g	0·12	0·03	0·03	0·06	—	—	1·08	1·11
			C_2g	<0·01	0·02	0·06	0·08	—	—	1·21	1·27
			C_3g	<0·01	<0·01	0·04	0·04	—	—	0·76	0·80
Stirling	Stirling	82	A_1g	1·67	0·12	0·42	0·54	0·02	0·07	0·39	0·81
			A_1g	2·51	0·19	0·45	0·64	0·02	0·08	0·36	0·81
			A_2g	0·50	0·05	0·12	0·17	—	0·01	0·61	0·73
			B_2g	0·12	0·02	0·08	0·10	—	—	0·82	0·90
			Cg	0·24	0·02	0·02	0·04	—	—	1·24	1·26

TABLE 15. PEATY GLEYS

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Dalbeattie	Eglin	87	H	7·95	0·80	0·73	1·53	—	—	0·16	0·89
			A_2g	0·66	0·47	0·06	0·53	0·06	0·13	<0·01	0·06
			B/Cg	0·75	0·49	0·04	0·53	0·08	0·16	<0·01	0·04
			B/Cg	1·12	0·53	<0·01	0·53	0·08	0·21	<0·01	<0·01
Ettrick	Dochroyle	88	H	7·10	0·08	0·62	0·70	—	—	0·10	0·72
			A_2g	3·98	0·54	0·13	0·67	0·04	0·27	0·08	0·21
			Bg	0·26	0·21	0·08	0·29	0·01	0·03	0·17	0·25
			Cg	0·24	0·21	0·05	0·26	0·01	0·02	0·30	0·35
Rhins	Glenstockadale	91	H	3·64	0·15	0·27	0·42	—	—	<0·01	0·27
			A_2g	5·56	0·95	0·33	1·28	0·06	0·31	<0·01	0·33
			B_2g	0·55	0·19	0·28	0·47	0·02	0·04	0·92	1·20
			B_3g	0·32	0·09	0·14	0·23	0·01	0·01	0·86	1·00
			Cg	<0·01	0·03	0·04	0·07	—	—	0·90	0·94
Stirling	Poldar	93	H/Ap	9·73	0·31	1·05	1·36	—	—	0·09	1·14
			A_2g	0·29	0·02	0·12	0·14	—	0·01	0·62	0·74
			B_2g	0·42	0·04	0·16	0·20	—	0·01	0·42	0·58
			Cg	0·10	<0·01	0·12	0·12	—	—	0·78	0·90

TABLE 16. SUB-ALPINE SOILS

Association	Series	Profile No.	Horizon	First Extraction, Potassium Pyrophosphate (pH 10) % Carbon	% Aluminium	% Iron	% (Fe + Al)	% (Fe + Al) / % Clay	% (C + Al) / % Clay	Second Extraction Sodium Dithionite % Iron	Total Iron Extracted
Dalbeattie	Mulltaggart	94	H/A	4·57	0·22	0·34	0·56	—	—	0·17	0·51
			H/A_2	2·31	0·21	0·12	0·33	0·05	0·42	0·04	0·16
			H/B	2·94	1·55	0·46	2·01	0·20	0·45	0·36	0·82

APPENDIX IV

Silicon and Aluminium Extracted by Cold 1 molar Sodium Carbonate and Hydroxyl Activity

TABLE 17 BROWN FOREST SOILS, FREELY DRAINED

				Extracted Cold 1 molar Sodium Carbonate				
Association	Series	Profile No.	Horizon	% SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	Hydroxyl activity me/100 g
Dalbeattie	Dalbeattie	5	H/A_1	0·18	3·0	0·81	7·9	516
			A_1	0·08	1·3	1·92	18·8	28
			B_2	0·26	4·3	4·53	44·4	120
			B_3	0·32	5·3	6·00	58·9	147
Ettrick	Linhope	6	A	0·10	1·7	0·96	9·4	22
			A	0·06	1·0	1·05	10·3	22
			B_2	0·09	1·5	1·52	14·9	55
			B_3	0·34	5·7	0·90	8·8	46
			C	0·22	3·7	0·66	6·5	29
Ettrick	Linhope (intergrade variant)	13	Ap	0·02	0·3	0·77	7·6	45
			B_2	<0·01	<0·2	1·53	15·0	133
			C	0·15	2·5	0·86	8·4	72
			C	0·07	1·2	0·57	5·6	67
Kirkcolm	Kirkcolm	15	Ap	0·14	2·3	0·32	3·1	43
			Ap	0·12	2·0	0·35	3·4	40
			A/B	0·16	2·7	0·25	2·5	35
			C	n.d.	n.d.	n.d.	n.d.	n.d.
Kirkcolm	Clachan	16	Ap	0·12	2·0	0·11	1·1	9
			Ap	0·12	2·0	0·12	1·2	18
			B/C	0·09	1·5	0·10	1·0	11
			C	0·10	1·7	0·06	0·6	40
Rhins	Portencalzie	18	Ap	0·06	1·0	0·70	6·9	74
			Ap	0·04	0·7	0·78	7·7	62
			B	0·26	4·3	2·50	24·5	167
			B/C	0·10	1·7	0·28	2·8	38
			B/C	0·13	2·2	0·12	1·2	31
Yarrow	Yarrow	25	L & F	0·54	9·0	0·32	3·1	15
			A_1/H	0·20	3·3	0·55	5·4	22
			A_1	0·07	1·2	1·03	10·1	66
			B_2	0·14	2·3	2·40	23·5	158
			C	0·33	5·5	3·05	29·9	190
Yarrow	Cairnside	28	Ap	0·04	0·7	0·56	5·5	64
			B_2	0·11	1·8	0·36	3·5	30
			B_3	0·04	0·7	0·41	4·0	23
			B_3	0·06	1·0	0·30	2·9	40
			C	0·08	1·3	0·27	2·7	25

n.d. Not determined

TABLE 18. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

				Extracted Cold 1 molar Sodium Carbonate				
Association	Series	Profile No.	Horizon	% SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	Hydroxyl activity me/100 g
Ettrick	Altimeg	36	Ag	0·10	1·7	0·71	7·0	19
			Bg	0·23	3·8	1·01	9·9	38
			Bg	0·20	3·3	0·70	6·9	19
			Bg	0·17	2·8	0·39	3·8	26
			B/Cg	0·16	2·7	0·42	4·1	29
Ettrick	Altimeg (intergrade variant)	37	Ap	0·01	0·2	0·62	6·1	52
			Bg	0·14	2·3	0·82	8·0	110
			Bg	0·18	3·0	0·80	7·9	66
			Bg	0·17	2·8	0·63	6·2	113
			B/C	0·08	1·3	0·44	4·3	52
Ettrick	Kedslie	39	A	0·18	3·0	0·50	4·9	37
			B_2g	0·02	0·3	0·37	3·6	72
			B_3g	0·04	0·7	0·37	3·6	35
			B_3g	<0·01	<0·2	0·36	3·5	26
			B_3g	0·04	0·7	0·32	3·1	21
			B/Cg	0·10	1·7	0·25	2·5	23
Rhins	Rhins	41	Ap	0·04	0·7	0·30	2·9	40
			Ap	<0·01	<0·2	0·31	3·0	28
			Bg	0·06	1·0	0·25	2·5	22
			C	0·02	0·3	0·19	1·9	27
			C	0·11	1·8	0·13	1·3	20
Rhins	Portpatrick	47	Ap	<0·01	<0·2	0·72	7·1	56
			Ap	0·01	0·2	2·21	21·7	52
			B_2g	0·03	0·5	0·93	9·1	49
			B/C	0·07	1·2	0·27	2·7	32
			B/C	0·09	1·5	0·16	1·6	22
			B/C	0·07	1·2	0·84	8·2	30

TABLE 19. HUMUS-IRON PODZOLS

Association	Series	Profile No.	Horizon	Extracted Cold 1 molar Sodium Carbonate: % SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	Hydroxyl activity me/100 g
Rhins	Mull	52	H/Ap	0·10	1·7	0·18	1·8	5
			A_2	0·02	0·3	0·18	1·8	10
			B_{21}	0·08	1·3	1·77	17·4	47
			$B_{2,\ 1\text{-}2}$	0·06	1·0	0·95	9·3	26
			B_{22}	0·06	1·0	0·65	6·4	22
			B/C	0·08	1·3	0·58	5·7	36
			B/C	0·15	2·5	0·62	6·1	23
Yarrow	Knockarod	53	H	0·20	3·3	0·45	4·4	n.d.
			A_2/H	0·07	1·2	0·73	7·2	10
			B_{21}	0·14	2·3	1·39	13·6	120
			B_{22}	0·44	7·3	1·48	14·5	120
			C	0·62	10·3	1·49	14·6	304
Yarrow	Larbrax	54	H	0·28	4·7	0·23	2·3	n.d.
			A_2/H	0·08	1·3	0·48	4·7	30
			B_{21}	0·11	1·8	1·11	10·9	46
			$B_{2,\ 1\text{-}2}$	0·02	0·3	1·16	11·4	80
			B_{22}	0·05	0·8	0·68	6·7	50
			C	0·24	4·0	1·83	18·0	105

n.d. Not determined

TABLE 20. PEATY PODZOLS

Association	Series	Profile No.	Horizon	Extracted Cold 1 molar Sodium Carbonate: % SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	Hydroxyl activity me/100 g
Dalbeattie	Carsphairn	56	H	0·11	1·8	2·00	19·6	42
			A_2	<0·01	<0·2	1·88	18·4	124
			B	0·24	4·0	9·10	89·3	322
			C	0·21	3·5	1·40	13·7	119
Ettrick	Dod	58	H	0·23	3·8	0·38	3·7	n.d.
			A_2g	0·10	1·7	0·86	8·4	23
			B_2	<0·01	<0·2	1·83	18·0	173
			B_3	0·11	1·8	1·63	16·0	128
			C	0·06	1·0	0·62	6·1	53
Rhins	Auchleach	62	Ap	0·08	1·3	0·68	6·7	19
			B_2	0·04	0·7	1·47	14·4	41
			B_3	0·09	1·5	0·42	4·1	20
			B/Cg	0·07	1·2	0·26	2·6	17

n.d. Not determined

TABLE 21. NON-CALCAREOUS GLEYS

Association	Series	Profile No.	Horizon	Extracted Cold 1 molar Sodium Carbonate % SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	Hydroxyl activity me/100 g
Ettrick	Littleshalloch	67	A_1g	0·02	0·3	0·57	5·6	81
			A_2g	<0·01	<0·2	0·73	7·2	69
			Bg	0·30	5·0	3·55	34·8	378
			B/Cg	0·79	13·2	3·05	29·9	281
Ettrick	Ettrick	71	Ap	0·11	1·8	0·33	3·2	68
			B_2g	0·11	1·8	0·58	5·7	120
			B_2g	0·12	2·0	0·35	3·4	85
			B_2g	0·17	2·8	0·23	2·3	58
			B/Cg	0·21	3·5	0·20	2·0	54
Rhins	Ardwell	75	Ap	0·06	1·0	0·37	3·6	34
			Ap	0·06	1·0	0·40	3·9	33
			B_2g	0·02	0·3	0·13	1·3	25
			C	0·33	5·5	0·06	0·6	36
			C	0·04	0·7	0·04	0·4	38
Rhins	Balscalloch	77	Apg	0·03	0·5	0·26	2·6	30
			Apg	0·02	0·3	0·24	2·4	42
			A_2g	<0·01	<0·2	0·11	1·1	41
			B_2g	0·02	0·3	0·10	1·0	25
			B/Cg	0·02	0·3	0·08	0·8	27
			B/Cg	0·10	1·7	0·04	0·4	26
Stirling	Fordel	79	Ag	0·20	3·3	0·08	0·8	8
			Ag	0·16	2·7	0·08	0·8	29
			Bg	0·12	2·0	0·03	0·3	12
			B/Cg	0·15	2·5	0·01	0·1	35
			B/Cg	0·08	1·3	<0·01	<0·1	12
Stirling	Newton Stewart	81	Ag	0·10	1·7	0·07	0·7	32
			A/Bg	0·08	1·3	0·13	1·3	40
			B_2g	0·10	1·7	0·09	0·9	46
			C_1g	0·08	1·3	0·05	0·5	35
			C_1g	0·14	2·3	0·03	0·3	48
			C_2g	0·12	2·0	0·02	0·2	27
			C_3g	0·10	1·7	0·04	0·4	32
Stirling	Stirling	82	A_1g	0·16	2·7	0·20	2·0	78
			A_1g	0·14	2·3	0·27	2·7	58
			A_2g	0·13	2·2	0·12	1·2	32
			B_2g	0·15	2·5	0·08	0·8	39
			Cg	0·15	2·5	0·06	0·6	32

TABLE 22. PEATY GLEYS

Association	Series	Profile No.	Horizon	Extracted Cold 1 molar Sodium Carbonate				Hydroxyl activity me/100 g
				% SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	
Dalbeattie	Eglin	87	H	0·14	2·3	1·76	17·3	n.d.
			A_2g	0·03	0·5	0·82	8·0	n.d.
			B/Cg	0·04	0·7	0·73	7·2	46
			B/Cg	<0·01	<0·2	0·78	7·7	25
Ettrick	Dochroyle	88	H	0·34	5·7	0·25	2·5	n.d.
			A_2g	<0·01	<0·2	0·96	9·4	25
			Bg	0·08	1·3	0·44	4·3	47
			Cg	0·16	2·7	0·44	4·3	50
Rhins	Glenstockadale	91	H	0·24	4·0	0·37	3·6	n.d.
			A_2g	0·10	1·7	1·00	9·8	26
			B_2g	0·05	0·8	0·45	4·4	37
			B_3g	0·10	1·7	0·25	2·5	36
			Cg	0·15	2·5	0·20	2·0	17
Stirling	Poldar	93	H/Ap	0·24	4·0	0·52	5·1	30
			A_2g	0·10	1·7	0·13	1·3	52
			B_2g	0·10	1·7	0·06	0·6	20
			Cg	0·20	3·3	0·04	0·4	31

n.d. Not determined

TABLE 23. SUB-ALPINE SOILS

Association	Series	Profile No.	Horizon	Extracted Cold 1 molar Sodium Carbonate				Hydroxyl activity me/100 g
				% SiO_2	m. mole SiO_2/100 g	% Al_2O_3	m. mole Al_2O_3/100 g	
Dalbeattie	Mulltaggart	94	H/A	0·25	4·2	0·44	4·3	5
			H/A_2	0·07	1·2	0·54	5·3	5
			H/B	0·05	0·8	2·32	22·8	97

APPENDIX V

Mineralogical Data

TABLE 24. CHEMICAL ANALYSES OF ROCKS

	1	2	3	4	5
SiO_2	68·68	61·52	59·02	69·22	58·80
TiO_2	1·12	0·62	0·64	0·62	0·61
Al_2O_3	12·84	13·42	13·84	9·78	14·97
Fe_2O_3	0·16	1·72	0·74	0·77	0·92
FeO	5·58	4·45	6·20	4·24	4·56
MnO	0·23	—	0·19	0·12	0·22
MgO	2·95	3·39	4·76	2·91	3·48
CaO	1·32	3·46	5·02	3·47	4·12
Na_2O	2·04	3·73	3·26	3·09	3·57
K_2O	1·47	2·17	1·88	1·74	2·82
P_2O_5	0·17	—	0·17	0·07	0·10
CO_2	—	3·04	1·34	2·04	2·09
$H_2O < 105°C$	0·10	0·06	0·08	0·48	0·19
$H_2O > 105°C$	2·98	2·33	2·96	1·82	3·48
	99·64	99·91	100·10	100·37	99·93

No. 1—Greywacke, Loch Doon complex. (Ordovician). Walton, E. K., 1955 (from McIntyre, private communication).
No. 2—Greywacke, average of three samples. Pettijohn, 1949 (from Todd, 1928).
No. 3—Greywacke, Edston Quarry, Peebleshire. (Silurian). Walton, E.K., 1955.
No. 4—Greywacke, Glentress Burn, Peebleshire. (Silurian). Walton, E.K., 1955.
No. 5—Dark shale, Edston Quarry, Peebleshire. (Silurian). Walton, E.K., 1955.

	6	7	8	9
SiO_2	73·26	71·18	67·72	57·76
TiO_2	0·30	0·47	0·48	1·24
Al_2O_3	14·29	14·78	14·74	15·17
Fe_2O_3	0·98	1·20	1·17	2·96
FeO	0·97	1·35	1·83	4·26
MnO	0·04	0·06	tr.	0·13
(CoNi)O	—	tr.	—	—
MgO	0·69	0·82	1·67	5·14
CaO	1·14	1·58	2·39	5·30
Na_2O	3·48	3·10	4·61	4·35
K_2O	4·04	4·82	4·38	2·07
Li_2O	tr.	—	—	—
P_2O_5	0·25	0·38	0·12	0·17
CO_2	0·45	0·29	Nil	—
H_2O at 105°C	0·04	0·11	0·09*	0·31*
$H_2O > 105°C$	0·42	0·15	$0·92^+$	$0·71^+$
	100·35	100·29	100·12	99·57

* $H_2O < 110°C$ $^+H_2O > 110°C$

No. 6—Muscovite-biotite-granite, Cairnsmore of Fleet. (E. G. Radley anal.). Gardiner and Reynolds, 1937.
No. 7—Biotite-granite, Cairnsmore of Fleet. (E. G. Radley anal.). Gardiner and Reynolds, 1937.
No. 8—Adamellite ("granite"), Portencorkrie complex. (W. H. Herdsman, anal.). Holgate, 1943.
No. 9—Typical diorite, Portencorkrie complex. Holgate, 1943.

APPENDIX V

TABLE 25. MINERALOGICAL ANALYSIS OF CLAY FRACTION

Association	Series	Profile	Horizon	Kaolin	Mica	Chlorite	Mica Vermi-culite	Chlorite Vermi-culite	Vermi-culite	Mont-morillonite	X-Ray amorphous Material	Goethite	Hematite
Dalbeattie	Dalbeattie	Fleet Viaduct No. 1	B_3	+	+						*		
Ettrick	Linhope	Dervaird No. 2	A	+	+ +	+ +					*		
			B_2	+	+ +	+ +					*		
			B_3	+	+ +	+ +						+	
			C	+	+ +	+ +						+	
	Kedslie	Balker No. 2	B_2g	+	+ +	+ +		+				+	
			$B_{32}g$	+	+ + +	+ +							
	Littleshalloch	Boreland No. 2	A_2g	+	+	+ + +	+ +					+	
			Bg)Cg	+	+	+ + +						+	
Kirkcolm	Kirkcolm	Cailliness No. 3	A/B	+	+ + +	+			+ + +				
			C	+	+ + +	+			+ + +				
Rhins	Portencalzie	Portencalzie No. 2	A_1g	+		+ +			+ + +				
			B_2	+		+ +			+ + +				
			B_3C	+	+	+ + +							
	Portpatrick	Balgown No. 2	B_2g	+	+ + +	+ +							+
			B_3/C	+	+ +	+ +						+	+
	Ardwell	Drumbreddan No. 1	A_1g	+	+ + +	+ +			+ +			+	
			B_2g	+	+ + +	+ +			+ +			+	
			C	+	+ + +	+ +			+ +				
Stirling	Newton Stewart	Grange No. 2	B_2g	+	+ + +	+			+ + +	+			
			C_2g	+	+ + +	+			+ + +	+			
			C_4g	+	+ + +	+			+ +	+			
Yarrow	Yarrow	Castle Kennedy	A_1	+ +					+ +				
			C								*		

Key: + + + Dominant (>50%); + + Abundant or co-dominant (25–50%); + Subordinate (5–25%); * Substantial amount of X-ray amorphous material

TABLE 26. PERCENTAGE OF MINERAL GROUPS AND MINERAL FREQUENCIES IN THE FINE SAND FRACTIONS OF C HORIZONS+ (20—200μ)

	Light Fraction (S.G. < 2·9)*							Heavy Fraction (S.G. > 2·9)*															
Association	Weight % Light	Quartz	Plagioclase	Potash Feldspars	Micas	$CaCO_3$	Weathered Material	Anatase	Apatite	Augite	Biotite/ chlorite	Epidote	Garnet	Hornblende	Hypersthene	Iron oxides	Muscovite	Rutile	Sphene	Tourmaline	Zircon	Rock Particles	Weathered Material
Dalbeattie	99·6	7	5	7	3	—	3	3	3	1	6	3	3	1	—	6	3	—	—	—	4	2	1
Ettrick	99·5	8	2	5	—	—	7	—	2	4	1	4	3	5	2	7	—	2	1	1	5	4	3
Kirkcolm	98·5	8	2	6	1	—	5	—	2	6	1	4	2	5	1	7	—	2	—	2	3	3	3
Rhins	98·7	8	2	5	—	—	6	—	2	5	1	4	3	4	1	8	—	1	—	2	3	4	3
Stirling	98·4	8	2	6	1	3	4	—	4	5	—	4	5	4	5	6	—	3	1	3	4	4	—
Yarrow	80·0	9	3	6	1	—	5	—	1	7	—	2	4	3	—	8	—	—	—	1	1	4	4

* Frequency scale used:— 0 = <½%, 1 = ½–1%, 2 = 1–2%, 3 = 2–4%, 4 = 4–7%, 5 = 7–15%, 6 = 15–30%, 7 = 30–50%, 8 = 50–70%, 9 = 70–90%, 10 = 90–100%.

+ Average values for a number of profiles from the Soil Association.

APPENDIX VI

Peat Analyses

TABLE 27. GLENGYRE MOSS

Depth m	Ash percent	pH	Percent total oven-dry weight					
			Ca	Na	K	Mg	P	N
0·0–0·5	2·5	3·8	0·160	0·039	0·019	0·176	0·029	1·22
0·5–1·0	1·8	3·9	0·120	0·043	0·015	0·168	0·020	1·29
1·0–1·5	1·9	3·8	0·123	0·038	0·009	0·176	0·021	1·09
1·5–2·0	1·3	4·0	0·108	0·050	0·014	0·207	0·018	0·79
2·0–2·5	1·3	4·0	0·137	0·062	0·019	0·200	0·017	0·69
2·5–3·0	1·3	4·1	0·133	0·065	0·025	0·196	0·018	0·87
3·0–3·5	1·5	4·1	0·145	0·053	0·023	0·223	0·019	0·84
3·5–4·0	1·8	4·1	0·215	0·083	0·035	0·293	0·019	0·73
4·0–4·5	1·9	4·1	0·241	0·082	0·037	0·250	0·021	0·79
4·5–5·0	2·0	4·0	0·280	0·072	0·038	0·228	0·020	0·71
5·0–5·5	2·4	4·0	0·306	0·056	0·018	0·183	0·023	0·76

TABLE 28. WEST FREUGH MOSS

Depth m	Ash percent	pH	Percent total oven-dry weight					
			Ca	Na	K	Mg	P	N
0·0–0·5	6·5	3·5	0·067	0·041	0·026	0·180	0·027	1·17
0·5–1·5	2·8	4·0	0·092	0·065	0·021	0·257	0·018	1·13
1·5–2·0	2·7	4·1	0·158	0·058	0·042	0·638	0·021	1·45
2·0–2·5	4·4	4·2	0·240	0·045	0·045	0·795	0·018	1·41
2·5–3·5	5·0	4·4	0·244	0·034	0·033	0·300	0·017	1·70

TABLE 29. FLOW OF DERGOALS

Depth m	Ash percent	pH	Percent total oven-dry weight					
			Ca	Na	K	Mg	P	N
0·0–0·5	3·6	3·5	0·192	0·027	0·019	0·134	0·032	1·62
0·5–1·0	3·1	3·4	0·285	0·031	0·015	0·161	0·025	1·41
1·0–1·5	3·1	3·6	0·402	0·030	0·018	0·211	0·023	1·43
1·5–2·0	3·5	3·8	0·641	0·028	0·017	0·297	0·021	1·29
2·0–2·5	3·4	3·7	0·457	0·028	0·015	0·122	0·040	1·76
2·5–3·0	5·6	4·0	0·841	0·022	0·011	0·300	0·025	1·06
3·0–3·5	3·7	3·9	0·661	0·021	0·009	0·267	0·022	1·13
3·5–4·0	3·6	3·7	0·641	0·017	0·011	0·207	0·026	1·17
4·0–4·5	4·3	3·9	0·978	0·022	0·006	0·222	0·021	1·04
4·5–5·0	5·0	4·0	1·261	0·023	0·011	0·232	0·022	0·85
5·0–5·5	4·7	4·0	0·991	0·027	0·018	0·174	0·022	1·04
5·5–6·0	4·9	4·1	1·211	0·019	0·020	0·143	0·020	0·76
6·0–6·5	3·7	4·0	0·776	0·027	0·010	0·133	0·021	1·09

TABLE 30. DRUMMODDIE MOSS

Depth m	Ash percent	pH	Percent total oven-dry weight					
			Ca	Na	K	Mg	P	N
0·0–0·5	3·4	3·5	0·101	0·028	0·012	0·076	0·024	1·61
0·5–1·0	2·0	3·9	0·088	0·038	0·010	0·266	0·017	1·27
1·0–1·5	1·8	4·2	0·095	0·043	0·015	0·300	0·014	1·13
1·5–2·0	1·7	4·4	0·074	0·055	0·016	0·240	0·013	1·26
2·0–2·5	1·8	4·2	0·098	0·056	0·011	0·270	0·014	1·27
2·5–3·0	1·4	4·3	0·088	0·049	0·018	0·258	0·012	0·98
3·0–3·5	1·2	4·4	0·067	0·044	0·019	0·186	0·015	0·93
3·5–4·0	1·4	4·3	0·101	0·043	0·025	0·219	0·016	0·90
4·0–4·5	1·2	4·1	0·145	0·045	0·012	0·146	0·020	0·87
4·5–5·0	1·3	4·1	0·181	0·045	0·015	0·155	0·019	0·89
5·0–5·5	1·6	4·1	0·157	0·036	0·010	0·210	0·017	0·97
5·5–6·0	1·7	4·1	0·405	0·044	0·012	0·136	0·016	1·05
6·0–6·5	3·0	4·0	0·668	0·043	0·012	0·154	0·019	1·25
6·5–7·0	3·8	3·8	0·907	0·037	0·014	0·151	0·017	1·18
7·0–7·5	3·7	4·1	0·818	0·041	0·015	0·092	0·020	1·23
7·5–8·0	4·9	4·1	0·665	0·037	0·016	0·068	0·034	1·39

TABLE 31. MOSS OF CREE

Depth m	Ash percent	pH	Percent total oven-dry weight					
			Ca	Na	K	Mg	P	N
0·0–0·5	5·3	3·5	0·140	0·035	0·028	0·119	0·030	1·41
0·5–1·0	2·5	3·3	0·130	0·045	0·013	0·136	0·017	0·99
1·0–1·5	2·9	3·3	0·134	0·050	0·010	0·159	0·020	0·95
1·5–2·0	2·7	3·3	0·186	0·065	0·018	0·209	0·025	0·85
2·0–2·5	3·7	3·4	0·290	0·081	0·029	0·267	0·023	0·78
2·5–3·0	3·5	3·6	0·440	0·093	0·027	0·253	0·023	0·93
3·0–3·5	4·6	3·7	0·575	0·081	0·026	0·221	0·025	1·01

APPENDIX VII

Plant Communities

Floristic tables (32–47) of relevés of plant communities recorded from Sheets 1, 2, 3 4 and part of Sheet 7.

The relevés have been abstracted from the tables of the 'Plant Communities and Soils of the Lowland and Southern Upland Regions of Scotland' (Birse and Robertson, 1976). All the character species and the relevant differential species are quoted from those tables, but only the companion species with constancy greater than 20 percent are listed unless they actually occur in the area.

The cover/abundance value for each species within each relevé is given according to the Domin scale (Poore, 1955b). The ratings for the scale are:

Cover about 100%	10
Cover greater than 75%	9
Cover 50–75%	8
Cover 33–50%	7
Cover 25–33%	6
Abundant, cover about 20%	5
Abundant, cover about 5%	4
Scattered, cover small	3
Very scattered, cover small	2
Scarce, cover small	1
Isolated, cover small	x

In the tables, (x) indicates a species outside the relevé but still considered to be part of the association: [ ] indicates that two or more species share the same cover/abundance value in a relevé. Because of difficulties in separation, the liverwort species *Calypogeia muellerana* and *C. trichomanis* are considered collectively as *C. muellerana*. In woodland stands, the tree and shrub seedlings of the field layer are considered as separate species from the adult trees and shrubs.

Presence of species within the communities is given by the scale:

Constancy Class V	80 to 100%
IV	60 to 79%
III	40 to 59%
II	20 to 39%
I	0 to 19%

A code reference is given alongside each association or community name to allow for brevity in the tables of environmental factors in appendix VIII.*

The nomenclature of the vascular plants is that of Clapham, Tutin and Warburg (1962), of mosses that of Warburg (1963), of liverworts that of Paton (1965), and of lichens that of James (1965).

* The figure in brackets following each reference number refers to the environmental table in which details for that relevé may be found.

TABLE 32.

Class: Asteretea tripolii Westhoff et Beeftink 1962
Order: Glauco-Puccinellietalia Beeftink et Westhoff 1962
Alliance: Puccinellion maritimae Christiansen 1927 em Tx. 1937
Association: Puccinellietum maritimae (Warming, 1890) Christiansen 1927—GP1

	1	*Constancy Class*
Association character species		
Puccinellia maritima	6	V
Alliance character species		
Spergularia media	3	V
Spergularia marina	.	I
Order/Class character species		
Plantago maritima	8	V
Armeria maritima	6	V
Aster tripolium	3	V
Glaux maritima	4	IV
Festuca rubra	.	IV
Triglochin maritimum	3	II
Companion species		
Suaeda maritima	.	IV
Algae	8	V
Salicornia spp.	.	III
Number of species per relevé	8	

Site Serial Numbers: 1—67084 (54)

TABLE 33.

Class: Asteretea tripolii Westhoff et Beeftink 1962
Order: Glauco-Puccinellietalia Beeftink et Westhoff 1962
Alliance: Armerion maritimae Br.–Bl. et De L. 1936
Association: Juncetum gerardii Warming, 1906—GP2

	1	2	3	4	*Constancy Class*
Association character species					
Juncus gerardii	.	.	.	7	III
Alliance character species					
Festuca rubra	8	6	8	8	V
Armeria maritima	3	3	5	3	V
Agrostis stolonifera	6	9	6	5	IV
Order/Class character species					
Plantago maritima	2	4	4	4	V
Glaux maritima	5	7	.	1	V
Triglochin maritima	2	2	3	5	IV
Aster tripolium	.	1	4	4	IV
Cochlearia anglica	.	.	2	2	II
Companion species					
Puccinellia maritima	3	.	.	.	II
Cochlearia officinalis	.	3	.	.	II
Number of species per relevé	7	8	7	9	

Site Serial Numbers: 1—67087 (54); 2—67114 (54); 3—67132 (54); 4—67113(54)

TABLE 34.

Class: Parvocaricetea (Westhoff, MS.) Den Held et Westhoff 1969
Order: Tofieldietalia Prsg. apud Oberd. 1949
Alliance: Eriophorion latifolii Br.–Bl. et Tx. 1943
Carex dioica–Eleocharis quinqueflora community Birse et Robertson 1976—T3

	1	*Constancy Class*
Pinus sylvestris	.	II
Community character species		
Carex dioica	3	V
Eleocharis quinqueflora	7	IV
Alliance/Order character species		
Fissidens adianthoides	2	V
Drepanocladus revolvens intermedius	6	V
Campylium stellatum	5	IV
Pinguicula vulgaris	.	III
Parnassia palustris	.	III
Eriophorum latifolium	3	III
Carex hostiana	6	II
Triglochin palustris	(x)	II
Carex lepidocarpa	.	II
Carex pulicaris	.	I
Class character species		
Carex panicea	4	V
Eriophorum angustifolium	3	V
Juncus articulatus	3	IV
Pedicularis palustris	3	IV
Carex demissa	.	II
Carex echinata	1	II
Carex nigra	.	I
Ranunculus flammula	.	I
Companion species		
Ctenidium molluscum	1	V
Succisa pratensis	3	IV
Potentilla erecta	.	IV
Molinia caerulea	4	IV
Selaginella selaginoides	.	III
Carex flacca	.	III
Festuca rubra	.	III
Equisetum palustre	x	III
Bryum pseudotriquetrum	1	III
Acrocladium cuspidatum	.	II
Prunella vulgaris	.	II
Juncus bulbosus	2	II
Agrostis stolonifera	.	II
Philonotis fontana	.	II
Scorpidium scorpioides	1	II
Pellia fabbroniana	.	II
Juncus acutiflorus	x	I
Number of species per relevé	21	

Site Serial Numbers: 1—67137 (56)

TABLE 35.

Class: Molinio-Arrhenatheretea Tx. 1937
Order: Molinietalia W. Koch 1926
Alliance: Juncion acutiflori Br.–Bl. 1947
Association: Potentillo-Juncetum acutiflori Birse et Robertson 1976—M1

	1	2	3	4	5	6	7	*Constancy Class*
Association character species								
Juncus acutiflorus	8	8	8	8	7	7	7	V
Carum verticillatum	5	4	x	2	4	x	.	II
*Subassociation with **Poa trivialis**–differential species*								
Poa trivialis	5	5	4	2	6	.	.	III
Holcus mollis	5	.	1	3	4	3	.	II
Ranunculus repens	.	2	4	3	.	.	.	II
Galium palustre	(x)	1	4	4	.	.	.	II
*Subassociation with **Festuca ovina**–differential species*								
Lophocolea bidentata	.	.	.	.	.	3	4	IV
Pseudoscleropodium purum	.	.	.	.	.	2	4	IV
Festuca ovina	.	.	.	.	.	5	5	III
Hylocomium splendens	.	.	.	.	.	5	5	III
Nardus stricta	.	.	.	.	.	3	3	III
Order character species								
Cirsium palustre	x	.	1	(x)	x	.	3	V
Deschampsia cespitosa	.	.	.	.	.	1	.	III
Achillea ptarmica	3	.	(x)	(x)	3	2	.	III
Lotus uliginosus	.	5	4	(x)	6	.	.	III
Succisa pratensis	.	3	3	.	x	.	.	II
Juncus conglomeratus	.	.	.	.	.	x	.	II
Juncus effusus	.	(x)	3	.	1	.	.	II
Galium uliginosum	.	.	.	.	2	.	2	II
Filipendula ulmaria	.	1	.	.	.	.	.	I
Taraxacum palustre	.	.	.	.	.	.	.	I
Equisetum palustre	.	.	.	.	.	.	x	I

Class character species								
Ranunculus acris	2	3	1	3	4	2	5	V
Festuca rubra	5	.	2	4	5	3	3	V
Holcus lanatus	4	5	5	3	6	.	4	V
Trifolium repens	7	5	.	.	4	1	.	IV
Poa pratensis	(x)	.	.	1	1	3	.	III
Rumex acetosa	.	.	3	3	x	1	.	III
Prunella vulgaris	.	1	.	x	1	.	x	III
Plantago lanceolata	.	.	.	.	3	.	.	III
Cardamine pratensis	x	1	(x)	3	.	.	.	II
Cerastium holosteoides	2	.	.	.	.	.	x	II
Cynosurus cristatus	.	.	.	.	3	.	.	II
Lathyrus pratensis	.	2	.	.	.	.	.	I
Centaurea nigra	.	1	(x)	.	.	.	.	I
Briza media	.	.	.	.	.	.	.	I
Festuca pratensis	.	.	.	.	.	.	.	I
Potentilla anserina	.	5	.	.	.	.	.	I
Trifolium pratense	.	.	.	.	3	.	.	I
Senecio jacobaea	.	.	.	.	x	.	.	I
Leontodon autumnalis	.	.	.	.	.	.	.	I
Achillea millefolium	.	.	.	.	.	.	.	I
Companion species								
Anthoxanthum odoratum	3	3	3	(x)	3	4	4	V
Potentilla erecta	4	.	.	3	3	6	4	V
Rhytidiadelphus squarrosus	.	5	2	.	.	4	4	V
Luzula multiflora	.	.	.	x	x	3	2	IV
Agrostis canina canina	.	3	4	2	.	4	.	III
Eurhynchium praelongum	1	3	3	.	.	1	2	III
Mnium undulatum	.	.	.	3	2	.	3	III
Carex panicea	5	4	.	2	.	3	1	III
Molinia caerulea	4	.	.	4	(x)	6	6	III
Thuidium tamariscinum	.	.	.	.	1	8	5	III
Carex nigra	3	1	5	4	4	1	.	III
Agrostis tenuis	.	.	.	.	.	2	.	III
Viola palustris	1	.	1	2	.	.	1	II

TABLE 35—*continued*

	1	2	3	4	5	6	7	*Constancy Class*
Galium saxatile	.	.	.	.	.	.	.	II
Acrocladium cuspidatum	3	6	.	6	4	1	.	II
Carex pulicaris	.	.	.	.	2	.	3	II
Polytrichum commune	.	.	.	.	.	1	.	II
Sieglingia decumbens	.	.	.	.	.	3	.	II
Hypnum cupressiforme ericetorum	.	.	.	.	.	.	x	II
Epilobium palustre	3	.	2	4	2	.	.	II
Carex spp.	.	.	.	.	.	x	.	II
Stellaria alsine	x	x	.	x	.	.	.	II
Pedicularis sylvatica	.	.	.	.	.	x	.	II
Pleurozium schreberi	.	.	.	.	.	.	.	II
Brachythecium rutabulum	1	.	3	.	.	.	.	I
Sagina procumbens	.	1	.	.	.	.	.	I
Brachythecium rivulare	.	1	.	5	4	.	.	I
Carex ovalis	.	.	.	(x)	1	.	.	I
Carex flacca	.	.	.	.	3	.	.	I
Juncus squarrosus	.	.	.	.	.	1	.	I
Atrichum undulatum	.	.	.	.	.	2	1	I
Anemone nemorosa	.	.	.	.	.	.	(x)	I
Agrostis canina montana	.	.	.	.	.	.	3	I
Ranunculus flammula	3	.	2	.	.	.	.	I
Carex echinata	.	.	.	(x)	1	.	.	I
Climacium dendroides	.	.	.	.	3	.	.	I
Calluna vulgaris	.	.	.	.	.	.	x	I
Calypogeia fissa	.	.	.	.	.	.	3	I
Bryum spp.	1	.	.	.	.	.	.	I
Lychnis flos-cuculi	(x)	.	.	4	.	.	.	I
Crepis paludosa	.	.	.	1	1	.	.	I
Polygonum hydropiper	x	.	.	.	.	.	.	I
Mentha aquatica	.	1	.	.	.	.	.	I
Iris pseudocorus	.	(x)	.	.	.	.	.	I
Myosotis caespitosa	.	(x)	.	.	.	.	.	I

Hydrocotyle vulgaris	.	.	1	.	.	.	.	I
Rhinanthus minor	.	.	1	.	.	.	.	I
Anagallis tenella	.	.	.	.	1	.	.	I
Taraxacum sp.	.	.	.	.	.	.	2	I
Mnium hornum	.	.	.	.	.	.	4	I
Dactylorchis maculata ericetorum	.	.	.	.	.	.	1	I
Number of species per relevé:	29	30	28	33	38	34	34	

Site Serial Numbers: 1–67091 (55); 2–67089 (55); 3–67102 (56); 4–67093 (58); 5–67092 (55); 6–67023 (55); 7–67118 (55)

TABLE 36.

Class: Molinio-Arrhenatheretea Tx. 1937
Order: Molinietalia W. Koch 1926
Alliance: Calthion Tx. 1937
Ranunculus repens–Juncus effusus community Birse et Robertson 1976—M2

	1	*Constancy Class*
Juncus effusus	7	V
Community differential species		
Poa pratensis	2	V
Anthoxanthum odoratum	4	IV
Agrostis tenuis	5	IV
Festuca rubra	3	IV
Ranunculus repens	1	III
Order character species		
Deschampsia cespitosa	.	II
Cirsium palustre	1	II
Achillea ptarmica	.	II
Equisetum palustre	.	I
Angelica sylvestris	.	I
Class character species		
Rumex acetosa	3	V
Holcus lanatus	.	III
Ranunculus acris	.	III
Poa trivialis	4	II
Cardamine pratensis	.	II
Trifolium repens	.	II
Prunella vulgaris	.	I
Cerastium holosteoides	.	I
Companion species		
Lophocolea bidentata	5	V
Eurhynchium praelongum	4	V
Galium saxatile	3	IV
Viola palustris	.	IV
Agrostis canina canina	3	III
Holcus mollis	7	III
Rhytidiadelphus squarrosus	.	III
Mnium undulatum	.	III
Carex nigra	.	II
Hylocomium splendens	.	II
Brachythecium rutabulum	.	II
Luzula multiflora	.	II
Thuidium tamariscinum	.	II
Cardamine sp.	x	I
Dryopteris dilatata	(x)	I
Number of species per relevé:	16	

Site Serial Numbers: 1–67033 (56)

TABLE 37.

Class: Molinio-Arrhenatheretea Tx. 1937
Order: Molinietalia W. Koch 1926
Alliance: Calthion Tx. 1937
Juncus effusus–Sphagnum recurvum community Birse et Robertson 1976—M3

	1
Juncus effusus	8
Community differential species	
Sphagnum recurvum	8
Polytrichum commune	6
Acrocladium stramineum	3
Order character species	
Equisetum palustre	.
Class character species	
Rumex acetosa	.
Holcus lanatus	.
Companion species	
Galium saxatile	2
Agrostis canina canina	2
Holcus mollis	3
Lophocolea bidentata	2
Rhytidiadelphus squarrosus	1
Carex nigra	x
Plagiothecium undulatum	2
Aulacomnium palustre	x
Anthoxanthum odoratum	1
Potentilla erecta	x
Juncus articulatus	2
Pohlia nutans	x
Hypnum cupressiforme ericetorum	1
Calypogeia fissa	3
Agrostis sp.	1
Dryopteris dilatata	2
Dryopteris spinulosa	1
Cephalozia connivens	x
Number of species per relevé:	22

Site Serial Number: 1–67030 (58)

TABLE 38.

Class: Molinio-Arrhenatheretea Tx. 1937
Order: Arrhenatheretalia Pawlowski 1928
Alliance: Cynosurion cristati Tx. 1947
Association: Lolio-Cynosuretum (Br.–Bl. et de L 1936) Tx. 1937—A1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	*Constancy Class*
Association character species																			
Trifolium repens	6	7	7	7	6	5	5	7	7	7	7	7	9	8	7	4	7	9	V
Cynosurus cristatus	2	3	.	5	1	4	6	.	6	4	.	4	4	.	.	.	.	4	IV
Leontodon autumnalis	.	.	3	.	.	x	2	.	.	.	.	3	1	.	.	.	.	.	II
Senecio jacobaea	.	.	.	.	1	.	.	.	.	.	1	.	x	(x)	1	1	.	.	II
Phleum bertolonii	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	I
*Subassociation with **Luzula campestris**–differential species*																			
Luzula campestris	6	2	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Lotus corniculatus	4	3	2	4	3	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Rhytidiadelphus squarrosus	.	.	5	3	7	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Ranunculus bulbosus	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Typical subassociation–differential species																			
Ranunculus repens	.	.	5	x	4	7	7	6	5	4	7	5	5	(x)	5	8	3	5	IV
Poa annua	.	2	1	2	.	x	.	3	5	4	.	5	3	3	4	5	3	2	III
Phleum pratense	.	.	.	.	.	.	.	.	3	.	5	.	2	3	3	1	2	3	II
Rumex obtusifolius	.	.	.	.	.	(x)	.	(x)	(x)	.	1	x	x	(x)	1	1	2	1	II
Order character species																			
Bellis perennis	x	.	(x)	1	1	.	.	.	4	.	(x)	(x)	2	2	4	4	2	4	III
Dactylis glomerata	.	.	.	.	4	.	.	x	.	.	4	1	3	5	5	.	.	3	III
Veronica chamaedrys	.	.	2	.	1	.	.	.	.	.	.	x	.	.	.	.	.	.	II
Taraxacum officinale	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	I
Trifolium dubium	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Trisetum flavescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Arrhenatherum elatius	.	.	(x)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Class character species																			
Holcus lanatus	1	2	4	3	4	5	4	1	3	5	.	1	(x)	2	4	(x)	1	1	V
Cerastium holosteoides	1	x	4	2	2	1	.	.	x	3	1	3	2	3	3	.	1	1	V
Poa trivialis	.	5	4	3	.	3	2	7	6	7	6	4	5	6	5	5	6		IV
Lolium perenne	.	.	.	2	1	.	6	6	6	4	4	7	6	6	7	4	8	6	IV
Festuca rubra	7	6	7	3	4	3	.	.	.	2	5	.	.	.	.	.	.	.	IV
Poa pratensis	5	5	.	3	(x)	4	.	.	.	3	2	.	.	.	.	.	.	.	IV
Plantago lanceolata	5	3	5	5	5	.	x	.	(x)	1	.	2	4	.	1	.	.	.	III
Achillea millefolium	3	4	2	5	.	.	.	.	.	(x)	.	x	4	.	.	.	.	.	II
Prunella vulgaris	.	x	3	.	.	(x)	3	(x)	.	1	.	x	.	x	.	.	.	.	II
Rumex acetosa	.	4	.	5	1	3	.	.	.	.	(x)	.	.	.	.	.	.	.	II
Ranunculus acris	.	.	.	.	.	x	.	(x)	1	.	.	.	(x)	.	.	.	.	.	II
Plantago major	.	.	.	.	.	.	.	1	1	.	.	2	3	x	.	1	x	.	I
Veronica serpyllifolia	.	.	x	.	.	(x)	.	.	.	x	.	.	.	x	.	x	.	.	I
Trifolium pratense	.	.	.	.	(x)	.	.	(x)	.	.	.	.	.	.	.	2	4	1	I
Centaurea nigra	.	.	.	.	2	.	.	.	.	.	(x)	.	.	.	.	.	.	.	I
Achillea ptarmica	.	1	.	.	.	.	.	.	.	.	(x)	.	.	.	.	.	.	.	I
Agrostis stolonifera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Lathyrus pratensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Deschampsia cespitosa	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Juncus effusus	.	.	.	.	.	4	(x)	.	.	.	.	.	.	.	.	.	.	.	I
Festuca pratensis	.	.	.	.	.	.	.	x	.	.	5	.	.	.	.	.	.	.	I
Heracleum sphondylium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cirsium palustre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Potentilla anserina	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	I
Companion species																			
Agrostis tenuis	7	5	8	7	7	7	3	.	.	5	.	6	5	6	.	2	4	.	IV
Anthoxanthum odoratum	3	4	3	6	5	5	4	.	.	.	.	.	.	.	1	.	.	.	III
Brachythecium rutabulum	.	.	.	.	x	1	.	.	.	.	6	.	.	.	.	.	.	1	II
Cirsium vulgare	.	1	3	.	.	.	.	.	.	1	.	(x)	.	.	1	(x)	.	.	II
Eurhynchium praelongum	.	.	.	.	2	1	.	.	.	.	5	.	.	.	.	3	.	.	II
Cirsium arvense	.	.	.	.	.	.	.	(x)	.	2	.	4	.	2	.	1	.	.	II
Stellaria media	.	.	.	.	.	.	.	.	.	4	.	3	.	(x)	1	x	.	.	I
Sagina procumbens	.	5	1	.	.	.	.	.	.	.	.	.	.	.	.	x	.	1	I
Holcus mollis	.	3	.	.	5	.	.	.	.	.	.	2	.	.	.	.	.	.	I

TABLE 38—*continued*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	*Constancy Class*
Alopecurus geniculatus	.	.	.	.	.	.	6	5	4	.	.	.	.	.	.	.	.	.	I
Carex caryophyllea	x	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Rumex acetosella	x	.	.	.	(x)	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Festuca ovina	.	.	(x)	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pseudoscleropodium purum	.	.	4	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Galium saxatile	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Hypochoeris radicata	.	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Potentilla erecta	.	.	.	.	x	2	.	.	.	.	.	.	.	.	.	.	.	.	I
Galium verum	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Euphrasia spp.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Sieglingia decumbens	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Koeleria cristata	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Taraxacum sp.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Acrocladium cuspidatum	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Viola canina	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Thuidium tamariscinum	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pteridium aquilinum	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Euphrasia brevipila	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Crataegus monogyna seedlings	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Rubus fruticosus	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Mnium undulatum	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	I
Stellaria graminea	.	.	.	.	.	(x)	.	.	.	.	.	.	.	.	.	.	.	.	I
Carex ovalis	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	I
Equisetum arvense	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	I
Odontites verna	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	I
Polygonum amphibium	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	I
Luzula multiflora	.	.	.	.	.	.	.	5	.	.	.	.	.	.	.	.	.	.	I
Rumex crispus	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	I
Stellaria alsine	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	.	.	.	I
Myosotis arvensis	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	.	.	.	I
Articum minus	.	.	.	.	.	.	.	.	.	.	.	(x)	.	.	.	.	.	.	I

DD

Crepis capillaris	.	.	.	.	.	.	.	.	.	.	.	(x)	.	.	.	.	.	.	I
Veronica arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	(x)	.	.	.	.	I
Lolium multiflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	I
Vicia sepium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	(x)	.	.	.	I
Ceratodon purpureus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	I
Bryum sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	I
Juncus bufonius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	(x)	.	.	I
Eurhynchium swartzii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	I
Myosotis discolor	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	(x)	I
Number of species per relevé:	21	23	28	23	30	24	17	18	16	18	18	26	19	19	18	22	13	18	

Site Serial Numbers: 1—67051 (49); 2—67020 (50); 3—67098 (49); 4—67063 (49); 5—67101 (49); 6—67129 (50); 7—67086 (55); 8—67111 (55); 9—67061 (55); 10—67097 (50); 11—67044 (55); 12—67110 (49); 13—67109 (50); 14—67100 (50); 15—67062 (53); 16—67060 (55); 17—67055 (49); 18—67064 (55).

TABLE 39.

Class: Nardo-Cullunetea Prsg. 1949
Order: Nardetalia Prsg. 1949
Alliance: Nardo-Galion saxatilis Prsg. 1949
Association: Achilleo-Festucetum tenuifolia Birse et Robertson 1976—N3

	1	2	*Constancy Class*
Association character species			
Veronica officinalis	x	(x)	IV
Association differential species			
Viola riviniana	x	4	IV
Trifolium repens	.	3	IV
Achillea millefolium	1	3	IV
*Subassociation with **Thymus drucei**-differential species*			
Thymus drucei	(x)	2	III
Plantago lanceolata	x	3	II
Carex caryophyllea	.	.	II
*Subassociation with **Holcus mollis**-differential species*			
Holcus mollis	.	2	II
Pteridium aquilinum	5	6	II
Alliance character species			
Galium saxatile	4	3	V
Polygala serpyllifolia	2	.	II
Juncus squarrosus	.	.	I
Order character species			
Nardus stricta	.	.	II
Class character species			
Potentilla erecta	6	4	V
Hypnum cupressiforme ericetorum	.	.	III
Carex pilulifera	5	3	III
Sieglingia decumbens	2	.	III
Calluna vulgaris	2	.	II
Luzula multiflora	.	.	I
Ptilidium ciliare	.	.	I
Carex binervis	.	.	I
Erica cinerea	1	.	I
Companion species			
Agrostis tenuis	6	6	V
Anthoxanthum odoratum	6	6	V
Rhytidiadelphus squarrosus	x	4	V
Festuca ovina	6	6	V
Luzula campestris	1	2	V
Hylocomium splendens	.	4	V
Pseudoscleropodium purum	x	2	IV
Pleurozium schreberi	.	.	IV
Dicranum scoparium	.	.	III
Lotus corniculatus	.	1	III
Agrostis canina montana	.	.	II
Lophocolea bidentata	.	.	II
Veronica chamaedrys	(x)	1	II
Campanula rotundifolia	2	.	II
Deschampsia flexuosa	.	.	II
Cerastium holosteoides	.	.	II
Rhytidiadelphus triquetrus	.	.	II
Vaccinium myrtillus	.	.	II
Festuca rubra	.	.	II
Holcus lanatus	.	.	II

TABLE 39—*continued*

	1	2	*Constancy Class*
Peltigera canina	.	.	II
Poa pratensis	.	.	II
Polytrichum alpinum	.	.	II
Thuidium tamariscinum	.	1	II
Euphrasia micrantha	1	.	I
Conopodium majus	.	3	I
Atrichum undulatum	.	2	I
Frullania tamarisci	.	(x)	I
Euphrasia sp.	.	2	I
Number of species per relevé:	22	25	

Site Serial Numbers: 1—67036 (49); 2—67021 (49)

TABLE 40.

Class: Nardo-Cullunetea Prsg. 1949
Order: Nardetalia Prsg. 1949
Alliance: Nardo-Galion saxatilis Prsg. 1949
Association: Junco squarrosi-Festucetum tenuifoliae Birse et Robertson 1976—N4

	1	2	*Constancy Class*
Association character species			
Nardus stricta	.	.	IV
Juncus squarrosus	1	5	IV
Luzula multiflora	1	2	IV
Association differential species			
Vaccinium myrtillus	1	5	IV
Plagiothecium undulatum	5	6	III
Polytrichum commune	4	4	III
Subassociation with Molinia caerulea-differential species			
Molinia caerulea	5	7	III
Trichophorum cespitosum	.	.	II
Alliance character species			
Galium saxatile	.	x	IV
Polygala serpyllifolia	.	.	I
Pedicularis sylvatica	.	.	I
Class character species			
Potentilla erecta	4	3	V
Hypnum cupressiforme ericetorum	.	4	V
Calluna vulgaris	.	(x)	II
Carex pilulifera	.	.	II
Carex binervis	.	.	I
Sieglingia decumbens	.	.	I
Ptilidium ciliare	.	.	I
Empetrum nigrum	.	.	I
Ulex europaea	.	.	I
Erica cinerea	.	.	I
Companion species			
Festuca ovina tenuifolia	6	5	V
Deschampsia flexuosa	4	4	V
Agrostis canina montana	4	.	IV
Pleurozium schreberi	.	7	IV
Anthoxanthum odoratum	3	.	V
Rhytidiadelphus squarrosus	1	.	III
Dicranum scoparium	.	2	III
Lophocolea bidentata	6	2	III
Hylocomium splendens	.	.	II
Carex nigra	6	.	II
Campylopus flexuosus	.	x	II
Pseudoscleropodium purum	1	.	II
Luzula campestris	.	.	II
Agrostis tenuis	.	.	II
Pohlia nutans	4	.	II
Eriophorum angustifolium	3	.	I
Poa pratensis	1	.	I
Calypogeia muellerana	.	3	I
Sphagnum capillaceum	.	2	I
Calypogeia fissa	.	3	I
Lipidozia reptans	.	1	I
Number of species per relevé:	18	20	

Site Serial Numbers: 1—67043 (56); 2—67031 (56)

TABLE 41.

Class: Nardo Callunetea Prsg. 1949
Order: Nardetalia Prsg. 1949
Alliance: Nardo-Galion saxatilis Prsg. 1949
Carex bigelowii-Juncus squarrosus community Birse et Robertson 1976—N5

	1
Community differential species	
Carex bigelowii	4
Alliance character species	
Juncus squarrosus	8
Galium saxatile	[illegible]
Order character species	
Nardus stricta	x
Class character species	
Hypnum cupressiforme ericetorum	6
Ptilidium ciliare	.
Potentilla erecta	(x)
Companion species	
Deschampsia flexuosa	5
Agrostis canina montana	3
Vaccinium myrtillus	6
Rhytidiadelphus loreus	4
Polytrichum aurantiacum	5
Dicranum scoparium	1
Polytrichum alpestre	5
Plagiothecium undulatum	2
Rhacomitrium lanuginosum	3
Cladonia uncialis	(x)
Cetraria islandica	3
Diplopyllum albicans	4
Lophozia ventricosa	5
Cladonia impexa	1
Cladonia furcata	1
Number of species per relevé:	21

Site Serial Numbers: 1—*67105 (57)*

TABLE. 42

Class: Nardo-Callunetea Prsg. 1949
Order: Calluno-Ulicetalia (Quantin 1935) Tx. 1937
Alliance: Ulicion minoris Duvign. 1944
Association: Carici binervis-Ericetum cinereae Br.-Bl. et Tx. (1950) 1952—CU1

	1	2	3	4	5	6	7	8	9	10	11	*Constancy Class*
Association character species												
Carex binervis	.	(x)	.	1	.	4	1	.	.	.	.	II
Association differential species												
Nardus stricta	.	(x)	.	3	.	(x)	.	1	1	.	.	III
Typical subassociation-initial phase-differential species												
Carex arenaria	3	.	.	.	.	.	.	.	.	.	.	I
Lotus corniculatus	.	.	.	.	.	.	.	.	.	.	.	I
Peltigera canina	.	.	.	.	.	.	.	.	.	.	.	I
Ammophila arenaria	3	.	.	.	.	.	.	.	.	.	.	I
*Variant with **Vaccinium myrtillus**-differential species*												
Vaccinium myrtillus	.	5	3	.	.	.	.	.	.	.	.	II
*Subassociation with **Molinia caerulea**-differential species*												
Trichophorum cespitosum	.	.	.	4	(x)	2	1	4	1	2	3	III
Molinia caerulea	.	.	.	7	.	.	.	(x)	7	1	5	II
Erica tetralix	.	.	.	3	.	.	(x)	x	.	3	3	II
*Variant with **Hylocomium splendens**-differential species*												
Hylocomium splendens	.	.	.	1	.	.	.	.	.	.	.	II
Plagiothecium undulatum	.	.	.	3	.	.	.	.	.	.	.	I
*Variant with **Cladonia floerkeana**-differential species*												
Cladonia floerkeana	.	.	.	.	1	x	.	.	.	.	.	I
Cladonia arbuscula	(x)	.	.	.	2	.	.	.	.	.	.	I
Cladonia coccifera	.	.	.	.	1	2	.	.	.	.	.	I
Cladonia uncialis	.	.	.	.	.	.	.	.	.	.	.	I
Cladonia furcata	.	.	.	.	1	.	.	.	.	.	.	I

*Variant with **Leucobryum glaucum**-*												
differential species												
Leucobryum glaucum	.	.	.	.	.	.	.	.	.	x	4	I
Mnium hornum	.	.	.	.	.	.	.	.	.	1	5	I
Order character species												
Calluna vulgaris	9	9	9	8	9	9	9	9	8	9	9	V
Erica cinerea	4	7	3	x	3	.	x	4	4	.	.	IV
Antennaria dioica	.	.	.	.	.	.	.	.	.	.	.	I
Ulex europaeus	.	.	(x)	.	.	.	.	.	.	.	.	I
Ptilidium ciliare	5	.	.	.	.	.	.	.	.	.	.	I
Genista anglica	.	.	.	.	.	.	.	.	.	.	.	I
Ulex galii	.	.	4	.	.	.	.	.	.	.	.	I
Empetrum nigrum	.	.	.	.	.	.	.	.	.	.	.	I
Class character species												
Hypnum cupressiforme ericetorum	5	x	3	7	6	x	.	3	.	2	3	V
Potentilla erecta	.	3	2	1	(x)	2	2	4	2	3	1	IV
Carex pilulifera	.	x	x	1	(x)	1	x	1	2	.	.	III
Juncus squarrosus	.	.	.	.	.	(x)	.	.	.	(x)	3	II
Galium saxatile	.	.	(x)	.	.	.	.	.	.	.	.	I
Luzula multiflora	.	.	.	.	.	.	.	.	.	.	.	I
Sieglingia decumbens	.	3	.	.	.	.	x	.	.	.	.	I
Pedicularis sylvatica	.	1	.	2	.	.	(x)	.	.	.	.	I
Dactylorchis maculata ericetorum	.	.	1	.	.	.	.	.	.	.	x	I
Polygala serpyllifolia	.	.	.	.	.	.	.	.	.	.	.	I
Companion species												
Dicranum scoparium	5	x	.	1	6	x	.	.	.	.	2	IV
Festuca ovina	.	4	3	3	(x)	3	2	4	4	2	(x)	IV
Pleurozium schreberi	4	.	3	4	1	x	.	.	.	.	.	IV
Agrostis canina montana	.	3	2	(x)	x	3	2	3	4	(x)	.	IV
Deschampsia flexuosa	.	3	.	.	.	3	.	.	.	.	.	III
Pohlia nutans	1	2	.	.	3	2	4	1	2	6	4	III
Cladonia impexa	3	.	.	.	4	.	.	.	.	.	.	II
Lophocolea bidentata	4	.	.	.	.	.	.	.	.	.	.	II
Rhytidiadelphus squarrosus	.	.	.	1	.	.	.	.	.	.	.	II
Cladonia spp.	.	2	.	.	6	x	3	.	1	.	.	I
Campylopus piriformis	.	.	.	.	.	.	.	x	4	4	x	I

TABLE 42—*continued*

	1	2	3	4	5	6	7	8	9	10	11	*Constancy Class*
Carex panicea	.	2	.	x	.	x	.	.	.	.	.	I
Pteridium aquilinum	x	1	.	.	.	.	.	.	.	.	.	I
Calypogeia fissa	1	.	.	.	.	.	.	.	.	.	1	I
Cladonia squamosa	.	.	.	.	1	2	.	.	.	.	.	I
Polytrichum juniperinum	.	.	.	.	4	.	.	.	3	.	.	I
Leptodontium flexifolium	.	.	.	.	.	1	.	1	.	.	.	I
Carex nigra	.	.	.	.	.	3	.	.	.	4	.	I
Cephaloziella starkei	.	.	.	.	.	2	.	.	.	2	.	I
Parmelia physodes	2	.	.	.	.	.	.	.	.	.	.	I
Pseudoscleropodium purum	(x)	.	.	.	.	.	.	.	.	.	.	I
Peltigera spp.	1	.	.	.	.	.	.	.	.	.	.	I
Lophocolea cuspidata	2	.	.	.	.	.	.	.	.	.	.	I
Campanula rotundifolia	.	x	.	.	.	.	.	.	.	.	.	I
Polytrichum piliferum	.	1	.	.	.	.	.	.	.	.	.	I
Cephaloziella hampeana	.	x	.	.	.	.	.	.	.	.	.	I
Thuidium tamariscinum	.	.	.	1	.	.	.	.	.	.	.	I
Sphagnum capillaceum	.	.	.	1	.	.	.	.	.	.	.	I
Polytrichum commune	.	.	.	.	2	.	.	.	.	.	.	I
Lophozia bicrenata	.	.	.	.	4	.	.	.	.	.	.	I
Cornicularia aculeata	.	.	.	.	4	.	.	.	.	.	.	I
Cladonia cervicornis	.	.	.	.	1	.	.	.	.	.	.	I
Nardia scalaris	.	.	.	.	4	.	.	.	.	.	.	I
Centraria glauca	.	.	.	.	1	.	.	.	.	.	.	I
Cladonia pyxidata	.	.	.	.	3	.	.	.	.	.	.	I
Lophozia ventricosa	.	.	.	.	.	1	.	.	.	.	.	I
Ceratodon purpureus	.	.	.	.	.	.	4	.	.	.	.	I
Funaria hygrometrica	.	.	.	.	.	.	1	.	.	.	.	I
Calypogeia sp.	.	.	.	.	.	.	.	x	.	.	.	I
Anthoxanthum odoratum	.	.	.	.	.	.	.	(x)	.	.	.	I
Calypogeia muellerana	.	.	.	.	.	.	.	.	.	2	.	I
Cephalozia connivens	.	.	.	.	.	.	.	.	.	1	.	I
Number of species per relevé:	19	21	13	21	25	24	15	15	14	17	15	

Site Serial Number: 1—67068 (48); 2—67139 (51); 3—67049 (51); 4—67141 (56); 5—67134 (51); 6—67140 (52); 7—67050 (51); 8—67142 (53); 9—67117 (53); 10—67057 (56); 11—67058 (56)

TABLE 43.

Class: Oxycocco-sphagnetea Br.-Bl. et Tx 1943
Order: Sphagnetalia Compacti Tx.
Alliance: Ericion tetralicis Swickerath 1933
Association: Campylopo-Ericetum tetralicis Birse et Robertson ass. no. prov.—Scl

	1	*Constancy Class*
Association character species		
Sphagnum compactum	4	V
Order character species		
Erica tetralix	5	V
Trichophorum cespitosum	7	V
Class character species		
Sphagnum tenellum	3	III
Aulacomnium palustre	.	II
Cephalozia connivens	3	II
Narthecium ossifragum	4	II
Mylia anomala	.	II
Drosera rotundifolia	.	II
Sphagnum papillosum	.	I
Odontoschisma sphagni	7	I
Sphagnum rubellum	.	I
Sphagnum plumulosum	.	I
Lepidozia setacea	.	I
Eriophorum vaginatum	.	I
Companion species		
Calluna vulgaris	8	V
Hypnum cupressiforme ericetorum	4	V
Juncus squarrosus	5	V
Dicranum scoparium	2	V
Cladonia impexa	.	IV
Campylopus flexuosus	4	III
Gymnocolea inflata	.	III
Cladonia floerkeana	.	III
Molinia caerulea	5	III
Pohlia nutans	3	III
Eriophorum angustifolium	.	III
Carex panicea	.	III
Polytrichum commune	.	III
Carex nigra	.	III
Cladonia squamosa	.	II
Diplophyllum albicans	.	II
Pleurozium schreberi	.	II
Rhacomitrium lanuginosum	.	II
Plagiothecium undulatum	1	II
Cladonia arbuscula	.	II
Cladonia uncialis	.	II
Empetrum nigrum	.	II
Nardus stricta	.	II
Sphagnum cuspidatum	.	II
Rhytidiadelphus loreus	.	II
Pinus sylvestris seedlings	.	II
Leucobryum glaucum	4	II
Lophozia ventricosa	.	II
Lepidozia trichoclados	.	II
Hylocomium splendens	.	II
Parmelia physodes	.	II
Sphenolobus minutus	.	II
Sphagnum capillaceum	2	II
Cladonia crispata	.	II
Calypogeia muellerana	3	I
Number of species per relevé:	18	

Site Serial Numbers: 1—67037 (53)

TABLE 44.

Class: Oxycocco-Sphagnetea Br.—Bl. et Tx. 1943
Order: Eriophoro vaginati-Sphagnetalia papillosi Tx.
Alliance: Calluno-Sphagnion papillosi Tx. (1970) 1972
Association: Erico-Sphagnetum magellanici J. J. Moore (1964) 1968—ES 1

	1	2	3	4	5	6	7	*Constancy Class*
Subassociation with Cladonia uncialis—differential species								
Cladonia uncialis	1	.	.	.	.	.	.	II
Parmelia physodes	.	.	.	.	.	.	.	II
Cladonia arbuscula	3	.	.	.	.	.	.	I
Rhacomitrium lanuginosum	.	.	.	.	.	.	.	I
Subassociation with Molinia caerulea—differential species								
Molinia caerulea	.	5	3	6	5	.	.	II
Potentilla erecta	.	(x)	2	3	.	.	.	II
Variant with Myrica gale								
Myrica gale	.	.	.	6	6	4	(x)	II
Order character species								
Eriophorum vaginatum	4	(x)	5	2	4	4	3	IV
Odontoschisma sphagni	6	1	4	4	6	6	6	IV
Sphagnum papillosum	1	9	6	8	(x)	(x)	4	IV
Class character species								
Erica tetralix	5	4	5	5	5	5	5	V
Trichophorum cespitosum	3	1	4	1	6	8	6	V
Drosera rotundifolia	5	3	2	2	1	4	3	IV
Narthecium ossifragum	4	3	1	3	1	.	3	IV
Sphagnum tenellum	7	.	4	.	(x)	6	5	III
Cephalozia connivens	5	2	3	.	(x)	5	3	III
Mylia anomala	4	5	5	.	2	3	3	III
Aulacomnium palustre	.	5	5	.	1	(x)	.	II
Mylia taylori	4	1	.	.	x	.	.	II

Sphagnum magellanicum	7	.	.	.	.	.	6	II
Lepidozia setacea	(x)	.	.	3	.	.	4	II
Polytrichum alpestre	.	1	.	.	.	.	.	I
Sphagnum plumulosum	.	.	.	2	.	.	.	I
Riccardia latifons	.	.	.	.	.	.	.	I
Vaccinium oxycoccos	.	.	5	.	.	.	x	I
Pleurozia purpurea	3	.	.	.	.	.	.	I
Sphagnum rubellum	.	.	.	.	.	.	.	I
Sphagnum imbricatum	(x)	.	.	.	.	.	.	I
Andromeda polifolia	3	.	.	.	.	.	2	I
Carex pauciflora	.	.	.	.	.	.	.	I
Calypogeia sphagnicola	.	.	.	.	.	.	.	I
Companion species								
Calluna vulgaris	7	5	6	3	7	6	7	V
Eriophorum angustifolium	2	7	4	3	3	4	4	IV
Hypnum cupressiforme ericetorum	1	4	2	4	6	5	1	IV
Sphagnum capillaceum	3	1	6	.	6	6	7	IV
Cladonia impexa	2	.	1	.	2	1	.	III
Dicranum scoparium	2	4	2	.	1	2	.	III
Pleurozium schreberi	.	3	5	x	3	.	.	III
Calypogeia muellerana	.	.	2	.	.	.	.	II
Sphagnum cuspidatum	1	.	.	.	.	5	.	II
Pohlia nutans	.	.	.	.	1	.	.	II
Lepidozia trichoclados	.	.	.	.	1	.	.	II
Calypogeia fissa	.	3	.	2	.	.	.	II
Campylopus flexuosus	.	.	.	.	2	.	.	II
Riccardia spp.	2	.	.	.	.	2	.	I
Polygala serpyllifolia	.	1	.	1	.	.	.	I
Calypogeia spp.	2	.	.	.	.	.	.	I
Rhynchospora alba	4	.	.	.	.	.	.	I
Lophozia porphyroleuca	.	3	.	.	.	.	.	I
Carex panicea	.	1	.	.	.	.	.	I
Rhytidiadelphus loreus	.	1	.	.	.	.	.	I
Lophozia ventricosa	.	.	1	.	.	.	.	I
Carex nigra	.	.	.	3	.	.	.	I

TABLE 44—*continued*

	1	2	3	4	5	6	7	*Constancy Class*
Juncus acutiflorus	.	.	.	4	.	.	.	I
Carex dioica	.	.	.	1	.	.	.	I
Cladonia pyxidata	.	.	.	.	1	.	.	I
Leucobryum glaucum	.	.	.	.	1	.	.	I
Gymnocolea inflata	.	.	.	.	.	x	.	I
Odontoschisma denudatum	.	.	.	.	.	.	(x)	I
Riccardia palmata	.	.	.	.	.	.	2	I
Number of species per relevé:	28	25	23	21	26	20	21	

Site Serial Numbers: 1—67099 (58); 2—67138 (58); 3—67024 (58); 4—67038 (58); 5—67065 (58); 6—67053 (58); 7—67124 (58)

TABLE 45

Class: Loiseleurio-Vaccinietum Eggler 1952 Em. Schubert 1960
Order: Empetretalia Hermaphroditi Schubert 1960
Alliance: Cetrario-Loiseleurion Br.-Bl. et Siss. 1939
Agrostis montana—Rhacomitrium lanuginosum community Birse et Robertson 1976—LV 1

	1	2	3	*Constancy Class*
Community differential species				
Agrostis canina montana	5	5	4	V
Carex bigelowii	5	4	7	V
Galium saxatile	4	6	5	V
Festuca ovina	3	7	6	IV
Festuca vivipara	5	3	5	III
*Sub-community with **Salix herbacea***				
Salix herbacea	3	.	.	III
Polytrichum piliferum	.	.	.	III
Diplophyllum albicans	1	.	.	III
Dicranella heteromalla	.	.	.	II
Pohlia nutans	.	.	.	II
Cladonia cervicornis	.	.	.	II
Alliance/Order/Class character species				
Rhacomitrium lanuginosum	9	6	5	V
Dicranum fuscescens	.	.	.	II
Polytrichum alpinum	.	.	.	II
Ochrolechia frigida	.	.	.	I
Sphaerophorus globosus	.	.	.	I
Alectoria nigricans	.	.	.	I
Companion species				
Deschampsia flexuosa	2	5	5	V
Vaccinium myrtillus	5	5	6	V
Cladonia uncialis	3	2	5	V
Cetraria islandica	4	3	3	IV
Cornicularia aculeata	(x)	1	(x)	IV
Vaccinium vitis-idaea	5	5	2	III
Dicranum scoparium	.	4	3	III
Hypnum cupressiforme ericetorum	1	6	5	III
Polytrichum aurantiacum	4	5	5	III
Cladonia coccifera	(x)	.	(x)	III
Cladonia gracilis	(x)	3	1	III
Cladonia spp.	1	.	.	III
Campylopus flexuosus	.	.	.	II
Potentilla erecta	.	x	.	II
Carex pilulifera	.	3	.	II
Cladonia impexa	.	5	3	I
Cladonia floerkeana	(x)	.	.	I
Rhacomitrium heterostichum	x	.	.	I
Empetrum nigrum	(x)	.	.	I
Juncus squarrosus	.	1	.	I
Cladonia pyxidata	.	.	1	I
Number of species per relevé:	22	20	19	

Site Serial Numbers: 1—67108 (57); 2—67107 (57); 3—67106 (57)

TABLE 46.

Class: Quercetea robori-petraeae Br.–Bl. et Tx. 1943
Order: Quercetalia robori-petraeae Tx. (1931) 1937 em. 1955
Alliance: Quercion robori-petraeae (Malcuit 1929) Br.–Bl. 1932
Association: Galio saxatilis-Quercetum Birse et Robertson 1976—QR 1

	1	2	3	*Constancy Class*
Betula pubescens	1	.	1	II
Betula pendula	.	.	7	II
Quercus robur	.	.	1	II
Quercus petraea	8	6	.	I
Fraxinus excelsior	1	.	.	I
Corylus avellana	1	.	.	I
Crataegus monogyna	.	.	1	I
Sorbus aucuparia seedlings	(x)	.	.	II
Quercus petraea/robur seedlings	.	.	(x)	II
Fraxinus excelsior seedlings	.	.	x	I
Corylus avellana seedlings	x	.	.	I
Association differential species				
Luzula pilosa	3	.	.	III
Dicranum majus	.	.	.	III
Alliance/Order/Class character species				
Holcus mollis	7	8	7	III
Pteridium aquilinum	2	7	8	III
Lonicera periclymenum	2	.	6	II
Teucrium scorodonia	1	.	4	II
Lonicera periclymenum-(lianes)	1	.	.	I
Subassociation with Endymion non-scriptus—differential species				
Endymion non-scriptus	3	6	1	II
Companion species				
Oxalis acetosella	6	4	.	V
Deschampsia flexuosa	.	.	.	IV
Lophocolea bidentata	.	2	5	IV
Galium saxatile	.	.	x	IV
Pseudoscleropodium purum	.	.	4	III
Rhytidiadelphus squarrosus	.	2	3	III
Viola riviniana	1	.	3	III
Hylocomium splendens	.	.	4	III
Thuidium tamariscinum	5	.	1	III
Anthoxanthum odoratum	.	.	3	III
Rhytidiadelphus triquetrus	.	.	5	III
Potentilla erecta	.	.	1	III
Vaccinium myrtillus	.	.	.	III
Pleurozium schreberi	.	.	.	II
Eurhynchium praelongum	3	8	.	II
Agrostis tenuis	2	(x)	4	II
Hypnum cupressiforme	.	.	.	II
Rubus fruticosus agg	x	x	.	II
Stellaria holostea	.	.	.	II
Agrostis canina montana	.	.	.	II
Mnium hornum	2	.	.	II
Veronica chamaedrys	.	.	2	II
Plagiothecium undulatum	.	.	.	II
Trientalis europaea	.	.	.	II
Calluna vulgaris	.	.	.	II
Polytrichum aurantiacum	4	.	.	II
Anemone nemorosa	.	.	.	II

TABLE 46—*continued*

	1	2	3	*Constancy Class*
Rhytidiadelphus loreus	.	.	.	II
Dryopteris filix-mas	(x)	(x)	.	I
Lysimachia nemorum	3	(x)	.	I
Athyrium filix-femina	x	1	.	I
Holcus lanatus	1	.	1	I
Poa trivialis	.	3	3	I
Rubus idaeus	.	4	(x)	I
Dryopteris dilatata	4	.	.	I
Silene dioica	2	.	.	I
Dryopteris borreri	(x)	.	.	I
Lophocolea cuspidata	1	.	.	I
Isothecium myosuroides	x	.	.	I
Solidago virgaurea	2	.	.	I
Thelypteris limbosperma	.	1	.	I
Viola palustris	.	4	.	I
Thelypteris phegopteris	.	(x)	.	I
Ajuga reptans	.	.	1	I
Festuca rubra	.	.	3	I
Angelica sylvestris	.	.	(x)	I
Fragaria vesca	.	.	1	I
Cirsium palustre	.	.	x	I
Parmelia physodes	.	.	1	II
Evernia prunastri	.	.	1	II
Number of species per relevé:	31	18	33	

Site Serial Numbers: 1—67145 (49); 2—67104 (49); 3—67122 (49)

TABLE 47.

Class: Queroco-Fagetea Br.-Bl. et Vl. 1937
Order: Fagetalia sylvaticae pawlowski 1928
Alliance: Fraxino-Carpinion Tx. et Diemont 1936
Association: Aceri-Ulmetum glabrae Birse et Robertson 1976—F1

	1	2	3	4	5	6	7	8	*Constancy Class*
Betula pubescens	.	.	.	6	.	.	.	.	II
Quercus petraea	.	.	4	.	1	.	.	.	I
Pinus sylvestris	3	.	.	.	.	.	.	.	I
Aesculus hippocastanum	.	.	.	.	.	.	3	.	I
Corylus avellana	.	.	.	8	.	4	.	.	II
Sambucus nigra	.	.	4	.	.	.	.	.	I
Crataegus monogyna	.	.	x	.	.	.	.	.	I
Sorbus aucuparia seedings	.	.	.	.	.	.	.	x	I
Alliance character species									
Eurhynchium striatum	.	2	4	3	6	3	5	4	IV
Lysimachia nemorum	4	.	1	4	1	.	.	1	II
Fissidens taxifolius	.	.	.	.	.	.	.	.	I
Veronica montana	.	.	.	.	(x)	.	.	.	I
Primula vulgaris	.	.	.	.	(x)	.	.	.	I
Potentilla sterilis	.	.	.	(x)	.	.	.	.	I
Stellaria nemorum	.	.	.	.	.	.	.	.	I
Tilia europaea	.	.	.	.	.	.	.	.	I
Stellaria holostea	.	.	.	.	.	.	.	.	I
Rumex sanguineus	.	.	.	.	.	.	.	.	I
Prunus avium	.	.	.	.	.	.	.	.	I
Order character species									
Acer pseudoplatanus	8	8	1	.	1	4	7	7	IV
Fraxinus excelsior	4	4	8	.	1	7	4	.	III
Fraxinus excelsior seedlings	.	.	x	.	3	1	(x)	.	III
Dryopteris filix-mas	.	(x)	(x)	(x)	1	.	.	.	III
Mercurialis perennis	(x)	.	8	1	8	9	5	.	III
Circaea lutetiana	(x)	7	7	5	6	6	5	.	III

EE

Endymion non-scriptus	.	1	.	6	4	.	6	8	II
Ulmus glabra	.	.	.	.	9	4	.	.	II
Acer pseudoplatanus seedlings	x	.	.	.	.	x	.	.	II
Anemone nemorosa	.	.	.	5	.	.	.	.	II
Ulmus glabra seedlings	.	.	.	.	1	(x)	.	.	I
Dryopteris borreri	.	(x)	.	(x)	x	x	.	.	I
Fagus sylvatica	.	.	.	3	.	.	5	.	I
Hedera helix	.	.	1	.	.	.	.	.	I
Sanicula europaea	.	.	.	.	.	.	.	.	I
Fagus sylvatica seedlings	.	.	.	.	.	.	.	.	I
Adoxa moschatellina	(x)	x	.	.	.	.	.	.	I
Galium odoratum	.	.	.	.	.	.	.	.	I
Ranunculus ficaria	.	.	.	.	.	.	.	.	I
Stachys sylvatica	.	.	.	.	.	(x)	.	.	I
Hedera helix-(lianes)	4	2	.	.	.	.	.	.	I
Scrophularia nodosa	.	.	.	.	.	.	.	.	I
Companion species									
Eurhynchium praelongum	4	4	4	4	5	5	(x)	7	V
Thuidium tamariscinum	.	.	(x)	3	4	3	1	4	III
Mnium undulatum	.	.	3	2	5	2	.	.	III
Geum urbanum	.	.	1	4	(x)	.	.	.	III
Dryopteris dilatata	6	x	.	.	.	.	6	5	III
Cirriphyllum piliferum	.	.	4	.	5	4	.	.	III
Oxalis acetosella	3	2	.	1	.	1	.	.	III
Urtica dioica	x	.	(x)	.	3	(x)	.	.	III
Athyrium filix-femina	.	.	.	6	.	.	.	7	II
Galium aparine	x	4	1	.	.	.	.	.	II
Atrichum undulatum	.	.	7	x	.	1	.	.	II
Brachythecium rutabulum	.	3	.	.	.	.	.	1	II
Poa trivialis	7	7	.	.	3	x	.	3	II
Viola riviniana	.	.	.	.	3	.	.	1	II
Mnium hornum	.	.	.	.	.	x	(x)	1	II
Rubus fruticosus agg.	.	.	1	.	1	.	.	2	II
Plagiochila asplenioides	.	.	.	.	4	2	.	.	II
Geranium robertianum	(x)	3	.	3	.	.	.	.	II

TABLE 47—*continued*

	1	2	3	4	5	6	7	8	*Constancy Class*
Lophocolea bidentata	x	4	3	.	.	3	1	.	I
Silene dioica	7	7	x	.	1	.	.	.	I
Plagiothecium sylvaticum	3	1	.	1	.	2	.	.	I
Stellaria media	x	.	.	.	.	x	(x)	1	I
Glechoma hederacea	3	1	.	.	.	1	.	.	I
Isothecium myosuroides	1	.	.	1	.	1	.	.	I
Ranunculus repens	(x)	.	.	x	.	.	.	(x)	I
Ajuga repens	.	.	.	2	.	.	(x)	4	I
Pteridium aquilinum	1	.	.	.	.	2	.	.	I
Pellia epiphylla	.	.	.	x	.	1	.	.	I
Rubus idaeus	.	.	.	.	(x)	.	.	2	I
Angelica sylvestris	1	.	.	.	.	.	.	.	I
Mnium sp.	.	1	.	.	.	.	.	.	I
Fissidens bryoides	.	.	3	.	.	.	.	.	I
Lophocolea cuspidata	.	.	.	1	.	.	.	.	I
Blechnum spicant	.	.	.	1	.	.	.	.	I
Filipendula ulmaria	.	.	.	1	.	.	.	.	I
Valeriana officinalis	.	.	.	4	.	.	.	.	I
Cardamine sp.	.	.	.	.	x	.	.	.	I
Cirsium palustre	.	.	.	.	1	.	.	.	I
Isothecium myurum	.	.	.	.	.	1	.	.	I
Veronica chamaedrys	.	.	.	.	.	.	.	x	I
Juncus effusus	.	.	.	.	.	.	.	1	I
Rumex acetosa	.	.	.	.	.	.	.	1	I
Cardamine flexuosa	.	.	.	.	.	.	.	x	I
Parmelia physodes	.	.	.	.	.	.	2	.	I
Evernia prunastri	.	.	.	.	.	.	1	.	I
Number of species per relevé:	25	21	24	29	29	30	18	22	

Site Serial Numbers: 1—67026 (49); 2—67027 (49); 3—67135 (49); 4—67080 (49); 5—67144 (49); 6—67079 (49); 7—67048 (49); 8—67047 (55)

APPENDIX VIII

Environmental Tables

Tables (48–58) of site characteristics and soil analytical data for the sites of relevés in tables 32 to 47, grouped according to soil type.

Code references of plant communities:

CM1	Mertensio-Atriplicetum laciniatae
AA2	Elymo-Ammophiletum
FS1	Euphrasio-Festucetum arenariae
GP1	Puccinellietum maritimae
GP2	Juncetum gerardii
T3	*Carex dioica-Eleocharis quinqueflora* community
M1	Potentillo-Juncetum acutiflori
M2	*Ranunculus repens-Juncus effusus* community
M3	*Juncus effusus-Sphagnum recurvum* community
A1	Lolio-Cynosuretum
N3	Achilleo-Festucetum tenuifoliae
N4	Junco squarrosi-Festucetum tenuifoliae
N5	*Carex bigelowii-Juncus squarrosus* community
CU1	Carici binervis-Ericetum cinereae
SC1	Campylopo-Ericetum tetralicis
ES1	Erico-Sphagnetum magellanici
LV1	*Agrostis montana-Rhacomitrium lanuginosum* community
QR1	Galio saxatilis-Quercetum
F1	Aceri-Ulmetum glabrae

Abbreviations used for subdivisions of the major soil groups:

R	Raw soil on non-calcareous sand
BFS	Brown soil of intermediate to high base status
BP	Brown soil of low base status
BL	Shallow brown soil of low base status
BHL	Shallow humic brown soil of low base status
GBS	Gleyed brown soil of intermediate to high base status
GBP	Gleyed brown soil of low base status
HIP	Humus-iron podzol
IP	Iron podzol
GP	Gleyed podzol
PP	Peaty podzol
SG	Saline gley
BG	Non-calcareous gley of intermediate to high base status
AG	Non-calcareous gley of low base status
HG	Peaty gley of intermediate to high base status
PG	Peaty gley of low base status
MP	Oroarctic podzolic soil
PMP	Oroarctic peaty podzolic soil
MHP	Oroarctic humus podzol
FPT	Fen and flushed peat of intermediate to high base status

BPT Basin and flushed peat of low base status
RM Raised moss peat
PT Blanket peat

Abbreviations used for soil series are explained in the Soil Map key.

Abbreviations used for drainage categories of the soils:

P freely drained
P– moderately well drained
PPH imperfectly drained
PH poorly drained
HP very poorly drained

Other abbreviations used:

LUC Land use capability. Classes and subclasses after Bibby & Mackney (1969)
C/N Carbon/nitrogen ratio
Climate abbreviations from Birse (1971)

T Tree layer
S Shrub layer
F Field layer
G Ground layer

Note: the height of the field layer is often given as two components—the height of inflorescences or ferns, then the general height.

The values for exchangeable cations (me per 100 g) and total phosphorus (mg per 100 g) have been modified by a factor of $\frac{100}{100+x}$, where x = percentage organic matter in the soil.

Base saturation and organic matter values are quoted as percentages.

The horizons quoted for the peats in the analytical data tables are arbitrary depths at approximately 15 to 20 cm intervals down the profile.

TABLE 48. Skeletal Soils

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
R														
	CU 1	67068	NX139557	20	N	7	4	95	60	46	P	LN	5S	01H3T1

Analytical Data

Stand	OM H	OM A	OM B	pH H	pH A	pH B	pH C	Base Saturation H	Base Saturation A	Base Saturation B	Base Saturation C	Exchangeable Calcium H	Exchangeable Calcium A	Exchangeable Calcium B	Exchangeable Calcium C	Exchangeable Magnesium H	Exchangeable Magnesium A	Exchangeable Magnesium B	Exchangeable Magnesium C
R																			
67068	**	4	**	***	4·7	***	5·2	****	11·5	****	100·0	****	0·01	****	0·01	****	0·56	****	0·16

Exchangeable Potassium H	Exchangeable Potassium A	Exchangeable Potassium B	Exchangeable Potassium C	Total Phosphorus H	Total Phosphorus A	Total Phosphorus B	Total Phosphorus C	C/N Ratio
****	0·14	****	0·01	****	46	****	33	20·8

TABLE 49. Brown Forest Soils

Site Characteristics

Plant Com.	Stand	Grid Ref.	Alt. m	Aspect	Slope degrees	Plot m^2	% Cover T	S	F	G	Veg. Ht. T m	S m	F cm	Drainage	Soil Series	LUC	Climate
BFS																	
A 1	67055	NX028694	38	SW	4	4	—	—	98	—	—	—	15	P	PR	2S	01H3T1
BP																	
A 1	67051	NW965615	1	NIL	0	4	—	—	95	—	—	—	5	P	KM	3S	01H3T1
A 1	67098	NX344655	1	W	18	4	—	—	98	15	—	—	5/3	P	LP	5T	02H2T1
A 1	67101	NX293607	99	NW	19	4	—	—	98	50	—	—	30/10	P	LP	5T	02H2T1
A 1	67110	NX475489	40	W	1	4	—	—	100	—	—	—	76/36	P	PR	3S	02H3T1
N 3	67036	NX239652	145	E	20	4	—	—	90	1	—	—	56/10	P	LP	5T	02H2B3
N 3	67021	NX227587	99	W	16	4	—	—	85	10	—	—	43/10	P	LP	5T	02H2T1
QR 1	67122	NX405672	50	NE	2	4	45	—	95	40	12·2	—	137/51	P	LP	3C	02H2T1
F 1	67026	NX127397	23	NIL	0	4	75	—	95	5	21·3	—	102	P	KM	4S	01H3T1
F 1	67079	NX131616	69	E	19	4	75	5	80	40	21·3	4·6	36	P	LP	5TS	02H2T1
F 1	67048	NW999562	104	NW	6	4	80	—	50	20	21·3	—	76/30	P	PR	3C	01H2T1
BL																	
A 1	67063	NX259584	94	S	4	4	—	—	98	2	—	—	15/5	P	LP	3SC	02H2T1
QR 1	67145	NX561538	53	S	19	4	70	—	80	12	13·7	—	28	P	LP	5T	02H2T1
QR 1	67104	NX475634	102	WNW	13	4	30	—	95	70	15·2	—	102	P	CY	3CS	02H2T1
F 1	67135	NX499538	40	SW	9	4	60	5	90	60	16·8	3·0	36	P	LP	4S	02H3T1
F 1	67080	NX166662	76	E	23	4	40	70	70	10	16·8	3·7	41	P	LP	5TS	02H2T1
F 1	67144	NX559537	40	W	1	4	80	—	75	90	18·3	—	38	P	LP	3SC	02H2T1
BHL																	
F 1	67027	NX125400	52	E	18	4	70	—	98	8	21·3	—	81/41	P	LP	5ST	01H3T1

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	H	A	B	H	A	B	C	H	A	B	C	H	A	B	C	H	A	B	C
BFS																			
67055	**	9	**	***	5·5	5·7	6·0	*****	54·1	51·0	67·3	*****	5·03	1·83	1·67	*****	0·23	0·05	0·19
BP																			
67051	**	12	**	***	5·3	5·9	***	*****	40·8	55·2	*****	*****	4·60	5·57	*****	*****	4·09	5·04	*****
67098	**	12	6	***	5·8	5·8	5·7	*****	48·6	20·8	14·1	*****	7·84	1·76	0·31	*****	0·42	0·21	0·09
67101	**	10	7	***	5·0	4·8	5·0	*****	14·2	8·4	11·3	*****	1·21	0·73	0·30	*****	0·37	0·05	0·01
67110	**	10	6	***	5·1	4·7	5·4	*****	31·5	13·4	22·9	*****	4·08	0·91	0·28	*****	0·36	0·07	0·25
67036	**	12	9	***	4·9	5·0	5·2	*****	10·3	2·0	7·1	*****	0·42	0·01	0·01	*****	1·20	0·05	0·13
67021	**	15	11	***	5·0	5·1	5·2	*****	19·7	14·7	17·0	*****	3·30	1·69	0·91	*****	0·73	0·23	0·13
67122	**	15	**	***	5·2	4·9	5·0	*****	11·2	0·4	0·9	*****	1·49	0·01	0·01	*****	0·63	0·01	0·01
67026	**	14	9	***	5·2	5·2	5·6	*****	23·0	17·9	29·6	*****	2·18	1·28	0·01	*****	1·40	0·77	0·46
67079	**	17	5	***	4·9	5·1	5·9	*****	29·7	6·1	51·9	*****	4·59	0·45	1·99	*****	1·99	0·10	1·68
67048	**	9	**	***	4·8	4·8	5·0	*****	9·8	4·3	2·1	*****	0·72	0·01	0·01	*****	0·72	0·40	0·11
BL																			
67063	**	13	7	***	4·9	5·2	***	*****	12·4	6·3	*****	*****	2·09	0·73	*****	*****	0·74	0·19	*****
67145	**	17	**	***	4·6	4·7	***	*****	12·1	2·6	*****	*****	0·81	0·01	*****	*****	1·02	0·14	*****
67104	**	13	**	***	4·7	4·8	***	*****	21·6	6·9	*****	*****	0·97	0·16	*****	*****	0·35	0·11	*****
67135	**	10	**	***	5·3	5·6	***	*****	41·5	43·6	*****	*****	4·91	3·84	*****	*****	1·51	0·62	*****
67080	**	13	10	***	5·2	5·2	***	*****	28·8	10·4	*****	*****	4·31	0·85	*****	*****	1·66	0·37	*****
67144	**	9	**	***	5·7	5·4	***	*****	40·2	4·6	*****	*****	4·96	0·01	*****	*****	1·28	0·24	*****
BHL																			
67027	**	43	**	***	4·6	***	***	*****	22·6	*****	*****	*****	4·36	*****	*****	*****	2·45	*****	*****

TABLE 49—*continued*

Analytical Data

Exchangeable Potassium H	A	B	C	Total Phosphorus H	A	B	C	C/N Ratio
*****	0·17	0·06	0·04	****	222	147	140	10·7
*****	0·40	0·24	*****	****	186	243	****	10·1
*****	0·21	0·09	0·08	****	213	156	94	14·1
*****	0·21	0·13	0·04	****	199	719	77	14·3
*****	0·91	0·31	0·24	****	276	192	112	11·2
*****	0·49	0·14	0·14	****	155	169	81	11·4
*****	0·75	0·29	0·15	****	176	150	70	19·7
*****	0·43	0·08	0·05	****	142	168	105	16·9
*****	0·51	0·35	0·14	****	157	125	83	16·4
*****	0·70	0·10	0·04	****	182	162	73	13·7
*****	0·45	0·22	0·01	****	152	149	110	13·6
*****	0·58	0·11	*****	****	220	183	****	13·7
*****	0·62	0·04	*****	****	185	109	****	14·1
*****	0·23	0·04	*****	****	127	66	****	13·8
*****	0·35	0·05	*****	****	195	185	****	12·2
*****	0·62	0·30	*****	****	133	124	****	11·7
*****	0·45	0·08	*****	****	217	238	****	11·9
*****	0·83	*****	*****	****	375	****	****	12·5

TABLE 50. Brown Forest Soils with Gleying

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m²	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
GBS														
	A 1	67020	NX228588	110	W	3	4	95	—	—	PPH	KZ	3SC	02H2T1
	A 1	67097	NX345655	79	NIL	0	4	98	—	10	PPH	KZ	3SC	02H2T1
	A 1	67109	NX435504	55	S	2	4	95	—	36/8	PPH	RN	4S	02H3T1
	A 1	67100	NX293607	110	NIL	0	4	100	—	25	PPH	KZ	4S	02H2T1
GBP														
	A 1	67129	NX433673	88	N	1	4	80	1	41/10	PPH	AX	3S	02H2T1

Analytical Data

Stand	OM H	OM A	OM B	pH H	pH A	pH B	pH C	Base Saturation H	Base Saturation A	Base Saturation B	Base Saturation C	Exchangeable Calcium H	Exchangeable Calcium A	Exchangeable Calcium B	Exchangeable Calcium C	Exchangeable Magnesium H	Exchangeable Magnesium A	Exchangeable Magnesium B	Exchangeable Magnesium C
GBS																			
67020	**	15	2	***	6·0	5·1	***	*****	60·7	17·9	*****	*****	14·06	1·79	*****	*****	0·70	0·16	*****
67097	**	11	1	***	6·3	5·6	5·5	*****	64·1	18·9	26·5	*****	11·61	0·75	1·30	*****	0·68	0·06	0·24
67109	**	8	2	***	5·9	6·1	5·6	*****	59·6	60·6	80·0	*****	5·99	1·04	2·59	*****	0·65	0·23	0·66
67100	**	10	1	***	6·6	5·7	5·8	*****	85·0	45·7	60·0	*****	15·28	2·86	2·29	*****	0·47	0·06	0·04
GBP																			
67129	**	14	3	***	5·4	5·9	5·8	*****	24·7	41·9	52·6	*****	2·19	1·18	0·91	*****	0·68	0·02	0·25

Stand	Exchangeable Potassium H	Exchangeable Potassium A	Exchangeable Potassium B	Exchangeable Potassium C	Total Phosphorus H	Total Phosphorus A	Total Phosphorus B	Total Phosphorus C	C/N Ratio
GBS									
67020	*****	0·57	0·35	*****	****	228	110	****	12·8
67097	*****	1·02	0·36	0·25	****	287	99	124	14·8
67109	*****	0·18	0·06	0·15	****	243	80	117	11·1
67100	*****	0·18	0·11	0·15	****	319	117	88	14·1
GBP									
67129	*****	0·40	0·27	0·21	****	332	155	198	12·2

TABLE 51. Humus-Iron Podzols (including iron podzols)

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
HIP														
	CU 1	67139	NX542539	229	SW	10	4	95	1	20	P –	MM	4C	02H2B3
	CU 1	67049	NW967623	75	S	6	4	90	3	23	P	LB	4S	01H3T1
	CU 1	67050	NW970616	64	SW	8	4	80	15	8	P	LB	4S	01H3T1
IP														
	CU 1	67134	NX551632	122	S	24	4	75	80	15	P	—	6T	02H2B3

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	H	A	B	H	A	B	C	H	A	B	C	H	A	B	C	H	A	B	C
HIP																			
67139	68	19	9	4·1	4·4	4·9	5·3	11·5	6·0	1·0	0·9	3·57	0·39	0·01	0·01	0·48	0·63	0·06	0·01
67049	61	18	20	3·8	4·1	4·6	5·4	17·1	9·1	2·4	11·6	5·71	1·46	0·01	0·01	5·36	1·51	0·64	0·54
67050	41	15	8	4·5	4·4	4·8	4·9	31·7	2·1	14·2	1·1	11·06	0·01	1·29	0·01	3·72	0·17	1·17	0·04
IP																			
67134	28	10	**	4·4	4·2	4·8	5·0	2·5	2·6	0·3	0·8	0·01	0·01	0·01	0·01	0·20	0·10	0·01	0·01

Exchangeable Potassium				Total Phosphorus				C/N
H	A	B	C	H	A	B	C	Ratio
HIP								
1·19	0·45	0·07	0·04	146	120	141	108	25·2
1·24	0·58	0·25	0·03	107	106	103	108	29·4
0·93	0·22	0·52	0·01	90	65	60	86	24·5
IP								
0·41	0·11	0·03	0·02	123	95	86	107	25·4

TABLE 52. Podzols with Gleying

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
GP														
	CU 1	67140	NX542539	229	S	8	4	90	1	15	PPH	—	4S	02H2B3

Analytical Data

Stand	OM H	OM A	OM B	pH H	pH A	pH B	pH C	Base Saturation H	Base Saturation A	Base Saturation B	Base Saturation C	Exchangeable Calcium H	Exchangeable Calcium A	Exchangeable Calcium B	Exchangeable Calcium C	Exchangeable Magnesium H	Exchangeable Magnesium A	Exchangeable Magnesium B	Exchangeable Magnesium C
GP																			
67140	71	17	16	4·2	4·6	4·8	4·9	14·7	3·3	1·4	0·6	3·51	0·01	0·01	0·01	2·37	0·38	0·07	0·01

	Exchangeable Potassium H	Exchangeable Potassium A	Exchangeable Potassium B	Exchangeable Potassium C	Total Phosphorus H	Total Phosphorus A	Total Phosphorus B	Total Phosphorus C	C/N Ratio
GP									
	1·57	0·38	0·10	0·05	158	97	175	190	20·9

TABLE 53. Peaty Podzols

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
PP														
	A 1	67062	NX019672	82	SW	3	4	98	9	23	P	AH	3S	01H3T1
	CU 1	67142	NX499635	267	S	16	4	95	1	30	PPH/P	FE	5CS	02H1B3
	CU 1	67117	NX492638	229	S	13	4	90	10	13	PPH/P	FE	5CS	02H1B3
	SC 1	67037	NX239649	145	E	7	4	75	75	15	PPH/P	DO	3CS	02H2T1

Analytical Data

Stand	OM H	OM A	OM B	pH H	pH A	pH B	pH C	Base Saturation H	Base Saturation A	Base Saturation B	Base Saturation C	Exchangeable Calcium H	Exchangeable Calcium A	Exchangeable Calcium B	Exchangeable Calcium C	Exchangeable Magnesium H	Exchangeable Magnesium A	Exchangeable Magnesium B	Exchangeable Magnesium C
PP																			
67062	**	12	5	***	6·4	5·5	5·2	*****	70·3	21·4	20·4	*****	16·27	1·91	0·46	*****	0·56	0·05	0·01
67142	75	14	8	3·7	4·2	4·5	4·6	12·1	1·7	0·8	0·7	4·37	0·01	0·01	0·01	2·89	0·22	0·05	0·03
67117	54	12	3	3·9	4·2	4·6	4·8	10·0	1·8	1·4	1·1	3·34	0·01	0·01	0·01	2·93	0·22	0·01	0·01
67037	72	11	12	3·7	4·0	4·6	4·7	12·2	3·0	0·3	6·5	2·99	0·42	0·01	0·01	3·78	0·43	0·06	0·40

Exchangeable Potassium H	Exchangeable Potassium A	Exchangeable Potassium B	Exchangeable Potassium C	Total Phosphorus H	Total Phosphorus A	Total Phosphorus B	Total Phosphorus C	C/N Ratio
PP								
*****	0·03	0·03	0·01	****	272	200	117	13·9
0·33	0·15	0·02	0·01	125	85	138	90	26·0
1·15	0·14	0·03	0·01	142	63	47	80	15·9
1·03	0·66	0·01	0·02	110	50	116	122	18·2

TABLE 54. Coastal Saline Gleys

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
SG														
	GP 1	67084	NX447533	0	NIL	0	4	90	50	3	HP	SA	6WS	02H3T1
	GP 2	67087	NX446532	0	NIL	0	4	95	—	15/3	HP	SA	6WS	02H3T1
	GP 2	67114	NX439557	0	NIL	0	4	98	—	20/10	PH	SA	6WS	02H3T1
	GP 2	67132	NX444559	0	NIL	0	4	95	—	33/15	PH	SA	6WS	02H3T1
	GP 2	67113	NX438556	0	NIL	0	4	98	—	—	HP	SA	6WS	02H3T1

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	H	A	B	H	A	B	C	H	A	B	C	H	A	B	C	H	A	B	C
SG																			
67084	**	6	5	***	7·3	7·8	8·2	*****	100·0	100·0	100·0	*****	30·66	28·55	53·34	*****	8·61	9·62	8·47
67087	**	1	3	***	7·9	7·4	8·3	*****	100·0	100·0	100·0	*****	42·65	29·44	41·11	*****	1·78	2·30	3·20
67114	**	4	2	***	8·1	7·6	8·5	*****	100·0	100·0	100·0	*****	13·14	12·49	40·59	*****	3·95	3·77	3·07
67132	**	10	4	***	7·1	7·1	7·9	*****	100·0	100·0	100·0	*****	9·53	9·51	32·95	*****	8·93	10·03	1·98
67113	**	12	**	***	6·8	***	8·2	*****	90·4	*****	100·0	*****	10·68	*****	40·82	*****	12·83	*****	5·34

Exchangeable Potassium				Total Phosphorus				C/N Ratio
H	A	B	C	H	A	B	C	
SG								
*****	1·42	1·72	1·38	****	109	130	104	12·4
*****	0·59	0·41	0·68	****	63	72	81	16·7
*****	0·90	0·83	0·72	****	107	92	86	12·3
*****	1·33	1·20	0·51	****	141	138	80	15·8
*****	2·04	*****	1·26	****	171	****	74	13·1

TABLE 55. Non-Calcareous Gleys

							Site Characteristics								
Plant Com.	Stand	Grid Ref.	Alt. m	Aspect	Slope degrees	Plot m^2	% Cover T	F	G	Veg. Ht. T m	F cm	Drainage	Soil Series	LUC	Climate
BG															
M 1	67091	NX402677	67	SW	1	4	—	95	3	—	66	PH	LQ	3SW	02H2T1
M 1	67089	NX431525	9	NIL	0	4	—	95	40	—	46	PH	NS	3SW	02H3T1
M 1	67092	NX398679	67	SE	6	4	—	98	15	—	61	PH	LQ	4SW	02H2T1
M 1	67118	NX491636	213	NW	6	4	—	80	65	—	43	PH	GB	4CW	02H1B3
A 1	67086	NX445532	3	NIL	0	2	—	95	—	—	41/13	PH	AL	3SW	02H3T1
A 1	67111	NX468473	20	NIL	0	4	—	98	—	—	—	PH	SG	3SW	02H3T1
A 1	67061	NX017673	55	W	2	4	—	95	—	—	51/18	PH	AD	3SW	01H3T1
A 1	67044	NX003589	149	SE	6	4	—	95	40	—	46/15	PH	AD	4C	01H2B3
A 1	67060	NX016670	40	NIL	0	4	—	90	5	—	10	PH	BL	3W	01H3T1
A 1	67064	NX253590	91	W	5	4	—	95	5	—	8	PH	ER	3SW	02H2T1
AG															
M 1	67023	NX227586	79	S	2	4	—	90	75	—	30/15	PH	ER	3SW	02H2T1
M 1	67047	NX001564	91	N	6	4	45	85	50	12·2	122/15	PH	AD	3WC	01H2T1

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	H	A	B	H	A	B	C	H	A	B	C	H	A	B	C	H	A	B	C
BG																			
67091	**	22	**	***	5·7	5·9	6·4	*****	67·6	47·2	93·9	*****	15·01	1·51	1·96	*****	1·00	0·17	0·75
67089	**	18	**	***	5·7	6·2	6·4	*****	65·8	100·0	100·0	*****	10·32	7·20	5·62	*****	4·08	3·92	2·28
67092	**	17	5	***	5·1	5·7	5·9	*****	38·2	20·0	31·1	*****	7·16	2·10	2·17	*****	0·81	0·09	0·12
67118	**	17	**	***	5·5	5·9	6·5	*****	43·5	46·5	89·1	*****	7·91	2·29	2·27	*****	1·24	0·23	0·20
67086	**	4	**	***	6·0	7·5	8·6	*****	81·8	100·0	100·0	*****	13·31	8·53	46·80	*****	2·11	3·33	1·06
67111	**	6	**	***	5·9	7·1	7·4	*****	77·4	100·0	100·0	*****	14·89	10·76	12·30	*****	1·58	3·89	4·45
67061	**	6	**	***	6·1	5·5	5·7	*****	89·9	90·5	91·5	*****	12·98	4·89	3·37	*****	1·10	3·76	6·32
67044	**	17	5	***	6·6	5·7	5·3	*****	97·3	26·2	19·5	*****	27·73	3·51	0·76	*****	1·66	0·50	0·23
67060	**	8	**	***	5·4	6·1	6·6	*****	63·3	88·9	88·3	*****	9·73	5·62	3·64	*****	0·89	1·61	3·19
67064	**	7	1	***	6·1	5·4	6·4	*****	63·3	13·7	75·3	*****	11·39	0·75	4·28	*****	0·68	0·10	7·17
AG																			
67023	**	14	**	***	4·7	5·0	5·1	*****	20·6	17·7	48·9	*****	2·89	0·91	2·75	*****	0·75	0·09	1·95
67047	**	14	7	***	5·1	4·9	5·0	*****	7·7	3·5	8·6	*****	1·25	0·01	0·93	*****	0·79	0·26	0·27

Exchangeable Potassium				Total Phosphorus				C/N Ratio
H	A	B	C	H	A	B	C	
BG								
*****	0·46	0·04	0·04	****	170	147	80	11·8
*****	0·51	0·13	0·10	****	159	58	87	14·0
*****	0·30	0·04	0·02	****	252	263	202	12·4
*****	0·35	0·03	0·21	****	109	111	111	12·9
*****	0·79	0·15	0·04	****	97	73	75	11·7
*****	0·21	0·24	0·38	****	224	180	179	11·3
*****	0·22	0·17	0·19	****	169	32	47	11·4
*****	0·09	0·02	0·02	****	211	104	100	19·9
*****	0·17	0·04	0·07	****	263	69	36	12·6
*****	0·12	0·08	0·12	****	152	89	117	13·5
AG								
*****	0·28	0·07	0·12	****	225	64	110	10·5
*****	0·33	0·21	0·03	****	313	103	84	14·8

TABLE 56. Peaty Gleys

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
HG														
	T 3	67137	NX544585	145	E	7	1	60	50	23/15	HP	CE	4W	02H2B3
PG														
	M 1	67102	NX290607	82	NIL	0	4	90	3	84	PH-HP	AL	4W	02H2T1
	M 2	67033	NX101666	192	SE	4	4	80	30	84	HP	DY	4WS	02H2B3
	N 4	67043	NX002588	152	SE	5	4	80	50	10	PH	GT	4WC	01H2B3
	N 4	67031	NX129692	183	N	10	4	75	75	15	PH	DY	4WC	02H2B3
	CU 1	67141	NX476631	137	NW	8	4	95	55	18	HP	CE	5W	02H2B3
	CU 1	67057	NX979612	46	SE	3	4	90	40	10	PH	LW	4WS	02H2T1
	CU 1	67058	NX980610	34	SW	6	4	90	25	18	PH	LW	4WS	01H2T1

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	H	A	B	H	A	B	C	H	A	B	C	H	A	B	C	H	A	B	C
HG																			
67137	58	**	**	6·1	6·0	***	6·1	90·1	83·4	*****	61·2	38·17	13·72	*****	3·63	9·61	3·19	*****	1·25
PG																			
67102	38	23	**	4·8	4·9	5·0	***	24·5	17·2	22·9	*****	3·83	1·96	4·03	*****	1·64	0·86	1·41	*****
67033	66	10	**	4·7	5·9	6·0	6·1	18·3	52·9	57·5	80·6	9·28	8·06	6·42	2·88	3·40	3·23	3·29	1·66
67043	63	19	**	3·6	4·2	4·6	5·6	14·3	3·1	6·0	56·1	5·83	0·66	0·01	1·22	6·90	0·90	0·40	2·54
67031	69	19	18	3·5	4·1	4·9	***	10·7	2·2	2·0	*****	3·02	0·01	0·01	*****	3·12	0·63	0·47	*****
67141	35	6	**	4·4	5·0	4·9	***	7·3	1·2	1·0	*****	0·59	0·01	0·01	*****	0·28	0·03	0·01	*****
67057	69	11	**	3·6	4·0	4·4	5·2	18·7	2·4	2·9	41·6	8·34	0·56	0·02	1·68	9·26	0·27	0·02	2·45
67058	64	6	**	3·7	4·5	4·7	4·8	32·0	3·8	5·4	14·5	28·49	0·58	0·61	0·61	3·73	0·17	0·14	0·37

Exchangeable Potassium				Total Phosphorus				C/N Ratio
H	A	B	C	H	A	B	C	
HG								
0·58	0·05	*****	0·10	135	118	****	72	15·2
PG								
0·53	0·17	0·08	*****	327	187	194	****	12·8
0·17	0·03	0·03	0·04	165	55	48	60	15·7
1·17	0·29	0·07	0·08	161	95	79	****	19·2
0·74	0·07	0·01	*****	161	86	209	****	15·6
0·62	0·04	0·02	*****	120	70	51	****	15·9
1·73	0·13	0·06	0·14	147	56	99	65	31·5
1·00	0·10	0·11	0·19	121	53	90	69	36·6

TABLE 57. Oroarctic Soils

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
MP														
	LV 1	67108	NX502672	704	NW	2	4	50	95	5	P	MT	7C	02PA2
PMP														
	N 5	67105	NX702672	701	N	2	4	70	80	13	PPH	MT	7C	02PA2
MHP														
	LV 1	67107	NX504665	692	E	2	4	80	70	8	P	MT	7C	02PA2
	LV 1	67106	NX503671	701	SE	2	4	80	60	5	P	MT	7C	02PA2

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	H	A	B	H	A	B	C	H	A	B	C	H	A	B	C	H	A	B	C
MP																			
67108	39	18	12	4·1	4·3	4·6	***	9·1	7·8	0·6	*****	0·01	0·01	0·01	*****	0·89	0·26	0·06	*****
PMP																			
67105	81	9	14	3·7	4·2	4·5	***	22·9	1·2	0·6	*****	4·25	0·01	0·01	*****	1·92	0·11	0·07	*****
MHP																			
67107	56	16	19	4·5	4·1	4·5	***	8·2	3·4	1·0	*****	0·01	0·01	0·01	*****	1·29	0·28	0·13	*****
67106	46	7	29	4·6	4·3	4·8	***	22·6	17·9	30·8	*****	2·51	0·14	6·46	*****	1·75	0·21	0·01	*****

Exchangeable Potassium				Total Phosphorus				C/N
H	A	B	C	H	A	B	C	Ratio
MP								
0·93	0·34	0·06	*****	175	124	137	****	15·9
PMP								
0·88	0·04	0·01	*****	176	94	146	****	17·9
MHP								
1·37	0·24	0·11	*****	301	134	221	****	16·6
2·49	0·26	0·13	*****	155	89	237	****	17·0

TABLE 58. Peat

Site Characteristics

	Plant Com.	Stand	Grid Ref.	Alt. m.	Aspect	Slope degrees	Plot m^2	% Cover F	% Cover G	Veg. Ht. F cm.	Drainage	Soil Series	LUC	Climate
FPT														
	M 1	67093	NX398677	56	NIL	0	4	80	50	71	—	PT	5S	02H2T1
BPT														
	M 3	67030	NX106668	183	NW	5	4	55	90	71	—	PT	5SW	02H2B3
	ES 1	67024	NX225586	69	NIL	0	4	60	98	15	—	PT	6WS	02H2T1
	ES 1	67038	NX241648	137	NIL	0	4	75	75	23	—	PT	7WS	02H2T1
	ES 1	67065	NX252590	88	NIL	0	4	90	70	30/15	—	PT	6WS	02H2T1
	ES 1	67053	NX973628	64	NIL	0	4	70	90	18	—	PT	6WS	01H2T1
	ES 1	67124	NX300561	85	NIL	0	4	75	98	23	—	PT	6WS	02H2T1
RM														
	ES 1	67099	NX357658	53	NIL	0	4	50	95	20	—	PT	6WS	02H2T1
PT														
	ES 1	67138	NX506600	122	NIL	0	4	60	98	25	—	PT	6WS	02H2B3

TABLE 58—*continued*

Analytical Data

Stand	OM			pH				Base Saturation				Exchangeable Calcium				Exchangeable Magnesium			
	I	II	III	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
FPT																			
67093	71	70	**	5·4	5·5	***	***	63·5	26·4	*****	*****	26·66	7·75	*****	*****	2·61	0·64	*****	*****
BPT																			
67030	55	37	**	4·4	5·1	5·4	***	17·8	26·9	52·5	*****	6·55	5·63	27·37	*****	3·71	4·84	17·01	*****
67024	86	70	77	3·9	3·8	4·0	4·2	18·8	12·1	11·9	10·2	7·14	7·62	7·27	10·43	4·70	5·11	4·01	7·88
67038	78	79	**	4·5	5·2	***	***	24·0	55·3	*****	*****	5·80	31·60	*****	*****	3·61	4·98	*****	*****
67065	72	56	79	3·6	3·6	3·8	4·0	10·6	7·3	8·9	9·7	2·56	1·11	2·45	4·38	4·43	5·21	5·35	10·15
67053	82	59	62	3·7	3·7	4·0	***	36·9	30·0	30·4	*****	32·48	29·65	23·68	*****	9·47	9·81	10·59	*****
67124	81	77	88	4·1	4·0	4·2	***	14·0	10·8	15·3	*****	4·29	2·93	2·76	*****	5·27	4·84	9·98	*****
RM																			
67099	77	77	97	3·7	4·0	4·5	***	18·6	15·4	21·2	*****	4·14	2·43	2·16	*****	4·70	4·37	5·32	*****
PT																			
67138	72	68	76	4·1	4·4	4·6	4·6	13·3	17·3	24·5	35·0	5·34	7·57	14·06	25·17	2·46	5·71	9·73	21·06

Exchangeable Potassium				Total Phosphorus				C/N
I	II	II	IV	I	II	III	IV	Ratio
FPT								
0·27	0·02	*****	*****	211	192	****	****	18·2
BPT								
0·18	0·01	0·01	*****	204	72	176	****	12·5
0·60	0·04	0·01	0·01	81	26	22	45	29·2
1·06	0·26	*****	*****	99	50	****	****	15·2
0·55	0·22	0·07	0·12	60	40	18	23	27·5
0·15	0·01	0·01	*****	43	25	22	****	33·1
0·48	0·07	0·01	*****	43	21	14	****	31·5
RM								
0·22	0·01	0·02	*****	53	21	15	****	30·2
PT								
0·45	0·10	0·01	0·01	134	41	20	37	14·0

Index

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R

S

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