THE SOILS ROUND KELSO AND LAUDER

THE SOIL SURVEY OF SCOTLAND

The Macaulay Institute for Soil Research, Aberdeen

DEPARTMENT OF AGRICULTURE FOR SCOTLAND

MEMOIRS OF THE
SOIL SURVEY OF GREAT BRITAIN

SCOTLAND

THE SOILS OF THE COUNTRY ROUND KELSO AND LAUDER

(SHEETS 25 and 26)

BY

J. M. RAGG, B.Sc.

The Macaulay Institute for Soil Research

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PREFACE

THE SOILS of the country round Kelso and Berwick-upon-Tweed, were surveyed during the years 1953-1956. The senior surveyor was Mr. J. M. Ragg who was assisted by Mr. E. L. Birse and Mr. J. Smith.

Other members of the staff of the Macaulay Institute for Soil Research have contributed to this memoir; Dr. W. G. Jardine Chapter I, Mr. E. L. Birse Chapter VII, Dr. D. J. Swaine the section on trace elements, Dr. R. C. Mackenzie and Mr. W. A. Mitchell the sections on the mineralogy of the fine sand and clay fractions and Mr. S. E. Durno the sub-section on peat.

Dr. H. G. M. Hardie and staff of the Soil Analysis section of the Pedology Department did the routine analyses with the exception of exchangeable calcium, sodium, potassium and some analyses of exchangeable magnesium which were determined by Dr. R. L. Mitchell and staff of the Spectrochemistry Department. Miss A. M. B. Geddes and Mr. J. W. Muir read the manuscript and offered much helpful advice. Dr. A. M. Smith and Mr. K. Simpson of the East of Scotland College of Agriculture and Mr. R. W. Gloyne of the Meteorological Office have shown considerable interest in this work and thanks are due to them for valuable discussions on subjects relating to the survey. Farmers and landowners in the area have co-operated during the survey and have willingly given help whenever asked.

Copies of the field maps (1:25,000) are kept at the Macaulay Institute for Soil Research, where they may be inspected.

ROBERT GLENTWORTH
Head of the Soil Survey of Scotland

The Macaulay Institute for Soil Research,
Craigiebuckler,
Aberdeen.
December, 1958.

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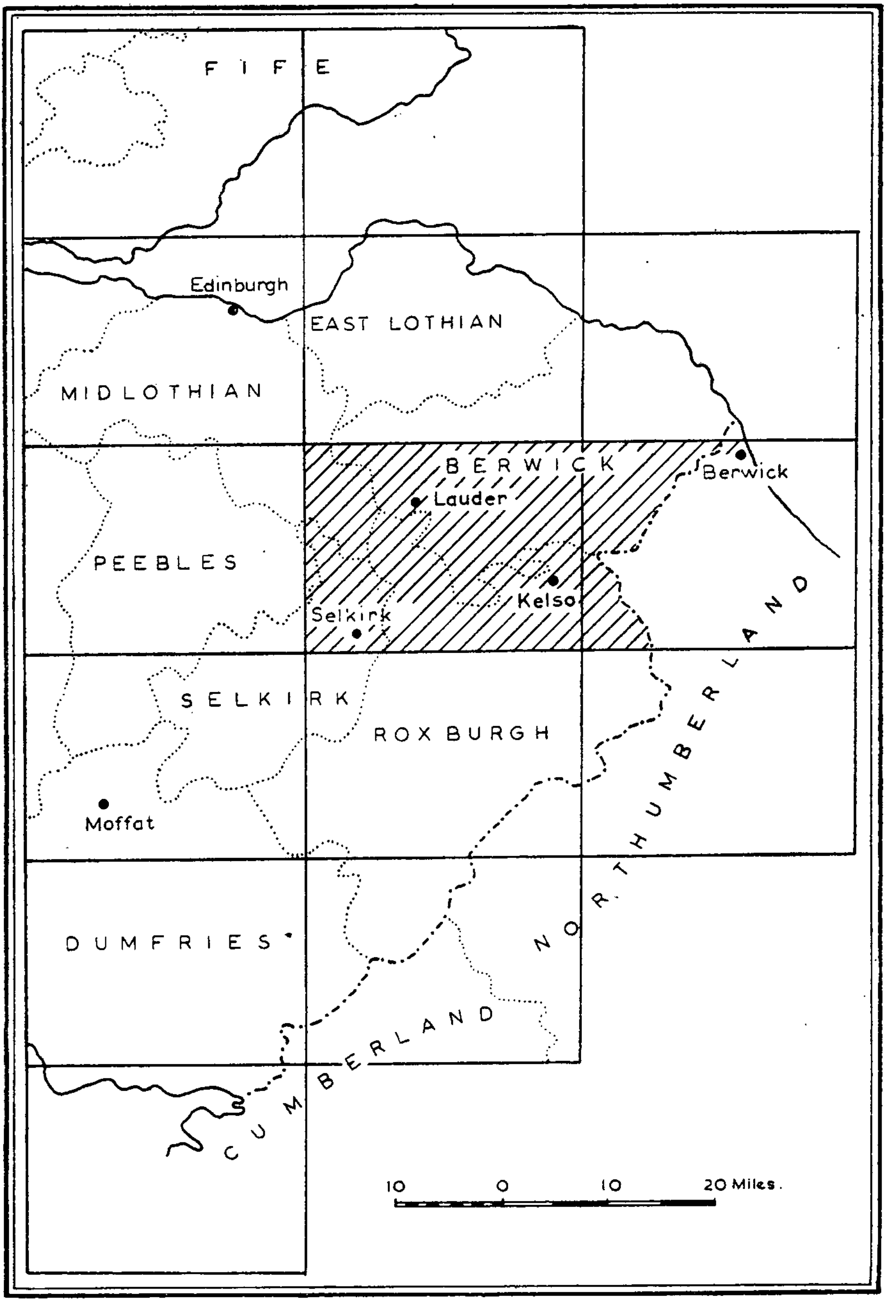


FIG. 1. Location of Area.

CHAPTER I

General Description of the Area

LOCATION AND EXTENT

THE area described in this Memoir lies south-east of Edinburgh. 540 square miles in extent (Sheet 25, 432 square miles; Sheet 26, 108 square miles), it includes northern Roxburghshire and the southern half of Berwickshire, together with much smaller portions of north-eastern Selkirkshire and south-eastern Midlothian, and a few square miles at the eastern extremity of Peeblesshire. The national boundary between Scotland and England is its eastern limit (Figs. 1 and 2).

Galashiels, Selkirk, and Kelso are three of the larger towns in the area, the first two being prominent centres of the woollen industry and Kelso a market town. St. Boswells, although only a small community, is an administrative centre and an important market town, especially during the autumn lamb sales, whilst Melrose situated near Abbotsford, the home of Sir Walter Scott, attracts a large number of tourists in the summer months.

PHYSICAL FEATURES

MAJOR STRUCTURAL DIVISIONS

The area lies near the north-eastern extremity of the hill mass of Ordovician and Silurian rocks to which, in 1865, Sir Archibald Geikie gave the name of the Southern Uplands. Traversing these Uplands in a north-south direction, the valleys of the rivers Nith and Clyde-Annan trisect them to form the Galloway Uplands, the Uplands of the Lowthers, and the Eastern Uplands which include the western and northern portions of Sheet 25. Each of these areas is distinctive, yet common to all is a stepped morphology broadly expressed by four groups of hill summits at elevations of approximately 2,000-2,800 feet, 1,600-2,000 feet, 1,000-1,600 feet, and 600-1,000 feet.

South-east of the area lies the high ground of the Cheviot (2,676 feet) and neighbouring hills which together with the Southern Uplands encloses the lower ground of the centre and east—the Border Lowlands of this account. A small portion of the Cheviot foothills projects into the south-east corner of the area. Thus, three major structural units may be recognised:

1. The Southern Uplands	—	underlain by tightly-folded, steeply-dipping Ordovician and Silurian sediments.
2. The Cheviots	—	underlain by granite and lavas of Old Red Sandstone age.
3. The Border Lowlands	—	underlain by Old Red Sandstone and Carboniferous sediments with occasional intrusive plugs and sills.

RIVER SYSTEM

The river system of the area is part of the much larger system which has the River Tweed as its trunk. The Tweed enters the area in the west, at

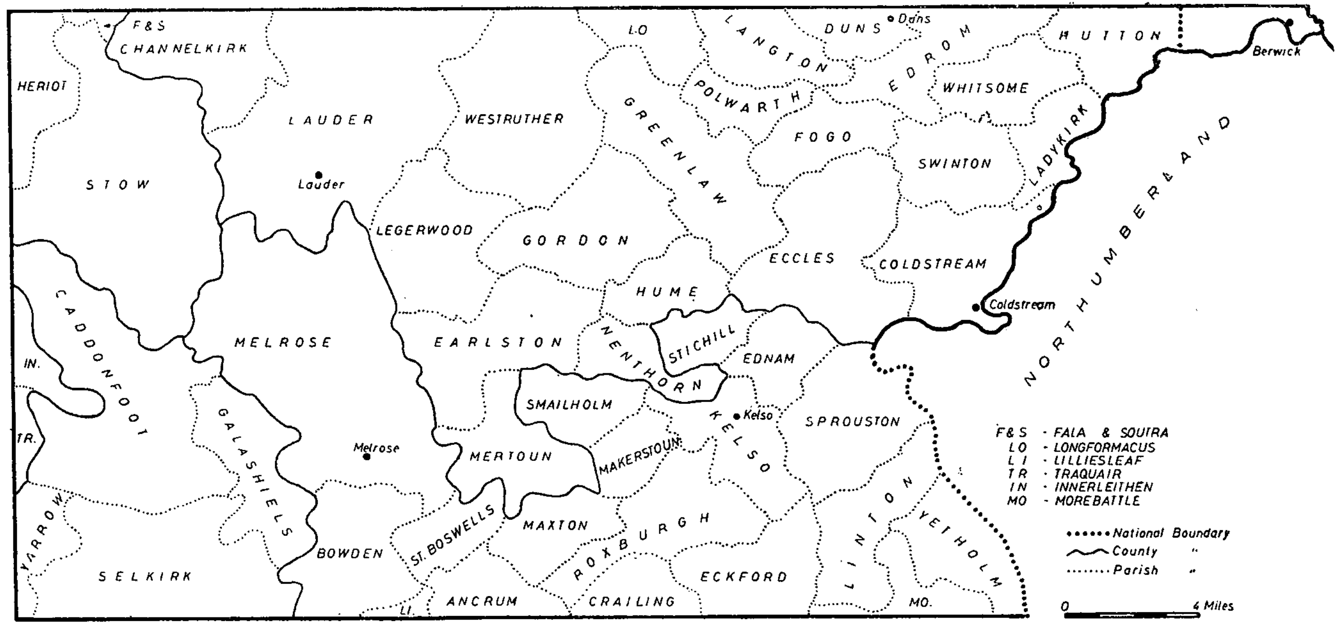


FIG. 2. Civil Parishes.

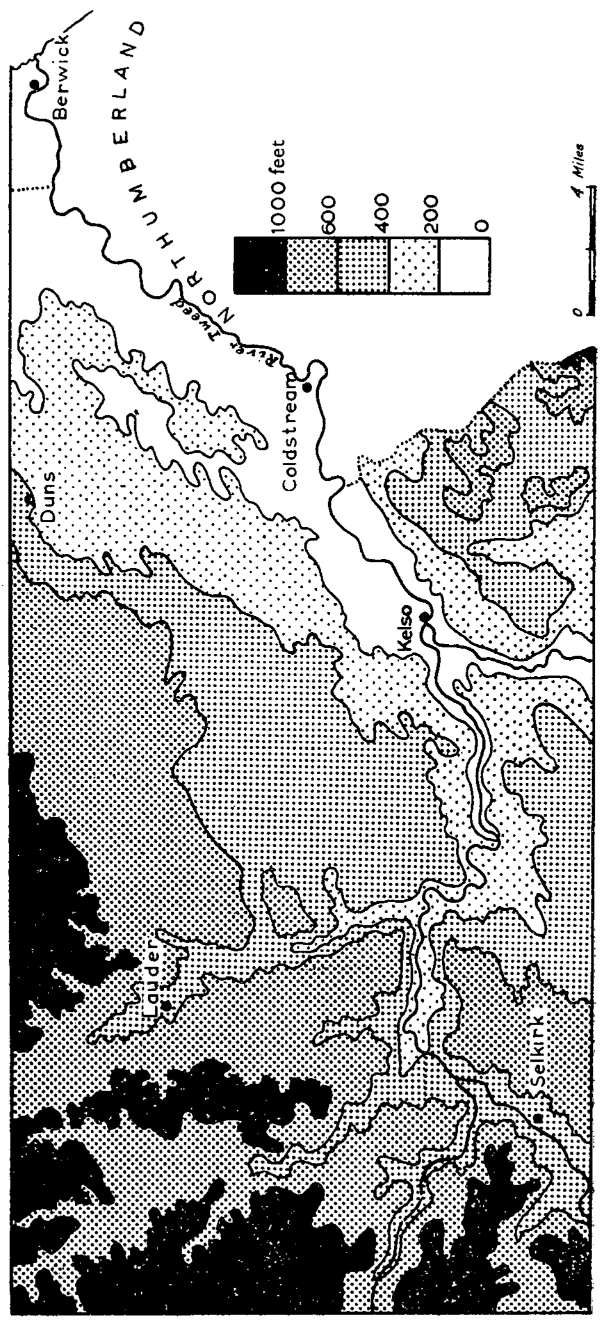


FIG. 3. Physical Map.

Walkerburn, and flows first in a general easterly direction and then north-easterly to the North Sea at Berwick upon Tweed (Fig. 3). The western portion of the Tweed and its affluents, the Ettrick and Gala Waters, are confined within steep valley walls of Silurian strata, though the valley floors themselves frequently are broad. In contrast, on emerging from the Silurian Southern Uplands to the softer and younger strata of the Border Lowlands, the eastern portion of the Tweed like its tributaries the Leader Water and the River Teviot, flows in a much wider valley. Nevertheless, in the immediate vicinity of the Tweed there is a fairly sharp change in slope where the rolling plain of the Border Lowlands drops, as much as 50-100 feet in places, to the flood plain of the river. For the most part the trough in which the river flows is only a few hundred yards wide, but in a few localities the floodplain opens out into wide stretches of alluvium. Agricultural communities have grown up around some of these alluvial expanses, as at Kelso and Coldstream.

In the Border Lowlands, the Blackadder, Eden, Leet and Kale Waters, and the numerous small rivulets of that area, appear to be post-glacial in origin although in several places they cut through solid rock as well as glacial deposits.

LAND FORM REGIONS

Three main structural divisions have been recognised already within the area. Each consists of several distinct land forms (Fig. 4). In the account below, descriptions of the separate land forms follow a discussion of the basis of their distinction within the major structural divisions.

The Southern Uplands

The western and northern portions of Sheet 25 are included in the Eastern Uplands, one of the three sections of the Southern Uplands. This area shows the characteristic stepped morphology; the highest level (2,000-2,800 feet) is not represented, but the 1,600-2,000 feet level is retained in the summit areas of the Moorfoot Hills and the third group (1,000-1,600 feet) in the Lammermuir Hills. The lowest group of hills (600-1,000 feet) of the Ordovician-Silurian Uplands are referred to as the Gala Uplands in this account and are represented in Sheet 25 by the high ground north of Galashiels. A more detailed description of these landforms follows.

Broad Law Group (2,000-2,800 feet)

This group is not represented in the area.

Moorfoot Group (1,600-2,000 feet)

The Moorfoot Group is represented by Deaf Heights (1,844 feet), near the western margin of Sheet 25, a long, peat-covered ridge at over 1,800 feet with steep drops of 300-400 feet to north and south.

Lammermuir Group (1,000-1,600 feet)

Five localities, with elevations between 1,000 and 1,600 feet, occur along the northern and western margins of Sheet 25.

North-east of Lauder, between Hog's Law (1,470 feet) and Twin Law (1,466 feet) a narrow tract of the summit uplands of the Lammermuir Hills projects into the territory of Sheet 25. The topography for the most part is gently rolling with occasional deep gullies where mountain streams descend rapidly to Lauderdale.

Elsewhere within the area the representatives of this hill group are not

PLATE 1

Broadly rolling countryside of Lower Tweeddale with intrusive plugs of Redpath and Brotherstone Hills in the middle distance.

PLATE 2

Lauderdale from a vantage point near Earlston.

[Facing p. 14]

PLATE 3

An aerial view due north from Coldstream Mains illustrating the elongate drumlins of Lower Tweeddale. Duns is in the top left hand corner of the photograph.

(*Air Ministry photograph*).

PLATE 4

Erratic boulders of dolerite and basalt from Peniel Heugh removed from the top soil of Hobkirk series on Upper Nisbet Moor.

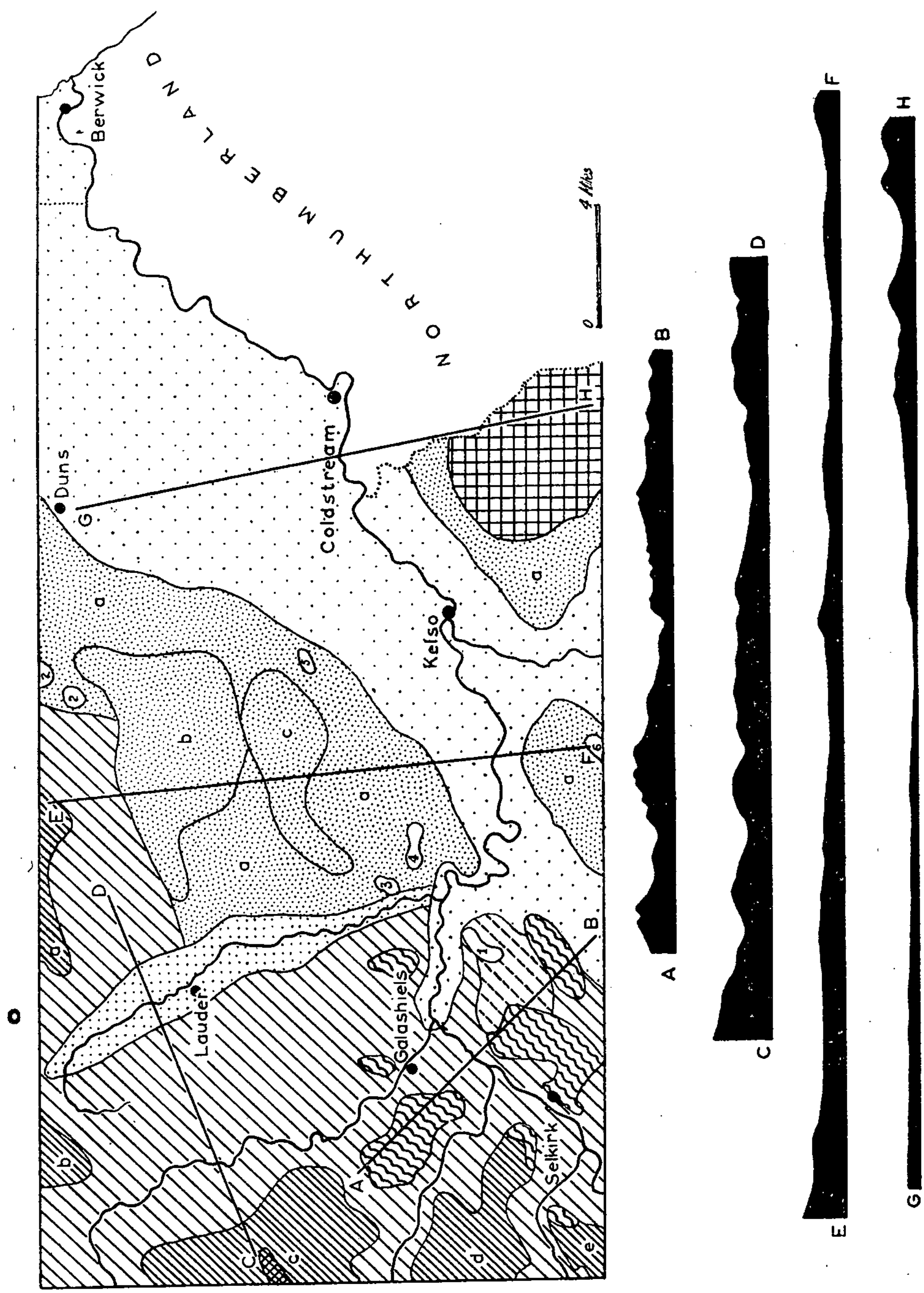
portions of major hill ranges but are the highest parts of the interfluves between the headwaters of the Leader and Gala Waters and between the lower reaches of the Yarrow and Ettrick Waters. Essentially they are parts of the Moorfoot and Ettrick Forest ranges and being located on the periphery of these hill masses they are much more dissected than their counterpart in the Lammermuirs. Characteristically they are smooth round-topped hills with sides which descend fairly rapidly to elevations of about 1,000 feet. From north to south, they centre on Hartside Hill (1,535 feet), Deaf Heights, Three Brethren (1,523 feet), and Fastheugh Hill (1,645 feet).

Gala Uplands (600-1,000 feet)

The most extensive portions of the Southern Uplands present in the area occur at elevations of about 600-1,000 feet. These Gala Uplands, as they are called here, occupy most of the western half of Sheet 25 and a small area north east of Lauder. Two small but important phases of the group are particularly noteworthy—the Corrugated Hills and Bowden Moor. Elements of the Corrugated Hills phase occur sporadically in the vicinity of Galashiels and Selkirk (Fig. 4). Like the rest of the Southern Upland hills they consist of tightly-folded, almost vertically disposed Lower Palaeozoic greywackes, conglomerates or shales, but in their case the effect of erosion on alternating hard greywacke and bands of softer rock has been to give a micro-relief of closely spaced ridges and hollows. The Lower Silurian (Llandoverian) rocks appear to have lent themselves particularly to this peculiar type of erosion for examples of corrugated relief are to be found wherever they outcrop from Wigtownshire in the west to Roxburghshire in the east. Corrugated relief, being an erosional effect, is not entirely confined to the Gala Uplands and instances occur both in ground above 1,000 feet and at elevations below 600 feet, but in this area it is a striking feature of this division of the Southern Uplands.

Bowden Moor skirts the eastern slopes of the Eildon Hills, south of Melrose, and extends west and south for more than a mile as an area of uncultivated country. It varies in elevation from about 700 feet at its northern and southern margins to about 900 feet along its central ridge which extends westwards from Eildon Mid Hill to Cauldshiels Hill (1,076 feet). The latter, rocky near the top, till-covered on its upper slopes, differs from the moor it overlooks in its somewhat freer drainage. The moor itself is a bleak upland shelf, water-logged for the most part, with occasional rocky ridges projecting above its general level.

Of the remainder of the Gala Uplands the two most extensive areas occur between the Gala and Leader Waters (Lauder Common), and immediately south of the summit area of the Lammermuir Hills. The latter area forms a dissected shelf descending to about 700 feet where a fairly distinct change of slope marks its junction with the flatter platform to the south around Westruther. The area centred on Lauder Common, and extending five or six miles to north and south, is a monotonous rolling upland in which flattish or gently curved hill-tops abound; the upper slopes are gentle, and the major streams run in deep steep-sided valleys several hundred feet below the hill summits. To the west and south west where smaller fragments of the Gala Uplands remain between the higher upland groups and the valley floors, relief is more pronounced and occasionally high bare rock faces are exposed on the eastern sides of the valleys. As a rule, the western sides of these hills



Berwick
NORTHUMBERLAND
Duns
Coldstream
Kelso
Lauder
Galashiels
Selkirk
0
4 Miles
A
B
C
D
E
F
G
H

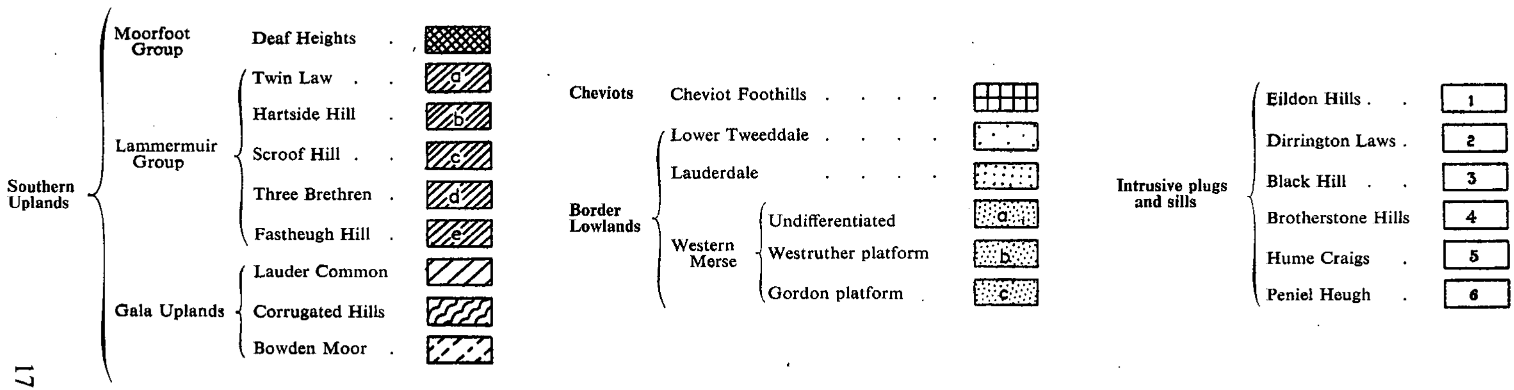


FIG. 4. Land Form Regions.

are covered in thick till and slope gently. The eastern slopes tend to have thinner coverings of till and are steeper.

The Cheviots

Just as the hills of the Southern Uplands are capable of division into groups on a height basis, so are those of the Cheviot hill mass. The area considered in this account, however, includes only the lower hills—the Cheviot Foothills. These centre on Town Yetholm and Kirk Yetholm and consist entirely of Old Red Sandstone lavas. The valley of the Bowmont Water, the deep abandoned valley to the west and north of Town Yetholm, and the valley of the Halter Burn cut deeply into these lavas. The result of this, in an area where the range of elevation is from about 500 feet at the junction of the Cheviot foothills and the Border Lowlands to more than 1100 feet (White Law, 1153 feet), is to give a terrain of high relief with numerous rounded hills separated by deep valleys.

The Border Lowlands

The territory occupying the eastern half of Sheet 25 and the whole of Sheet 26 is underlain by rocks which are Old Red Sandstone or Carboniferous in age, rocks which have not been subjected to the same induration or intense orogenic folding as the Ordovician and Silurian strata which form the Southern Uplands in the west and north. Consequently erosion has been more effective in the east and relief tends to be more subdued. Two fairly distinct areas can be distinguished. These flank the River Tweed and the Leader Water and are designated Lower Tweeddale and Lauderdale. The rest of the Border Lowlands forms a transition zone, the Western Merse, between the low ground of Lower Tweeddale and the higher areas of the Southern Uplands and the Cheviot Foothills around the margins of the Sheets.

Lower Tweeddale

The valley of the River Tweed from Galashiels eastwards as far as St. Boswells consists of a wide, gently undulating floor with steep sides. It is an embayment within the Silurian upland country, a westward extension of the broad rolling lowland plain which opens out on either side of the Tweed eastwards from St. Boswells to form a unique area which is partly in southern Berwickshire and north-eastern Roxburghshire, and partly across the national boundary in Northumberland (Fig. 4). Most of the countryside lies between sea-level and an elevation of about 350 feet in the form of a broad depression (Plate 1). The somewhat abrupt rise from the floodplain of the Tweed is more marked than the gradual rise from the centre of the depression to its margins.

Essentially Lower Tweeddale is a till plain, the low ground where the Pleistocene ice, moving eastwards off the Uplands altered the pre-existing physical features by rounding off obstructing projections and plastering rubble unevenly in its wake. In common with several other lowland areas of Scotland and Ireland where till plains are to be found, a large part of Lower Tweeddale, particularly in the neighbourhood of Kelso and Coldstream, is dominated by the type of elongate hillocks of till called drumlins. These drumlins are orientated approximately from west-south-west to east-north-east, their average length is about a mile, and they range in height up to forty or fifty feet above the surrounding countryside (Plate 3). Together with the less regular ridges and mounds of re-worked till and fluvio-glacial sands and gravels, they add variety to a topography which otherwise would be monotonously regular in its gentle undulations.

Lauderdale

Lauderdale is a much narrower valley than Lower Tweeddale. Southwards from Oxton, where the Leader Water is eroding its bed at about 700 feet, the valley opens out to a width of about one mile on both sides of the water-course. The floor is either flat or composed of low terraces in the vicinity of the river, becoming steeper as the junction with the higher ground of the Gala Uplands is approached (Plate 2). South east of Lauder, where the valley narrows and abuts part of the Western Merse around Legerwood, the eastern wall, here of Old Red Sandstone conglomerate, is as steep as it is farther north where it is of Silurian greywacke. In the last three miles below Earlston, Lauderdale narrows considerably, but there is still a distinct break in slope between the valley sides and the valley floor at about 400 feet.

The Western Merse

The ground occupied by the Western Merse occurs at intermediate elevations and possesses some of the characteristic features of both the Southern Uplands and the lowland country of Lower Tweeddale. The most extensive portion lies in the centre of the area; it is underlain by Old Red Sandstone or Carboniferous rocks, and shows a general rise from south to north though most of the higher ground occurs in the west in the parish of Legerwood where Old Red Sandstone conglomerates are the basement rocks. Two much smaller areas, around Peniel Heugh south west of Kelso and on the western and northern flanks of the Cheviot Foothills, are non-descript broadly-rolling areas, higher than the general level of Lower Tweeddale yet not integral parts of either the Cheviots or the Southern Uplands.

A special feature of the most extensive part of the Western Merse is the occurrence of two broad expanses of comparatively flat countryside which have been termed the Westruther platform and the Gordon platform. The first of these varies in elevation from about 600 feet to 700 feet covering an area of about ten square miles north east and south west of a line through Westruther and Greenlaw. For the most part it is a bleak moorland area, its rolling relief broken here and there by the spectacular sinuous ridge of fluvio-glacial sands and gravels known as The Kaims, and by deep water channels, the most pronounced of which is that of the Blackadder Water.

The Gordon platform occupies a much smaller area around the village of West Gordon. Its relief is rather more varied than that of the Westruther platform, the distinctive feature being a series of low ridges and mounds of sand and gravel interspersed with flatter stretches of peaty alluvium. The tops of the mounds, being at approximately the same height, add a platform effect to the overall pitted and pockmarked appearance of the landscape.

Intrusive plugs and sills

In a few places small but striking projections appear above the general level of the countryside. These are plugs or sills of intrusive rock which have proved more resistant to erosion than the surrounding strata. Bare rocky patches are common over much of the ground occupied by such outcrops.

Most important of these are:

The Eildon Hills (1,385 feet, 1,327 feet and 1,216 feet).
Dirrington Great Law (1,309 feet) and Dirrington Little Law (1,191 feet).
Earlston Black Hill (1,031 feet).
Redpath Hill (886 feet) and Brotherstone Hill (807 feet).
Hume Craig (737 feet).

CHAPTER II

Climate and Weather

WEATHER

THE weather in this North Border region is similar to that in most of eastern Scotland. The south westerly and westerly winds, which prevail over most of Britain, are also dominant in south east Scotland, but much of the low cloud and rain associated with this damp maritime tropical or maritime polar air falls upon the Southern Uplands before reaching the Borders. Some showery weather is associated with north west, north or north east winds which bring cold maritime polar air. In winter, northerly winds veering to the east often bring snow, especially to the Lammermuirs. Fine weather inland often occurs with easterly or south easterly air streams in the summer, but these continental winds pick up much moisture from the North Sea and become colder as they approach the Scottish coast. If the dew point of this air is higher than the sea surface temperature, and the wind is not too strong, sea fog, or haar, forms. This haar which hangs over the coast is frequently funnelled up the Lower Tweed valley sometimes as far as St. Boswells. Haar occurs from March to September but is worst in the early summer months. The growing season can be seriously shortened by continuous haar in the spring months, a time of year when there may be a partial drought. Heavy and continuous rain is associated with cyclonic conditions with a depression centred over central England or the North Sea. High north or north easterly winds, behind south moving fronts, blow into the area from the North Sea bringing snow in winter and rain at other times of the year. The Lower Tweed valley is shielded to some extent from this by the Lammermuirs to the north. Fine, settled weather occurs in conjunction with anticyclonic conditions and low winds; clear sky, high day temperature and high percentage possible sunshine typify this condition in summer, and in winter continuous cloud sheets and associated town fogs are likely to occur. In the Tweed, Ettrick and Teviot valleys mists form very readily in winter under these conditions, often accompanied by frost.

CLIMATE

Climate, or the average weather over a long period of years, is one of the most important soil forming factors in the area and its effects on the soil are considered in a later section.

Climate may be divided into seven elements: pressure, wind, sunshine, temperature, precipitation, humidity and cloud. Of these, precipitation and temperature are of particular importance with regard to soil forming processes. Sunshine and cloud are related variables and, together with wind, affect plant growth, indirectly by their control of the evaporation of moisture from the soil and directly by their influence on plant transpiration. Atmospheric pressure has an indirect bearing on soil conditions through the other elements as well as having a direct influence on the gaseous content of soil moisture.

Wind

There is unfortunately little data available on wind, as there are no wind recording stations in the area. The Climatological Atlas of the British Isles (Meteorological Office 1952) gives the average wind speed for the area at 33 feet above the ground as 12.5 m.p.h., but it is probably considerably higher than this in the Lammermuirs and Moorfoots. The average number of gales (mean wind speed 39 m.p.h.) is 10 per annum but is double this on the coast near Berwick.

Sunshine

TABLE A. NORMALS FOR SUNSHINE AT MARCHMONT HOUSE (498 feet)

Month	Length of day (hrs.)	Bright Sunshine (hrs.)	Percent of Possible
January	7·65	1·35	18
February	9·50	2·38	25
March	11·76	3·45	29
April	14·09	4·83	34
May	16·15	5·65	35
June	17·35	6·23	36
July	16·83	5·42	32
August	14·98	4·77	32
September	12·73	4·03	32
October	10·42	2·68	25
November	8·28	1·70	21
December	7·03	1·10	16
Year	12·25	3·64	30

The sunshine normals for the area, especially Lower Tweeddale, are high. In Table A, from the Book of Normals Section I (Meteorological Office 1919), the percentage possible (30%) and mean daily duration (3·64 hrs.) of sunshine for the year are similar to the normals for Ireland, the west coast of Scotland, north-east and central England. The duration of winter sunshine (October to March) is high for Scotland and helps to extend the growing season. The daily mean is in excess of 4 hours from late March until mid September, some 3-4 weeks shorter than for most of England.

Temperature

Normals for temperature for two stations in the area are given in Averages of Temperature for the British Isles (Meteorological Office 1935) and are quoted in Table B together with estimated values for the Gala Uplands and the Lammermuir Group. These have been estimated using known values from the nearest station and the lapse-rate of 1°F per 300 feet.

Though none of the temperature normals for this area are outstanding or extreme, several points of interest arise out of Table B. In all cases the July temperatures are the greatest and the January temperatures are the

TABLE B.—AVERAGE MONTHLY AND ANNUAL MEANS OF DAILY MAXIMUM, DAILY MINIMUM AND DAILY MEAN TEMPERATURE (°F) FOR PERIOD 1906-1935.

Month	Berwick-upon-Tweed* 76 ft.			Kelso 193 ft.			Marchmont 498 ft.			Gala Uplands 800 ft. (Estimated)			Lammermuir Group 1400 ft. (Estimated)		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Jan.	44·3	34·9	39·6	43·1	32·5	37·8	42·3	32·3	37·3	42·1	30·5	35·8	39·3	29·3	34·3
Feb.	44·0	34·6	39·3	44·2	32·3	38·3	43·1	32·0	37·5	42·2	30·3	36·3	40·1	29·0	34·5
Mar.	46·7	35·9	41·3	47·6	33·4	40·5	45·9	33·1	39·5	45·6	31·4	38·5	42·9	30·1	36·5
April	49·2	38·3	43·7	52·3	36·1	44·2	50·3	35·6	42·9	50·3	34·1	42·2	47·3	32·6	39·9
May	53·0	42·6	47·8	58·6	41·5	50·1	56·4	40·8	48·6	56·6	39·5	48·1	53·4	37·8	45·6
June	59·8	47·5	53·7	64·0	45·9	54·9	62·0	45·5	53·7	62·0	43·9	52·9	59·0	42·5	50·7
July	64·4	52·1	58·3	66·6	49·9	58·3	64·9	49·3	57·1	64·6	47·9	56·3	61·9	46·3	54·1
Aug.	63·6	51·4	57·5	65·7	49·3	57·5	64·1	48·9	56·5	63·7	47·3	55·5	61·1	45·9	53·4
Sept.	59·5	47·6	53·5	61·4	45·0	53·2	60·0	45·0	52·5	59·4	43·0	51·2	57·0	42·0	49·5
Oct.	53·5	42·2	47·9	54·4	40·4	47·4	53·1	40·5	46·8	52·4	38·4	45·4	50·1	37·5	43·8
Nov.	47·7	37·9	42·8	46·9	34·7	40·8	46·0	35·1	40·5	44·9	32·7	38·8	43·0	32·1	37·5
Dec.	44·7	36·4	40·5	43·6	33·2	38·4	42·6	33·1	37·9	41·6	33·2	36·4	39·6	30·1	34·8
Year	52·5	41·8	47·1	54·0	39·2	46·7	52·6	39·3	45·9	52·0	37·2	44·7	49·6	36·3	42·9

*1924-1935

lowest, except at Berwick where the lowest temperatures are in February. In spite of being on the coast, Berwick has a July mean only equal to that of Kelso and spring temperatures below those of Kelso. This is a reflection of the haar mentioned above and cool coastal breezes, which cause a lower day maximum at Berwick. Compared with Scotland as a whole, and eliminating altitudinal effects, the mean temperatures for Kelso and Berwick are on a par with those of the Midland Valley but lower than for the west coast. Maximum temperatures, except at Berwick, are high and minimum temperatures relatively low making the average mean of daily range high for Scotland; it is exceeded only in the central Southern Uplands and the Cairngorms. The data of first and last screen frosts are little affected by altitude, the lower average temperature in the Southern Uplands being offset in the Border Lowlands by the greater fall in temperature in the valleys at night. In the western part of the area the first screen frost occurs about September 15th and the last about June 1st but in Lower Tweeddale the first is October 15th and last May 1st. The average number of days with frost is 50 for Lower Tweeddale but it is more than double that for west of Kelso and Lauderdale.

TABLE C. LENGTH OF GROWING SEASON

Place	Altitude	Growing Season
Berwick-upon-Tweed	76 ft.	238 days
Kelso	193 ft.	219 days
Marchmont	498 ft.	208 days
Gala Uplands	800 ft.	195 days
Lammermuir Group	1400 ft.	175 days

The length of "growing season", which is conventionally defined as the number of days per year when the daily mean temperature exceeds 42°F, shows considerable variation. This is shown in Table C. When these figures are compared with a map of land utilization it can be seen that the main arable farming is conducted in an area with a growing season longer than 210 days per annum. Mixed arable and stock farming requires 190-210 days of growing season and marginal farming is practised within the range of 185-200 growing days. Oats ripen only with difficulty above 1000 feet, which is equivalent in this area to about 180 growing days. Hill farming with little or no arable land is confined to the districts with less than 185 growing days.

Rainfall

Precipitation embraces two associated elements of climate, rainfall and snowfall, but for statistical purposes they are usually considered together under the comprehensive heading of rainfall. Rainfall is the climatic element for which there is the greatest detail in the area, and Table D is extracted from The Book of Normals Section V (Meteorological Office 1924) and Fig. 5 from Rainfall Average Annual 1881-1915, Sheet 1 (Ordnance Survey 1949).

The most outstanding feature of the rainfall in the area is the low annual value for Lower Tweeddale of about 25 inches; this is comparable with much of south-eastern England. It rises sharply, as is indicated by the

TABLE D.—AVERAGE MONTHLY AND ANNUAL RAINFALL FOR THE PERIOD 1881-1915

(Inches)

Month	Coldstream 94 ft.	Kelso 193 ft.	Hutton (West Foulden) 240 ft.	St. Boswells 260 ft.	Galashiels 416 ft.	Marchmont 498 ft.	Selkirk (The Hangingshaw) 670 ft.
Jan.	1·81	1·75	1·76	1·96	2·62	2·25	2·76
Feb.	1·58	1·70	1·55	1·89	2·49	2·08	2·78
Mar.	2·14	1·95	2·05	2·17	2·75	2·65	3·16
April	1·44	1·57	1·62	1·64	1·86	2·02	2·21
May	1·90	1·93	1·98	2·03	2·13	2·47	2·47
June	1·92	2·11	1·93	2·36	2·26	2·31	2·31
July	2·50	2·63	2·55	2·72	2·83	3·05	3·00
Aug.	2·62	2·95	2·72	3·14	3·11	3·31	3·39
Sept.	1·90	1·90	1·93	2·02	2·05	2·41	2·26
Oct.	3·06	2·91	3·06	2·84	3·26	3·82	3·59
Nov.	2·48	2·31	2·31	2·57	3·09	3·00	3·31
Dec.	2·28	2·32	2·00	2·68	3·30	2·81	3·55
Year	25·63	26·03	25·46	28·02	31·75	32·18	34·79

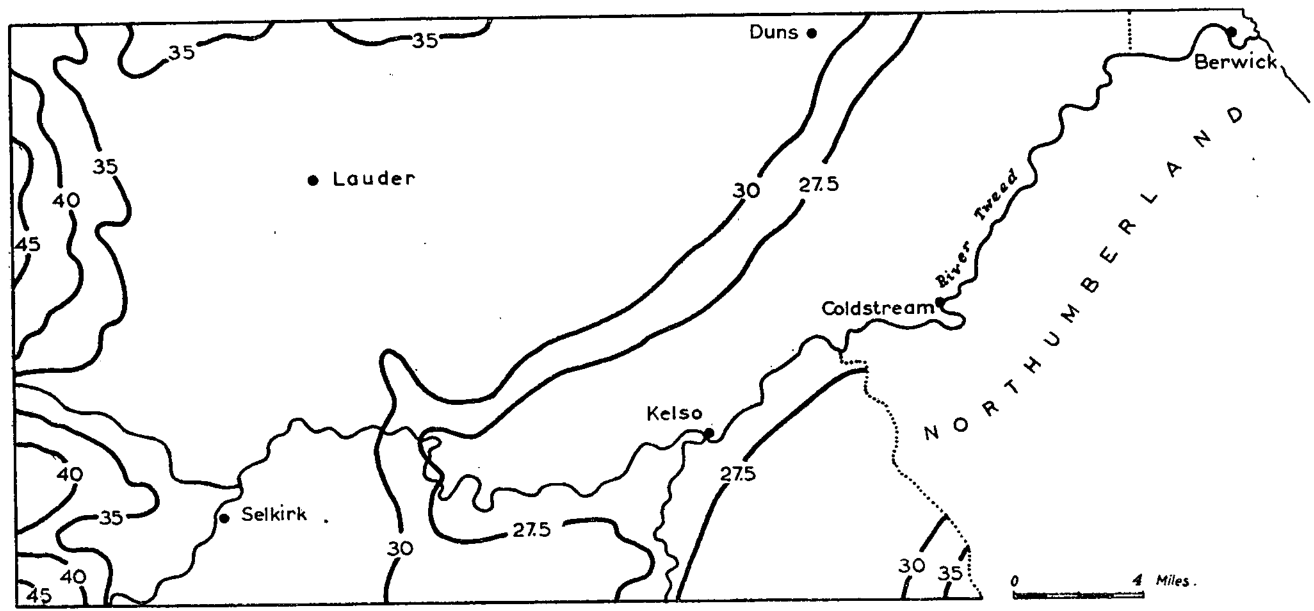


FIG. 5. Annual Average Rainfall in Inches (1881-1915).

closeness of the 25 and 27·5 inch isohyets in Fig. 5, on moving into the Western Merse which, together with Lauderdale and the Gala Uplands, receives 30-35 inches in the year. The Lammermuir Group of hills receive 35-40 inches of rain in the year and the Moorfoot Group about 40-45 inches. The larger part of the area, however, receives 32-33 inches. That the fall is so moderate is mainly due to the shelter provided from the prevailing westerlies by the Southern Uplands. The rainfall is fairly uniformly distributed throughout the year. The driest months are February, April, May, June and September, and the wettest months August and October. The contrariness of rainfall is illustrated by the fact that the minimum rainfall usually occurs during April when rain is needed for the germination and young growth of cereals and the maximum occurs in August when dry weather is required for commencement of harvest.

Snowfall is often heavy in the Borders with snow lying for 20-30 days in the year everywhere except in the region near Berwick. Snowfall usually commences in mid November with one or two days of falling snow, rises to a maximum of five to six days in January and ends in April with one or two days. In the Borders snow is usually accompanied by winds between north and south east, the heaviest falls being associated with east or east north east winds to which the area is most exposed.

Humidity

No records for humidity are available for the district but Table E gives the estimated average monthly and annual means of relative humidity for five stations. These values have been interpolated from The Climatological Atlas of the British Isles (Meteorological Office 1952) and corrected for temperature and altitude by the method quoted in that publication. The values are given to the nearest 2·5 per cent. A study of these values reveals an overall high relative humidity near the coast and lower values inland. This trend is shown throughout the year but is most noticeable during the summer months. Distance from the coast can be closely correlated with both annual and monthly distribution of relative humidity. In January and December this variation is small as there is little differentiation across the whole country, but it is at a maximum in the summer months. Both the lowest and the highest values of relative humidity are exhibited in the Lammermuir Group, the former in November and the latter in June. The distribution is similar, but not as marked at the other stations. No published data are available for the diurnal variation of humidity in the area, but values for Eskdalemuir from Averages of Humidity for the British Isles (Meteorological Office 1938) show this to be very small in the months of November, December, January and February and highest in the summer months. Early morning values (06 hrs.) are at their highest in July, August and September and early afternoon values (13 hrs.-15 hrs.) are lowest.

Evaporation

Evaporation has been found to depend closely upon several climatic elements (Penman, 1949), namely temperature, humidity, sunshine and wind, all of which have been dealt with above. As will be seen in Chapter V, evaporation is a very useful climatic index which can be used to good advantage in the study of soil processes.

TABLE E.—AVERAGE MONTHLY AND ANNUAL MEANS OF RELATIVE HUMIDITY AT 13 h. (PER CENT.)

(Estimated for the period 1901-1930)

Month	Berwick-upon-Tweed 76 ft.	Kelso 193 ft.	Marchmont 498 ft.	Gala Uplands 800 ft. (Estimated)	Lammermuir Group 1400 ft. (Estimated)
Jan.	82·5	82·5	85·0	85·0	87·5
Feb.	82·5	80·0	82·5	82·5	82·5
Mar.	75·0	75·0	77·5	75·0	75·0
April	75·0	70·0	72·5	70·0	72·5
May	80·0	75·0	77·5	75·0	70·0
June	75·0	70·0	72·5	67·5	67·5
July	75·0	70·0	72·5	70·0	72·5
Aug.	75·0	70·0	72·5	72·5	75·0
Sept.	75·0	70·0	72·5	72·5	75·0
Oct.	75·0	75·0	77·5	77·5	80·0
Nov.	80·0	82·5	85·0	85·0	90·0
Dec.	82·5	82·5	85·0	85·0	87·5
Year	80·0	75·0	77·5	77·5	77·5

TABLE F.—ESTIMATED MONTHLY EVAPO-TRANSPIRATION (E_t), AND WATER SURPLUS ($P-E_t$)

(Inches)

Month	West Foulden Nr. Hutton, Berwickshire 240 ft.			Talla Reservoir, Peebles-shire 1000 ft.		
	Evapo-transpiration E_t	Precipitation P	Water Surplus $P-E_t$	Evapo-transpiration E_t	Precipitation P	Water Surplus $P-E_t$
Jan.	0·15	1·76	+1·61	0·02	4·30	+4·28
Feb.	0·55	1·55	+1·00	0·03	3·95	+3·92
Mar.	1·10	2·05	+0·95	0·29	4·15	+3·86
April	1·75	1·62	−0·13	0·82	3·00	+2·18
May	2·60	1·98	−0·62	1·81	3·25	+1·44
June	3·25	1·93	−1·32	2·01	3·35	+1·34
July	2·95	2·55	−0·40	1·78	4·15	+2·37
Aug.	2·50	2·72	+0·22	1·44	5·10	+3·66
Sept.	1·55	1·93	+0·38	0·66	3·60	+2·94
Oct.	1·10	3·06	+1·96	0·25	4·95	+4·70
Nov.	0·55	2·31	+1·76	0·04	4·75	+4·71
Dec.	0·25	2·00	+1·75	0·06	5·45	+5·39
Year	18·30	25·46	+7·16	9·21	50·00	+40·79

The major parameter upon which evaporation is dependent is the amount of total radiation received by unit area, a value with a close statistical relationship to the percentage of bright sunshine, provided averages over several weeks are considered. The effect of a rise in temperature is also important for it increases the vapour pressure of water and hence the rate of evaporation. A reasonably close relationship has been found by the author between temperature and evaporation for 24 British stations. A fall of 1°F of the annual mean temperature is roughly equivalent to a fall in potential annual evapo-transpiration of 1·4 inches. Penman found that evapo-transpiration (E_t) from different crops and grass bore a constant relationship to evaporation from an open water surface (E_o). For the entire year this was 75 per cent, for the months of May to August 80 per cent, for September, October, March and April 70 per cent and for November to February 60 per cent. Values for E_t are of greater application to soil processes than E_o and are quoted in Table F above. The E_t values for Berwickshire have been calculated by the Meteorological Office by a modified Penman method and the values for Talla have been calculated from the averages for E_o measured by the Edinburgh Corporation Water Department for the period 1930-1954 with an evaporation gauge. Also in the table are the monthly rainfall averages (P) and the monthly water surplus (P-E_t). The significance of these values is discussed in Chapter V.

PLATE 5
An asymmetric valley of a minor tributary of the Yarrow Water with gentle slopes on the western (left hand) side.

PLATE 6
Moundy relief of fluvio-glacial deposits (Yarrow series) near Melrose.

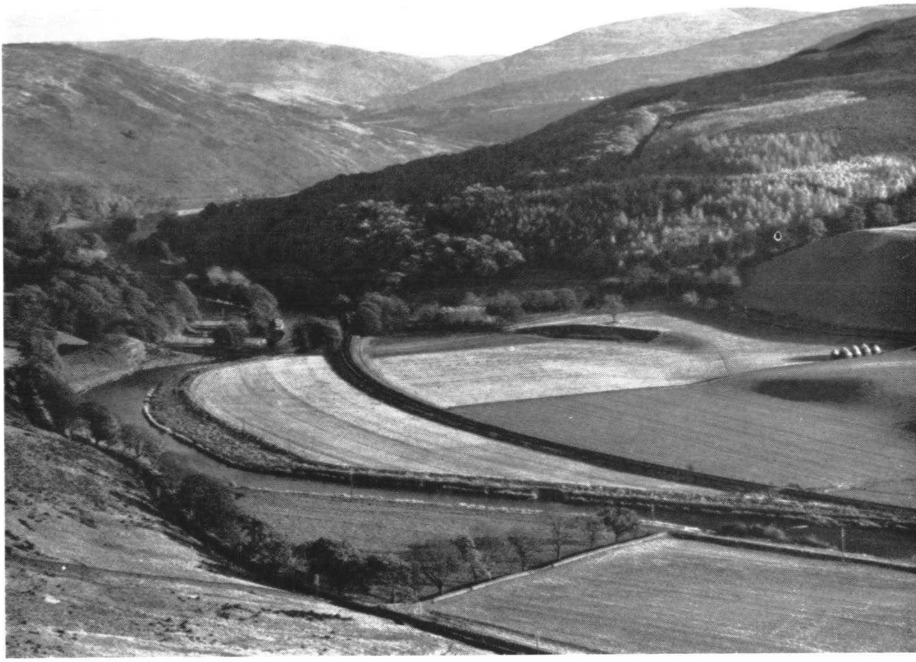


PLATE 7
Alluvium and fluvio-glacial terraces in the Tweed Valley near Walkerburn.
(By courtesy of 'The Scotsman').

PLATE 8
Alluvial haughs of the Upper Gala Water with the freely drained Linhope series on the steep slopes above.

CHAPTER III

Geology and Parent Materials

ALL the consolidated rocks in the area belong to the Palaeozoic era representing an interval of time extending from 200 to 500 million years ago. These rocks are divided into various geologic systems which range from the Ordovician, when marine life was very primitive and terrestrial life was unknown, to the Carboniferous, when plant life was showing its first major developments. A table (based largely on Scottish Geological 1 inch sheets 16, 17, 24, 25, 26, and 33) of the geologic systems and their various subdivisions found in the area is given below and their distribution is shown in Fig. 6.

Recent	Peat; alluvium
Pleistocene	Solifluction deposits; fluvio-glacial sands and gravels; till
	Unconformity
	Lower Middle Limestone groups
Lower Carboniferous	Cementstone Group
	Kelso Lavas
Upper Old Red Sandstone	Sandstones and Marls (and Lavas locally)
	Lauderdale Conglomerates
	Unconformity
Lower Old Red Sandstone	Cheviot Lavas
	Unconformity
	Hawick Rocks
Silurian	Buckholm or Queensberry Grits, Grierston Shales and Abbotsford Flags
	Birkhill Shales
	Lowther Shales
Ordovician	Hartfell Shales
	Glenkiln Shales
	Radiolarian Cherts

Intrusive igneous rocks occur in the Kelso Lavas, in the Upper Old Red Sandstone and in older sediments; many are of Lower Carboniferous age.

Before the eruption of the Cheviot Lavas in Lower Old Red Sandstone times, the marine sediments of the Ordovician and Silurian systems had been affected by intense lateral pressure—the Caledonian orogeny—and subsequently to long continued erosion. The Caledonian orogeny produced steep, highly compressed folds, the fold axes having a general south west to north east strike which, together with the steepness of the dip of the strata, is one of the salient structural features of the Ordovician and Silurian rocks of the western half of Sheet 25.

Less intense folding, followed by renewed erosion, affected the area (including the Cheviot Lavas) before the deposition of the Upper Old Red Sandstone sediments which were dominantly fluviatile in origin. During the period of erosion large valleys were carved out of the Ordovician and Silurian rocks in Lauderdale and from Dunbar to Jedburgh and thence towards the Solway Firth. In these valleys fluviatile and some wind blown

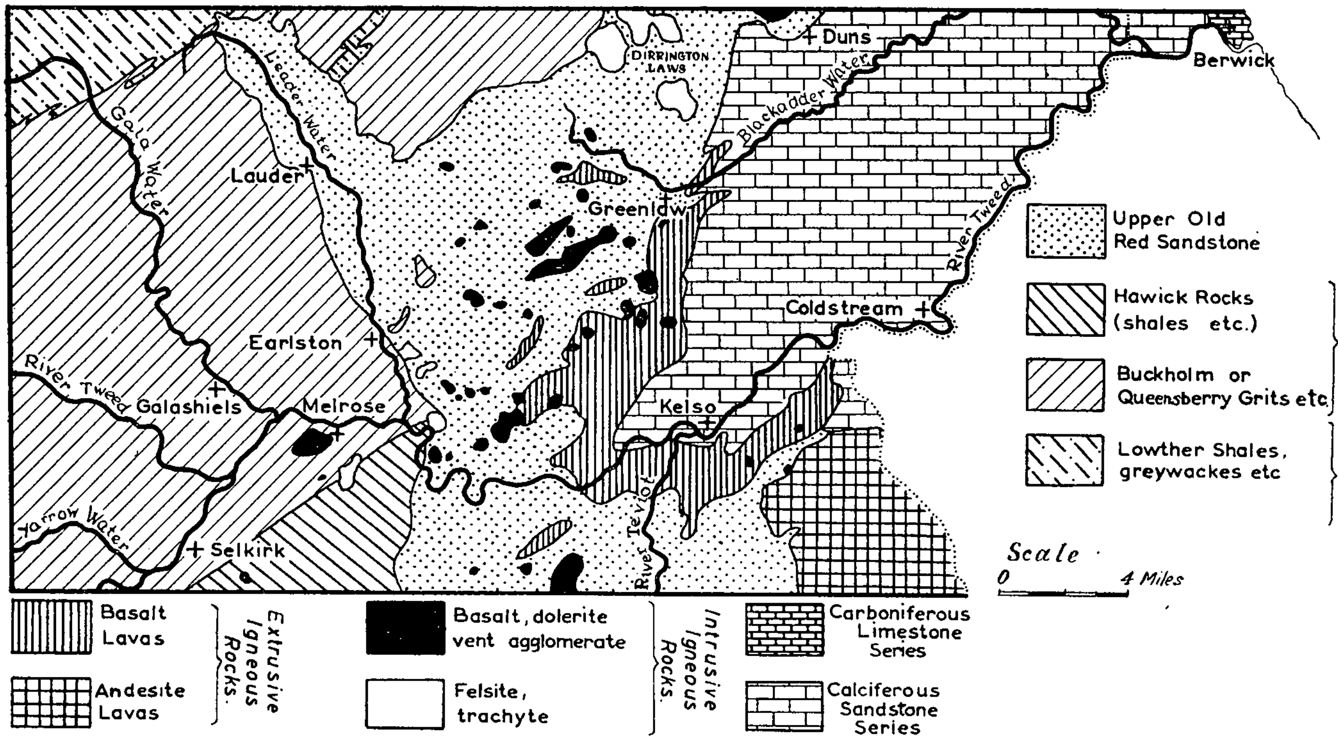


FIG. 6. Solid Geology.
(Based on MacGregor and Eckford (1948) by permission of the Edinburgh Geological Society).

arenaceous deposits were laid down. Gradual submergences followed and sediments of the Carboniferous system were laid down under lagoonal conditions. Subsequent folding associated with the Hercynian orogeny was small and produced, for example, the synclinal structure of the outcrops in the Kelso area (Fig. 6). The angles of dip of post-Silurian sediments are comparatively gentle.

Since Carboniferous times the South of Scotland has probably remained above sea level. The form of the land during this long period of some 200 million years is subject to conjecture, but for most of the time probably little denudation was taking place. The climate, according to Brooks (1948) and others, remained warm and dry for most of this period but during Tertiary times it was warm by present day standards with heavy rains and consequent erosion. Earth movements of the Alpine orogeny occurred causing a series of uplifts of the land surface. The pre-Tertiary land surface then suffered rapid erosion and dissection, peneplains being formed during the halts between the upward movements. Traces of these have been noted by the author at 2,700, 2,400, 2,000, 1,800, 1,600, 1,400, and 1,000 feet. By Pliocene times a drainage system similar to that of today was established over the South of Scotland. Gradual deterioration of the climate before and during Pliocene times heralded the "ice age" to follow.

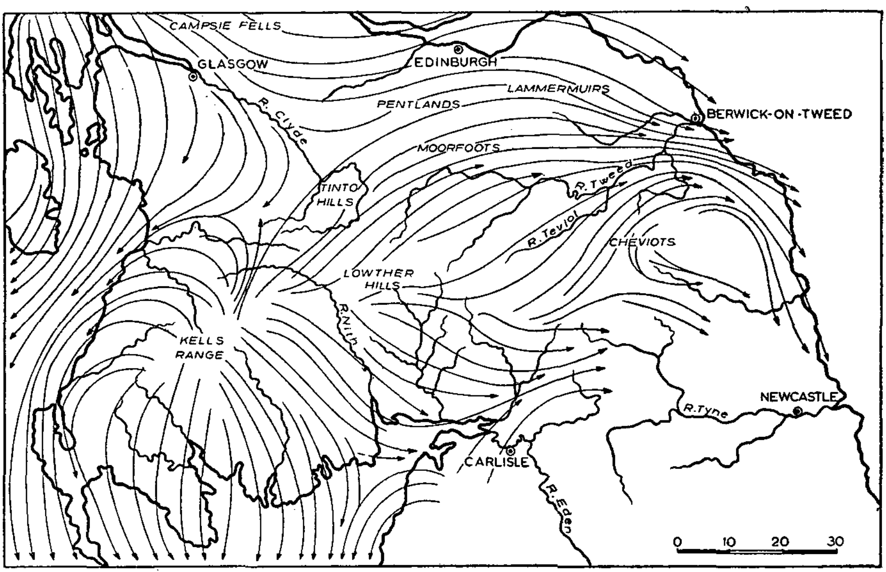


FIG. 7. Generalised Direction of Ice Movement in the South of Scotland.

(Based on Fig. 14 from British Regional Geology: The South of Scotland, 1948, by permission of the Director of the Geological Survey and Museum).

At the period of maximum glaciation during Pleistocene times the Southern Uplands were covered by an ice sheet that completely buried the highest hills. The ice moved outwards from the high ground where it was renewed by precipitation. The areas of accumulation and the general directions of ice movement in Southern Scotland are shown in Fig. 7. These general trends have been plotted by identifying the sources of the boulders, stones and

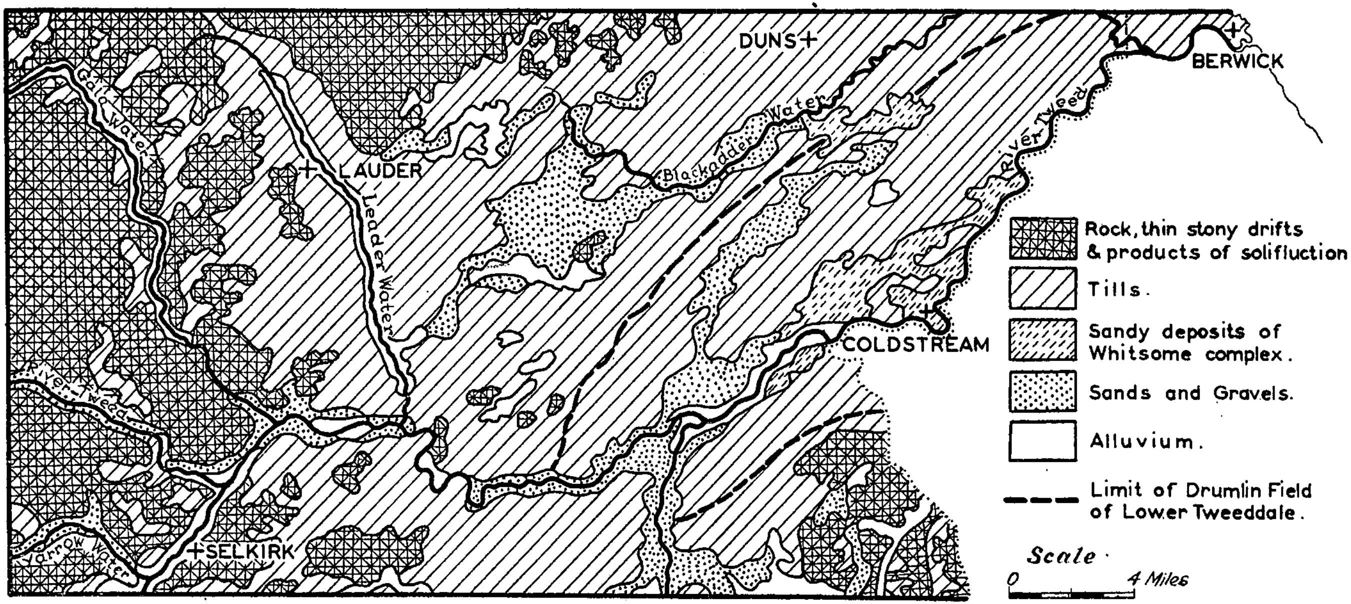


FIG. 8. Distribution of Drifts.

finely comminuted rock materials forming the till (ground-moraine or boulder clay) and by noting the alignment of "crag and tail", drumlin and rock ridge moulded by the moving ice, and the direction of glacial striae that are not located within deep upland valleys.

In areas of relatively high relief formed by the Ordovician and Silurian rocks and Cheviot lavas little till, or shallow stony drift, was deposited. On the higher ground the main action of the ice sheet was erosive, moulding the hills and rock ridges after the removal of any rock debris or soil that had accumulated in Tertiary times.

As has already been mentioned, the till in the western part of Sheet 25 is mostly confined to valleys. In those with a north and south trend, such as the valley of the Gala Water and Lauderdale, the fact that the deposit is usually thicker on the western side has been attributed to the general west to east ice flow (Pringle 1948, p. 80). This feature is illustrated in Plate 5. The main deposit of till is in the Border Lowlands (Fig. 8) where it forms a "till plain". In Lower Tweeddale long whaleback ridges of till arranged *en echelon* (drumlins) are developed most strikingly; the approximate limits of this main drumlin field are indicated in Fig. 8. "Crag and tail" features are widely developed in connection with the hard intrusive igneous masses that pierce the relatively soft rocks of the Upper Old Red Sandstone and Carboniferous areas.

During the slow amelioration of the climate at the end of the glacial period the ice first disappeared from the higher ground where its thickness had been at a minimum, remaining much longer on the relatively lower ground and in upland valleys. Ice of local upland valley glaciers probably outlasted the relict lowland ice. As the ice-sheet waned, torrents of melt water, often impounded by temporary ice-barriers at various levels, deposited fluvio-glacial sands and gravels in the form of flat-topped lake deposits, fans, moundy spreads (kames) and sinuous ridges (eskers).

Clays and silts that now occupy the sites of former small lakes on relatively low ground were probably deposited during the last stages of ice-decay. Tileworks using such lake clays were once operated 2 miles east of Gordon, 2 miles south west of Smailholm and one mile south of Selkirk. Finally, after the disappearance of all the ice, when the modern drainage system was being established, the rivers cut their way down through the glacial debris, often into rock, and in the major valleys formed alluvial terraces at successively lower levels.

Parent Materials

There are two main types of parent material in the area. One is the fine textured till (boulder clay) of the Border Lowlands and upland valleys and the other either a stony drift or a deposit formed by the action of frost and gravity (solifluction) on rock or on the thin mantle of debris left on the hills by the ice. The textural range of these two deposits is illustrated in Fig. 9. The tills are clay loams and clays, and the stony drifts loamy sands, sandy loams, and loams. Other parent materials, of less widespread occurrence, are fluvio-glacial sands and gravels and recent alluvium, all sorted deposits of fairly coarse texture (Fig. 9).

The character of these various deposits or soil parent materials, varies considerably with the nature of the parent rock, which forms the basis of the cartographic unit known as the Soil Association. Their distribution is shown in Fig. 10 and a description of each, together with the rocks from which it is formed, is given in the remainder of this chapter.

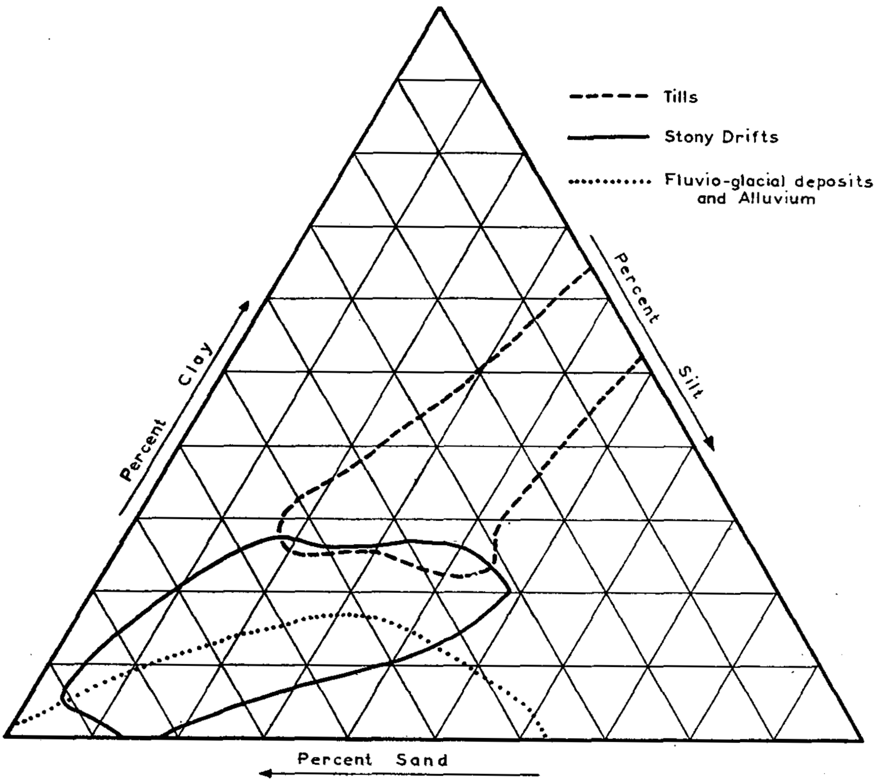


FIG. 9. Range of Texture of Soil Parent Materials.

ORDOVICIAN AND SILURIAN

The Ordovician and Silurian rocks occupy most of the western half of Sheet 25 and extend north-eastwards, beyond the unconformable Upper Old Red Sandstone of Lauderdale, to form a large triangular area adjacent to the northern sheet boundary.

The Ordovician rocks are found mainly in an area of about 12 square miles in the north west of Sheet 25; a small inlier occurs in the adjacent Silurian area, about 3 miles N.N.E. of Lauder. Most of the Ordovician sediments belong to the Lowther Shales, and in Sheet 25 consist of interbedded grey and reddish brown greywackes and greenish and red shales with some coarse grits and conglomerates. There are also a few narrow lenticular outcrops of black shale and grey mudstone associated with chert and jasper. These are the oldest Ordovician rocks (Hartfell and Glenkiln Shales and Radiolarian Cherts) exposed generally in the cores of tightly compressed anticlinal folds.

The Silurian rocks, which comprise the larger part of the Lower Palaeozoic formations in this area, consist of, in ascending stratigraphical order, Birkhill Shales; Abbotsford Flags, Grierston Shales, Buckholm or Queensberry

Grits; and Hawick Rocks. (Peach and Horne 1899, pp. 201-208). The Birkhill Shales where they outcrop in Sheet 25, are generally represented by narrow lenticular bands near Melrose and Selkirk. Abbotsford Flags, with associated shales, form a belt between Melrose and Galashiels. The Buckholm or Queensberry Grits, with some associated shales, lie immediately to the north west and extend across the strike to the Ordovician boundary; they form the major component of the Silurian area of Sheet 25. The main outcrop of the Hawick Rocks is to the south and east of Selkirk; infolds however do occur for some 10 miles north west of this.

The Abbotsford Flags and associated shales consist of brown flagstones and green and grey shales and mudstones. The Buckholm or Queensberry Grits are massive grey and reddish brown grits and greywackes with local bands of conglomerate and of grey, green or red shales. The Hawick rocks, dominantly argillaceous, consist of grey, green or red shales, brown flagstones and thin grey brown or yellowish brown greywackes, with occasional grits and conglomerates.

Collectively or individually the rocks described above give rise to the parent materials of the Ettrick Association. In the hilly areas the majority of these are relatively thin stony drifts on which soils of the Linhope, Minchmoor and sometimes the Dod series have been developed.

Generalised description of stony drift of the Ettrick Association. Brown (10YR5/3) loam; weak crumb; loose; abundant angular fragments of fresh and partly weathered greywacke.

The diagnostic characters of this drift are the brown colour and the stony loam texture, but where red greywacke is present the colour may have a slight reddish tinge. The relatively unweathered drift is found at a depth of 24-36 inches, overlying either solid or shattered greywacke.

Within the area of the Hawick Rocks are localities with many parallel rock ridges aligned in a south west to north east direction. These ridges are mainly composed of well cemented and fresh greywackes which are resistant to erosion and give rise to the "corrugated" topography on which the Ettrick complexes are formed.

The more highly comminuted tills on the lower ground are usually deeper; they are associated with smooth, flatter topography and the confines of river valleys where they give rise to poorly and imperfectly drained soils. These tills may contain far-travelled fragments, but in the main they are local in origin, and are the parent materials for the Ettrick, Peden, Hardlee and Kedslie series.

Generalised description of till of the Ettrick Association. Grey (10YR6/1) clay loam; massive; plastic; abundant sub-angular and sub-rounded fresh and weathered greywacke stones.

The colour of this till is not invariably grey; it is sometimes greyish brown or brown and where red shales and greywackes are present, as for instance around the Eildon Hills, Galashiels and Melrose, it is decidedly reddish. The redness is attributable to the presence of a ferric hydroxide gel and haematite (p. 146). The red shales and greywackes themselves often appear to be associated with minor intrusions such as those on Bowden Moor.

The main petrological feature of the greywackes and shales is the presence of the primary clay mineral, chlorite, which is found in all the Ettrick profiles (Table 19). Chlorite does appear in other soils of the area, but this may be attributed to glacial contamination. For example, greywackes are quite a common minor constituent of the till of the Whitsome Association of Lower

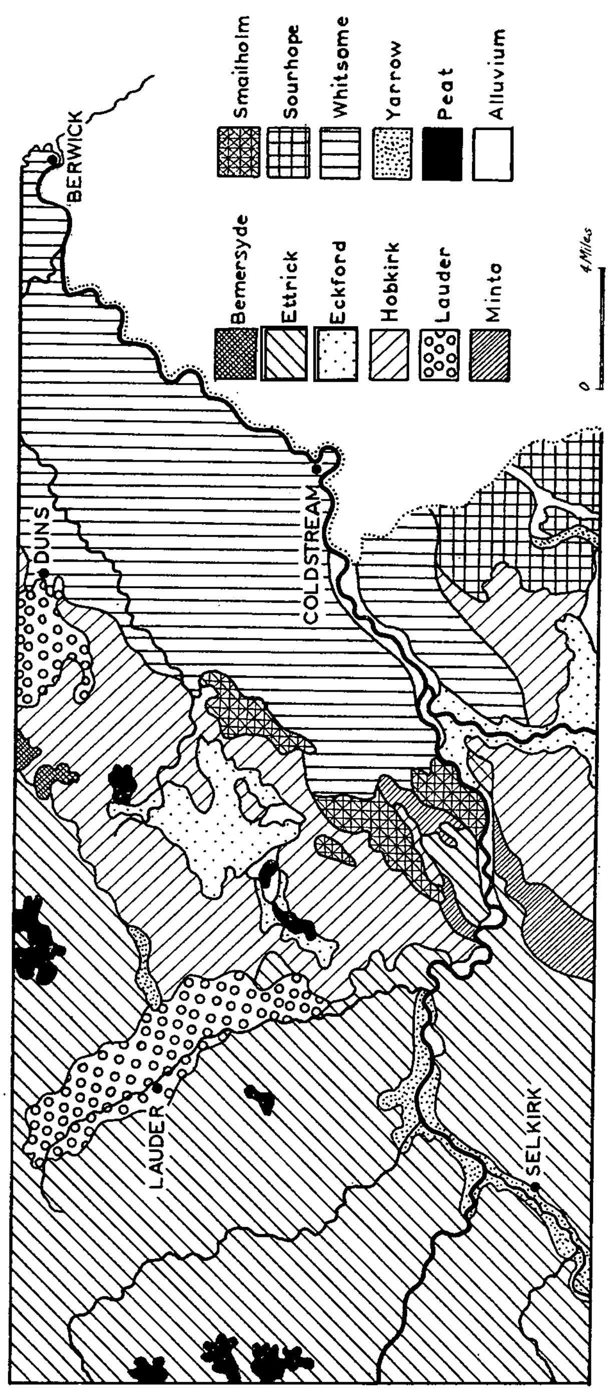


FIG. 10. Distribution of Soil Associations.

Tweeddale. A recent work by Walton (1955) describes wide variation in the petrology of a S.W. to N.E. belt of these rocks around Innerleithen in Peeblesshire. The northern margin of this belt is the south westerly continuation of the Ordovician/Silurian boundary in Sheet 25 (Fig. 6): the southern margin, some 8½ miles to the south east, is in the vicinity of Thorneylee Quarry five miles west of Galashiels. Thus almost all of the Silurian area of the north western half of Sheet 25 forms a north easterly continuation of the broad belt studied by Walton. It is therefore reasonable to assume that the general mineralogical characteristics of the rocks of these adjacent areas are very similar. Walton has divided his Silurian belt into three parallel south west to north east zones. The greywackes of the northern zone (Pyroxenous Group), about 1¾ miles wide, are characterised by the presence of augite and hornblende, and of fragments of andesite, granite and variolite. The greywackes of the central (Intermediate Group) and southerly (Garnetiferous Group) zones are similar, and together they form a belt about 6¾ miles wide. The central zone is largely composed of granite debris while the southerly zone has relatively abundant garnets as well as granite fragments. Calculation of the percentage of quartz plus siliceous fragments from micrometric analyses has shown a wide range. In greywacke analysed chemically the percentage of total silica ranges from 60·81 to 74·33, equivalent to a range of igneous rocks from trachyte to granite (Walton 1956 p. 344). The Pyroxenous Group averages about 60 per cent silica while the Intermediate and Garnetiferous Groups average about 70 per cent. This variation of composition explains, to some degree, certain anomalies in the intensity of podzolisation at any one altitude in the area and also variations of pH in some soil series.

LOWER OLD RED SANDSTONE; CHEVIOT LAVAS

The Cheviot Lavas cover some 20 square miles in the vicinity of Kirk Yetholm in the south west corner of Sheet 26. They consist of augite-hypersthene andesites, and glassy pitchstone-like andesites (Pringle 1948, p. 47). The colour of the rocks varies with the degree of weathering; purplish and chocolate brown are common colours, but red, grey or black tints are also seen. Some flows are highly vesicular and the vesicles are not uncommonly filled by agate. The felspar phenocrysts (oligoclase, andesine and labradorite) are usually much kaolinised, and felspar is one of the first minerals to weather out and become part of the soil constituents. The ferromagnesian minerals, of which augite and hypersthene form small phenocrysts, are also much weathered, usually to chlorite and calcite. Chemical analyses (Guppy *et al* 1931 pp. 45-48) show these rocks to be acid rather than basic andesites; the silica percentage ranges from 59·29 to 63·38. Study of the heavy mineral content by the author shows these minerals to be mainly the ferromagnesian minerals described above and iron oxides. There are occasional fragments of zircon and garnet but apatite, a phosphorous bearing mineral, is very erratically distributed.

The andesites described above are largely contributory to the parent materials of the Sourhope Association. As in the case of the Ettrick Association, the majority of the drifts are thin and stony; they give rise to freely drained soils of the Sourhope series.

Generalised description of stony drift of the Sourhope Association. Reddish brown (2.5YR4/4) gritty sandy loam; single grain; loose; abundant small angular fragments of andesite.

The gritty texture and reddish brown colour are typical features of this stony drift, but the texture may also be a loam. The stones are always highly weathered and crumbly and, as in the case of the stony drift of the Ettrick Association, may form a colluvial layer over till at the foot of a hill slope.

Fine textured till derived from andesite is not widespread and gives rise to poorly drained soils of the Atton series. Till of this type is to be found in the valleys of the Halter Burn and Bowmont Water as well as in small subsidiary valleys and hollows elsewhere.

Generalised description of till of the Sourhope Association. Reddish brown (5YR5/3) clay loam; massive; plastic; abundant large sub-angular and sub-rounded much weathered andesite stones.

The texture of this till varies between sandy clay loam and clay and is often gritty. Except when it borders on the stony drift, the till is generally more than four feet thick.

UPPER OLD RED SANDSTONE

The Upper Old Red Sandstone formation is conglomeratic in Lauderdale and around Duns where there are coarse basal conglomerates bright red in colour consisting mainly of pebbles and cobbles of greywacke. The conglomerates are locally interbanded with sandstones and extend south and east of the Dirrington Laws to the neighbourhood of Greenlaw Moor and Polwarth. They occur also as small patches between the Dirrington Laws and Lauderdale. These conglomeratic facies give rise to shallow, coarse textured drifts on which soils of the Lauder Association are formed. These soils, particularly the freely drained members, have many features in common with the soils of the Ettrick Association due to the large proportion of greywacke in both parent materials. The freely drained Lauder and Langtonlees series are developed either on the conglomerate itself or on a thin (<3 feet) stony drift derived from the conglomerate.

Generalised description of stony drift of Lauder Association. Dark red (10YR3/6) stony loam; very weak sub-angular blocky; loose and very friable; abundant rounded, relatively fresh, greywacke cobbles and boulders.

The texture by mechanical analysis is usually a sandy loam for the stony drift described above, but this may be anomalous because the soft cementing material readily breaks down during the analyses to give an unduly high content of sand. The field texture is invariably a loam. The main features of this drift are its distinctive colour and the presence of rounded greywacke stones.

The poorly drained Lylestone series is developed on a thicker deposit (>3 feet) of finer texture which is of very limited extent. As in the case of the stony drift, the mechanical analysis texture is coarser than the field texture, the latter being a clay loam.

Generalised description of fine textured drift of the Lauder Association. Red (10YR4/6) clay loam; massive; plastic; abundant rounded and sub-rounded stones of greywacke; some soft and weathered.

The red colour is very strong and is only absent in the solum under conditions of strong gleying or leaching. It is thought that the content of shale is largely responsible for the fine texture rather than comminution by glacial transportation.

The sandstones to the south of the conglomerates give rise to soils of the Hobkirk Association and consist of red and yellow sandstones with interbedded red or purplish brown shales and marls. The sandstones are highly siliceous and consequently the soils derived from them are liable to podzolisation. Micrometric analysis by the author indicates that felspar, usually microcline or orthoclase, forms less than 5 per cent of the rock and that cementing materials (secondary quartz or carbonate) may amount to 15 per cent. MacGregor and Eckford (1948, p. 241) have pointed out that the secondary quartz is not firmly attached to the quartz grains; the rocks cemented by silica are in fact comparatively soft and give rise to soils of coarse texture.

The shales and marls which impart a fine texture to the soils, in some places contain much material of the clay and silt grades; little is known of their petrology. Minor constituents in the sandstones, according to analyses carried out by the author, constitute less than 0·05 per cent of the whole and are in order of abundance: iron oxides, zircon, biotite, apatite, tourmaline, garnet and muscovite. This sequence is closely paralleled in Table 18 for the fine sand fraction of the soil; the exception is apatite which has presumably weathered in the soil.

Where near the surface, the soft sandstones often form the C horizon of the freely drained Hobkirk and Faw series. Examples of soft rock near the surface have been noted by surveyors at Bowmont Forest, near Gordon, and at Graham's Law, as well as in isolated patches east of Earlston. Elsewhere the freely drained soils are developed on a thin sandy till differing little from the rock itself except for a few fragments of erratics and broken sandstones.

Generalised description of sandy till of the Hobkirk Association. Weak red (10R4/4) sandy loam; weak sub-angular blocky; loose; frequent small rounded quartz stones and red sandstone fragments.

The texture of the material described above is fairly constant but examples of loamy sand, sandy clay loam and loam texture are not uncommon. If the parent material is transported and is near another geological formation the stone content is more variable.

The poorly drained soils of the Hobkirk Association, the Cessford series and the Wauchope series, are developed on a till of fine texture generally found in low lying ground and with a greater depth than the till described above.

Generalised description of clay loam till of the Hobkirk Association. Red (10R4/6) clay loam; massive; plastic; occasional, much weathered, sub-rounded greywacke stones; sandstone fragments rare.

The Upper Old Red Sandstone formations also contribute material to the mixed drifts of the Minto and Smailholm Associations. The former is a fine textured till derived from a mixture of Silurian greywackes and shale and red sandstones of the Upper Old Red Sandstone formation and the latter a loam till derived from a mixture of the same red sandstones and intrusive or extrusive olivine basalts of Lower Carboniferous age.

The till of the Minto Association is similar to the till of the Ettrick Association in morphology and location. It also gives rise to imperfectly drained and poorly drained soils, the Belses and Minto series.

Generalised description of till of the Minto Association. Reddish brown (2.5YR4/4) clay loam; massive; frequent sub-rounded greywacke stones and red sandstone fragments.

When overlying Old Red Sandstone formations, this till becomes redder and coarser in texture with depth, due to the increasing content of red sandstone. For the same reason the horizons of the solum are often finer in texture than the C horizon immediately below. As would be expected with a mixed till, the texture is variable. Near the boundary with the tills of the Ettrick Association a clay loam texture is very common while near the Hobkirk Association a till of loam or sandy loam texture is more frequent.

The till of the Smailholm Association is generally less than four feet thick and like that of the Minto Association, of very variable composition.

Generalised description of till of Smailholm Association. Reddish brown (2.5YR4/4) loam; friable; abundant sub-rounded and sub-angular stones of weathered olivine basalt.

Where the till of the Smailholm Association thins to less than two feet the red sandstone content is usually much reduced and the colour becomes browner. The texture remains constant, however, though more stony.

LOWER CARBONIFEROUS

At the base of the Carboniferous sequence are the Kelso Traps, a series of olivine basalt lavas that extend from the neighbourhood of Kelso northwards to Greenlaw. These lavas are, as a rule, much decomposed and olivine phenocrysts are represented by red pseudomorphs. Large porphyritic plagioclase felspars and augites are present in some types. In three lavas measured micrometrically Tomkeieff (1945, p. 64) found that the weight percentages of the felspars and ferromagnesian minerals are as follows: felspar (calcic plagioclase) 43·2-57·9; olivine 7·65-9·2; pyroxene 12·95-39·25 and iron ore 8·75-12·8. The chemical analysis of one specimen of lava had a silica percentage 45·55 showing this to be one of the most basic rocks in the area. Tomkeieff has shown the intrusive basalts to be similar in composition but much fresher than the lavas. These rocks together form the parent material of the Darleith series, a freely drained soil found only on rocky eminences where contamination from other formations by glaciation is small.

Generalised description of stony drift of the Darleith Association. Dark reddish brown (5YR3/2) loam; weak blocky; loose; abundant angular stones of fresh and lightly weathered olivine basalt, some rounded or sub-rounded fragments of highly weathered basalt.

The parent material of the Darleith Association can also be formed of sub-aerially weathered basalt *in situ*, in which case it can be many feet thick. Normally, however, the stony drift described above is no more than two feet thick.

Acid intrusions, all probably of Lower Carboniferous age, occur in the Eildon Hills, Black Hill, White Hill, Bemersyde Hill, the Dirrington Laws and Kyles Hill. All except the last give rise to a thin stony drift on which soils of the Bemersyde Association are formed. The rocks are variously described as felsites, trachytes and orthophyre. The chemical analyses of Irving (1930, pp. 540-541) for a specimen from Dirrington Little Law show it to be a very acid rock containing 74·45 per cent of silica. A calculated "norm" for the rock was quartz 29·26 per cent; orthoclase felspar 29·25 per cent; and albite felspar 36·96 per cent. Ferromagnesian minerals are very sparse. The acidity of the rock is reflected in the routine analyses for the soils of the Bemersyde Association (Appendix I Nos. 1 and 17) and in the mineralogical analyses of the fine sand fraction (Appendix IV Table 18).

Generalised description of stony drift of the Bemersyde Association. Dark reddish brown (2.5YR3/4) loose, angular fragments of trachyte or felsite rubble. Interstitial matter of dark reddish brown (5YR3/4) sandy loam.

The parent material described above is seldom more than 2 feet thick and lies directly on the rock *in situ*.

Lower Carboniferous sediments, described by Macgregor (1938, p. 57 and 1940, p. 56) and MacGregor and Eckford (1948, pp. 236-241), extend over most of Lower Tweeddale from Kelso to Berwick upon Tweed. They belong almost entirely to the Cementstone Group and consist essentially of alternating sandstones, shales or marls and thin ribs of cementstone (impure dolomitic limestone). The sandstones, usually buff to yellowish, but locally pink or red, are thick enough to be quarried for building purposes. Compared with the Upper Old Red Sandstone they are much richer in mica (biotite being more abundant than muscovite) and have a higher alkali-felspar/quartz ratio.

A very small area of rocks of the Lower and Middle Limestone Groups of northern England forms a coastal strip east of Berwick upon Tweed. These rocks are of little or no importance as sources of soil parent materials.

The sedimentary rocks described above together with small proportions of basalt, greywacke and Old Red Sandstone sediments comprise the main constituents of the till on which soils of the Whitsome Association in Lower Tweeddale are formed. This till is a tough deposit of clay loam or, more commonly, of clay texture from which the conspicuous drumlins of Lower Tweeddale are moulded. Exposures in stream and river sections show this till to be many feet thick, but this is not general throughout Lower Tweeddale. The till thins to three feet or less in some patches around Swinton and Whitsome and in a belt one mile wide by five miles long north east of Fogo.

Generalised description of till of the Whitsome Association. Reddish brown (5YR4/3) clay; massive; plastic; rounded and sub-rounded stones of fresh and weathered greywacke and basalt; also fragments of coal, red and pale coloured sandstones and shales, felsite and andesite.

The clay content of the till averages 40 per cent but percentages of 50-60 occur in the east of Lower Tweeddale around Paxton and Hutton.

FLUVIO-GLACIAL MATERIALS

The largest spread of fluvio-glacial deposits is on the Gordon Platform where sands and a few gravels form the parent material of soils of the Eckford Association. These sands are largely derived from the sandstones of the Upper Old Red Sandstone formations nearby but also contain stones of greywacke from the west and fragments of local basalt. Sands of the Eckford Association also occur on the old river terraces of the Teviot near Eckford where they are of more mixed composition and contain material derived from the Cheviot Lavas as well as from the Silurian sediments to the west.

Generalised description of sands of the Eckford Association. Reddish brown (5YR4/4) sand; single grain; loose; frequent small rounded stones of greywacke and quartz.

Where the material is entirely of Silurian origin, i.e. greywacke gravels, the fluvio-glacial deposits form the parent material of the Yarrow Association and are found as old river terraces in the Ettrick, Tweed and Yarrow valleys. A river terrace composed of greywacke gravel can be seen in Plate 7.

Generalised description of gravels of the Yarrow Association. Brown (7.5YR4/4) gravelly sandy loam; single grain; loose; very abundant sub-rounded and rounded stones of fresh and lightly weathered greywacke.

Thin deposits of sand and gravel intimately associated with till, into which they apparently pass by gradations, give rise to the Whitsome complex in Lower Tweeddale. These deposits are particularly well developed around Leitholm where they have been studied in detail. Here sand and gravel of variable thickness has been laid on the till of the Whitsome Association. The boundary between till and sorted material is usually indistinct but it can be very sharp. The sands and gravels are distributed in long irregular finger-like strips with local interconnections. The mode of formation of these deposits is not clear but it is thought that they were formed during the last stages of ice melting and were caused by deposition from short-lived, braided streams on or between the last scattered remnants of ice.

CHAPTER IV

Methods and Definitions

FIELD METHODS

ONE of the principal functions of a soil survey is to identify and describe soil types and record their distribution on a map. Soils are identified in the field principally by their morphology, that is, by a comparative study of their appearance. Certain other characteristics such as handling properties, are also used but, generally speaking, they are subsidiary. A study of soils at different points on the landscape by this method soon reveals that whilst each has an individual identity some are so much alike that they can be placed into the same primary category. The primary category, for both mapping and classification, is the soil series.

To establish a soil series it is necessary for the pedologist to have a clear appreciation of the permissible range of general morphology. It is unwise to base a separation of soil series on a single characteristic: significantly different soils are distinguishable usually on the whole morphology of the profile.

When it comes to mapping established soil series one problem invariably faces the pedologist, that of drawing suitable boundaries between series. Although typical profiles of two soil series differ markedly from each other, when they have a common boundary, it is usual for one to merge into the other over an appreciable distance, say 20 yards. A line is placed on the map to effect a separation but it must be remembered that the two series in fact merge and no sharp change in morphology occurs.

CARTOGRAPHIC METHODS

The series is the primary soil unit both for mapping in the field and for classification. Its place in classification is discussed in Chapter V. For the purposes of describing series in relation to their environment and especially to geology they are placed into a larger cartographic unit, the soil association. Each soil association consists of series developed on similar parent rock. The significance of the word similar is determined by the effect the parent rock has on the soil profile and it is the job of the pedologist to assess this. Thus the association is a flexible cartographic unit and can be made to suit the needs of any particular area. Different series, which are developed on similar parent rock, in the same locality have usually common boundaries. The usefulness of the association as a cartographic unit is emphasised when it is remembered that these series will merge, one into the other.

The Soil Survey of Scotland uses field maps with a scale of 1:25,000 (about 2½ inches to 1 mile). They are reduced to a scale of 1:63,360 (1 inch to 1 mile) for publication. Scale introduces certain difficulties. On a scale of 1:63,360 it should be possible to delineate an area of about 5 acres but areas smaller than this cannot be shown. Thus it is possible for any uniformly-coloured area on the published map to contain within it an area, less than 5 acres in extent, of some other series. In practice this seldom happens. Any locality where this happened repeatedly would be mapped as a soil complex, with the constituent soil types enumerated and defined in the text.

DESCRIPTION OF SOIL PROFILES

During the survey of an area, sites, typical of each soil series, are selected and profile pits dug. The depth of each pit varies somewhat, but, in general, it is about 4 feet. Each profile is then described in standard terms which are defined and explained later in this chapter.

A soil profile is described by noting first certain features of the site followed by a few characteristics of the profile as a whole. The profile is then subdivided into its constituent horizons and these are described separately. It is usual to designate each horizon by a symbol, the same symbol being used for the same horizon in any profile of the same series or, for that matter, of the same major soil group. It should be noted, however, that when a symbol is used for a horizon in two profiles, the first belonging to one major soil group and the second to another major soil group, it may not have quite the same significance. The horizons will probably correspond only in a general way.

LABORATORY INVESTIGATIONS

Each horizon, occasionally each sub-division of an horizon, is sampled. The samples are taken to the Macaulay Institute for Soil Research where each is given a routine physico-chemical examination. The analyses carried out are shown in Appendix I.

Some profiles are selected and are further analysed by mineralogical, differential thermal, spectrochemical, and X-ray methods. Occasionally clay separates are subjected to silica-sesquioxide analysis by chemical methods.

STANDARD TERMS AND DEFINITIONS

When describing a soil profile it is usual to describe certain characteristics in standard terms. Some of the characteristics apply to the site, others to the soil profile proper. Those which refer to the site, namely Relief and Slope Classes, Aspect, Altitude and Vegetation, are treated first. The terms used to describe the last three properties are self-explanatory and have not been defined.

Drainage Class and Horizon Nomenclature are properties which apply to the profile as a whole and their standard terms are next to be defined. Finally certain properties namely, Colour, Texture, Structure, Consistence, Induration, Amount of Organic Matter, Stoniness, Number of Roots, Mottling and Horizon Boundaries are properties which apply to each soil horizon. Standard terms are listed and defined for each.

RELIEF AND SLOPE CLASSES

The soil map shows relief by means of contours at 100 foot intervals. In addition, it is usual to give a description of the area in terms of landform or similar units. This has been done in Chapter I.

It may be useful, however, to relate soil series to slope. To facilitate this,

PLATE 9
The rolling landscape of the Hobkirk Association. The absence of stone walls and the high proportion of broad-leaved woodland is typical of this Association.

PLATE 10
Part of the drumlin field of Lower Tweeddale with soils of the Whitsome Association. This landscape is typical of the intensive arable farming area of the Borders.

[*Facing p. 46*]

PLATE 11
Large, well-formed, prismatic peds from the B_2g horizon of a poorly drained soil (Ettrick series).

PLATE 12
The exposed Gala Uplands with mixed and coniferous shelterbelts.

single slope classes are given below. They are the single slope classes used by the U.S. Soil Survey. (U.S.D.A. 1951).

Class A		
Limits		
Lower 0 per cent.	(0°)	Name:—level
Upper 1-3 per cent.	(½-1½°)	
Class B		
Limits		
Lower 1-3 per cent.	(½-1½°)	Name:—gentle
Upper 5-8 per cent.	(3-4½°)	
Class C		
Limits		
Lower 5-8 per cent.	(3-4½°)	Name:—moderate
Upper 10-16 per cent.	(6-9°)	
Class D		
Limits		
Lower 10-16 per cent.	(6-9°)	Name:—moderately steep
Upper 20-30 per cent.	(12-17°)	
Class E		
Limits		
Lower 20-30 per cent.	(12-17°)	Name:—steep
Upper 45-65 per cent.	(24-33°)	
Class F		
Limits		
Lower 45-65 per cent.	(24-33°)	Name:—very steep
Upper none	(90°)	

HORIZON NOMENCLATURE OF SOIL PROFILES

Typical soil horizons can be readily compared and contrasted if a symbol is assigned to each one. The symbols normally used are L. F. H. A. B. C. and D. General definitions of the layers, or horizons to which these symbols are assigned are given first followed by more precise definitions suitable for each major soil group represented in the area.

L, F and H layers are subdivisions of the organic matter lying on the surface of the solum.

L — a superficial layer of relatively undecomposed plant litter generally of the past year.
F — a superficial layer of partially decomposed litter with recognisable plant remains.
H — a superficial layer of decomposed organic matter with few or no recognisable plant remains.

The A horizon is the upper mineral part of the solum. It is the horizon of maximum biological activity and the horizon most subject to the direct influence of climate, plants and animals.

The S horizon is the surface horizon of a cultivated soil.

The B horizon is the lower part of the solum lying between A and C horizons. It is characterised by *either* a relatively high content of sesquioxides or clay *or* by having a more or less blocky or prismatic structure. Quite often there are accessory characteristics such as a bright colour.

The C horizon—the parent material from which the soil has been developed.

The D horizon—the rock from which the C horizon has been formed or a stratum of material not related to the C horizon.

HORIZON NOMENCLATURE OF CERTAIN SOIL GROUPS

Peaty Podzol (with iron pan)

L undecomposed plant litter.
F partially decomposed litter.

H decomposed organic matter—dark brown or black, raw humus, usually >2 inches thick.

A_1 the uppermost mineral layer, dark coloured 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. May show signs of gleying: it is designated either $A_2(g)$ when the gleying is slight or A_2g when the 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 $\frac{1}{16}''$ thick. Maximum enrichment of sesquioxides. May be continuous and impermeable to water and impenetrable to roots; then strong tendency for gleying and for roots to concentrate immediately above in the A_2.

B_2 brighter 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.

When a horizon has a moderate amount of gleying its symbol is modified by adding (g), for example $B_2(g)$.

Iron Podzol

L undecomposed plant litter.

F partially decomposed litter.

H decomposed organic matter—dark brown or black raw humus, usually <4 inches.

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 colour and rich in silica.

B_2 brighter than A or C horizons. Relative enrichment of sesquioxides.

B_3 not so bright as B_2. Shows some relative enrichment of free sesquioxides and may be indurated.

C the relatively unweathered parent material.

Brown Forest Soil (low base status)

These soils are roughly equivalent to the brown podzolic soils of the U.S.A.

L undecomposed plant litter.

F partially decomposed plant litter.

H trace of decomposed organic matter—may be absent.

A brown colour with medium organic matter, 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 relatively unweathered parent material.

When a horizon has a moderate amount of gleying, its symbol is modified by adding (g), for example $B_2(g)$.

Brown Forest Soil with gleyed B and C horizons

These soils are roughly equivalent to the grey-brown podzolic soils of the U.S.A.

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 clay content greater 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.

There is little colour differentiation between the A, B and C horizons.

Peaty Gley

- L undecomposed plant remains.
- F partially decomposed litter.
- H raw humus usually more than 2 ins. thick and dark brown or black in colour.
- A_1g mixed organic and mineral layer. A little ochreous mottling associated with roots. Weak structure.
- A_2g pale coloured layer. There may be some ochreous mottling. Weak structure. Low content of organic matter.
- B_2g blocky or prismatic structure very apparent. Peds coated with grey but inside show ochreous and grey mottling.
- B_3g blocky or prismatic structure less apparent. Still grey coating to peds and inside, ochreous and grey mottling.
- Cg original colour of parent material more apparent. Structure more massive but peds still coated with grey and inside there is still ochreous mottling.

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 mottling inside.

Calcareous Gley

- L undecomposed plant litter.
- F partially decomposed litter.
- H trace of decomposed organic matter—normally 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. May be slightly calcareous.
- B_2g well defined blocky or prismatic structure. Peds coated with grey; ochreous and grey mottles within. Calcareous.
- B_3g less well defined blocky or prismatic structure. Peds coated with grey; ochreous and grey mottling within. Calcareous.
- Cg original colour of parent material more apparent. Structure more massive although peds may still have grey coatings and ochreous and grey mottling inside. Calcareous.

DRAINAGE CLASSES

The word drainage has several meanings but in this instance it refers strictly to the morphology of profiles. In general, freely drained soils have bright, uniformly coloured B horizons while poorly drained soils have dull, mottled B horizons. Mottling, especially grey mottling, is considered to be evidence of gleying. Thus drainage classes are distinguished purely on morphology.

The sequence of terms used to describe these general profiles is given below, along with general definitions. Precise descriptions of characters are possible only with individual series.

Drainage:—excessive

The soil horizons are much shallower than usual. The B horizons are bright and uniform in colour. This type of profile is not common in the area.

Drainage:—free

The B horizons are bright and uniformly coloured, although those with a small degree of dullness and some mottles are permitted within the class.

Drainage:—imperfect

The B horizons are not quite so bright as those of the well drained soil and have appreciable mottling. They are designated $B_2(g)$, $B_3(g)$ etc. to indicate a moderate amount of gleying.

Drainage:—poor

The Bg horizons are dull and mottling is very evident.

Drainage:—very poor

The Bg horizons are dull and mottling is very evident.

The imperfectly drained soil is intermediate between the well and poorly drained soil though it is generally rather closer in character to the well drained soil.

The poorly drained and the very poorly drained soils require tile drainage before successful cultivation can be undertaken. Both may have an A_2g horizon which is often a dull grey colour but it is usually more evident in the very poorly drained. It seems that this horizon is one of maximum gleying.

COLOUR

Colour is an obvious characteristic of the soil. It is one which gives rise to many local soil names e.g. "whitelands" for the poorly drained series of the Ettrick Association and "red soils" for the Hobkirk Association.

Pedologists attach great importance to the colour of soil horizons; it is one of the characteristics which indicate whether the drainage class of a soil is free or poor. Individuals vary greatly in their ability to describe soil colour accurately and concisely and therefore use is made of colour charts. The Munsell Soil Colour Charts (Munsell Color Co. Inc. 1954) are used by the Soil Survey of Scotland.

According to the Munsell system each colour can be considered as the resultant of three variables, hue, value and chroma. There are a number of charts each with coloured chips. On any one chart all the coloured chips have the same hue but differ from each other in value and chroma. Different charts have chips with different hues. By comparing a small piece of soil with the coloured chips on the charts, it is possible to find a chip which matches or nearly matches most soil colours. Each coloured chip is designated by hue, value and chroma in that order e.g. 10YR6/3. The hue is 10YR the value is 6 and the chroma is 3. Again each chip is given a standard name e.g. 10YR6/3 pale brown.

Hue refers to the dominant spectral colour e.g. whether red or yellow; value refers to apparent lightness as compared to absolute white and is a function of the intensity of light; chroma refers to the purity of hue or, alternatively, the apparent departure from neutral greys or whites.

TEXTURE

Several related subjects are discussed under this heading. Soil texture is the relative proportions of the various size groups of primary particles in a mass of soil; it refers specifically to the proportion of sand, silt and clay in that part of a soil sample which passes through a 2 mm. sieve. The presence of particles larger than 2 mm. does not affect the texture of the soil directly, but it can be indicated by additional descriptive terms such as stony, pebbly, etc. The texture of a soil horizon is one of its most important properties.

Soil separates are the arbitrarily selected size-groups of mineral particles which together make up the soil. Specifically they are the sand, silt and clay fractions into which the soil material is separated when subjected to mechanical analysis. The coarse sand fraction consists of all those particles in a soil with effective diameters between 2000μ (or 2 mm.) and 200μ; the fine sand fraction of particles with effective diameters between 200μ and 20μ; the silt fraction of particles with effective diameters between 20μ and 2μ; and the clay fraction of particles with effective diameters less than 2μ. Fractions with these limits are defined by the International Scheme of Mechanical Analysis which, however, is by no means in universal use. The U.S. Dept. Agric. also has a scheme which is widely used. The main difference between the schemes is in the size limits of the silt fraction. Both schemes are given below:

U.S. Dept. Agric. Scheme		*International Scheme*	
Name of Separate	Effective Diameter (range)μ	Fraction	Effective Diameter (range)μ
sand: very coarse sand	2000—1000	sand: coarse sand I	2000—200
sand: coarse sand	1000— 500	sand: fine sand II	200— 20
sand: medium sand	500— 250		
sand: fine sand	250— 100	silt III	20— 2
sand: very fine sand	100— 50		
silt	50— 2	clay IV	<2
clay	<2		

The Soil Survey of Scotland makes use of both schemes and two sets of results are quoted in Appendix I. Only values obtained by the U.S.D.A. scheme should be used with the triangular diagram (Fig. 11) to determine textural class.

Textural Class Names

In assigning textural class names to soil horizons the Soil Survey of Scotland has combined all the sand separates into one with the general name sand. The percentage of each separate is plotted on a triangular diagram and the area on the diagram into which the soil fits is ascertained. Each area has a Textural Class Name and the soil is now given the appropriate name. Fig. 11 is a triangular diagram showing the areas of the various Textural Class Names. These areas have been defined after years of experience, especially in the United States, and should be used only in conjunction with the U.S. Department of Agriculture Scheme of Mechanical Analysis.

General Grouping of Soil Textural Classes

It is often convenient to distinguish broad groups of textural classes and, although the terms "heavy" and "light" have been used for this purpose for many years, they may lead to confusion as they do not necessarily bear any relation to the actual weight of the soil; they refer in fact to the power required in ploughing.

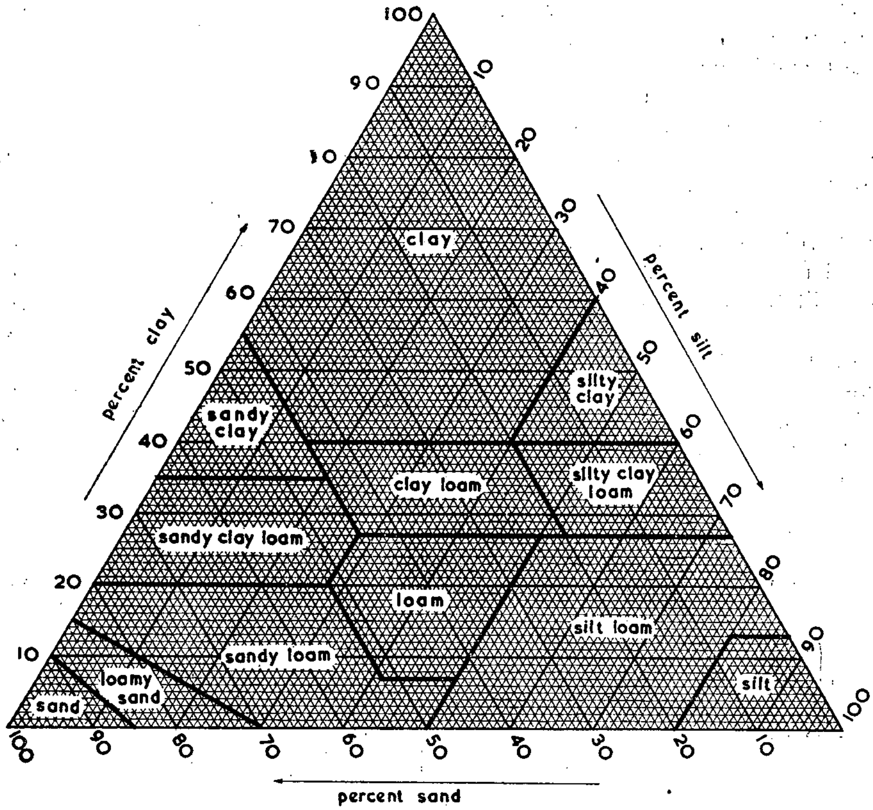


FIG. 11. The percentages of Clay ($<2\mu$), Silt (2-50 μ) and Sand (50-2,000 μ) in the Basic Soil Textural Classes.

Acceptable general terms, in three classes and in five, are shown below with their relationship to the basic soil textural classes (U.S.D.A., 1951):

General terms		*Basic terms*
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 soil particles into compound units which are largely independent of each other. Generally speaking soils with aggregates of spheroidal shape have much more pore

TABLE G.—TYPES AND CLASSES OF SOIL STRUCTURE

Type (Shape and arrangement of peds)

Class (size)	Platelike with one dimension (the vertical) limited and greatly 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 around 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 the 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 m.m.	very fine prismatic <10 m.m.	very fine columnar <10 m.m.	very fine angular blocky <5 m.m.	very fine subangular blocky <5 m.m.	very fine granular <1 m.m.	very fine crumb <1 m.m.
fine	fine platy 1-2 m.m.	fine prismatic 10-20 m.m.	fine columnar 10-20 m.m.	fine angular blocky 5-10 m.m.	fine subangular blocky 5-10 m.m.	fine granular 1-2 m.m.	fine crumb 1-2 m.m.
medium	medium platy 2-5 m.m.	medium prismatic 20-50 m.m.	medium columnar 20-50 m.m.	medium angular blocky 10-20 m.m.	medium subangular blocky 10-20 m.m.	medium granular 2-5 m.m.	medium crumb 2-5 m.m.
coarse	coarse platy 5-10 m.m.	coarse prismatic 50-100 m.m.	coarse columnar 50-100 m.m.	coarse angular blocky 20-50 m.m.	coarse subangular blocky 20-50 m.m.	coarse granular 5-10 m.m.	
very coarse	very coarse platy >10 m.m.	very coarse prismatic >100 m.m.	very coarse columnar >100 m.m.	very coarse angular blocky >50 m.m.	very coarse subangular blocky >50 m.m.	very coarse granular >10 m.m.	

space between aggregates, have more rapid permeability and are more productive than soils of comparable fertility with massive or blocky structure.

Field descriptions of soil structure note (I) the shape and arrangement (II) the size and (III) the distinctness and durability of the structural units or, as they are called, peds. Each of these qualities is described by a separate set of terms which, when combined, form a terminology. The shape and arrangement is designated as type of soil structure; size as class; and degree of distinctness as grade. The terms used are defined below (U.S.D.A. 1951) and Table G shows the relationships of the various classes and types.

Type. There are four primary types of structure.

(I) Platy with one dimension, the vertical, greatly less than the other two.
(II) Prism-like with two dimensions (horizontal) greatly less than the vertical.
(III) Block-like with three dimensions of the same order of magnitude but having plane or curved surfaces that are casts of the moulds formed by 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 surrounding peds.

Each of the last three types has two subtypes namely prismatic (without rounded ends) and columnar (with rounded ends); angular blocky (with relatively sharp angles) and sub-angular blocky (with rounded faces); and granular (relatively non-porous) and crumb (porous).

Class designates the size of the aggregates; five are recognised for each type. The terms used are very fine, fine, medium, coarse, very coarse.

Grade of structure is the degree of aggregation and expresses the differential between cohesion within the aggregates and adhesion between the aggregates. In practice, grade of structure is determined mainly by noting the durability of the aggregates and the ratio of aggregated material to unaggregated when the aggregates are gently displaced or crushed.

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 distinct units, some broken units and a little unaggregated material.
3. Strong—well-formed units, distinct in undisturbed soil; adhere only weakly to one another. When disturbed consist of entire units with few broken and very little unaggregated material.

When the soil horizon shows no structure it is termed structureless and can be either single-grain (if non-coherent) or massive (if coherent).

Terms describing each of these three qualities are combined to give the structural description, grade first, then class and finally type e.g. strong, coarse, blocky.

CONSISTENCE

Soil consistence is a quality of soil material which is expressed by the degree of cohesion and adhesion. It is measured by the resistance of soil material to deformation or rupture. Structure and consistence are interrelated, the former being the resultant of forces within the natural soil while the latter is concerned with the forces themselves.

As consistence is strongly influenced by the moisture condition of the soil it is necessary to have a series of terms for each significant moisture state. (U.S.D.A., 1951).

Consistence when wet

To evaluate, roll the 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 a mass that appears moist.

0. Loose — non-coherent.
1. Friable — soil material crushes under very gentle pressure but coheres when pressed together.
2. Firm — soil material crushes under moderate pressure between thumb and forefinger but resistance distinctly noticeable.
3. Very firm — soil material crushes 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 hands but is barely breakable between thumb and forefinger.
3. Very hard — can normally be broken in the hands but only with difficulty.

In Scotland soil horizons are usually either wet or moist.

INDURATION

Induration of soil material refers to a handling property of the soil which appears not to be markedly affected by moisture content. Consistence, however, varies greatly with moisture. Three terms are used to describe this property and they are defined below.

1. Weakly indurated — not usually detected when digging but presence shown by stabbing a knife into the 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 in a soil may be described qualitatively and quantitatively. In profile descriptions it is usual to estimate the amount present in each horizon. If a horizon contains more than 20% organic matter it is considered an organic horizon; if less than 20% organic matter it is considered a mineral horizon. The amount of organic matter in mineral horizons may vary and it is usually indicated by standard terms which are listed and defined below.

high	13%-20%
moderate	8%-13%
low	<8%

Organic horizons may often be subdivided into 3 layers, L, F and H. The L layer is relatively fresh litter; the F layer is fermented litter with the origin of the remains still recognisable; and the H layer is the well-decomposed humus with very few recognisable constituents. When the H layer is more than 12 ins. thick the soil is considered a peat.

There are three principal types of humus in this area namely mull, moder (silicate moder) and raw humus. Mull is an intimate mixture of mineral and organic matter in the A horizon with the constituent parts not identifiable by means of a lens. Silicate moder has an appearance similar to mull but its constituent organic and mineral parts can be identified by a good lens. The third type, raw humus or mor, is usually found where there is a well developed L, F and H layer. There is no intimate mixing of organic and mineral parts, the two remaining obviously distinct. The H layer itself has a very low mineral content.

A certain humus type is associated with each major soil group. The brown forest soils of low base status have typically silicate moder but occasionally may have mull. The peaty podzols and peaty gleys have a mor type of humus while the non-calcareous gleys have a form of silicate moder.

It should be noted that the terms mull, moder and raw humus are used in accordance with Kubiena (1953).

STONINESS

Stoniness is an important property of a soil or a soil horizon. Stones dilute the finer material and make the soil more permeable. In addition it may have marked effects on the ease with which cultivations are carried out. When a soil is stony or very stony the cost of wear and tear on implements is likely to be high.

The method adopted for describing the stoniness of soil horizons is not very precise. The terms in use are listed below but it must be emphasised that the percentage stones is estimated and is by no means accurate.

few stones	— $<15\%$ by volume
stony	— 15-50% by volume
very stony	— $>50\%$ by volume

When the stone content reaches 80% or 90% by volume it is probable that the soil will be considered skeletal and placed in the appropriate category.

MOTTLING

To describe mottling accurately it is necessary to note colour and pattern. Colour may be noted by Munsell colour charts but sometimes a general descriptive term "ochreous" is used to denote different shades of brown. The pattern is described in terms of:—

(1) Abundance

few	— mottles $<2\%$ of surface
frequent	— mottles 2-20% of surface
many	— $>20\%$ of surface

(2) Size

fine	— <5 m.m.
medium	— 5-15 m.m.
coarse	— >15 m.m.

(3) Contrast

faint	— hue and chroma of matrix closely related.
distinct	— matrix and mottles vary 1-2 hues and several units in chroma and value.
prominent	— matrix and mottles vary several units in hue, value and chroma.

These terms are combined in the order in which they are given above e.g. few fine distinct ochreous mottles.

HORIZON BOUNDARIES

Horizon boundaries differ in their distinctness and regularity. The terms used to describe distinctness depend on the width of the boundary and are given below.

1. Sharp — 1 inch
2. Clear — 1-2½ inches
3. Gradual — 2½-5 inches
4. Diffuse — 5 inches

CHAPTER V

Soil Classification and Formation

THE system of classification used in this memoir has been provisionally adopted by the Soil Survey of England and Wales and the Soil Survey of Scotland. In drawing it up, all the properties of soil were taken into account, although for survey teams primarily concerned as they are with mapping, it is the field characteristics which are of first importance for the practical purposes of soil differentiation.

Soil series with very similar profiles are placed into the same major soil groups and sub-groups, which are then selected on the basis of general characteristics and placed into divisions, the highest taxonomic categories used. Table H gives a summary of the series, major soil groups and divisions found in this area.

TABLE H. CLASSIFICATION OF SERIES

Division	Major Soil Group	Sub-group	Series
Leached Soils	Normal Brown Earths	Brown Forest Soils of low base status	Bemersyde, Darleith, Eckford, Hobkirk, Lauder, Linhope, Smailholm, Sourhope, Yarrow
		Brown Forest Soils with gleyed B and C horizons	Kedslie, Belses Whitsome
	Podzols	Iron Podzols	Dirrington, Minchmoor, Langtonlees, Hexpath
		Peaty Podzols (with thin iron pan)	Dod, Faw
Gleys	Surface-water gleys	Non-calcareous gleys	Atton, Cessford, Ettrick, Lylestone, Minto, Peden
		Calcareous Gleys	Horndean
		Peaty Gleys	Hardlee, Wauchope
Organic Soils	Blanket Peat	Hill Peat	
	Basin Peat	Low Moor Raised Moss	

As an aid to the identification of the soil categories found in this area, the more important field properties of each division, major soil group and sub-group are given below.

Division of Leached Soils

Leached soils are characterised by a uniformly coloured B horizon, absence of free lime in the upper horizons and an acid reaction.

MAJOR SOIL GROUP: NORMAL BROWN EARTHS

Normal brown earths are characterised by a uniformly coloured B horizon. They have a weakly to moderately acid reaction and a mull or moder humus formation. Each soil horizon merges into the one below.

Sub Group: brown forest soil (low base status)

Brown forest soils (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 soil with gleyed B and C horizons

Brown forest soils with gleyed B and C horizons are usually of moderate or high base status with a near neutral reaction. The B and C horizons may contain free carbonates and show slight gleying. They are generally formed on parent material of fine texture.

MAJOR SOIL GROUP: PODZOLS

Podzols have a grey bleached A_2 horizon with a very weak structure, an H layer of raw humus and a strongly acid reaction. There is usually evidence, morphological or chemical, of translocation of sesquioxides.

Sub-group: iron podzol

The iron podzol has a raw humus H horizon 1 to 3 in. thick. The A_1 horizon is dark in colour and incorporates raw humus while the A_2 horizon, having a low organic content, is paler. The B_2 horizon is well developed and bright in colour; there may be strong humus/iron staining at the top.

Sub-group: peaty podzol (with thin iron pan)

Peaty podzols have an H layer of raw humus up to 12 in. thick. The A_2 horizon is usually not well defined and may show evidence of gleying. The B_1 horizon is a thin iron pan, often continuous, which may be impermeable to water and roots. In the B_2 and B_3 horizons there is little evidence of gleying.

Division of Gleys

Gleys are mineral or peaty (H layer less than 12 in.) soils which have developed under conditions of permanent or intermittent water-logging. The mineral horizons of gleys are grey or greenish in colour with ochreous mottling. These are secondary colours which often mask colours inherited from parent material.

MAJOR SOIL GROUP: SURFACE-WATER GLEYS

A surface water gley is a soil where effects of gleying are shown which decrease with depth. In these the soil colour inherited from parent material is more apparent in the B_3g and Cg horizons than in any other.

Sub-group: non-calcareous gley

A non-calcareous gley has no free calcium in the upper mineral horizons.

The H layer is usually not more than 1 in. thick and although the A_2g may be well-defined it is not invariably so.

Sub-group: *calcareous gley*

There is free calcium carbonate in the B and C horizons of a calcareous gley. The H layer is either absent or rudimentary, and while the A_2g may be well defined this is not critical.

Sub-group: *peaty gley*

A peaty gley has no free calcium in the upper mineral layers but the H layer is usually well-formed and over 2 in. thick. The A_2g horizon is always prominent.

Division of Organic Soils

Organic soils have more than 12 in. organic matter and are usually formed under waterlogged conditions.

MAJOR SOIL GROUP: BLANKET PEATS

Blanket peat is an organic soil formation formed over convex as well as over concave slopes. The profile is usually much more uniform than that of basin peat.

Sub-group: *hill peat*

Hill peat is found at high elevations on level ground or gently convex slopes, i.e. on high-level plateaux.

MAJOR SOIL GROUP: BASIN PEATS

Basin peat is formed under the influence of ground water in localities where relief is definitely concave. The profile is usually more complex than that of blanket peat.

Sub-group: *low moor*

Low moor is formed under marshy conditions with the level of the ground water at or above the surface of the formation. Consisting principally of remains of *Sphagnum* and sedges, the low moor formations are oligotrophic in this area.

Sub-group: *raised moss*

Raised moss is a more advanced stage in the development of basin peat than low moor. It is characterised by the position of the ground water which is below the surface of the formation. The upper horizons are largely remains of *Sphagnum*, sedges, cottongrass etc. and are acidic (oligotrophic).

SOIL FORMATION

Joffe (1949 p. 41), a representative of the Russian school of soil science defines soil as, " . . . a natural body of mineral and organic constituents, differentiated into horizons, of variable depth, which differ from the parent material below in morphology, physical makeup, chemical properties and composition and biological characteristics". These soil characters are the resultant of the integrated action of five external factors, namely climate, organisms, relief, parent material and time (Jenny, 1941). The effect of these factors is universal but naturally their relative importance varies from one part of the world to another. Within a restricted area such as the South of Scotland, however, the factors might be expected to have the same relative importance and in general this is so. A comparison of the surveyed area with two others in the South of Scotland (Muir, 1955 and Mitchell and Jarvis, 1956) indicates that such differences as there are, are more of degree than of kind.

SOIL FORMING FACTORS

Climate

The most important components of climate which affect soil processes are those which impart moisture and energy; namely precipitation and temperature. The amount of soil moisture is governed firstly by the amount received by precipitation and secondly by the loss due to evaporation and transpiration (Evapo-transpiration, E_t). The simple subtraction $P–E_t$ represents the water surplus. Tables B, D, and F show monthly and annual values of these figures. The water surplus $P–E_t$ represents, approximately, the amount of water available for soil processes—some is lost by run off. A study of Table F shows that although Talla in Peeblesshire receives double the rainfall of Hutton, Berwickshire, the water surplus at Talla is nearly sixfold that at Hutton. It is also notable, in comparing these two places, that at Hutton during April, May, June and July (or May and June in a wet summer), the water surplus is a negative value, causing depletion of capillary soil moisture, even to the wilting point in sandy soils. At Talla and other hill areas, however, this only happens under very exceptional circumstances, and then only for a short period in a very hot summer.

Combined with low temperatures, the high moisture content of the soils in the Lammermuirs and Moorfoots tends to retard the decomposition of organic matter and leads to an accumulation of raw humus or peat as a surface horizon. Fig. 12 shows these peaty soils, hill peat, and podzols, confined mainly to the Lammermuir Group which have an annual water surplus of about 20 inches or more. The presence of peaty gleys and other peaty soils outside this area is due either to topographic or parent material effects. In the eastern part of Sheet 25 and on most of Sheet 26, where the annual water surplus is 10 inches or less, a different effect is noted. The area is mainly a till plain, where run off is slight because of the small relative relief. Percolation of water through the soil is retarded by clayey texture and low permeability. These conditions are usually conducive to the formation of a surface water gley soil, the result of the collection of a relatively high amount of water in the upper horizons. It has been shown above, however, that the amount of available water is comparatively low, or nil, especially during the summer months when chemical soil processes are most active. Consequently a brown forest soil with gleyed B and C horizons is formed rather than a calcareous or non-calcareous gley which are more strongly gleyed soils.

The effect of temperature, and of evaporation which is related to temperature through solar radiation, is mentioned above in connection with the formation of raw humus. The temperature of a soil determines the rate of chemical reactions and bacterial action within it and so the colder the soil

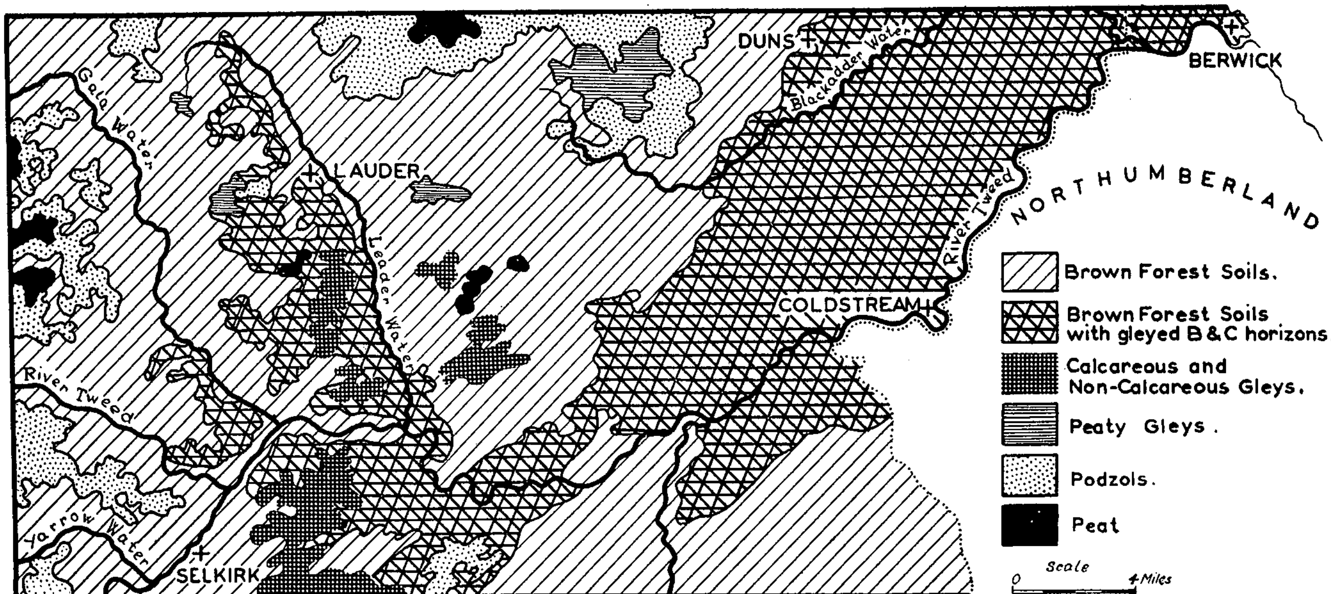


FIG. 12. Distribution of Major Soil Sub-groups.

PLATE 13
Foulshiels from Black Andrew Wood. The dominant soil on these hill tops is an iron podzol (Minchmoor series) under a *Calluna* dominant heath.

PLATE 14
Heath on Minchmoor series with more vigorous growth of *Nardus stricta* compared with *Calluna vulgaris* after burning.

Plate 15
Pasture dominated by *Deschampsia caespitosa* and *Juncus effusus* on the poorly drained Cessford series.

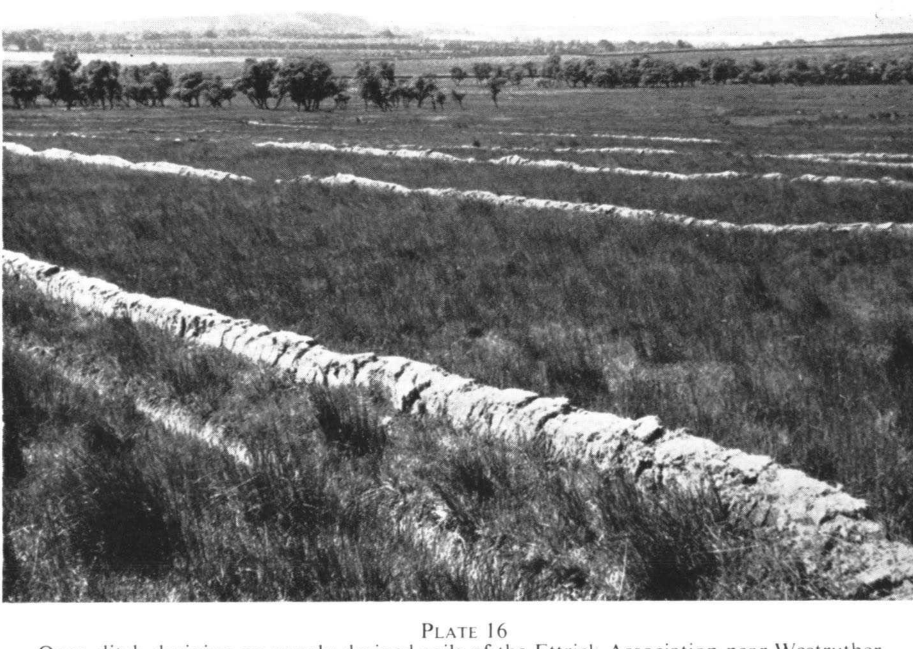


Plate 16
Open ditch draining on poorly drained soils of the Ettrick Association near Westruther.

the less severe are the chemical changes and bacterial breakdown of organic matter. This retardation of organic decomposition reinforces the effect of waterlogging mentioned above. A further consequence of temperature is the expansion of soil water upon freezing which tends to break up soil peds and produce a fine structure. In this area soil freezing seldom extends below 12 inches in depth.

Organisms

Organisms may be divided into micro-organisms and macro-organisms. The effect on soil of various micro-organisms, fungi, bacteria, mites and springtails, is very complex and outwith the scope of this memoir but their chief role in a soil is in the decomposition of organic matter and the formation of soil aggregates. Together with plant remains the coprogenic products of the mites and springtails are a common constituent of moder humus. Of the macro-organisms the earthworm, which ingests soil and organic matter and excretes them as casts intimately mixed with the organic matter in the mull form, is probably the most important.

The relationship between the vegetation and the soils of the area is more readily discerned where the vegetation is in a natural or semi-natural state. Generally coniferous and ericaceous vegetation is associated with raw humus and peaty-topped soils, while broad leaved trees and shrubs and herbaceous flora are associated with moder and mull forms. Correlation between major soil sub-groups and vegetation is also marked and is described in Chapter VII.

Man also must be taken into account as a soil forming factor; cultivation alone will destroy the natural vegetation and cause change of structure and mixing of the various A horizons. The addition of fertilizers and the removal of crops have marked effects on the chemical and organic properties of the surface soil and the practice of artificial drainage, whether tile or surface drainage, can completely alter the soil water relationships. The cultivation of hill ground in the Gala Uplands has altered many soils which were podzols and peaty gleys into what now appear to be brown forest soils and non-calcareous gleys respectively. Conversely the forester by planting coniferous species on non-calcareous gleys and brown forest soils has initiated their transformation to peaty gleys and weak podzols. Much of the land with brown forest soils with gleyed B and C horizons is artificially drained by 3 inch clay tile drains, 5 yards apart and 2-4 feet deep. The removal of these drains, or their blockage by poor maintenance, would result in the reversion of the slightly gleyed brown forest soils to a form of gley, a soil much less suited to arable agriculture or hardwood forestry.

Relief

The soil water regime is governed by the nature of the parent material and by the steepness of the slope upon which the soil is sited. The steeper the slope the greater is the gravitational effect causing lateral movement of soil water and the greater is the surface run off. Therefore, other conditions being equal, the steeper the slope, the smaller is the amount of soil water and gleying. On a flat site the lateral movement of soil water is at a minimum and waterlogging at a maximum. Thus on flat and concave sites gleying is at a maximum. This principle also applies to the formation of peat and raw humus resulting from wet and anaerobic conditions. Peat is more likely to form on flat or concave sites.

Relief also partly determines what type of parent material is deposited or formed at any spot. During the Pleistocene period the local ice movement in the hill areas was determined largely by the pre-existent valleys. In the Gala Uplands, therefore, till is more likely to be found in the valley bottoms and hollows. On the steeper slopes the effect of gravity, together with frost, has caused solifluction and the consequent collection of solifluction products further down the slope.

Parent Material

Parent material plays an important part in soil formation in the area by virtue of its texture (effecting permeability and porosity) and its acidity or quartz content.

Next to the relief factor, the parent material is the factor which largely determines the drainage of a soil. If a soil is developed on a clayey till it is almost certain to show signs of gleying due to the impermeability and consequent waterlogging of the till. The deposits associated with the Old Red Sandstone formations and the stony solifluction products on the hill land are both coarse in texture, relatively permeable and have a low water retention capacity. Freely drained soils are generally found in these areas.

The acidity of the parent rock is also important and is most noticeable on soils developed on parent materials derived from Old Red Sandstone formations. These parent materials have a high quartz content and give rise to soils with a low pH. The acid condition of these soils restricts the activity of the soil micro-organisms and thereby retards the break down of organic matter. Raw humus forms and gives rise to podzols and peaty gleys at about 750 feet, such as at Greenlaw Moor and around Westruther. As the other parent materials on Sheet 25 are not so markedly acid the conditions conducive to raw humus formation do not prevail except at 900 feet or above.

Time

Except for alluvial soils, where accumulation of mineral matter has ceased in recent times, the time factor exerts no differentiating influence on the soils in this area for all are, geologically and pedologically speaking, the same age.

CHAPTER VI

The Soils

TWENTY-SEVEN soil series have been distinguished in the area, of which sixteen are common to the South Borders already described by Muir (1956).

Table J shows the areas covered by these series and other soil categories. All the soil categories which make up a soil association are on the same horizontal line. Series are given place names, but other soil categories are designated by symbols only. Each association bears the same name and symbol as one of its series, usually of the most characteristic of the area in which the association was first described. Vertically each series is related to drainage class and major soil group; skeletal soils and soil complexes are in separate columns. Soil series can be divided into phases on the basis of some single characteristic which usually affects agricultural practice; stone content, depth of surface horizon, proximity of rock to surface and slope are a few of these. Thus, in the North Borders (Sheets 25 and 26) the surface horizon is of intermediate thickness (i.e. 8 to 12 inches) in most soils, but shallow phases (surface horizon <8 inches) have been noted on the Darleith, Linhope, Lauder and Sourhope series and deep phases (>12 inches) on the Eckford and Whitsome series. A stony phase of the Eckford series and steep phases of Linhope and Sourhope series also occur. These phase differences are recorded on field maps but not on the published map.

The areas and percentage areas of major soil groups and sub-groups and other soil categories may be extracted from Table J. Normal brown earths account for most of the North Border region; including those incorporated in soil complexes they occupy almost three-quarters of this area. Of these, however, about 40 per cent show some signs of gleying and are imperfectly drained, normally requiring artificial drainage for arable farming to be successfully accomplished. Gley soils are not particularly widespread accounting for only 10·6 per cent; of these 1·3 per cent are peaty gleys. The only other organo-mineral soils are the podzols which cover 7·4 per cent of the area. The remaining 15·9 per cent is made up of peat, alluvium, skeletal soils, soil complexes, mixed bottom land and built up areas.

When Table J is compared with Table G for the area in the South Borders given by Muir (1956) two main features emerge. Firstly in the northern area, normal brown earths are almost twice as frequent as in the south and secondly gleys are three times more prevalent in the south than in the north. The main explanation for this is that although fine textured tills, which are conducive to gley formation, are more widespread in the north, the rainfall is much lower and on balance fewer gleys are formed. Similarly in the north organo-mineral soils are only half as frequent as in the wetter and colder South Borders. (This climatic factor is also discussed under the section on soil formation). Other soil categories are in similar proportions in the two areas.

The eleven soil associations are described in detail in this chapter. Parent materials and parent rocks are dealt with generally under each association

TABLE J.—AREA OF SOIL CATEGORIES (Sq. Miles)

Association	Brown Forest Soils (SERIES)		Calcareous and Non-Calcareous Gleys (SERIES)		Podzols (SERIES)		Peaty Gleys (SERIES)		Complexes		Skeletal Soils
	Freely Drained	Imperfectly Drained	Poorly Drained	Very Poorly Drained	Freely Drained	Freely Drained below B_1	Poorly Drained	Very Poorly Drained			
Bemersyde 4·2	Bemersyde 0·2				Dirrington 3·5						BE. z. 0·5
Darleith 1·4	Darleith 1·2										DL. z. 0·2
Eckford 10·0	Eckford 9·5				Hexpath 0·5						
Ettrick 224·5	Linhope 80·6	Kedslie 53·9	Ettrick 34·8	Peden 0·5	Minchmoor 29·0	Dod 1·0		Hardlee 1·5	ER. c. 18·6	ER. ch. 1·1	ER. z. 3·5
Hobkirk 86·3	Hobkirk 68·3		Cessford 6·7		Faw 5·8		Wauchope 5·5				
Lauder 23·1	Lauder 22·4		Lylestone 0·7		Langtonlees 0·04						
Minto 7·5		Belses 5·0	Minto 2·5								
Smailholm 6·7	Smailholm 6·7										
Sourhope 14·6	Sourhope 10·9		Atton 1·9								SH. z. 1·8
Whitsome 118·5		Whitsome 91·7	Horndean 3·4						WH. c. 23·4		
Yarrow 6·7	Yarrow 6·7										
503·5	206·5	150·6	50·0	0·5	38·8	1·0	5·5	1·5	42·0	1·1	6·0

Hill Peat, 4·0; Basin Peat, 3·4; Alluvium, 21·1; Peat Alluvium Complex, 2·1; Mixed Bottom Land, Towns etc., 6·2. TOTAL AREA: 540·3 heading but further data on the parent rocks may be obtained from the chapter on Geology. Soil morphology is discussed in detail under series headings together with details of local variations or phase differences. Peat, alluvium, and mixed bottom land are described at the end of the chapter.

ASSOCIATIONS

THE BEMERSYDE ASSOCIATION

The Bemersyde Association is one of the smallest associations and covers only 0·8 per cent of the area. The association occurs on intrusive plugs and sills, namely the Eildon Hills, the Dirrington Laws and White Hill, Black Hill and Bemersyde Hill, and is always very stony and entirely uncultivated.

PARENT MATERIAL

The parent rocks are fine grained riebeckite trachytes and allied acid igneous rocks which have suffered frost shattering and solifluction. The main constituents of the rock are quartz and felspar, the former being as high as 75 per cent.

SOILS

In this area the Bemersyde Association is represented only by two freely drained series, the Bemersyde and the Dirrington, and by skeletal soils. Because of stoniness, shallowness and exposure, the soils are of little agricultural use other than for the provision of rough grazing.

Series

BEMERSYDE SERIES

The Bemersyde series covers some 6 per cent of the association. It is a brown forest soil of low base status, usually less than 3 feet deep and very stony.

PROFILE DESCRIPTION

SLOPE	moderately steep
ASPECT	west
ALTITUDE	650 feet
ANNUAL PRECIPITATION	28 inches
VEGETATION	*Festuca ovina* and *Deschampsia flexuosa* *(a & co-d), *Vaccinium myrtillus* (a), *Erica cinerea* (a) *Ulex europaea* (la), *Agrostis tenuis* (f), *Calluna vulgaris* (o) *Rhytidiadelphus squarrosus* (la)
DRAINAGE CLASS	free to excessive

Horizon	*Depth*	
L	1-0″	Grass litter
A_1	0-1″	Dark reddish brown (5YR2/2) sandy loam; fine crumb structure; friable; high organic content; no stones; roots abundant; clear change into
A	1-7″	Dark reddish brown (5YR3/4) loam; fine crumb structure; friable; moderate organic content; abundant small angular stones; abundant roots; clear change into
B_2	7-21″	Yellowish red (5YR4/6) stony loam; fine crumb structure; friable; low organic content; very abundant angular stones; gradual change into
D	21″+	Angular trachyte rubble with dark reddish brown (2·5YR3/4) weathered skin.

*d=dominant; co-d=co-dominant; a=abundant; la=locally abundant; f=frequent; c=common; o=occasional; r=rare.

The main characteristic throughout the profile is the fine crumb structure and friable consistence. The A_1 horizon has a high organic content and may be capped by a thin H layer. In the A horizon organic matter is only moderate. No mottling is seen in the profile and the B_2 horizon is very stony and contains many air spaces. Solid rock or shattered rock is seldom more than 24 inches below the surface.

DIRRINGTON SERIES

Over 80 per cent of the Bemersyde Association is made up of the Dirrington series, an iron podzol developed on the same parent material as the Bemersyde series but at higher altitude and under higher rainfall. The dominant vegetation is a Callunetum.

PROFILE DESCRIPTION

SLOPE		moderately steep
ASPECT		north west
ALTITUDE		1,100 feet
ANNUAL PRECIPITATION		35 inches
VEGETATION		*Calluna vulgaris* (a & d) *Festuca ovina* (a) *Anthoxanthum odoratum* (f) *Nardus stricta* (f) *Hypnum cupressiforme* (la)
DRAINAGE CLASS		free
Horizon	*Depth*	
L	4-3½″	Litter of grass and heather
F	3½-3″	Partially decomposed litter
H	3-0″	Very dusky red (2·5YR2/2) dry, fibrous humus
A_1	0-3″	Very dark grey (5YR3/1) humose sandy loam; medium crumb structure; friable; high organic content; angular stones frequent; grit abundant; roots abundant; clear change into
A_2	3-5″	Light grey (10YR7/2) sandy loam; weak platy structure breaking into very fine angular blocky; moderate organic content; small stones abundant; roots abundant; sharp change into
B_2	5-13″	Dark red (2·5YR3/6) loam; medium sub-angular blocky; friable; large angular stones very abundant; roots occasional; sharp change into
D	13″	Shattered pink trachyte.

The H horizon is a dry raw humus which is easily reduced in thickness by heather burning. In summer, due to shallowness, the upper horizons are usually very dry and consequently light in colour but a heavy period of rain can render the A_1 almost black and the A_2 a very dark colour. A humus-iron B_1 horizon is sometimes shown. The B_2 horizon is characterised by its dark red or reddish brown colour and extreme stoniness.

Skeletal Soils

Skeletal soils are fairly well represented in this association and account for some 12·5 per cent. Angular trachyte blocks are always present at the surface and solid rock, if not visible, is seldom more than 12 inches down. These soils usually have a sparse heath vegetation with *Calluna vulgaris* as the dominant species. In some places, if a profile can be dug through the rubble, a weak peaty podzol can be seen with a humus B_1 horizon at about 4 inches.

THE DARLEITH ASSOCIATION

The Darleith Association is the least extensive in the area, covering only 0·3 per cent of the whole. Its soils cover the tops of the Brotherstone Hills, Redpath Hill, Peniel Heugh and many small knowes around Smailholm and Gordon. As in the case of the Bemersyde Association, the stoniness and shallowness of these soils preclude cultivation, but on the Darleith series, which is the only series represented, good semi-natural grazing turf of bent-fescue is established.

PARENT MATERIAL

The Darleith Association in Ayrshire as described by Mitchell and Jarvis (1956) is developed on till derived from lavas of intermediate and basic composition. In the Borders the freely drained series is developed on frost shattered or soliflucted basalt with little or no contamination from ice-transported material. The basalts in the form of plugs, are all olivine bearing, about 10 per cent, and have a high ferro-magnesian content generally exceeding 20 per cent. The phosphorous bearing mineral apatite is also present. Further petrological details are given in the chapter on geology.

SOILS

In this area the Darleith Association is represented only by the Darleith series and by skeletal soils. The former is usually to be found on steep and hilly topography and the latter on hill tops. This is illustrated in Fig. 13.

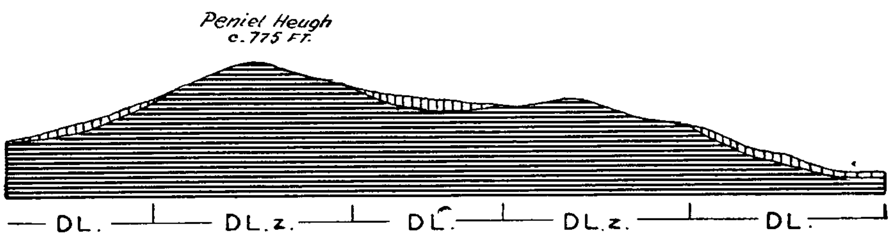


FIG. 13. Section through Darleith Association.

Series

DARLEITH SERIES

The Darleith series comprises approximately 87 per cent of the association. The soils are brown forest soils of low base status, usually less than 3 feet deep and very stony.

PROFILE DESCRIPTION

SLOPE	moderate
ASPECT	south west
ALTITUDE	700 feet
ANNUAL PRECIPITATION	28 inches
VEGETATION	*Agrostis tenuis* (a & d) *Festuca ovina* (a) *Luzula multiflora* (f) *Urtica dioica* (f) *Trifolium repens* (f) *Rumex acetosella* (o) *Rhytidiadelphus squarrosus* (lf)
DRAINAGE CLASS	free

Horizon	*Depth*	
L	½-0″	Grass roots
A	0-3″	Very dark grey brown (10YR3/2) loam; fine crumb structure; friable; moderate organic content; occasional small angular stones; abundant roots; clear change into

B_2	3-15"	Dark brown (7·5YR3/2-4/4) loam; medium crumb structure; friable; weakly indurated; low organic content; very abundant angular stones; roots abundant; gradual change into
B_3	15-27"	Dark brown (7·5YR4/4) gritty loam; sub-angular blocky; firm; indurated; angular stones very abundant; roots rare; sharp change into
D	27"+	Shattered basalt.

This series is invariably shallow, provided the underlying basalt has not undergone subaerial weathering, the D horizon being rarely more than 3 feet from the surface. It is very stony, all the stones being angular. Unlike the other freely drained series of the Borders which are developed on more acid parent materials, the humus form is mull-like rather than moder, and can be equated with the ferritic braunerde of Kubiena (1953). The characteristic morphology of this series is a loose, friable crumb structure in the A and B_2 horizons and slight induration in the B_3 horizon.

Skeletal Soils

The skeletal soils cover some 13 per cent of the association occurring mostly where solid basalt outcrops or is within a few inches of the surface. The skeletal soils are not restricted to sites adjacent to Darleith series and are found on isolated intrusions surrounded by soils of the Hobkirk, Smailholm and Whitsome Associations.

THE ECKFORD ASSOCIATION

Soils of the Eckford Association are formed on glacial lake deposits and fluvioglacial sands which are found in scattered areas on the eastern half of Sheet 25, and in the south-west of Sheet 26. They form a group of soils which are among the coarsest textured soils of the Borders.

Distribution

Relatively extensive areas of this association are found in the Teviot valley around Eckford and also around Gordon. Minor areas are found near Hallyburton, Cammerlaws, Greenlaw, Earlston, Legerwood and Yetholm, and there are traces around Din Moss which are not sufficiently important to be mapped.

Parent Material

The parent material of the Eckford Association is fluvio-glacial or lacustro-glacial sands. The deposits around Eckford are old river terraces while the Gordon deposits are mostly of lacustrine origin. The latter often contain large olivine basalt boulders and the surface soil may be quite stony. These sands are derived, in the main, from the sandstones of the Upper Old Red Sandstone formation but may also incorporate gravel lenses, kames and eskers which contain greywacke pebbles. Around Yetholm, however, the parent rocks are the intermediate lavas of the Cheviot Hills. In both cases the parent material is a pale pink or weak red sandy deposit.

Soils

The only series found in the area are the Eckford and the Hexpath. The former is a freely drained brown forest soil, the latter a podzol. Small areas

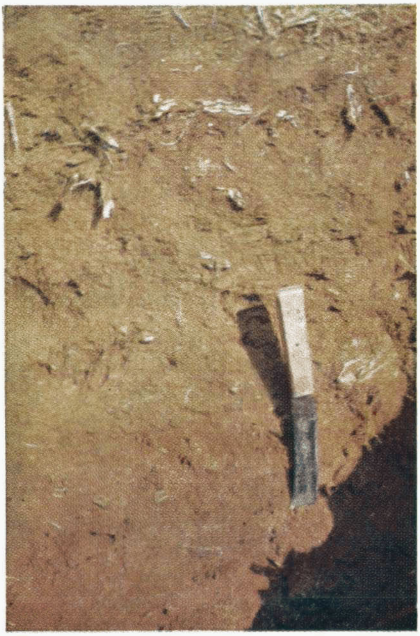


PLATE 1.
Linhope series, a brown forest soil of low base status.

PLATE 2.
Whitsome series, a brown forest soil with gleyed B and C horizon.

PLATE 3.

Hardlee series, a peaty gley.

PLATE 4.

Ochreous mottling within a prismic ped.

of a poorly drained soil (Woodend Series) are also found, but are too small to be delineated on a one inch to the mile map. The Woodend series is described by Muir (1956). Fig. 14 illustrates the moundy topography associated with this association and the relationship with the Hobkirk Association.

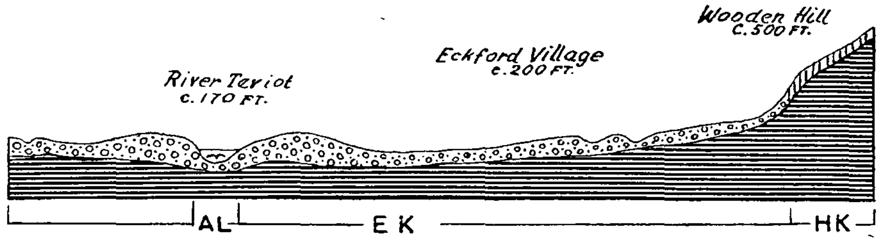


FIG. 14. Section through Eckford Association.

Series

ECKFORD SERIES

The Eckford series, a brown forest soil of low base status, is by far the most extensive covering over 95 per cent of the association. Being of coarse texture the soils are easily worked and are generally suitable for arable farming.

PROFILE DESCRIPTION

SLOPE		gentle
ASPECT		south west
ALTITUDE		450 feet
ANNUAL PRECIPITATION		28 inches
VEGETATION		third year grass
DRAINAGE CLASS		free
Horizon	*Depth*	
S	0-9″	Reddish brown (5YR5/4) sandy loam; fine sub-angular blocky; friable; low organic content; occasional small rounded greywacke pebbles; roots abundant; sharp change into
B_2	9-18″	Reddish brown (2·5YR4/4) loamy sand; single grain structure; loose; no organic matter except in worm tracks containing S horizon material; occasional small pebbles; roots occasional; boundary diffuse
C	18″+	Weak red (10YR4/4) and reddish yellow (5YR6/6) stratified sand and fine sand; single grain structure; loose; no organic matter; no stones; roots rare.

The S or A horizon varies in thickness from 9-12 inches and has a crumb or fine blocky structure. The B and C horizons are always very coarse in texture; usually they show well marked stratification and have a single grain structure. Where more fine sand is present a weak crumb structure may develop. A stony phase is developed on kames and eskers in the Earlston, Gordon and Greenlaw districts.

HEXPATH SERIES

The Hexpath series is not extensive and accounts for only 4·8 per cent of the association. This series, an iron podzol, is always found under a semi-natural vegetation which is some form of Callunetum. Cultivation and liming change it into a soil closely resembling Eckford series.

GENERALISED PROFILE DESCRIPTION

SLOPE	level
ASPECT	north
ALTITUDE	550 feet
ANNUAL PRECIPITATION	33 inches

VEGETATION		*Calluna vulgaris* (a & d), *Juncus squarrosus* (f), *Nardus stricta* (f)
DRAINAGE CLASS		free
Horizon	*Depth*	
H	2-0″	Black, dry, fibrous humus
A_1	0-1″	Very dusky red (2·5YR2/2) sand; medium angular blocky; friable; high organic content; no stones; conspicuous quartz grains; frequent roots; sharp change into
A_2	1-3″	Dark grey (5YR4/1) loamy sand; single grain structure; medium organic content; occasional small sub-rounded stones; frequent roots; gradual change into
B_1	3-7″	Dark reddish brown (5YR2/2) loamy sand; weak medium platy structure; firm, compacted; high organic content; trace of thin iron pan at base; occasional stones; roots frequent; boundary very sharp
B_2	7-13″	Yellowish red (5YR5/8) loamy sand; single grain; friable; no organic matter; occasional sub-rounded stones; roots frequent; gradual change into
B_3	13-20″	Yellowish red (5YR4/8) loamy sand; single grain; friable; frequent sub-rounded olivine basalt stones; roots occasional; gradual change into
C	20″+	Red (2·5YR4/8) sand; single grain, stratified; friable; frequent sub-rounded basalt stones; roots rare.

The L and F layers are frequently missing in this profile due to severe heather burning; for the same reason the H horizon may be only 1 inch thick. The A_1 and A_2 horizons are typical of a podzol with their dark grey or grey colour and conspicuous quartz grains. The B_1 horizon is enriched with iron and humus and has a characteristic dark reddish brown colour. It is almost always compacted and may or may not show iron accumulation in the form of a thin pan at its base. The B_1 horizon gives the profile the character of an iron-humus podzol as described by Kubiena (1953). Both the B_2 and B_3 horizons have a high chroma on the Munsell charts in the brown colours indicating an enrichment of free iron oxides.

THE ETTRICK ASSOCIATION

The Ettrick Association is the most extensive, covering most of the western part and some of the northern part of the area; it amounts to some 40 per cent of the whole. It is developed on both Ordovician and Silurian rocks and on drifts derived from them.

DISTRIBUTION

The Ettrick Association falls naturally into two geographical divisions which are part of the Southern Uplands.

Area I is in the west of Sheet 25 and is one of the largest areas of one association to be described in this memoir. To the east it extends to Lauderdale and to the south it has a common boundary with the Minto and Hobkirk Associations.

Area II lies west of Lauderdale and to the north of a line from the Boondreigh Water to Dirrington Burn.

In both areas the underlying strata are isoclinally folded and the relief is hilly to mountainous with the exception of west Lauderdale and Bowden Moor where it is of a rolling nature. Around and to the east of Selkirk where the nature of the folding is excessively steep the micro-relief is so intensive that it is more important than the hilly or rolling macro-relief; the term given to this is "corrugated" and is the basis of the delineation of the soil complexes described at the end of this section.

PARENT MATERIAL

The Ettrick Association is developed on grey and reddish brown greywackes, flagstones and shales ranging in age from Caradocian (Upper Ordovician) to Llandoverian (Middle Silurian), and from drifts derived from these rocks. The main petrologic feature of these rocks is that they are arkosic and contain the clay mineral chlorite. The acidity of the greywackes varies considerably and this is reflected in the soils.

Throughout the association there are areas where the rocks and the drifts have a reddish tinge caused by a small percentage of haematite. This has already been described by Muir (1956 p. 46) for an area near Hawick. Around the Eildon Hills, Bowden Moor, Heriot, Galashiels, Earlston and west of the Leader Water all series of the association inherit a red colour. Peach and Horne (1930, p. 19) attribute this red colouration to staining from pre-existent Old Red Sandstone rocks above. This may be so, but the frequency with which red soils and red drifts occur is greatest where igneous sills and dykes are found, suggesting that thermal metamorphism may also be a cause of the red colouration.

In this association a clayey till is most extensive in depressional sites and on the flanks of river valleys and their tributaries. It is seldom found to any thickness in a convex site except between Selkirk and St. Boswells on Bowden Moor. This till, which is a brownish or reddish grey colour contains many large sub-rounded greywacke boulders, but does not appear to be far travelled. The soils developed on it are always gleyed, and are imperfectly, poorly or very poorly drained. On the hill ground tills are rare or absent and the soils are derived from solifluction products or frost debris of greywacke and shale. Whereas in the till the stones are sub-rounded, they are angular or sub-angular on the hills and show a tendency to align themselves downhill rather than in the direction of ice movement.

Except to the east of Lauderdale where there is some carry over of Old Red Sandstone conglomerates the area is free from other rocks. Some fragments of strained quartz or calcite are found, but these are secondary minerals occurring in fissures in the greywackes.

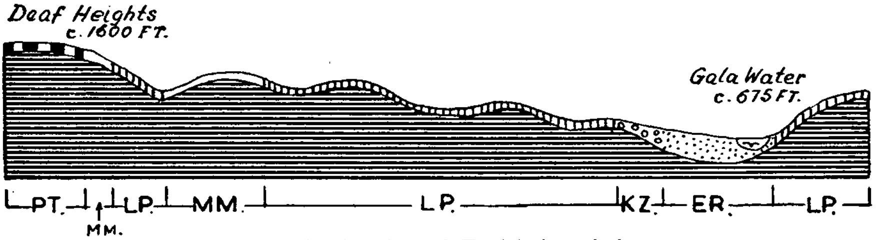


FIG. 15. Section through Ettrick Association.

SOILS

All the major soil groups found over the two maps are represented in the Ettrick Association. They include brown forest soils, peaty podzols, iron podzols, non-calcareous and peaty gleys.

Within the association there are series with drainage varying from free to very poor, several of which are further distinguished by having peaty tops.

Two complexes developed on corrugated topography have also been recognised—one, ER.c, distinguished by the lack of an organic surface horizon and the other, ER.ch, by the presence of a peaty top. Both the freely drained series, Linhope and Minchmoor, are generally found associated with hilly topography while the poorly drained series, Ettrick, Peden and Hardlee occupy depressional sites. The imperfectly drained Dod and Kedslie series develop on sites of intermediate nature. The topographical relationship of the more important series is shown in Fig. 15.

Most of the profile descriptions given below, are of uncultivated soils under a semi-natural vegetation.

Series

LINHOPE SERIES

The Linhope series, the most extensive series in the association is developed on material of medium texture derived from frost shattered or soliflucted greywacke and shale. This material has a high stone content and is found on steep slopes and hill tops. Solid rock is seldom more than four feet from the surface. This series occurs mainly in the Gala Uplands and is almost unrepresented in the Lammermuir Group. The vegetation is usually some form of acid grassland. The series is a brown forest soil of low base status and the drainage class is free (Colour Plate 1).

PROFILE DESCRIPTION

SLOPE		steep
ASPECT		south
ALTITUDE		1000 feet
ANNUAL PRECIPITATION		35 inches
VEGETATION		*Pteridium aquilinum* (a & co-d), *Agrostis spp.* (a & co-d) *Poa pratensis* (a) *Oxalis acetosella* (f) *Potentilla erecta* (f) *Deschampsia flexuosa* (la) *Hylocomium squarrosum* (la)
DRAINAGE CLASS		free
Horizon	*Depth*	
L	½-0″	Litter
A	0-7″	Dark brown (7·5YR3/2) loam; medium crumb structure; very friable; low organic matter; stony; roots abundant; no mottling; gradual change into
B_2	7-18″	Strong brown (7·5YR5/6) loam; fine crumb structure; very friable; low organic content; stony; roots frequent; no mottling; clear change into
B_3	18-27″	Yellowish brown (10YR5/6) loam; medium crumb structure; weakly indurated; friable; no organic matter; stony; roots occasional; no mottling; clear change into
C	27-40″	Brown (10YR5/3) loam; very stony; no organic matter; roots rare; no mottling; sharp change into
D	40″+	Shattered greywacke with trace of C horizon material in interstices.

The A horizon has a moder type humus and generally a well developed crumb structure. The B_2 horizon has a colour of greater chroma than either the A or C horizons and a loose, fine crumb structure. The B_3 horizon is not always present or clearly defined. When present it is often weakly indurated and always merges into a very stony C horizon. Mottling is usually absent from the profile but may sometimes occur to a slight extent in the B_3 and C horizons. A phase of this series with reddish brown colours is located around the Eildon Hills, Bowden Moor, Heriot, Galashiels, Earlston and west of the Leader Water.

MINCHMOOR SERIES

The Minchmoor series, an iron podzol, is developed on a parent material identical with that of Linhope series but is not found on steep slopes or at altitudes less than 1000 ft. i.e. in the Moorfoot and Lammermuir Groups. When it is found lower than 1000 ft. it is always poorly developed and is easily changed by cultivation or heavy liming to a profile resembling Linhope series. The vegetation is almost always a form of Callunetum.

Profile Description

SLOPE		gentle
ASPECT		north
ALTITUDE		1250 feet
ANNUAL PRECIPITATION		40 inches
VEGETATION		*Calluna vulgaris* (a & d) *Vaccinium myrtillus* (f) *Festuca ovina* (f) *Agrostis spp.* (f) *Deschampsia flexuosa* (o) *Empetrum nigrum* (o) *Hypnum cupressiforme* (o) *Dicranum scoparium* (o)
DRAINAGE CLASS		free
Horizon	*Depth*	
L	Trace	Litter
F	Trace	Partially decomposed litter
H	2-0″	Black, dry, fibrous humus.
A_1	0-1″	Very dark grey (5YR3/1) organic loam; medium granular structure; firm (caused by binding action of roots); high organic matter; occasional sub-angular stones; roots abundant; sharp change into
A_2	1-4″	Grey brown (10YR5/2) sandy loam; medium granular structure; medium organic content; angular stones abundant; sharp change into
B_1	4-5″	Dark reddish brown (5YR2/2); humose sandy loam; firm; high organic content; angular stones abundant; roots locally frequent; very sharp change into
B_2	5-15″	Strong brown (7·5YR5/8) loam; fine crumb structure; very friable; angular stones very abundant; roots frequent; gradual change into
B_3	15-22″	Brown (7·5YR5/4) loam; fine sub-angular blocky; weakly indurated; roots occasional; stones very abundant; gradual change into
C	22-28″	Yellowish brown (10YR5/4) loam; structure obscured by stones; roots rare; stones very abundant
D	28″+	Shattered greywacke.

The thickness of the H layer is variable but seldom more than about four inches; frequent burning of heather reduces the thickness of this horizon. The humus form is raw humus (mor) and is almost always dry and friable. The A_1 and A_2 horizons both show signs of bleaching. Both contain white quartz grains, generally visible to the naked eye. The B_1 horizon is usually a diffuse humus iron-pan, seldom a thin iron pan as in Dod series; on some sites this horizon is rudimentary or absent. The B_2 horizon is granular or crumb in structure and always has an abundance of angular stones. The profile usually shows good texture differentiation across the B_1 horizon. The A_2 horizon is generally a sandy loam and the B_2 and B_3 horizons of loam texture.

DOD SERIES

In contrast to the proportion on Sheet 17, the Dod Series is here of minor significance amounting to only 0·5 per cent of the association. The till upon which it is developed is of medium texture and is often stony. The vegetation can be a form of Nardetum, Molinietum or Callunetum. This series is a peaty podzol and is freely drained below the A_2g horizon.

Profile Description

SLOPE	moderate
ASPECT	south east

ALTITUDE	1100 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	*Molinia caerulea* (a & d) *Nardus stricta* (la) *Festuca ovina* (f) *Juncus squarrosus* (f) *Anthoxanthum odoratum* (o) *Galium hercynicum* (o) *Luzula multiflora* (o) *Deschampsia flexuosa* (o) *Vaccinium myrtillus* (o)
DRAINAGE CLASS	free below A_2g.

Horizon	*Depth*	
L	Trace	
F	8-7″	Decomposing root mat
H	7-0″	Black greasy humus
A_1	0-5″	Very dark brown (10YR2/2) sandy loam; fine sub-angular blocky; friable; angular stones occasional, some white quartz grains; roots abundant, no mottling; sharp change into
A_2g	5-9″	Dark grey brown (10YR4/2) loam; weak platy structure breaking into medium sub-angular blocky; friable; very dark brown (10YR2/2) organic staining; sub-angular stones frequent; roots frequent; occasional dark reddish brown (5YR3/3) mottles; sharp change into
B_2	9-15″	Brown (7·5YR5/5) fine sandy clay loam; medium sub-angular blocky; friable; no organic matter; stones frequent; roots frequent; occasional reddish yellow (5YR6/8) mottles; clear change into
B_3	15-20″	Pale brown (10YR6/3) loam; medium sub-angular blocky structure; weakly indurated; sub-angular stones abundant; occasional reddish yellow mottles; gradual change into
C	20″+	Pale brown (10YR6/3) clay loam; massive; firm; sub-angular and sub-rounded stones abundant; roots rare; no mottles but black (manganiferous) staining.

The thickness of the H horizon which is of the raw humus type, varies but is generally greater than 2 inches. The A_1 horizon is sometimes rudimentary or absent but if present contains white quartz grains. The A_2 horizon shows signs of bleaching and gleying by the grey colour and mottling. Thin iron pan (as described by Muir 1956) is often absent. The B_2 and B_3 horizons are generally freely drained but the B_2 may be gleyed as above. There is little differentiation of structure in the B horizon but the B_3 is generally compacted and tending towards a massive rather than a blocky structure. The C horizon usually has the finest texture while the A_1 horizon, and sometimes the A_2, has a coarse texture influenced by organic matter.

KEDSLIE SERIES

The Kedslie series, a brown forest soil with gleyed B and C horizons, covers 24 per cent of the Ettrick Association and accounts for the major part of the arable land within the association. It is found developed on a till of fine texture, usually on a gentle or moderate slope. Its drainage class is imperfect, often because of its fine texture. The major areas covered by this series are in the lower parts of the Gala Uplands around Melrose, St. Boswells and to the west of the Leader Water.

PROFILE DESCRIPTION

SLOPE	moderate
ASPECT	south east
ALTITUDE	600 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	second year grass
DRAINAGE CLASS	imperfect

Horizon	*Depth*	
S	0-8″	Brown (7·5YR4/2) loam; medium sub-angular blocky structure; firm; medium organic content; frequent sub-angular and sub-rounded stones; roots abundant; occasional small ochreous specks; sharp change into

$B_2(g)$	8-11″	Brown (7·5YR5/4) loam; sub-angular blocky; firm; low organic content; frequent sub-angular and sub-rounded stones; roots abundant; large, strong, reddish yellow (7·5YR6/7) mottles; clear change into
$B_2(g)$	11-19″	Reddish brown (5YR5/4) clay loam; weak medium prismatic; low organic content; frequent sub-angular and sub-rounded stones; roots occasional; reddish yellow (7·5YR6/7) and brown (7/5YR4/4) mottles with many light brown grey (10YR6/2) streaks and patches; gradual change into
C(g)	19″+	Reddish brown (5YR4/3) clay loam; massive; very firm; abundant stones as above; roots rare, mostly dead; fine reddish yellow (7·5YR6/7) and light brown grey (10YR6/2) mottles; strong black staining.

The surface horizon has usually a fine or medium sub-angular blocky structure and the organic matter content is moderate to low. The $B_2(g)$ horizon lacks the high chroma of the freely drained series often having a similar colour to the C(g) horizon. The structure is either sub-angular blocky or prismatic and the peds usually have a uniform grey colour, mottling being confined within the peds. The C(g) horizon is always massive and less gleyed than the $B_2(g)$.

ETTRICK SERIES

The Ettrick series, a non-calcareous gley, is to be found mostly in the Gala Uplands on till of fine texture and on flat or gently sloping sites. Its drainage class is poor, usually due to the fine texture of the parent till.

Where it is found in an uncultivated state the Ettrick series shows a distinctive vegetation with *Deschampsia caespitosa*, *Juncus effusus*, *J. acutiflorus* and *Holcus lanatus* as common members.

PROFILE DESCRIPTION

SLOPE	level
ASPECT	nil
ALTITUDE	600 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	*Nardus stricta* and *Festuca ovina* (a & co-d) *Agrostis stolonifera* (a) *Carex spp.* (a) *Deschampsia caespitosa* (f) *Holcus lanatus* (f) *Juncus acutiflorus* (a) *J. effusus* var. *compactus* (f) *Calluna vulgaris* (o) *Luzula campestris* (o) *Hylocomium splendens* (a) *Rhytidiadelphus squarrosus* (a) *Pseudoscleropodium purum* (a) *Thuidium tamariscinum* (f)
DRAINAGE CLASS	poor

Horizon	*Depth*	
L	Trace	
F	Trace	
A_1g	0-5″	Very dark brown (10YR2/2) sandy clay loam; medium sub-angular blocky; firm; medium organic content; no stones; abundant roots; slight brown stains following some root channels; clear change into
A_2g	5-11″	Light brownish grey (2·5Y6/2) clay loam; coarse sub-angular blocky; low organic content; few stones; abundant roots; narrow strong brown (7·5YR5/6) tubes around roots; some mottles; clear change into
B_2g	11-20″	Light olive grey (5Y6/2) clay loam; prismatic; firm; frequent highly weathered stones; roots abundant, mostly dead; strong grey coating of silt or clay on unweathered stones and peds; strong reddish yellow (5YR6/8) mottling within peds; diffuse change into
Cg	20″+	Light grey (5Y6/1) clay loam; very coarse angular blocky structure tending to massive structure; very firm; abundant sub-rounded stones, less weathered than in B_2g horizon; frequent dead roots, rare live roots; yellowish red (5YR5/8) and (5YR4/6) mottles.

Although usually absent a thin raw humus H horizon may be present in this series. The humus being usually of the moder type is incorporated in the A_1g horizon. This horizon has a weak medium sub-angular blocky structure. The A_2g and B_2g horizons show maximum gleying both having drab grey colours and prismatic or coarse blocky structure; mottles are more intense and more frequent than in other horizons and the peds and stones are coated with grey silt or silty clay (Colour Plate 4). The peds of the B_2g horizon are more firm than in the A_2g horizon. The change from B_2g to Cg horizons is usually diffuse, sometimes passing through a B_3g horizon. The Cg horizon is much less gleyed than the A and B horizons and in regions affected by red greywacke has a distinct red coloration.

PEDEN SERIES

Amounting to only 0·2 per cent the Peden series is the least extensive within the association and is usually found in small depressions within areas of Ettrick series. The parent material is similar to that of the Ettrick series but the A horizons tend to be alluvial or colluvial in character. The sites occupied by this series are liable to periodic flooding. The series is a non-calcareous gley and is very poorly drained.

PROFILE DESCRIPTION

SLOPE	level
ASPECT	nil
ALTITUDE	900 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	*Juncus effusus, Carex spp. Nardus stricta* and *Agrostis tenuis* (a & co-d) *Deschampsia caespitosa* (f) *Festuca ovina, Hylocomium splendens* (a) *Rhytidiadelphus squarrosus* (a)
DRAINAGE CLASS	very poor

Horizon	*Depth*	
L	Trace	Litter
F	Trace	Partially decomposed litter
H	1-0″	Black raw humus
A_1g	0-3″	Dark reddish brown (5YR3/2) loam; weak fine blocky; friable; high organic content; occasional small stones; roots very abundant; no mottles; sharp boundary into
A_2g	3-10″	Grey brown (10YR5/2) loam; medium sub-angular blocky; friable; moderate organic content; frequent small stones; abundant roots, many dead; yellowish red (5YR5/8) and light olive brown (2·5Y5/4) mottles; gradual change into
B_2g	10-18″	Grey (10YR5/1) clay loam; medium prismatic; plastic; low organic content; frequent much weathered stones; frequent roots, mostly dead; reddish yellow (7·5YR6/8) mottling, mostly associated with dead roots; gradual change into
B_3g	18-30″	Blue grey (2·5Y6/0) and grey (2·5Y5/1) clay loam; massive; firm; no organic matter; abundant, weathered, blue-grey stones, giving a local sandy texture; occasional dead roots; reddish yellow (7·5YR6/8) mottling following dead root channels; diffuse change into
Cg	30″+	Blue grey (2·5Y6/0) clay; massive; firm; no organic matter, abundant weathered and some fresh sub-rounded stones; dead roots rare; mottling as in B_3g but less intense.

The upper horizons of this soil tend to be wet and the lower horizons moist. This is apparent from the terms used to describe consistence. From the B_2g horizon downwards the colours of the horizons have a blue hue unlike any chip in the Munsell soil colour charts where it is most nearly matched by the grey colours.

PLATE 17
Tussocky *Molinia-Nardus* grassland on the Dod series.

PLATE 18
Large Sphagnum Tussock, approximately 18 inches high, colonised by *Calluna vulgaris* and *Eriophorum vaginatum* on Threepwood Moss.

[*Facing p. 78*]

PLATE 19
Tollishill, an isolated shepherd's house in the Lammermuir Hills.

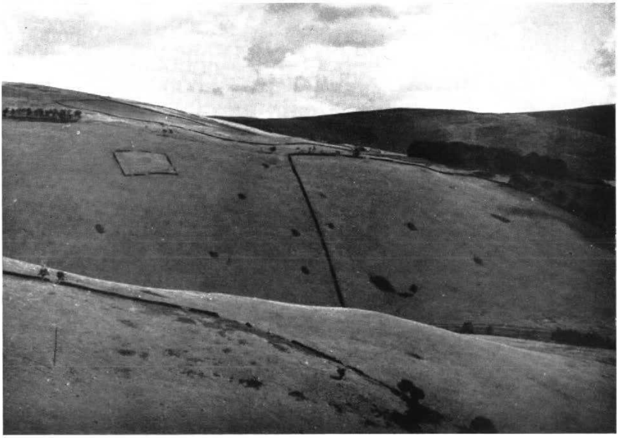


PLATE 20
Very steep fields in the Yarrow Valley. These are on stony soils of the Linhope series and were cultivated during the nineteenth century with steam-ploughs. The dark patches in the fields consist of large stones removed from the surface soil.

Sometimes a thin raw humus H horizon is present but in the drab grey A_1g horizon most of the humus is of the moder type. This horizon has little or no mottling. The A_2g is the zone of maximum gleying, and in this series is usually more than 6 inches thick. It has a medium sub-angular blocky structure. The B_2g horizon, however, shows good prismatic structure, the ped faces being a uniform grey colour; mottling is confined to within the peds. The B_3 horizon has a blue grey colour, its structure is massive, and there is little sign of living matter; all roots are dead and easily seen due to an ochreous or olive brown coating.

HARDLEE SERIES

Where the Hardlee series occurs in this area it is almost always accompanied by the Alemoor series, as described by Muir (1956); this, however has not been delineated due to limitations of scale. The Hardlee series occurs mainly on the southern flanks of the Lammermuir Hills, amounting in all to 1·5 square miles.

The parent material is a till of fine texture identical in every respect to that of the Ettrick series. The series is a peaty gley and the typical vegetation is a form of Molinietum (Colour Plate 3).

PROFILE DESCRIPTION

SLOPE		gentle
ASPECT		south
ALTITUDE		900 feet
ANNUAL PRECIPITATION		35 inches
VEGETATION		*Molinia caerulea* (a & d) *Festuca ovina* (a) *Agrostis tenuis* (a) *Juncus squarrosus* (a) *Luzula campestris* (f) *Carex nigra* (f) *Potentilla erecta* (f) *Galium hercynicum* (f) *Trichophorum caespitosum* (f) *Anthoxanthum odoratum* (f) *Polytrichum commune* (a) *Hylocomium splendens* (f) *Rhytidiadelphus squarrosus* (f)
DRAINAGE CLASS		very poor
Horizon	*Depth*	
L	8½-8″	Grass litter
F	8-7″	Decomposing litter
H	7-0″	Black (7·5YR2/0) and very dusky red (2·5YR2/2) inter-layered greasy humus
A_1g	0-2″	Dark grey (10YR4/1) loam; medium sub-angular blocky; friable; medium organic matter content; no stones; roots abundant; slight strong brown (7·5YR5/6) mottling; sharp change into
A_2g	2-8″	Light brown grey (10YR6/2) clay loam; medium angular blocky structure; firm; low organic content; occasional sub-rounded stones; slight strong brown (7·5YR5/6) mottling; sharp change into
B_2g	8-16″	Light yellowish brown (2·5YR6/4) clay loam; coarse prismatic structure; firm; no organic matter; abundant rounded and sub-rounded stones; frequent dead roots, live roots rare; strong yellowish red (5YR4/8) mottling; merging into
B_3g	16-24″	Light yellowish brown (10YR5/6) clay loam; massive; very firm; abundant rounded and sub-rounded stones; mottles as in B_2g but less intense; diffuse change into
Cg	24″+	Brown (7·5YR5/4) clay; massive; very firm; abundant large rounded and sub-rounded stones; occasional dead roots; faint yellowish red (5YR4/8) mottling, strongly developed bluish grey (2·5Y7/0) streaks.

This series seldom supports less than 6 inches of black raw humus which rarely drys out even during the severest droughts. The wet H horizon acts as a sponge, causing strong gleying in the A horizons accompanied by a leaching action. The A_2g horizon has generally a fine or medium blocky structure and some fine mottles near root channels. The A_2g horizon is the horizon of maximum gleying, having a light colour and weak blocky structure. Strong brown or reddish yellow mottles are present but not to the same degree as in the B_2g horizon. The B_2g has a prismatic structure with grey faces to peds and stones. The Cg horizon is always less gleyed than the B_2g horizon and the B_3g is intermediate.

Skeletal Soils

Skeletal soils are to be found throughout most of the freely drained members of the Ettrick Association, but many of the areas are so small that they have been mapped along with these series or as a complex. Areas of mappable size do occur, especially near the Yarrow Water and immediately north of the Tweed valley that lies to the west of Galashiels.

The plant cover on these soils is very sparse, more than half of the surface consisting of bare rock or scree. At high altitudes and under high rainfall there is a tendency for organic matter to accumulate, which may reach a thickness of 12 inches over the rubble or rock. This variant has been noted mainly in the environs of the Yarrow Water. These soils are skeletal soils with peaty top, but it was considered impracticable to delineate them.

Soils having similar characteristics to the skeletal soils found in this area have been termed ranker by Kubiena (1953 p. 163). A generalised profile is described below.

PROFILE DESCRIPTION

SLOPE		very steep
ASPECT		south
ALTITUDE		1000 feet
ANNUAL PRECIPITATION		30 inches
VEGETATION		*Agrostis tenuis, Festuca ovina* (la & co-d) *Deschampsia flexuosa* (lf)
Horizon	*Depth*	
L	Trace	Litter
A_1	0-3″	Brown (7·5YR4/3) gritty loam forming interstitial matter between stones.
C	3″+	Shattered greywacke.

Complexes

Areas of corrugations are common where the underlying sediments are highly folded and over folded around Selkirk and Galashiels. These are described in Chapter I as the Corrugated Hills. The kinds of soil on and near corrugations change quickly, and it has been impracticable to delineate each soil series. In consequence each area of corrugations has been separated as one of two types of complex, ER.c. or ER.ch.

The constituent soils of the complex ER.c. are characterised by the absence of a peaty top whereas most of the constituent soils of the complex ER.ch. have a peaty top. The complex ER.ch. normally occurs where the rainfall is greater than 40 in.

CONSTITUENT SOILS OF COMPLEX ER.C.

(i) Linhope series
(ii) skeletal soils
(iii) soils developed on colluvium.

The Linhope series has been described earlier but when a constituent of a complex it is stonier and shallower than normal.

The description given previously for skeletal soils applies to those in the complex.

Soils developed on colluvium are to be found in the hollows between corrugations. The colluvium is usually not more than 4 ft. thick. The drainage class of these soils is not easy to determine. They are best described as "flush" soils, that is, soils which receive flushing water from the neighbouring slopes. The colluvium has a loamy texture and is often stony to very stony. Consequently the flushing water passes readily through the soil and there is little evidence of the morphological characters associated with gleying. A description of a soil developed on colluvium is given below.

PROFILE DESCRIPTION

SLOPE		very gentle; at bottom of hollow between two corrugations
ASPECT		north west
ALTITUDE		800 feet
VEGETATION		*Deschampsia flexuosa* (f) *Cynosurus cristatus* (f) *Pteridium aquilinum* (o) *Anthoxanthum odoratum* (f) *Nardus stricta* (o) *Hypnaceous mosses* (f)
DRAINAGE CLASS		flush, with good aeration.
Horizon	*Depth*	
L & F	Trace	Litter
H	1-0″	Dark brown organic matter
A	0-8″	Brown (10YR4/3) clay loam; weak medium crumb; moderate organic matter; some stones; roots abundant; few fine distinct dark ochreous mottles; merging into
B_2(g)	8-19″	Yellowish brown (10YR5/4) clay loam; weak medium subangular blocky; firm; low organic matter; stony; roots frequent; distinct grey coatings to stones; sharp change into
B_3 C	19-29″+	Dark grey brown (2·5Y4/2) gritty loam; weak medium blocky; very firm; low organic matter; very stony (small angular stones); roots rare; no mottling.

CONSTITUENT SOILS OF COMPLEX ER.ch.

(i) Linhope series
(ii) Minchmoor series
(iii) Dod series
(iv) skeletal soils with no peaty top
(v) skeletal soils with peaty top
(vi) soils with peaty top on colluvium.

The Linhope series has been described earlier. Although not a common constituent it is found in the complex ER.ch. usually on steep slopes which have a sufficient depth of till.

The Minchmoor series, described earlier, occurs on flat rocky tops where drainage is free to excessive. The B_1 horizon is often absent.

The Dod series is to be found on the less steep slopes where there is a sufficient depth of parent material. It has often an iron pan and is a common constituent of the complex.

Skeletal soils without a peaty top are found on steep slopes where there is no till, but they are not a common constituent of the complex.

Skeletal soils with peaty top are one of the principal constituents of the Complex ER.ch. These occur on less steep slopes where there is no till.

Soils with peaty top on colluvium are to be found in the hollows between the corrugations. They belong to a flush type which is less well aerated than that described previously. Gleying is more intense with prominent grey coatings to the stones.

THE HOBKIRK ASSOCIATION

The Hobkirk Association, one of the more extensive associations, covers 16 per cent of the area described in this memoir. The outstanding characteristic of this association is the red colour of all its soils which is inherited from the parent rocks. The soils occur on gently rolling topography (Plate9) typical of the low lying land in the Tweed and Teviot valleys and the Western Merse described in Chapter I but the relief lacks the strong drumlinoid form of other parts of the Merse where deep tills of fine texture occur.

DISTRIBUTION

Apart from areas of peat and "islands" of the Eckford Association this association covers an area of about 4 miles radius around Gordon; it also occurs in two extensive areas on either side of the Teviot Water which are continuous with those already described by Muir (1956). Contiguous with the Gordon area, a strip 1-2 miles wide extends north-east by Greenlaw and Polwarth towards Duns where another small area is found. The association is also represented around Earlston, Brotherstone and Bemersyde.

To the north and west this association is bounded by the Ettrick Association and the division is well marked; but in the north west and south east it borders upon the Lauder, Minto and Smailholm Associations, all of which contain Upper Old Red Sandstone sediments, and here the boundary is not so well defined.

PARENT MATERIAL

The Hobkirk Association is developed on thin till of coarse texture or on the solid rock. The parent materials are of similar character and produce similar soils. In some cases the A and B horizons develop on the thin till and lie on sandstone rotting *in situ*. Strictly speaking this sandstone cannot be termed the parent rock, for the parent rock of the till (which travelled from the S.W.) may be a different facies of the Upper Old Red Sandstone Series; to avoid confusion however, this horizon—sandstone *in situ*—is referred to in the generalised profile descriptions and appendix as the D horizon. Areas where the rock is near the surface are found east and north of Peniel Heugh and in that part of the association which lies to the north of the Kale Water. These areas have a D horizon of sand or loamy sand texture. Similar parent materials of coarse texture are also found around East Nisbet, Kirkbank and Roxburgh where fluvioglacial action has removed some of the finer constituents. These modified deposits merge into the fluvioglacial terraces of the Eckford Association to the west of the Teviot Water.

The main facies of the Upper Old Red Sandstone Series contributing to this association are red, chocolate brown or yellow sandstones. Shales and marls which are interbedded with the sandstones contribute much of the clay and silt grades to the till but little is known about their petrology. A high concentration of marl gives the till a loam or sandy clay loam texture in localised areas.

All the drainage classes, bar the very poorly drained, are represented both as mineral and organo-mineral soils. The imperfectly drained members, occasionally found in depressional sites or where the till is locally fine in texture, have been grouped with the Hobkirk series as they are not particularly widespread and often too small to be delineated. The relationship of these series to the topography is shown in Fig. 16.

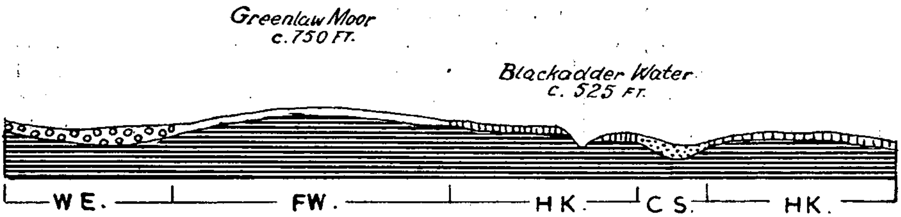


FIG. 16. Section through Hobkirk Association.

The Hobkirk series is the most common series and together with small areas of the Cessford series accounts for all the arable land in this association. The major part of the association occurs below the 30 inch isohyet. Where the annual precipitation exceeds 30 inches and the parent material is particularly siliceous peaty topped series (Faw and Wauchope) occur. These are utilised for rough hill pasture, usually at the grazing rate of 1 sheep to 2 or more acres.

Series

HOBKIRK SERIES

The Hobkirk series, a brown forest soil of low base status, is developed on till of sandy loam texture seldom more than four feet thick. It occurs on gentle or moderate slopes and on flat hill tops. When uncultivated and unfertilized it supports a form of acid grassland. It is the most extensive series and accounts for almost 80 per cent of the association.

PROFILE DESCRIPTION

SLOPE		moderate
ASPECT		south east
ALTITUDE		700 feet
ANNUAL PRECIPITATION		30 inches
VEGETATION		first year grass
DRAINAGE CLASS		free
Horizon	*Depth*	
S	0-9″	Reddish brown (5YR4/3) sandy loam; fine crumb structure; friable; medium organic content; occasional sub-rounded stones; abundant roots; no mottling; clear change into
B_2	9-17″	Red (10YR5/6) sandy loam; fine sub-angular blocky structure; friable; low organic matter; occasional sub-rounded and sub-angular greywacke stones; roots frequent; no mottling; gradual change into
B_3	17-22″	Red (10YR4/6) sandy loam; weak medium platy structure; friable; weakly indurated; low organic matter; occasional stones; occasional roots; no mottling; gradual change into
C	22″+	Red (10YR4/6) sandy loam; medium sub-angular blocky; friable; weakly indurated; occasional stones; no mottling.

The humus form in the S or A horizon is of the moder type; this horizon invariably has a medium or fine crumb structure. Provided the red hue is not too strong the B_2 horizon usually shows a yellowish colour of high chroma indicating enrichment in sesquioxides; the structure may be sub-angular blocky or crumb. The B_3 horizon, if present, is characterised by a redder colour and slight induration. Mottling in any of these horizons is rare. Below the B_3 horizon there may be rotten rock (D horizon) of variable texture or a till of sandy loam texture. Localities where the former occurs are indicated above.

FAW SERIES

The Faw series, covering 6·7 per cent of the association, is developed on parent material morphologically identical with that of the Hobkirk series. Except for minor patches this series occurs above 750 feet where the annual precipitation exceeds 32 inches, that is around Greenlaw Moor and the Dirrington Laws. This series is a peaty podzol and the vegetation is usually some form of Callunetum.

PROFILE DESCRIPTION

SLOPE		gentle
ASPECT		south east
ALTITUDE		800 feet
ANNUAL PRECIPITATION		33 inches
VEGETATION		*Calluna vulgaris* (a & d) *Trichophorum caespitosum* (f) *Erica tetralix* (f) *Juncus squarrosus* (o) *Sphagnum sp.* (o) *Polytrichum commune* (o) *Hypnum cupressiforme* var. *ericetorum* (f)
DRAINAGE CLASS		free below B_1
Horizon	*Depth*	
H	2-0″	Black raw humus
A_1	0-4″	Dark reddish brown (5YR3/2) sandy loam; weak medium crumb structure; firm (due to dryness and binding action of roots); high organic content; occasional small stones; roots abundant; no mottling; clear change into
A_2	4-10″	Dark grey brown (7·5YR4/1) sandy loam; fine sub-angular blocky structure; friable; medium organic content; occasional small stones; roots frequent; faint strong brown (7·5YR5/6) mottling; sharp change into
B_1	10″	Thin iron pan
B_2	10-18″	Red (2·5YR4/6) sandy loam; weak sub-angular blocky; friable; low organic content; occasional small stones; roots rare; faint, very fine, strong brown (7·5YR5/6) coatings to root channels; clear change into
B_3	18-26″	Red (10YR4/6) sandy loam; fine sub-angular blocky structure; firm, indurated; frequent sub-angular and sub-rounded stones; roots rare; gradual change into
C	26″+	Red (10YR4/6) sandy loam; massive; firm, compacted; frequent small sub-angular and sub-rounded stones; no roots.

The H layer of raw humus is seldom more than 2 inches thick in this area due to the frequent agricultural practice of heather burning in the early spring. For this reason L and F horizons are seldom represented. The A_1 horizon consists of bleached quartz grains and organic matter and is transitional in nature between the H and A_2 horizons. The A_2 horizon also contains bleached siliceous material and usually a root mat at its base, just above the iron pan. When the iron pan is continuous and impermeable to water the A_2 horizon shows evidence of gleying. The B_2 horizon, when the inherited red colour does not mask it, shows enrichment of sesquioxides by a yellow colour and high chroma; the structure is fine or medium sub-angular blocky. The B_3 and C horizons are similar, usually of intense red colour and of sandy loam texture; the former is indurated.

These soils can be readily cultivated provided the iron pan is ruptured and liberal dressings of lime and other fertilizers are given. When this is carried out successfully the profile is changed into Hobkirk series or one closely resembling it.

CESSFORD SERIES

The Cessford series, a non-calcareous gley, comprises 7·8 per cent of the association. It is usually developed on a loam till, or occasionally on a sandy clay loam till, which is thicker than in the Hobkirk series. It is to be found only on flat or gentle slopes and in depressional sites. The vegetation, in the semi-natural state, is grassy, with *Deschampsia caespitosa* dominant, or some form of Juncetum (Plate 15).

PROFILE DESCRIPTION

SLOPE		flat
ASPECT		nil
ALTITUDE		600 feet
ANNUAL PRECIPITATION		30 inches
VEGETATION		Old grass pasture containing *Juncus effusus* (a & d) *Agrostis tenuis* (a) *Holcus lanatus* (a) *Trifolium repens* (f) *Cynosurus cristatus* (f) *Ranunculus repens* (f) *Cirsium palustre* (o)
DRAINAGE CLASS		poor
Horizon	*Depth*	
S	0-8″	Very dark grey brown (10YR3/2) sandy loam; medium crumb structure; friable; moderate organic content; occasional small stones; roots abundant; occasional dark yellowish brown (10YR4/4) mottles; clear change into
B_2g	8-18″	Pale brown (10YR6/3) sandy loam; medium prismatic structure; friable; low organic matter; occasional sub-rounded stones; roots frequent; abundant large reddish yellow (5YR6/6) streaks and yellowish red (5YR4/8) mottles; gradual change into
B_3g	18-30″	Red (2·5YR5/6) sandy loam; weak medium sub-angular blocky; friable; no organic matter; occasional sub-rounded stones; occasional roots; abundant large yellowish red (5YR5/6) mottles and grey (5YR5/1) patches; gradual change into
Cg	30″+	Weak red (7·5YR5/4) loam; massive structure; loose; occasional small stones; roots rare, mostly dead; abundant mottling and grey patches as in B_3g.

The humus in the S horizon is of the moder type. This horizon is of very variable structure, usually crumb or fine sub-angular blocky and may be formed from a thin layer of silty or fine sandy alluvium which sometimes overlies the till. In the B_2g horizon gleying is at its maximum, characterised by abundant mottles and grey streaks and by prismatic peds with grey faces. The structure in the B_3g horizon is much weaker and in the Cg horizon is usually massive. If the texture of the C horizon is sandy loam or loamy sand the structure may be single grain.

WAUCHOPE SERIES

The Wauchope series is almost as extensive (6·4 per cent of the association) as the Cessford series. It has quite a different distribution, however, in spite of the fact that it is developed on a similar parent material. Excepting Corsbie Moor this series is confined to the flat or gently undulating moorland to the north of Dogden Moss. An annual precipitation of around 33 inches and an altitude exceeding 700 feet are normally required for its formation. The series is a peaty gley and the vegetation is usually a form of Molinietum, occasionally Callunetum or Nardetum.

Profile Description

SLOPE	flat
ASPECT	nil
ALTITUDE	750 feet
ANNUAL PRECIPITATION	33 inches
VEGETATION	*Molinia caerulea, Calluna vulgaris* (a & co-d) *Nardus stricta* (f) *Juncus squarrosus* (f) *Erica tetralix* (f) *Deschampsia flexuosa* (f) *Rhytidiadelphus squarrosus* (f) *Hylocomium splendens* (f)
DRAINAGE CLASS	poor

Horizon	*Depth*	
L	Trace	Grass and heather litter
F	6-5″	Black (10YR2/1) and very dark brown (10YR2/2) decaying roots and litter
H	5-0″	Black (10YR2/1) greasy raw humus
A_1g	0-3″	Dark brown (7·5YR3/2) and very dark grey brown (10YR3/2) fine sandy loam; fine sub-angular blocky; friable; moderate organic content; no stones; roots abundant; no mottling; clear change into
A_2g	3-7″	Grey brown (10YR5/2) fine sandy loam; fine sub-angular blocky structure; friable; moderate organic content; no stones; frequent roots, many dead; fine yellowish brown (10YR5/6) mottling; clear change into
B_2g	7-16″	Red (2·5YR5/7) sandy clay loam; fine prismatic structure; firm; low organic content; frequent weathered stones; occasional dead roots; abundant fine yellowish red (5YR5/6) and coarse grey (5YR6/1) mottles; gradual change into
B_3g	16-26″	Red (10YR5/7) sandy clay loam; massive; firm; frequent weathered stones including greywacke; dead roots rare; fine yellowish red (5YR5/6) and coarse grey (5YR6/1) mottles; gradual change into
Cg	26″+	Red (10YR4/6) sandy clay loam; massive; firm; frequent stones; no roots; occasional fine yellowish red (5YR5/6) and grey (5YR6/1) mottles.

The raw humus horizon is usually over 2 inches deep. The A_1g horizon has a fine sub-angular blocky structure but generally no mottling. The A_2g horizon has similar structure but with slightly larger peds; fine mottling begins to appear in this horizon which is easily distinguished by its pale colour. Prismatic structure is characteristic of the B_2g horizon and gleying is strongly evidenced by mottling and grey faces to peds. Mottling and structure fade out through the B_3g and Cg horizons which show strong red colours and have a loam or sandy clay loam texture.

These soils are difficult to manage mainly because of drainage difficulties in flat or depressional sites. The H horizon is very wet throughout the year and causes strong leaching in the upper mineral horizons. Due to a poor type of vegetation the grazing value of these soils is very low.

THE LAUDER ASSOCIATION

The Lauder Association, covering 4·3 per cent of the whole area, is confined to Lauderdale and an area around Duns where conglomerates of the Upper Old Red Sandstone formation occur. These conglomerates form the parent rock of the till which is the parent material of this association.

Distribution

With the exception of two small patches near Wedderlie, soils of this association occur only in Lauderdale and to the west of Duns around Langton House. Their extent is less than that of the parent rocks due to carry over of other material, which, in Lauderdale, is till of the Ettrick Association and in the Langton House area, material of the Hobkirk

Association. Because of this transportation most of this association occurs on the eastern side of the Leader Water, and to the east of the conglomerates which outcrop in the Langton Burn near Hanged Man's Hill.

Parent Material

The Lauder Association is developed on parent materials derived from Upper Old Red Sandstone conglomerates and sandstones. These show affinities both to the Siluro-Ordovician greywackes from which they are derived and to the sandstones of the same geological formation. The grade of these sediments ranges from coarse cobbly conglomerates with individual stones up to 6 inches in diameter, to the coarse sandstones already described under the Hobkirk Association. The mineralogy of these rocks ranges from that of the greywacke, already described, to the sandstones of the Hobkirk association.

The tills derived from these conglomerates vary in depth. The thick till of fine texture, which closely resembles the till giving rise to Ettrick series, forms the parent material of the Lylestone series. The thin tills or, as in the Hobkirk Association, the rotten rock itself, give rise to the Lauder and Langtonlees series. East of Edgarhope and on Lylestone Hill, where the conglomerate contains a very high proportion of greywacke and there is little carry over of sandy material, soils of the Linhope series (Ettrick Association) have been mapped. At the other extreme, around Earlston and Legerwood, the conglomerates are interbedded with sandstones and the soils merge into those of the Hobkirk Association.

Soils

For the geologic reasons stated above the soils range in character from those of the Ettrick Association to those of the Hobkirk Association. Except for the Lylestone series all are stony and have a strong red colour.

The Lauder series is the most extensive and occurs on a rolling landscape and on gentle valley slopes. Locally the micro-relief is moundy due to the proximity to the surface of ridges of coarse conglomerate. The two mineral soil series of the association receive about 30 inches of rain per annum but to the west of Duns the annual precipitation approaches 35 inches and a small area on Hardens Hill shows definite signs of podzolisation; this has been mapped as Langtonlees series. An imperfectly drained soil of this association occurs, but it is not widespread and has been included with the Lauder series.

Series

LAUDER SERIES

The Lauder series accounts for almost 97 per cent of the association and is developed on a shallow stony loam till over solid conglomerate. In some cases the solum is developed directly on the conglomerate. Tree roots have been noted at a depth of 16 feet in solid conglomerate near Lauder, indicating how readily the parent rock can be penetrated and consequently incorporated into a soil profile. This series is a brown forest soil of low base status and is freely drained.

Profile Description

SLOPE	moderate
ASPECT	south west
ALTITUDE	650 feet

ANNUAL PRECIPITATION	30 inches
VEGETATION	second year grass
DRAINAGE CLASS	free

Horizon	*Depth*	
S	0-9″	Reddish brown (5YR4/3) loam; fine sub-angular blocky; friable; moderate organic content; frequent rounded and sub-rounded greywacke stones; roots abundant; no mottling; sharp change into
B_2	9-18″	Dark red (10YR3/6) loam; medium crumb structure; friable; low organic content; frequent small rounded greywacke stones; roots frequent; no mottling; gradual change into
C	18″+	Dark red (10YR3/6) loam; massive; friable; no organic matter; frequent rounded stones; roots rare; occasional black manganiferous stains.

The S or, if uncultivated, the A horizon has usually a fine or medium sub-angular blocky structure and the organic content, of the moder form, is moderate to low. The B_2 horizon may also have similar structure but is generally crumb and of a redder hue. The C horizon usually has a massive structure, but in some profiles it is absent and the B_2 horizon rests directly on rock. Near the association boundaries in Lauderdale, at Raecleugh Head and Hardens Hill, this series shows close affinities to the Linhope series found near Galashiels and Earlston, the soils of which have already been described under the Ettrick Association.

Although arable farming is practised over most of this series, on the higher ground in east Lauderdale and north of Raecleugh Head it is used for hill grazing and forestry.

LANGTONLEES SERIES

This series, an iron podzol, is the smallest in the area, amounting to only 0·04 square mile or 0·2 per cent of the association. It occurs at Hardens Hill and also near Langtonlees where, however, the area is too small to delineate on the one inch map.

PROFILE DESCRIPTION

SLOPE	moderate
ASPECT	south west
ALTITUDE	900 feet
ANNUAL PRECIPITATION	33 inches
VEGETATION	*Calluna vulgaris* (a & d), *Juncus squarrosus* (a) *Deschampsia flexuosa* (f) *Vaccinium myrtillus* (o) *Luzula campestris* (o)
DRAINAGE CLASS	free

Horizon	*Depth*	
H	4-0″	Black humus
A_2	0-5″	Dark reddish grey (5YR4/2) sandy loam; fine sub-angular blocky; friable; moderate organic content; occasional small sub-rounded and sub-angular stones; roots abundant; no mottling; sharp change into
B_1	5-5½″	Dark reddish brown (5YR2/2) humus-iron pan
B_2	5½-13″	Red (10R4/6) fine sandy loam; medium sub-angular blocky; friable; low organic content; frequent sub-angular and sub-rounded stones; roots occasional; no mottling; gradual change into
C	13″+	Red (10YR4/6) stony loam; massive; firm, compacted; no organic matter; abundant sub-angular and sub-rounded greywacke stones.

This series covers such a small area that it is difficult to characterise it adequately. The H horizon is usually 2-4 inches thick, and there may be an intermediate dark grey A_1 horizon between it and the A_2 horizon. The latter shows bleached quartz grains diagnostic of a podzol. The humus-iron pan or B_1 horizon may be absent or discontinuous. Below this the B_2 horizon is finer in texture, usually fine sandy loam or loam, and has a fine or medium sub-angular blocky structure. At Langtonlees the C horizon is a till of loam texture as described above. On Hardens Hill the solid rock, or D horizon, takes the place of the C horizon.

LYLESTONE SERIES

The Lylestone series, a non-calcareous gley, is found on a till of fine texture which usually occurs on moderate slopes and in depressions. The drainage class is poor because of the imperviousness of the parent material. When in the semi-natural state the vegetation is a form of Juncetum with *Deschampsia caespitosa* and *Holcus lanatus* as its subsidiary components.

PROFILE DESCRIPTION

SLOPE		gentle
ASPECT		south
ALTITUDE		700 feet
ANNUAL PRECIPITATION		30 inches
VEGETATION		second year grass
DRAINAGE CLASS		poor
Horizon	*Depth*	
S	0-7″	Brown (10YR5/3) loam; fine sub-angular blocky; friable; medium organic content; occasional sub-rounded greywacke stones; roots abundant; slight, fine, strong brown (7·5YR5/6) mottling; clear change into
A_2g	7-13″	Brown (10YR5/3) clay loam; medium sub-angular blocky; firm; low organic content; occasional stones; roots frequent; strong brown (7·5YR5/6) and reddish yellow (5YR6/6) mottling; sharp change into
B_2g	13-22″	Red (2·5YR4/6) clay loam; weak, fine prismatic structure; firm; low organic content; frequent rounded stones; roots occasional; frequent reddish yellow (5YR6/6) mottling; gradual change into
Cg	22″+	Dark red (10YR3/6) clay loam; massive; very firm; no organic matter; sub-rounded and rounded greywacke stones abundant; faint, fine reddish yellow (5YR6/6) mottling, black manganiferous staining.

This series, occurring near Oxton and Hardens Hill, resembles the Ettrick series very closely. It has an S or A horizon containing humus of the moder type. The A_2g and B_2g horizons both show signs of gleying, the peds being grey coated and having reddish yellow mottles within. The Cg horizon has less mottling and a massive structure.

In Lauderdale this series is completely utilised for arable farming, but near Hardens Hill much is left in permanent grass.

THE MINTO ASSOCIATION

The Minto Association, developed on till derived from Silurian and Upper Old Red Sandstone sediments, is usually found between the Ettrick and Hobkirk Associations. It is one of the smaller associations accounting for only 1·4 per cent of the area and occurs only where the topography is rolling.

DISTRIBUTION

The main area of this association is a narrow strip 1-2 miles wide between Belses Mill and Rutherford, continuous with the area already described by Muir (1956). Following the same S.W. to N.E. strike across the Tweed, another strip runs from Dalcove Mains almost to Nenthorn. A small area occurs near Maidenhall.

Parent Material

The parent material is a mixed till derived from Silurian shales and greywackes and Old Red Sandstone marls and sandstones. South of the Tweed it is usual to find a greater concentration of Silurian material in the surface horizon than in the B and C horizons. This is because the ice movement was from the south west and much Silurian material was carried with it and laid on top of the deeper, local till. For the same reason Silurian material is thicker in the hollows than on ridges. To the north of the Tweed the mixture is much more uniform and this difference between surface and parent material horizons is not so marked.

In spite of the admixture of Old Red Sandstone, the parent till of this association shows some marked morphological similarities to that of the Ettrick and Kedslie series, which has been described by Muir (1956) for the area near Ancrum.

Soils

Only imperfectly and poorly-drained mineral soils are represented in this association. These soils receive something in the region of 28 inches of rain in the year and are not subject to exposure. Both soils are utilised for arable farming.

Series

BELSES SERIES

The Belses series, a brown forest soil with gleyed B and C horizons, is developed on till of fine texture with moderate stone content. As mentioned above, it occurs only on moderate or gentle slopes and under relatively low rainfall. It is the dominant series in this area and accounts for two thirds (67·3 per cent) of the association. No profiles under semi-natural vegetation have been encountered.

Profile Description

SLOPE		gentle
ASPECT		south
ALTITUDE		400 feet
ANNUAL PRECIPITATION		27 inches
VEGETATION		first year grass
DRAINAGE CLASS		imperfect
Horizon	*Depth*	
S	0-10″	Reddish brown (5YR4/3) loam; medium angular blocky; firm; moderate organic content; frequent small angular stones of greywacke; roots abundant; few small yellowish red (5YR5/8) mottles; sharp change into
B_2(g)	10-18″	Yellowish brown (10YR5/6) clay loam; coarse angular blocky; firm; low organic content; frequent large sub-rounded greywacke stones; roots frequent; few yellowish red (5YR5/8) and strong brown (7·5YR5/6) mottles; gradual change into
B_3(g)	18-27″	Yellowish brown (10YR5/4) clay loam; massive; firm; no organic matter; frequent stones of greywacke and sandstone; few mottles as in B_2(g); clear change into
C(g)	27″+	Reddish brown (5YR4/4) clay loam; massive; firm; no organic matter; frequent large sub-rounded greywacke stones and small red sandstones; no roots; slight yellowish red (5YR4/8) mottling.

The surface horizon has usually an angular or sub-angular blocky structure and the organic content is moderate or low. The B_2(g) and B_3(g) horizons show maximum gleying and may exhibit prismatic instead of blocky structure; both are pale in colour unless affected by the red colour inherited from the red marls and sandstones. Gleying is much less intense in the C(g) horizon which usually has a massive structure; if the sandstone content is greater than normal then some form of blocky structure occurs.

MINTO SERIES

The Minto series, a non-calcareous gley, is developed on a similar parent material to the Belses series. It only occupies gentle or level slopes in depressions. Less widespread than the Belses series, it covers 32·7 per cent of the association, the largest occurrence being around Longnewton Forest.

Profile Description

SLOPE		level
ASPECT		south
ALTITUDE		400 feet
ANNUAL PRECIPITATION		30 inches
VEGETATION		first year grass
DRAINAGE CLASS		poor
Horizon	*Depth*	
S	0-9″	Brown (10YR4/2) loam; fine sub-angular blocky; moderate organic content; frequent small sub-rounded stones; roots abundant; no mottling; sharp change into
B_2g	9-17″	Yellowish brown (10YR5/4) clay loam; coarse angular blocky structure; firm; low organic content; occasional sub-rounded stones; frequent yellowish red (5YR5/8) mottles; gradual change into
B_3g	17-28″	Light yellowish brown (10YR6/4) clay loam; very coarse angular blocky; very firm; sub-rounded and sub-angular stones abundant; roots rare; frequent mottles as in B_2g; gradual change into
Cg	28″+	Brown (7·5YR5/4) and reddish brown (5YR5/4) clay; massive; very firm; abundant stones; roots absent; few yellowish red (5YR5/8) mottles.

This series shows similar morphology to the Belses series but lighter colours and stronger mottling in the Bg horizons indicate greater gleying. The greywacke content is higher and the red hue is less evident.

The surface horizon shows little mottling, but like the Ettrick series it has a brown or light brown colour when cultivated. The B_2g and B_3g horizons are very similar both having strong mottling; the structure is coarser in the B_3g horizon. The Cg horizon is usually more gleyed than in the Belses series and is of finer texture.

THE SMAILHOLM ASSOCIATION

The Smailholm Association, one of the smaller associations, occurs centrally on Sheet 25, and usually near soils of the Hobkirk Association. It covers 1·3 per cent of the area.

Distribution

The main area, as the name implies, is located around Smailholm. Three other fairly extensive areas occur at Mellerstain, Hume, and Makerstoun, the last area being divided by the River Tweed. There are also small areas at Hallyburton, Lill Rig, Hexpath, Rumbleton Law, Lightfield, Fans, Fans

Hill, East Gordon, Byrewalls, Fallsidehill, Brotherstone Hill, Heiton and Nisbet Hillhead.

Parent Material

The parent material of the Smailholm Association is a thin drift derived from Upper Old Red Sandstone shales and sandstones and from intrusive and extrusive olivine basalts. The parent material in the main areas is relatively uniform, but in the minor areas listed above it varies considerably according to the proportion of the constituents and the degree of weathering of the basalt. The extrusive basalts are much more weathered than the intrusive basalt plugs which usually form the sites for the minor areas.

Series

SMAILHOLM SERIES

The Smailholm series, a brown forest soil of low base status, is the only soil in this association and covers some 6·7 square miles. Where basalt is close to the surface (i.e. at a depth not more than 12 inches) over an extensive area this is indicated on the map by a special symbol.

Profile Description

SLOPE		moderate
ASPECT		south east
ALTITUDE		400 feet
ANNUAL PRECIPITATION		27 inches
VEGETATION		third year grass
DRAINAGE CLASS		free
Horizon	*Depth*	
S	0-9″	Dark reddish brown (5YR3/3) loam; medium crumb structure; friable; moderate organic content; frequent small sub-rounded and sub-angular stones, mostly weathered basalt; roots abundant; no mottling; clear change into
B_2	9-19″	Dark reddish brown (5YR3/3) loam; fine sub-angular blocky structure; friable; low organic content; abundant sub-angular and sub-rounded stones; roots abundant; no mottling; gradual change into
B_3	19-28″	Reddish brown (2·5YR4/4) loam; fine sub-angular blocky; friable; no organic matter; abundant stones including some large cobbles of unweathered basalt; roots frequent; no mottling; gradual change into
C	28″+	Dark reddish brown (2·5YR3/4) loam; coarse sub-angular blocky; firm; no organic matter; abundant sub-rounded and sub-angular stones of weathered basalt; roots rare; few faint yellowish red (5YR4/6) mottles.

The stone content of the surface horizon is usually fairly high, especially when the basalt content is derived from a plug instead of the more weathered lava flows. The B_2 and B_3 horizons are similar, both with a coarser structure than the S horizon; their stone content is high. In areas indicated by the special symbol on the map the C horizon described above is often replaced by a D horizon of basalt rubble.

In some areas this series becomes very similar to the Hobkirk series, but with a coarser texture, and it retains the dark brown or dark reddish brown colour so common in soils derived from a basic igneous rock. The reaction of this series is less acid than the Hobkirk series and the natural fertility is higher.

THE SOURHOPE ASSOCIATION

The Sourhope Association, extending for 14·6 square miles, is found only on the south-west corner of Sheet 26, in the Cheviot foothills—a hilly area with a rainfall ranging from 28 to 40 inches per annum.

Distribution

In the west this association has a common boundary with the Hobkirk Association from Lempitlaw to Linton, whilst to the north, at Eastfield, it is adjacent to the Whitsome Association; dissimilarity of parent material makes these boundaries easily discernible. The limits to the east and south are the National Boundary and the map edge respectively. This area is continuous with that described by Muir (1956).

Parent Material

The parent materials of this association are all derived from andesitic lavas of Lower Old Red Sandstone age. These lavas range from trachyte to basic andesite but are mostly acid andesites. They are of various colours, usually red brown or purple but sometimes black or grey. Some are scoriaceous, the amygdaloidal cavities being filled with agate, calcite and other secondary minerals.

Two kinds of parent material are formed from these lavas, as in some of the other associations. The first is a reddish brown rubble of loam texture which is soliflucted andesite in the more hilly areas and probably soliflucted shallow till north and west of Yetholm Loch. It is upon this material that the freely drained Sourhope series is formed. Near Hoselaw Loch, south-east of a line between Greenlees and Hoselaw Mains, a strip of this thin till about one mile wide has suffered fluvio- or lacustro-glacial modification. Together with Hoselaw Loch and Din Moss, this area formed an evanescent post-glacial lake site and water action removed much of the finer constituents from the till imparting a sandy texture. The second parent material is a reddish brown till of clay loam or clay texture, and it is this till which forms the Cg horizon of the Atton series. The skeletal soils are developed directly on frost shattered or solid andesite.

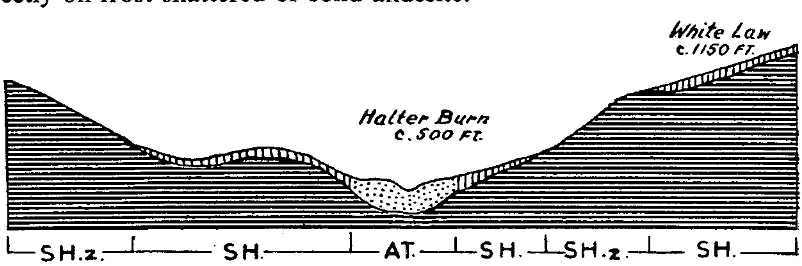


FIG. 17. Section through Sourhope Association.

Soils

The two main soils are the Sourhope series (freely drained) and Atton series (poorly drained). Skeletal soils also occur. An imperfectly drained soil has been identified around Lochside, Graden, Wideopen and Lempitlaw; but as gleying in it is usually slight and it never occurs in areas of mappable size it has been classed with the freely drained soils. The relationship between these soils and the steepness of the hilly topography is shown in Fig. 17.

Series

SOURHOPE SERIES

The Sourhope series, a brown forest soil of low base status, is developed on the stony parent materials described above and usually occupies the moderate to very steep slopes and hill tops. It is the dominant soil series, accounting for 74·6 per cent of the association. The drainage class is free and the vegetation an *Agrostis-Festuca* grassland.

PROFILE DESCRIPTION

SLOPE	steep
ASPECT	west
ALTITUDE	600 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	*Pteridium aquilinum* (a & d), *Agrostis tenuis* (a) *Festuca ovina* (a) *Anthoxanthum odoratum* (f) *Poa pratensis* (f) *Nardus stricta* (f) *Luzula multiflora* (o) *Galium hercynicum* (o) *Rhytidiadelphus squarrosus* (la)
DRAINAGE CLASS	free

Horizon	*Depth*	
L	Trace	Grass litter
F	1-0″	Decomposing litter
A	0-9″	Dark reddish brown (2·5YR3/4); medium crumb structure; friable; moderate organic content; abundant small angular and sub-angular stones; roots abundant; no mottling; gradual change into
B_2	9-16″	Dark reddish brown (2·5YR3/4) loam; coarse crumb structure; friable; low organic content; abundant angular and sub-angular stones; roots abundant; no mottling; clear change into
B_3	16-28″	Reddish brown (5YR4/4) gritty loam; coarse crumb structure; indurated; low organic content; abundant small angular stones; roots frequent; no mottling; clear change into
C	28-42″	Weak red (10YR4/4) gritty clay loam; massive; firm; no organic matter; roots rare; abundant sub-angular and sub-rounded stones; no mottling; clear change into
D	42″	Reddish brown (5YR4/4) rotten lava.

In the uncultivated state this series usually has an F or H layer of up to one inch thickness. The A horizon has humus of the moder type and a crumb structure. The B_2 horizon has a high chroma on parent materials of light colour, often masked by a red hue inherited from haematite-bearing andesite. Some degree of induration is shown by the B_3 horizon but is of variable intensity. In the profile described above, the C horizon is a massive till of clay loam texture with striated and sub-rounded stones, the till being rarely more than two feet thick. The A and B horizons, however, show a predominance of angular or sub-angular stones derived by solifluction from the slopes above the profile. This soliflucted material may also comprise the C horizon, or the solum may lie directly on a D horizon of rotten lava.

ATTON SERIES

The Atton series, a non-calcareous gley, is developed on till of fine texture which is normally more than four feet thick. It occurs on gentle to moderate slopes in or near valleys. It is not extensive and accounts for only 12·9 per cent of the association. The vegetation is usually grassy, under semi-natural conditions, often with *Deschampsia caespitosa* and *Juncus* sp.

PLATE 21
Part of a hill farm in the Lammermuir Hills. The grazing on the steeper slopes is mostly heather but in the foreground is much *Eriophorum vaginatum* and *Trichophorum caespitosum.*

PLATE 22
A well kept stell or sheep pen in the Lammermuirs.

PLATE 23
Shelter belts near Earlston. This landscape is typical of much of the upland farming in the area.

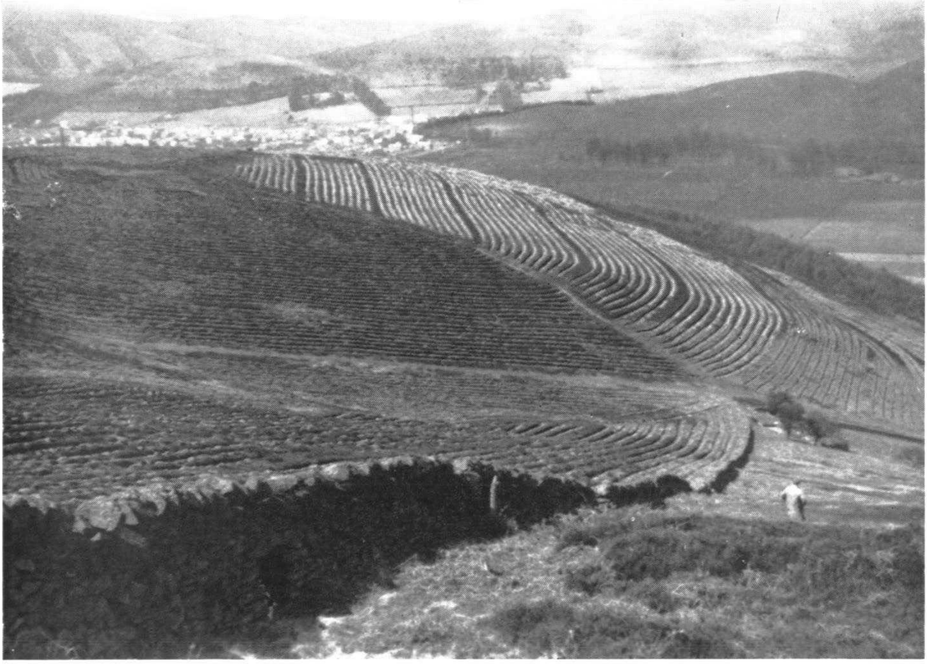


PLATE 24
Contour ploughing on Middlebar Knowe (Elibank Forest) on soils of the Ettrick complex ER.ch. and Linhope series.
(By courtesy of the Forestry Commission).

PROFILE DESCRIPTION

SLOPE	gentle
ASPECT	west
ALTITUDE	550 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	*Juncus acutiflorus* (a & d), *Agrostis tenuis* (a & d) *Nardus stricta* (a) *Holcus lanatus* (f) *Festuca ovina* (f) *Deschampsia caespitosa* (f) *Potentilla erecta* (f) *Galium hercynicum* (f) *Anthoxanthum odoratum* (f) *Carex nigra* (f) *Poa pratensis* (f)
DRAINAGE CLASS	poor

Horizon	*Depth*	
A_1g	0-7″	Very dark grey brown (10YR3/2) silt loam; coarse crumb structure; firm; moderate organic content; frequent small sub-angular and sub-rounded stones; roots abundant; no mottling; clear change into
A_2g	7-12″	Grey brown (10YR5/2) clay loam; weak medium sub-angular blocky structure; low organic content; frequent small sub-angular and sub-rounded stones; roots frequent; few faint dark yellowish brown (10YR4/4) mottles; gradual change into
B_2g	12-22″	Light yellowish brown (10YR6/4) gritty clay loam; medium angular blocky; firm; low organic content; frequent sub-angular and sub-rounded stones; occasional roots; frequent dark yellowish brown (10YR4/4) mottles; clear change into
B_3g	22-30″	Reddish brown (5YR4/4) clay; massive; firm; no organic matter; frequent large sub-rounded and weathered stones; roots rare; few dark yellowish brown (10YR4/4) mottles; diffuse change into
Cg	30″+	Reddish brown (5YR4/4) clay; massive; firm; no organic matter; abundant sub-rounded stones, fresh and weathered; roots absent; few mottles.

A thin H layer may occur on this profile but the organic matter is usually all incorporated in the A_1g horizon in the moder form. The A_2g horizon is very pale in colour and has little or no mottling, and the structure is invariably sub-angular blocky. In the B_2g horizon the peds are more angular and may be prismatic; this horizon shows maximum gleying with strong mottling and grey coatings to peds. Gleying is much less intense in the B_3g and Cg horizons which generally have a reddish hue. Their structure is usually massive although a weak coarse prismatic structure is sometimes found.

Skeletal Soils

Skeletal soils are found on most of the hill tops throughout the association though the most extensive areas lie on the higher ground to the east of the Bowmont Water. They account for 12·5 per cent of the association.

The character of these soils is dominated by the parent rock. On the hill tops they are usually developed on rock outcrops, and, on the very steep slopes, on screes.

As in the Ettrick Association there are two types of skeletal soils, one with an organic top and the other, a more common variety, an entirely mineral soil. It was considered impractical to map them separately. The organo-mineral soil is confined to the ground over 1,000 feet with a rainfall greater than 35 inches per annum. A profile of this type is described by Muir (1956).

The mineral soil type is more widespread and supports very rough grazing. The vegetation is sparse and subject to drought.

Profile Description

SLOPE	steep
ASPECT	south
ALTITUDE	900 feet
ANNUAL PRECIPITATION	30 inches
VEGETATION	*Agrostis tenuis* (a & d) *Festuca ovina* (la)

Horizon	*Depth*	
L	Trace	
A	0-4″	Dark brown (10YR4/3) gritty sandy loam; low organic content; stone content 80%; roots abundant.
D	4″+	Andesite rubble with traces of A material in interstices.

THE WHITSOME ASSOCIATION

The Whitsome Association is the second most extensive association and covers 118·5 square miles or 21·9 per cent of the area. It occupies almost all that part of the Merse below the 350 feet contour line and contains the main arable soils of any extent in the Borders. The parent material is a mixed till of fine texture, similar in character and composition to some of those already mapped in the till plain of Ayrshire and described by Mitchell and Jarvis (1956).

Distribution

The Whitsome Association occupies only one area, extending from Nenthorn, Kelso and Heiton in the south west through the lowlands of Berwickshire to Berwick upon Tweed. This area is about 8 miles wide at its widest and 20 miles long, and has a pronounced S.W.-N.E. strike imparted by ice movement.

Parent Material

The parent material is a mixed till of exceedingly diverse provenance, in which the following *stones* have been identified. They are given in order of occurrence as found at a site in the centre of the association near Leitholm:—

Silurian greywackes	71%
Olivine basalt lavas (weathered)	10%
Olivine basalt intrusions (fresh)	6%
Lower Carboniferous sandstones and cementstones	4%
Vein quartz and chalcedony	4%
Cheviot andesite lavas	2%
Coal	1%
Acid igneous intrusions	1%
Other sandstones	1%

This table should not be taken as representing the average composition of the till as the finer constituents have been ignored. It does, however, illustrate the wide variety of parent rock.

The main component of this till is made up of various argillaceous sediments. West and south of Kelso the sediments are shales and marls from the Silurian and Old Red Sandstone formations, but north east of Kelso these are augmented or replaced by Lower Carboniferous shales and thin limestones of the Cementstone Series. It is these rocks which impart the fine texture to the till. The presence of cementstones and limestones in the till is not often noted, but the fact that they have contributed to it is borne out by chemical data, which show that in most places east of Kelso the C horizon contains free calcium carbonate.

Unfortunately little is known about the petrology of these Lower Carboniferous rocks. For some of them the morphology has been well described by Macgregor (1937, 1938) and MacGregor and Eckford (1948), but beyond the fact that the sandstones are micaceous and that the other sediments contain calcite little is known of the accessory minerals. Muir *et al* (1956) quote analyses for three limestones in this area. One (SL207) near Berwick upon Tweed, is almost entirely calcareous ($CaCO_3$ 95%), but the other two, near Carham Station, are dolomitic. In some areas of the association the till is very thin, less than two feet, and the bed rocks have a strong local influence on the texture of the parent material. Where the rocks are sandstones the texture of the soil is sandy or fine sandy. Where shales are near the surface the soil texture becomes much finer. When shales and sandstones are interbedded the soil texture can vary very suddenly within a few yards. Areas such as these, at Swinton, Milne Graden, Caldra House, Kimmerghame House and Reedy Loch, have been given a special symbol on the map. Near Stichill, basalt is found near the surface, making cultivation difficult; this has also been noted on the map.

The Whitsome complex is derived from a thin veneer of coarse textured material which overlies the till described above. This, for the most part, occurs in long narrow interdigitating strips following the strike of the surrounding country, but is also found in isolated mounds and patches scattered throughout the area. This is illustrated in Fig. 18. As already stated in the chapter on geology, these probably represent minor halts in the shrinking of the ice when melt water and blocked drainage water from the Blackadder Water and "Gordon Lake", and later the Tweed itself, flowed in braided channels marginal to ice lying in the lower reaches of the Tweed valley. These deposits consist of gravel eskers and thin sands of mixed or unknown origin. Around Kelso some of the sandy deposits are extensive and deeper, and very closely resemble the sands of the Eckford Association. Further north east, however, around Eccles, Coldstream, Fogo, and Swinton, the deposits are more scattered and the soil pattern consequently becomes very complicated.

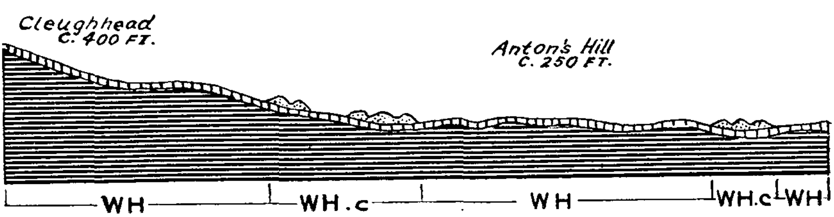


FIG. 18. Section through Whitsome Association.

SOILS

Only two series have been identified in this association, the Whitsome (imperfectly drained) and the Horndean (poorly drained). The former is by far the more extensive and is a brown forest soil with gleyed B and C horizons. The latter is more intensively gleyed and is classified as a calcareous gley. For most of the association the clay content is fairly constant at 30 per cent; between Duns and Hutton, however, the texture tends to be more sandy and in the extreme east around Paxton and in Northumberland there is an area of till of very fine texture with a clay percentage exceeding 50 per cent.

WHITSOME SERIES

This series, a brown forest soil with gleyed B and C horizons, is the most extensive over the whole area, covering 91·7 square miles. This is 77·3 per cent of the association, almost all arable land of a high natural fertility.

As mentioned above and in the chapter on geology, this series is developed on a till with well developed elongated drumlins 25 or 30 feet high and up to a mile long. These are a prominent feature of the landscape between Kelso and Ladykirk but gradually give way, to the north and farther east, to a rolling relief where the till is not so thick. North of the Blackadder Water, as mentioned above, the till may be only a few feet thick and the soils are strongly influenced by the texture of the local bed rock.

Where the drumlins are close together, or bifurcate, deep colluvial soils collect in the hollows between them. These colluvial soils may rest on, or incorporate, alluvium of very fine texture. The colluvium is partly formed from solifluction or "head" deposits derived from the slopes above and partly from contemporaneous erosion of the soils on the drumlins. This erosion has been intensified in some places by ploughing up and down the slopes, as evidenced by colluvium built up against hedges and fences at the bottom of slopes. Examples are given of the normal Whitsome series and of the colluvial phase.

Apart from minor variations such as the colluvial phase described above, the low rainfall, the uniformly rolling or drumlinoid relief and the thoroughly mixed nature of the parent material have imparted a marked degree of uniformity to the soils in this series.

PROFILE DESCRIPTION

SLOPE	gentle
ASPECT	south west
ALTITUDE	200 feet
ANNUAL PRECIPITATION	26 inches
VEGETATION	second year grass
DRAINAGE CLASS	imperfect

Horizon	*Depth*	
S	0-10″	Dark brown (7·5YR4/2) loam; medium sub-angular blocky; friable; moderate organic content; frequent small sub-rounded stones; roots abundant; no mottling; sharp change into
$B_2(g)$	10-21″	Reddish brown (5YR5/3) clay loam; weak medium sub-angular blocky; firm; low organic content; frequent rounded and sub-rounded stones; occasional roots; few fine yellowish red (5YR5/8) and grey (7·5YR5/0) mottles; gradual change into
$B_3(g)$	21-28″	Reddish brown (5YR4/3) clay loam; weak coarse sub-angular blocky; firm; frequent rounded and sub-rounded stones; roots occasional; slight yellowish red (5YR5/8) mottling; gradual change into
C(g)	28″+	Reddish brown (5YR4/3) clay loam; massive; firm; no organic matter; frequent rounded and sub-rounded stones; roots rare; very faint yellowish red (5YR5/8) mottles.

The surface horizon varies in texture from loam to clay loam and has a coarse crumb or medium sub-angular blocky structure. When left under grass for a long period dark reddish brown (5YR3/4) mottles may form along root channels in this horizon. A weak medium prismatic or sub-angular blocky structure is associated with the $B_2(g)$ horizon, and this structure is stronger if the texture is clay rather than clay loam. The clay content of this horizon may be up to 10 per cent higher than that of either the $B_3(g)$ or C(g) horizon. As in the Kilmarnock series (Mitchell and Jarvis 1956), which it resembles, there is little colour change in this series below the surface horizon and the $B_2(g)$ and $B_3(g)$ horizons both have a sub-angular blocky structure. Black manganiferous staining is often found in the $B_3(g)$ and C(g) horizons.

This series has been classified as a brown forest soil with gleyed B and C horizons. Usually it is of high base status with a base saturation of 100 per cent except in the surface horizon where the base saturation is 80 to 90 per cent. It often contains free calcium carbonate or magnesium carbonate, or both, in the B and C horizons. Prismatic structure and clay increase in the $B_2(g)$ horizon are features also exhibited by the grey brown podzolic soils of U.S.A. with which the brown forest soils with gleyed B and C horizons may be equated.

PROFILE DESCRIPTION
(Colluvial phase)

SLOPE	flat
ASPECT	nil
ALTITUDE	200 feet
ANNUAL PRECIPITATION	26 inches
VEGETATION	second year grass
DRAINAGE CLASS	imperfect

Horizon	*Depth*	
S	0-9″	Dark brown (7·5YR3/2) loam; medium sub-angular blocky; friable; low organic content; occasional small sub-angular and sub-rounded stones; abundant roots; no mottling; clear change into
$B_2(g)$	9-22″	Dark brown (7·5YR3/2) clay loam; coarse sub-angular blocky; firm; low organic content; occasional small sub-angular and sub-rounded stones; roots frequent; no mottles; faint grey cast on peds; gradual change into
$B_3(g)$	22-30″	Dark brown (5YR3/2) clay loam; coarse sub-angular blocky; firm; low organic content; occasional sub-rounded stones; occasional roots; faint yellowish red (5YR4/6) mottles; sharp change into
D(g)	30″+	Reddish brown (5YR4/3) clay; massive; very firm; no organic matter; frequent sub-rounded stones; roots rare; occasional yellowish red (5YR4/6) mottles.

The main feature of this profile is the similarity of colour, texture, and structure in the S, $B_2(g)$ and $B_3(g)$ horizons. The dark brown colour is due partly to the humus in all these horizons, up to 15 per cent in the surface horizon and about 2 per cent in the $B_2(g)$ and $B_3(g)$ horizons. Mottling in the $B_2(g)$ and $B_3(g)$ horizons is always sparse and fine; it increases slightly in the D(g) horizon. Gleying is also indicated by the coarse sub-angular blocky structure with the peds having a dark greyish brown (10YR4/2) cast. The D(g) horizon, the same till which forms the C horizon in the normal Whitsome series, is usually of finer texture than the colluvial horizons and has a massive structure. This horizon is about 2 to 3 feet deep but can be covered by 6 feet, or more, of colluvium.

HORNDEAN SERIES

The Horndean series, a calcareous gley, is a poorly drained soil restricted to depressions and almost level sites. The parent material is a reddish brown till as in the Whitsome series. The series is not extensive and is seldom found covering areas of more than 40 acres. The total area of the Horndean series is 3·4 square miles, only 2·9 per cent of the association.

PROFILE DESCRIPTION

SLOPE	flat
ASPECT	nil
ALTITUDE	200 feet
ANNUAL PRECIPITATION	26 inches
VEGETATION	Old pasture containing *Poa annua* (a & co-d) *Lolium sp.* (a & co-d) *Trifolium repens* (f), *Ranunculus repens* (f) *Bellis perennis* (o) *Juncus effusus* (o)
DRAINAGE CLASS	poor

Horizon	*Depth*	
Ag	0-9″	Very dark grey brown (10YR3/2) clay loam; coarse sub-angular blocky; firm; moderate organic content; frequent small sub-rounded stones; roots abundant; occasional faint dark brown (7·5YR4/4) mottles; clear change into
B_2g	9-18″	Reddish brown (5YR4/3) clay loam; weak medium prismatic; plastic; low organic content; frequent sub-rounded stones; roots occasional; frequent yellowish brown (10YR5/6) and strong brown (7·5YR5/8) mottles; merging into
B_3g	18-30″	Reddish brown (5YR4/3) clay loam; coarse sub-angular blocky; plastic; low organic content; frequent sub-rounded stones; roots rare; frequent strong brown (7·5YR5/8) and grey (2·5YR6/0) mottles; black manganiferous stains; merging into
Cg	30″+	Dark reddish grey (5YR4/2) clay loam; massive; plastic; no organic matter; abundant sub-rounded stones; roots rare; few strong brown and grey mottles as in B_3g; black manganiferous stains.

The surface horizon is of coarse or medium blocky structure and is either firm or slightly plastic, depending on the water content. It may also be contaminated with alluvial deposits which give it a silty clay or clay texture. The humus is incorporated in the moder form. As in the Whitsome series the B_2g and B_3g horizons show maximum gleying; indeed, apart from degree of gleying these horizons are very similar to those of the Whitsome series. The B_2g tends to be the more prismatic in structure. Black manganiferous staining is frequently found in the B_3g and Cg horizons. All the B and C horizons contain calcium carbonate, a characteristic which places this soil in the calcareous gley group.

Soil Complex

As mentioned above, divers sorted deposits have been superimposed on the till in some areas of the association, giving rise to a very complicated soil pattern. These areas have been mapped as a complex (the Whitsome complex) and given the symbol WH.c. on the map. Within the complex there is a continuous variation in the depth and texture of the sorted material, the only clearly defined series being the Whitsome series, and for the purpose of description it is necessary to adopt four arbitrary groups which are given below. The Whitsome complex accounts for 19·8 per cent of the association.

CONSTITUENT SOILS OF WHITSOME COMPLEX

(1) Whitsome series
(2) Surface horizon S of fluvioglacial sand over B and C horizons of Whitsome series.
(3) Surface horizon S and B horizons of fluvioglacial sand or gravel over the C horizon of Whitsome series.
(4) Soils developed on deep fluvioglacial sand.

Profile descriptions of (2), (3) and (4) are given below.

Profile Description of No. 2

SLOPE	gentle
ASPECT	south
ALTITUDE	300 feet
ANNUAL PRECIPITATION	27 inches
VEGETATION	third year grass
DRAINAGE CLASS	imperfect

Horizon	*Depth*	
S	0-11″	Brown (7·5YR5/2) sandy loam; medium crumb; friable; low organic matter; small sub-rounded and rounded stones frequent; roots abundant; no mottling; sharp change into
B_2(g)	11-16″	Brown (7·5YR5/4) clay loam; medium sub-angular blocky; firm; low organic content; frequent sub-rounded and sub-angular stones; roots frequent; few yellowish red (5YR5/8) mottles; gradual change into
B_3(g)	16-22″	Reddish brown (5YR4/4) clay loam; coarse sub-angular blocky; firm; low organic content; frequent sub-rounded and sub-angular stones; roots occasional; few yellowish red (5YR5/8) and grey (7·5YR5/0) mottles; black manganiferous staining; gradual change into
C(g)	22″+	Reddish brown (2·5YR4/4) clay loam; massive; firm; no organic matter; abundant sub-rounded stones; roots rare; few yellowish red (5YR5/8) mottles.

The main characteristic of this profile is the coarse texture of the surface horizon derived from fluvioglacial material. The B_2(g), B_3(g) and C(g) horizons are identical with the corresponding horizons of the Whitsome series. In the profile described above, the change of texture at the base of the S horizon is abrupt, but in some profiles the change is a gradual one merging through sandy clay loam to clay loam.

Profile Description of No. 3

SLOPE	gentle
ASPECT	south
ALTITUDE	300 feet
ANNUAL PRECIPITATION	27 inches
VEGETATION	third year grass
DRAINAGE CLASS	free

Horizon	*Depth*	
S	0-12″	Dark brown (7·5YR4/2) sandy loam; medium crumb; friable; low organic content; frequent small rounded stones; roots abundant; no mottles; gradual change into
B_2	12-18″	Light brown (7·5YR6/4) sandy loam; weak medium crumb; loose; frequent small rounded stones; roots frequent; no mottles; sharp change into
B_3(g)	18-24″	Reddish brown (2·5YR4/4) clay loam; coarse sub-angular blocky; firm; no organic matter; frequent sub-rounded stones; roots rare; few yellowish red (5YR5/8) and grey (7·5YR5/0) mottles; black manganiferous staining
C(g)	24″+	Reddish brown (2·5YR4/4) clay loam; massive; firm; no organic matter; abundant sub-rounded stones; roots rare; few yellowish red (5YR5/8) mottles.

The S and B_2 horizons often resemble the same horizons in the Eckford series in texture, colour and structure. The B_3(g) and C(g) horizons are the same as the corresponding horizons in the Whitsome series. The change in texture from the B_2 horizon into the till may be sharp or gradual.

Profile Description of No. 4

SLOPE	flat
ASPECT	nil
ALTITUDE	200 feet
ANNUAL PRECIPITATION	26 inches
VEGETATION	old grass pasture
DRAINAGE CLASS	free

Horizon	*Depth*	
S	0-12″	Brown (7·5YR4/4) loamy sand; weak medium crumb; loose; low organic content; no stones; roots abundant; no mottling; clear change into

B_2	12-20″	Reddish brown (5YR4/4) sand; single grain; low organic content; no stones; roots frequent; no mottles; gradual change into
B_3	20-28″	Light brown (7·5YR6/4) sand; single grain; no organic matter; occasional rounded stones; roots occasional; sharp change into
C	28″+	Red (2·5YR4/6) interbedded sand and fine sand; single grain; no organic matter; no stones; roots occasional; no mottling.

Apart from the intense red colour at the base, this soil resembles Eckford series. It is, however, much more variable in colour, and the texture is coarse throughout. In the surface horizon the organic content is low and the structure weak. In the B_2 horizon structure is absent altogether and in the lower limit of the horizon all signs of a profile are absent and any variation is purely stratigraphic. A coarser textured version of this profile developed on a gravel is also found but is not common.

THE YARROW ASSOCIATION

The Yarrow Association, one of the smaller associations, covers only 1·2 per cent of the area. It is developed on sorted moraines, eskers or river terrace gravels and is associated with the Ettrick and Yarrow Waters and the River Tweed above Kelso. The terrace, in general flat, has been eroded in places to give a moundy micro-relief with slopes up to 20 degrees. A good example of the moundy terrain can be seen in Plate 6.

Distribution

The soils are found flanking the Ettrick and Yarrow Waters in narrow strips. Along the River Tweed the terraces are also narrow, but at Holylee (Plate 7), Elibank and Fernilee, below the meeting of the Ettrick and Tweed, they widen to about one mile. Minor eskers or moraines belonging to the Yarrow Association occur at Philip Burn and at Canny Knowes in the upper reaches of the Cockburn Burn.

Parent Material

The parent material of the Yarrow Association is a fluvioglacial gravel derived from Silurian greywackes. These gravels, especially on the western side of the map where the terraces are narrow, have a very coarse texture with more than 50 per cent cobbles and pebbles. East of Galashiels, however, they are less stony and the matrix may be of loam texture.

Soils

The Yarrow series (freely drained) is the only one so far identified. Because of stoniness it is left in grass as long as possible. A woodland at Elibank with *Quercus petraea* and *Holcus mollis* dominant, is the only extensive semi-natural vegetation found on this association.

Series

YARROW SERIES

The Yarrow series covers 6·7 square miles and is a freely drained brown forest soil of low base status.

Profile Description

SLOPE	moderately steep
ASPECT	north

ALTITUDE	450 feet
ANNUAL PRECIPITATION	33 inches
VEGETATION	*Quercus petraea* (d) *Holcus mollis* (a & d) *Pteridium aquilinum* (la) *Lonicera periclymenum* (la) *Oxalis acetosella* (a) *Rhytidiadelphus triquetrus* (a)
DRAINAGE CLASS	free

Horizon	*Depth*	
L	1½-½″	Leaf and grass litter
F	½-0″	Partly decomposed litter
A	0-14″	Dark brown (7·5YR3/2) loam; medium crumb; friable; moderate organic content; frequent rounded pebbles; abundant roots; no mottling; clear change into
B_2	14-27″″	Strong brown (7·5YR5/7) sandy loam; medium crumb; friable; low organic content; abundant cobbles and pebbles of greywacke; roots abundant; no mottling; gradual change into
B_3	27-32″	Yellowish brown (10YR5/4) sandy loam; single grain structure; friable; weakly indurated; no organic matter; abundant cobbles and pebbles; tree roots occasional; no mottles; gradual change into
C	32″+	Brown (10YR5/3) sandy loam; single grain; loose; no organic matter; abundant greywacke cobbles; occasional tree roots; no mottling.

Under semi-natural vegetation or old pasture the deep A horizon has a very well developed medium or coarse crumb structure; the humus form is of the moder type. The B_2 horizon shows a strong brown colour similar to Linhope series and has also an open, well-developed crumb structure. The B_3 and C horizons are much paler in colour, provided no red greywacke is present; the former horizon is usually indurated where the parent material is of finer texture. The B_3 and C horizons have a weak sub-angular blocky structure.

ALLUVIUM

Alluvium is a sedimentary deposit, a product of the most recent (post glacial) erosion cycle, which is laid down from a suspension in water under marine, estuarine, deltaic, lacustrine or fluviatile environments. By nature it is a sorted deposit with a well developed modal peak in its grade size frequency distribution. This modal grade size may vary from coarse sand to clay depending upon the velocity of the water current from which it was laid down. Although most of the deposits in this area have a fine sandy or silty texture, coarse sand and clay grades are also found.

All alluvial deposits can be classified according to the degree of contemporary sedimentation, the method recommended by the Soil Survey Field Handbook Committee (1956). The following groups are quoted:—

(a) *Active alluvium*

Alluvial deposits that are continually being added to at the present time, sedimentation being the dominant process, are referred to as active alluvium. This term applies to deposits such as those along braided river courses or those within tidal influence on coasts and in river estuaries.

(b) *Alluvium of intermittent accumulation*

Alluvium of intermittent accumulation is the term applied to an intermediate group where additions of mineral matter are intermittent and infrequent. This applies to deposits along river valleys which may be subject to short periods of flooding in winter.

(c) *Stable Alluvium*

Stable alluvium is used to describe those areas where virtually no accumulation is taking place. This includes all areas abandoned by rivers or by the sea or reclaimed by man from flooded conditions. Such areas, known under a variety of local names, e.g. Fen, Moors, Levels, Marshes, Saltings, Warpland etc., are only under exceptional circumstances flooded to such an extent that mineral matter is left behind in any quantity on the surface.

Alluvium covers some 21·1 square miles, or 3·9 per cent, of the area with which this memoir is concerned. The main deposits are described under the categories defined above. Whilst these categories are usually easily distinguished in the field, their extent could not be readily delineated on the published one inch map where all the alluvium is consequently shown as undifferentiated.

ACTIVE ALLUVIUM

The amount of alluvium falling into this category is very small. Along the water courses of the Yarrow, Ettrick, Gala and Leader Waters braided channels are occasionally found between which are low gravel banks of coarse greywacke. These channels always lie within the confines of the main river banks which are marked on the base map. Very small areas of estuarine alluvium occur at the mouth of the Whiteadder Water and along the banks of the Tweed in Northumberland. These are very variable in composition, ranging from gravel to black silty mud.

ALLUVIUM OF INTERMITTENT ACCUMULATION

About half of the alluvium in the area falls into this category. It is usually found along both sides of the main river systems in the area at a few feet above the normal river level. This type of alluvium is flooded annually for short periods in the autumn and winter when it is subject to both erosion and accumulation. In consequence the soil profile is immature and shows little or no horizon development other than stratification. The sites of this alluvium are usually clearly defined in the micro-relief as they are of level or very gently undulating ground, quite distinct from the surrounding steeper land. Their delineation can often be determined from the arrangement of field boundaries on the Ordnance Survey maps. Failing this, configuration is usually easily seen on stereoscopic pairs of air photographs. Colluvium from steep land surrounding the alluvium can obscure the boundaries, and sometimes the alluvium merges into higher terraces of stable alluvium or fluvioglacial material.

Absence of profile development often makes it difficult to place these soils in a drainage class. If the texture is coarse they are freely or imperfectly drained, but if the texture is clay or silty clay they are poorly drained. Ground water is usually more important than surface water in the soil forming processes of these soils.

STABLE ALLUVIUM

Most of the stable alluvium is post glacial and lacustrine in origin. If fluviatile it is either divorced from the present river system or occupied by a misfit stream much too small to have contributed to it. Some of the rivers in the area, notably the Tweed, Leader and Gala, have old terraces now situated well above the flood plain. These also come into this category of stable alluvium.

Many of the sites where lacustrine alluvium has collected are hollows or depressions with no run off into rivers or streams. Because the velocity of the water from which deposition took place was very low, these deposits are of very fine texture with a modal peak in the silt or clay grade. Sandy alluvium, however, is not precluded. Soils developed on the finer deposits are permanently waterlogged for there is seldom easy run off into the present river courses. Often standing water can be seen during all but the summer months. Gleying is strong, with grey or bluish grey colours and very coarse ochreous mottling or "pipes" following old root channels. Good examples of such soils are readily found on Bowden Moor, between ridges of the corrugated Ettrick complex, and, together with peat-alluvium complex, in the post-glacial drainage channels around Mellerstain, Gordon and Westruther. Isolated patches also occur within the Whitsome Association.

The fluviatile stable alluvium forms second, third and sometimes fourth terraces to the existing river systems. The most extensive area of these terraces is in the Tweed valley around Dryburgh, but smaller areas also occur in the Ettrick, Yarrow, Gala and Leader valleys. They are usually gravelly deposits intermediate in composition and profile development between the intermittently accumulating alluvium of the first terrace and the fluvio-glacial terraces of the Yarrow Association.

PEAT-ALLUVIUM COMPLEX

The peat-alluvium complex is self explanatory, referring to a complex of stable alluvium of the lacustrine type described above and basin peat. The two deposits may be interstratified or contiguous, forming a complicated soil pattern.

The dominant areas of this complex are in the glacial drainage courses near Westruther, Gordon and Bemersyde. Permanently waterlogged and very difficult to drain, these sites are of little agricultural value.

PEAT

Within the area covered by the maps two types of peat deposit can be recognised, namely hill peat and basin peat. Both the low moor and the raised moss stages of the basin peat type are represented. Hill peat is extensive on the Moorfoots and Lammermuirs.

BASIN PEAT

Gordon Moss is an example of basin peat which has not reached the raised moss stage. The moss has been subject to much interference and peat development has probably stopped. Its surface is wet and uneven, and on part of it there are small trees and shrubs such as birch, hazel, alder and willow. There are many herbaceous plants principally sedges, rushes, and semi-aquatic grasses, and among the mosses *Polytrichum commune* is particularly evident. The peat is about 2 metres deep, of medium humification, dark in colour and composed of sedge-grass remains with fragments of wood.

Threepwood Moss is a raised moss basin peat with a very well-defined domed structure. The surface is rough and difficult to walk over mainly because of large tussocks of thick woody old heather (*Calluna vulgaris*) combined with cottongrass (*Eriophorum vaginatum*). On parts of the moss there are unusually well-developed hummocks of *Sphagnum* (Plate 18); these may be up to 18 inches high and usually engulf an old plant of *Calluna* the branches of which stick out beyond the surface of the *Sphagnum*. *E. vaginatum*, growing through the *Sphagnum*, also plays a part in the formation of these hummocks. There are no real hags or erosion channels, but near the steep margin of the moss there are deep, steep-sided cracks in the peat apparently caused by drying. At one or two places on the northern side of the deposit there is evidence of peat cutting but this has obviously been discontinued many years ago.

The surface vegetation is remarkably constant with *C. vulgaris*, *E. vaginatum* and *Sphagnum* spp. (mainly of the Cymbifolia group) very abundant. The following species occur less frequently:—

Betula pubescens/verrucosa, *Drosera rotundifolia*, *Empetrum nigrum*, *Erica tetralix*, *Eriophorum angustifolium*, *Narthecium ossifragum*, *Oxycoccus palustris*, *Pinus sylvestris*, *Trichophorum caespitosum*.

The moss was burned over in March 1956. Examination in June of the same year showed some regeneration of *C. vulgaris*. *E. vaginatum* was growing vigorously but most of the *Sphagnum* appeared to be dead. Although the Pine trees suffered severely from the fire some were still alive.

A series of borings at intervals of about 80 metres from one side of the deposit to the other showed depths of peat as follows:—

Boring	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Depth in metres	2	4·6	7	7·2	6·9	6·6	6·5	8·1	7·0	8·9	7·9	6·3	3

The botanical origin of the peat is shown in Fig. 19 and the following table:—

Depth in Metres	*Botanical Origin*
0—5·4	Mainly *Sphagnum* with varying amount of *E. vaginatum* and *C. vulgaris*
5·4—5·7	*E. vaginatum* with *Sphagnum* and *C. vulgaris*
5·7—6·6	*C. vulgaris*, *E. vaginatum*, *Sphagnum* with remains of *Betula* sp.
6·6—7·5	Sedge/Grass with much *Betula*, *C. vulgaris* and *Sphagnum*
7·5—8·2	*C. vulgaris* and *Sphagnum*
8·2—8·4	Sedge/Grass with *C. vulgaris* and *Sphagnum*
8·4—8·7	Amorphous black sedge peat (highly humified).

Jordanlaw Moss is a raised moss basin peat which is being used by the Forestry Commission for experimental work. Before planting with various coniferous species such as Sitka Spruce, Douglas Fir, and Lodgepole Pine, the surface was drained by ditching.

The principal species here are *Calluna vulgaris*, *Erica tetralix* and *Eriophorum vaginatum*. *E. angustifolium* is present but few *Sphagnum* plants are seen.

A sample boring gave the following data of depth and botanical origin:—

Depth in Metres	*Botanical Origin*
0·0—2·0	Mainly *Sphagnum*
2·0—5·5	*Sphagnum*—*E. vaginatum* with varying amounts of *C. vulgaris*
5·5—6·9	Sedge/Grass with seeds of *Menyanthes trifoliata*; becoming black and amorphous near the base.

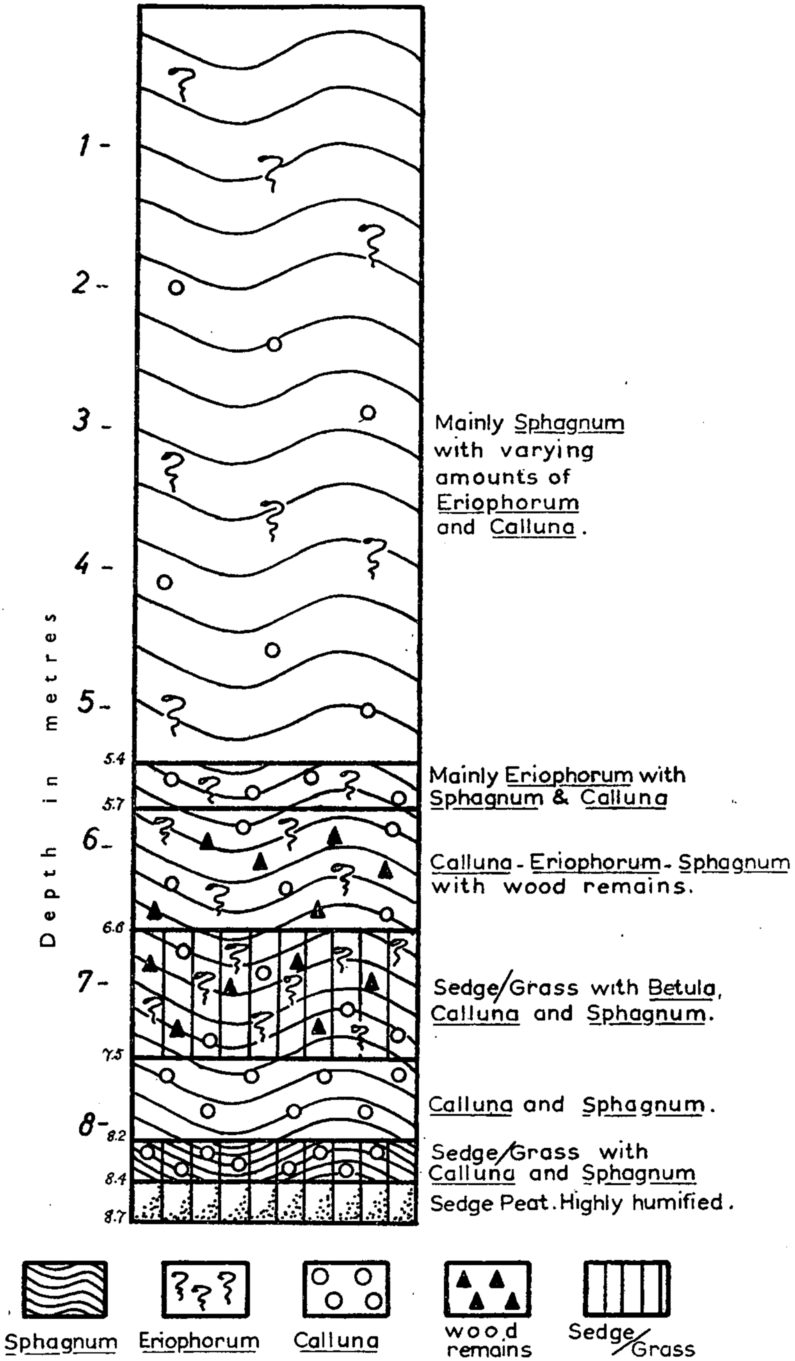


FIG. 19. Peat Stratigraphy of Threepwood Moss.

Dogden Moss is another of the basin peat type which has developed to the raised moss stage. In contour it is flatter than Threepwood and has a smooth surface which is not difficult to walk over although very wet. There is no sign of erosion nor is there much open water.

Over large areas the vegetation is dominated by *Sphagnum* (mainly of the Cymbifolia group) which covers the surface with a continuous thick spongy growth. On other parts of the moss *Sphagnum* is co-dominant with *Eriophorum vaginatum* but neither this species nor *Calluna vulgaris* forms the tussocks so well developed on deposits such as Threepwood. A list of the principal plants is as follows:—

Sphagnum spp. (co-d & d), *Eriophorum vaginatum* (a & co-d), *Calluna vulgaris* (f), *Erica tetralix* (f), *Eriophorum angustifolium* (o-f), *Trichophorum caespitosum* (o-f), *Drosera rotundifolia* (o), *Empetrum nigrum* (o), *Oxycoccus palustris* (o), *Aulacomnium palustre* (f), *Pleurozium schreberi* (f).

A profile 7·5 metres in depth was sampled and the botanical origin ascertained at metre intervals.

Depth in Metres	*Botanical Origin*
0·2—0·5	*Sphagnum*
1·2—1·5	*Sphagnum—Eriophorum vaginatum*
2·2—2·5	*Sphagnum—E. vaginatum* with *Calluna vulgaris*
3·2—3·5	*Sphagnum—E. vaginatum*
4·2—4·5	*Sphagnum—E. vaginatum*
5·2—5·5	*Sphagnum—E. vaginatum* with *C. vulgaris*
6·2—6·5	*Sphagnum—E. vaginatum* with *C. vulgaris* and Sedge/Grass.

HILL PEAT

The hill peat of the Moorfoots was examined on Deaf Heights which rise to 1800 feet. The surface contours of these hills are smooth and on the flatter summits and ridges erosion is not extensive. On the steeper slopes, however, there is widespread hagging and backward erosion. In this area peat is found to a depth of up to 2 or 3 metres locally although much of it is shallower. Vegetation is variable and depends to some extent on local conditions of drainage and degree of erosion. On the uneroded flat summit, on 2·5 metres of peat, the following species were noted:—

Calluna vulgaris (a), *Eriophorum vaginatum* (a), *Trichophorum caespitosum* (a), *Sphagnum* spp. (f-a), *Erica tetralix* (f).

Also recorded were:—

Eriophorum angustifolium, Empetrum nigrum, Hylocomium splendens, Pleurozium schreberi.

In wet depressions the principal species were:—

Sphagnum spp., *Empetrum nigrum, Eriophorum angustifolium, E. vaginatum, Erica tetralix.*

In the erosion channels about half the shallow or re-deposited peat was uncolonised by any plant; the remainder carried abundant *Eriophorum vaginatum* and *Calluna vulgaris* and occasional plants of *Empetrum nigrum, Vaccinium myrtillus, Polytrichum commune* and *Pleurozium schreberi.*

A peat boring on Deaf Heights gave the following stratigraphical data:—

Depth in Metres	*Botanical Origin*
0 —0·2	*Sphagnum*
0·2—0·5	*Sphagnum* with some *Eriophorum vaginatum*
0·5—0·8	*Sphagnum—E. vaginatum*
0·8—1·1	*Sphagnum—E. vaginatum* with *Calluna vulgaris*

1·1—1·4	Black highly humified peat with *Sphagnum*, *E. vaginatum* and *C. vulgaris*
1·4—2·0	Highly humified black amorphous peat.

On the Lammermuir Hills at Nun Rig the stratigraphy showed that peat had developed from a drier type of vegetation:—

Depth in Metres	*Botanical Origin*
0 —0·6	*Calluna vulgaris—Eriophorum vaginatum*
0·6—0·9	*C. vulgaris*
0·9—1·2	Highly humified amorphous peat.

MIXED BOTTOM LAND

Mixed bottom land indicates a soil complex and is essentially a cartographic unit; the term is applied to stream channels containing a heterogeneous mixture of soils. Included within the unit are the soils, often skeletal, on the steep sides of stream or river channels, the colluvial soils at their base and the assortment of soils developed on alluvium at the bottom. Marked differences in the age, drainage, and texture of these soils are evident.

CHAPTER VII

Vegetation

THERE is within the altitudinal limits found in the area, a wide variety of habitat from the river shingle of the Tweed and its tributaries to subalpine peat. None of the major plant communities, woodland, grassland or heath, is entirely natural; all are interfered with to some extent by man.

The least altered of the woodlands is found at Elibank, which is said to be a remnant of the old Ettrick Forest. At the other extreme the natural vegetation has been cleared and the soil used for the growing of crops. Between these extremes lie semi-natural communities which are variously modified by forest clearance and planting, drainage and cutting of peat, burning of heather and grazing by sheep and cattle. In describing the vegetation the terms used are largely those laid down by Tansley (1953).

TYPES OF VEGETATION

WOODLAND

From the pollen record of Threepwood Moss (Durno, unpublished data) the primitive forest of the lowlands had a fair proportion of oak together with some elm. In that forest birch was probably the most abundant tree up to the Atlantic Period of the postglacial climate. There was then an increase of alder which persisted as an abundant tree until recent times while birch continued to be an important tree.

In the more upland areas birch and oak were probably common on the lower hill slopes and birch the dominant tree at the higher levels. Scots pine may have been the dominant of certain upland sites on sandy soils but it did not constitute a large proportion of the forest.

Present day woodlands are mainly planted and contain exotic broad-leaved and coniferous trees along with the native species. Pure stands of conifers are common in plantations and the area of these has been recently extended by the Forestry Commission.

The ground vegetation on dry acid sites is often dominated by *Holcus mollis* or *Pteridium aquilinum* and exacting species of base rich conditions are either absent or sparse. On the more base rich sites, which at the same time are usually more moist, the more exacting species such as *Circaea lutetiana*, *Mercurialis perennis*, *Fragaria vesca* and *Geum urbanum* are common.

Events in the past history of individual woods have often modified the ground vegetation but their influence is difficult to trace. The effect of tree canopy, however, of a species such as *Fagus sylvatica* is more easily seen. Where mature beech is present in closed canopy there are few vascular

PLATE 25

B grade Norway spruce in Bowmont Forest sample plots (Hobkirk series).
(By courtesy of the Forestry Commission).

[Facing p. 110]

PLATE 26
Elite oak on Floors estate.
(*By courtesy of the Forestry Commission*).

plants which can survive under its heavy shade, competing at the same time with the heavy concentration of surface roots. Species which are found are *Dryopteris austriaca* and *D. filix-mas*, and the ground layer of bryophytes is often well developed. *Mnium hornum* is the most abundant species and the other species present are *Isopterygium elegans*, *Hypnum cupressiforme*, *Polytrichum formosum*, *Isothecium myosuroides* and *Diplophyllum albicans*.

Growth to maturity of crops of conifers has also a profound effect on the ground vegetation. By the time a plantation is 20 years old the ground vegetation is usually sparse and consists of shade tolerant plants. *Dryopteris austriaca*, *Oxalis acetosella*, *Deschampsia flexuosa* and *Galium saxatile* are common on the dry acid soils. On the moist more base rich soils broad leaved trees are usually planted along with the conifers and in the field layer the ferns *Dryopteris austriaca*, *D. filix-mas* and *Athyrium filix-femina* are prominent. In the latter case bryophytes of the ground layer are *Eurhynchium praelongum*, *E. striatum* and *Brachythecium rutabulum*, and on the more acid soils *Lophocolea bidentata*, *Plagiothecium undulatum* and *Hylocomium splendens* are typical. With aging of a plantation the canopy opens as thinning operations are carried out and the ground vegetation may again become closed. The shade tolerant species increase in abundance and species of more open situations enter the community.

The different species of conifers affect the ground vegetation to a varying degree. Of the most commonly planted species the two spruces, *Picea abies* and *P. sitchensis*, cast the most dense shade and in certain plantations the ground vegetation is practically absent.

The high level of soil moisture in some woods is indicated by the abundance of marsh species. Such woodland is probably on the site of former alderwood although *Alnus* may not now be an abundant species in it. Marsh species in the field layer are *Juncus conglomeratus*, *J. effusus*, *Cirsium palustre*, *Filipendula ulmaria*, *Lychnis flos-cuculi*, *Epilobium palustre*, and *Carex* spp.

Wet acid conditions, with *Calluna vulgaris* dominant in the field layer and *Molinia caeurulea* and *Erica tetralix* important subordinate species, usually occur within the area of hill grazing but trees are established locally. Species of *Sphagnum*, *S. plumulosum* and *S. girgensohnii*, may be locally abundant. Tree species occurring naturally are *Pinus sylvestris*, *Betula verrucosa* and *B. pubescens*.

HEATH

Natural heath, in the absence of human interference, would occur above the former tree-line. This community, however, is periodically burned, along with the heath which has developed from the ground vegetation of cleared woodland, and must be considered semi-natural (Plate 14).

Dry heath on the excessively drained soils of the Eildon Hills has *Calluna vulgaris* as the general dominant and *Erica cinerea* is locally abundant. Frequent to locally abundant *Vaccinium myrtillus* forms an understorey below the two heathers and *Deschampsia flexuosa* is frequent throughout most of the vegetation. The most abundant mosses are *Hypnum cupressiforme* var. *ericetorum*, *Pleurozium schreberi*, *Hylocomium splendens* and *Dicranum scoparium*. Where burning has been too frequent or followed by conditions unfavourable to the regeneration of *Calluna*, *Erica cinerea* becomes the dominant.

Freely drained soils on the Moorfoots and Lammermuirs have similar heath communities to the above with often the addition of wet heath species. This is particularly true for heath on gentle slopes where conditions approach more nearly to those under which peat is formed. *Trichophorum caespitosum*, *Molinia caerulea*, *Erica tetralix* and *Juncus squarrosus* are then occasional or even frequent species in the vegetation. With increasing altitude *Empetrum nigrum* becomes locally frequent and in the region of Deaf Heights *Blechnum spicant* is occasional to frequent.

Heath on poorly drained soils is distinctly wet in character. Dominance by *Calluna* is less marked and *Molinia caerulea* may be the dominant. The other wet indicator species are frequent to abundant and highly constant in the vegetation. Evidence of affinity to the community on hill peat is seen in the occasional occurrence of *Eriophorum vaginatum*. *Sphagnum compactum* is common on the wet heaths and other species of *Sphagnum* and *Aulacomnium palustre* locally occur.

On both the dry and wet heaths species of lichen, mainly the genus *Cladonia*, are locally abundant. After burning of the heath they are especially common until the ground layer of mosses has been re-established. At the same time species of orthotropic mosses, *Pohlia nutans*, *Polytrichum juniperinum* and *Ceratodon purpureus*, are often abundant. With closing of the vegetation these decrease and the larger plagiotropic mosses replace them. *Pohlia nutans* persists under heavy canopy of *Calluna* and *Polytrichum juniperinum* to some extent but *Ceratodon* is suppressed except on local bare areas.

The flowering plants also react differently to the periodic burning. Carefully controlled burning favours the establishment of an even and almost pure crop of *Calluna vulgaris*—provided that conditions of soil, exposure and grazing are not unfavourable to that species. Where burning is too frequent *Erica cinerea* may replace *Calluna* as dominant but eventual and fairly rapid succession to Callunetum is still assured. Burning heather which has become too old may favour establishment of grass species or *Vaccinium myrtillus*. This phase is usually temporary although the subsequent sward of heather is not so pure and those species may remain prominent. Continued heavy grazing of grassy vegetation after the burning of old *Calluna* may bring about permanent establishment of grassland.

GRASSLAND

The major area of semi-natural grassland occurs on land which formerly carried forest. The one notable exception may be Nardetum on redistributed peat. The possible local extension of grassland on to the area of natural heath cannot be overlooked but its area must be small. Grassland is of prime importance in the economy of the hilly areas and much of it is of long standing. The physical marks of former cultivation are still present on many pastures but the influence of this is no longer apparent in the vegetation and of the biotic factors grazing alone has an evident effect.

Agrostis-Festuca

The general dominants of this grassland are *Agrostis tenuis* and *Festuca ovina*. Local areas are dominated by *Ulex europaeus* and much larger areas by *Pteridium aquilinum*. The soil is usually a freely drained brown forest soil and its acidity may vary but it is often fairly acid. The other common grasses, along with the dominants, are *Agrostis canina* var. *arida, Deschampsia flexuosa, Anthoxanthum odoratum* and *Festuca rubra*. *Nardus stricta* is frequent or even locally abundant at higher elevations where there is a more acid humose topsoil. It may be common at low elevations also where grazing pressure is heavy and the soil is very acid. *Helictotrichon pratense* and *Trisetum flavescens* are occasionally present and may indicate the presence of soil parent material of higher base status. The heath grass, *Sieglingia decumbens,* is sometimes present but its frequency is low. Presence of the meadow grass, *Poa pratensis,* and of *Deschampsia caespitosa* indicates more moist and perhaps more fertile conditions, and the grasses *Holcus lanatus, Poa annua* and *Aira praecox* are associated with heavy grazing and treading of animals.

Leguminous species which form varying amounts of the herbage are *Trifolium repens, Lotus corniculatus* and *Lathyrus montanus*. Under heavy grazing, pasture improvement or natural flushing *Trifolium repens* is frequent, but where grazing pressure is less and more acid conditions prevail *Lotus corniculatus* may be the more common plant. *Lathyrus montanus* is less constant than the first two species and usually occurs under low grazing pressure.

As with the grass species there are some dicotyledons which indicate higher calcium or general base status in the soil. The species are *Helianthemum chamaecistus, Plantago lanceolata* and to a less extent *Thymus drucei, Hieracium pilosella* and *Galium verum*. The last three species and even *Helianthemum chamaecistus* may be found in dry heath vegetation but, taken in aggregate, their presence does indicate more fertile conditions.

Ulex europaeus is often present and may occur locally as dominant, forming a low scrubby vegetation. Gorse scrub is not, however, so common as in north-eastern Scotland and this may be due to the high concentration of sheep in the Border country. The heath undershrubs *Calluna vulgaris* and *Vaccinium myrtillus* are locally present and their abundance increases with decrease in grazing and increase in soil acidity.

Pteridium aquilinum is a common dominant on the hill pastures and the species associated with it are those of the general community of *Agrostis-Festuca*. The shading influence of the bracken has a slight differential effect on the vegetation and *Agrostis tenuis* is more abundant under it than *Festuca ovina*. *Anthoxanthum odoratum* is more abundant than in the open grassland and other species which may have a higher frequency are *Veronica chamaedrys* and *Viola riviniana*. *Oxalis acetosella* is recorded as a locally abundant plant at one site and other species which further demonstrate the more woodland character of the vegetation are *Dryopteris austriaca* and *Potentilla sterilis*.

Pastures laid down after ploughing show various transitional stages to permanent *Agrostis-Festuca* grassland. There is a tendency for *Agrostis tenuis* to be more rapidly established than *Festuca ovina,* and *F. rubra* is often more abundant than *F. ovina*. Sown out grasses are common in the early stages of the succession and *Trifolium repens* is abundant.

Nardus

Nardus stricta is often an important constituent in both heath and *Agrostis-Festuca* grassland and the community dominated by that species has affinities with both these types of vegetation and with peat vegetation. *Deschampsia flexuosa* and *Agrostis canina* are the most important subsidiary grass species in many localities and in others *A. tenuis* and *Festuca ovina* are abundant. The heath rush, *Juncus squarrosus*, is prominent in the community, especially where intense grazing has recently caused *Nardus* to replace heath or where heath vegetation has been formerly destroyed by such practices as feeding hay to sheep.

Calluna vulgaris and *Vaccinium myrtillus* are usually present but in well developed *Nardus* pasture they form only a minor proportion of the vegetation. Certain of the *Nardus* communities show kinship with marsh and peat vegetation (Plate 17). The presence of *Trichophorum caespitosum* and *Molinia caerulea* indicates affinities with peat vegetation and *Juncus conglomeratus* and *J. effusus* with marsh vegetation. *Oxalis acetosella* is locally frequent on certain sites and its presence is perhaps due to the humose nature of the topsoil and the shelter and protection afforded by the tussocks of *Nardus* rather than indicative of former woodland.

MARSH VEGETATION

Marsh vegetation uninfluenced by grazing is extremely limited and only the more widespread community of marshy pasture has been recorded. The vegetation has strong affinities with the field layer of alderwood and most probably occupies the site of former woodland of that type.

Juncus acutiflorus is the most common dominant, although often there is no clear dominant but an abundance of this species along with grasses and dicotyledonous herbs. Abundant grasses are *Deschampsia caespitosa, Agrostis tenuis, A. canina, Holcus lanatus, Festuca rubra, F. ovina*, and *Anthoxanthum odoratum*. Where the topsoil is more humose *Molinia caerulea* and *Nardus stricta* are common. *Trifolium repens* is often abundant and many of the pasture species are those to be found in grassland laid down after ploughing. At the same time species such as *Potentilla erecta* which occurs frequently are more characteristic of permanent pasture.

RAISED MOSS AND BASIN PEAT VEGETATION

Raised moss may have been widespread in the lowland area prior to the use of peat as fuel. None of these deposits is now beyond the low moor or acid basin peat stage and only above 600 ft. are a few raised mosses still extant.

Basin peat near Gordon bears a semi-natural "carr" vegetation usually dominated by *Betula pubescens* and *B. verrucosa*. In the past the deposit has been extensively used for fuel, as seen from old banks of peat and the presence of a road for extraction. The ground vegetation shows a high proportion of fen species together with plants of raised moss or wet heath conditions. One community which had not been recently disturbed is locally dominated by *Carex paniculata*. The vegetation is an irregular patchwork of locally frequent species due, in part, to past disturbance of the peat. Hollows are occupied by species important in early stages of a natural hydrosere such as *Equisetum fluviatile, Menyanthes trifoliata* and *Potentilla palustris*. Remnants of an upper layer of acid peat are perhaps present as *Calluna vulgaris, Erica tetralix* and *Galium saxatile* are locally frequent.

A neighbouring community has been disturbed by partial felling but at the same time the vegetation shows a stronger raised moss character. *Eriophorum vaginatum* and *Erica tetralix* are locally abundant and *Calluna* *vulgaris* locally frequent. There is also local occurrence of the sundew *Drosera rotundifolia.*

HILL PEAT VEGETATION

Hill peat is not extensive although more common than lowland peat. Vegetation of the active building phase is still evident where *Eriophorum vaginatum* and *Sphagnum* spp. are dominant. In many cases, however, erosion is greater than peat formation and regression of these deposits to the gentler slopes is taking place. Burning of the vegetation is perhaps largely responsible while climatic change cannot be ignored.

The remains of *Eriophorum vaginatum* are very evident in the peat and the species of *Sphagnum* play an important role in peat formation. The major peat forming species, *S. papillosum* and *S. magellanicum* are locally abundant while *S. plumulosum* is the most abundant and widespread. *S. cuspidatum* is locally present in pools and depressions and there is a large number of other bryophytic species.

The plant community growing on peat formed on saddles and in depressions differs somewhat from the general hill peat vegetation. A greater supply of water is assured from its topographical position and there is less tendency for erosion to occur. *Eriophorum vaginatum* is the dominant vascular plant but *E. angustifolium* is abundant as indicative of the higher—yet extremely low—nutrient content of water draining from surrounding peat or mineral soils. *Carex nigra* is locally abundant and *Sphagnum palustre* may replace *S. papillosum.*

VEGETATION IN RELATION TO MAJOR SOIL GROUPS

The predominant major soil group is the brown earth and on the freely drained brown forest soils of low base status is found much of the semi-natural vegetation. Brown forest soils with gleyed B and C horizons form the main area of arable land. Comparison of the vegetation on the different major soil groups and their sub-groups is thus made difficult by man's past and present use of the land. Increased soil impoverishment has often been the case in the hills, where removal of crops of livestock and trees has been unattended by application of fertilisers, and lowland soils, while cropped more heavily, have been enriched with applied lime and fertilisers. In spite of this the vegetation can be correlated with the morphological and chemical characteristics of the soils.

BROWN EARTHS

Brown Forest Soils of low base status.

Vegetation on these soils ranges from deciduous woodland to pastures improved by ploughing. The ground vegetation of the woodland is characterised by the abundance of species of fairly acid conditions and generally an absence of exacting species. Towards the base of slopes, however, where more moist and more base rich conditions prevail, these species may be present. This is seen at Elibank where *Mercurialis perennis* is locally abundant in an area of dominant *Holcus mollis* at the lower levels. Leaching of the soil increases with increase in altitude and *Agrostis canina, Deschampsia flexuosa, Galium saxatile* and *Vaccinium myrtillus* become more abundant.

The main semi-natural community on these soils is grassland. The central type is *Agrostis-Festuca* pasture which varies from vegetation with a proportion of exacting species to transition to heath with frequent heath undershrubs. The increase in heath species is accompanied by more pronounced leaching and the soil approaches the podzolic.

Brown Forest Soils with Gleyed B and C horizons.

When compared with the previous category the brown forest soils with gleyed lower horizons have a limited area of semi-natural vegetation. As well as being imperfectly drained, they are usually of medium to high base status. Local areas are found in association with the freely drained but the main extent is arable land and semi-natural vegetation is found in the vicinity of mansion houses, in shelter belts and in marginal areas unfit for cultivation.

Woodland, where the canopy is not too dense, has a greater abundance of species such as *Mercurialis perennis, Circaea lutetiana* and *Fragaria vesca.* Where the canopy is very heavy, as in some mixed woods of coniferous and broad-leaved trees, the field layer of shade tolerant species differs little from that on the freely drained soils. The ground layer in the latter case does show influence of the higher base status by the abundance of *Eurhynchium striatum, Mnium undulatum* and *Fissidens taxifolius.*

Grassland on the imperfectly drained soils has a more abundant element of moisture demanding plants. The species, among others, are *Deschampsia caespitosa, Juncus* spp. and *Achillea ptarmica.* At the same time *Festuca ovina* is less important and there is a greater abundance of *F. rubra. Trifolium repens* is locally abundant and *Plantago lanceolata* is locally frequent.

PODZOLS

The podzolic soils mainly carry a heath type of vegetation although, in the past, the upper reaches of the natural woodland extended on to them.

Iron Podzols

The typical heath on the freely drained podzols is dominated by *Calluna vulgaris* and wet heath species are generally absent. As already noted in the description of 'heath' there are, on certain gentle slopes, scattered plants of peat vegetation. Cessation of periodic burning might cause a greater build-up of raw humus with a resultant increase in these plants.

Nardus grassland occurs on these soils and perhaps the community has often replaced heath through heavy grazing.

Woodland is represented by coniferous plantations. Oxyphilous species such as *Deschampsia flexuosa* and *Galium saxatile* are common in the ground vegetation and *Calluna vulgaris* may become frequent as the canopy opens.

Peaty Podzols with thin Iron Pan

Heath and *Nardus* grassland are the types of vegetation recorded on podzols with iron pan. Impedance of the drainage by the iron pan is apparent in the heath vegetation. *Trichophorum caespitosum, Erica tetralix* and *Juncus squarrosus* are more common than on the iron podzols and *Sphagnum compactum* and *Aulocomnium palustre* occur locally.

Under *Nardus* the evidence of impeded drainage is less clear since the community often grows on more moist humus even where the subsoil is freely drained. On Deaf Heights *Juncus effusus* and *J. conglomeratus* are present where there is an iron pan above the B_2 horizon and the moss *Polytrichum commune* is abundant.

GLEYS

Non-Calcareous Gleys

The non-calcareous gleys are subdivided into poorly and very poorly drained. This division is largely a matter of degree and is expressed in the vegetation in a similar manner. Vegetation on the poorly drained soils ranges from wet grassland to marsh and on the very poorly drained it is distinctly marshy.

The marshy pasture characteristic of the poorly drained soils shows abundant occurrence of *Deschampsia caespitosa, Holcus lanatus* and *Anthoxanthum odoratum* which are much less common in dry *Agrostis-Festuca* grassland. *Juncus acutiflorus* is abundant or locally dominant and the other two rushes *J. effusus* and *J. conglomeratus* are locally frequent. *Trifolium repens* is abundant and frequent dicotyledonous herbs are *Potentilla erecta, Ranunculus acris, Cirsium palustre* and *Succisa pratensis.*

Vegetation on the very poorly drained soils, where woody species are not established, is often dominated by *Juncus acutiflorus.* The associated species are the same as those on the poorly drained soils while the marsh element is more pronounced. The species are *Caltha palustris, Potentilla palustris, Galium palustre, Stellaria alsine, Ranunculus flammula* and *Filipendula ulmaria.* The moss *Acrocladium cuspidatum* is common and Sphagna of more base rich conditions, such as *S. subsecundum* var. *inundatum,* are locally present.

Calcareous Gleys

Artificial drainage of the poorly drained soils of the Whitsome Association has enabled their conversion to arable land. Semi-natural vegetation is very limited and the woodland dominated by *Quercus robur* in the policies of The Hirsel is the only example recorded. Under the heavy canopy of the planted oak the field layer is dominated by ferns and *Urtica dioica* and gives no indication of the high base status of these soils. Species of the ground layer, *Eurhynchium striatum, Fissidens taxifolius* and *F. bryoides* do bear out their fertility.

Peaty Gleys

The peaty gleys are sometimes found situated topographically between podzols and hill peat in the southern part of the Lammermuirs. They also occur, within the zone of heath, on gentle slopes where they are transitional in site between basin peat and non-calcareous gleys.

In the former case the soils are poorly drained and the vegetation is wet heath and in the latter they are poorly or very poorly drained and the vegetation varies from wet heath to a community containing heath, grassland and marsh elements. This mixed community, when compared with the wet heath, shows the higher level of nutrients in the soil water from the presence of *Juncus acutiflorus, Holcus lanatus, Deschampsia caespitosa, Anthoxanthum odoratum, Achillea ptarmica* and *Trifolium repens.*

CHAPTER VIII

Agriculture

by W. A. Buckpitt, B.Sc., N.D.A., N.D.D., *and* H. H. Corner, O.B.E. B.Sc., Ph.D. *Edinburgh and East of Scotland College of Agriculture*

THE area of this survey was settled in prehistoric times by a race of people who built fortifications on hill-tops consisting of circular ramparts of earth reinforced with stone. Many sites of these "forts" are recorded on the Ordnance Survey maps of the district. They are numerous in the Cheviot Hills around Yetholm and are found at strategic points in the valleys of the Tweed and Teviot and their tributaries. By far the largest fort occupies the summit of the most easterly of the Eildon Hills near Melrose. Crops were grown by these early inhabitants, and the cultivation terraces which they used are still to be seen in the hill country. The subject of prehistoric settlements in the Borders has been investigated by Piggot (1949), and other valuable information is contained in The Ancient and Historical Monuments of Roxburghshire (H.M.S.O. 1956).

During the Middle Ages, the Church founded many establishments in the Tweed valley and had great influence in promoting agriculture and pastoral interests. The abbeys of Dryburgh, Jedburgh, Kelso, and Melrose were founded about the twelfth century and in the course of time these institutions, and Coldingham Priory, became the owners of large tracts of land. From the records of the abbeys it is known that large flocks of sheep were kept on the low ground and also on the Cheviot Hills and that the export of wool was a valuable source of revenue to the whole region.

It is probable that in these early days the feudal barons had numerous retainers settled on farms near the ancestral keep and that the size of the farms would not be very large. If this was the case on Tweedside, all traces of this early economy have completely disappeared. Somewhere about the beginning of the eighteenth century most of lower Tweeddale was parcelled off into large arable farms of about 400 acres. The researches of Handley (1953) into the agriculture of Scotland in the eighteenth century provide a valuable source of information on this period.

Throughout the eighteenth century, an immense amount of capital was invested in the agriculture of the region. The land was drained, limed and enclosed with hedges and stone-dykes, houses and steadings were erected on a substantial scale, the rotation of crops was introduced, and woods and shelter belts were planted. By the end of the eighteenth century the process of modernisation was complete and no essential difference in the lay-out of the farms has taken place since that time. Several writers have given detailed accounts of the state of agriculture at the end of the eighteenth century including Douglas (1798), Johnston (1794), and Ure (1794). There also appeared at this time the parish surveys which were written for the Statistical Account of Scotland edited by Sir John Sinclair (1791-1799).

The eighteenth century probably marked the greatest development which ever took place in the agriculture of the region. Labour was plentiful and wages were low while prices of produce were at a good level owing to the demands of the rising industrial population. The mainspring of improvement was the spirit of enterprise among proprietors and farmers who carried through the modernisation of agriculture with remarkable skill. They were supported by a race of workers and craftsmen who, in this beautiful countryside with its wide sweeps of tillage alternating with pasture-land, have left an enduring monument to their labours.

CLIMATE

The climate is typical of the eastern half of Scotland, being comparatively dry and suitable for the growing of cereal crops. While spring rainfall is liable to variation, one can usually depend on dry weather in March for the sowing of grain crops. During the months of May, June and July, there is usually sufficient moisture for crops and grass and perhaps too much moisture during August for the harvesting of crops. September is the main harvest month and is reckoned to give settled weather with fairly long dry periods.

As far as sheep are concerned, dry weather in March and April is of great benefit at lambing time both in lowland and upland flocks. Grass is often slow to come in spring, however, due to drying winds which tend to blow from a somewhat northerly direction and cause the temperature to remain low. A full bite of grass cannot usually be depended on until the latter part of April on low ground, or mid May on high ground. Consequently, farmers must have on hand a supply of roots and hay to see sheep and cattle through to the end of April and into May.

Severe frost seldom occurs before New Year so that farmers are usually able to complete the storage of turnips as well as the ploughing of stubble and ley before hard weather sets in during January and February. A winter without frost is rather a calamity because the clayey soils miss the pulverising effect of frost and are much more difficult and costly to break down in preparation for the sowing of seed. A hard spell of frost dries the land and puts ewes in a thriving state so that they make better progress and are in fitter condition at lambing time.

Falls of nine inches or over of snow are not frequent on low ground. Perhaps once in ten years a severe snow storm occurs with a fall of a foot or more. In 1947, snow-storms swept the Borders and persisted from February until the beginning of April causing great losses among sheep stock on the higher farms. Others occurred in 1937 and in 1917.

SIZE OF FARMS

A noteworthy feature of the arable farms in the area is their relatively large size. According to the returns of the Department of Agriculture for Scotland, the average size of the arable holdings of five acres and upwards is 267 acres in that part of the surveyed area which is situated in Roxburghshire. In the parishes of Eckford, Linton and Sprouston, in Roxburghshire, the average size exceeds 400 acres. The arable farms in the Merse of Berwickshire over 5 acres in extent are also on a large scale, averaging 275 acres with occasional holdings of 1000 acres or more. At Hume, the Department of Agriculture for Scotland created a number of small holdings of about 50 acres each after the 1914-1918 war.

The large size of the arable farms gives scope for a distinctive feature of the farming of the region. This is the running of a flock of breeding sheep on almost every farm under the charge of a skilled shepherd. The shepherd's calling has been followed since early times and is still handed on from father to son.

Farm mechanisation has made great strides since the beginning of the second World War. Tractors have now replaced horses almost entirely and most of the barley and wheat crops are handled by combine harvesters. Machinery on these large farms has done much to retain the area of tillage at a high level.

As regards the hill farms in the parishes of Morebattle and Yetholm, these are not large in area. The average size is about 1600 acres but as the hill land is entirely covered with a grassy type of vegetation it supports a concentration of sheep a good deal higher than in most districts. Hill sheep farms on the Lammermuirs often exceed 3000 acres.

LAND TENURE

About 60 per cent. of the farms are rented. In former days, farms were let to tenants on leases which ran from ten to fourteen years with a break at five or seven years. Nowadays, however, on some estates new leases are on a year to year basis. This has been brought about as a result of the Agricultural Holdings Act of 1949 and other post-war legislation. In addition to rent, the tenant often pays half of the cost of the upkeep of fences and hedges and half the cost of the upkeep of roofs and paintwork.

The situation as regards farm rents in 1957 is rather confused owing to the Agricultural Holdings Act of 1949. There is no longer a free market in the letting of farms when existing leases come to an end. Where new leases for sitting tenants are negotiated, the annual rent in 1957 on low-ground farms is £2 to £3 per acre. Where the proprietor has been in a position to advertise such farms, however, the rent is from £4 to £4 10. per acre. The large arable farms have been selling with vacant possession in recent years at around £70 per acre.

High-lying arable stock-rearing farms over 600 feet in elevation are still in 1957 rented at around 15/- to £1 per acre. As leases expire, the rent of these farms to sitting tenants is often increased by the addition of about 20% to these figures.

In the case of purely hill farms, the annual rent is not usually expressed on an acreage basis but is fixed according to the number of breeding ewes (excluding ewe hoggs) which the farm will carry. A figure of 12/- per ewe is common where there is a good farmhouse, or 10/- per ewe on a led-farm without a farmhouse.

SOIL FERTILITY

Throughout the lower levels of the Tweed basin from Melrose to Ladykirk, a distance of thirty-five miles, there lies a wide stretch of first-class arable land capable of the highest production. Much of this land lies in the Merse of Berwickshire and consists of soils of the Whitsome Association.

During the recent war, the whole of this area of land was classed as Grade I, and farmers were required to have 70-75 per cent. of the ploughable area under tillage crops each year.

The surface texture of these soils is mainly a loam but on Kedslie and Belses series it may sometimes be a clay loam near St. Boswells. Around Kelso and Coldstream sandy loams on Whitsome complex are more common, while around Swinton, and between Paxton and Berwick clay loams and even clays are found.

On these low-ground farms it was feared that intensive cropping during the war would exhaust the supplies of organic matter and drain away the reserves of plant nutrients. This did not happen to a marked extent, however, because the change-over to tractors in place of horses enabled deep ploughing to be carried out on a scale hitherto unknown and so provided a greater body of soil for the roots of crops. It also buried the weeds and kept the land clean. The use of selective weed-killers has assisted the process. Lime has been used on an extensive scale and a much greater quantity of artificial fertilizer is applied to crops and grass than in pre-war days. A return since the war to leys of two to three years' duration has done much to restore the supply of organic matter in the soil. The net result has been that yields of crops and grass have risen and are still rising.

In the upland district of Lauderdale there is good sound land providing excellent conditions for the breeding and rearing of livestock together with arable cropping. There are good deep alluvial soils on the narrow valley floors of the Leader Water and its tributaries, but the fields on the sides of the valleys are stony loams of the Lauder and Linhope series, often with steep slopes and occasional outcrops of rock. These give way above 900 feet to unenclosed sheep walks of natural grass and heather. These soils are mostly those of the Minchmoor series with 2-3 inches of raw humus over a pale grey leached sandy loam A_2 horizon. There are pockets of peat and outcrops of rock. Excepting the alluvial haughland, all these soils are typically deficient in lime and phosphate.

In the Gala Uplands the soils, all of the Ettrick Association, are dominated by the nearness of the rock to the surface, especially in the Ettrick Complex, ERc., where arable agriculture is precluded or very difficult. The steep hill slopes support a very stony and often thin version of the Linhope series which can never be ploughed to a greater depth than about 6 inches. Leys on these steeper slopes are slow to knit and are often maintained for longer periods than the 4-5 years mentioned below. Most of the fields with an arable rotation are established on the less stony parts of the Linhope series and on the more clayey Kedslie series which has a much better level of fertility. The farms are sound and healthy and are noted for the quality of the sheep-stock which they carry and for the size and character of the lambs and draft ewes which are annually disposed of in the markets. Soil fertility on these upland farms is maintained by leys of four or five years duration, or longer, and by the application of lime according to need. Artificial fertilizers are applied to arable crops and to grass at approximately three times the pre-war amounts.

All farmers throughout the surveyed area have made full use of the scheme whereby the application of lime is subsidised by the government. On most low-ground farms the pH of the surface soil ranges from 6·2 to 6·6 and sometimes over 7·0 where much liming has been carried out. On upland farms the range is typically pH 5·8 to pH 6·5, except that outlying fields may still be below pH 5·8. The position now is that the liming of arable land, both low-ground and upland, must be done with care, as too much lime tends to lock up trace elements in the soil and to reduce the yield of oats. It also favours the disease of brown-heart in turnips which occurs when there is a lack of available boron.

In most soils of the region there is a natural lack in the supply of available phosphorus. This deficiency, however, has been made good by the free use of phosphatic fertilizers such as basic slag and ground mineral phosphate. Many farmers apply a dressing of a phosphatic fertilizer of this type once in the rotation, amounting to about 200 lbs. of phosphoric acid per acre. It is given to roots or to first year grass. This is in addition to compound fertilizers applied to roots and to grain crops. This generous application of phosphatic fertilizer usually leaves its mark.

As regards the supply of available potash, this tends to be lacking under conditions of intensive cropping and where the soils are light in texture, as in the neighbourhood of Kelso, Roxburgh, Greenlaw, and Hume. Elsewhere there is usually a good supply of potash.

SYSTEMS OF FARMING

The arable farms, both low-ground and upland, are large in size, probably larger than in any other district of Scotland. The reason for this is that when the farms were squared off in the eighteenth century sheep were already on the ground and the production of wool had for long been a primary enterprise. It had brought wealth to the area and many farmers had capital at their command. Accordingly, the proprietors had sheep-husbandry in view as the main enterprise when they enclosed the land, and they were able to get farmers with sufficient capital to stock these large places with breeding sheep. Sheep, therefore, are the key to the situation, past and present.

Sheep production in Berwickshire, Roxburghshire, and in the neighbouring counties, is now more firmly established than ever owing to the geographical situation of the area. Lying to the north are the fertile districts of the Lothians, Fife and Angus, which are mainly concerned with arable cropping, while to the south are wide arable districts in the north of England and the Midlands. These areas demand supplies of sheep for fattening purposes and for flying flocks of draft ewes (a flying flock being one in which all the females are replenished annually and are lambed once). The Border counties are in a position to meet this demand and to concentrate on the production of sheep for the store market.

The Border counties are large enough to enable the whole system of breeding sheep for the store market to be carried through on an organised scale. Buyers want graded lots of sheep, all level in size and condition and of the same type. Not too many breeds and crosses are wanted, just a few standard types that the buyers know. Not too many auction markets are required, just a few highly organised centres such as St. Boswells, Hawick, and Reston. Approximately 500,000 store sheep and breeding sheep pass through these centres each year in about 16 different classes.

The Border area as a whole is geared to an export trade in sheep, so within the area the three following classes of farms are closely integrated so as to keep the whole system running. Firstly the hill farms carry Cheviot sheep on the grassy hills and Blackface sheep on the heather hills. Secondly the upland farms derive ewe lambs from the hills to carry on their breeding stocks. Thirdly the low-ground farms concentrate on the production of fat cross lambs or store cross lambs for export outwith the area but they require to replenish their breeding stocks by annual drafts of ewe lambs from the upland farms. The distribution of these three types is shown in Fig. 20.

Milk production is not an important feature of the farming of the area surveyed although a few farms have over 50 cows.

Silage has not made a great impact but is gradually finding favour for beef and dairy cattle: turnips are still considered essential for sheep.

Hill Farms

Hill farms comprise a relatively small part of the surveyed area, being mainly situated in parishes in the Lammermuir and Moorfoot country such as Caddonfoot, Channelkirk, Lauder, Westruther and Longformacus, and in the parishes of Morebattle and Yetholm in the Cheviot hills. Several noted flocks of Cheviot and Blackface sheep are to be found in these districts and their produce is in demand at the pedigree ram sales at Hawick.

The Lammermuir Hills are noted for the healthiness and soundness of the grazings, in which there is usually a good acreage of heather to provide a valuable source of winter forage. Except where reseeding or heavy liming has been practised, almost all the soils have a raw humus or peaty surface and show evidence of leaching in the A_2 horizon immediately under the humus. The principal soil is the Minchmoor series, a stony iron podzol upon which the dominant vegetation is almost pure heather. Peaty gleys and peaty gleyed podzols of the Hardlee and Dod series also occur in the wetter parts but do not provide such good grazing. Hill and basin peat both have cotton grass (*Eriophorum vaginatum*) as the main species which provides an early bite on these hill grounds.

The sheep-stock is chiefly Blackface and the concentration is about two acres of hill land per ewe. The lamb crop at weaning time generally runs at 90 per cent. of the total stock of ewes. The Cheviot Hills carry a more grassy type of vegetation on Sourhope series and the breed of sheep is mainly Cheviot from which five crops of lambs are usually taken. The grazings are sound, being free from some of the commoner diseases of hill sheep. The concentration of stock is very high, amounting to $1\frac{1}{2}$ acres of hill land per ewe. The average lamb crop amounts to 90 per cent. As heather is largely absent from the grazings, however, a supply of hay for winter use is essential, and is generally fed from the beginning of March onwards.

Hill cattle have increased in recent years both on the Lammermuirs and on the Cheviot Hills, partly due to the subsidy for encouraging the breeding of beef cattle in hill country. Galloway cows are the chief breed where the animals are wintered out of doors all the year round. If there is accommodation for in-wintering, the Blue-grey cow is favoured and calving takes place early in the New Year which enables the calves to grow more quickly when the grass comes. Cattle however, cannot be greatly increased in hill country as the mainstay of the hill farms is sheep. Too many cattle leave the hill pastures bare of herbage in winter so that additional hay has to be provided at considerable cost.

These hill farms have a limited acreage of in-by rotation ground which is

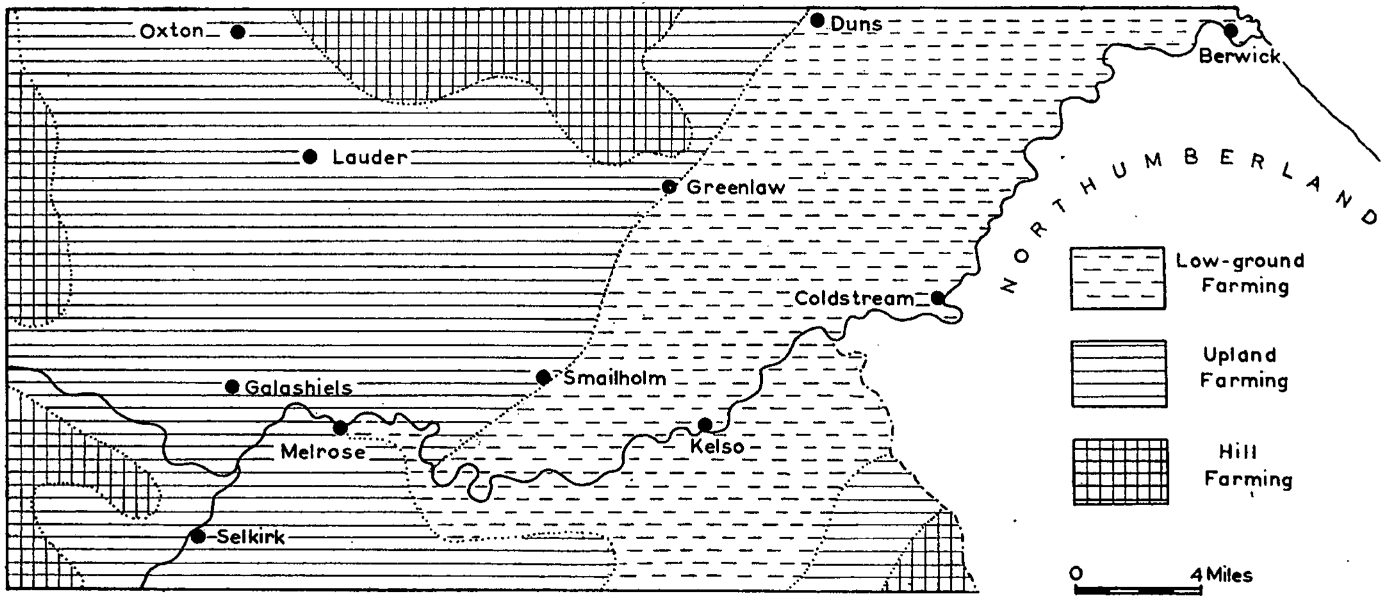


FIG. 20. Types of Farming.

devoted almost entirely to the production of hay, oats, turnips and rape for farm consumption.

Upland Farms

Most of the upland farms occur in the Gala Uplands, Lauderdale, the Cheviots and in the Western Merse between the Gala Uplands and Lower Tweeddale. All the freely drained soils, of which Linhope and Hobkirk series are predominant, are essentially acid soils and of low fertility. To maintain productivity a regular application of lime and phosphatic fertilizers is required. The soils most usually utilised for arable rotation are the Hobkirk, Eckford and Kedslie series and also the alluvial haughland; the two former because they are easily tilled and the latter because of their superior natural fertility. Most of the alluvial soils and all of the Kedslie series require tile drainage before cultivation. The Lauder series is also cultivated but, because of its variable depth, stoniness and chemical characteristics, no generalisations can be made about it. Of the wet or gleyed soils the Ettrick and Cessford series predominate. Much of these soils is kept under permanent grass with open ditches for drainage (Plate 16). Parts of these soils can be cultivated if the texture is coarse enough and where adequate tile drainage can be made.

On the upland farms, the breeding and rearing of live-stock is the main consideration and consequently the growing of arable crops is chiefly undertaken for the winter feeding of stock and in order to renew the pastures. Pastures are down for three to five years and in some cases for as long as eight years. This is about the maximum period for which pastures can be kept productive as wild grasses such as bent (*Agrostis* spp.) or Yorkshire fog (*Holcus lanatus*), begin to gain a hold and live-stock then do not make satisfactory progress. The use of leafy strains of grasses and wild white clover (*Trifolium repens*) has done much to maintain pastures in good condition for many years, while the free use of lime and phosphatic fertilizer, such as basic slag, has kept the grass fresh and productive for a much longer period than before. The increase in the number of cattle since the war has enabled rough growth to be eaten off and the life of the sown grasses to be prolonged. There is much progress, therefore, to be recorded in the production and general management of pastures on upland farms.

North Country Cheviot ewes are the typical stock. These are crossed with Border Leicester rams to provide Halfbred ewe-lambs for sale to low-ground farms. The upland farms act as a reservoir for this class of stock and produce well grown, stylish sheep which have a reputation far beyond the Borders. Halfbred ewe-lambs from Gala Water and the farms bordering on the Lammermuirs are acknowledged to be among the best obtainable anywhere. Special sales of ewe lambs are held each autumn at St. Boswells, Reston, and Hawick.

On some upland farms, Greyface ewes are preferred as they are very prolific, are excellent milkers, and carry more wool than the North Country Cheviot. Wool at 5/- per lb. is an important consideration. The Greyface ewe is bred on the hill farms by crossing Blackface ewes with Border Leicester rams. A suitable type of Border Leicester to use is the blue-headed Leicester from Northumberland, a type which is specially bred for the purpose. In order to meet the demand for store lambs of a thick, fleshy, early-maturing character, the Greyface ewe is crossed with one or other of the Down breeds such as the Oxford, Suffolk, or Hampshire.

Lambing on upland farms generally begins around the middle of March. A large lambing shed of straw is erected in the lambing field and is fitted with small pens along the sides to house ewes and newly-born lambs over-night. Assistance at lambing is given when required but it is generally agreed that the less interference the better. The modern antibiotic drugs are of great assistance in warding off metritis (inflammation of the womb) and udder troubles and are universally employed.

The ewes and lambs are drafted out to the pasture fields where they remain as a set-stock all summer. The largest concentration is carried by first year grass, where the stocking is usually two ewes with twin lambs per acre. On older pastures the typical rate of stocking is 1½ ewes with twin lambs per acre. If the concentration is much greater the lambs scour and fall away in condition and there is loss instead of gain. The number of lambs reared to the weaning stage is approximately 140 per cent. of the ewe stock.

The breeding and rearing of beef cattle is an important activity on all upland farms. An ample supply of cattle is vital to the interests of sheep as cattle graze off the rough herbage and give a thicker and finer sward of grass. Ewes and lambs always do better on short leafy herbage and so the two classes of live-stock thrive together. The usual type of breeding cow is the Blue-grey obtainable from hill farms by crossing a Galloway cow with a white Shorthorn bull. These cows are hardy and can be outwintered if provided with shelter. Another type of Blue-grey cow which has come largely into favour is the Irish Blue-grey which is a cross between the Aberdeen Angus and the Shorthorn of the dual-purpose type. These cows require better treatment in winter but they produce more milk than the ordinary Blue-grey and the calves grow to a bigger size.

Blue-grey cows are generally crossed with the Aberdeen Angus bull and sometimes with the Shorthorn or Hereford. The calves are suckled by the cows until the autumn when they are disposed of at special sales held at St. Boswells, Reston, and Hawick. Thousands of calves go through these sales each year and provide animals of the best beef-type for the feeding farms on the low ground. Prices are around £40 for bullock calves and £35 for heifer calves at live-weights of about 4½ hundredweights and 4 hundredweights respectively.

The arable land on upland farms is devoted largely to the production of oats and turnips for farm use but a limited amount of cash cropping with oats, barley and potatoes is usually possible.

Low-Ground Farms

Almost all the low-ground farms lie between 350 feet and sea level and occupy the area delineated in Chapter I as Lower Tweeddale. Lower Tweeddale comprises soils mainly with clayey texture inherited from their parent materials. The most extensive group of soils is the Whitsome series covering about three quarters of the low-ground farms. The soils of the Whitsome series are among the most fertile in Scotland but require careful management, due to the high clay content of about 30 per cent. in the surface soil. Artificial drainage is of prime importance as these soils would contain much water in their upper horizons, preventing good root development. Tile drains at about 2½ feet and up to 5 yard intervals are required to maintain the soils

PLATE 27
Beech at the Hirsel, Coldstream.
(By courtesy of the Forestry Commission).

PLATE 28
Douglas Fir on Hobkirk series at Duns Castle.
By courtesy of the Forestry Commission).

of this series at the correct moisture content. Similar soils of the Belses and Kedslie series also occur on the low-ground farms and freely drained soils of the Smailholm and Hobkirk series are also to be found.

The cattle which are maintained on the low-ground farms are fattening cattle brought in from the upland farms and also from Ireland. They are generally rising two years old and weigh from 8 to 9 hundredweights live-weight. The feeding courts in the steading are filled up in the autumn with these animals which are put through a course of feeding lasting for about five months. Large quantities of roots, straw, hay, and home-grown grain are consumed. The animals generally yield an increase of about 2 lbs. of live-weight per day or a total increase of 2½ to 3 hundredweights over the feeding period. This gives a gross return of about £20 per head out of which all expenses have to be met and so the net return is not large. In many cases there is no profit at all. The large supply of dung made throughout the winter, however, is of great value for keeping up the fertility of the land. Store cattle are again purchased in spring so as to stock up the grass fields. One bullock to about two acres of pasture, along with sheep, is a common rate of stocking.

As store cattle are dear to buy, many low-ground farmers increase the supply by running a herd of breeding cows and producing part of their own needs. They are thereby able to obtain store animals of superior quality at no more than the cost of production and are less dependent on the vagaries of the market. While this is practised on many low-ground farms, there is no doubt that the low ground is best adapted for fattening cattle and not for rearing although the latter is economically sound under present circumstances. Cattle on low ground fatten more readily both in winter and in summer and yield a carcase of a superior quality. This is partly due to the fact that the land is generally of better quality in the low-ground and the produce is often of higher feeding value. The grazings are more sheltered, while at the same time the climatic conditions throughout the year are more favourable to comfort and well-being. It is, therefore, accepted as a principle of good husbandry that good low-ground farms should confine their attention to the fattening of cattle while the raising of store animals should be left to the upland areas.

Sheep breeding is the main live-stock enterprise on the great majority of low-ground farms in the surveyed area. The local markets have a firm demand for store lambs at prices which have risen steadily since the war and so the farmers concentrate on raising lambs for this market and for fattening. The practice is to carry a sufficient number of Halfbred ewes to stock all the grass fields with ewes and lambs throughout the summer, except those fields required for hay. From the end of July onwards, on farms catering for the store market, the lambs are weaned off their mothers and every effort is made to dispose of them as rapidly as possible in regular lots by the middle of September, so as to get the fields cleaned and ready for the tupping season. Lambs in less forward condition, such as gimmers' lambs, are usually put on rape or other forage crop on arable land where they usually do better than on grass fields which have by this time become stale.

The lambs having been disposed of and the ewes put on the poorest pastures to dry them off, all the better fields of grass are then rested from sheep for a period. This allows the land to clean and it brings on a fresh growth of herbage ready for the ewes during the tupping season in October.

This process is known as flushing the ewes. The ewes improve in condition on the fresh herbage and consequently more ripened ova are shed and more twin lambs are ultimately produced in spring. The extent of the lamb-crop is mainly decided by the bodily fitness and vitality of the ewes at the mating season.

The breed of tup used on Halfbred ewes is usually either the Oxford Down or the Suffolk Down. A very large number of rams is needed and these are obtainable at the ram sales held at Kelso in September. This is the biggest sale of rams in Scotland, the animals being disposed of in twelve auction rings working simultaneously.

After tupping, the ewes are maintained on the fields until New Year with little or no supplementary feeding except during hard weather or snowstorms when hay is fed. The regular feeding of hay commences at New Year. About the middle of January the ewes are folded on turnips for four or five hours each day, being run off on to grass fields at night. This gives them exercise and keeps them in fit condition. Concentrates are fed during the month prior to lambing. This helps to build up the lambs and prepares the ewe's udder for lactation. Great care is taken at lambing-time to provide for the needs of the ewe and her newly born lambs, and to protect the animals from the weather. The same procedure is followed as on the upland farms. The average rate of lambs weaned is around 165 per cent. of the ewe-stock. It was formerly the custom to take only three crops of lambs from the ewes but, owing to the high cost of replacements, four crops of lambs are often taken.

When the ewes and lambs are drafted from the lambing enclosures to the pasture fields on which they will remain as a set-stock all summer, the numbers are kept at a moderate level per acre of pasture. However good the pasture may be it cannot be more than lightly stocked with ewes and lambs throughout the season. Young lambs are peculiarly subject to infestation by threadworms which tend to build up to a dangerous level on heavily stocked pastures. While three ewes with twin lambs per acre may be maintained on a pasture for a few weeks, if this concentration is continued throughout the season the results are generally unsatisfactory. Only about half of this amount of stock can safely be carried, with rather more on first year grass which is regarded as clean ground. Rotational grazing is being tried as a method of increasing the carrying capacity of pastures and these experiments are being watched with interest. Meantime, as sheep cannot in a normal season keep pace with the growth of grass, cattle are always run along with them so as to graze down the rough stuff and make a finer and more leafy sward.

The practice on many low-ground farms is to fatten the lambs bred thereon on sugar beet tops with or without turnips, hay and box-feed during the winter months. Sometimes additional purchased lambs are also similarly fattened. The intensive feeding period lasts 3 to 4 months, each score of lambs consuming 1 acre of turnips.

As regards the financial return from sheep on low-ground and upland farms, wool amounts to about £3 per acre, lambs bring in about £22, cattle £8, making a gross return of £33, per acre of pasture. From this there must be deducted an allowance for the winter-keep of the ewes on roots, hay, and grain amounting to £3. 10., leaving a gross figure of £29. 10. This is not far short of the returns received from grain crops in recent years.

These low-ground farms are adapted by soil, elevation, and climate to grow a wide range of crops not only for farm utilisation, such as turnips and oats, but also for sale as cash crops, such as barley, oats, wheat, potatoes and sugar beet.

CROPPING AND YIELDS

The low-ground arable-stock farms of the Merse of Berwickshire and higher up the Tweed valley follow a rotation roughly as follows—temporary grass of 2 or 3 years duration; cereal; potatoes, roots for feeding, and sugar-beet; cereal; cereal. There is little permanent grass. A feature is the high barley acreage which is currently 2½ times the 1939 level and reflects the ease of handling this crop mechanically, especially the harvesting by combine-harvester. Wheat is not a very important crop. The acreage of winter sown wheat depends largely upon weather conditions in the autumn for seeding. Some spring-sown wheat is grown. The barley acreage exceeds the oat plus wheat acreages.

The turnip acreage is receding year by year from the wartime peak but is still not significantly less than in 1939. This is attributable to the high yields of turnips achieved and to the unquestioned suitability of the crop for sheep.

Sugar-beet is a minor crop but is more commonly grown than before the 1939-1945 war. The annual acreage in the low-ground covered by this survey will be about 1300 acres. The beet tops are valued for sheep feed.

Potatoes are not such an important crop as in other arable areas of East Scotland. This is due to the prevailing shortage of labour for harvesting the crop and the acreage is declining annually as labour gets scarcer.

Typical average yields per acre of recent years for these Merse farms would be:—

Barley	31 cwt.
Oats	30 ,,
Winter Wheat	28 ,,
Spring Wheat	25 ,,
Maincrop Potatoes	200 ,,
Sugar Beet	180 ,,
Swedes	440 ,,

The upland farms of this area have less emphasis on cash-cropping and more on livestock breeding and rearing. There is more grass, both permanent and temporary. A typical rotation is temporary grass of 3 to 7 years duration; cereal; turnips and potatoes; cereal. Oats are the principal cereal with an appreciable acreage of barley but very little wheat. The potato acreage is not large and the potatoes are mainly for sale as certified seed.

Typical average yields per acre of recent years for these upland farms would be:—

Oats	23 cwt.
Barley	26 ,,
Swedes	360 ,,
Potatoes	160 ,,

The hill sheep farms only crop a limited acreage annually. The in-by enclosed ground suitable for ploughing is farmed on an extended rotation such as temporary pasture for 5-15 years; oats; turnips and rape; oats. Almost all the oats are farm consumed. Some farms grow a limited acreage of potatoes for seed.

Typical yields per acre might be:—

Oats	20 cwt.
Swedes	320 ,,

LABOUR

Vital statistics show that the human birth rate in the Borders is very low. This, combined with the drift from the land, common to United Kingdom farms generally, is resulting in a progressive decline in farm labour. During the 1939-45 war there was a substantial increase of agricultural workers due to government action but to-day the numbers are back to the prewar level and the average age is higher. Considering the much bigger tillage acreage than in 1939, the farm labour situation is serious and a decline in production has only been arrested because of the high degree of mechanisation.

A feature is that the workers live on the farms and not many are available from the widely scattered villages. The large farms usually have a row of up to ten cottages. Considerable reliance has been placed hitherto on Irish itinerant labour but this is much less plentiful than formerly.

The shepherd is the most highly paid employee. The large farmers generally employ a working steward who is responsible for the organisation of the farm labour. Roughly three workers are required per 100 acres on the low-ground farms. On the hill farms a typical staffing is one shepherd per hirsel of 400-500 breeding sheep, plus other essential workers.

FARM MECHANISATION

In the last fifteen years, a notable change has taken place on all arable farms in the area by the introduction of machinery on a large scale. This has been followed by the disappearance of the horse as a source of power. The larger farms possess five or six tractors along with a wide range of complicated machinery so that it is often found worth-while to employ a full-time engineer with a properly equipped work-shop. The large amount of capital which has been invested in machinery has had the effect of keeping the acreage of tillage at a high level in order to employ the machines to the fullest extent. There is a certain resistance to the policy of laying land down to grass.

Mechanisation has meant a much increased output from the regular farm worker. In the matter of ploughing, cultivation, and harvesting of crops the output per man has been doubled. This has meant that although the regular labour force has diminished, farmers have been able to keep a high acreage in cultivation, with much benefit to the national economy.

Mechanisation continues apace. The setting up of plant for drying and storing grain on the farm direct from the combine-harvester is receiving attention. This enables farmers to hold their grain off the market in times of glut and to market it in better condition. The hay crop is now largely handled by machinery, the hay being baled out of the rick and stored in hay-sheds in a convenient form for winter feeding. In favourable weather, hay is sometimes baled out of the swath at the rate of about one acre per hour.

The making of silage as a substitute for the labour-consuming root crop is spreading every year as it can readily be mechanised at all stages. Turnips and other root crops are sown with a precision seeder by which individual seeds are deposited at regular intervals of about two inches, thus reducing the labour of singling the crop. Sugar beet is almost all harvested by machinery, but an efficient machine which will lift potatoes without damaging the tubers has not yet appeared.

The latest development is in the sphere of farm buildings where plans are going forward to overhaul farm steadings and make them more suitable for present-day needs. Most buildings were erected at a time when little attention was given to the saving of labour so there is plenty of scope for planning and re-adjustment. Buildings are also being extended to house more cattle, a move which promises to have far-reaching effects in maintaining the fertility of the soil and in helping to keep pastures in a high state of productivity.

CHAPTER IX

Forestry

by I. W. VARTY, B.Sc. (For.) Ph.D.
Forestry Commission (Scotland)

THE main topographical feature of the region described in this memoir is the drainage system comprising the River Tweed and its principal tributaries, the River Teviot, the Leader, Gala and Ettrick Waters. The pattern of drainage to some extent determines the location of woodlands, as many lie along the steep banks of the rivers themselves or on the steep slopes between the pastoral hills and the arable haughs. Forestry is a secondary rural industry over the whole area, but it has greater importance and potential in the less fertile upland to the west. The study region as a whole, even in highly arable areas, has a well wooded appearance to the casual eye, due to the abundance of hedgerow and park trees, game coverts and shelter belts. This appearance belies the facts of measurement. In the Census of Woodlands, 1949, there were found only 41,000 acres of forest land in the three counties of Berwick, Roxburgh, and Selkirk, representing approximately 5 per cent. of the whole. In the smaller area under study, it is estimated that there are some 8,200 acres of estate woodlands under the Dedication and Approved Woodlands Schemes, and a rather smaller area of other woods in private hands. In addition the Forestry Commission has about 5,000 acres of young woods and plantable land in its three forests of Edgarhope, Yair Hill and Elibank (part), forming one quarter of the total woodland within the area. At the time of the Census the composition of the woodland was 33 per cent. coniferous, 15 per cent. mixed, 22 per cent. broad-leaved and 30 per cent. unstocked over the three counties. In the intervening years the proportion of purely coniferous stands has steadily risen.

These Border woodlands provide timber, farm shelter, general amenity and sport in that order of value. Dependent upon the timber production is a small-scale scattered sawmilling industry of non-specialised organisation, dealing in all classes of produce from large sawn hardwoods to pit props and fencing materials. Although the revenue from timber has been generally recognised, the value of woodland in soil conservation and flood reduction has not been fully appreciated. The results of this failure are evident in many places, notably along the Gala Water. Since the last war, however, interest in re-afforestation has quickened and considerable progress is being made.

LOWLAND WOODS

It is no easier to classify a woodland estate as lowland or upland than so to describe a farm, since many incorporate features of both; nevertheless such a classification is sometimes useful. Lowland woods are usually mixed but sometimes they are dominated by broad-leaved trees such as oak, beech, ash, sycamore and elm. The old broad-leaved woods—for some are still intact after two major wars—bear testimony to the knowledge and patience of the foresters of the early nineteenth century, by their longevity, wind-firmness and qualities of soil amelioration. Outstandingly good oak can be seen at the Hirsel and Floors Castle (Plate 26), and very good beech stands at Marchmont, Duns Castle, Rutherford and Mellerstain. Elm, although of good form, is blemished frequently by heart rot in mature years. Good stems of ash and sycamore can be seen in many woods, but the role of these trees has not been important and perhaps it is true to say that their treatment has been inadequate. The best hardwoods almost always occur on rich, deep, natural, well-drained soils with a ground vegetation of mixed herbs such as nettles (*Urtica dioica*) dog's mercury (*Mercurialis perennis*) and wild strawberry (*Fragaria vesca*).

Excellent stems of 50 to 100 cubic feet may be grown in 100 to 150 years, but the longevity of broad-leaved trees on these sites is much greater. Good conifers, especially Scots pine, do occur in the old mixed woods, but for various reasons the exotic species frequently do not grow to best advantage on these lowland loams.

UPLAND WOODS

In general, upland woods are at an altitude between 500 and 1500 feet. They are predominantly coniferous, sometimes mixed, but rarely wholly broad-leaved. The older woods characteristically incorporate one or more of the species Scots pine, Norway spruce and European larch, generally well sited. There are examples of outstandingly good old Scots pines at Bowhill, Eildon, Mellerstain and Charterhall. European larch is not so common, but there are good stems here and there, especially in mixed woods. Individuals of both these species more than two hundred years old can be found but these are exceptional and most have been felled at less than half that age. Norway spruce grows fast and well but appears to be a short-lived species in the Borders, and good old specimens are rare.

The younger upland woods still maintain the overwhelming preponderance of Scots pine with smaller proportions of Norway spruce, but the new exotics such as Sitka spruce, Japanese larch and Douglas fir are becoming increasingly popular. European larch and European silver fir, once firm favourites, have not been planted so much in recent years because of their susceptibility to disease. The rotation for conifer crops is short, 70 to 100 years, and is likely to be shorter still.

These woods have been sited on a variety of soils ranging from brown forest soils and podzols to gleys and even peats. The better sites on brown forest soils are generally indicated by the presence of bent grasses (*Agrostis* spp.) tall bracken (*Pteridium aquilinum*), ferns and abundant herbs such as the speedwells (*Veronica* spp.); the poorer sites on acid podzolic soils and gleys are indicated by heather (*Calluna vulgaris*), sheep's fescue (*Festuca ovina*), wavy hair grass (*Deschampsia flexuosa*) and even by mat-grass (*Nardus stricta*) and purple moor grass (*Molinia caerulea*) at high elevations.

SHELTER BELTS

Small woods form a large proportion of the total forest land. Estate owners and farmers have been quick to appreciate woodland shelter, but not always knowledgeable on how best to procure it. Some woods were designed specifically as shelter for farm crops and stock. Other shelter belts came into being primarily as the fox coverts which are so characteristic of the Borders, or as a source of farm timber. They frequently take the form of narrow strips 20 to 50 yards wide, sited either along the steep banks of a stream or, more artificially, between fields (Plate 23).

The Westruther area of Berwickshire affords some good examples of woodland laid out in very narrow belts for shelter. Such belts, although rather open below the leafy canopy, serve quite well to protect the crops and pasture of lowland fields from excessive wind force, but generally they function poorly as timber producers since the exposure or edge effect on the trees is felt throughout the breadth of the wood. They produce heavily-tapered knotty timber. These narrow shelter belts can be seen in very exposed upland areas where they are much less effective. It must be recognised that on the open hill broad belts and blocks with a deep dense crown layer are required to give adequate shelter to stock, to provide stability against strong winds and to encourage vigorous growth for timber production. On exposed ground the wind suffers little diminution of force in passing over or through a very narrow belt, and frequently such woods become wind-thrown in middle age. A broad belt, however, deflects rather than decelerates a wind, and is much more productive and long-lived.

In the past a mixture of Scots pine and Norway spruce, sometimes with European larch, has been favoured in upland shelter belts. Norway spruce, in a high proportion in narrow belts, has proved to be a source of weakness as it suffers badly from exposure and wind-throw in middle age, more especially when thinning has been neglected. Broad-leaved species are generally absent from hill shelter belts, except as fringes; quite often one sees a rim of beech still standing when the coniferous body has long since been thrown by strong winds.

In the lowland areas of Roxburghshire and Berwickshire, the older shelter strips generally carry a good stocking of mixed broad-leaved trees; the middle-aged and young strips are generally coniferous. There will be many who will agree that the increased use of conifers, especially the monoculture of Scots pine, is already out of keeping with the nature of Lower Tweeddale. The selection of species for shelter belts is especially important, not least in their landscaping effect, and is discussed in a later section.

NOTES ON THE WOODLAND ESTATES

A brief description of some of the larger or more characteristic estates follows.

Yair Hill Forest

This is a Forestry Commission property of 2,300 acres in process of afforestation. In the Yair block itself the uppermost areas are gentle slopes, with peaty podzols of the Minchmoor series, extending down to 800 feet. Below this on the steeper slopes are freely drained brown forest soils of the Linhope series. The valley bottoms and burn sides have non-calcareous gleys of the Ettrick series. In the allocation of species for planting, wide use is made of the exotic conifers. Contorta pine, Sitka spruce, Japanese larch, and noble fir are used at high elevation. Douglas fir, Japanese larch, Scots pine and European larch are planted at the middle levels, and spruces on the clayey soils (Ettrick series) in the valley bottoms. The mixing of these and other species is a general practice, and on suitable sites broad-leaved trees are being established.

Elibank Estate

Sited on a gravelly river terrace with a shallow stony soil of the Yarrow series, the Elibank estate preserves the largest remnant of oak of the ancient Ettrick Forest which reputedly covered a large part of Middle Tweeddale.

Bowhill Estate

This has a large and varied forest area. Parts of it such as Pernassie Hill and Black Andrew Wood are mapped as the freely drained, somewhat rocky, Linhope series. It carries good coniferous crops of many species. The policies in the vicinity of the house, also on Linhope series, are attractive mixed woods characterised by fair to moderate oak trees. Over most of the Howebottom area there are poorly to imperfectly drained soils of the Ettrick and Kedslie series. An interesting semi-natural block of birch and hawthorn scrub is being converted to mixed and coniferous forest, mainly Sitka spruce, in this area.

Philiphaugh and Sunderland Hall estates share with Bowhill varied brown forest soils on steep hillsides (Linhope series) and gravelly river terraces (Yarrow series), supporting good stands of conifers of many species.

Eildon Estate

The forest land is mainly imperfectly drained (Kedslie series). The standing crop is predominantly coniferous and includes good Scots pine planted about 1790, some of it at an elevation of more than 900 feet above sea-level.

Wooplaw

The woodland of the estate lies on poorly drained soils of the Ettrick series at 800 to 1,200 feet. One of the most interesting and encouraging features is the small stand of old Sitka spruce not far from Wooplaw House. At an elevation of 850 feet in an annual average rainfall of 30 to 35 inches, this gley soil, peaty in places, with a rooting depth of 18 inches, has produced in 90 years individual trees up to 110 feet in total height and up to 336 cubic feet per stem, generally free of butt rot. It is also noteworthy that the effect of a single rotation of spruce has been to dry up the site and reduce signs of gleying.

The woodland of Sorrowlessfield Mains is a similar example of a local peaty gleyed soil developed in the uplands on imperfectly to poorly drained till. The old crop of Scots pine with some European larch is not entirely suitable to this soil type, and delayed thinning has resulted in extensive wind-throw.

Roxburghe Estate

The main blocks are Bowmont Forest and Floors Castle. The former has very sandy soils, mainly of the freely drained Hobkirk series. These coarse textured soils have produced good crops of Scots pine; Japanese larch also shows vigorous and shapely growth. Locally, areas of Bowmont Forest are imperfectly and even poorly drained; the well known Norway spruce thinning sample plots are sited on such an area (Plate 25).

The Floors block lies in the fertile Tweed valley near Kelso, and has a complex but generally sandy or stony soil with broad-leaved woods, especially in the older age classes. The clay loam soils (Whitsome series) which occur in some places produce some very good specimens of pedunculate oak.

Mellerstain

This estate has a generally sandy soil of Smailholm series similar to Bowmont, but enriched by basic igneous material. It is noted for the excellent Scots pine, many 160 years old with volumes exceeding 100 cubic feet. The younger crops also are mainly Scots pine. There are some good quality old beech stands which bear testimony to the suitability of a light fertile soil to the species.

Edgarhope

This is a rather scattered forest belonging to the Forestry Commission. The conspicuous Edgarhope Hill has shallow freely drained soils (Lauder and Linhope series) and carries promising young coniferous crops, notably European larch of good strain. The Spottiswoode section has a soil complex incorporating widely different types. From the forestry point of view, one of the most difficult soils is the basin peat of Jordanlaw Moss with a depth of up to 20 feet. This heather, cotton grass and sphagnum moss was concentrically ploughed, cross-drained radially and afforested with a variety of coniferous species in 1954. It gives every promise of developing as a highly successful project of afforestation.

Charterhall

The forest land lies at 400 feet above sea-level, having a soil complex of poorly and imperfectly drained soils. Some areas have been modified in the post-glacial period by water and show a light sandy top; other parts, possibly more difficult to drain, have a thin peaty surface horizon. The sandy areas bear crops of Scots pine which are among the best in Scotland; much of it falls within Quality Class 1 for height, and stems of 200 cubic feet at 150 years are typical.

Langton, Marchmont and Choicelee Estates

The district incorporating these estates has generally freely drained gravelly or sandy soils of Lauder Series. The woodlands have been sited mainly in deans and on banks where arable development has been excluded or difficult. These favourable forest soils give rise to good crops of beech and other hardwoods. A few woods have been sited on podzolised moorland soils, especially at Choicelee, and produce crops of fair Scots pine.

The Hirsel, Ladykirk and Lochton Estates

This is an area of complex drainage. In general the woods have been planted on mixed bottom lands which are difficult to farm. It is of note that in The Hirsel where some good agricultural soils of the Whitsome series have been planted, the most excellent crops of oak and beech are grown.

MODERN PLANTING PRACTICE

In the preparation of ground for planting, the most notable advance in post war years has been the use of ploughing, now a standard practice by the Forestry Commission but less common in private woodlands. Ploughing confers multiple benefits on afforestation; it improves soil structure and releases nutrients; it achieves with equal success moisture conservation in dry areas and drainage in wet areas; it decreases planting and weeding costs. In the Tweed valley the plough is usually fitted with a tine to break up the soil below the trenches, which are 5 to 5½ feet apart. The plants are usually notched into the bottom or side of the trench. Ploughing is directed along the contour to prevent rapid run off and erosion. Excellent examples of ploughing for planting can be seen in the Commission forests of Yair Hill, Elibank and Edgarhope (Plate 24).

A more general regional problem in the Borders is the conversion of birch scrub to high forest. The conventional method is to clear fell and replant. This is expensive, but various semi-experimental cost-cutting treatments, such as strip and group fellings with inter-planting and thinning with under planting, are also under trial.

In the selection of species for planting, research has brought about marked improvements, although these are by no means universally applied. In any area, the choice of species for a site is governed by factors which are mainly edaphic and climatic, and these vary in the Borders as elsewhere. In general, it can be said that in this area the forest soils are so suitable that many species can be expected to prosper on a given site. More interest is now being shown in mixed stands which are more wind-firm, more adaptable to management, and usually more productive than woods of one species only. In particular, it will be recognised that plantations of pure Scots pine, so characteristic of the area, are a poor economic investment, are deleterious to soil structure and fertility, provide inferior shelter and are more subject to insect damage than mixed woods.

The lowland woods of the Tweed Valley should rightly carry a larger proportion of broad-leaved species as well as a greater diversity of conifers. At planting the best way to establish these hardwoods is to introduce them as groups in a mixed coniferous matrix. There are good recent examples of this pattern at The Cants, Bowhill Estate. Alternatively, selection felling with interplanting, as at Floors Castle, can be adapted to re-establish good oak and other species.

In the upland forests and shelter belts, the choice of species narrows with increasing exposure, but it is none-the-less important to have a mixture of species. On good soils at high elevation, it is often possible to include a proportion of sycamore and even beech in conifer crops, provided hare damage can be controlled. On poor and wind-swept sites Japanese larch, Contorta pine and Sitka spruce can be expected to thrive better than the more conventional European larch, Scots pine and Norway spruce. The European silver fir, Douglas fir and Western hemlock withstand exposure well on good soils. Where snow breakage is considered a limiting factor, the proportion of deciduous trees such as larch and sycamore can be increased. On the most exposed sites mountain pine and noble fir are useful species. On deep or shallow peats at all elevations Sitka spruce and Contorta pine are excellent matrix species.

The proper use of these species, especially on ploughable sites, can result in the establishment of forests and shelter belts at elevations much higher than normal; farmers have yet to exploit this new prospect of hill shelter for stock.

Species referred to in the Text

Ash	*Fraxinus excelsior* L.
Beech	*Fagus sylvatica* L.
Birch	*Betula verrucosa* Ehrh., and *B. pubescens* Ehrh.
Contorta pine	*Pinus contorta* Dougl.
Douglas fir	*Pseudotsuga taxifolia* Britt.
European larch	*Larix decidua* Mill
European silver fir	*Abies alba* Mill.
Japanese larch	*Larix leptolepis* Murray
Mountain pine	*Pinus mugo* Turra Coste
Noble fir	*Abies procera* Rehder
Norway spruce	*Picea abies* Karst
Pedunculate oak	*Quercus robur* L.
Scots pine	*Pinus sylvestris* L.
Sessile oak	*Quercus petraea* Lieb.
Sitka spruce	*Picea sitchensis* Carr.
Sycamore	*Acer pseudoplatanus* L.

CHAPTER X

Discussion of Analytical Data

SOIL profiles considered typical of the soil series present in this area have been sampled during the period of survey. Each sample taken has been analysed for loss on ignition, soil separates, exchangeable cations, percentage base saturation, pH, carbon, nitrogen and readily soluble and total phosphorus. A number of profiles have been considered worthy of more detailed investigation involving specialised techniques. Clay samples from these profiles have been analysed chemically for total silica, iron and aluminium; the clay mineral composition has been determined by X-ray and differential thermal methods; the minerals in the fine sand fractions have been identified and their frequencies estimated by specific gravity and optical methods; and the trace element contents have been obtained by spectro-chemical methods.

The data from the routine analyses are given in Appendix I, each profile receiving a number which provides a ready means of identification whenever a profile is referred to in other sections of this chapter: the other data are grouped in Appendices II-IV. When the values for each constituent are correlated and compared it is apparent that certain trends are common to members of a soil sub-group and others to members of an association. In the discussion that follows each constituent is dealt with separately and any trend in the values is noted.

LOSS ON IGNITION

The loss on ignition values for the organo-mineral soils of this area—podzol profiles (Nos. 17-22), and peaty gley profiles (Nos. 41-43)—exhibit a marked decrease with depth. In the A_2 or B_1 horizons of the peaty podzols and iron podzols, however, the organic matter content is often quite high due to a dense root mat or humus staining, e.g. profiles No. 18, 19, 20 and 21. A decrease in the loss on ignition with depth is also a feature of the mineral soils. The profiles of the brown forest soils with gleyed B and C horizons (Nos. 23-31) and non-calcareous and calcareous gleys (Nos. 32-40) generally exhibit a comparatively high (>4 per cent.) loss on ignition in the C horizon due to high clay content (e.g. profiles No. 23 and 29), or the presence of calcium carbonate (e.g. profiles No. 25, 27, 28 and 40), while the coarser textured soils show low values for the C horizon (e.g. profiles No. 3, 4, 7, 10, 11 and 15).

SOIL SEPARATES

Soil separates, namely sand, silt and clay are determined by mechanical analysis. The size limits are those laid down by the International Scheme of Mechanical Analysis (sand 20-2000μ, silt 2-20μ and clay $<2\mu$) and by the U.S.D.A. (sand 50-2000μ, silt 2-50μ and clay $<2\mu$). Values obtained using both schemes, which are discussed in Chapter IV, are quoted in Appendix I.

Relationships exist between the proportions of the three soil separates and the members of both associations and major soil groups. The brown forest soils of low base status (Table 1), iron podzols (Table 2) and peaty podzols (Table 3) are almost all developed on parent materials of medium to coarse texture which contain less than about 35 per cent. clay. The brown forest soils with gleyed B and C horizon (Table 4), the non-calcareous gleys (Table 5), the calcareous gley (Table 6) and the peaty gleys (Table 7) are all formed on tills of fine texture. The range of texture of these parent materials is illustrated in Fig. 9.

Within the brown forest soils with gleyed B and C horizons there is a significant trend shown in the clay content. All the imperfectly drained mineral soils of the area have been placed in this category which is in many respects comparable with the American group of grey-brown podzolic soils. A maximal clay content in the B horizon is one of the characteristics of the grey-brown podzolic soils and the majority of the brown forest soils with gleyed B and C horizons of this area exhibit this feature. In profiles No. 27 and 29 (Whitsome series) the clay content of the B_2(g) horizon is 5 to 10 per cent. higher than that of the S and C horizons. The B_2(g) horizon of the Belses series (profile No. 26) has a clay content 3 per cent. higher than those of the horizons above and below, but in the Kedslie series (No. 23 and 24) there is little differentiation.

High clay content is to be found in the soils of the Whitsome Association (No. 27-30 and 40). Water sorting, which is a feature of the Eckford and Yarrow Associations, is reflected in the high values of the sand fraction, e.g. profiles No. 3, 4, 16 and 18. High sand content is also shown in the alluvial soils (Nos. 44 and 45) while a moderately high value is shown in profile No. 46. Soils of the Hobkirk and Lauder Associations (Nos. 10-13, 27, 35-37 and 43) also show high sand figures due to the high proportion of sandstones and conglomerates in their parent materials.

EXCHANGEABLE CATIONS

Exchangeable Calcium

For all levels of exchangeable calcium, the brown forest soils of low base status show a regular decrease with depth, e.g. profiles No. 1, 3-6, 8, 10-13, 15, 16, but profile No. 14 shows a minimum, No. 7 a maximum and No. 2 an increase down the profile. No obvious trend is apparent for exchangeable calcium in the brown forest soils with gleyed B and C horizons. In profiles No. 25, 27, 28 and 40 figures quoted as exchangeable calcium are high but in fact are due largely to the presence of free calcium carbonate. The values recorded for this constituent in soils of the non-calcareous gley group tend to be moderate or high and show a decrease down the profile: profile No. 39, however, falls to a minimum in the B_2g then increases down the profile. In iron and peaty podzols (profiles No. 17-22) the values for exchangeable calcium are low, i.e. $<3/0$ m.e./100 gms., except for a maximum concentration in the H layer which is sometimes moderate or high. The values for exchangeable calcium in peaty gleys are usually low to moderate with a minimum in the A_1g or B_2g horizon. In the calcareous gley (profile

No. 40) there is a high figure for exchangeable calcium in the B_3g and Cg horizons due to free calcium carbonate.

Exchangeable Magnesium

The values for exchangeable magnesium, when moderate to low, are generally a tenth to a fifth of the exchangeable calcium. The brown forest soils of low base status in this area usually contain moderate (0·3-5·0 m.e./100 gms.) or low amounts of exchangeable magnesium, and generally show a decrease down the profile, e.g. profiles No. 1, 3, 5, 6, 8-12, and 15. Profile No. 2 exhibits high values with an increase down the profile, while profiles No. 4, 13, 14, and 16 show a decrease from a moderate to a low and minimal value, usually in the B horizon, before increasing again to a moderate figure. In the brown forest soils with gleyed B and C horizons the concentration of exchangeable magnesium is normally moderate and either increases down the profile (Nos. 24, 25, 28 and 29) or shows a minimum in the B_2(g) horizon (Nos. 23, 27, 30 and 31). The values of this constituent in the non-calcareous gleys and calcareous gley, are moderate and some show a minimal value in one of the Bg sub-horizons (exceptions 32-34). In the podzol group the exchangeable magnesium values, apart from that of the H layer, are generally low and there tends to be a decrease down the profile. Peaty gleys contain moderate amounts of this cation which, except in the H horizon, increases directly with depth.

Exchangeable Potassium

The values for this cation in the brown forest soils of low base status almost invariably show a decrease with depth. A minimal value, however, is shown in the B horizon of the Sourhope series, e.g. profiles No. 14 and 15. The values in the brown forest soils with gleyed B and C horizons, tend to show a minimal value in the B(g) horizon. The calcareous and non-calcareous gleys either show a minimal value in the Bg horizon (e.g. Nos. 35, 36, 39, 40) or a decrease down the profile (e.g. Nos. 32, 33 and 38). Peaty podzols, iron podzols and peaty gleys also show either a decrease down the profile (e.g. Nos. 21 and 42), a minimal value in the eluvial horizon (e.g. Nos. 17, 19, 22, 41, 43) with maximal values in the H horizon, or no recognisable trend (18, 20).

Exchangeable Sodium

In the majority of brown forest soils of low base status the values for exchangeable sodium decrease with depth (e.g. Nos. 1, 5 and 16), but others show a minimum in the B_2 (e.g. Nos. 6 and 12). The amounts in the brown forest soils with gleyed B and C horizons show little variation, with approximately uniform concentrations throughout the profile. In non-calcareous gley soils there is often a similar trend but with a maximum in the A_1g or S horizons. The values for exchangeable sodium show a maximum in the H horizon of the podzols and peaty gleys and a decrease down the profile.

Exchangeable Hydrogen

The values for exchangeable hydrogen decrease with depth for all soil sub-groups, and if the organic matter content of the surface horizons is high there is a pronounced decrease in the hydrogen ion value on passing into the B horizon (e.g. profiles No. 21 and 41).

PERCENTAGE BASE SATURATION AND pH

When the percentage base saturation in the brown forest soils of low base status is high it normally shows an increase with depth, but when low or moderate the tendency is for the B horizon to be a minimum, e.g. profiles No. 1, 6, 8 and 14. An exception is the Hobkirk series (profiles No. 10 and 11) where there is a decrease with depth. In the brown forest soils with gleyed B and C horizons, however, the percentage base saturation is generally higher and also increases with depth. The values for non-calcareous gleys, poorly and very poorly drained, vary with texture. Those on clayey parent materials are high while those on coarser parent materials are lower and nearly all increase down the profile. Peaty and iron podzols have low values throughout, with a minimum in the A_2 or B_2 horizon. The percentage base saturation in peaty gleys tends to be low in the upper horizons and moderate or high in the C horizon, with a minimum in the A_1g or A_2g horizons. In the calcareous gley the values for base saturation are high.

The pH values of the brown forest soils of low base status increase with depth, except in some of those developed on coarse parent materials when no definite trends are observable, e.g. profiles No. 1, 10, and 11. In brown forest soils with gleyed B and C horizons also the pH value increases down the profile, and is generally higher, e.g. profiles No. 24-29. The majority of non-calcareous gleys and the calcareous gley show an increase in pH with depth but there are a few instances of a decrease in the Cg horizon, e.g. profiles No. 36 and 37. The highest values recorded are in the Horndean series (profile No. 40), a calcareous gley, where the basal horizon attains a pH of 8·84. Many of the non-calcareous gleys, however, exceed pH 7·0 in the Bg and Cg horizons. In the podzols, the most acidic group (pH 3·5-5·2), the values increase gradually down the profile. The peaty gleys show a similar trend but in this case the increase is very sharp, e.g. profiles No. 42 and 43.

CARBON AND NITROGEN

The percentage of carbon and the percentage of nitrogen decrease down the profile of all major soil groups, with the exception of profiles No. 18 and 20 where the B_1 horizon has carbon and nitrogen percentages greater than that in the A horizons.

PHOSPHORUS

Total Phosphorus

In the brown forest soils of low base status the contents of total phosphorus are mainly moderate although a number are low (profiles No. 5 and 11) and a few high (profiles No. 13 and 15). The majority either show a regular decrease with depth (e.g. profiles No. 5, 9, 15, 19) or a minimum in the A or B horizon (e.g. Nos. 1, 3, 4, 6, 10, 12, 13). Some, however, show a minimum in the A or B horizon, followed by a maximum (Nos. 7, 8, 11, 14). The amount of total phosphorus in nearly all the brown forest soils with gleyed B and C horizons is moderate but in two profiles it is low (Nos. 24 and 29). There is a minimal value in the $B_2(g)$ or $B_3(g)$ horizon of every profile except Nos. 28 and 30. The calcareous and non-calcareous gleys have moderate to low values for this constituent, but irrespective of the amount there is a minimum in the B_2g or B_3g horizon of all profiles except No. 32. Values are mostly moderate in the podzol group with some low (Nos. 18 and 20); and a few high in the H horizon (e.g. profiles No. 20 and 21). There is usually a minimum in the A_2 horizon (e.g. profiles No. 20 and 22). Peaty gleys generally contain moderate to low amounts of total phosphate and have a minimal value in the Bg horizon.

Acetic or Readily Soluble Phosphorus

Brown forest soils of low base status show a wide range of values for acetic soluble phosphorus, varying between 0·3 and 59 mg./100 g. soil. If the values are low to moderate there is either a decrease with depth (Nos. 1, 8), or a minimum in the B_2 horizon (Nos. 4, 5, 6, 7, 9, 12, 14, 16). Where the values are moderate to high, however, there is generally an increase with depth (e.g. profiles No. 2, 3, 10, 13, and 15). Almost all the brown forest soils with gleyed B and C horizons (Nos. 25, 26, 27, 28, 29, 30, 31) have a high content of readily soluble phosphorus which is related in each case to a moderately high or high content of exchangeable calcium and a moderately high pH. In the B or C horizon of some (Nos. 25, 27, 28) the content of readily soluble phosphorus is very low compared with that of the horizon above. This is related to a very high pH ($>8·2$ approx.) and a very high content of exchangeable calcium. A similar relationship was noted by Muir (1956, p. 115). The explanation can be inferred from work by Williams and Saunders (1956). Most of the readily soluble phosphorus in these soils is calcium-bound and when the acetic acid extractant is added this phosphate goes into solution so long as the pH has not been raised too much by the presence of free calcium carbonate in the soil. Above a certain pH the calcium-bound phosphorus ceases to be soluble. This explains the sudden drop in the content of readily soluble phosphorus in some of the lower horizons. Similar considerations apply to many of the non-calcareous gleys (Nos. 34, 35, 38, 39), the calcareous gley (No. 40) and even to two peaty gleys (Nos. 42, 43). In the iron and peaty podzols the amount of this constituent is generally low and no definite trends are recognised. There is, however, a high value in the H horizon of the iron podzols (profiles No. 17-20).

FREE CARBONATE

The content of carbon dioxide, representing free carbonate, was determined in selected profiles, all except one, a calcareous gley, belonging to the group of brown forest soils with gleyed B and C horizons. All the profiles examined (Tables 9, 10, Appendix II) contain free carbonate, especially in the lower horizons. The carbonate is almost entirely in the form of calcium carbonate and consequently is responsible for abnormally high contents of exchangeable calcium. As pointed out in the section on readily soluble phosphorus, the contents of free carbonate and readily soluble phosphorus are closely interrelated.

SILICA-SESQUIOXIDE RATIOS OF THE CLAY FRACTIONS

Determinations of silica, iron and aluminium were carried out on the clay fraction ($< 1·4\mu$) of several typical profiles. The procedures followed are listed in the summary of analytical methods at the end of this chapter.

The percentages of silica, iron oxide and aluminium oxide, and the following molecular ratios, SiO_2/R_2O_3, SiO_2/Fe_2O_3, SiO_2/Al_2O_3 and Al_2O_3/Fe_2O_3, are given in Appendix III, Tables 11 to 17. Silica-sesquioxide ratios indicate the relative leaching and differential movement of iron and aluminium oxides compared with silica and thus enable a comparison to be made between soils of various major soil groups.

Most of the brown forest soils of low base status, Table 11, exhibit little or no leaching of sesquioxides. This lack of differentiation of sesquioxides is in accord with the definition of this soil sub-group and is similar to the results obtained by Muir and Fraser (1940), Glentworth (1944) and Mitchell and Jarvis (1956). Profiles No. 1 and 8, however, do show variations in the SiO_2/Fe_2O_3 ratio, which indicate some leaching but there is no significant trend in the aluminium oxide figures. This is not very surprising as both these soils are developed on acidic parent materials under a relatively high water surplus.

The percentage of silica in brown forest soils with gleyed B and C horizons, Table 14, is remarkably constant throughout the profile, and variations in silica-sesquioxide ratios are small. Translocation of the sesquioxides is therefore slight.

There is some leaching of iron oxide from the upper horizons of a non-calcareous gley (No. 36, Table 15) but no zone of accumulation in the B_3g or Cg is indicated. The other non-calcareous gley (No. 33) has ratios with no consistent pattern. In the calcareous gley (No. 40, Table 16) the ratios indicate an accumulation of iron oxide in, or a leaching of silica from, the upper horizons.

The most striking differential movement of silica and sesquioxides occurs in a peaty podzol, Table 13. It shows decided leaching of iron oxide from the A_1 and A_2 horizons, with accumulation in the B horizon. Translocation of aluminium oxide is exhibited by the iron podzol, Table 12.

Both the peaty gley profiles examined (Nos. 41, 42, Table 17) show very strong leaching of iron oxide from the A_1g and A_2g horizons. In contrast, no translocation of aluminium oxide is apparent.

MINERALOGY OF THE FINE SAND FRACTIONS

The minerals in the fine sand fractions of samples from a number of profiles were separated into two groups according to specific gravity, the heavier group ($>2{\cdot}9$) being characterised by ferromagnesian silicate minerals and iron oxides and the lighter ($<2{\cdot}9$) by quartz and felspar.

Table 18 shows the results of this separation. Within an association (e.g. the Ettrick) there are variations in the percentage of the ferromagnesian silicate minerals, but this can be accounted for by variations in the concentration of the minerals in the glacial till, or by varying rates of solution of the minerals due to texture, or by drainage differences in the soils.

The soils developed on igneous rocks (e.g. the Darleith Association) or on till derived from igneous rocks have the highest proportion of ferromagnesian silicate minerals. The soils in this area developed from Old Red Sandstone or from Carboniferous rocks do not show marked differences in the heavy group figures.

The minerals composing each of the fractions were identified and their frequency of occurrence estimated. These results are also given in Table 18. The same frequency scale is applied separately to both the light and heavy fractions. The figures indicate the following ranges 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%.

The soils of the Ettrick Association have a large content of rock fragments, mainly fine-grained shale, in the light fraction. Chlorite, biotite and muscovite are also a feature of the fine sand fractions of these soils. Similar results have already been found for soils developed on Silurian rock in south-east Scotland by Hart (1929) and Muir (1956).

In soils of the Yarrow and Eckford Association similar features are to be noted.

Garnet and chlorite are prominent minerals in the soils of the Hobkirk Association, while in the soils of the Whitsome Association there is an increased proportion of pyroxene and amphibole minerals, due probably to igneous rocks influencing the till.

In the Lauder Association the presence of chlorite appears to be a feature of the soil, again probably due to the influence of eroded Silurian material forming the Old Red Sandstone parent rocks.

Both the soils from the Bemersyde and Darleith Associations show the marked influence of igneous rock material, especially in the case of the soil from the Darleith Association, where olivine, plagioclase and pyroxene minerals are prominent.

MINERALOGY OF THE CLAY FRACTIONS

The examination of the clay fraction of these soils was carried out by X-ray diffraction and differential thermal analysis (d.t.a.) on the $<1{\cdot}4\mu$ fraction, and some typical results are given in Table 19. As these show there is little variation in the clay mineralogy over the whole area.

The Darleith soils, however, are quite distinctive and show the influence of the olivine basalts. They contain montmorillonite and vermiculite, and a high proportion of amorphous sesquioxides which was indicated by a dense background on the x-ray diffraction diagrams. Similar results were found for the Darleith soils in the Kilmarnock area (Mitchell and Jarvis 1956).

In the associations, Ettrick, Hobkirk, Whitsome and Lauder, the dominant minerals in the clay fractions are very similar in nature and amount, averaging 60-70% of illite and 10-20% each of kaolin and chlorite. Distinctions between these associations are only apparent in the amounts of minor constituents such as the haematite content of the Hobkirk and Lauder soils which are derived from Old Red Sandstone sediments.

In the Bemersyde Association on trachyte (profile 1) the illite content is lower and vermiculite occurs. The amount of felspar in the clay fraction of this soil is greater than normal. The wide occurrence of chlorite in the soils of the area can be related to the chlorite content of the extensive Silurian sediments from which the bulk of the later sedimentary formations were derived. Glacial transportation may also have resulted in the presence of chlorite in soils overlying the non-Silurian rocks.

Variations in the clay mineralogy within the associations which can be ascribed to pedological effects are not marked, but it may be noted that in some poorly drained representatives of the Ettrick Association (e.g. profile 41), mixed-layer vermiculite-chlorite mineral is found suggesting that chlorite is not stable under gleying conditions. Lepidocrocite also occurs in similar conditions. Within the Ettrick Association haematite was found in profiles from the red phase only, and in the bottom layer of these some ferric hydroxide gel (Mackenzie, 1949), was identified by d.t.a.

The d.t.a. curves for some of these soils showed two endothermic peaks at approximately 600°C where there is normally only the main illite peak.

TRACE ELEMENTS

The trace-element contents of samples from fourteen representative profiles have been determined spectrographically using the methods described by Mitchell (1948). These profiles are from the most important associations represented in the area and the parent materials include olivine basalt, trachyte, sandstone, shales, marls and fluvio-glacial gravels. Total contents and the amounts extracted by 2·5% acetic acid are used to indicate the trace element status of the soils.

The Peniel Heugh soil (profile No. 2), the profile examined from the Darleith Association, has total contents of 500-800 p.p.m. barium, 15-40 p.p.m. cobalt, 20-80 p.p.m. chromium, 30-40 p.p.m. copper, >1500 p.p.m. manganese, <1-2 p.p.m. molybdenum, 40-60 p.p.m. nickel, <10-15 p.p.m. lead, 40-80 p.p.m. strontium, 50-100 p.p.m. vanadium and 60-100 p.p.m. zirconium, which agree reasonably well with Darleith profiles from the Jedburgh and Kilmarnock areas (Muir, 1956, p. 118; Mitchell and Jarvis, 1956, p. 172).

Profile No. 1, from the Bemersyde Association, has quite low total cobalt (4-8 p.p.m.) and copper (<5-5 p.p.m.) but the extractable cobalt in the surface (0·84 p.p.m.) is probably adequate from the animal nutrition aspect. Total chromium and vanadium (60 p.p.m.), manganese (1500 p.p.m.), nickel (25-40 p.p.m.), barium (300-400 p.p.m.), strontium (80 p.p.m.) and zirconium (>1000 p.p.m.) are in keeping with trachytic parent material. The total molybdenum (3-5 p.p.m.) is higher than normally found in Scottish soils.

Three profiles from the Whitsome Association (Nos. 28, 30, 40), developed on a mixed till from igneous and sedimentary rocks, have contents of essential trace elements which would appear adequate to supply plant and animal requirements. Values for total contents are 800-1000 p.p.m. barium, 15-20 p.p.m. cobalt, 80 p.p.m. chromium, 10-20 p.p.m. copper, 600-800 p.p.m. manganese, <1-2 p.p.m. molybdenum, 40-60 p.p.m. nickel, 80-200 p.p.m. strontium, 80-100 p.p.m. vanadium, 200-400 p.p.m. zirconium. The profile from the Whitsome colluvial phase (No. 30) does not show the usual increase in extractable cobalt, nickel or iron with gleying, but these effects are shown by the other profile in the Whitsome series (No. 28).

The Ettrick Association is developed on Silurian greywacke and shale. Four profiles were examined (Nos. 6, 8, 9, 41). Total contents in the Newark Hill (No. 6) and Longmuir Rig (No. 41) profiles are as follows:—barium 300-1500 p.p.m., cobalt 1-20 p.p.m., chromium 30-100 p.p.m., copper 5-40 p.p.m., manganese 70-800 p.p.m., molybdenum <1-1 p.p.m., nickel 10-80 p.p.m., strontium 30-80 p.p.m., vanadium 20-150 p.p.m., zirconium

100-300 p.p.m. In each case the lowest values are from the H horizon of profile No. 41, a peaty gley. Comparison of the Raecleugh (No. 8) and Faldonside (No. 9) profiles indicate that acetic acid has extracted slightly more cobalt and nickel from Faldonside (the red phase), but much less aluminium.

From the Hobkirk Association two profiles were examined (Nos. 11 and 36). The well-drained profile has 1000 p.p.m. barium, 6-10 p.p.m. cobalt, 80 p.p.m. chromium, 8-15 p.p.m. copper, 250-600 p.p.m. manganese, about 1 p.p.m. molybdenum, 20-40 p.p.m. nickel, 60-80 p.p.m. strontium, 80 p.p.m. vanadium and 400 p.p.m. zirconium, with similar values for the poorly-drained profile. The extractable cobalt in the surface of the well-drained profile is 0·38 p.p.m. falling to 0·03 p.p.m. in the C horizon. Higher values are found in the poorly-drained soil, as is usual for acetic acid extractable cobalt under these conditions.

Soils developed on fluvioglacial sand and on fluvioglacial gravels are represented by samples from the Eckford Association (profile No. 3) and the Yarrow Association (profile No. 16) respectively. Although the Eckford soils have lower clay contents, their trace element contents are similar to those in the Yarrow soils. Total contents in these two profiles are 600-800 p.p.m. barium, 10-15 p.p.m. cobalt, 60-100 p.p.m. chromium, 8-20 p.p.m. copper, 400-800 p.p.m. manganese, 1-4 p.p.m. molybdenum, 30-60 p.p.m. nickel, 40-80 p.p.m. strontium, 60-100 p.p.m. vanadium and 200-250 p.p.m. zirconium. Acetic acid extracts about the same amounts from the two surface soils, but somewhat less from other horizons of the Eckford profile than from the Yarrow. For example, in the Eckford profile, cobalt varies from 0·65 p.p.m. in the surface to 0·08 p.p.m. in the C horizon, the corresponding values for the Yarrow profile being 0·98 to 0·50 p.p.m.

Results for profile No. 13 on Upper Old Red Sandstone conglomerates (Lauder Association) indicate that total trace element contents are not as low as might have been expected, values being 1000 p.p.m. barium, 20 p.p.m. cobalt, 100 p.p.m. chromium, 8-15 p.p.m. copper, 400-1000 p.p.m. manganese, 1-2 p.p.m. molybdenum, 40 p.p.m. nickel, 150 p.p.m. vanadium and 200 p.p.m. zirconium. Acetic acid extracts 1·2 p.p.m. cobalt, 0·77 p.p.m. nickel and 9·6 p.p.m. zinc from the surface soil.

In the three associations (Ettrick, Hobkirk and Whitsome), for which well-drained and poorly-drained profiles were examined, increased solubility of certain elements was noted in the lower horizons where gleying had occurred. This is illustrated by the Upper Huntlywood soils (profile No. 36) where 30% of the total cobalt, 10% of the total nickel and 3% of the total vanadium are extracted by acetic acid from the poorly-drained soil, compared with about 0·3% of each element for the well-drained profile (No. 11). The tendency for lead to be high in surface soils is also seen in the several profiles from this area.

In addition to the elements which have been mentioned above, others have been detected, the ranges of their contents being within those found for other Scottish soils (Swaine, 1955). These elements include gallium, lanthanum, lithium, rubidium and yttrium, which were found in all the profiles, and scandium and beryllium which were observed in some profiles from the Whitsome, Ettrick, Yarrow and Lauder Associations. Beryllium was detected also in the Bemersyde soils. It is interesting to note that germanium (2 and 5 p.p.m.) and tin (3 and 6 p.p.m.) were detected in two

H horizons (from profiles Nos. 20 and 22) with high loss-on-ignition (80% and 65% respectively).

The results indicate that very few problems of deficiency or excess of trace elements in stock or plants are likely to be encountered in the soils examined from this area. This is shown well by considering molybdenum which is essential for the healthy growth of plants and cobalt which is important in the rearing of sheep. Fifty samples of soil from the various associations had 1-5 p.p.m. with a mean 1-2 p.p.m. total molybdenum, which values are of the same order as found for other parts of Scotland (Swaine, 1955). Acetic acid extractable cobalt was above 0·3 p.p.m. in all surface soils examined, and seldom below this value in subsoils, with the exception of some from the Hobkirk Association. These values are in keeping with an adequate content of cobalt. Low total copper contents were found in the Bemersyde profile, but further work would be necessary before one could decide whether this area is likely to show copper deficiencies. There are no indications of excesses of elements like nickel, tin, lead, molybdenum or zinc. Even under gleyed conditions the highest extractable nickel was 5·4 p.p.m. (profile No. 41, Ettrick Association), and lead and tin never exceeded 1 p.p.m. extractable.

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 colorometrically (Hunter, 1950), and 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 Kjeldahl method (Markham, 1942).
6. Total phosphate was determined by a colorimetric method using hydrazine sulphate, after fusing the soil with sodium carbonate (Muir, 1952).
7. Acetic soluble phosphate was determined colorimetrically in a 2·5 per cent. acetic acid extract (Williams and Stewart, 1941).
8. Carbon dioxide was determined by an indirect method (Kolthoff and Sandell, 1950).
9. Silica sesquioxide determinations of the clay fraction were carried out as follows:—ignited clay was fused with sodium carbonate (Robinson, 1939), and the silica determined after a double evaporation with hydrochloric acid. Aluminium (Robertson, 1950) and iron (Scott, 1941) were determined colorimetrically in aliquots of the filtrate from the silica.

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APPENDIX I

Routine Analytical Data

TABLE 1. BROWN FOREST SOILS OF LOW BASE STATUS

Horizon	Depth in.	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g.: Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
1.	BEMERSYDE ASSOCIATION; Bemersyde Series. Bemersyde, 114799-114801																		
A	2-6	20·10	39·2	36·7	62·5	13·4	8·5	0·80	0·44	0·07	0·45	24·40	6·7	4·71	10·78	0·610	208	2·8	Low exchangeable bases, % saturation, pH and readily soluble P_2O_5 throughout.
B_2	8-11	10·90	36·9	42·7	58·1	21·5	14·9	0·33	0·11	0·04	0·18	15·16	4·2	4·96	3·90	0·253	133	1·1	
B_3	16-20	7·48	31·3	42·1	48·0	25·4	22·9	0·33	0·10	0·02	0·13	9·34	5·9	4·87			152	1·0	
2.	DARLEITH ASSOCIATION; Darleith Series. Peniel Heugh, 111073-111075																		
A	2-7	20·60	45·9	24·7	55·7	14·9	13·9	15·51	8·42	0·28	0·96	22·70	53·0	5·42	7·50	0·731	203	19·8	High exchangeable bases and readily soluble P_2O_5 throughout.
B_2	10-18	9·64	46·6	23·8	57·2	13·2	24·8	24·66	10·72	0·39	0·29	14·02	72·0	6·07	2·50	0·256	248	41·7	
B_3	22-26	7·93	54·8	24·3	62·4	16·7	16·9	24·30	11·00	0·36	0·26	10·12	77·9	6·12			209	42·2	
3.	ECKFORD ASSOCIATION; Eckford Series. East Morriston, 114778-114781																		
S	2-6	4·51	42·6	40·7	67·2	16·1	14·4	7·30	3·63	0·14	0·24	2·62	81·3	5·91	1·43	0·132	172	3·9	Low clay content in B and C. Very high silt content (U.S.D.A.) in bottom sample of C. High readily soluble P_2O_5 in C.
B_2	11-15	2·32	60·4	29·4	79·1	10·7	7·9	2·89	0·29	0·02	0·15	1·13	74·8	6·18	0·36	0·031	116	8·9	
C	22-26	1·97	63·1	28·4	82·7	8·8	6·5	2·27	0·14	0·02	0·13	Nil	100	6·35			95	11·3	
C	36-40	2·43	35·1	57·9	75·2	17·8	4·6	2·57	0·15	0·02	0·13	0·80	78·2	6·49			122	25·1	

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
4.								ECKFORD ASSOCIATION; Eckford Series. Huntlywood, 114788-114791											
S	2-6	7·43	52·3	31·1	69·7	13·7	12·9	11·04	0·56	0·06	0·22	2·17	84·5	6·63	3·03	0·222	316	50·0	Low clay content in B_2 and C. High exchangeable Ca in S. High total P_2O_5 in S. Very high readily soluble P_2O_5 in S.
B_2	11-15	2·68	64·3	26·6	79·0	11·9	6·4	3·48	0·26	0·03	0·05	Nil	100	7·07	0·43	0·052	105	12·0	
C	20-24	2·58	70·0	19·3	77·6	11·7	8·1	3·78	0·34	0·03	0·03	Nil	100	7·15			96	3·2	
C	34-38	2·49	75·5	13·1	83·8	4·8	8·9	3·48	0·27	0·03	0·03	Nil	100	7·39			103	5·5	
5.								ETTRICK ASSOCIATION; Linhope Series. Meigle Pots, 105197-105200											
A	1-5	19·10	17·3	49·2	36·7	29·8	19·2	43·50	1·13	0·19	0·50	Nil	100	7·40	8·72	0·557	198	1·5	Very high exchangeable Ca in A. Low exchangeable Mg in B_3 and C. Low total P_2O_5 in B_3 and C. Low readily soluble P_2O_5 except in C.
B_2	10-14	7·89	16·9	52·4	34·7	34·6	26·8	14·68	0·33	0·17	0·21	Nil	100	7·41	2·55	0·197	130	0·8	
B_3	18-20	5·49	29·8	46·3	48·1	28·0	21·2	9·10	0·13	0·10	0·17	Nil	100	7·50			94	1·2	
C	20-26	3·93	28·1	47·4	45·5	30·0	20·6	4·12	0·08	0·09	0·11	Nil	100	7·11			88	4·7	
6.								ETTRICK ASSOCIATION; Linhope Series. Newark Hill, 105183-105186											
A	1-5	13·95	32·9	46·4	55·1	24·2	13·7	0·64	0·38	0·15	0·57	18·63	8·6	4·45	5·67	0·418	241	9·3	Low exchangeable bases, % saturation and pH throughout. Very low readily soluble P_2O_5 except in A.
A-B	7-11	12·30	32·6	43·8	55·8	20·6	17·4	0·32	0·20	0·15	0·38	25·33	4·0	4·38	5·26	0·368	209	0·7	
B_2	20-24	6·01	31·1	39·5	47·8	22·8	26·4	0·16	0·06	0·06	0·02	8·55	3·5	4·82			138	0·5	
C	30-36	5·45	34·3	36·6	48·8	22·1	26·4	0·15	0·07	0·09	0·02	5·53	3·6	4·80			141	0·9	

Horizon	Depth in.	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g.: Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
4.								ECKFORD ASSOCIATION; Eckford Series. Huntlywood, 114788-114791											
S	2-6	7·43	52·3	31·1	69·7	13·7	12·9	11·04	0·56	0·06	0·22	2·17	84·5	6·63	3·03	0·222	316	50·0	Low clay content in B_2 and C. High exchangeable Ca in S. High total P_2O_5 in S. Very high readily soluble P_2O_5 in S.
B_2	11-15	2·68	64·3	26·6	79·0	11·9	6·4	3·48	0·26	0·03	0·05	Nil	100	7·07	0·43	0·052	105	12·0	
C	20-24	2·58	70·0	19·3	77·6	11·7	8·1	3·78	0·34	0·03	0·03	Nil	100	7·15			96	3·2	
C	34-38	2·49	75·5	13·1	83·8	4·8	8·9	3·48	0·27	0·03	0·03	Nil	100	7·39			103	5·5	
5.								ETTRICK ASSOCIATION; Linhope Series. Meigle Pots, 105197-105200											
A	1-5	19·10	17·3	49·2	36·7	29·8	19·2	43·50	1·13	0·19	0·50	Nil	100	7·40	8·72	0·557	198	1·5	Very high exchangeable Ca in A. Low exchangeable Mg in B_3 and C. Low total P_2O_5 in B_3 and C. Low readily soluble P_2O_5 except in C.
B_2	10-14	7·89	16·9	52·4	34·7	34·6	26·8	14·68	0·33	0·17	0·21	Nil	100	7·41	2·55	0·197	130	0·8	
B_3	18-20	5·49	29·8	46·3	48·1	28·0	21·2	9·10	0·13	0·10	0·17	Nil	100	7·50			94	1·2	
C	20-26	3·93	28·1	47·4	45·5	30·0	20·6	4·12	0·08	0·09	0·11	Nil	100	7·11			88	4·7	
6.								ETTRICK ASSOCIATION; Linhope Series. Newark Hill, 105183-105186											
A	1-5	13·95	32·9	46·4	55·1	24·2	13·7	0·64	0·38	0·15	0·57	18·63	8·6	4·45	5·67	0·418	241	9·3	Low exchangeable bases, % saturation and pH throughout. Very low readily soluble P_2O_5 except in A.
A-B	7-11	12·30	32·6	43·8	55·8	20·6	17·4	0·32	0·20	0·15	0·38	25·33	4·0	4·38	5·26	0·368	209	0·7	
B_2	20-24	6·01	31·1	39·5	47·8	22·8	26·4	0·16	0·06	0·06	0·02	8·55	3·5	4·82			138	0·5	
C	30-36	5·45	34·3	36·6	48·8	22·1	26·4	0·15	0·07	0·09	0·02	5·53	3·6	4·80			141	0·9	

TABLE 1—continued

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
7.								ETTRICK ASSOCIATION; Linhope Series. Tinnis, 105156-105159											
A	2-6	10·00	32·0	38·3	48·7	21·6	24·6	1·10	0·70	0·08	0·38	12·21	15·6	4·82	3·80	0·290	122	0·5	Low exchangeable Ca
B_2	9-13	6·24	32·0	34·6	46·7	19·9	30·3	1·40	0·84	0·06	0·22	7·83	24·1	5·28	1·49	0·130	101	0·4	throughout.
B_3	16-20	5·07	49·4	23·2	61·7	10·9	24·5	0·93	0·50	0·05	0·14	7·15	18·5	5·54			118	0·4	Low total P_2O_5 in C.
C	24-30	3·41	43·4	31·7	57·8	17·3	21·5	0·61	0·38	0·03	0·10	1·93	36·8	5·95			69	0·8	Very low readily soluble
																			P_2O_5 throughout.
8.								ETTRICK ASSOCIATION; Linhope Series. Raecleugh, 119165-119168											
A	1-5	10·38	29·3	42·5	47·8	24·0	23·0	2·03	1·09	0·10	0·74	12·90	23·5	4·94	4·62	0·291	160	1·2	Low exchangeable Ca
A	7-10	7·00	28·5	41·9	43·0	27·4	26·1	1·87	0·78	0·08	0·31	10·45	22·6	5·00	2·77	0·181	125	1·1	throughout.
B_2	16-20	9·64	36·7	43·5	53·7	26·5	15·0	1·75	0·66	0·12	0·16	13·45	16·7	5·34			194	0·3	Low total P_2O_5 in C.
C	25-30	4·77	47·1	35·0	63·5	18·6	15·5	0·77	0·07	0·05	0·10	4·74	17·3	5·27			80	0·3	Low readily soluble P_2O_5
																			throughout.
9.								ETTRICK ASSOCIATION; Linhope Series (red phase). Faldonside, 105191-105194											
A	1-5	10·45	17·7	43·0	31·0	29·7	34·1	8·43	0·82	0·12	0·46	7·28	57·3	5·63	3·55	0·348	272	1·2	Clay content above average
A-B	7-11	6·93	18·5	40·1	34·6	24·0	37·9	6·95	0·46	0·08	0·73	4·68	63·7	5·84	1·72	0·197	239	1·0	for Linhope Series, except
B_2	13-17	5·76	27·2	36·0	38·9	24·3	33·9	8·02	0·43	0·09	0·56	3·38	72·9	6·44			231	1·0	in C.
C	27-31	4·45	34·9	39·5	46·3	28·1	23·4	5·50	0·17	0·09	0·22	1·61	78·8	6·66			164	1·2	Low readily soluble P_2O_5
																			throughout.

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
10.	HOBKIRK ASSOCIATION; Hobkirk Series. Nisbet No. 1, 109960-109964																		
S	2-6	5·02	45·7	40·1	76·8	9·0	11·4	6·26	0·16	0·07	0·03	3·98	62·0	6·03	2·46	0·200	119	4·0	Low exchangeable bases, except Ca in S
B_2	8-12	2·64	43·8	41·3	76·7	8·4	12·3	2·87	0·10	0·05	Nil	2·26	57·2	6·20	0·66	0·051	87	4·6	Low pH in bottom sample of C.
C	15-18	2·34	48·2	36·2	77·5	6·9	13·3	2·57	0·08	0·05	Nil	2·26	54·5	6·25			80	5·2	Low total P_2O_5 in B_2 and top of C.
C	24-28	1·35	65·9	23·4	86·1	3·2	9·3	1·21	0·06	0·03	Nil	2·26	36·6	5·42			89	11·3	High readily soluble P_2O_5 at bottom of C.
C	36-40	1·46	59·0	22·7	79·3	2·4	16·8	0·46	0·04	0·03	Nil	3·95	11·8	4·97			120	18·4	
11.	HOBKIRK ASSOCIATION; Hobkirk Series. Upper Huntlywood, 112199-112202																		
S	2-6	5·13	46·6	38·9	65·2	14·3	17·9	9·64	0·33	0·07	0·13	Nil	100	6·84	1·83	0·153	160	5·9	Low exchangeable bases, except Ca in S.
B_2	14-18	1·65	67·5	19·9	78·0	9·6	10·9	2·43	0·28	0·03	0·05	1·94	59·0	5·75	0·16	0·045	79	7·1	Low total P_2O_5 in B_2.
B_3	24-28	1·74	70·3	16·8	80·4	6·7	11·2	2·02	0·24	0·04	0·07	1·48	61·7	5·37			108	17·0	High readily soluble P_2O_5 in B_3 and C.
C	36-42	1·58	64·0	22·2	74·4	11·8	12·2	1·37	0·16	0·03	0·08	1·48	52·5	5·13			99	14·8	
12.	LAUDER ASSOCIATION; Lauder Series. Lylestone, 118362-118365																		
S	2-5	6·40	37·9	31·3	50·7	18·5	27·6	11·92	1·11	0·10	0·18	2·22	85·8	6·73	1·74	0·176	207	6·7	Low silt content in C.
B_2	11-15	4·59	50·6	24·9	63·2	12·3	22·2	8·65	0·71	0·09	0·13	1·75	84·5	6·65	0·63	0·090	102	1·5	High exchangeable Ca in S and B_2.
C	19-23	3·61	68·9	11·7	73·2	7·4	15·8	7·41	0·39	0·10	0·11	0·59	93·2	6·75			92	4·9	Low readily soluble P_2O_5 in B_2.
C	28-32	3·49	65·5	15·8	73·1	8·2	15·2	6·62	0·32	0·10	0·11	0·35	95·3	6·71			114	11·5	

TABLE 1—continued

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
13.								LAUDER ASSOCIATION; Lauder Series. Wanton Walls, 114782-114787											
S	1-5	8·30	48·5	29·0	62·4	15·1	18·3	4·20	0·95	0·10	0·43	13·09	30·3	4·80	3·29	0·204	342	17·2	Low silt content in C.
B_2	6-10	6·30	53·9	29·4	70·9	12·4	13·5	4·50	0·85	0·12	0·11	8·80	38·8	5·59	1·95	0·134	486	18·8	Low exchangeable Ca and Mg in upper part of C.
C	36	3·46	54·1	30·4	78·0	6·5	12·0	1·98	0·20	0·08	0·05	3·31	41·1	5·49	0·36	0·052	192	29·1	High total P_2O_5 in S and B_2.
C	72	3·43	61·3	26·0	78·3	9·0	9·3	2·44	2·05	0·13	0·10	2·73	63·4	5·68			156	24·5	High readily soluble P_2O_5 throughout.
C	108	3·53	57·1	27·8	75·8	9·1	11·6	3·50	2·69	0·17	0·13	1·92	77·2	5·63			165	22·8	
C	144	3·47	69·0	14·5	78·0	5·5	13·0	5·64	3·46	0·19	0·24	1·82	84·0	6·14			190	26·0	
14.								SOURHOPE ASSOCIATION; Sourhope Series. Halterburn, 119155-119159											
A	1-5	15·50	44·5	30·4	57·8	17·1	17·3	0·95	0·76	0·19	0·62	22·10	9·8	4·20	7·43	0·433	275	4·8	Low exchangeable Ca throughout.
B_2	10-14	10·37	42·7	27·0	53·0	16·7	25·1	0·16	0·24	0·07	0·15	10·80	4·6	4·69	3·35	0·246	192	1·7	Low exchangeable Mg in B_2 and B_3.
B_2	18-22	9·71	43·1	30·7	54·5	19·3	21·3	0·16	0·18	0·07	0·08	12·76	3·7	5·04			224	2·1	Low % saturation except in C.
B_3	24-28	7·99	49·8	33·7	67·0	16·5	12·5	0·16	0·10	0·07	0·16	12·53	3·8	5·10			278	7·2	Low readily soluble P_2O_5 in B_2.
C	28-32	6·29	54·4	22·1	64·3	12·2	20·4	1·52	0·83	0·08	0·11	4·11	38·2	5·53			148	9·9	
15.								SOURHOPE ASSOCIATION; Sourhope Series. Lochside, 118371-118374											
S	2-6	10·90	44·4	30·9	58·1	18·2	18·2	9·40	1·25	0·10	1·18	7·08	62·8	6·06	4·31	0·385	424	29·0	High exchangeable Ca in S.
B_2	8-12	3·88	48·1	26·9	57·3	17·7	21·1	6·81	0·74	0·08	0·95	3·50	71·1	6·00	0·63	0·054	377	39·4	High total P_2O_5 in S and B_2.
B_3	14-18	3·52	43·7	26·4	54·0	16·1	26·4	6·35	0·62	0·09	0·97	4·08	66·3	5·64			283	51·8	High to very high readily soluble P_2O_5 throughout.
C	23-27	2·15	51·0	19·2	56·8	13·4	27·6	3·92	0·42	0·07	0·76	5·88	46·8	5·35			223	58·8	

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
16.																			
YARROW ASSOCIATION; Yarrow Series. Easter Langlee, 112208-112212																			
S	2-6	8·51	43·7	34·4	57·7	20·4	17·6	11·11	1·35	0·11	0·31	4·42	74·5	6·60	3·11	0·288	252	8·8	High exchangeable Ca in S and A-B.
A-B	10-13	6·62	46·3	30·9	57·7	19·5	19·5	8·80	0·52	0·09	0·13	4·16	69·5	6·30	1·81	0·190	208	2·1	Low exchangeable Mg in B_2 and C.
B_2	16-20	5·91	44·5	35·2	57·0	22·7	17·3	6·64	0·19	0·07	0·15	2·78	71·8	6·28			207	1·9	Low readily soluble P_2O_5 except in S.
B_3	27-31	4·71	56·7	25·8	66·5	16·0	15·1	5·37	0·34	0·05	0·07	2·06	73·9	6·58			147	1·4	
C	36-42	3·98	63·8	21·5	69·4	15·4	11·2	3·67	0·24	0·04	0·03	1·72	70·0	6·59			127	1·6	

TABLE 2. IRON PODZOLS

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
17.	BEMERSYDE ASSOCIATION; Dirrington Series. Blacksmill Hill, 122236 & 114796-114798																		
H	1-0	62·82	N.D.	N.D.	N.D.	N.D.	N.D.	7·63	5·13	0·53	1·79	77·80	16·3	3·82	40·00	1·533	231	14·8	Low clay content in A_1. Low exchangeable Ca except in H. Low exchangeable Mg in A_2 and B. Low % saturation and pH throughout. Low readily soluble P_2O_5 in A_2 and B.
A_1	0-3	18·60	49·2	31·4	63·9	16·7	5·4	0·94	0·83	0·12	0·55	25·88	8·6	4·11	11·02	0·365	139	3·9	
A_2	3-5	7·45	42·3	39·5	61·8	20·0	14·5	0·15	0·10	0·03	0·14	13·40	3·0	4·49	3·24	0·187	124	1·2	
B	6-11	7·79	32·1	28·5	44·4	16·2	35·5	Nil	0·10	0·04	0·30	14·35	3·0	4·75			192	1·4	
18.	ECKFORD ASSOCIATION; Hexpath Series. Mack's Mill, 122237 & 112184-112189																		
H	1-0	82·63	N.D.	N.D.	N.D.	N.D.	N.D.	11·00	6·82	0·61	2·64	84·90	19·9	3·79	51·80	2·079	318	26·5	Low exchangeable bases except in H. Low % saturation and pH throughout. Low total P_2O_5 in A_2, B_3 and C. High readily soluble P_2O_5 in H, low in A_2, B_1, B_2 and B_3.
A_2	1-3	5·59	58·7	34·8	84·4	9·1	3·7	0·45	0·35	0·07	0·13	8·23	10·8	4·10	2·90	0·190	59	2·6	
B_1	4-7	15·14	74·0	16·0	86·2	3·8	2·4	0·47	0·43	0·12	0·15	39·20	2·9	4·26	8·26	0·308	213	2·0	
B_2	8-12	2·83	71·6	19·6	81·3	9·9	7·4	Nil	0·06	0·04	0·03	6·19	2·1	4·80	0·98	0·044	126	2·3	
B_3	15-19	1·94	73·0	19·8	84·8	8·0	5·3	Nil	0·01	0·02	0·03	2·03	2·9	5·02			63	1·2	
C	24-28	1·25	81·0	13·6	87·9	6·7	4·1	Nil	0·03	0·04	0·03	1·13	8·1	4·91			58	3·5	
C	35-40	0·95	81·6	13·3	91·4	3·5	4·1	Nil	0·04	0·04	0·03	2·03	5·1	4·92			59	9·0	

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
19.																			ETTRICK ASSOCIATION; Minchmoor Series. Brockhouse, 121864-121869
H	2-0	68·00	N.D.	N.D.	N.D.	N.D.	N.D.	2·69	3·14	0·36	2·26	63·80	11·7	3·71	37·80	1·560	272	17·3	Low silt content in A_1, A_2 and B_2. Low exchangeable bases except in H. Low % saturation and pH throughout. Low total P_2O_5 in B_3. Low readily soluble P_2O_5 except in H.
A_1	1-4	14·20	57·5	21·8	70·2	9·1	13·6	0·16	0·42	0·09	0·42	25·10	4·2	4·21	7·22	0·373	148	2·4	
A_2	8-11	14·41	60·4	18·3	70·1	8·6	14·1	0·16	0·15	0·06	0·19	31·42	1·8	4·79	6·23	0·337	227	1·5	
B_2	14-18	8·58	61·0	14·7	68·0	7·7	20·0	Nil	0·04	0·06	0·11	14·60	1·4	4·81			158	0·6	
B_3	22-26	4·34	46·8	39·2	65·6	20·4	11·8	Nil	0·01	0·03	0·05	5·64	1·6	4·91			82	0·9	
C	29-33	4·68	48·7	35·7	63·6	20·8	13·3	Nil	0·14	0·05	0·07	8·84	2·9	4·95			100	0·4	
20.																			ETTRICK ASSOCIATION; Minchmoor Series. Newark Hill, 122233 & 105179-105182
H	3-0	79·23	N.D.	N.D.	N.D.	N.D.	N.D.	4·64	5·02	0·69	2·62	83·50	13·5	3·49	52·40	1·870	339	32·4	Low exchangeable bases except in H. Low % saturation and pH throughout. High total P_2O_5 in H and B_2. High readily soluble P_2O_5 in H, low in B_1 and C.
A_2	½-3½	11·90	38·5	43·5	65·6	16·4	12·0	0·31	0·18	0·12	0·25	18·70	4·4	3·92	5·71	0·268	126	4·6	
B_1	4-6	17·60	41·9	34·8	63·2	13·5	10·1	0·16	0·20	0·14	0·26	39·30	1·8	4·36	8·71	0·438	227	2·4	
B_2	9-15	9·24	45·4	35·9	59·5	21·8	14·1	0·16	0·12	0·06	0·09	19·18	2·2	4·68			385	9·9	
C	23-29	4·92	45·4	34·4	56·8	23·0	17·7	0·15	0·15	0·08	0·08	6·55	6·6	5·07			154	1·9	

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TABLE 3. PEATY PODZOLS WITH THIN IRON PAN

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
21.								ETTRICK ASSOCIATION; Dod Series. Brockhouse, 122202-122205											
H	6-2	80·10	N.D.	N.D.	N.D.	N.D.	N.D.	3·65	3·61	0·75	1·63	76·90	11·1	3·71	46·50	1·885	319	7·8	Low exchangeable bases except in H. Low % saturation and pH throughout. High total P_2O_5 in H. Low readily soluble P_2O_5 except in H.
A_2	2-5	24·60	51·4	18·3	60·2	9·5	11·8	0·16	0·26	0·14	0·12	41·60	1·6	4·57	12·48	0·695	275	1·5	
B_2	12-16	7·69	39·0	43·0	60·3	21·7	14·2	Nil	0·05	0·07	0·03	11·45	1·3	4·88			165	1·6	
C	20-24	5·23	46·0	37·9	64·5	19·4	13·5	Nil	0·05	0·06	0·03	6·06	2·3	5·04			132	2·1	
22.								HOBKIRK ASSOCIATION; Faw Series. Greenlaw Moor, 122239 & 109951-109955											
H	1-0	64·98	N.D.	N.D.	N.D.	N.D.	N.D.	2·79	2·56	0·67	2·52	52·60	13·9	3·91	40·50	0·582	238	4·5	Low silt and clay content in A_1. Low exchangeable bases except in H. Low % saturation and pH throughout. Low total P_2O_5 in A_1, A_2 and B_2. Low readily soluble P_2O_5 in A_1 and A_2, high in B_3 and C.
A_1	2-4	8·25	68·1	24·3	85·7	6·7	3·5	0·46	0·17	0·06	0·15	12·45	6·3	4·43	4·03	0·329	72	1·1	
A_2	6½-9½	3·36	54·8	30·5	75·7	9·6	11·3	Nil	0·02	0·05	0·03	7·01	1·4	4·46	1·40	0·118	69	0·8	
B_2	13-16	2·56	44·8	35·1	63·6	16·4	17·4	Nil	0·04	0·04	0·03	3·54	3·0	4·84			97	3·0	
B_3	21-23	3·09	50·9	20·9	62·2	8·6	25·1	Nil	0·15	0·06	0·07	4·71	8·4	5·12			189	19·3	
C	36-40	2·23	40·1	33·5	57·3	16·3	24·2	0·46	0·29	0·07	0·07	3·76	19·1	5·18			144	31·8	

TABLE 4. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

Horizon	Depth in.	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g.: Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
23.								**ETTRICK ASSOCIATION; Kedslie Series. Cauldshiels, 112190-112193**											
S	3-7	10·50	21·3	40·0	35·8	25·5	33·4	8·19	5·49	0·10	0·19	8·31	62·6	5·61	4·32	0·307	147	1·0	High clay content throughout. High exchangeable Ca and Mg in S. Low readily soluble P_2O_5 throughout.
$B_2(g)$	13-17	5·35	27·2	34·0	39·5	21·7	36·1	4·43	0·60	0·06	0·18	4·11	56·2	5·65	0·78	0·074	106	0·8	
$B_3(g)$	20-24	4·31	30·9	33·1	42·3	21·7	33·8	3·05	1·26	0·06	0·29	3·64	56·2	5·48			101	0·7	
C(g)	28-32	4·58	25·4	34·4	38·7	21·1	37·9	3·05	1·31	0·05	0·23	1·49	74·8	5·65			120	0·9	
24.								**ETTRICK ASSOCIATION; Kedslie Series. Easter Langlee, 112213-112216**											
S	2-6	6·11	29·1	44·1	38·6	24·6	23·7	9·10	0·59	0·06	0·10	2·78	77·8	6·31	2·32	0·269	160	6·8	High exchangeable Ca in S. Low total P_2O_5 in $B_2(g)$ and $B_3(g)$. Low readily soluble P_2O_5 in $B_2(g)$.
$B_2(g)$	13-17	3·03	27·2	43·2	47·7	22·7	26·6	5·52	0·89	0·06	0·07	1·27	88·7	6·88	0·29	0·053	66	1·0	
$B_3(g)$	22-26	2·85	29·8	39·1	47·1	21·8	28·2	5·50	2·43	0·06	0·08	Nil	100	7·11			97	6·5	
C(g)	30-34	2·78	32·7	35·9	45·9	22·7	28·6	4·77	3·86	0·08	0·08	Nil	100	7·55			112	7·4	
25.								**MINTO ASSOCIATION; Belses Series. Mainberry, 114802-114806**											
S	2-6	7·40	26·7	43·1	45·3	24·5	26·5	13·80	1·77	0·10	0·11	1·74	90·0	6·75	2·47	0·208	221	32·1	High exchangeable Ca throughout. High pH in $B_3(g)$ and C(g). Very high readily soluble P_2O_5 in S and $B_2(g)$.
$B_2(g)$	12-16	3·17	37·7	41·7	59·6	19·8	17·4	8·42	1·78	0·06	0·07	Nil	100	7·50	0·44	0·056	190	66·5	
$B_3(g)$	19-23	4·42	52·7	28·3	66·1	14·9	16·8	19·35	2·04	0·06	0·13	Nil	100	8·69			183	15·9	
C(g)	26-30	5·73	44·1	30·0	55·3	18·8	23·0	38·20	2·72	0·08	0·18	Nil	100	8·70			206	3·3	
C(g)	38-42	6·25	40·5	23·6	52·5	11·6	32·8	38·40	3·34	0·10	0·27	Nil	100	8·66			193	2·8	

TABLE 4—continued

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
26.	MINTO ASSOCIATION; Belses Series. Wellrig, 121833-121836																		
S	4-8	5·24	32·4	42·3	50·9	23·8	22·7	5·38	0·82	0·07	0·76	2·77	71·8	6·36	1·72	0·148	141	11·5	Low clay content in C(g). Low total and readily soluble P_2O_5 in B_2(g). Very high readily soluble P_2O_5 in B_3(g) and C(g).
B_2(g)	12-16	3·44	34·0	36·8	46·6	24·2	25·8	5·23	0·59	0·08	0·29	1·27	83·0	6·67	0·47	0·048	69	2·5	
B_3(g)	20-24	3·16	37·3	33·8	52·3	18·8	25·7	8·01	0·63	0·09	0·18	Nil	100	7·08			123	34·8	
C(g)	30-34	2·09	60·9	24·1	72·4	12·6	12·9	5·01	0·35	0·04	0·10	Nil	100	7·30			140	62·1	
27.	WHITSOME ASSOCIATION; Whitsome Series. Anton's Hill No. 1, 103855-103859																		
S	3-7	5·91	26·4	35·4	42·8	19·0	35·2	11·33	1·44	0·11	0·56	3·06	81·4	6·32	1·63	0·159	114	5·0	High exchangeable Ca, particularly in C(g). High pH in C(g). Low total P_2O_5 at top of B_2(g). Low readily soluble P_2O_5 at top of B_2(g), very high in B_3(g).
B_2(g)	9-11	4·69	20·2	37·0	37·7	19·5	40·5	12·50	1·24	0·14	0·49	1·92	88·2	6·68	0·66	0·083	81	1·7	
B_2(g)	13-17	3·86	25·9	34·1	38·4	21·6	36·1	12·76	1·52	0·13	0·27	Nil	100	7·04			102	16·0	
B_3(g)	24-28	3·14	29·1	33·6	41·6	21·1	34·2	12·38	2·00	0·12	0·19	Nil	100	7·57			195	84·8	
C(g)	36-42	5·32	30·9	34·4	42·8	22·5	32·0	41·20	2·76	0·12	0·21	Nil	100	8·55			195	10·1	
28.	WHITSOME ASSOCIATION; Whitsome Series. Little Swinton, 109932-109936																		
S	1-4	9·95	27·6	41·0	47·3	21·3	26·4	15·93	2·18	0·11	0·96	2·30	89·3	6·69	4·20	0·442	253	24·3	High to very high exchangeable Ca. Very high pH in B_2(g), B_3(g) and C(g). High readily soluble P_2O_5 in S.
S	6-10	6·07	28·1	33·6	43·7	18·0	35·2	15·97	2·15	0·09	1·18	Nil	100	7·84	1·83	0·202	207	34·5	
B_2(g)	13-17	6·70	29·6	32·8	40·1	22·3	34·2	44·90	2·40	0·12	0·60	Nil	100	8·40			190	9·4	
B_3(g)	25-30	6·95	31·0	29·7	41·3	19·4	35·8	49·40	2·59	0·14	0·61	Nil	100	8·49			186	6·0	
C(g)	35-39	7·64	24·2	33·8	39·7	18·3	38·2	49·75	2·57	0·14	0·37	Nil	100	8·61			177	7·0	

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
29.	WHITSOME ASSOCIATION; Whitsome Series. Third Lowhaugh No. 1, 103843-103848																		
S	2-6	12·17	0·9	37·0	15·7	22·2	56·0	16·80	3·48	0·30	0·34	2·67	88·2	6·54	3·54	0·280	166	4·6	Very low sand and high clay content throughout.
$B_2(g)$	12-16	6·84	Nil	29·5	2·5	27·0	69·5	14·18	4·58	0·26	0·33	Nil	100	7·60	0·72	0·090	79	1·7	High exchangeable Ca throughout.
$B_2(g)$	17-21	6·66	Nil	38·8	5·0	33·8	60·2	13·71	4·62	0·28	0·30	Nil	100	7·57	0·63	0·078	73	0·7	High exchangeable Mg in $B_3(g)$ and C(g).
$B_3(g)$	24-28	5·97	2·2	38·6	7·2	33·6	58·2	13·44	5·68	0·27	0·27	Nil	100	7·59			108	1·7	Low total P_2O_5 in $B_2(g)$.
C(g)	32-36	5·66	Nil	37·0	2·8	34·2	62·0	12·30	7·60	0·27	0·29	Nil	100	7·86			192	70·4	Low readily soluble P_2O_5 in $B_2(g)$ and $B_3(g)$, very high in C(g).
C(g)	42-46	5·16	3·0	34·5	7·5	30·0	61·5	11·28	6·48	0·29	0·27	Nil	100	8·01			209	97·5	
30.	WHITSOME ASSOCIATION; Whitsome Series (colluvial phase). Little Swinton, 109946-109950																		
S	3-7	7·95	31·0	35·5	46·5	20·0	29·5	8·97	2·71	0·09	0·38	3·15	79·5	6·34	3·07	0·270	225	17·7	High exchangeable Ca throughout.
$B_2(g)$	14-18	4·20	34·5	34·2	47·9	20·8	29·2	8·32	1·70	0·13	0·22	1·96	84·0	6·62	0·99	0·128	171	16·6	Low total and readily soluble P_2O_5 at top of D.
C(g)	26-30	5·95	22·8	32·7	39·5	17·0	40·5	10·40	2·61	0·18	0·24	2·44	84·7	6·82			198	4·5	High readily soluble P_2O_5 in S, $B_2(g)$ and at bottom of D.
D	35-39	4·10	15·9	42·4	35·4	22·9	39·6	7·85	2·63	0·18	0·22	2·19	83·3	6·78			88	1·7	
D	49-53	3·16	29·3	32·1	42·8	18·6	35·4	9·65	3·97	0·18	0·20	0·35	99·0	6·86			135	14·7	

TABLE 4—continued

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
31.					WHITSOME ASSOCIATION; Whitsome Complex. Kinnetside Heads No. 1, 111098-111102														
S	3-8	6·84	36·4	36·1	51·5	21·0	24·1	12·51	1·71	0·08	0·21	3·46	80·9	6·24	1·99	0·155	307	33·6	High exchangeable Ca throughout.
B_2(g)	11½-15½	3·68	61·4	23·0	71·6	12·8	11·9	9·24	1·45	0·12	0·13	2·53	81·5	6·80	0·42	0·057	208	26·5	High total P_2O_5 in S and bottom sample of C(g).
B_3(g)	17-21	3·38	55·4	26·6	66·2	15·8	14·6	9·72	1·82	0·10	0·13	Nil	100	7·00			169	34·1	High readily soluble P_2O_5 in S, B_2(g) and B_3(g), very high in C(g).
C(g)	24-28	3·71	42·3	28·9	55·0	16·2	25·1	14·63	3·78	0·15	0·15	Nil	100	7·39			235	84·4	
C(g)	32-40	3·58	43·6	27·7	56·9	14·4	25·1	14·40	5·24	0·16	0·17	Nil	100	7·30			304	126·5	

TABLE 5. NON-CALCAREOUS GLEYS

Horizon	Depth in.	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g.: Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
32.								ETTRICK ASSOCIATION; Ettrick Series. Cauldshiels, 112194-112198											
S	1-5	11·40	8·8	48·3	27·5	29·6	37·2	7·14	1·04	0·14	0·28	5·56	60·8	5·47	3·90	0·365	197	1·0	Low total P_2O_5 at top of Cg.
B_2g	10-14	6·73	9·7	44·4	25·8	28·3	42·5	5·55	1·46	0·10	0·13	5·18	58·1	5·80	1·29	0·150	136	0·9	Low readily soluble P_2O_5 throughout.
B_3g	16-20	5·13	21·0	40·6	39·0	22·6	35·8	4·43	1·49	0·13	0·10	2·96	67·5	6·14			108	0·8	
Cg	23-27	4·37	15·7	40·3	31·8	24·2	41·8	4·28	2·27	0·09	0·08	1·14	85·5	6·19			73	0·6	
Cg	36-40	4·46	27·6	34·9	40·2	22·3	35·3	4·14	2·39	0·08	0·08	0·46	93·5	6·39			124	0·7	
33.								ETTRICK ASSOCIATION; Ettrick Series. Raecleugh, 119169-119173											
A_1g	1-5	10·30	27·2	46·6	45·9	27·9	21·1	4·21	2·28	0·17	0·39	7·54	48·3	5·51	4·30	0·349	110	2·5	Low total P_2O_5 except in A_1g.
A_2g	7-11	4·55	30·9	47·2	46·3	31·8	19·6	3·69	2·89	0·11	0·15	3·36	67·0	5·75	0·71	0·060	67	10·5	Low readily soluble P_2O_5 in A_1g, high in A_2g.
B_2g	14-18	3·81	20·2	47·2	35·7	31·7	28·8	4·60	3·09	0·11	0·15	1·61	83·2	6·44			·51	9·5	
B_3g	23-27	3·45	22·1	47·2	38·0	31·3	27·2	4·92	3·25	0·11	0·14	Nil	100	6·64			65	7·2	
Cg	36-40	3·67	29·8	39·7	43·8	25·7	26·8	4·61	2·99	0·10	0·15	Nil	100	6·66			68	4·4	
34.								ETTRICK ASSOCIATION; Peden Series. Raecleugh, 119174-119178											
A_1g	0-2	17·88	11·6	33·0	21·6	23·0	42·0	13·50	5·93	0·37	0·25	8·20	71·0	6·09	7·78	0·515	189	2·7	High exchangeable Ca and Mg in A_1g.
A_2g	3-7	4·16	28·4	44·5	42·5	30·4	25·0	5·98	2·68	0·15	0·15	1·96	82·0	6·25	1·01	0·051	88	27·7	Low total P_2O_5 except in A_1g.
B_2g	10-14	3·78	22·9	44·5	41·1	26·3	28·8	5·36	2·58	0·16	0·17	0·35	96·0	6·78			73	27·2	Low readily soluble P_2O_5 in A_1g, otherwise high.
B_3g	18-22	3·24	28·9	37·3	41·1	25·1	30·6	4·75	2·13	0·17	0·15	0·92	78·8	6·65			70	19·2	
Cg	29-33	3·94	33·1	40·0	47·6	25·5	23·0	5·05	1·59	0·15	0·15	Nil	100	7·34			88	27·4	

TABLE 5—continued

Horizon	Depth in.	% Loss on Ignition	Soil Separates % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g. Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
35.																			HOBKIRK ASSOCIATION; Cessford Series. Bedshiel, 118348-118352
A_1g	2-5	15·70	26·5	30·6	33·5	23·6	35·0	13·70	5·88	0·20	0·34	7·78	72·2	6·12	5·51	0·470	227	2·0	High exchangeable Ca in A_1g and A_2g. High exchangeable Mg in A_1g. Low total P_2O_5 in B_2g and B_3g. Low readily soluble P_2O_5 in A_1g, otherwise high.
A_2g	6-9	7·44	22·3	36·9	36·8	22·4	37·1	8·41	4·12	0·14	0·15	2·57	83·4	6·37	1·59	0·135	133	10·8	
B_2g	11-15	4·20	33·3	37·6	49·9	21·0	27·0	6·45	4·05	0·10	0·10	Nil	100	6·82			78	14·3	
B_3g	20-24	3·71	40·9	29·6	51·3	19·2	25·8	5·04	3·57	0·07	0·08	Nil	100	7·33			77	13·8	
Cg	35-39	3·93	40·5	28·4	49·6	19·3	27·2	5·21	3·78	0·06	0·13	Nil	100	7·81			119	35·6	
36.																			HOBKIRK ASSOCIATION; Cessford Series. Upper Huntlywood, 112203-112207
A_1g	2-6	10·00	43·9	34·5	66·5	11·9	16·6	7·06	0·58	0·09	0·17	5·73	58·0	5·85	5·22	0·254	102	1·4	Low exchangeable Ca in B_3g and Cg. Low total P_2O_5 except in A_1g. Low readily soluble P_2O_5 throughout.
B_2g	11-15	2·01	42·0	41·8	69·6	14·2	14·2	3·34	0·52	0·04	0·07	0·57	87·7	5·84	0·12	0·024	43	0·5	
B_3g	23-27	1·38	56·4	34·7	82·2	8·9	7·5	1·98	0·68	0·04	0·03	0·46	86·6	5·67			47	0·9	
Cg	36-40	1·57	49·7	38·2	78·5	9·4	10·5	1·82	1·35	0·06	0·10	1·48	69·2	5·54			61	0·8	
Cg	48-52	1·47	60·0	28·8	81·3	7·5	9·7	1·37	1·20	0·05	0·14	2·15	56·2	4·85			59	1·4	
37.																			LAUDER ASSOCIATION; Lylestone Series. Lylestone, 118357-118361
S	2-6	6·29	32·3	35·8	46·5	21·6	28·8	11·02	1·09	0·10	0·14	2·19	85·0	6·90	1·64	0·150	123	2·9	High exchangeable Ca in S and B_2g. Low total P_2O_5 in B_2g and B_3g. Low readily soluble P_2O_5 throughout.
B_2g	8-12	4·89	29·9	39·1	46·6	22·4	28·6	10·10	0·93	0·09	0·13	2·19	83·7	6·92	0·95	0·103	71	0·4	
B_2g	15-19	4·27	30·0	31·5	42·2	19·3	36·4	9·21	1·21	0·08	0·15	Nil	100	7·29			73	1·0	
B_3g	23-27	3·65	59·1	19·3	69·1	9·3	17·9	7·33	1·22	0·07	0·11	Nil	100	7·20			63	1·8	
Cg	33-37	3·50	58·7	20·0	67·1	11·6	17·8	7·40	1·27	0·08	0·10	Nil	100	7·11			109	1·3	

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
38.								MINTO ASSOCIATION; Minto Series. Wellrig, 121837-121840											
S	3-7	5·01	30·5	41·2	46·0	25·7	25·8	5·84	0·65	0·07	0·14	3·83	63·5	5·91	1·57	0·118	158	13·8	Low total P_2O_5 in B_2g.
B_2g	11-15	3·08	28·9	44·8	47·1	26·6	23·2	5·81	0·59	0·06	0·10	0·81	89·1	6·73	0·39	0·045	74	10·3	High readily soluble P_2O_5 in S and B_2g, very high in B_3g and Cg.
B_3g	20-24	2·60	29·2	50·7	53·5	26·4	17·5	5·35	0·57	0·06	0·08	Nil	100	7·20			145	66·8	
Cg	36-40	2·24	35·9	48·5	60·0	24·4	13·4	5·73	0·62	0·06	0·07	Nil	100	7·49			181	82·2	
39.								SOURHOPE ASSOCIATION; Atton Series. Halterburn, 119160-119164											
A_2g	3-7	16·28	47·3	26·4	60·1	13·6	14·1	1·94	1·31	0·27	0·34	19·45	16·5	4·85	7·38	0·601	333	3·1	Low exchangeable Ca in A_2g and B_2g.
B_2g	10-14	5·90	45·9	30·1	60·5	15·5	21·1	0·93	0·89	0·13	0·11	9·90	17·2	5·19	1·89	0·129	189	8·5	High exchangeable Mg in Cg.
B_2g	18-21	4·75	40·3	29·0	53·9	15·5	28·3	1·25	1·35	0·16	0·16	7·17	29·0	5·50			176	5·2	High total P_2O_5 in A_2g.
B_3g	24-28	4·60	33·7	25·0	43·0	15·7	39·0	3·31	2·98	0·21	0·24	6·75	50·0	5·60			188	3·9	High readily soluble P_2O_5 in Cg.
Cg	38-42	3·96	32·9	30·4	45·5	17·8	32·7	7·08	6·62	0·30	0·28	1·78	88·9	6·25			193	29·7	

TABLE 6. CALCAREOUS GLEY

Horizon	Depth in.	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g.: Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
40.			WHITSOME ASSOCIATION; Horndean Series. Little Swinton, 109927-109931																
S	3-7	8·15	26·4	37·5	44·1	19·8	32·0	12·02	3·01	0·14	0·68	2·84	84·8	6·62	2·76	0·274	223	38·1	High exchangeable Ca throughout.
B_2g	11-15	5·50	25·7	35·5	43·2	18·0	36·0	11·17	2·92	0·11	0·27	Nil	100	7·50	0·68	0·089	183	66·2	High pH in B_3g and Cg.
B_3g	21-24	7·68	43·7	20·9	46·7	17·9	31·6	53·30	3·50	0·17	0·27	Nil	100	8·57			214	5·8	High readily soluble P_2O_5 in S, very high in B_2g.
Cg	31-35	8·25	26·9	30·9	42·4	21·4	32·1	53·20	3·64	0·29	0·29	Nil	100	8·78			173	6·2	
Cg	42-46	8·10	24·0	37·4	38·0	23·4	34·6	50·80	4·91	0·15	0·29	Nil	100	8·84			199	8·6	

TABLE 7. PEATY GLEYS

Horizon	Depth in.	% Loss on Ignition	Soil Separates: % Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Exchangeable Cations m.e./100g.: Ca	Mg	Na	K	H	% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
41.	ETTRICK ASSOCIATION; Hardlee Series. Longmuir Rig, 121859-121863																		
H	5-1	62·34	N.D.	N.D.	N.D.	N.D.	N.D.	1·39	1·61	0·44	0·83	74·00	5·5	4·02	44·30	1·670	280	2·2	High clay content in B_2g. Low exchangeable Ca throughout. Low exchangeable Mg in A_1g and B_2g, high in Cg. Low total P_2O_5 in B_2g. Low to very low readily soluble P_2O_5 throughout.
A_1g	1-4	14·19	34·1	33·4	52·0	15·5	25·4	0·16	0·25	0·12	0·13	30·75	2·1	4·30	5·92	0·371	234	0·6	
B_2g	6-10	5·80	10·7	34·7	23·4	22·0	51·7	Nil	0·18	0·09	0·10	11·70	3·1	4·91			85	0·2	
B_3g	14-18	4·64	20·7	41·6	35·2	27·1	35·4	0·31	1·18	0·11	0·09	6·30	21·1	5·30			100	0·2	
Cg	28-32	4·13	32·9	33·8	42·3	22·4	31·2	2·63	6·35	0·13	0·15	1·63	84·9	6·34			132	0·4	
42.	ETTRICK ASSOCIATION; Hardlee Series. Raecleugh, 119179-119184																		
H	3-0	65·75	N.D.	N.D.	N.D.	N.D.	N.D.	4·96	5·70	0·67	1·51	49·60	20·6	4·01	39·60	1·626	309	10·5	High sand content in Cg. High exchangeable Mg in H, B_2g and B_3g. High total P_2O_5 in H, low in A_2g, B_2g, B_3g and Cg. High readily soluble P_2O_5 in H and Cg, low in A_2g, B_2g and B_3g.
A_1g	0-2	34·60	N.D.	N.D.	N.D.	N.D.	N.D.	3·31	3·04	0·30	0·42	36·55	16·2	4·45	21·48	1·062	292	4·4	
A_2g	3-5	7·77	27·8	38·8	43·2	23·4	29·5	3·74	3·68	0·16	0·16	10·08	43·3	5·61	3·34	0·186	64	0·4	
B_2g	7-11	5·60	22·5	38·2	37·3	23·4	36·5	4·78	5·28	0·17	0·15	1·62	86·5	6·63			44	0·8	
B_3g	14-18	4·90	30·7	31·4	43·5	18·6	35·4	5·72	5·86	0·14	0·15	Nil	100	7·22			40	2·8	
Cg	26-30	3·32	67·6	17·5	75·6	9·8	11·3	3·19	2·80	0·07	0·10	Nil	100	7·02			89	30·8	

TABLE 7—continued

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
43.			HOBKIRK ASSOCIATION; Wauchope Series. Bedshiel, 122234 & 118343-118347																
H	5-1	78·20	N.D.	N.D.	N.D.	N.D.	N.D.	4·98	4·54	0·64	1·90	76·50	13·6	3·95	53·50	1·845	285	4·2	Low exchangeable Ca in A_1g and A_2g.
A_1g	0-3	13·71	54·3	17·7	61·4	10·6	21·1	0·91	0·70	0·10	0·13	19·56	8·6	4·54	5·15	0·314	123	0·4	High. exchangeable Mg in Cg.
A_2g	3-6	6·82	42·4	25·2	52·4	15·2	29·0	0·92	0·78	0·08	0·05	12·49	12·8	5·08	2·04	0·135	77	0·4	Low total P_2O_5 in A_2g and B_2g.
B_2g	9-13	4·70	32·6	28·4	42·2	18·9	36·6	3·07	3·00	0·08	0·08	3·25	65·8	5·87			57	0·6	Low readily soluble P_2O_5 in A_1g, A_2g and B_2g, high in B_3g and Cg.
B_3g	18-22	3·72	25·4	43·1	45·5	23·0	27·8	4·60	4·75	0·07	0·10	Nil	100	7·00			120	34·3	
Cg	36-40	5·86	39·5	28·5	48·8	19·2	29·1	7·07	6·79	0·05	0·15	Nil	100	8·25			142	22·8	

TABLE 8. ALLUVIUM

Horizon	Depth in.	% Loss on Ignition	Soil Separates					Exchangeable Cations m.e./100g.					% Saturation	pH	% Carbon	% Nitrogen	mg./100g. Total P_2O_5	mg./100g. Read. Sol. P_2O_5	Remarks
			% Sand U.S.D.A.	% Silt U.S.D.A.	% Sand Inter.	% Silt Inter.	% Clay	Ca	Mg	Na	K	H							
44.								ALLUVIUM. Little Swinton, 109942-109945											
A_1	0-4	7·25	79·4	12·5	87·6	4·3	4·5	6·14	2·07	0·11	0·22	4·26	66·7	5·84	3·36	0·305	95	2·8	Low total P_2O_5 in A_1 and A_2g.
A_2g	6-10	2·98	81·9	5·8	85·9	1·8	9·3	3·94	1·36	0·06	0·13	1·05	84·0	6·67	1·53	0·160	80	8·9	Low readily soluble P_2O_5
B_2g	17-21	1·48	88·4	4·9	91·4	1·9	5·2	3·50	1·40	0·09	0·07	Nil	100	7·00			120	25·1	in A_1, high in B_2g and C.
C	27-31	1·77	92·6	3·2	95·7	0·1	2·4	3·03	2·29	0·06	0·03	Nil	100	7·82			116	19·7	
45.								ALLUVIUM. Stichill Eastfield, 121846-121848											
S	3-7	12·88	47·9	23·0	58·6	12·3	22·7	24·30	2·99	0·14	0·30	3·23	89·5	6·62	6·33	0·482	121	13·8	High exchangeable Ca in S and Cg.
Bg	13-17	1·96	78·5	12·0	84·2	6·3	7·5	6·39	1·38	0·06	0·10	Nil	100	7·06	0·47	0·059	274	62·7	High readily soluble P_2O_5
Cg	25-29	9·32	50·3	29·6	65·9	14·0	15·4	17·05	4·36	0·10	0·18	0·82	96·5	6·72			171	54·3	in S, very high in Bg and Cg.
46.								ALLUVIUM. Wiselaw Mill, 120292-120296											
A_1	0-2	11·21	36·4	45·3	57·5	24·2	12·7	14·58	1·40	0·09	0·29	1·18	93·3	6·35	4·79	0·402	236	15·0	High exchangeable Ca except in C and lower part of D.
C	6-10	5·28	33·2	47·2	53·5	26·9	17·0	7·40	1·18	0·07	0·15	Nil	100	7·12	1·26	0·139	132	10·6	Low total P_2O_5 in lower part of D.
Cg	14-18	5·44	24·8	54·1	46·7	32·2	18·4	13·18	0·89	0·09	0·16	Nil	100	7·39			148	4·1	High readily soluble P_2O_5
D	22-26	5·20	23·2	51·7	45·5	29·4	22·5	12·25	0·71	0·10	0·13	Nil	100	7·44			139	2·9	in A_1, C and lower sample of D.
D	34-38	3·51	47·0	32·6	58·9	20·7	16·9	6·58	0·35	0·07	0·11	Nil	100	7·36			92	15·4	

APPENDIX II

Free Carbonate

TABLE 9. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

Profile No.	Horizon	CO_2	$CaCO_3$ (calculated)
25	S	0·05	0·12
	B_2(g)	0·81	1·84
	B_3(g)	2·42	5·50
	C(g)	3·36	7·64
	C(g)	3·60	8·18
27	S	0·22	0·50
	B_2(g)	0·30	0·68
	B_2(g)	0·24	0·55
	B_3(g)	0·39	0·89
	C(g)	2·30	5·23
28	S	0·30	0·68
	S	0·35	0·80
	B_2(g)	3·26	7·41
	B_3(g)	3·69	8·38
	C(g)	4·42	10·03

TABLE 10. CALCAREOUS GLEY

Profile No.	Horizon	CO_2	$CaCO_3$ (calculated)
40	S	0·31	0·70
	B_2g	0·11	0·25
	B_3g	4·60	10·45
	Cg	5·30	12·05
	Cg	5·38	12·23

APPENDIX III

Silica-sesquioxide Ratios of the Clay Fractions ($<2\mu$)

TABLE 11. BROWN FOREST SOILS OF LOW BASE STATUS

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Bemersyde	Bemersyde	1	A	59·3	10·1	26·4	2·79	14·25	3·47	4·11
			B_2	46·4	14·7	29·9	2·00	8·39	2·63	3·18
			B_3	45·4	17·3	27·6	1·99	7·00	2·79	2·50
Darleith	Darleith	2	A	43·9	18·0	16·3	2·68	6·48	4·57	1·41
			B_2	45·5	19·7	18·0	2·53	6·16	4·30	1·43
			B_3	45·5	20·4	18·6	2·44	5·91	4·15	1·42
Eckford	Eckford	3	S	45·4	16·4	26·8	2·07	7·35	2·88	2·55
			B_2	44·3	18·7	26·2	1·97	6·31	2·87	2·20
			C	46·9	14·8	27·0	2·18	8·40	2·95	2·85
			C	37·3	17·4	21·3	2·06	5·70	2·97	1·92
Ettrick	Linhope	8	A	51·3	8·5	29·4	2·50	16·11	2·96	5·43
			A	51·2	9·1	27·9	2·59	14·95	3·11	4·80
			B_2	42·3	18·9	28·9	2·34	5·97	2·49	2·40
			C	43·3	16·6	29·4	1·84	6·93	2·50	2·77
Ettrick	Linhope (red phase)	9	A	49·7	11·0	29·6	2·31	12·00	2·85	4·20
			A-B	51·8	10·1	28·8	2·50	13·68	3·06	4·48
			B_2	50·7	10·1	28·4	2·47	13·40	3·04	4·41
			C	47·2	15·3	27·8	2·13	8·19	2·88	2·84
Hobkirk	Hobkirk	11	S	49·7	10·3	28·7	2·38	12·66	2·93	4·32
			B_2	48·7	11·3	29·6	2·25	11·42	2·80	4·08
			B_3	48·4	11·3	27·4	2·37	11·35	2·99	3·79
			C	49·1	11·3	26·4	2·48	11·52	3·16	3·65

TABLE 11—continued

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Lauder	Lauder	13	S	41·8	14·0	26·4	2·01	7·91	2·69	2·94
			B_2	39·0	16·4	29·6	1·65	6·30	2·24	2·82
			C	42·5	17·7	27·4	1·86	6·38	2·63	2·42
			C	43·6	17·8	25·3	2·02	6·48	2·93	2·21
			C	43·7	18·0	26·2	1·97	6·44	2·83	2·27
			C	44·4	18·3	26·2	1·99	6·43	2·87	2·23
Yarrow	Yarrow	16	S	47·0	14·3	29·5	2·07	8·70	2·71	3·21
			A-B	45·2	15·4	29·0	1·98	7·84	2·65	2·96
			B_2	44·1	16·6	29·8	1·85	7·06	2·51	2·81
			B_3	43·6	16·4	29·0	1·88	7·05	2·56	2·76
			C	46·2	15·4	30·1	1·98	8·01	2·62	3·05

TABLE 12. IRON PODZOL

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Ettrick	Minchmoor	20	A_2	47·0	12·6	26·1	2·34	9·91	3·06	3·24
			B_1	45·3	16·5	26·5	2·08	7·32	2·90	2·52
			B_2	41·7	18·1	29·9	1·71	6·14	2·37	2·59
			C	45·7	15·2	28·2	2·05	8·01	2·76	2·90

TABLE 13. PEATY PODZOL

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Hobkirk	Faw	22	A_1	51·3	6·6	30·0	2·55	20·83	2·90	7·17
			A_2	44·1	2·6	32·4	2·20	45·87	2·31	19·87
			B_2	47·0	15·0	29·8	2·03	8·35	2·68	3·11
			B_3	39·7	26·3	26·0	1·57	4·01	2·59	1·54
			C	44·7	19·7	27·0	1·92	6·05	2·81	2·15

TABLE 14. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Ettrick	Kedslie	24	S	48·2	12·6	29·8	2·16	10·16	2·75	3·70
			B_2(g)	47·4	13·9	27·3	2·22	9·07	2·94	3·08
			B_3(g)	49·0	12·4	26·8	2·39	10·46	3·10	3·37
			C(g)	48·5	12·4	26·4	2·39	10·33	3·11	3·32
Whitsome	Whitsome	28	S	48·9	12·7	23·3	2·65	10·17	3·59	2·84
			S	50·0	12·6	23·2	2·72	10·54	3·67	2·87
			B_2(g)	50·3	12·0	23·4	2·75	11·16	3·65	3·05
			B_3(g)	50·1	12·3	24·0	2·67	10·83	3·55	3·05
			C(g)	50·1	12·1	23·4	2·73	10·97	3·64	3·01
Whitsome	Whitsome (colluvial phase)	29	S	48·3	13·2	25·4	2·42	9·69	3·23	3·00
			B_2(g)	50·1	12·1	29·9	2·26	10·97	2·85	3·85
			C(g)	51·3	10·8	26·1	2·64	12·56	3·34	3·76
			D	48·8	13·3	25·7	2·43	9·79	3·23	3·04
			D	50·8	11·6	25·0	2·66	11·59	3·45	3·36

TABLE 15. NON-CALCAREOUS GLEYS

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Ettrick	Ettrick	33	A_1g	46·4	11·6	28·8	2·18	10·59	2·74	3·86
			A_2g	46·5	13·5	27·9	2·16	9·11	2·82	3·22
			B_2g	47·6	12·5	28·4	2·23	10·17	2·85	3·56
			B_3g	46·9	13·9	27·9	2·16	8·98	2·85	3·15
			Cg	47·4	12·1	27·6	2·27	10·38	2·91	3·57
Hobkirk	Cessford	36	A_1g	52·1	5·7	30·2	2·61	24·08	2·93	8·22
			B_2g	50·9	6·6	29·6	2·56	20·66	2·92	7·07
			B_3g	50·1	7·5	33·7	2·21	17·74	2·53	7·02
			Cg	50·9	8·3	27·0	2·67	16·29	3·20	5·10
			Cg	50·6	9·2	27·1	2·60	14·52	3·16	4·59

TABLE 16. CALCAREOUS GLEY

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Whitsome	Horndean	40	S	47·6	15·2	24·8	2·35	8·35	3·26	2·56
			B_2g	48·3	15·3	24·0	2·43	8·37	3·42	2·45
			B_3g	49·3	13·4	23·2	2·64	9·77	3·61	2·70
			Cg	49·7	13·0	22·7	2·72	10·22	3·71	2·75
			Cg	50·6	12·5	23·7	2·72	10·79	3·63	2·97

TABLE 17. PEATY GLEYS

Association	Series	Profile No.	Horizon	Percentages			Ratios			
				SiO_2	Fe_2O_3	Al_2O_3	SiO_2/R_2O_3	SiO_2/Fe_2O_3	SiO_2/Al_2O_3	Al_2O_3/Fe_2O_3
Ettrick	Hardlee	41	A_1g	53·9	4·5	33·0	2·55	32·04	2·77	11·57
			B_2g	48·1	10·7	30·0	2·22	11·95	2·72	4·39
			B_3g	48·2	13·3	30·3	2·11	9·67	2·70	3·58
			Cg	49·8	11·3	28·9	2·34	11·68	2·93	3·99
Hobkirk	Wauchope	42	A_1g	55·5	3·5	34·5	2·57	42·00	2·73	15·36
			A_2g	54·0	5·7	35·8	2·32	24·97	2·56	9·75
			B_2g	46·7	15·4	28·2	2·09	8·10	2·82	2·87
			B_3g	48·3	14·0	27·9	2·22	9·14	2·93	3·11
			Cg	49·6	12·4	26·9	2·41	10·59	3·13	3·38

APPENDIX IV

Mineralogical Data

TABLE 18. PERCENTAGE OF MINERAL GROUPS AND MINERAL FREQUENCIES IN THE FINE SAND FRACTIONS (20-200μ)

					Analysis of Light Fraction (S.G. < 2·9)*				Analysis of Heavy Fraction (S.G. > 2·9)*													
Association	Series	Profile No.	Horizon	Weight % Light	Quartz	Potash Felspar	Plagioclase	Rock Particles	Apatite	Augite	Biotite	Chlorite	Epidote	Garnet	Hornblende	Hypersthene	Iron Oxides	Muscovite	Olivine	Rutile	Tourmaline	Zircon
BEMERSYDE	Bemersyde	1	A	98·8	10	4	1	0	0	6	6	0	3	3	0	0	7	5	0	0	3	5
			B_3	99·5	10	5	2	0	0	6	6	0	3	3	0	0	6	5	0	0	2	4
DARLEITH	Darleith	2	A	93·6	9	0	6	0	3	6	5	0	0	0	2	5	7	0	3	3	0	5
			B_3	92·9	9	2	6	0	4	6	5	0	0	0	3	5	6	0	5	2	0	4
ECKFORD	Eckford	3	S	98·2	10	0	1	3	0	4	6	6	0	4	3	0	6	5	0	0	2	4
			C	98·0	10	1	1	4	0	4	6	6	0	3	4	0	6	5	0	0	1	4
ETTRICK	Linhope	8	A	97·6	10	0	1	3	0	4	6	6	0	3	3	0	6	5	0	1	1	4
			C	96·9	10	1	2	4	0	5	6	6	0	3	4	0	6	5	0	1	1	4
	Linhope (red phase)	9	A	97·9	10	1	2	3	0	4	6	6	0	1	4	0	6	5	0	0	2	4
			C	97·3	10	1	2	4	0	5	6	6	0	1	4	0	6	5	0	0	3	4
	Kedslie	24	S	97·9	10	0	1	3	0	4	6	6	0	3	3	0	6	5	0	2	2	5
			C(g)	97·1	10	1	2	4	0	5	6	6	0	3	4	0	6	5	0	2	2	4

ETTRICK	Ettrick	33	A_1g	97·5	10	1	1	3	0	5	6	6	0	3	0	0	6	4	0	0	2	4
			Cg	96·8	10	1	1	3	0	5	6	6	0	3	4	0	6	5	0	0	1	4
	Minchmoor	20	A_2	97·7	10	1	3	4	0	5	6	6	0	1	4	0	6	5	0	1	2	4
			C	97·1	10	1	3	4	0	5	6	6	0	1	4	0	6	5	0	2	3	4
	Hardlee	41	A_1g	96·8	10	1	1	3	0	5	6	6	0	3	3	0	6	5	0	0	2	4
			Cg	96·1	10	2	2	3	0	5	6	6	0	0	4	0	6	5	0	1	1	4
HOBKIRK	Hobkirk	11	S	96·9	10	1	3	0	0	5	4	6	0	5	4	0	7	4	0	2	2	5
			C	96·3	10	1	4	0	0	5	5	5	2	5	5	0	7	4	0	1	3	4
	Cessford	36	A_1g	97·7	10	2	3	0	0	5	5	5	0	5	5	0	7	4	0	2	3	5
			Cg	96·2	10	2	4	0	0	5	5	5	0	4	5	0	7	4	0	2	3	5
	Faw	22	A_1	97·1	10	1	2	0	0	5	4	6	0	5	4	0	7	4	0	2	1	5
			C	96·5	10	1	3	0	0	5	5	5	0	5	5	0	7	4	0	2	3	5
	Wauchope	43	A_1g	97·5	10	1	2	0	0	5	5	6	0	4	4	0	7	4	0	2	3	5
			Cg	97·1	10	1	4	0	0	5	5	3	0	4	4	0	6	4	0	2	3	5
LAUDER	Lauder	13	S	97·2	10	2	1	0	0	4	6	6	0	4	0	0	6	5	0	2	3	5
			C	96·8	10	3	2	0	0	5	6	5	0	3	0	0	6	5	0	2	2	4
WHITSOME	Whitsome	28	S	95·3	10	1	1	0	0	5	5	5	0	3	4	0	7	5	0	1	3	5
			C(g)	94·8	10	1	3	0	3	5	5	5	1	3	5	0	6	5	0	1	2	4
	Whitsome (colluvial phase)	30	S	96·9	10	1	2	0	0	5	5	5	0	4	4	0	7	5	0	1	1	4
			D	96·6	10	1	3	0	1	5	5	5	0	3	5	0	7	5	0	1	2	4
	Horndean	40	S	96·1	10	1	1	0	0	5	5	4	1	1	4	0	7	5	0	0	1	4
			Cg	95·7	10	1	3	0	3	5	5	5	1	1	4	0	7	5	0	0	1	4
YARROW	Yarrow	16	S	98·3	10	1	1	3	0	4	6	7	0	2	3	0	6	5	0	0	2	4
			C	97·9	10	1	2	4	0	5	6	6	0	1	4	0	6	5	0	0	1	3

* 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%

TABLE 19. PERCENTAGE OF MINERALS IN THE CLAY FRACTIONS ($<1{\cdot}4\mu$)

Association	Series	Profile No.	Horizon	Kaolin	Illite	Chlorite	Vermiculite	Ch. Ver.[1]	Iron Oxides [2]	Quartz	Felspars
BEMERSYDE	Bemersyde	1	A	20	45	10	15	—	—	5	10
			B_2	20	45	10	15	—	5 H	5	10
			B_3	20	45	10	15	—	5 H	5	10
ETTRICK	Linhope	8	A	25	70	0	—	—	—	5	5
			A	25	70	0	—	—	5 H	5	5
			B_3	25	70	< 5	—	—	5 H	5	5
			C	25	70	5	—	—	5 H	5	5
ETTRICK	Minchmoor	20	A_2	15	60	5	—	—	—	5	15
			B_2	20	40	25	—	—	—	5	10
			C	15	45	25	—	—	—	5	10
ETTRICK	Kedslie	24	S	20	65	10	—	—	5 L	5	—
			B_2(g)	20	70	5	—	—	5 L	5	—
			B_3(g)	15	75	5	—	—	5 L	5	—
			C(g)	10	80	5	—	—	5 L	5	—
ETTRICK	Hardlee	41	B_2g	15	60	—	—	20	—	5	—
			B_3g	15	65	—	—	10	5 L	5	5
			Cg	15	65	5	—	5	5 L	5	5
HOBKIRK	Hobkirk	11	S	10	75	10	—	—	—	5	5
			B_2	10	75	10	—	—	5 H	5	5
			B_3	10	70	10	—	—	5 H	5	5
			C	10	70	10	—	—	5 H	5	5
HOBKIRK	Cessford	36	B_2	15	70	10	—	—	5 G	5	—
			B_3	15	75	10	—	—	—	5	—
			C	10	75	10	—	—	5 H	5	—
			C	10	75	10	—	—	5 H	5	—
WHITSOME	Whitsome	28	S	10	75	10	—	—	5 G	5	5
			S	10	75	10	—	—	5 G	5	5
			B_2(g)	10	75	10	—	—	—	5	5
			B_3(g)	10	75	10	—	—	—	5	5
			C(g)	10	75	10	—	—	—	5	5

(1) Ch.Ver. = regularly interstratified chlorite—vermiculite. (2) Iron Oxides:—H = haematite, G = goethite, L = lepidocrocite, A = amorphous ferric oxide gel.

APPENDIX V
Plant Lists

The following are selected species lists of the vegetation occurring on the soil categories. They indicate the range of the vegetation on any one soil category and the differences between the vegetation on the separate soil categories listed below:

- Brown Forest Soils of low base status.
- Brown Forest Soils with gleyed B and C horizons.
- Iron Podzols.
- Peaty Podzols with thin iron pan.
- Non-Calcareous Gleys.
- Calcareous Gleys.
- Peaty Gleys.
- Basin and Hill Peat.

The nomenclature of pteridophytes, gymnosperms and angiosperms is that of Clapham, Tutin and Warburg (1952), mosses that of Richards and Wallace (1950), liverworts that of MacVicar (1912) and lichens that of Watson (1953).

In the tables which follow the subjective frequency symbols used are:

d—dominant　co-d—co-dominant　va—very abundant
f—frequent　o—occasional　r—rare
l—local or locally

TABLE 20.—BROWN FOREST SOILS OF LOW BASE STATUS
Woodland

Species	Planted oakwood	Remnant of old Ettrick Forest—lower slope	Beechwood	Young plantation —5 years old	Plantation with closed canopy —25 years old
Trees					
Betula pubescens		o	o		
B. pubescens/B. verrucosa	co-d			a	o-lf
Fagus sylvatica			d		
Larix leptolepis					d
Picea sitchensis				a-d	d
Quercus petraea/(Q. robur)		d			
Q. robur	co-d				
Sorbus aucuparia	lf		o		lf
Shrubs					
Crataegus monogyna		o			
Salix atrocinerea				o	
Herbs and Undershrubs					
Acer pseudoplatanus seedlings			o		
Agrostis canina	la	l		la	lf
A. tenuis	la	lf		a	
Ajuga reptans		l			
Anemone nemorosa		l			
Anthoxanthum odoratum	f	f-la			

TABLE 20—continued

Species	Planted oakwood	Remnant of old Ettrick Forest—lower slope	Beechwood	Young plantation —5 years old	Plantation with closed canopy —25 years old
Athyrium filix-femina		o			
Calluna vulgaris				l	o
Chamaenerion angustifolium		lf		la	o
Deschampsia flexuosa	f-la	lf-la		lf	l-lf
Digitalis purpurea		o-lf		o	o-f
Dryopteris austriaca	lf	o-lf	o-lf	o-lf	f
D. filix-mas	lf	lf-la	o-lf	o	
Endymion nonscriptus		lf			
Epilobium montanum		l			
Festuca ovina	la			lf	
Fraxinus excelsior seedlings		l			o
Galium saxatile		o-lf		f	f
Geranium sylvaticum		lf			
Holcus mollis	a-ld	d			
Hypericum pulchrum		o-lf			
Lathyrus montanus		o			
Lonicera periclymenum		f			
Luzula pilosa	lf-la	lf			lf
L. sylvatica	l				
Lysimachia nemorum		l			
Mercurialis perennis		lf-la			
Oxalis acetosella	a	a		lf	f
Potentilla erecta	f	o		f	
P. sterilis		lf			
Primula vulgaris	l	l			
Pteridium aquilinum	a	ld			
Quercus seedlings		o			l
Rubus idaeus		o		l	lf
Rumex acetosa	o-lf	f			
Sarothamnus scoparius		o			
Scrophularia nodosa		o			
Solidago virgaurea	l				
Stellaria graminea	l				
S. holostea	lf				
Thelypteris dryopteris	l				
T. oreopteris	o				
Vaccinium myrtillus	la				
Valeriana officinalis		l			
Veronica chamaedrys		o			
V. officinalis				o	
Vicia sepium		o			
Viola riviniana	f	f			
Mosses and Liverworts					
Atrichum undulatum		l			
Brachythecium rutabulum		l			
Calypogeia trichomanis				l	
Cirriphyllum piliferum		l			
Dicranella heteromalla			l		
Dicranella sp.		l			
Dicranum majus	l				lf-la
D. scoparium		l		l	l
Dicranum sp.	l				
Eurhynchium praelongum		la		l	
E. striatum		l			
Hypnum cupressiforme		l	l	l	f

TABLE 20—continued

SPECIES	Planted oakwood	Remnant of old Ettrick Forest—lower slope	Beechwood	Young plantation —5 years old	Plantation with closed canopy —25 years old
H. cupressiforme var. *ericetorum*				l	
Hylocomium splendens				la	
Isopterygium elegans			lf		
Lepidozia reptans	l		l		
Lophocolea bidentata	lf	lf		l	f
L. cuspidata	l				f
Mnium hornum		l	la	l	l
M. undulatum		l-lf			
Plagiochila asplenioides	lf	l			f
Plagiothecium denticulatum					l
Pleurozium schreberi	lf	lf			
Polytrichum commune		l			
P. formosum	l				l
P. juniperium		l			
Pseudoscleropodium purum	lf	lf-la		l	
Ptilium crista-castrensis	l				
Rhytidiadelphus loreus	lf			l	lf
R. squarrosus	lf			la	l
R. triquetrus	la	lf		l	lf-la
Thuidium tamariscinum	l	la-a			

Grassland

SPECIES	Typical pasture	Local area of more basic soil parent material	Old pasture—fairly recently laid down	Old pasture—of considerable age	Bracken dominant
Herbs and Undershrubs					
Achillea millefolium	f-a	o		f	
Agrostis canina					lf
A. tenuis	a-d	a-cod	a-d	a-d	a
Anthoxanthum odoratum	f-a		o-f	f-a	o-f
Campanula rotundifolia	f	o			o
Calluna vulgaris					l
Cerastium vulgatum	o	o		o	
Cirsium arvense		lf	lf		
C. vulgare		o-lf	o		
Conopodium majus				o	
Cynosurus cristatus		o-f	a		
Dactylis glomerata			f-la		
Deschampsia flexuosa	f				la
Festuca ovina	a-d			a	f-la
F. rubra	a	a-cod	a	a	
Galium saxatile	f-a			lf	f-a
G. verum		f			
Helictotrichon pratense		f			

TABLE 20—continued

SPECIES	Typical pasture	Local area of more basic soil parent material	Old pasture—fairly recently laid down	Old pasture—of considerable age	Bracken dominant
Holcus lanatus		lf	f-a	f	
Lolium perenne			o		
Lotus corniculatus	lf	f		lf	
Luzula campestris	o			o	
Luzula sp.					lf
Nardus stricta					o
Oxalis acetosella					f-la
Plantago lanceolata			f		
Poa pratensis	f-la	la	f-la	la	lf
P. trivialis			la		
Potentilla erecta	o-f	o		f	f-la
Pteridium aquilinum					d
Ranunculus acris		o			
R. repens				o-lf	
Rumex acetosa	f-la	f		f-la	lf
Stellaria graminea	l				o
Trifolium repens	f	f	a	f-a	la
Trisetum flavescens		a			
Thymus drucei		l		o	
Veronica chamaedrys	f	f		f	lf
V. officinalis	o	o		o	
Viola lutea	lf			o	
V. riviniana		lf			o
Mosses					
Dicranum scoparium	l				
Hylocomium splendens	o-f				l
Hypnum cupressiforme	l				
Pleurozium schreberi	o-f				
Pseudoscleropodium purum	l				l
Rhytidiadelphus squarrosus	f		f		la
Lichens					
Peltigera sp.	l				

TABLE 21.—IRON PODZOLS

SPECIES	Plantation of mature Scots pine	Young plantation of Norway spruce —4 years old	Dry heath	Heath with deep peat species	*Erica cinerea* heath after frequent burning	*Nardus* grassland
Trees						
Picea abies		a				
Pinus sylvestris	d					
Herbs and Undershrubs						
Agrostis canina	l			o-lf	f-la	a
A. tenuis	lf					lf
Anthoxanthum odoratum				o		o
Betula pubescens seedlings	o					
Blechnum spicant				o		
Calluna vulgaris	f-la	lf	d	d	a	l
Carex binervis				o	o-lf	
C. nigra				o		
C. panicea				l		
C. pilulifera				o	o	
Carex spp.					o	l
Chamaenerion angustifolium	l					
Deschampsia flexuosa	f-a	d	f		f-a	
Dryopteris austriaca	a-d	lf-la		f		f
D. filix-mas		lf				
Empetrum nigrum				lf		
Erica cinerea	o		o-la	o	d	
E. tetralix	o					
Festuca ovina	l			lf	f-la	f
Galium saxatile	f	a				f-a
Holcus mollis	l					
Juncus squarrosus						lf
Luzula multiflora		o		o		
L. pilosa	lf					
L. sylvatica						lf
Luzula sp.					o	
Lycopodium clavatum					o	
Molinia caerulea				o		
Nardus stricta			f	l	l	d
Oxalis acetosella	la	lf				lf
Pinus sylvestris seedlings	f					
Poa pratensis						lf
Potentilla erecta		o-lf	o-f	o		f
Pteridium aquilinum	ld					
Rumex acetosella	lf.					
Sieglingia decumbens			o		o	
Sorbus aucuparia seedlings			o			
Trichophorum caespitosum				o		
Ulex europaeus			o			
Vaccinium myrtillus		l-lf	f-a	a	l	lf-f
Veronica chamaedrys	o					
V. officinalis	o					
Mosses and Liverworts						
Campylopus flexuosus	l					
Ceratodon purpureus	l			l		
Dicranella heteromalla	l					
Dicranum scoparium	f-la		f	f	o	
Hylocomium splendens	a		la			la
Hypnum cupressiforme	l		l			lf

TABLE 21—continued

SPECIES	Plantation of mature Scots pine	Young plantation of Norway spruce —4 years old	Dry heath	Heath with deep peat species	*Erica cinerea* heath after frequent burning	*Nardus* grassland
H. cupressiforme var. *ericetorum*				la-a		
Lophocolea (*cuspidata*)	l					
Plagiothecium undulatum	la					l
Pleurozium schreberi	la	a	a	la		a
Polytrichum commune				la	l	
P. gracile	l-lf					
P. juniperium				l		
Pseudoscleropodium purum	la-a	l				l
Ptilidium ciliare	l					l
Rhytidiadelphus squarrosus	l	la	l			la
R. triquetrus	l-lf					
Splachnum ovatum				l		
Lichens						
Cladonia cenotea var. *glauca*				l		
C. digitata				f		
Cladonia spp.	l					

TABLE 22.—PEATY PODZOLS WITH THIN IRON PAN

Species	Heath	Heath—recently burned	*Nardus* grassland
Herbs and Undershrubs			
Agrostis canina	l		a
A. tenuis			a
Anthoxanthum odoratum			f
Calluna vulgaris	d	d	o
Carex nigra	l		
Deschampsia flexuosa	f		lf
Erica tetralix	o-lf	f	
Festuca ovina	o-lf		f
Galium saxatile	l		f
Juncus conglomeratus			lf
J. effusus var. *compactus*			lf
J. squarrosus	f	o	lf
Luzula multiflora	o		o
Nardus stricta	l		d
Potentilla erecta	l		f-a
Rumex acetosa			o-lf
R. acetosella			o
Trichophorum caespitosum	o-lf	f	
Vaccinium myrtillus	lf		lf
Mosses and Liverworts			
Aulacomnium palustre	l		
Campylopus flexuosus	l		
Dicranum scoparium		f	
Gymnocolea inflata		l	
Hylocomium splendens			f-la
Hypnum cupressiforme var. *ericetorum*	a		
Plagiothecium undulatum	lf-la		
Pleurozium schreberi	l		la
Pohlia nutans		f-a	
Polytrichum commune			a-d
Rhytidiadelphus squarrosus	l		f
Sphagnum compactum		l	
Lichens			
Cladonia coccifera		f-la	
C. pyxidata		f-la	
Cladonia sp.		a	

TABLE 23.—BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

SPECIES	Deciduous woodland	Mixed coniferous and deciduous woodland	Coniferous plantation—dense canopy	Permanent pasture	Old pasture
Trees					
Acer pseudoplatanus	f	f-la			
Aesculus hippocastanum		o			
Fagus sylvatica	lf	o			
Larix decidua		f-la			
Picea abies		f			
P. sitchensis			d		
Quercus robur	d				
Taxus baccata	f				
Tilia vulgaris	o	o-f			
Ulmus sp.	f				
Shrubs					
Crataegus monogyna	o				
Rhododendron sp.	la				
Sambucus nigra		a			
Herbs and Undershrubs					
Achillea millefolium					lf
A. ptarmica				o	
Agrostis canina				a	
A. tenuis				a-d	d
Anthoxanthum odoratum				f	f-a
Athyrium filix-femina	lf-la	o			
Bellis perennis					lf
Carex pilulifera				o	
Carex ovalis					o
Cerastium vulgatum					o
Chamaenerion angustifolium	la				
Circaea lutetiana	lf-la				
Cirsium arvense					lf
C. vulgare					o

TABLE 23—continued

SPECIES	Deciduous woodland	Mixed coniferous and deciduous woodland	Coniferous plantation—dense canopy	Permanent pasture	Old pasture
Conopodium majus				o-f	
Cynosurus cristatus					o-lf
Dactylis glomerata					l
Deschampsia caespitosa				o	
Dryopteris austriaca	lf	f			
D. filix-mas	f-la		o		
Euphrasia nemorosa					lf
Eurphrasia sp.					o
Festuca ovina				la	la
F. pratensis					o
F. rubra				f-la	f-la
Fragaria vesca	lf				
Galeopsis tetrahit					o
Galium saxatile					la
Glechoma hederacea	la				
Holcus lanatus				f	f-a
Juncus acutiflorus				f	
J. conglomeratus				o	
J. squarrosus				lf	l
Lonicera periclymenum	l				
Lotus corniculatus				lf	lf
Luzula multiflora					lf
Molinia caerulea				lf	
Nardus stricta				lf	
Orchis ericetorum				o	
Plantago lanceolata				lf	
Poa pratensis				lf	f
P. trivialis	l				
Potentilla erecta				f-a	
Prunella vulgaris	l				
Pteridium aquilinum				a-d	
Ranunculus repens	l				f
Rumex acetosa					o
Senecio jacobaea					o
Sieglingia decumbens				f	
Stellaria graminea					o
Trifolium repens				la	a
Urtica dioica	lf-la	a-d			
Veronica chamaedrys	lf				o
V. officinalis	o				o
V. serpyllifolia	o				
Viola riviniana	o				
Mosses and Liverworts					
Atrichum undulatum	la	l			
Brachythecium rutabulum	l	la			
Cirriphyllum piliferum	l				
Eurhynchium praelongum	lf-la	a	l		
E. striatum	la	l			
Fissidens bryoides		l	l		
F. taxifolius	l				
Hylocomium splendens					f-la
Hypnum cupressiforme		l			
Lophocolea heterophylla		l			
Mnium hornum	la				
M. punctatum	l				
M. undulatum	la	l-lf			

TABLE 23—continued

SPECIES	Deciduous woodland	Mixed coniferous and deciduous woodland	Coniferous plantation—dense canopy	Permanent pasture	Old pasture
Pellia epiphylla	l				
Plagiochila asplenioides	lf				
Rhytidiadelphus loreus	l				
R. squarrosus					f
Lichens					
Peltigera sp.					l

TABLE 24.—NON-CALCAREOUS GLEYS

SPECIES	Alderwood	Felled woodland —replanted with Sitka spruce	Poorly drained marshy pasture	Poorly drained —more humose top soil	Very poorly drained marshy pasture
Trees and Shrubs					
Alnus glutinosa	a-d	lf			
Betula verrucosa/B. pubescens	f-la	f-a			
Crataegus monogyna		o			
Salix atrocinerea		f-la			
S. caprea		lf			
Salix hybrids		o			
Herbs and Undershrubs					
Acer pseudoplatanus seedlings	o-lf				
Achillea ptarmica				o	
Agrostis canina		a		lf	
A. tenuis	f-la	f-la	f-la	f-a	f-la
Alchemilla glabra		lf			
Anemone nemorosa		lf			
Angelica sylvestris		f-la			
Anthoxanthum odoratum				f	f-a
Athyrium filix-femina	o-lf				
Blechnum spicant	o				
Briza media					o
Calluna vulgaris	l				
Cardamine sp.				o	o
Carex ovalis		o-lf	o-f		lf
Carex spp.			lf		o
Cerastium vulgatum				o	
Chamaenerion angustifolium		la			
Cirsium arvense			lf		
C. palustre	lf	f	f	lf	lf
Cynosurus cristatus			f		l
Deschampsia caespitosa	a	a-d	a	l	lf
Digitalis purpurea	o				
Dryopterus austriaca	o	o			

TABLE 24—continued

SPECIES	Alderwood	Felled woodland —replanted with Sitka spruce	Poorly drained marshy pasture	Poorly drained— more humose topsoil	Very poorly drained marshy pasture
D. filix-mas		o			
Epilobium palustre					o
Epilobium sp.		o			
Festuca ovina	l		la	lf	
F. rubra	lf		lf-la	lf	f-a
Filipendula ulmaria					l
Fragaria vesca	lf	l			
Fraxinus excelsior seedlings	o-f				
Galium palustre	o-lf				o
G. saxatile	o-f				
G. uliginosum			l	lf	lf
Geranium robertianum	f-la				
Holcus lanatus	o-la	o-lf	a	f-a	a
H. mollis		la			lf
Hypericum pulchrum		o			
Juncus acutiflorus			f-la	a	d
J. conglomeratus		lf	f	f	o
J. effusus	lf	f-la			
J. effusus var. *compactus*					l
J. squarrosus		l			
Lathyrus montanus				l	
Leontodon autumnalis				o-lf	o
Lotus corniculatus			lf		
L. uliginosus			l	l	
Luzula multiflora		o			o
Lychnis flos-cuculi		lf			
Molinia caerulea				f-a	
Nardus stricta			lf	f-la	
Oxalis acetosella	a				
Parnassia palustris				o	
Plantago lanceolata			o	o	o
Poa trivialis	lf				
Potentilla erecta		f-la	lf	o-f	f
P. sterilis	lf				
Prunella vulgaris		lf			
Pteridium aquilinum	a				
Ranunculus acris			f	f	o-f
R. repens	lf	l			
Rubus idaeus	l				
Rumex acetosa		o-lf	o		f
Senecio sp.		o			
Sieglingia decumbens				o	
Stellaria graminea				o	o-f
S. media	o				
Succisa pratensis				o-lf	
Taraxacum spectabile					lf
Taraxacum sp.				l	
Trifolium repens			a	a	l
Trisetum flavescens			f		
Ulex europaeus		o			
Veronica officinalis		o			
Vicia sepium				o	
Viola riviniana	f	o-f			
Mosses and Liverworts					
Acrocladium cuspidatum					l
Atrichum undulatum	la				

TABLE 24—continued

SPECIES	Alderwood	Felled woodland —replanted with Sitka spruce	Poorly drained marshy pasture	Poorly drained —more humose topsoil	Very poorly drained marshy pasture
Brachythecium rutabulum	l			l	
Ceratodon purpureus		l			
Cirriphyllum piliferum	lf				
Climacium dendroides					l
Dicranella (*heteromalla*)		l			
Dicranella sp.	l				
Dicranum rugosum		l			
D. scoparium	l	l			
Eurhynchium praelongum	lf-la	l		l	f-la
Fissidens bryoides	lf				
Hylocomium splendens		la	lf	lf	
Hypnum cupressiforme		l			
Lophocolea bidentata	l				
Mnium undulatum	lf-la			l	l
Pellia epiphylla	lf				
Plagiochila asplenioides	lf				
Pleurozium schreberi		la-a			
Pohlia nutans		l			
Polytrichum commune		l-la			
P. gracile	lf				
Pseudoscleropodium purum		la	la	lf	
Rhytidiadelphus squarrosus		lf	la	lf	f-la
R. triquetrus	lf	lf			
Thuidium tamariscinum	lf-la	l		l	
Lichens					
Cladonia cornuta		l			
C. fimbriata		l			
C. floerkeana		l			
C. (*sylvatica*)		l			
Hypogymnia physodes		l			
Peltigera sp.		l			l

TABLE 25.—CALCAREOUS GLEY

SPECIES	Woodland
Trees	
Quercus robur	d
Q. cerris	o
Shrubs	
Crataegus monogyna	f
Herbs and Undershrubs	
Acer pseudoplatanus seedlings	o
Athyrium filix-femina	o-lf
Dryopteris austriaca	a
D. filix-mas	f-a
Urtica dioica	f-la

TABLE 25—continued

SPECIES	Woodland
Mosses and Liverworts	
Atrichum undulatum	lf
Brachythecium sp.	l
Eurhynchium praelongum	lf-la
E. striatum	lf-la
Fissidens bryoides } *F. taxifolius* }	lf
Hypnum cupressiforme	l
H. cupressiforme var. *resupinatum*	l
Mnium undulatum	lf
Pellia epiphylla	lf
Thuidium tamariscinum	l

TABLE 26.—PEATY GLEYS

SPECIES	Heathy birchwood	Plantation of mature Scots pine	Wet heath	Wet grassland
Trees				
Betula verrucosa/B. pubescens	a-d			
Pinus sylvestris		d		
Herbs and Undershrubs				
Achillea ptarmica				o
Agrostis canina	o		l	f-a
A. tenuis			l	f-a
Anthoxanthum odoratum				o-lf
Betula verrucosa/B. pubescens seedlings		lf		
Calluna vulgaris	d	f	a	
Carex binervis	o			
C. echinata	o			
Carex sp.			o-lf	
Chamaenerion angustifolium		o		
Deschampsia flexuosa		lf		f
D. caespitosa				o
Dryopteris austriaca		f-la		
Empetrum nigrum			lf	
Erica tetralix	o	a-ld		
Festuca ovina	o			a
Galium saxatile		o-f		f
Goodyera repens		l		
Holcus lanatus				f
Juncus acutiflorus				o-la
J. conglomeratus				f
J. squarrosus		o	f	
Molinia caerulea	lf		a	a
Nardus stricta			lf	a
Oxalis acetosella		l		
Pedicularis sp.			l	
Pinus sylvestris seedlings		lf		
Potentilla erecta	o		o	a

TABLE 26—continued

SPECIES	Heathy birchwood	Plantation of mature Scots pine	Wet heath	Wet grassland
Trichophorum caespitosum			f	
Trifolium repens				l
Viola palustris				l
Mosses and Liverworts				
Aulacomnium palustre	lf	l		
Calypogeia trichomanis	l			
Campylopus flexuosus		lf	lf-la	
Cephalozia (media)	l			
Cephalozia sp.			f	
Cephaloziella sp.	l			
Dicranella heteromalla		l		
Dicranum majus		l		
D. scoparium	l-lf	f-la		
Hylocomium splendens	la-a	la-a		f
Hypnum cupressiforme	l	l	lf	
H. cupressiforme var. *ericetorum*	la			
Gymnocolea inflata			lf	
Lophocolea bidentata	l			
Lophozia sp.	l			
Plagiothecium undulatum	lf-la	la		
Pleurozium schreberi	la-a	la-a		f
Pohlia nutans		l	l	
Polytrichum commune	lf-f	l		la
Pseudoscleropodium purum	lf	la-a		f-la
Ptilidium ciliare		l		
Rhytidiadelphus squarrosus				f-la
Sphagnum compactum			f-la	
S. girgensohnii	l-la			
S. plumulosum	l-la			
S. subsecundum var. *inundatum*			l	
Lichens				
Cladonia fimbriata var.		l		
Cladonia spp.	l	l		
Hypogymnia physodes		lf		

TABLE 27.—PEATS

SPECIES	Basin peat-cut over. Mixed community	Hill peat	Saddle peat
Trees			
Betula pubescens/B. verrucosa	a		
Shrubs			
Salix atrocinerea	a		
S. aurita	f-a		
Herbs and Undershrubs			
Agrostis canina	f-la		
Calluna vulgaris	l-lf	a	a
Carex (*curta*)	l		
C. nigra	la		lf
C paniculata	o-lf		
C. rostrata	l		
Cirsium palustre	o-f		
Deschampsia flexuosa			o-lf
Drosera rotundifolia	l		
Dryopteris spinulosa	lf		
Empetrum nigrum		lf	f
Epilobium palustre	o-f		
Erica tetralix	o-la	lf	f-la
Eriophorum angustifolium		lf	a
E. vaginatum	lf-la	a-d	d
Festuca ovina	lf		
Filipendula ulmaria	lf		
Galium palustre	l		
Geum sp.	l		
Holcus lanatus	lf		
H. mollis	lf		
Juncus effusus	lf		
J. squarrosus		o	
Luzula sp.	o		
Lychnis flos-cuculi	l		
Polygala serpyllifolia	o		
Potentilla erecta	f-a		l
P. palustris	f		
Rumex acetosa	o		
Salix repens	o		
Senecio jacobaea	o		
Succisa pratensis	f-a		
Trichophorum caespitosum		a	o
Vaccinium myrtillus		l	
Valeriana officinalis	lf		
Viola palustris	lf		
Mosses and Liverworts			
Acrocladium cuspidatum	la		
Aulacomnium palustre	lf	l	f
Calypogeia trichomanis		l	l
Dicranum scoparium		f	f
Drepanocladus fluitans			l
Hylocomium splendens	lf		
Hypnum cupressiforme	la		
H. cupressiforme var. *ericetorum*		l	

TABLE 27—continued

SPECIES	Basin peat-cut over. Mixed community	Hill peat	Saddle peat
Leptoscyphus anomalus			l
L. taylori		f	
Lophozia (*ventricosa*)		l	l
Mnium hornum	l-lf		
Odontoschisma sphagni		l	
Plagiothecium undulatum		l	
Pleurozium schreberi		l	f-la
Polytrichum commune	l		la
Rhytidiadelphus squarrosus	l	l	
Sphagnum cuspidatum		l	l
S. fimbriatum	lf-la		
S. palustre	la		f-la
S. papillosum		la	
S. plumulosum	la		} f-la
S. recurvum			
S. squarrosum	lf		
Sphagnum sp.		a	
Thuidium tamariscinum		r	
Lichens			
Cladonia uncialis		l	
Cladonia sp.		l	

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