# THE SOILS ROUND ABERDEEN INVERURIE AND FRASERBURGH

*THE SOIL SURVEY OF SCOTLAND*

The Macaulay Institute for Soil Research, Aberdeen

DEPARTMENT OF AGRICULTURE AND FISHERIES
FOR SCOTLAND

MEMOIRS OF THE SOIL SURVEY
OF GREAT BRITAIN

SCOTLAND

# The Soils of the Country round Aberdeen, Inverurie and Fraserburgh

(SHEETS 77, 76 and 87/97)

BY

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AND

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Mr. K. J. Peters, Editor of *The Press and Journal*, gave assistance in the selection of, and permission to publish, certain air photographs.

# PREFACE

SOIL survey commenced in this region in the Insch area and was extended north and east to the coastal areas by R. Glentworth and Dr. R. Hart in 1942. They were later joined by Dr. R. C. Mackenzie and Dr. H. G. Dion. A provisional soil association map of Aberdeenshire was compiled in 1946.

With the formation of the Soil Survey Research Board in 1946, the present policy of publishing soil maps on a scale of 1 in. to 1 mile was commenced. Detail lacking in the original maps has since been obtained by the present senior soil survey staff who have spent varying periods on these sheets: Mr. B. M. Shipley in the Peterhead area, Mr. R. Grant and Mr. C. J. Bown in the Pennan–Fraserburgh area, Mr. J. C. C. Romans in the Cruden Bay–Newburgh area, and Mr. D. Laing in the Skene Lowlands. Mr. J. W. Muir distinguished and delineated the peaty podzols in the Grampian Foothills and separated the imperfectly drained soils throughout the Tarves Association.

The Memoir could not have been compiled without the contributions of other Departments of the Macaulay Institute. Dr. H. G. M. Hardie and staff of the Soil Analysis Section of the Department of Pedology did the analyses, with the exception of exchangeable magnesium, sodium and potassium determinations which were carried out by Dr. R. L. Mitchell and staff of the Department of Spectrochemistry. Dr. Hardie checked the discussion on analytical data. Dr. R. L. Mitchell was responsible for the account of the trace constituents. Mr. B. D. Mitchell and Mr. W. A. Mitchell of the Physical Chemistry and Soil Mineralogy Sections of the Department of Pedology respectively carried out the differential thermal and X-ray analyses and wrote the section on the mineralogy of the fine sand and clay fractions. Mr. R. A. Robertson and Dr. R. Boggie of the Peat Ecology Section wrote the first section of the chapter on peat deposits; Mr. S. E. Durno contributed the second on pollen analysis and vegetational history. Mr. E. L. Birse of the Department of Soil Survey wrote the chapter on vegetation. Thanks are due to the many farmers and landowners for their co-operation.

Copies of the field maps (1 : 25,000) may be inspected in the Department of Soil Survey at the Macaulay Institute.

ROBERT GLENTWORTH
*Head of the Soil Survey of Scotland*

The Macaulay Institute for Soil Research,
Craigiebuckler,
Aberdeen.
*August*, 1962.

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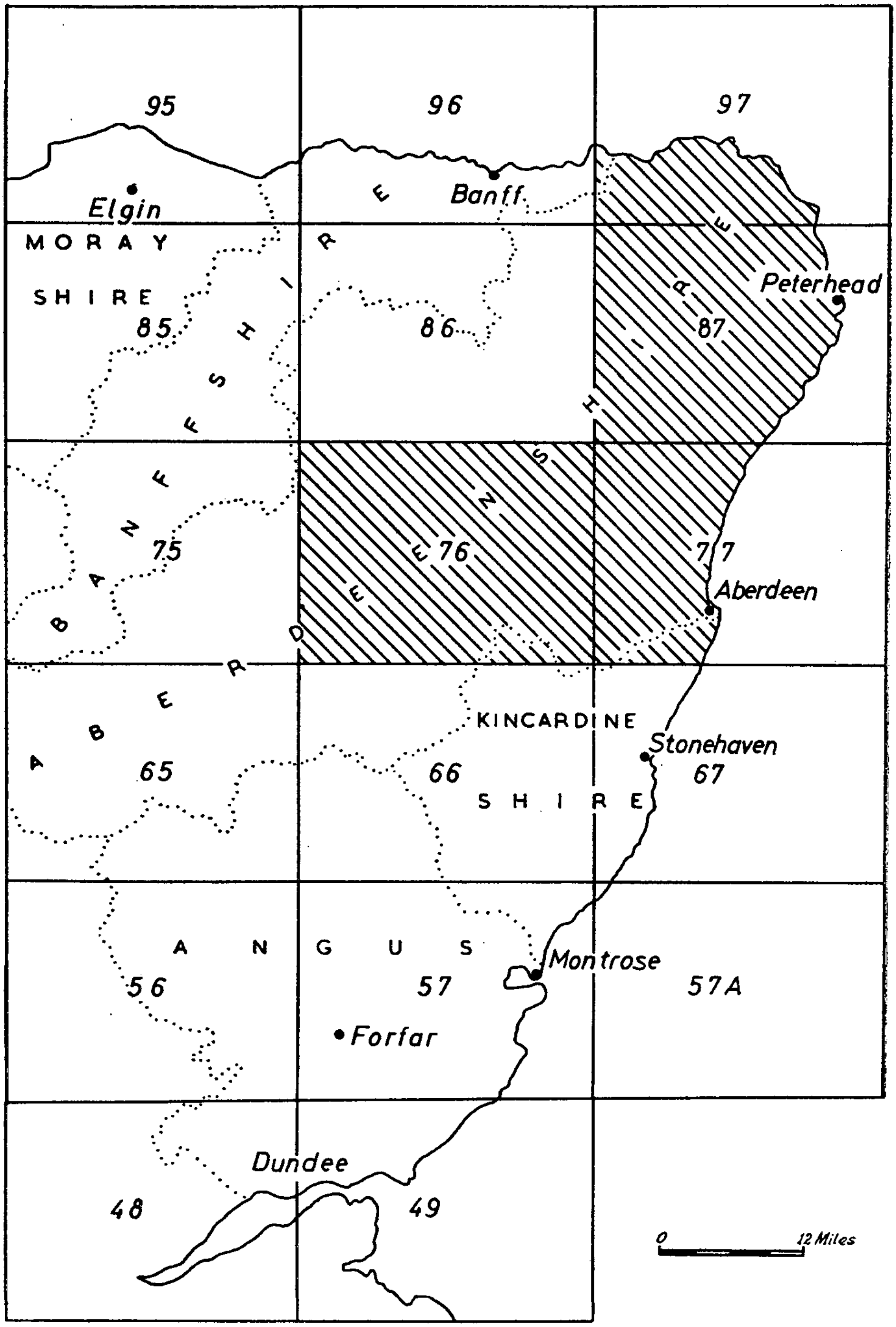


FIGURE 1. Location of Area.

# CHAPTER I

# General Description of the Area

## LOCATION AND EXTENT

THE area dealt with in this memoir is situated in north-east Scotland and lies to the north and west of Aberdeen. It comprises some 1011 square miles, of which 90 square miles are on Sheet* 97 (Fraserburgh); 311 on Sheet 87 (Peterhead); 178 on Sheet 77 (Aberdeen) and 432 on Sheet 76 (Inverurie). The major part of the area is in Aberdeenshire, but the survey included one and a half square miles in Banffshire, on the north-west corner of Sheet 97, and also a triangular-shaped area of 16 square miles to the south of the River Dee and an area of approximately 9 square miles to the north of the river at Banchory, both of which lie in Kincardineshire (Figs. 1 and 2).

Peterhead and Fraserburgh, two of the larger towns in the area, are fishing centres and have minor industries. The small towns of Inverurie, Ellon, Strichen, Maud, Insch and Alford are important market centres, but have few industries apart from the paper-making factory and locomotive works at Inverurie. Aberdeen, the main business centre for this extensive agricultural region and for the fishing industry of the north-east, attracts a large number of holiday visitors in the summer months.

## PHYSICAL FEATURES

### MAJOR STRUCTURAL DIVISIONS

The area lies to the north of the Highland Boundary Fault where the basement rocks are the folded metamorphics of the Highland Schist formation. These vary greatly in composition, but are mainly acidic schists and gneisses. Intrusions of granite and basic igneous rocks, together with outliers of Old Red Sandstone, are prominent geological formations all of which impart distinctive features to the landscape.

There are two major physical regions (Fig. 3), the lowlands, which includes the Buchan peneplain lying below 750 feet, and the highlands and foothills forming part of the extensive Grampian Highlands to the west. Within these broad divisions seven distinct landform regions can be recognised.

### RIVER SYSTEM

The main outlines of the present drainage system were laid down on a peneplain thought to have been elevated in Tertiary times. The east-sloping surface was formerly covered by Old Red Sandstone rocks, and the rivers cut through these sediments to the underlying Highland Schists. Several of the former lines of drainage can still be traced. The present drainage system has

* One-inch Soil Survey Sheets.

evolved by the development of subsequent streams on the earlier valleys and by the adjustment of streams to the harder rocks exposed by the removal of the Old Red Sandstone. Some of these adjustments were subsequently modified by the action of ice during the Ice Age and by the deposits it left behind.

The main river draining the area is the Don which passes through the area covered by Sheets 76 (Inverurie) and 77 (Aberdeen). Small rivers and streams drain the Buchan area and these are dealt with by following their occurrence along the coastline from the Moray Firth to Aberdeen.

The extreme north-west of the area is drained by the Tore Burn and its tributaries which flow in deep glacial meltwater channels cut through the loosely cemented Old Red Sandstone conglomerate underneath. The Tore of Troup forms a spectacular valley about a mile wide and 500 feet deep which is now occupied by a comparatively small stream; this is the only drainage of note entering the Moray Firth within the area. Moving eastward, the coastal land bordering the Moray Firth is drained by the Water of Tyrie; a small sluggish stream flowing over a flat plain of fluvio-glacial deposits, which has required considerable attention to keep it clear. The Water of Tyrie is joined by the Water of Philorth, draining the coastal plain and reaching the sea in Fraserburgh Bay.

The Loch of Strathbeg lying between St. Combs and Rattray Head, south of Fraserburgh, provides a local drainage basin for the low ground lying immediately to the west. Once an arm of the sea, it is now connected to the sea by a narrow ditch-like channel at its northern end.

The central part of the Buchan Platform is the catchment area for the North and South Ugie Waters; they join east of Longside to form the River Ugie which enters the North Sea immediately north of Peterhead.

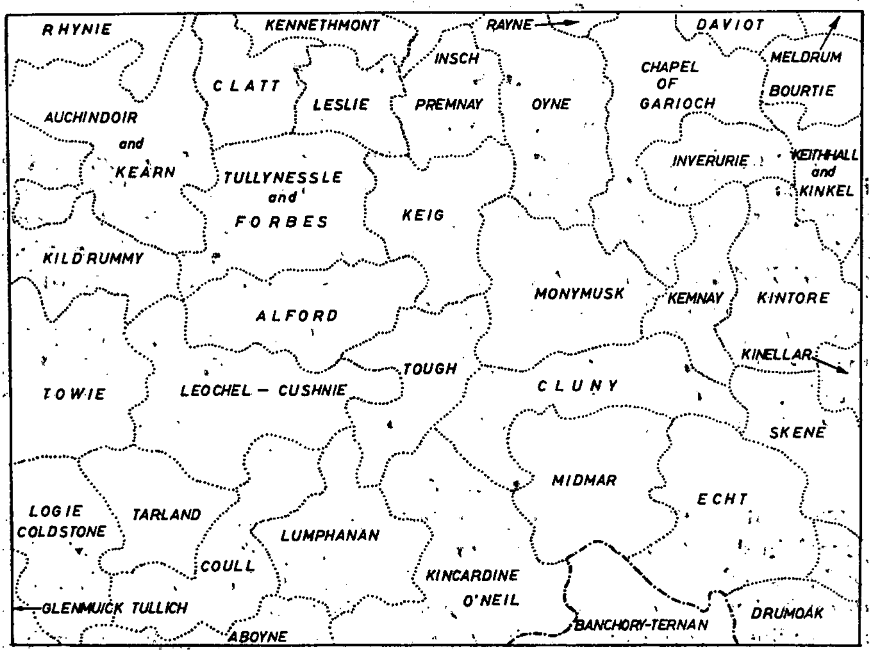


FIGURE 2A. Civil Parishes.

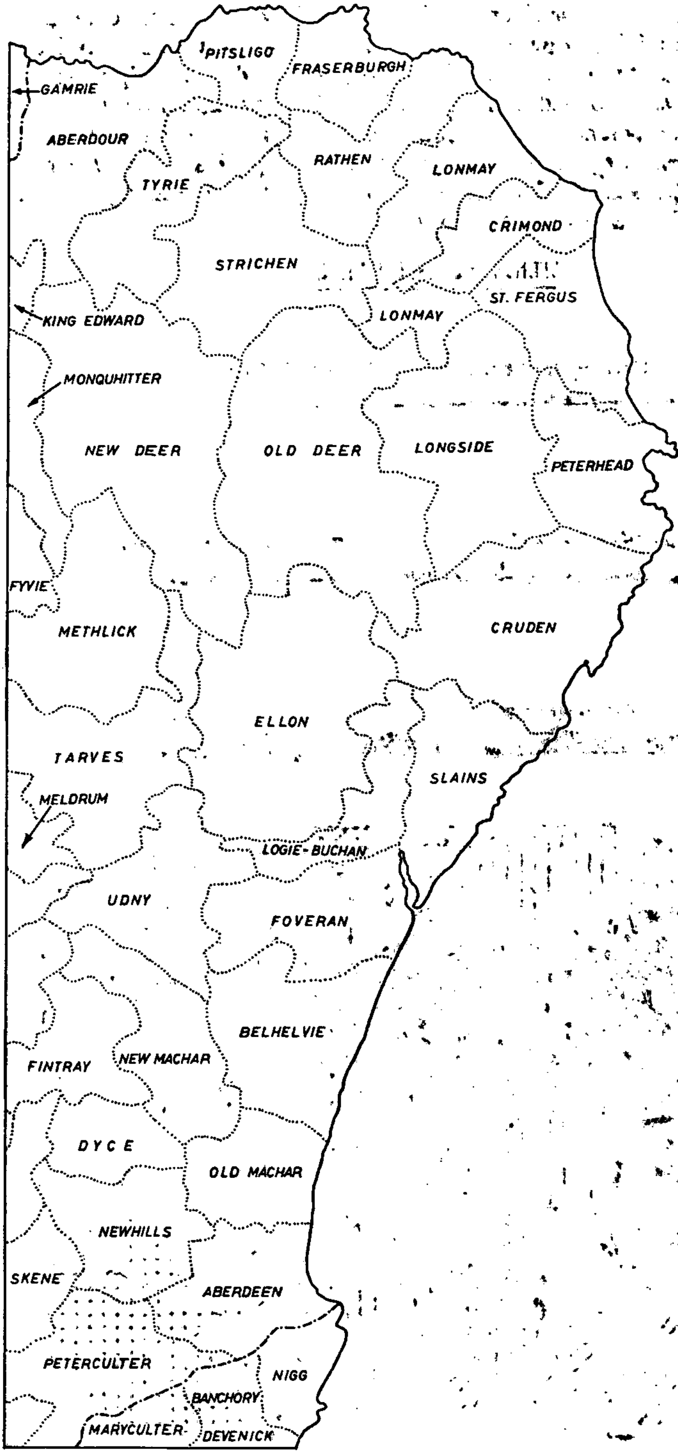
PITSLIGO
FRASERBURGH
GAMRIE
ABERDOUR
RATHEN
LONMAY
TYRIE
CRIMOND
STRICHEN
ST. FERGUS
LONMAY
KING EDWARD
MONQUHITTER
NEW DEER
OLD DEER
LONGSIDE
PETERHEAD
FYVIE
METHLICK
CRUDEN
ELLON
TARVES
SLAINS
MELDRUM
LOGIE-BUCHAN
UDNY
FOVERAN
BELHELVIE
FINTRAY
NEW MACHAR
DYCE
OLD MACHAR
NEWHILLS
SKENE
ABERDEEN
PETERCULTER
NIGG
BANCHORY
MARYCULTER
DEVENICK

FIGURE 2B

The catchment basin of these rivers is wide, marked by a periphery extending through Mormond Hill, New Pitsligo, New Deer and Stuartfield and the Corse of Balloch. In the upper reaches of the North and South Ugie Waters the drainage valleys are broad and shallow with extensive alluvium, but after the junction of the waters the Ugie becomes entrenched and its channel is, for short stretches, gorge-like. Further south a small river, the Water of Cruden, enters the sea at Cruden Bay, draining the undulating ground within a radius of some 2 to 5 miles of the bay.

VERTICAL is 2·64×HORIZONTAL

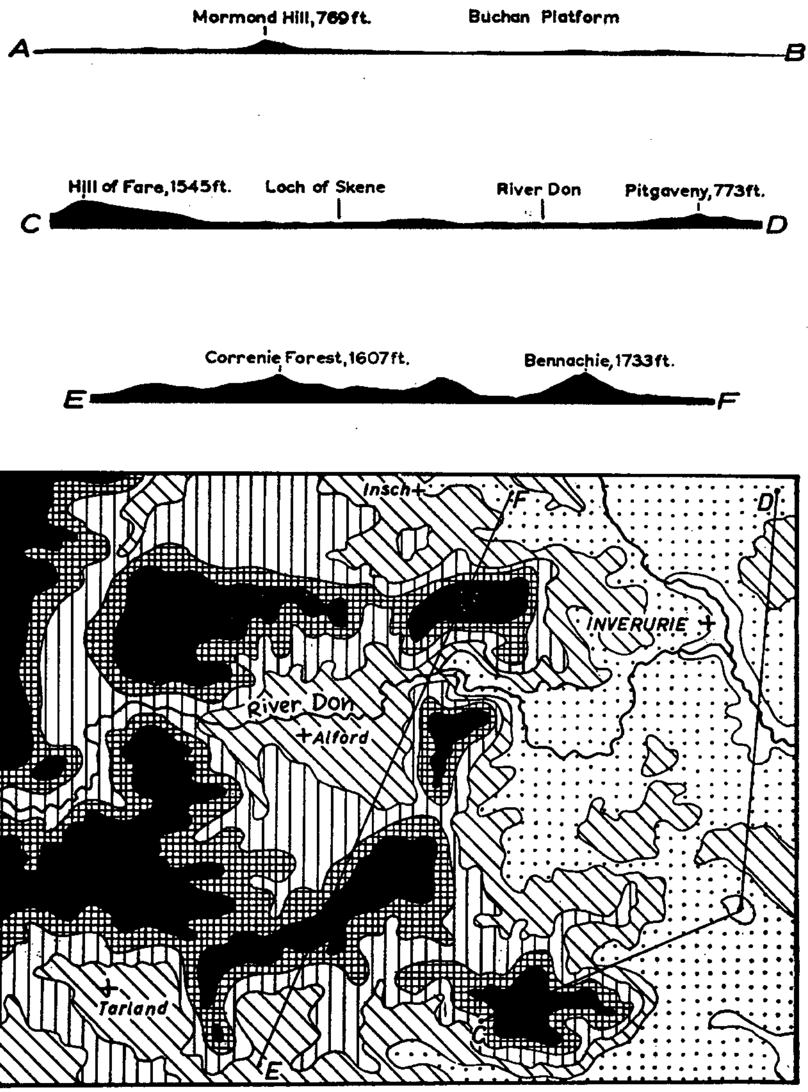


FIGURE 3A. Physical Map.

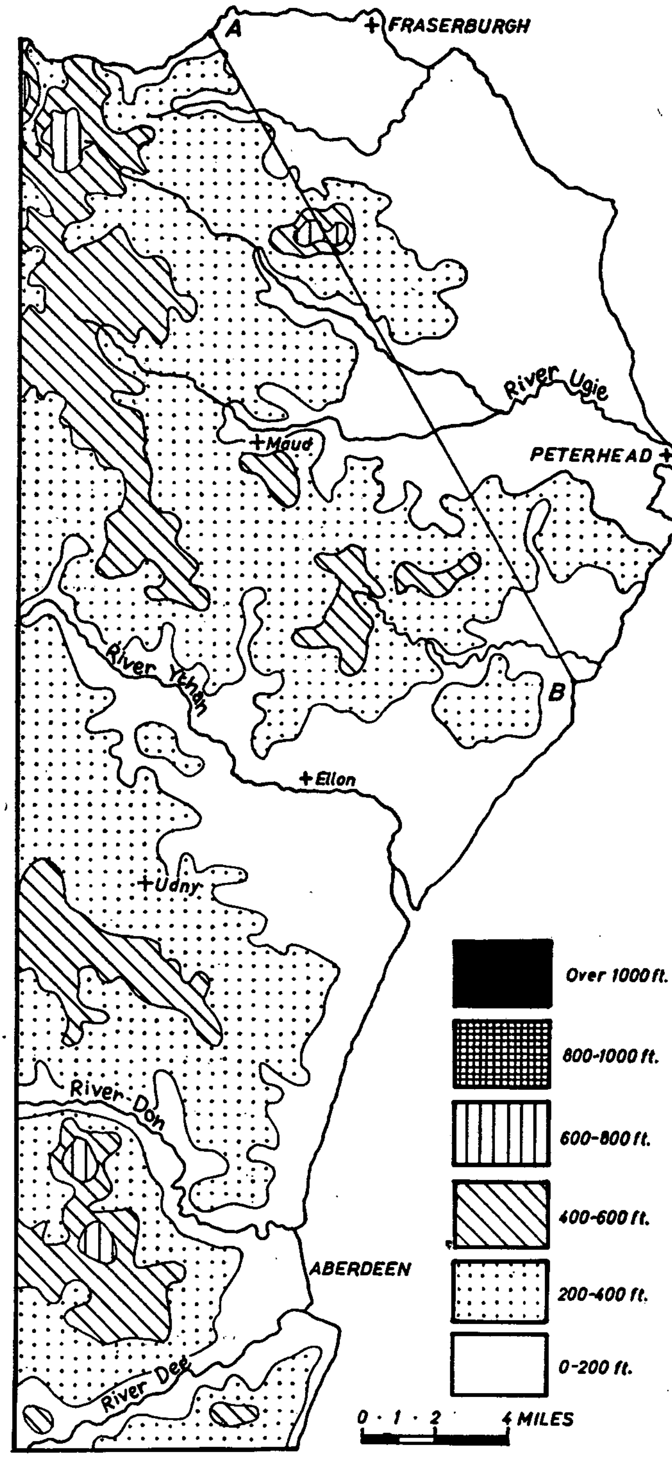
A
FRASERBURGH
River Ugie
PETERHEAD
Maud
River Ythan
B
Ellon
Udny
River Don
ABERDEEN
River Dee
Over 1000 ft.
800-1000 ft.
600-800 ft.
400-600 ft.
200-400 ft.
0-200 ft.
0 · 1 · 2 4 MILES

FIGURE 3B

Sixteen miles north of Aberdeen the River Ythan running in a south-easterly direction from Methlick passes through Ellon to enter the sea at Newburgh. The river rises to the west at Ythan Wells in the Foudland Hills, and by the time it enters the area it has carved a very deep channel through the Highland Schist rock. Below Methlick the channel becomes less incised and the river passes through a narrow well-defined valley, which broadens below Logie Buchan into a tidal channel with mud flats. The catchment area is a large one, especially to the north of the river, being bounded by a line from Collieston on the coast north-westwards to Auchnagatt and on the south by a line from Newburgh to Udny and Tarves.

Several small streams drain the area between the Ythan at Newburgh and the Don at Aberdeen; the Potterton Burn is the only one worthy of mention.

The Water of Bogie, cut through Old Red Sandstone and flowing in a north-easterly direction, drains the Rhynie–Lumsden valley and at Huntly joins the River Deveron which empties into the Moray Firth at Macduff.

The River Don enters the sea on the north side of the City of Aberdeen, whilst the Dee passes through on the south side. The River Don and its tributaries constitute the most extensive drainage system affecting the area, the river having a length of 54 miles through Sheets 76 and 77. It enters Sheet 76 at the Towie Basin, on soft Old Red Sandstone rocks, and continues by way of "close gorge and open reach" from Towie to Aberdeen. On leaving the Towie Basin the river follows a wandering course north to the Kildrummy Basin, which is also on Old Red Sandstone, then turns south through a water gap over 1000 feet deep into the Alford Basin, which measures some 10 miles from east to west. After leaving this basin it traverses an equally deep gap through resistant granite between Bennachie and Cairn William to the Kemnay Basin, from which it follows a north-easterly course through a narrow winding valley, cut through glacial till overlying granite, until it reaches Inverurie. Here it turns to the south-east, passes through the Kintore Basin and continues in a wide valley as far as Pitmedden Station. Below this its course is restricted to a narrow valley to Aberdeen.

Draining the Insch Valley, tributaries of the river; the Gadie, the Shevock, the Urie and the Lochter, converge to join it at Inverurie. On the south side of the river the only stream of importance is the Leochel Burn which enters the Don west of Alford.

The River Dee traverses the area for a distance of only eight miles, in the south-east corner of Sheet 77. The lower Dee Valley is about a mile wide and the flood plain has extensive stretches of alluvium. Both the Dee and Don Valleys have been comprehensively described by Bremner (1912 and 1921). Several tributaries of the Dee namely, the Tarland Burn, the Beltie Burn, and the Gormack Burn, drain the extensive granite area of the Skene Lowlands, whilst the Kinnernie Burn drains into Loch Skene from whence the Leuchar Burn discharges into the Dee at Peterculter.

## LANDFORM REGIONS

An obvious separation is the broad division into highlands and lowlands. The highlands, or, as they might better be termed in relation to the mountainous country which lies to the west, the foothills, occupy the western half of the area of Sheet 76. The lowlands cover the remainder of the area surveyed, that is the areas of Sheets 87/97, 77, and the eastern half of Sheet 76.

PLATE 1
Rolling landscape of the Buchan Platform north of Ellon.

[*Facing page* 16]

PLATE 2
A characteristic landscape of the Lower Buchan Platform near Boddam.

*(By courtesy of Aberdeen Journals Ltd.)*

PLATE 3
Foveran links and Sands of Forvie, Ythan estuary.

Despite the smoothing of the contours by glaciation, the relief of the country is clearly defined and within the above two major divisions seven landform regions have been distinguished (Fig. 4).

| | |
|---|---|
| Lowland region | 1. The Buchan Platform |
| | 2. The Upper Buchan Platform |
| | 3. The Skene Lowlands, including the lower Dee and Don Valleys |
| Foothill region | 4. The Grampian Foothills |
| | 5. The Insch Valley |
| | 6. The Bogie and Upper Don Valleys |
| | 7. The Alford and Tarland Basins |

Some of these landform regions can be subdivided and are discussed below.

1. The Buchan Platform (50–450 feet) can be regarded as stretching approximately from Aberdeen to the Moray Firth and it tongues into the Upper Buchan Platform following the rivers. The lower valleys of the Dee and Don could be considered part of the Buchan Platform but have been included in the Skene Lowlands. The Buchan Platform consists of a peneplain tilted to the east. It is mainly underlain by the Highland Schists and is covered by glacial drift. The topography is gently rolling. Practically the whole of the area is occupied by farmland, and, except for wooded areas about Haddo, Lenabo and Strichen, it is singularly devoid of trees. Scenically the region can be described as flat and monotonous, with the exception of the coastal landscape. A number of sub-divisions on the basis of topography can be made. Most extensive, stretching from the Don to the Ugie Water, is an area of rolling relief underlain by gneiss, in which low hills grade down into wetter and flatter slopes and depressions. This kind of topography tends to lie between the 200 and 450 feet contours and covers the inland side of the Buchan Platform.

Part of the coastal belt, covering areas between Balmedie in the south and Crimond in the north, lies at an altitude generally below 200 feet. This region is characterised by smooth, gently rolling topography and for the most part is underlain by the red Strathmore drift (Fig. 16). North of the Corse of Balloch is an area of low relief characterised by poorly drained soils on a mixed till. The Cardno and Memsie district is essentially an almost level plain underlain by gravel. Flat terraces of gravel and sand flank the North and South Ugie Waters and the River Ythan.

Hill and basin peat occupy a total area of about 17 square miles, mainly in the New Pitsligo, Rora and St. Fergus districts.

Hummocky relief, with ridges and wet hollows formed from moraine, delta, or kame gravels, extends from the mouth of the River Don to Balmedie. Similar relief occurs about the Meikle Loch and in several places inland from the Moray Firth coast, namely about New Aberdour, Blackhills, the Sinclair Hills and Rathen.

Three outliers of the Upper Buchan Platform forming enclaves within the Buchan Platform are the Hill of Mormond (769 feet), Hill of Dens (550 feet) and the Hill of Dudwick (572 feet)—Corse of Balloch (456 feet) ridge. These hills have rock close to the surface and are wholly or partially heather covered.

2. The Upper Buchan Platform (450–750 feet) extends along the western side of the Buchan Platform. Over the greater part of it, from New Pitsligo

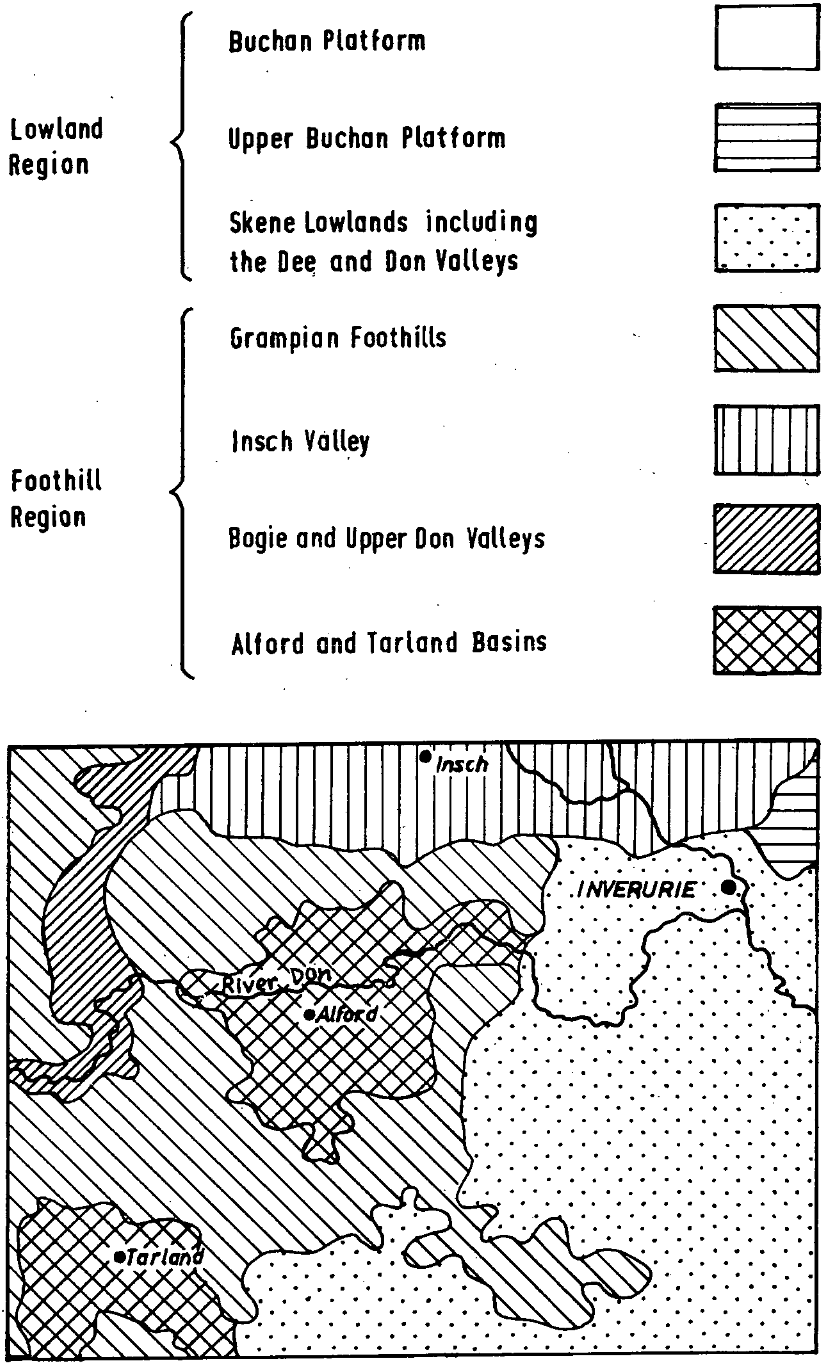


FIGURE 4A. Landform Regions.

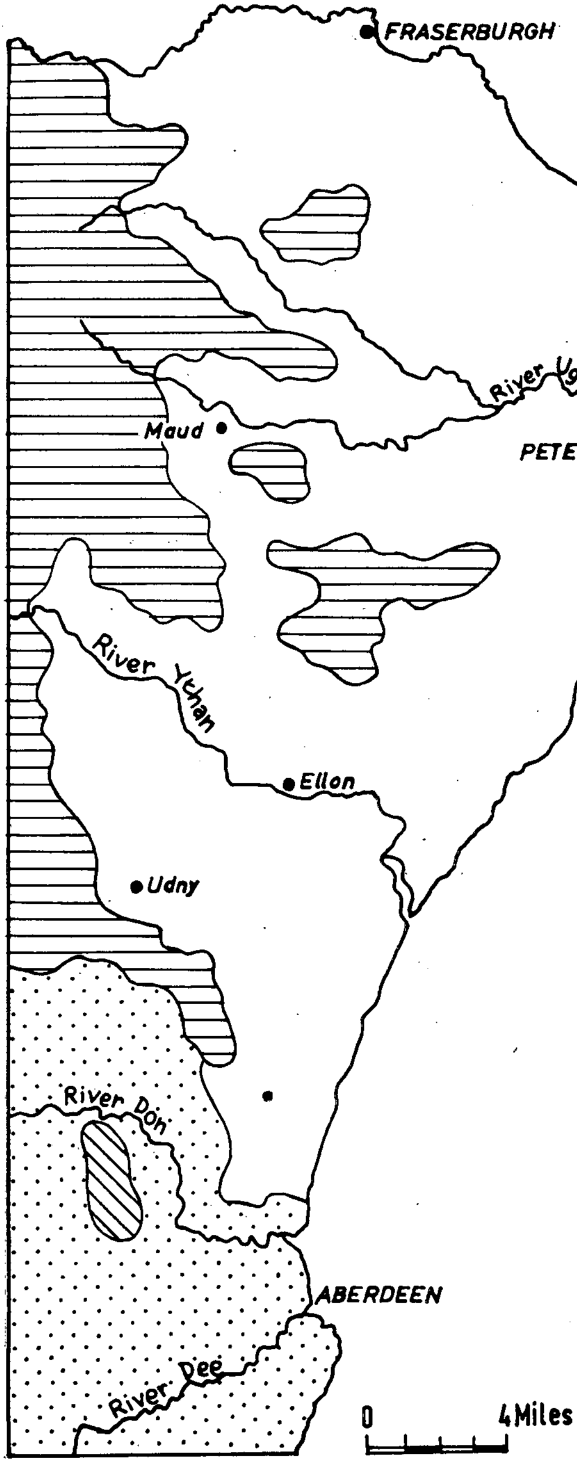
FRASERBURGH
River Ugie
Maud
PETERHEAD
River Ythan
Ellon
Udny
River Don
ABERDEEN
River Dee
0
4 Miles

FIGURE 4B

southwards, folded metamorphosed Highland Schist rocks have produced a broadly rolling terrain with the hills tending to be aligned in a north-west–south-easterly direction. The smooth slopes are well drained and covered by a thin till and the whole platform is arable land. In the northern part, a high plateau north-west of New Pitsligo of which Bracklamore Hill (723 feet) and Windyheads Hill (757 feet) are the highest points, Old Red Sandstone rocks of the Gamrie–Turiff outlier occur. Between these hills and Pennan a highly dissected landscape has been formed through intense erosion by glacial meltwaters which have cut deeply into the sandstone, producing steep-sided valleys and gullies.

3. The Skene Lowlands (250–800 feet) extend from Aberdeen westwards over granite and granitic gneiss rocks. Three hills stand above the general elevation, Tyrebagger (821 feet), Brimmond Hill (870 feet) and the Barmekin (920 feet), and could be considered as outliers of the Grampian Foothills. The moderately rolling topography with long smooth slopes is characteristic, particularly in the eastern and central part of the region. Shorter, steeper slopes with more varied relief are confined to the land bordering the Grampian Foothills west of a line drawn north–south through Echt. The natural soil drainage is free for the most part but is imperfect on the gentler slopes, particularly from the vicinity of Loch Skene eastwards to the coast. The glacial till throughout the area is bouldery and stone dykes built with boulders removed from the fields form a characteristic feature of the region.

Centred about Loch Skene are flat depressional areas generally covered with peat mosses. The main streams have a north-west–south-easterly inclination and tend to have terraces of fluvio-glacial sand and gravel. A significant channel occupied by the Kinnernie Burn, Loch Skene and the Leuchar Burn, connects the valleys of the Dee and the Don and has deep deposits of sand and gravel along its entire length.

The broad valleys of Dee and Don have recent alluvial floodplains varying from quarter to half-a-mile in width. The sides of the channel are flanked by fluvio-glacial gravel terraces lying approximately 100 feet above the level of the flood plain. The long axes of the hills tend to be aligned with the direction of the streams. The entire area is extensively cultivated, but many of the hilly summits are planted with trees and this greatly enhances the scenic attractiveness of the region.

4. The Grampian Foothills (800–2000 feet), which occupy the western half of Sheet 76 are situated on the western side of the Bogie Valley, the south side of the Insch Valley and thence in a crescentic belt from Bennachie to the north of Tarland. An eastern extremity protruding into the Skene Lowlands is the Hill of Fare. Generalised altitudinal ranges of these hills are, Hill of Fare, 1300–1500 feet; Corrennie Forest, 1300–1650 feet; Pressendye, 1400–2050 feet; Bennachie, 1400–1750 feet; Clova, 1600–1800 feet. All these hill masses have smooth plateaux-like summits with steep to moderately sloping sides. Except in isolated instances, cultivation seldom exceeds the 1000 feet contour, and most frequently stops at an altitude of 800 feet—and at a considerably lower level on the granite hills. Bennachie, of granite, has rather conspicuous rock tors. The hills are predominantly heather-covered with only isolated patches of hill peat. Coniferous plantations on an extensive scale have been established by the Forestry Commission on the slopes above the arable land.

5. The Insch Valley (200–800) feet), which is bisected by the northern margin of Sheet 76, consists of a tract roughly 5 miles wide and 19 miles long extending from the Bogie Valley in the west to Oldmeldrum in the east and terminating at the Coreen Hills and Bennachie on the south. Underlain by basic igneous rocks from which the till cover has been derived, the valley has soils which are inherently fertile and have been extensively cultivated from pre-historic times. East of Insch, shelterbelts of trees surrounding policy fields of large estates lend a pleasing park-like appearance to the landscape.

On a topographical basis, the Insch Valley can be separated into three broad divisions. The western, separated by a line through the Hill of Flinder and Hill of Johnston, has an altitude of 600–800 feet and has broadly rolling relief. The central division, separated by a line through Largie and Insch, is a hilly tract with altitudes varying between 400 and 1000 feet. It includes the conical grassy hills of Dunnideer and Christ's Kirk. The eastern division has a gently rolling topography varying in altitude between 200 and 600 feet.

6. The Bogie and Upper Don Valleys (600–1000 feet) form a continuous trough running from north to south, with a mean altitude of about 750 feet, flanked by hills of 1400 to 1500 feet. The valley floor is about 2 miles wide but, allowing for the flanks of the hills, a trough of some 4 miles in width is formed between the hill summits. Old Red Sandstone rocks of the Rhynie–Kildrummy outlier underlie the whole valley.

Near Lumsden the drainage divides, with the River Bogie flowing northwards to the Deveron and the Burn of Mossat southwards to the Don. From Lumsden northwards the Bogie and subsidiary channels are deeply incised into the soft sandstone, after passing through a great thickness of morainic and fluvio-glacial gravel which plugs the valley. The gravel is distinguished by its characteristic moundy morainic topography. The good farmland is confined to areas of till derived from the sandstone. South of the drainage divide morainic gravel continues to fill the centre of the valley, and on the valley sides good farmland is again encountered on smooth slopes underlain by sandstone. From Kildrummy southwards the Bogie trough widens until it meets the Upper Don Valley at the Towie Basin, through which the River Don with its wide flood plain passes. The land rises gently from the floodplain towards the high ground surrounding the basin. A mixed till containing a high proportion of basic-igneous rocks covers the slopes of the valley.

7. The Alford and Tarland Basins (450–1000 feet) are comparatively large depressions within the Grampian Foothills, constituting, by comparison with the surrounding hill land, isolated areas of good arable land. The Alford Basin is the larger, covering approximately 20 square miles. Bisected by the River Don, which has extensive alluvial floodplains, the topography gradually rises from the river by gentle undulations to the slopes of the surrounding hills. The basin is covered by a thick till mantle with a varied stone content. On the somewhat flatter eastern side the soils tend to have poor natural drainage. The pleasing appearance of the landscape is enhanced by a scattering of clusters of broad-leaved and coniferous trees.

The Tarland Basin is crescentic in shape, the western extremity opening into the valley of the Dee, into which the basin drains. The eastern extremity is drained by the Tarland Burn which has wide stretches of alluvium. Sheltered by high hills on the north (Pressendye, 2032 feet) and east (Craiglich, 1565 feet), the valley is bounded by a flank of lower hills (Scar Hill, 984 feet) on the south and west. Rising from the Tarland Burn, gently at first, the valley sweeps up to the moorland edge of Pressendye on the north. The eastern side of the basin rises abruptly on the steep slopes of Craiglich. Gradually rising, rolling ground stretches towards the south. Tarland village stands at the centre of the basin. The till mantle of the basin contains a high proportion of basic igneous material, giving soils of good agricultural quality. The soil quality is further enhanced by the south facing aspect, which permits cultivation at higher altitudes than would otherwise be possible. Morainic gravel is widespread in the south-western part and extends from about Loch Davan to the River Dee. This land, with its characteristic moundy relief, is largely uncultivated and partly covered by peat mosses.

# CHAPTER II

# Climate and Weather

THE appreciation of the climate of the area and the weather experienced is materially assisted by a brief recapitulation of the topography.

The Buchan Platform, rarely rising to 450 feet and much of it lying below 250 feet, is an open expanse of low-lying country where trees are relatively sparsely distributed, whilst the Upper Buchan Platform, rising above 600 feet, is topographically almost as featureless. Combined, they form a wedge-shaped promontory projecting north-eastwards which has an inordinately long coastline (something over 70 miles) in proportion to its area. Thus the area is open to the relatively cold waters of the North Sea to the north, east, and south, whilst deriving no marked benefit from any important offshoot of the warm Atlantic Drift.

The Skene Lowlands, especially from Inverurie southwards to the River Dee, again rising above 350 feet only in localised areas, are rather similarly exposed to these winds and gain little in shelter from the somewhat higher ground between Inverurie and Udny. The western part of the Skene Lowlands, however, and the section south-west of the Hill of Fare, together with the Insch Valley, are not only further from the sea but have rapidly rising ground to the west and some higher ground immediately to the north.

The Bogie and Don Valleys and the Alford and Tarland Basins on the other hand are differently situated and have very considerable protection, ringed as they are by the Grampian Foothills rising to between 1200 and 1600 feet.

### *General Climate Survey*

Unlike most of Britain, north-east Scotland does not receive the major part of its rainfall from the warm humid south-west to west winds from the Atlantic, since these winds, being associated for the most part with cyclonic depressions whose centres pass to the west and north of the Hebrides, deposit much of their moisture over the mountain barriers to the west and south-west. But when the depression systems approach, or even cross, the Scottish mainland they frequently give a period of winds from between east and south, and it is these winds which bring the heavier and continuous rains; depressions which move in over the North Sea have a similar effect, although in this case the winds are backed more toward north-east. Since these last two synoptic patterns are much less frequent than the Hebridean depressions, the total cyclonic rainfall is very much less than that of western Scotland, but, with the winds having a considerable "fetch" over the North Sea, the resulting rains are cold rains, especially in spring and early summer. The other source of appreciable precipitation is the winds from between north-west and north-east which often bring showery weather. In winter the showers are sometimes sufficiently frequent and extensive to constitute periods of continuous precipitation and, in suitable conditions, to bring appreciable snow.

The haar of the spring and summer months, with its fog or mist and very low cloud, must be attributed to the effect of the cold waters of the North Sea on warm air from the Continent (or even from England) brought in on the easterly winds. The surface layers of the air mass are chilled to the fog point if the air is over the sea sufficiently long. The haar tends to be worst in early summer when the differences between air and sea temperatures are usually greatest.

A beneficient influence which can be very pronounced at times, and which is probably effective over the whole area, is the foehn effect associated with a blow of westerly winds across northern and central Scotland. As already noted, these winds deposit much of their moisture over the mountains. Having crossed the mountain barrier, however, they filter down to the low plains and this descent warms the air and reduces the relative humidity; the associated cloud sheets break up and may clear completely, causing further warming of the air by insolation. In the circumstances most favourable for foehn development, usually in autumn or early winter, temperatures recorded in the Aberdeen area (which in these cases reflect those generally over the area) can be amongst the highest for the British Isles. These occurrences are very transient, but even apart from these exceptional cases, the foehn does bring to the whole area warmer and sunnier weather and lower humidities than would otherwise occur.

*Winds*

The prevailing wind over the area is southerly, and winds from this direction have a maximum frequency at all seasons, whilst there is a steady, if lower, frequency of south-easterly winds throughout the year. Winds from south-west, west and north-west often occur in the winter half-year, blowing with approximately the same frequency from each of these points. Whilst the north-westerlies are still fairly common in summer, the south-west to westerly winds fall off markedly, and in the Aberdeen area there is a pronounced increase in the frequency of south-easterly and easterly winds, especially in the daytime. This is due to the sea breezes of summer and the effect is probably most marked in the coastal zone; round the bulge of the promontory the direction of the winds is more often north-easterly. Well away from the coast, and especially in the foothill areas, the effect of the sea breezes is probably much less noticeable and the breezes are controlled in direction by the local topography, but even the most favourable situations are affected by the sea breezes which penetrate long distances inland up the river valleys.

The marked tendency for north-westerly winds to occur during the late spring and early summer is worthy of comment. These winds are associated with the development of high pressure off north-west Scotland, a seasonal feature in many years which can be quite persistent.

The areal climate of the Buchan Platform is sometimes described as bleak—although the term has no meteorological definition. This description may well have been occasioned by the lack of shelter, either topographical or vegetative, to break the winds which thus sweep unhindered over the plains. To this must be added, if the wind is off the sea, the relatively low temperature, the high humidity, and at times the cold rain—all factors opposed to human comfort. The average wind speed is not very different from that in the eastern and southern counties of England, decreasing from about 12 m.p.h. over the coastal belt to below 10 m.p.h. over the more sheltered areas toward the Grampian Foothills.

Gales are experienced on average on some 5 days (or rather less) per year over the open country inland, but in the north-east section the weather becomes progressively more stormy toward the coast, and on the coast the

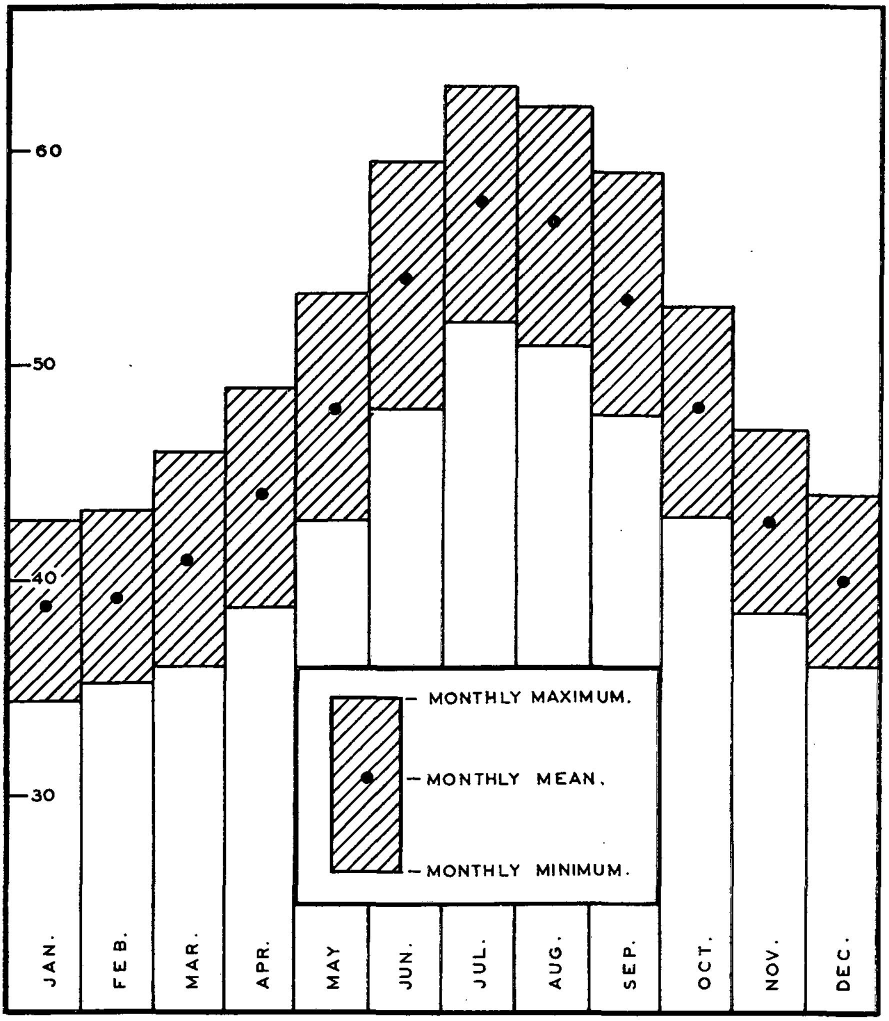


FIGURE 5. Average Monthly Temperatures in °F at Aberdeen (King's College, 1921–1950).

average number of days of gale rises to about ten. In the gales extreme gusts of over 80 m.p.h. have been measured, mainly near or on the coast, and in the exceptionally severe northerly gale of 31st January 1953 a gust speed of 101 m.p.h. was recorded at Dyce. The area is fully exposed to these occasional gales which are associated with a deep depression over the North Sea.

*Temperature*

The pattern of the temperature regime is much the same over most of the area, especially toward the coast of the Buchan Platform and the Skene Lowlands; average day maxima range from about 43°F in January, the coldest month, to 61°–62° in July and August (Fig. 5). With increasing distance from the coast the winter maxima tend to fall away somewhat and the summer afternoon temperatures tend to be a little higher, although the maritime influence prevents any very marked differences.

In the coastal zone the average night minimum temperatures from the north coast southward to the Aberdeen area are very uniform at about 35°F in winter to 51°F in July. The Upper Buchan Platform is probably a little colder, especially in winter, but the somewhat higher elevation probably does not have sufficient effect to warrant any re-appraisal. The significant change is toward progressively colder nights at all seasons with increasing distance to the south-westward. Mean temperatures for the period 1921–1950 are given in Table A.

The Grampian Foothills, the Bogie and Don Valleys and the Alford and Tarland Basins show subtle temperature changes. The winter climate is more severe than on the Buchan Platform; increase in altitude lowers the mean temperature by about 1°F for every 300 feet, whilst in the partially landlocked valleys, cold air drainage down the hillsides and the decrease in wind contribute to give distinctly lower temperatures on clear and partly clear nights. Frost is more frequent in these inland districts, harder, and often more persistent, as is evidenced by the fact that from about mid-November to the end of March the long period night minima means average out at freezing point or below. At Logie Coldstone (608 feet), from December to March, the average minimum is below freezing point (29·7°F in January). There is an altitude effect operative at Logie Coldstone, but it may well be that equally low, or lower, values rule at lower altitudes at the bottom of the valleys.

In these south-western districts, consequently, afternoon winter maxima tend to be a little lower than over the open plains, but early in the spring the run of maximum day temperatures here overhauls that of the plains, and, particularly in locations adjacent to the south facing slopes of the foothills, warmer afternoons (greater diurnal range) are the normal feature until late September or early October.

Conditions in the Insch Valley may be expected to lie between these two extremes with a tendency toward the climate of the open plains. The trend is indicated by a comparison of the mean monthly temperature values from Craibstone and those from Fyvie Castle for a few recent years. The mean maximum for Fyvie exceeds that for Craibstone in all months, the difference being greatest from July to September. There is little difference in the mean night temperatures round the middle of the year, but the nights at Fyvie are very distinctly the colder during the winter half-year, probably partly because the Fyvie station is situated in a local frost hollow.

The complete range of temperature experienced during any year is quite wide over the whole area, and between the warmest day of summer and the coldest night of the winter it is rarely less than 55°F and can be very much more, especially well inland. Absolute extreme summer maxima of 83°F or above (86°F in June and July at Logie Coldstone) have been recorded at all reporting stations in the area and, except toward the coast, most have noted

TABLE A. AVERAGE MONTHLY MEANS OF TEMPERATURE (°F) FOR PERIOD 1921–50

| Month | Aberdeen 79 ft. | | | Craibstone 300 ft. | | | Logie Coldstone 608 ft. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | Max. | Min. | Mean | Max. | Min. | Mean |
| January | 42·7 | 34·7 | 38·7 | 41·7 | 32·6 | 37·1 | 41·3 | 29·7 | 35·5 |
| February | 43·3 | 35·2 | 39·3 | 42·4 | 33·1 | 37·8 | 42·2 | 30·4 | 36·3 |
| March | 45·9 | 36·4 | 41·2 | 45·9 | 34·6 | 40·2 | 46·4 | 31·8 | 39·1 |
| April | 49·2 | 38·8 | 44·0 | 49·4 | 37·0 | 43·2 | 50·7 | 35·1 | 42·9 |
| May | 53·4 | 42·8 | 48·1 | 54·4 | 40·8 | 47·6 | 56·7 | 38·7 | 47·7 |
| June | 59·6 | 47·9 | 53·8 | 60·3 | 45·4 | 52·9 | 62·9 | 44·4 | 53·6 |
| July | 63·0 | 52·2 | 57·6 | 63·5 | 49·8 | 56·6 | 65·3 | 48·8 | 57·1 |
| August | 62·1 | 51·3 | 56·7 | 62·8 | 49·2 | 56·0 | 63·9 | 47·2 | 55·6 |
| September | 58·7 | 47·8 | 53·2 | 59·1 | 46·1 | 52·6 | 59·6 | 43·5 | 51·6 |
| October | 52·7 | 43·3 | 48·0 | 52·6 | 41·5 | 47·0 | 52·6 | 38·6 | 45·6 |
| November | 46·9 | 38·5 | 42·7 | 46·1 | 36·7 | 41·4 | 45·4 | 33·4 | 39·4 |
| December | 44·1 | 36·3 | 40·2 | 42·8 | 34·4 | 38·6 | 42·5 | 31·2 | 36·9 |
| Year | 51·8 | 42·1 | 47·0 | 51·7 | 40·1 | 45·9 | 52·6 | 37·7 | 45·1 |

## TABLE B. EXTREMES OF TEMPERATURE (PERIODS AS STATED)

| Month | Aberdeen 1914–1947* | | | | Craibstone 1925–1959 | | | | Logie Coldstone 1914–1959† | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max. | | Min. | | Max. | | Min. | | Max. | | Min. | |
| | °F | Year | °F | Year | °F | Year | °F | Year | °F | Year | °F | Year |
| January | 57 | 1922, 27 | 14 | 1945 | 56 | 1932, 38, 44, 53 | 10 | 1945 | 57 | 1922, 35, 53 | −3 | 1958 |
| February | 60 | 1939 | 17 | 1936 | 61 | 1939 | 13 | 1947 | 60 | 1953 | −12 | 1955 |
| March | 65 | 1938 | 12 | 1931 | 68 | 1929, 53 | 11 | 1958 | 70 | 1929 | −9 | 1958 |
| April | 69 | 1946, 48 | 23 | 1917 | 70 | 1942, 46 | 25 | 1927, 50, 58 | 74 | 1914 | 14 | 1917 |
| May | 73 | 1922 | 30 | 1935, 38 | 73 | 1939 | 28 | 1942 | 81 | 1939 | 21 | 1938 |
| June | 83 | 1939 | 35 | 1936 | 84 | 1939 | 33 | 1952 | 86 | 1940 | 27 | 1923 |
| July | 83 | 1921, 32 | 39 | 1919 | 81 | 1933 | 37 | 1958 | 86 | 1933 | 31 | 1918, 58 |
| August | 81 | 1933 | 38 | 1919, 28 | 80 | 1941 | 35 | 1954 | 82 | 1933, 47 | 29 | 1932 |
| September | 76 | 1929 | 33 | 1940 | 77 | 1953 | 27 | 1944 | 79 | 1953 | 24 | 1954 |
| October | 68 | 1921 | 29 | 1917, 26, 31 | 73 | 1926 | 26 | 1926 | 74 | 1921 | 17 | 1948 |
| November | 62 | 1938 | 13 | 1919 | 63 | 1947 | 18 | 1947 | 63 | 1938, 46 | −4 | 1919 |
| December | 61 | 1931 | 15 | 1937 | 60 | 1931 | 12 | 1937 | 59 | 1926, 40 | −5 | 1937 |
| Year | 83 | 1921, 32, 39 | 12 | 1931 | 84 | 1939 | 10 | 1945 | 86 | 1933, 40 | −12 | 1955 |

* Ceased May 1947. † A few minor breaks in the record; closed May 1941—June 1945.

readings of 0°F or below in the very coldest spells (−12°F at Logie Coldstone and −5°F at Dyce in February). It is interesting to note how frequently the coldest night of the year comes in March. Extreme temperatures for over 30 years are given in Table B.

*Freezing Days*

A useful pointer to the severity of winter conditions is the number of days on which frost (for all practical purposes at least) does not "give out" during the day or does so for only a short period, having little or no effect on the frozen soil. Belasco (1961) has tabulated the number of freezing days* at seven city locations in Great Britain for the 20 winters 1927/28 to 1946/47. Aberdeen has a total of 217 days for the 20 years—the lowest of all—as compared with 276 days for Edinburgh and 372 days for Newcastle. Of the unbroken spells of freezing days at Aberdeen one lasted 28 days, one between 15 and 17 days, and two between 9 and 11 days. Belasco considers it has not been very conclusively shown that increasing distance from the sea is an important factor in increasing the number of "freezing days", so that the Aberdeen figures, with perhaps some slight increase, are probably representative of the Buchan area. Altitude, however, has a definite effect, and a considerable increase should be allowed for in the much more elevated districts surrounding the basins and the valleys towards the south-west. Some indication of this appears in the figures for the growing season given in the following paragraphs.

*Growing Season*

The growing season in the British Isles is conventionally defined as the period of the year when the mean daily temperature exceeds 42°F. Although on a long period average basis the season is uniquely defined, there must obviously be some variability in the dates of the beginning and end of the season from one year to another.

TABLE C. LENGTH OF GROWING SEASON

| Station | Altitude (ft.) | Duration (days) |
|---|---|---|
| Aberdeen | 79 | 241 |
| Craibstone | 300 | 222 |
| Logie Coldstone | 608 | 207 |

The average number of growing days (Table C) is at a maximum in the coastal zone from the north coast round to Aberdeen where the figure is consistently round 241 days; inland at Craibstone (at 300 feet) the value is 222 days, and it is probably very similar throughout the area at most inland locations below 300 feet and could well be a little more in the sheltered reaches of the main river valleys. The influence of altitude is shown by the figure of 207 days for Logie Coldstone (608 feet). A general working figure

* A freezing day is defined as one on which the arithmetic mean of the maximum and minimum temperatures for the day is below 32·6°F.

| | | |
|---|---|---|
| 1. | PETERHEAD (MAINS OF BUTHLAW) | 120 ft. |
| 2. | NEW DEER | 397 ft. |
| 3. | HADDO HOUSE | 186 ft. |
| 4. | ABERDEEN (MANNOFIELD) | 171 ft. |
| 5. | CRAIBSTONE | 300 ft. |
| 6. | DRUM CASTLE | 320 ft. |
| 7. | LITTLEWOOD PARK | 750 ft. |
| 8. | LOGIE COLDSTONE | 608 ft. |
| 9. | LUMPHANAN | 490 ft. |
| 10. | ABERDEEN (KINGS COLLEGE) | 79 ft. |
| 11. | DYCE AIRPORT | 220 ft. |

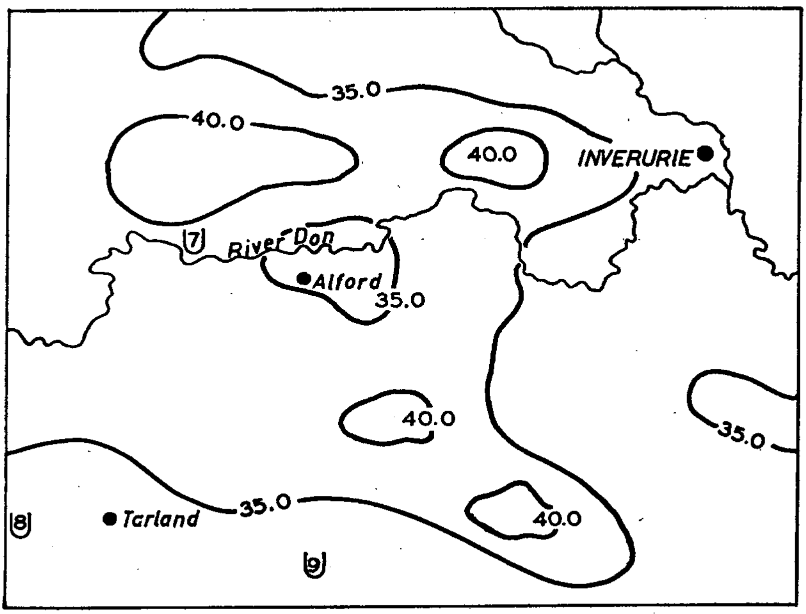


FIGURE 6A. Average Annual Rainfall (in inches) (1916–1950).

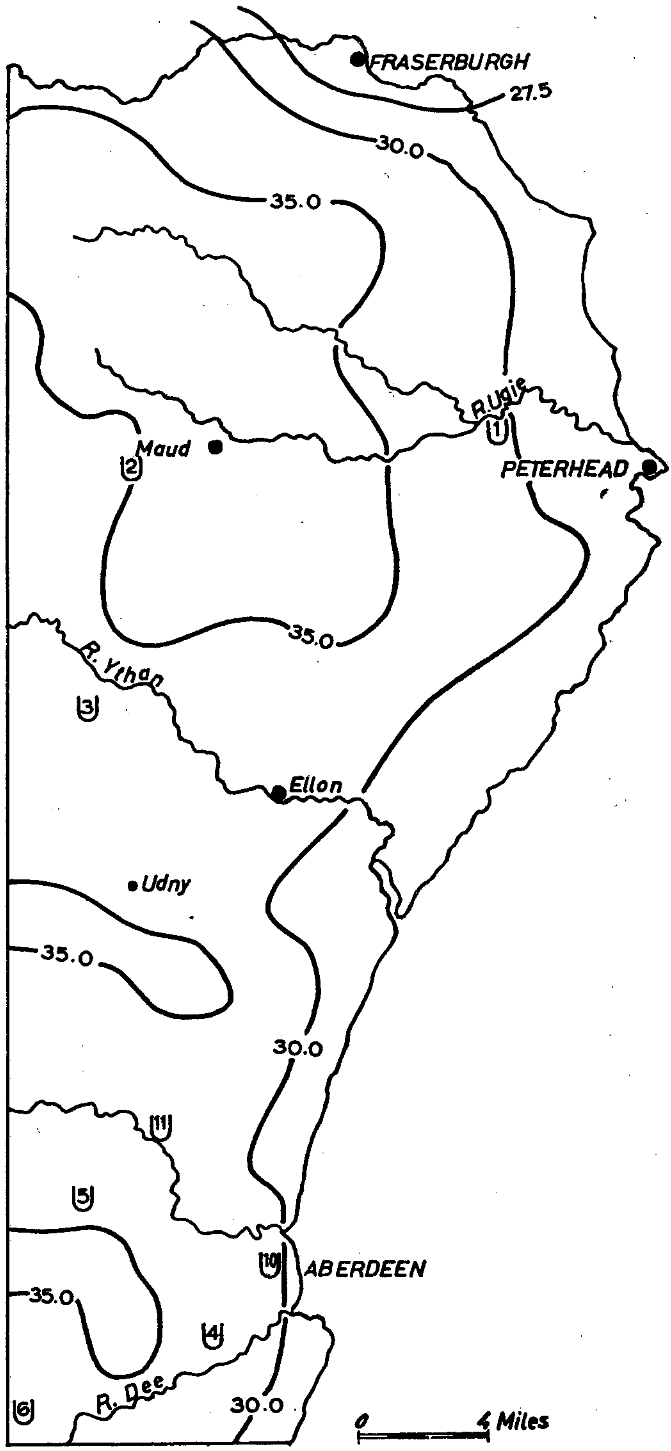
FRASERBURGH
27.5
30.0
35.0
R. Ugie
1
Maud
2
PETERHEAD
35.0
R. Ythan
3
Ellon
Udny
35.0
30.0
11
5
10
ABERDEEN
35.0
4
R. Dee
6
30.0
0
4 Miles

FIGURE 6B

can be calculated by allowing for every 100 feet increase in height above 200 feet a decrease of about 5 days on the figures for the lowest levels.

The relative effectiveness of the level of temperature reached during the growing season can be assessed from the "Accumulated Temperature" ("Heat units" in much botanical literature) above the threshold of 42°F. The data for Aberdeen and Logie Coldstone for a 30-year period (Shellard, 1959) are given in Table D.

TABLE D. ACCUMULATED TEMPERATURE—NUMBER OF DEGREE-DAYS ABOVE 42°F

| Month | No. of Degree-Days above 42°F | |
|---|---|---|
| | Aberdeen Alt. 79 ft. | Logie Coldstone Alt. 608 ft. |
| January | 46 | 31 |
| February | 48 | 36 |
| March | 90 | 77 |
| April | 103 | 84 |
| May | 192 | 183 |
| June | 351 | 348 |
| July | 484 | 468 |
| August | 456 | 422 |
| September | 336 | 288 |
| October | 192 | 130 |
| November | 74 | 33 |
| December | 53 | 34 |
| Year | 2425 | 2134 |

*Rainfall*

Practically the whole of the area can be rated as moderately dry, with the long period average rainfalls mostly 30 inches and, except for relatively local areas of higher ground, less than 35 inches, so effective is the desiccating effect of the mountain masses on the south-westerly and westerly winds. A small area round Fraserburgh is distinctly dry for the latitude, with about 27 inches, and the whole of the relatively narrow coastal strip from this north-east corner south to Aberdeen averages less than 30 inches. Until the foothills of the Grampians are reached only two small areas, the Corrennie Forest and the Hill of Fare, are credited with 40 inches or more.

The general distribution (Fig. 6) clearly shows the association of the contour with the major rain-bearing easterly winds. On the higher ground exposed to these winds the increase to over 30 inches up to the 35 inches annually is established rapidly with increasing distance from the coast, although the altitude change is fairly small.

Drier tongues penetrate noticeably well inland along the major river valleys of the Ythan and the Don (33 to 34 inches) and in the Don Valley as far westwards as the Tarland Basin where the values are of the order of 31 to 32 inches. This latter area is, in fact, the driest inland area, but the western Skene Lowlands from the middle reaches of the Don southwards to

(*By courtesy of The Scotsman Publications Ltd.*)

PLATE 4
The Don Valley and Callievar Hill west of Alford.

PLATE 5
The Upper Don Valley near Towie.

[*Facing page* 32]

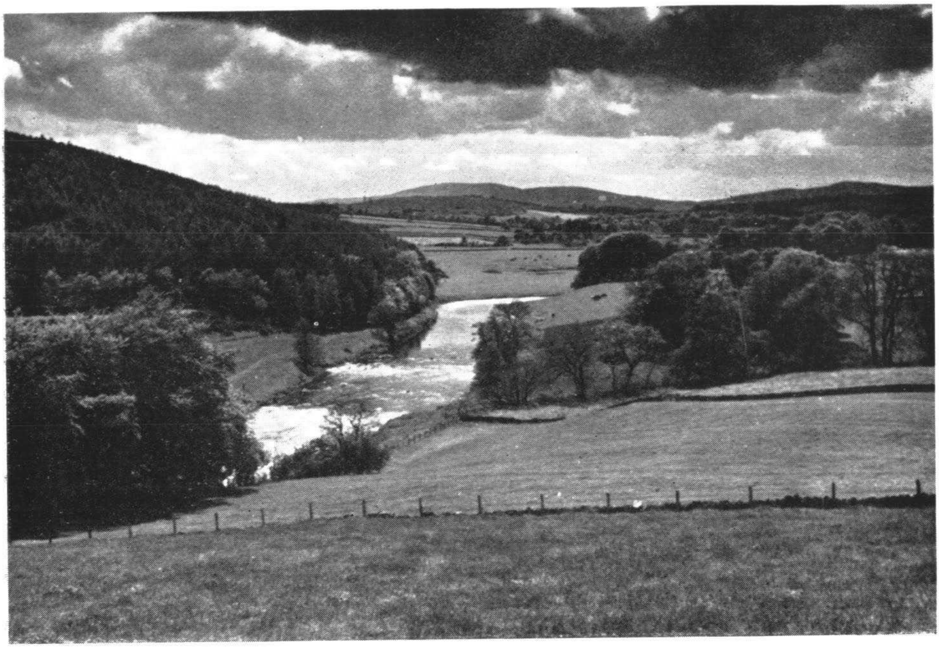

PLATE 6
The Don Valley west of Inverurie.

(*By courtesy of Aberdeen Journals Ltd.*)

PLATE 7
The Vale of Alford looking towards Bennachie.

beyond Echt and the Loch of Skene, well screened from the west and with useful shelter to the north, are also distinctly drier than a rigid interpretation of the general pattern would suggest.

It is of interest to note that over the belt extending northwards from a line from the Hill of Fare to the mouth of the River Dee, but excluding the north-east coastal zone, the latest official averages of annual rainfall for the period 1916–50 (Met. Off., 1959), on which the accompanying map is based, show increases of round 7% to 9% over those for the earlier standard period 1881–1915. Caution must be exercised in the interpretation of this apparent increase; some of it may well be due to improved standards and fuller information, and any decision as to the proportion to be ascribed to these causes and to a real increase in the rainfall must await a detailed assessment. The need for caution applies particularly to any temptation to predict a continuing trend towards increased rainfall.

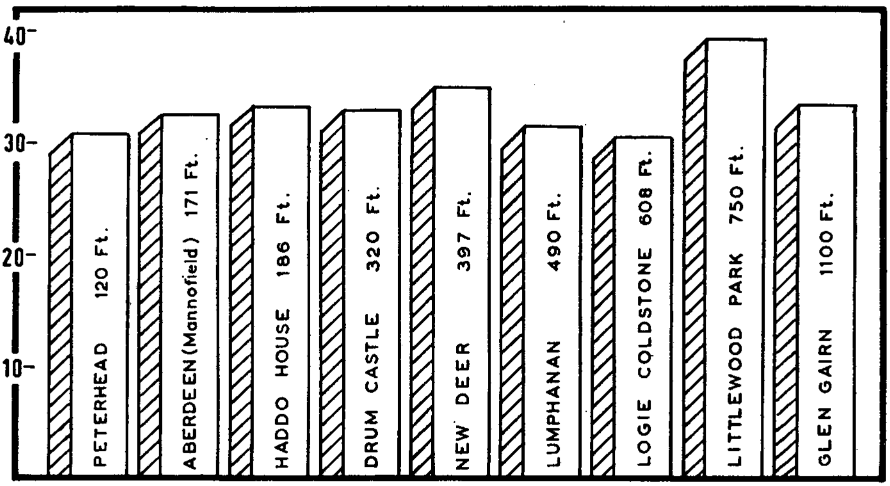


FIGURE 7. Average Annual Rainfall (in inches) of Meteorological Stations in the Area.

The distribution of rainfall through the year follows fairly closely the pattern for much of East Scotland (Fig. 7). The March/April and June periods are easily the driest, with February and May among the drier months. Compared with the much larger totals for July and October the rainfall figures for August and September suggests a drier period covering the second half of August and the first half of September. Very appreciably more than half the annual rainfall falls, on average, during the remaining six-month period, as can be assessed from the figures of Table E. It is worth noting that in respect of rainfall July takes its place alongside the autumn and early winter months.

Representative monthly and yearly average rainfall figures for five stations are given in Table E.

This distribution has two implications for agriculture: (i) there is a tendency, reflected in the low April average, for dry spells to occur in spring, the time when germination and/or quick growth is desirable, and (ii) there

TABLE E. AVERAGE RAINFALL TOTALS (IN INCHES)—PERIOD 1916–50

| Station | Alt. | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ft. | | | | | | | | | | | | | |
| Aberdeen (Mannofield Res.) | 171 | 2·84 | 2·11 | 2·01 | 2·21 | 2·61 | 2·08 | 3·29 | 2·87 | 2·97 | 3·43 | 3·40 | 3·11 | 32·93 |
| Craibstone | 300 | 3·03 | 2·26 | 2·04 | 2·20 | 2·68 | 2·05 | 3·33 | 2·98 | 3·05 | 3·59 | 3·53 | 3·16 | 33·90 |
| Fyvie Castle | 200 | 3·13 | 2·60 | 2·28 | 2·27 | 2·51 | 2·21 | 3·20 | 2·94 | 3·13 | 3·73 | 3·67 | 2·96 | 34·63 |
| Peterhead (Mains of Buthlaw) | 120 | 2·68 | 1·86 | 1·82 | 1·87 | 2·06 | 1·86 | 2·81 | 2·71 | 3·08 | 3·17 | 3·28 | 2·93 | 30·13 |
| Lumphanan | 490 | 2·81 | 2·22 | 1·92 | 2·05 | 2·48 | 1·90 | 3·06 | 2·88 | 2·73 | 3·39 | 3·23 | 3·00 | 31·67 |

may be a lack of drying winds in the harvest season and this, especially if it happens in September, can considerably delay or prolong the harvest. The figures also suggest the desirability of considering carefully whether it is better to make sure of a hay crop of good quality though of small bulk by harvesting before the probable break in the weather in July, or to harvest at a later date and take the risk of having adverse weather conditions affect the quality of a heavier crop.

*Hail and Thunder*

By mid and late spring the precipitation results largely from the showery, north-westerly type of weather, and the build-up to the summer rainfall maximum is largely due to periods of rather widespread development of showers of a thundery type. Hail (of the hard type), and thunder are associated with this convective activity.

Hail is very much a phenomenon of the colder half of the year, November to April, and probably occurrences show little variation over the area. The general pattern is probably best shown by the figures for the years 1942–59 (1945 excluded) given in Table F and taken from the records of the Meteorological Office station at Dyce where a close and more or less continuous watch is kept on this evanescent phenomenon. Maximum frequency is indicated for April, which has the high average of 3·3 days for the month, but the figures for the three months January to March are only slightly lower, whereas those for June to September indicate that in these months hail is very infrequent. It should be noted however that the figures include occurrences of both the hard hailstone and the soft hail or granular snow. These last types contribute very considerably to the figures for the winter months—perhaps constitute the majority of occurrences—but from March on to October, or even into November, the more vicious hard hailstone is undoubtedly the more normal form.

The distribution of thunderstorms throughout the year, as given for Dyce and Craibstone (again in Table F), is completely different from that of hailstorms. Thunder is quite unusual from December to March and only very occasional in April and in the October/November period. The liability to thunder storms increases sharply in May and then increases to a maximum in August, falling off very sharply in September. This pattern would seem to be typical of the Skene Lowlands and the lower reaches of the Don and Dee. It is probable however that the average total number of storms annually is less over the Buchan Platform. The picture is less clear in the south-western part of the area which, however, appears from the Logie Coldstone records to be less prone to thunderstorms. Whilst the Alford and Tarland Basins may not be topographically "convenient" for close storms, it is fairly certain that the rising ground surrounding them and the foothills generally, with their tendency to high local maximum temperatures, are favourable to the initiation of incipient storms and to an increase in the severity of storms drifting in to the area. Such storms occurring in the foothills (or even outside the area) can occasionally give rise to temporary surges in the rivers and some local flooding may occur in the higher reaches of the Don.

*Snow*

In spite of the relatively low total of annual precipitation, the area is considered to be a rather snowy one. In addition to the occasional widespread

## TABLE F. AVERAGE NUMBER OF DAYS OF SNOW, HAIL, THUNDER

| Month | Craibstone (1925–1959) | | | | Dyce (1942–1959)* | | | | Logie Coldstone (1926–1959)† | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Snow | Snow Lying | Hail‡ | Thunder‡ | Snow | Snow Lying | Hail | Thunder | Snow | Snow Lying | Hail | Thunder |
| January | 7·6 | 9·3 | 3·1 | 0·1 | 11·0 | 7·2 | 2·9 | 0·1 | 8·1 | 11·1 | 0·1 | 0 |
| February | 7·6 | 8·7 | 3·2 | 0 | 10·7 | 9·2 | 2·9 | 0·1 | 8·4 | 11·4 | 0+ | 0 |
| March | 6·7 | 5·8 | 2·4 | 0·2 | 7·7 | 6·4 | 3·0 | 0·1 | 6·1 | 8·6 | 0·1 | 0+ |
| April | 3·8 | 0·8 | 2·1 | 0·3 | 3·5 | 0·2 | 3·3 | 0·3 | 4·1 | 1·7 | 0·2 | 0·1 |
| May | 1·4 | 0·1 | 1·1 | 0·9 | 1·7 | 0·1 | 2·1 | 1·2 | 0·8 | 0·1 | 0·2 | 0·5 |
| June | 0 | 0 | 0·2 | 1·5 | 0 | 0 | 0·5 | 1·1 | 0 | 0 | 0·1 | 0·5 |
| July | 0 | 0 | 0·1 | 1·6 | 0 | 0 | 0·2 | 1·3 | 0 | 0 | 0 | 1·0 |
| August | 0 | 0 | 0 | 1·5 | 0 | 0 | 0·3 | 1·7 | 0 | 0 | 0+ | 0·8 |
| September | 0 | 0 | 0·2 | 0·7 | 0+ | 0 | 0·3 | 0·8 | 0 | 0 | 0+ | 0·3 |
| October | 1·3 | 0·3 | 0·7 | 0·3 | 0·9 | 0 | 1·4 | 0·4 | 0·8 | 0·6 | 0 | 0+ |
| November | 2·6 | 2·1 | 1·3 | 0·2 | 2·5 | 1·3 | 1·6 | 0·3 | 2·5 | 1·6 | 0 | 0+ |
| December | 4·9 | 5·1 | 0·8 | 0+ | 5·8 | 3·9 | 2·2 | 0·1 | 5·3 | 6·7 | 0 | 0 |
| Year | 35·6 | 32·5 | 15·2 | 7·5 | 43·8 | 28·3 | 20·7 | 7·5 | 36·1 | 41·8 | 0·7 | 3·2 |

(0+) signifies phenomenon has occurred but frequency less than 0·1.

* No observations 1945. † No observations May 1941—June 1945: some minor breaks in record. ‡ Period 1942–59.

general snow storms, winds from between NNW and NNE, particularly from December to March, bring extensive and prolonged showers which are often of snow (sometimes of soft hail or granular show). The average number of days per annum on which snow falls is about 35 (see Table F), but the figure varies very considerably from year to year—60 days or more for example have been noted inland in bad years like 1937 and 1955. Usually the coastal zone is less markedly affected; not only does snow fall less frequently—Aberdeen (Mannofield) logged only 48 days in the bad year 1955—but it does not lie for long or accumulate badly. Because of the maritime influence road blockage, for instance, is not usually serious below about 300 feet above mean sea level.

Figures for the number of days annually when the ground is covered with snow for more than half a day clearly indicate that both the amount of snowfall and the duration of "snow lying" increase with height. The Aberdeen district has on average more days of "snow falling" than of "snow lying", whereas Logie Coldstone has some 5 to 6 days of "snow lying" in excess of its average of "snow falling". In all probability this trend is accentuated for heights up to 1000 feet.

In the "basin areas" the snowfall is generally heavier on north-easterly facing slopes and the snow lies longer than on southerly facing slopes. Accumulations of snow in the basins themselves also tend to persist longer.

In general however considerable depths of snow are not very frequent in relation to the relatively high frequency of "snow falling", and the main problem is that of local drifting with the high winds over the areas lacking natural shelter.

*Haar*

Earlier reference was made to the advantage gained by the ease of penetration of winds from the sea over much of the area. This is more than offset by a disadvantage which is operative for much of the year. Winds with considerable fetch off the sea have the *relative* humidity of the surface layers increased during their passage over the sea as long as there is a positive temperature difference between air and sea. These winds, with the surface layer rather heavily charged with moisture, penetrate deeply over the area under review. This factor predisposes to that "raw" feeling and in the spring and summer the haar provides visible evidence of the penetration of this high relative humidity.

The haar (or low stratus cloud) sweeps in over the plain, penetrating up the river valleys, sometimes for considerable distances in the worst cases, although a hill barrier is usually effective in preventing further penetration. Clearance usually begins well inland where the cloud (fog) is thinnest and proceeds progressively coastwards. Temperatures then rise quickly and the relative humidity falls steadily, except perhaps in the coastal zone where dissipation may not be effected during the day and the rather cold raw damp persists. As soon as the afternoon warmth wanes, the cloud (fog) begins to extend inland again and the process may be repeated for several consecutive days, although the degree of penetration and the duration at any one locality is very sensitive to the surface wind direction. Meanwhile the south-western part of the area, in the shelter of the higher ground, enjoys longer sunshine and higher maximum temperatures and humidities of 50% or less.

### *Humidity*

Average mid-day values (13 hours GMT) suggest that relative humidity is lowest in May and June (and sometimes in July) when the average is 70%, or just below this, for the south-west of the area and just over 70% for the Buchan Plain. In the winter months the figure generally rises to 80–85%. The records at Dyce provide a more comprehensive analysis for an area lying slightly inland and thus unaffected by unfavourable maritime influences of a purely coastal location, and Table G shows for 1500 hours GMT (approximately the warmest part of the day) the percentage frequency of occurrence of relative humidities within the limits given. The averages are based on a period of 10 years and have been aggregated in the table to show the four differing patterns as the seasons change. For the three months November, December and January the frequency distribution is very similar with humidity of 80% or more on well over 60% of occasions; figures for February are not very different. March is a transition month leading to the rather remarkable distribution shown for late spring, and especially for April, when on almost half the days the afternoon humidity is in the rather low range of 50–69% with an almost equal chance of being between 50 and 59%. This distribution cannot of course be entirely dissociated from the low rainfall of this season.

The figures for the summer months show the effects of the haar and the sea breezes, and must to some degree reflect the greater rainfall. There are fewer occasions in the 50–59% range (and below) and a corresponding increase in the higher ranges, especially the 70–79% range. The figures for April/May are probably reasonably representative of the Buchan area, but cannot legitimately be applied without qualification to the higher ground or to the basins, or even the river valleys. In these areas the influence of sea winds is less and the haar normally disperses earlier in the day; maximum temperatures are consequently higher and convection more active, so that relative humidities would be expected to be lower than in the flatter areas towards the coast. In the more western parts of the area the summer shower activity can bring higher afternoon humidities though the effect is often only temporary.

An interesting feature of the analysis is the very occasional but significant occurrences of relative humidities below 50% at 1500 hours. Such low values are reasonable on very fine summer days well away from the coast, but their occurrence in months such as February, April and October is highly significant. It will be noted that relative humidities of less than 30% have been recorded in April and of less than 40% in December. These very low humidities must be mainly associated with days of unusually well-developed foehn, and such values are likely to occur somewhat more frequently in the areas more sheltered by the (western) mountains; this supports the contention made earlier that foehn in varying degree of development does from time to time reduce humidity values to below the normal for the season.

### *Sunshine*

The annual average of sunshine is round 3·5 hours per day, rather more toward the coast and rather less in the more westerly districts. June is the sunny month with a daily average of over 6 hours; the tendency to unsettled weather in July and August is responsible for a sharp drop in the averages

TABLE G. PERCENTAGE FREQUENCY OF OCCURRENCE OF RELATIVE HUMIDITIES BETWEEN CERTAIN LIMITS AT 1500 h. GMT. AT DYCE AIRPORT

1951–60

| Period | | Limits of Relative Humidity per cent. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Season | Months | 90–100 | 80–89 | 70–79 | 60–69 | 50–59 | 40–49 | 30–39 | 20–29 |
| Winter | November, December, January, February | 26·2 | 36·6 | 23·5 | 11·1 | 2·1 | 0·4 | 0·1 | 0·0 |
| Spring | April, May | 9·0 | 15·2 | 20·8 | 25·5 | 18·5 | 8·1 | 2·6 | 0·3 |
| Summer | June, July, August | 12·7 | 20·0 | 25·2 | 23·1 | 13·8 | 4·8 | 0·9 | 0·0 |
| Transitional | March, September, October | 17·5 | 23·7 | 24·7 | 20·3 | 11·2 | 2·3 | 0·3 | 0·0 |

for these months so that May is normally the second best month. Where June has been exceptionally sunny (e.g. in 1936 and 1940) monthly totals of over 250 hours have been recorded, with a maximum of 284 hours at Craibstone. The sunny July of 1955 gave a total of 260 hours at Craibstone, in sharp constrast to the mere 77 hours recorded there in July 1957. Normals of sunshine for the two stations with suitably long records are given in Table H.

TABLE H. AVERAGES OF BRIGHT SUNSHINE 1921–50

(in hours)

| Station | J | F | M | A | My | Ju | Jy | A | S | O | N | D | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aberdeen | 47 | 68 | 106 | 136 | 170 | 183 | 150 | 144 | 123 | 96 | 57 | 37 | 1317 |
| Craibstone | 53 | 77 | 116 | 144 | 178 | 189 | 156 | 151 | 130 | 102 | 64 | 45 | 1405 |

*Evaporation*

The difficulties of measuring evaporation from extensive areas are well known but some estimates of water-loss, obtained by various methods, are available for Aberdeenshire.

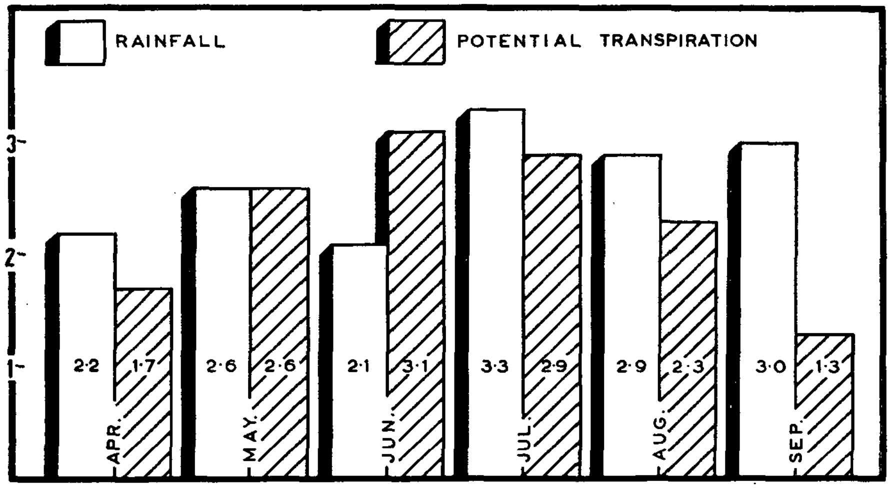


FIGURE 8. Relation of Precipitation to Calculated Potential Transpiration at Aberdeen.

(*a*) *Evaporation as estimated from percolation gauges at Aberdeen* 1921–46. Three percolation gauges, each one thousandth of an acre in area and containing 40 inches depth of soil and each subject to different fertilizer treatment were in operation at Craibstone in Aberdeen. Monthly estimates of calculated evaporation (defined as the rainfall during the month less percolation in the same period) (Fig. 8) and the annual totals are given in the appropriate issues of *British Rainfall*.

The mean annual values of calculated evaporation for the period 1921–46 for the three gauges are:

Gauge No. 1—unmanured—17·00 inches.

Gauge No. 2—manured—17·48 inches.

Gauge No. 3—manured and limed—18·34 inches.

For various reasons—e.g. cropping on gauges 2 and 3, assumptions of zero run-off and an equal level of soil moisture each time the monthly balance was struck—the results are difficult to interpret and are not directly comparable with water-loss from an open water surface. Compared with the other estimates of evaporation in the British Isles published in *British Rainfall*, the Craibstone results seem high, both absolutely and in relation to such geographical factors as may be deemed relevant.

(*b*) Penman (1950), using an independent method based mainly on meteorological data (Penman, 1954), computed the following mean values of the evaporation in inches of water from *an open water surface* for Aberdeen:

| J | F | M | A | My | Ju | Jy | A | S | O | N | D | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0·2 | 0·6 | 1·3 | 2·3 | 3·2 | 3·6 | 3·5 | 2·9 | 1·7 | 0·9 | 0·2 | 0·1 | 20·5 |

(*c*) A further estimate is that obtained by measuring the potential transpiration (P.T.), representing the water-loss from an established turf surface assuming that the roots never run short of available water. On general physical and biological principles it is to be expected that water-loss by P.T. will be less than that from an open water surface, and Penman (1950), using the method mentioned in (*b*), estimated a rate of P.T. of 15–16 inches for Aberdeen. Relevant extracts of the latest estimates (Irrigation, 1962) of potential transpiration for Scotland are given below:

TABLE I. POTENTIAL TRANSPIRATION

(inches of water)

| County | Apr. | May | June | July | Aug. | Sep. | Summer Total | Winter Total | Annual Total |
|---|---|---|---|---|---|---|---|---|---|
| Aberdeen–North | 1·55 | 2·45 | 2·80 | 2·75 | 2·20 | 1·30 | 13·05 | 2·70 | 15·75 |
| Aberdeen–Central and Southeast | 1·70 | 2·60 | 3·05 | 2·85 | 2·35 | 1·35 | 13·90 | 2·60 | 16·50 |
| Aberdeen–West | 1·55 | 2·65 | 3·25 | 2·85 | 2·20 | 1·35 | 13·85 | 2·25 | 16·10 |

# CHAPTER III

# Microclimatic Conditions

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IN the present context, micrometeorology may be considered as the study of meteorological conditions at levels affected by plant and soil characteristics, i.e. to a height of a few feet above the surface (the range being taken to include the height of the canopy in afforested areas), and to a depth of a few feet below the surface. The amounts of solar radiation and of natural precipitations reaching the ground obviously depend upon the extent of interception by the vegetative cover. Thus the temperatures and humidities differ from those recorded with normal exposure at meteorological stations. Further, the back radiation and evaporation from the surface are decreased on account of the vegetative cover, while the loss of moisture from the soil is increased by plant transpiration; the relative magnitude of these component factors determine whether the moisture content of the soil is increased or decreased by the presence of the vegetative cover.

Meteorological records have been maintained for a long period at Craibstone†, and in addition to the data quoted in the tables in Chapter II soil temperature data are also available. These long term readings are valuable in considering seasonal changes, but since they provide only once-daily spot readings, consideration of diurnal fluctuations have been based upon records obtained with recording thermographs over a period of 5 years at Alltcailleach Forest, Birkhall, near Ballater (Coutts, 1955, 1958).

*Temperature*

The mean annual temperatures at Craibstone for the period 1952–61 are shown in Table J: the corresponding mean values of air temperature, hours of sunshine, number of frost days and of days with snow cover, and annual precipitation quoted in Chapter II show that this 10-year sample gives a reasonable approximation to the long period results.

The soil temperatures were measured at depths of 4 inches and 8 inches under bare soil and at depths of 1 foot and 4 feet under a grass covered soil: the two pairs of readings are not strictly comparable, but it is unlikely that the temperatures measured in the lower strata differ appreciably on account of the surface cover (see Table K). It may be noted that there is

* Present address: Santo Rey 30, Seville, Spain.

† Data supplied by courtesy of Mr. R. Bain, North of Scotland College of Agriculture.

close agreement between the mean annual temperatures in the four different strata. A similar result was obtained at Alltcailleach Forest, Birkhall.

TABLE J. METEOROLOGICAL DATA: MEAN ANNUAL VALUES
(Craibstone, 1952–1961)

| | *Temp.*, °F | | |
|---|---|---|---|
| Air | 46·7 ± 0·9 | Hours of sunshine | 1376 ± 40 |
| Soil—4″ | 45·1 ± 0·9 | No. days with ground frost | 81·4 ± 5·1 |
| 8″ | 45·4 ± 0·8 | No. days with snow cover | 36·4 ± 6·6 |
| 1′ | 46·6 ± 0·8 | Annual precipitation (ins.) | 33·0 ± 1·5 |
| 4′ | 46·5 ± 0·8 | | |

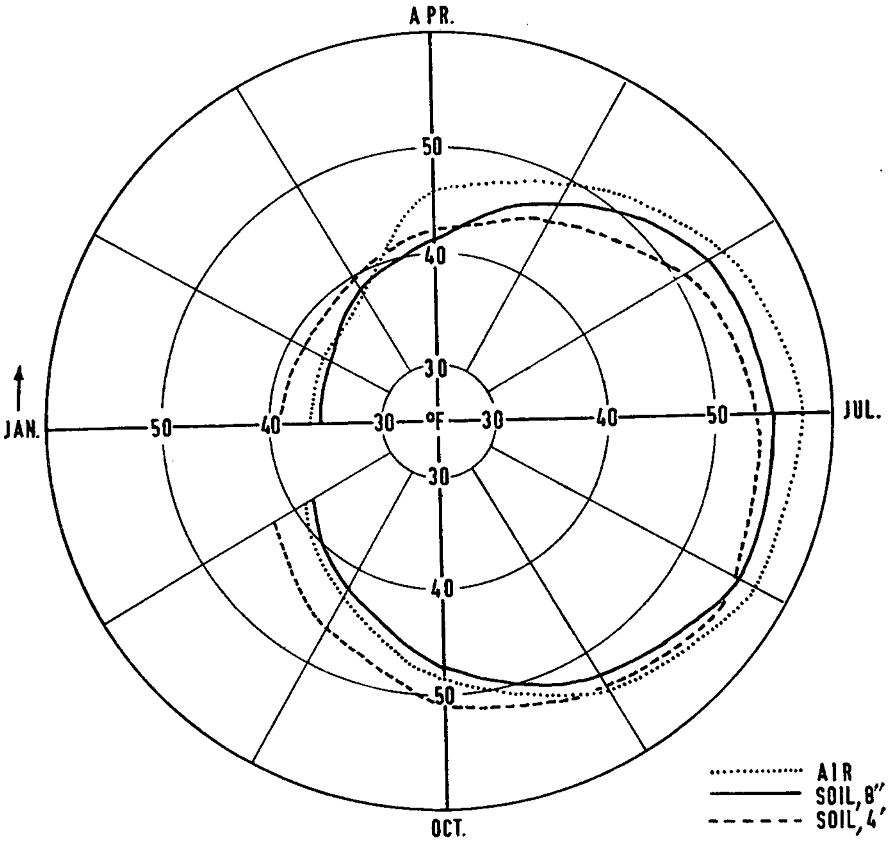



FIGURE 9. Monthly Temperatures at Craibstone (1952–1961).

While these similarities between the temperatures throughout the profile are of interest, the differences between their seasonal fluctuations are of more practical importance. These are illustrated by the curves in Fig. 9 which show the mean monthly temperatures in air and at two different depths in the soil. Two important features are apparent from these curves—the phase

TABLE K. TEMPERATURES (°F) AND NUMBER OF FROST DAYS

(Alltcailleach Forest, 1952–1956)

| | 1952 | | | | | 1953 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Soil Under Canopy | | | | Air | Soil Under Canopy | | | |
| Depth ins. | | 1 | 6 | 12 | 18 | | 1 | 6 | 12 | 18 |
| Mean temp. | 42·6 | 42·4 | 42·4 | 42·6 | 42·6 | — | 44·2 | 44·6 | 44·4 | 44·6 |
| Max. temp. | 79·9 | 69·1 | 59·4 | 54·9 | 53·2 | 75·7 | 65·1 | 58·3 | 56·7 | 53·6 |
| Amp. de | 67·9 | 40·2 | 22·4 | 22·0 | 19·4 | 58·6 | 35·4 | 26·3 | 23·4 | 18·7 |
| No. frost days | 99 | 87 | 9 | 0 | 0 | 68 | 22 | 3 | 0 | 0 |

| | 1954 | | | | | 1955 | | | | | 1956 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air | Soil | | | | Air | Soil | | | | Air | Soil | | | |
| | | In Ride | | Under Canopy | | | In Ride | | Under Canopy | | | In Ride | | Under Canopy | |
| Depth ins. | | 1 | 6 | 1 | 6 | | 1 | 6 | 1 | 6 | | 1 | 6 | 1 | 6 |
| Mean temp. | 43·2 | — | — | 42·1 | 42·4 | 41·7 | 41·9 | 42·6 | 41·9 | 42·3 | 42·1 | 41·9 | 42·4 | 41·4 | 41·9 |
| Max. temp. | 76·3 | 64·0 | 55·8 | 53·2 | 52·2 | 86·2 | 63·1 | 57·9 | 61·3 | 58·3 | 75·9 | 61·3 | 55·2 | 55·2 | 51·8 |
| Amp. de | 67·9 | 34·5 | 23·8 | 19·4 | 18·0 | 81·7 | 33·3 | 25·4 | 31·1 | 26·1 | 68·0 | 30·6 | 22·3 | 23·7 | 19·4 |
| No. frost days | 101 | — | — | 57 | 2 | 126 | 82 | 0 | 53 | 0 | 115 | 44 | 0 | 26 | 0 |

lag in the occurrence of maxima and minima and the reduction in the soil of the range of temperature fluctuations. The phase lags are small in the upper strata of the soil, but a lag is clearly shown in the curve for the 4 feet depth; and an inspection of a table of mean monthly values for each year leads to the comparison shown in Table L.

TABLE L. NUMBERS OF MAXIMUM AND MINIMUM TEMPERATURES IN VARIOUS MONTHS

(Craibstone, 1952–1961)

| | No. Maxima in | | | | No. Minima in | | | |
|---|---|---|---|---|---|---|---|---|
| | June | July | Aug. | Sept. | Dec. | Jan. | Feb. | Mar. |
| Air . . | 2(*) | 5 | 3 | 1 | 1 | 4 | 5 | 0 |
| Soil—4′ . | 1 | 0 | 8 | 1 | 0 | 2(†) | 7 | 2 |

* Equal maxima, June and August, 1957. † Equal minima, January and February, 1952

The Alltcailleach Forest data provide material for the more detailed examination of the analogous changes in diurnal temperature fluctuations. It was found that maxima and minima at a depth of 6 inches lagged by about 4 hours behind those at a depth of 1 inch, the time varying to some extent with changes in the thermal capacity of the soil associated with its moisture content.

The amplitudes of temperature fluctuations at various depths in the soil are included in Table K. On an average the amplitude at 1 inch below the surface is 0·52 times that in the atmosphere and the amplitude at 6 inches below the surface is 0·29 times that at 1 inch below the surface. There is, however, a fairly wide scattering of points about the straight line representing the relationship between the amplitudes in air and at a depth of 1 inch, and in winter apparently anomalous cases occur in which the amplitude at 6 inches is greater than that at 1 inch. Such anomalies may be accounted for if the upper stratum is partly or wholly frozen, while the lower is not: for then small heat exchanges cause temperature fluctuations in the lower stratum, but isothermal phase changes above.

The depth of frost penetration is profoundly affected by the nature of the surface vegetation, and a good example of the protective influence of the forest canopy and accompanying forest litter lying on the ground is provided by the Alltcailleach Forest data. At this site, at an altitude of 1100 feet, winter conditions are fairly severe, and grass minimum temperatures fell to freezing point at least once in every month of each year throughout a period of 5 years, although air temperatures remained above freezing point from (approximately) mid-May to mid-September. But the data presented in Table K show that on an average there were 102 frost days in air, while under the canopy there were 49 at a depth of 1 inch, but only 3 at a depth of 6 inches. The observations at depths of 12 inches and 18 inches were discontinued after two years, but it appears that frosting in these strata must be very infrequent. On the other hand two years' data for temperatures at 1 inch and 6 inches below the soil in an open ride suggest that frosting here at a depth of 1 inch is significantly higher than under the canopy.

A forest stand provides the most effective screening of the surface, but other types of vegetative cover also have an appreciable influence. These are illustrated by the data in Table M which are based upon continuous

TABLE M. AIR TEMPERATURES AND SOIL TEMPERATURES (°F) AT DEPTHS OF 3 INS. AS AFFECTED BY TYPE OF SURFACE VEGETATION

(Countesswells Forest, 1959/1960)

| | Soil Cover | | | | | |
|---|---|---|---|---|---|---|
| | Air | T.1 | T.2 | H | G | B |
| *Autumn* | | | | | | |
| Max. | 66·0 | 52·3 | 53·6 | 54·1 | 54·5 | 57·9 |
| Amp. de | 25·0 | 4·1 | 3·1 | 3·6 | 5·8 | 14·2 |
| *Winter* | | | | | | |
| Min. | 12·2 | — | 33·8 | 33·3 | 31·8 | 28·0 |
| Amp. de | 21·8 | — | 1·3 | 5·9 | 0·0 | 0·0 |
| *Spring* | | | | | | |
| Max. | 61·5 | 46·8 | 47·5 | 39·6 | 54·5 | — |
| Amp. de | 36·5 | 3·1 | 7·0 | 11·7 | 10·1 | — |
| *Summer* | | | | | | |
| Max. | 70·5 | 52·2 | 52·9 | 58·8 | 64·4 | 68·7 |
| Amp. de | 28·6 | 2·5 | 3·4 | 6·7 | 10·3 | 16·2 |

temperature recordings at Countesswells Forest, 7 miles west of Aberdeen, at an altitude of 500 feet, where areas with differing vegetative cover were available. Area *T.1* carried a sitka spruce stand with almost closed canopy, *T.*2 carried a more open Scots pine stand, in area *H* heather was dominant, area *G* was a grass plot and area *B* was bare ground. The exposure in area *H* was less than that on open ground on account of the proximity of the trees. The temperature profiles under grass and under bare soil at sites near the Countesswells Forest (Fig. 10*b*, *c*) show the moderating effect of the grass during a warm period; and the changes in temperature profiles (Fig. 10*a*) during a period of thaw provide another example of the relatively small depth of frost penetration even under a bare soil.

*Air temperatures* near the ground show considerable variations over a height of a few inches. The air temperatures quoted earlier are those recorded in a Stevenson screen at a height of 4 feet above the surface, but such values may frequently give a misleading impression of conditions in a crop.

Day and Peace (1946) give a detailed account of the incidence of spring frosts and their effects upon various tree species in different parts of Britain (including Binn Moss, Aberdeenshire).

Temperature profiles in the air within a crop have been discussed very fully by Geiger (1950), and local observations, so far as they are available, appear to be in accordance with his descriptions. An example for the densely canopied area *T.1* in Countesswells Forest, where it was found that variations were most pronounced within 6 inches of the soil surface, is shown in Fig. 11.

In this environment, wind disturbance is negligible, and the changes depend mainly upon the distance to which the solar radiation penetrates below the canopy.

Temperatures, humidities and wind within agricultural crops have been studied in detail at Rothamsted—in potato crops by Broadbent (1950) and in wheat crops by Penman and Long (1960). Valuable data under conditions approximating to those prevailing locally are provided by Waterhouse's

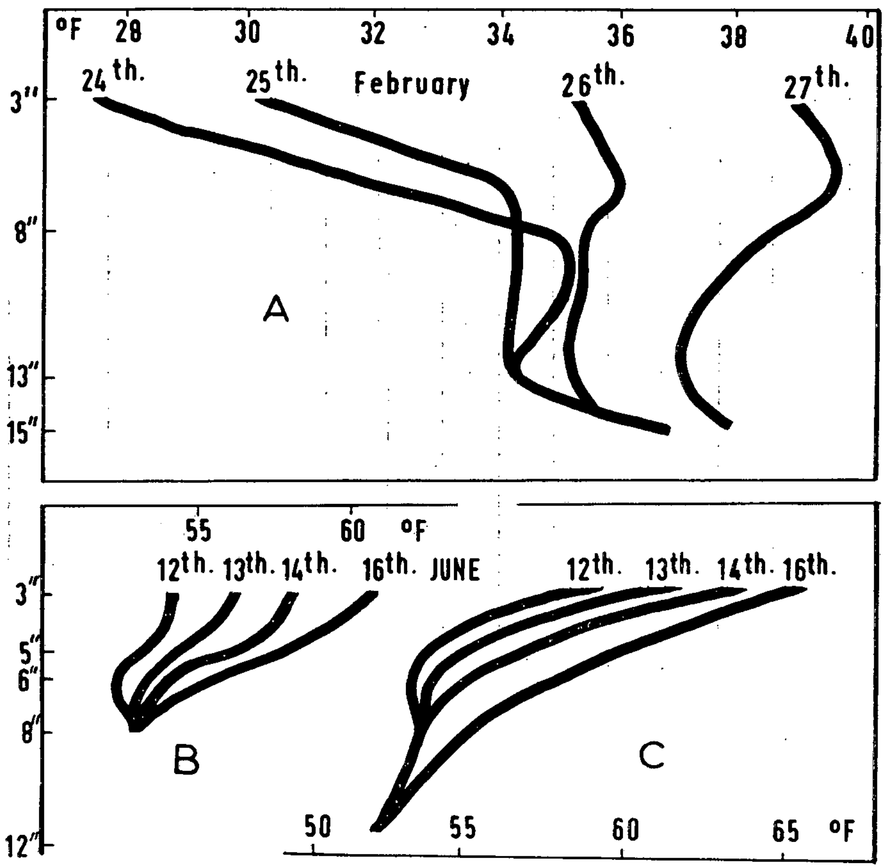



FIGURE 10. Soil Temperature Profiles (Countesswells, 1960).
a. Period of Thaw, 24th–27th February.
b. Warm Period under grass, 12th–16th June.
c. Warm Period, arable land, 12th–16th June.

measurements made near Dundee (1955). Waterhouse remarks that in tall grass, "since the air in the crop is mainly heated conductively by encountering the warmed grass stalks and leaves, the hottest air level will be found where the crop is beginning to increase in density, and the strength of incident radiation has not yet fallen off greatly. When a high sun is shining therefore, air stratification in grasses may consist of a warm middle to upper region sandwiched between two cooler layers," and he gives a graphical example of such a case, contrasting it with the steadily decreasing temperature at increasing heights above a short grass crop, and also with the steadily increasing temperature with increasing height in the long grass, when the low altitude sun warms only the upper surface of the crop. Under conditions favouring nocturnal long wave radiation, it is shown that inversions may occur, since radiation losses are greatest from the upper part of the crop and the cool air does not readily sink to ground level through the thicker lower stalks. Other cases discussed include consideration of the effects of a mat or an undergrowth of clover near the ground, of autumnal decline in vegetation and of rainstorm flattening of the crop.

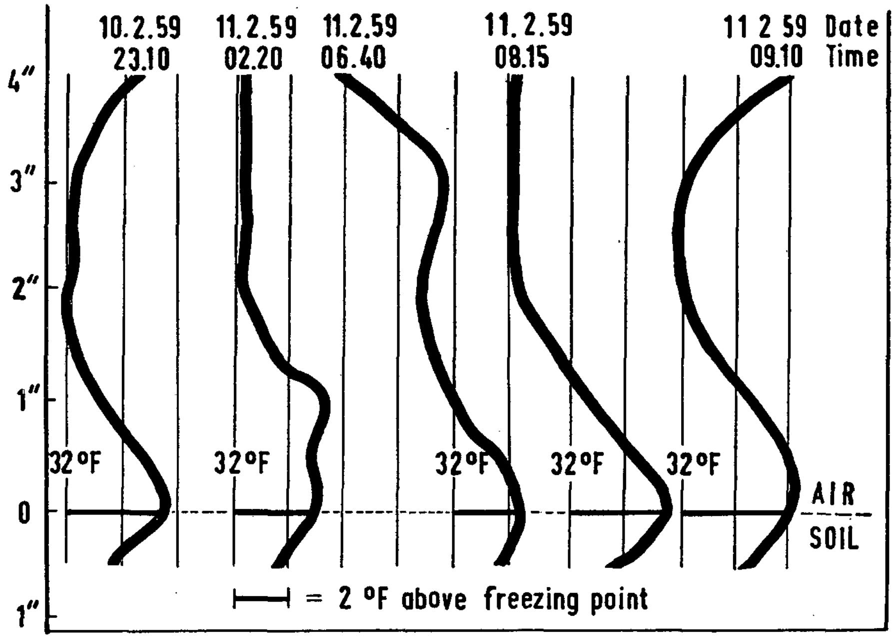



FIGURE 11. Air Temperature Profiles (Countesswells Forest Area T.1).

*Precipitation*

The 10 years mean precipitation at Craibstone is 33·0 inches (0·9 inches lower than the long period mean quoted in Table J), and the annual totals vary between a minimum of 27·1 inches (1959) and 42·8 inches (1960). The extent to which the rain penetrates the crop and reaches the surface of the soil presents a problem of considerable difficulty; factors concerned depend upon both the nature of the vegetation and the characteristics of the rainfall. Recent work at Countesswells Forest (Martin Aranda, 1960) provides some information on the nature of the results to be expected under local conditions.

Within the forest thirty-six rain gauges in all were distributed in the areas *T.1*, *T.2* and *H*, mentioned above. Most of the gauges in area *H* were protected by the heather, but two were placed in bare patches and the data from them provided a standard for comparisons between the penetrations of rain to the other gauges. A rainfall recorder, with the same exposure as the "standard" gauges, provided information on rainfall intensity. Results obtained in this experiment give percentage penetrations of rainfall of 57·6 ±

*(By courtesy of the Forestry Commission)*

PLATE 8

The Loch of Skene, a glacial kettle hole in the Skene Lowlands.

PLATE 9

The Upper Insch Valley.

*(By courtesy of The Scotsman Publications Ltd.)*

PLATE 10
The Moray coast at Pennan.

1·7 in *T.1*, 57·3 ± 1·6 in *T.2* and 55·2 ± 2·2 in *H*. The difference between the penetration through the trees and that through the heather is perhaps significant (at $P \sim 0{\cdot}2$), but there is obviously no significant difference between the penetrations in areas *T.1* and *T.2*, a result which appears to be inconsistent with the statement made above with reference to the differing densities of the canopies. The effect is largely accounted for by the dripping of rain drops from the leaves on which they are temporarily retained in the denser canopy. Workers elsewhere have found that the amount of main stem flow is small in conifers, but it may be of greater importance in straggling heather plants: if this be the case, the penetration measured by the gauges in area *H* will be an underestimate of the amount of water reaching the ground. It is hoped to publish elsewhere a fuller analysis of the data derived from this experiment, and to show the extent to which the penetration depends upon such factors as the rainfall intensity and the intervals between the occurrence of precipitation.

*Humidity*

The presence of a crop influences the humidity of the atmosphere since the ground cover retards evaporation and the transpiring plant supplies water. Waterhouse (*loc. cit.*) quotes examples of humidity measurements within a tall grass crop with matted clover undergrowth. On a cool summer day (grass temperature 57°F (14°C)), the air within the surface mat remained nearly saturated while there was a saturation deficiency of about 3 mm. Hg above the grass. On a warmer day (grass temperature 70°F (21°C)), the saturation deficiency was about 1 mm. Hg in the mat, and 7·5 mm. Hg above the grass.

In a forest the humidity profile beneath the canopy is probably more uniform than in an arable crop, but the humidity is generally higher than under grass or at an exposed site. At Countesswells Forest (area *T.2*) a continuous record of relative humidity was obtained with a hair hygrograph over the period November 1960 to February 1962, and mean weekly values of the relative humidity were obtained by integrating the charts. As data are available for only one complete seasonal cycle the figures must be treated with reserve, but the seasonal averages are unlikely to vary widely from year to year. Table N shows the results, using the same conventional periods for the seasons as in Table G. The daily relative humidities at 1500 hours G.M.T. were read from the charts and the frequencies of occurrence are shown in cumulative form in Table N, with the corresponding Dyce data of Chapter II. It will be seen that the humidities are consistently higher in the forest than at the exposed site. The difference between the two sites is least in summer; this is to be expected, because the higher altitudes attained by the sun in this season promote penetration of the solar radiation to greater depths below the canopy. It should be noted that while the 1500 hours readings were required in order to make the comparisons shown in Table N, the lowest humidities at Countesswells frequently occurred at about 1300 hours near the time of maximum solar altitude.

*Solar Radiation*

Accurate data for absolute measurements of incoming solar radiation require high-grade radiometric recorders and the only "official" observatories in Scotland that provide such data are those at Eskdalemuir and at Lerwick. Estimates can, however, be made from semi-empirical formulae involving data for humidity, temperatures and hours of sunshine, together with standard values for the solar constant. Fairly simple experimental methods provide comparisons between the values at neighbouring sites with different exposures. The results of such comparisons at Countesswells Forest in 1959 and 1960 gave the following mean results (solar radiation in open area $G = 100$): Area *T.1* 4; Area *T.2* 7; Area *H* 88.

These data refer to measurements at a height of 4 feet above the ground. There is therefore no relation between the penetration of radiation and the rainfall penetration through the heather on area *H*; but at first sight it may be surprising that under the trees in areas *T.1* and *T.2* the proportions of

TABLE N. PERCENTAGE NUMBER OF RELATIVE HUMIDITIES OBSERVED IN SPECIFIED GROUPS IN OPEN SITE (DYCE) AND AFFORESTED AREA (T.2, COUNTESSWELLS)

| | 90+ | 80+ | 70+ | 60+ | 50+ | 40+ | 40− |
|---|---|---|---|---|---|---|---|
| *Winter* | | | | | | | |
| Dyce | 26·2 | 62·8 | 86·3 | 97·4 | 99·5 | 99·9 | 100 |
| T.2 | 66(50) | 88(88) | 98(98) | 99(100) | 100 | — | — |
| *Spring* | | | | | | | |
| Dyce | 9·0 | 24·2 | 45·0 | 70·5 | 89·0 | 97·1 | 100 |
| T.2 | 24 | 42 | 84 | 97 | 100 | — | — |
| *Summer* | | | | | | | |
| Dyce | 12·2 | 32·2 | 57·4 | 80·5 | 94·3 | 99·1 | 100 |
| T.2 | 15 | 42 | 70 | 93 | 99 | 100 | — |
| *Transitional* | | | | | | | |
| Dyce | 17·5 | 41·2 | 65·9 | 86·2 | 97·4 | 99·7 | 100 |
| T.2 | 31 | 55 | 76 | 99 | 100 | — | — |

Dyce: 10 year average.
T.2: November 1960 to October 1961;
November 1961 to February 1962 (in brackets).

penetration of radiation and of rainfall are very different. The explanation of this apparent anomaly is provided by noting that in the case of the radiation there is no effect analogous to the "delayed action" of dripping of water from the leaves or of trickling of water along the tree branches.

### *Wind*

The extent of sheltering from wind in the Countesswells sites was estimated from readings of 3-cup anemometers at a height of 6 feet. The mean values are shown in Table O.

The result in area *H* is, of course, determined by the shelter from the adjacent plantations. The values vary to some extent with the wind direction and intensity. Correlation coefficients between the wind velocity in area *G* and areas *T.1* and *T.2* are very much lower than the coefficient between the wind velocities in areas *G* and *H*. In the case of the wooded areas the shelter provided is more efficient at low wind velocities, and the ratio of velocity in either of these areas to the velocity of *G* tends to be lower in such cases than under gale conditions.

*Evaporation*

At Countesswells Forest, evaporation data were obtained by four different methods, (1) by direct reading of evaporation from open water surfaces in pans 1 square metre area, (2) by the use of Stanhill evaporimeters*, (3) from water balance computations in microlysimeters, and (4) by using Penman's method (Penman, 1954).

Data were collected from June 1959 to September 1962 except in the months October to February when evaporation was negligible in rainy periods or the experiments were interrupted by freezing. The mean values of the evaporation, relative to those for the open site, as derived from Penman's computations and the Stanhill evaporimeters are shown in Table P. The agreement between the results for area *T.1* is much closer than was expected and is perhaps fortuitous—in view of the approximate nature of many of the terms involved in the computations, the two results for area *T.2* are not unreasonably discordant. The figures for area *H* are also shown, but in this case they represent data for two different physical environments: the Penman calculation is based upon the meteorological factors as measured in the Stevenson screen above the heather, while the Stanhill evaporimeter was sited beneath the heather. The interpretation of the two results, therefore, is that the screening effect of the trees surrounding area *H* reduces the evaporation to about 82% of that on the open site *G* while the ground cover of heather reduces it by a further 30%.

TABLE O. WIND VELOCITIES, MEAN VALUES

(Countesswells Forest, Aug.–Dec. 1960)

| Area | G | T.1 | T.2 | H |
|---|---|---|---|---|
| Velocity (miles/day) | 84·5 ± 7·9 | 8·3 ± 1·3 | 18·9 ± 2·6 | 41·1 ± 4·2 |
| Correlation coeff. with vel. in area *G* | — | 0·47 | 0·44 | 0·83 |

TABLE P. EVAPORATION: RELATIVE VALUES IN COUNTESSWELLS FOREST

(Area $G = 100$)

| | T.1 | T.2 | H |
|---|---|---|---|
| Calculated (Penman) | 14·3 | 20·7 | 81·9 |
| Observed (Stanhill) | 15·5 | 29·3 | 51·2 |

Water balance studies with microlysimeters on area *G* provide results for potential evapotranspiration if the moisture content is not less than field

* These evaporimeters are porous plates which are kept saturated with water; the loss of water is measured and the instruments are standardised by comparing their water losses with evaporation from the pans.

capacity, but losses are reduced as the surface soil becomes drier. According to Penman, the potential evapotranspiration should be given by multiplying the computed evaporation by a factor $f$ which varies with the season around a mean value of about 0·7. The results in Table Q based upon the mean results from three microlysimeters, provide satisfactory evidence in favour of the use of these simple microlysimeters in water balance studies.

TABLE Q. EVAPORATION FROM MICROLYSIMETERS IN COUNTESSWELLS FOREST, EXPRESSED AS PERCENTAGE OF CALCULATED EVAPORATION FROM FREE WATER SURFACE

Area *G*

| Wet Periods | | Dry Periods | |
|---|---|---|---|
| 7.3.60—2.5.60 | 75·6 | 7.6.59—11.9.59 | 36·8 |
| 4.7.60—5.9.60 | 71·4 | 2.5.60—4.7.60 | 42·2 |

Total evaporation, June 1959 to September 1960
Area *G*: 54·9%; Area *T.1*: 22·3%; Area *T.2*: 38·4%.

Results obtained with microlysimeters in areas *T.1* and *T.2* cannot be compared with computations from Penman's formulae for potential evapotranspiration, because the factor $f$ is unknown except when the surface is covered with grass. The mean values shown for these areas are lower than the mean value for *G*, but it will be noted that they are higher relative to *G* than the corresponding figures given in Table O: this is explained when it is recalled that in the shaded areas the soil moistures remain at least as high as the field capacity for a longer period than in area *G*.

## SUMMARY

Changes in climatic conditions in positions a short distance above and a short distance below the soil surface differ in many of their characteristics from those found at a normally exposed observatory.

(1) Temperature fluctuations are reduced under a crop and in the soil; with a dense vegetative cover, diurnal changes are very small at depths of about a foot, and frost penetration is limited to the upper few inches of the soil. Within a crop the temperature varies between the crown and ground level.

(2) Rainfall is intercepted by the crop, and under a dense forest canopy between 50% and 60% of the rain reaches the ground, a considerable proportion of this amount being accounted for by dripping from the leaves and stems of the plants.

(3) The humidity of the atmosphere inside the crop is usually higher than in the open, and may approach saturation near the surface although there is a considerable saturation pressure deficiency above the crop.

(4) The solar radiation is drastically reduced by interception by the crop: in a forest with closed canopy, the radiation received may be about 5% of that incident on a bare surface.

(5) The sheltering effect of trees may reduce the wind velocity to about 10% of that experienced at an open site, but the effect is smaller for high than for low wind velocities.

(6) All the preceding factors influence the loss of water by evaporation from the soil; but evaporation is also a function of the soil moisture content, and the rate of evaporation is reduced if the soil moisture content falls below field capacity. In order to estimate seasonal changes in the soil moisture content, data are required also for plant transpiration and for run-off and drainage.

# CHAPTER IV

# Parent Materials

THERE are three main groups of soil parent materials in the area, namely rock weathered *in situ*, Pleistocene deposits, which are glacial in origin, and recent deposits (Table R). The areas of rock *in situ* which have been delineated are comparatively small and almost all are hard, igneous or metamorphic rocks. The recent deposits consist in the main of fresh water alluvium adjoining rivers, and peat. By far the most important are the Pleistocene deposits which vary from tenacious glacial till to single grain fluvio-glacial gravel. One of the factors responsible for this wide variety of deposit is the nature of the rocks from which they are derived: on glaciation a hard, coarse igneous rock yields a gritty, sandy or loamy till, while a soft fine-grained mudstone yields a clay till. For this reason short descriptions of the rock types in the area are given.

## ROCKS

Metamorphic and igneous rocks are much more extensive than sedimentary, accounting for about 75% of the area (Fig. 12). In the following account a brief description of each group of rocks is given. Further details may be found in Read and MacGregor (1948), Read (1956) and Read and Farquhar (1956).

TABLE R. GEOLOGICAL FORMATIONS

| | | |
|---|---|---|
| Quaternary | Recent and Pleistocene | Blown sand<br>Peat<br>Freshwater alluvium<br>Marine alluvium including raised beach deposits<br>Fluvio-glacial sands and gravels<br>Morainic drift and till |
| Tertiary | ? Pliocene | Gravels and clays |
| Upper Paleozoic | Old Red Sandstone | Upper, Middle: flags, sandstones, shales, conglomerates |
| | Old Red Sandstone-Silurian | Intrusive igneous rocks |
| ? Pre-Cambrian | Highland Schists | Dalradian Series |

### HIGHLAND SCHISTS

Metamorphic rocks of the Dalradian Series of the Highland Schists underlie a large part of the area. They are mostly of sedimentary origin and are considered to be of pre-Cambrian or possibly early Cambrian age. The series includes many metamorphic types—quartzites and schistose grits, limestones and calc-silicate rocks, slates, phyllites, andalusite—and knotted schists, mica-schists, black schists, gneisses etc. The order of succession of the numerous bands has been determined in many localities, but their correlation has still to be finally accomplished and accepted.

These rocks, formed from the original sediments by heat and pressure, can be placed into five main lithological groups, each of which gives rise to a characteristic parent material. The first group contains acidic gneisses which, along with granite, provide the parent material of the Countesswells Association. The intermediate and basic gneisses are sufficiently different to form the second group, which yields the parent material of the Tarves Association. The third consists of quartzites and quartz-schists from which the parent material of the Durnhill Association is derived. Quartz-mica-schists form the fourth group, and from them the parent material of the Strichen Association has been produced. A fifth group, consisting of knotted schists, andalusite-schists, slates and greywackes, is the source of the parent material of the Foudland Association. A short account of each group follows.

*Acidic Gneisses*

In the southern half of Sheet 77 the gneiss is of a granitic character, resulting from the intrusion of many small sills and veins of granite along the planes of foliation of the country rock. A typical specimen is a coarse biotite-gneiss with a few thin bands of fine-grained mica-schist which are less resistant than the rugged gneiss.

*Intermediate and Basic Gneisses*

The gneiss occupying the west central portion of Sheet 76 varies from a coarse, massive, grey rock, very micaceous and sometimes garnetiferous, to a colour-banded rock in which the light bands are composed of quartz and felspar and the dark bands are rich in biotite. Associated with this rock is a hornblende-chlorite-rock composed of a confused aggregation of hornblende, with grains of iron ore and small scales of chlorite. In the area of Sheet 87 the gneisses are grey, with black mica and felspar arranged in parallel bands. In this ground too, there are zones of dark green rock rich in hornblende. Calcareous schist bands are associated with the gneiss at a number of places. Some of these have been quarried in the past, but they are, for the most part, too thin and not sufficiently calcareous to warrant commercial exploitation. Only locally do they affect the soil parent material and then not markedly.

*Quartzites, Quartz-Schists and Quartz-Mica-Schists*

Quartzites, quartz-schists and quartz-mica-schists occur in a two- to three-mile wide belt running south from Fraserburgh to the Ythan. They are in alternating bands and the dominance of any one lithology often influences the character of the soil parent material. The quartzites and quartzose grits are much shattered and tend to produce many angular fragments. The schists are very variable, ranging from a rock approaching a quartzite with micaceous partings to a highly micaceous phyllite. Where the quartzite and the more siliceous schists predominate the parent material produced is that of the Durnhill Association. The other schists provide the parent material of the Strichen Association.

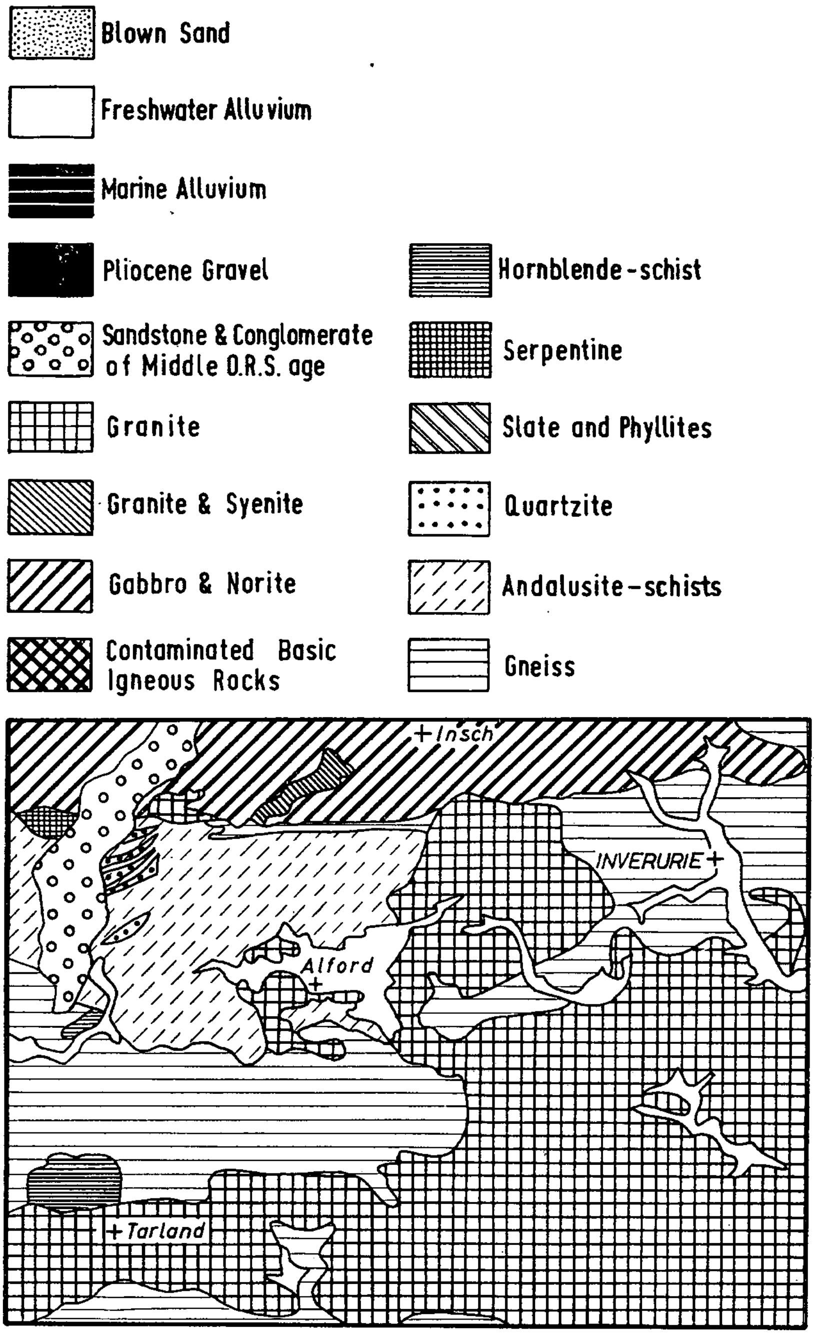



FIGURE 12A. Geological Map.

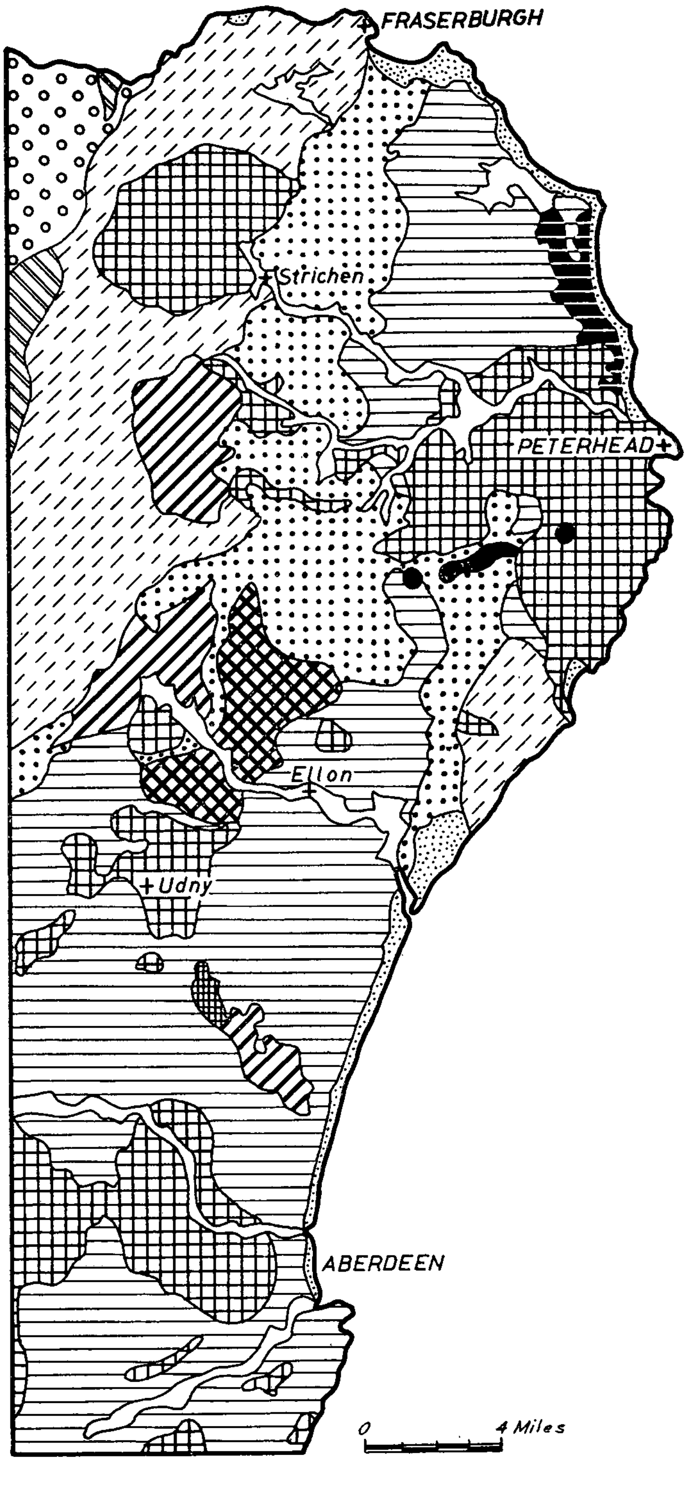

FRASERBURGH
Strichen
PETERHEAD
Ellon
Udny
ABERDEEN
0
4 Miles

FIGURE 12B

About Fraserburgh the schists are chiefly tough, purplish and thin-bedded, with many contortions and folds. They yield the parent material of the Strichen Association, the presence of calcareous bands having little effect on its character.

*Knotted Schists, Andalusite-Schists, Slates and Greywackes*

Many varieties of metamorphosed argillaceous rocks, including knotted schists, andalusite-schists, slates and greywackes, are the source of the parent material of the Foudland Association. They occur extensively within the area of Sheet 76, especially in the north-west where they underlie the Clova Hills, the eastern spurs of the Buck of the Cabrach and the Correen Hills. In these areas the beds are steeply folded, the dips being sometimes almost vertical.

Knotted and andalusite-schists occupy the western part of Sheet 87, forming an extension of their outcrops within the adjacent Sheet 86 (Read, 1923*a*). Their characteristics are similar to those of the schists described in the previous paragraph. Occurring in a narrow strip on the extreme north-western part of Sheet 87 are blue, grey, or greenish slates, which weather with a brownish crust; they also give rise to the parent material of the Foudland Association. Thin laminae of fine greywacke or grit are often interleaved with the close-textured slate.

Throughout these formations there are thin strata of felspathic and quartzose grits, composed of small pebbles of quartz, orthoclase and acid plagioclase felspar set in a base of biotite plates, quartz granules and decomposed felspathic material. Their contribution to the soil parent material is relatively small and without significant effect.

## INTRUSIVE IGNEOUS ROCKS

Within the regions of the sedimentary and metamorphic rocks, a series of igneous intrusions, later than the regional metamorphism but earlier than the Middle Old Red Sandstone, is extensively developed. The exact age of these plutonic and hypabyssal rocks is uncertain but they are considered to be related to the Caledonian Orogeny. The intrusions are of two groups, gabbros and granites. Field evidence shows that the gabbros were intruded first.

*Gabbros*

The largest of the intruded masses of basic composition is more than 80 square miles in extent and underlies the Insch Valley. Part is within the area described by Glentworth (1954), the remainder, amounting to some 50 square miles, is within the boundaries of Sheet 76. There are many rock types in this intrusion, the most important being olivine-norite, hypersthene-gabbro and syenite. Both olivine-norite and hypersthene-gabbro are rich in plagioclase-felspar, hornblende, augite, hypersthene, magnetite and biotite. The texture is holocrystalline. The derived parent material gives rise to soils of the Insch Association.

Four smaller intrusions occur in the area, at Maud, Haddo (Read, 1935), Arnage (Read, 1923*b*), and Belhelvie (Stewart, 1947). In these, particularly the one at Arnage, "the original gabbro magma has reacted with sedimentary country-rocks of argillaceous composition to produce norites containing cordierite, garnet and other minerals not normal in pure igneous rocks. Such *contaminated igneous rocks* are crowded with innumerable small xenoliths of country-rock" (Read and MacGregor, 1948, p. 49).

On the tops of hills these basic rock types yield a soil parent material approximating that of the Insch Association. The main areas underlain by these rocks have a cover of mixed drift and the soils belong to the Tarves Association.

*Serpentine*

Serpentine occurs in a series of irregular patches in the north-west of Sheet 76, south of Clatt and west of Leslie. It is described by Wilson and Hinxman (1890, p. 25) as "a beautiful variety, being dark green in colour, veined and streaked with chrysolite and with the joint faces coated with noble serpentine and asbestos". The Hill of Towanreef (or, as it is sometimes called, the Hill of Tombhreac) is composed of "dark green serpentine, veined with steatite and containing crystals of enstatite".

Beauty Hill on Sheet 77 is composed of a compact rock described by Stewart (1947, p. 469) as dark green dunite serpentine. Its principal minerals are serpentine after olivine and a little bastite after pyroxene. The derived till, rich in magnesium, forms the parent material of the Leslie Association.

*Granites*

Several outcrops of granite occur within the area. The greatest mass, referred to as the Hill of Fare granite, stretches along the north side of the Dee from Ballater to Aberdeen. Other large outcrops occur near Peterhead and New Pitsligo. In addition, there are numerous small patches of granite throughout the area.

The Hill of Fare itself is composed of a red acid granite very like that of Bennachie. It is typically pink or flesh-coloured, with orthoclase felspar, quartz and biotite crystals. The texture is mostly uniform but in places, for instance the crags of Bennachie, the felspar is coarse and often porphyritic, the quartz forming large rounded blebs with occasional perfect crystals. The mica is in small flakes and far less conspicuous than the other component minerals (Wilson and Hinxman, 1890, p. 16). Small outcrops of granite at Tarland, Alford, Cairn William and Coldstone are very similar. The remainder of the Hill of Fare mass, which is referred to as the Skene complex, is quite different. It is a grey granite, and although its composition is by no means uniform throughout the area it has many consistent features. At Rubislaw Quarry, Aberdeen, it is a medium-grained, grey rock, composed of microcline, orthoclase, a little plagioclase, quartz, abundant biotite and a little muscovite. The granite at Sclattie, Dancing Cairns, Lower Persley and Dyce quarries, which are all in the neighbourhood of Aberdeen, is very similar and even at Kemnay, fourteen miles from Aberdeen, it is of the same type but paler in colour. A greyish pink rock, intermediate in colour between the Rubislaw and Bennachie granites, has been quarried at Tyrebagger and Clinterty. At Corrennie, two rocks are present in the same quarry, one a bright pink, quartz-rich type, of gneissose structure, and the other "grey quartz-diorite which occurs in narrow bands through the more acid rock" (Anderson, 1939, pp. 27–34).

On Sheet 87 there are two large areas of granite, one near Peterhead and the other near New Pitsligo. The first "is a coarse, flesh-coloured, silica-rich type consisting essentially of quartz and orthoclase". The second "is a fairly coarse granite, light grey, with large porphyritic crystals of orthoclase. The other essential minerals are quartz, plagioclase in a rather decomposed condition and abundant biotite. The rock frequently has a yellowish stain of iron oxide" (Anderson, 1939, pp. 34–36).

Granite and granitic gneiss rocks form the till parent material of the Countesswells Association.

*Syenite*

Syenite, which is chiefly composed of pink felspar and hornblende with no quartz, is contiguous with the Insch mass of basic igneous rock and forms the Hill of Johnston, Hill of Newleslie, Gallows Hill, the summit of Dunnideer, the summit of Hill of Flinder, and outcrops south-west of Kennethmont. It is a very decomposed, coarse crystalline rock which yields a soil parent material very similar to that derived from granite (Countesswells Association).

*Felsite*

Two small areas of felsitic rock, one intruded into the serpentine of Towanreef Hill, and the other north-west of Rhynie, give soil parent materials similar to that from granite. Various felsitic dykes scattered throughout the area have similar characteristics but they are too small appreciably to affect soil parent materials.

## OLD RED SANDSTONE SEDIMENTS

Only the Middle and Upper divisions of the Old Red Sandstone formation are represented north of the Grampians (Read and MacGregor, 1948, p. 58). Two outliers, one between Gamrie and Turriff and the other at Rhynie, occur within the present area, while small occurrences are found near Aberdeen. Geikie (1878) divided the outlier at Rhynie into zones which, arranged in descending order, consist of (1) flags and shales, (2) sandstones, (3) sandstones with volcanic zone, (4) red shales with calcareous bands, (5) breccia and conglomerate. The main contribution to the soil parent materials comes from the sandstones, which at Quarry Hill "consist of thick-bedded, white, grey and pale red sandstones, with occasional gritty or even pebbly bands". At Tillybrachty they are "soft, crumbling and incoherent, varying in colour from white and pale reddish-grey to deep purple and blood red" (Wilson and Hinxman, 1890, p. 28). All the beds appear at the surface in a number of places and contribute to a reddish brown sandy loam till, the parent material of the Cuminestown Association. The shales have some effect on the soil parent materials north and south of Rhynie, where they appear to give rise to more clayey textured soils with poor drainage within the Cuminestown Association.

The Gamrie–Turiff outlier, situated in the north-west of the area, is exposed in the coastal sections from New Aberdour westward and is seen to rest unconformably on the Dalradian schists. It is principally a conglomerate of subangular and rounded fragments of the schists, cemented by an arenaceous matrix in which veins of calcite are conspicuous. In places there are bands of a red sandstone. This rock yields the parent material of the Ordley Association. Quartzite pebbles are common in the soil parent material about Windyheads Hill, suggesting the presence of a conglomerate with a different stone content; this conglomerate and associated sandstone give rise to the stony loam till parent material of the Hatton Association.

PLEISTOCENE AND RECENT DEPOSITS

The glacial history of north-east Scotland undoubtedly presents a very complex pattern which has been carefully studied by several geologists. Jamieson (1882 and 1906) considered that glacial ice had travelled from four directions across parts of the area. Geikie (1874) stated that Scandinavian ice filled the North Sea and formed an ice barrier off the north-east coast (Fig. 13). Bremner (1916, 1934 and 1937) recognized three distinct glacial periods (Fig. 14). The first was characterized by ice moving across the area from north-west to south-east, the second by ice moving from approximately south to north; both these ice movements were deflected by the barrier of Scandinavian ice. His third ice period was less intensive than either the first or second and was characterized by ice moving down the valleys from west to east. Read and MacGregor (1948) support Bremner's theory. Soil

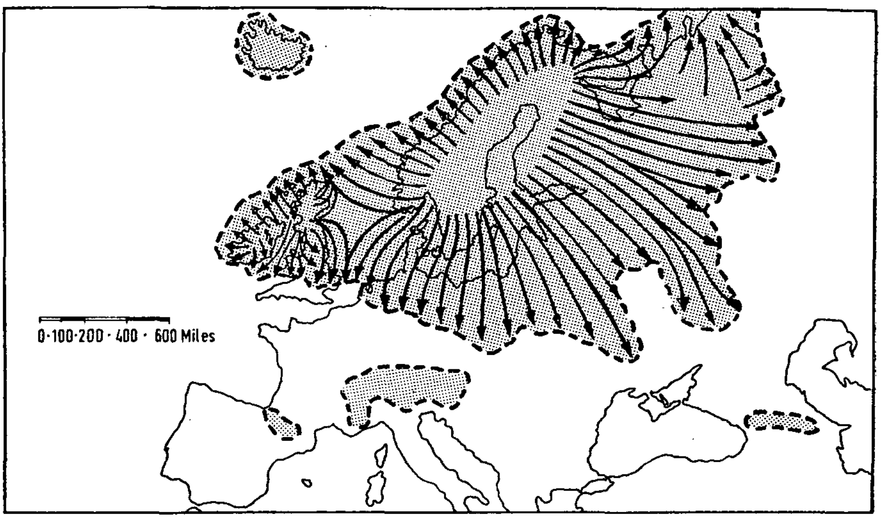



**FIGURE 13.** The Extent of Maximum Glaciation in Europe.

Survey observations also support Bremner's theory, and some evidence to confirm these different movements has been given by Glentworth (1954). Charlesworth (1956), while concurring with Bremner in the direction of ice movement contends that an area in Buchan north of the Ythan, and north of Bennachie, is "moraine free" and was largely unaffected by any of the ice movements as reported by Bremner. Synge (1956) agrees with Charlesworth's observation. Simpson (1955) casts doubt on the evidence of a third glaciation.

A consistent interpretation of events can be made only by assigning each feature and deposit to its appropriate stage. The difficulty of this problem is witnessed by the lack of agreement in the accounts published. Whatever the details of the history of the glaciation of the area, the material left behind on the melting of the ice-sheets includes thick deposits of till, containing a variety of erratics, fluvio-glacial sands and gravels and lacustrine deposits. The character of these deposits can, however, be readily ascertained, and as this is what matters most in soil development the remainder of this account is confined to a description of the deposits.

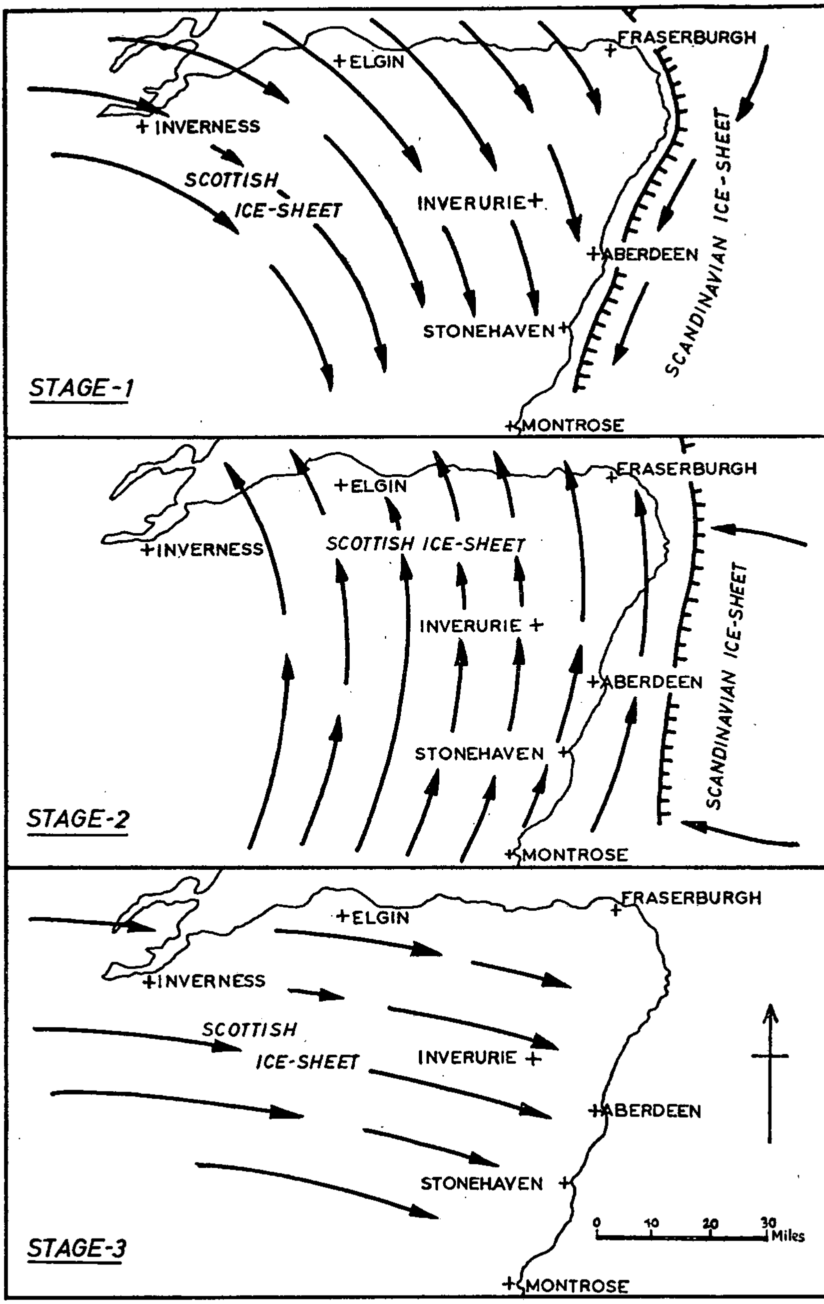



FIGURE 14. The Three Stages in the Glaciation of North-East Scotland, after A. Bremner.

Glacial drift is a term which includes tills and fluvio-glacial deposits. Till is ground-up rock material, characteristically unsorted, which has been deposited by ice. Fluvio-glacial sands and gravels are water-sorted deposits of sub-aerial and sub-glacial rivers formed during the final stages of melting and ice retreat. Observations in the field indicate that till usually reflects the solid formations over which the ice has passed. Till in the area surveyed shows a displacement of finer material, along the line of travel, of about one mile from the contributing solid formations. Erratics are frequently displaced for much greater distances than this. The thickness of the till is variable. In valleys it varies between 4 feet and 20 feet, but on the hills and local prominences it is seldom more than 4 feet. The deep till has a higher clay content and sometimes a greater variety of stones than the shallow till.

Fluvio-glacial deposits are generally sands or gravels, which in this area consist predominently of water-rounded fragments from granite or acid metamorphic rocks. A description follows of characteristic deposits, given under the name of the derived Soil Association (Fig. 15).

*Till of the Countesswells Association*

Fragments of quartz and felspar are conspicuous in the till of this association, derived from granite and granitic gneisses and, to a limited extent, from syenite and felsite. The colour of the till is influenced by the colour of the rock. The pink granites give rise to a pinkish till and the grey granites to a buff till. On convex slopes the till is a coarse sandy loam with many stones and boulders. On concave positions it is often a loam or sandy clay loam with fewer stones and boulders. In several areas, e.g. in the grounds of Dunecht House, at Pittodrie on the north side of Bennachie, at Auchenhuive south-east of Old Meldrum and in the New Pitsligo Basin, the solid granite is itself strongly decomposed, and in these and similar localities imparts a high content of coarse sand and fine gravel to the till.

*Till of the Foudland Association*

Argillaceous and weakly metamorphosed schists are the principal parent rocks of the Foudland Association. These give rise to a fawn-coloured till with a fine sandy loam texture and a high silt content, in which stones between three and six inches long are very common. On concave slopes the till is slightly finer than on convex slopes and contains fewer stones. In the New Pitsligo area, felspathic grit is an important parent rock and the till derived from it is more sandy and less silty than that from the other two schists. When the till is gleyed, the dominant colour is light grey. Ochreous mottles are not common.

*Till of the Insch Association*

The parent material of this association is a till derived from basic igneous or metamorphic rocks. On convex slopes the till is a sandy loam, while on flatter sites it is either a loam or a sandy clay loam. Large boulders, locally referred to as "blue heathens", are present in the till on uncultivated sites; most of them have been removed from arable land. The till under conditions of free drainage is yellowish brown with a notable content of vermiculite mica. Under poor drainage conditions, the till is a light olive brown, with large prominent ochreous mottles and smaller, less prominent, grey mottles. White specks of decomposed felspars are plentiful.

*Till of the Leslie Association*

The till of this association is thin, generally no more than 2 to 3 feet. In the neighbourhood of Leslie it is a brown loam containing angular fragments of green serpentine together with norite rock. Over the Hill of Towanreef, north of Rhynie, the till is also a brown loam with angular serpentine fragments, but at the base passes into greyish weathered serpentine. On the knolls it has a very high content of shattered rock. On the western side of Beauty Hill the till is thicker, and in addition to serpentine includes erratic rock fragments such as granite, schist, gneiss, quartzite and gabbro. The eastern side of the hill has a shallow stony till, dark brown in colour, which overlies black, shattered, angular serpentine. Many of the serpentine stones in the till are partially weathered and, while retaining their angular shape, have a bluish black skin, are light in weight and can be easily cut with a knife.

*Till of the Tarves Association*

The till of the Tarves Association contains both acidic and basic material, although the proportion of each in the till varies. The acid rocks are usually granites, acid gneisses or mica-schists while the basic rocks are gabbros, norites or hornblende-schists. On convex slopes the till, a sandy loam or loam, is often thin and reflects the character of the underlying rock. In the valleys, where it is thicker and of loam or sandy clay loam texture, the till contains a greater assortment of stones of diverse origin. Under free drainage the till is light yellowish brown with very few mottles, whereas under poor or very poor drainage the colour is grey or dark grey with contrasting ochreous and less prominent grey mottles.

*Till of the Strichen Association*

The Strichen Association till is derived mainly from quartz-mica-schists and coarser interbedded quartzose bands. Over most of the area, the till is a relatively shallow deposit of yellow stony sandy loam or loamy sand overlying shattered angular rock. In places the schist is highly weathered and in a soft decomposed state. In that part of the association lying between New Aberdour and Fraserburgh quartzo-felspathic grits have contributed to the till, producing a coarser texture. In this locality Old Red Sandstone conglomerate cobbles are generally present in the till. Between Rosehearty and Fraserburgh a belt of sandy clay loam till has, under poor drainage conditions, a pale yellow colour with ochreous and grey mottles. The colour of the freely drained till is similar to that of the Foudland till.

*Till of the Ordley Association*

The Ordley Association is one of several developed on till derived from Old Red Sandstone sediments. The parent rock in this case is a basal conglomerate of Middle Old Red Sandstone age, containing flat argillaceous schists and felspathic grits with rounded edges, derived from the Highland Schist rocks which underlie it. The till, retaining the characteristic red-brown colour of the solid formation, includes a high proportion of the small conglomerate stones. Where the stones are very numerous, the till resembles that of the Foudland Association in texture, but its colour remains distinctive. It is a stony, friable loam with a moderately high level of exchangeable calcium derived from calcite veins in the rock.

PLATE 11
The Tarland Basin looking towards Broom Hill.

PLATE 12
The Howe of Cushnie.

[*Facing page* 64]

PLATE 13

Pre-glacially weathered olivine-norite with dolerite dyke. Auchinbradie Quarry, Insch.

*Till of the Hatton Association*

The Hatton till is derived from a conglomerate with some sandstone, both of Middle Old Red Sandstone age. It differs from the Ordley till in that the stones in the conglomerate are mainly quartzite cobbles, not schist chips. The matrix is usually of finer texture than that of the Ordley till. In the valleys and gentle slopes where the till is thick, the texture is often a stony clay loam. On hills, where it is thinner, it is a stony loam. Under conditions of free drainage the till is red-brown in colour, whereas under conditions of poor drainage it is red-brown with extensive ochreous and grey mottles. The stoniness is sufficiently high to make cultivation difficult.

*Till of the Cuminestown Association*

The Cuminestown till is derived mainly from sandstone strata with occasional conglomerates of Old Red Sandstone age. On moderate to steep slopes with free drainage it is a reddish brown sandy loam or loamy sand which passes into rotten sandstone. On more level sites the till is thicker and has a clay loam texture. Under poor drainage the reddish brown colour is modified by ochre and grey mottles. A moderate content of stones is found in the till, schist, granite and rounded cobbles being the most common.

*Till of the North Mormond Association*

The till is derived mainly from a mixture of Old Red Sandstone and schist drift. It has a weak reddish brown colour and clay loam texture. An assortment of subangular stones, granite, schist and quartzite is contained in it, but most common are rounded quartzite cobbles. Below an altitude of approximately 150 feet the till has a water-worked surface, and this gives rise to sandy loam textured surface soils overlying the slightly mottled clay loam till.

*Till of the Peterhead Association*

The red-brown massive till of the Peterhead Association is derived from sedimentary rocks of Old Red Sandstone age. It is thought to have been carried northwards by the Strathmore Glacier, and deposited near the coast between the River Don and Rattray Head (Fig. 16). Its texture varies from sandy clay loam to heavy clay. In certain cliff sections south of Peterhead, the till reaches a thickness of 50 feet, while 20 feet is common between Stirling Hill and St. Fergus. Where the till thins out it often contains a high proportion of local rock. In general, the stone content is low to moderate; cobbles of lava, jasper, quartz, black porphyry, quartzite and granites are present in the till north of the Ythan, as well as locally derived fragments of gneiss, spotted schist, mica-schist, quartzite and granite.

Under poor drainage the till is conspicuously mottled with grey and ochre and has a massive structure. Embedded shell fragments have been found at a few sites, indicating probable transportation over the sea floor.

*Fluviatile Deposits of the Collieston Association*

Water-sorted bands of sand, mainly red in colour but with some yellow and grey, in which there are layers of red clay, occur in the form of large mounds within the Strathmore Drift (Fig. 16). The deposits are often more than 10 feet thick, and at Ardiffery, south of Hatton of Cruden, Jamieson (1906, p. 17) considers them to be from 100 to 150 feet in depth. Shell fragments are sometimes present in the sand. The deposits usually overlie gravel at some depth.

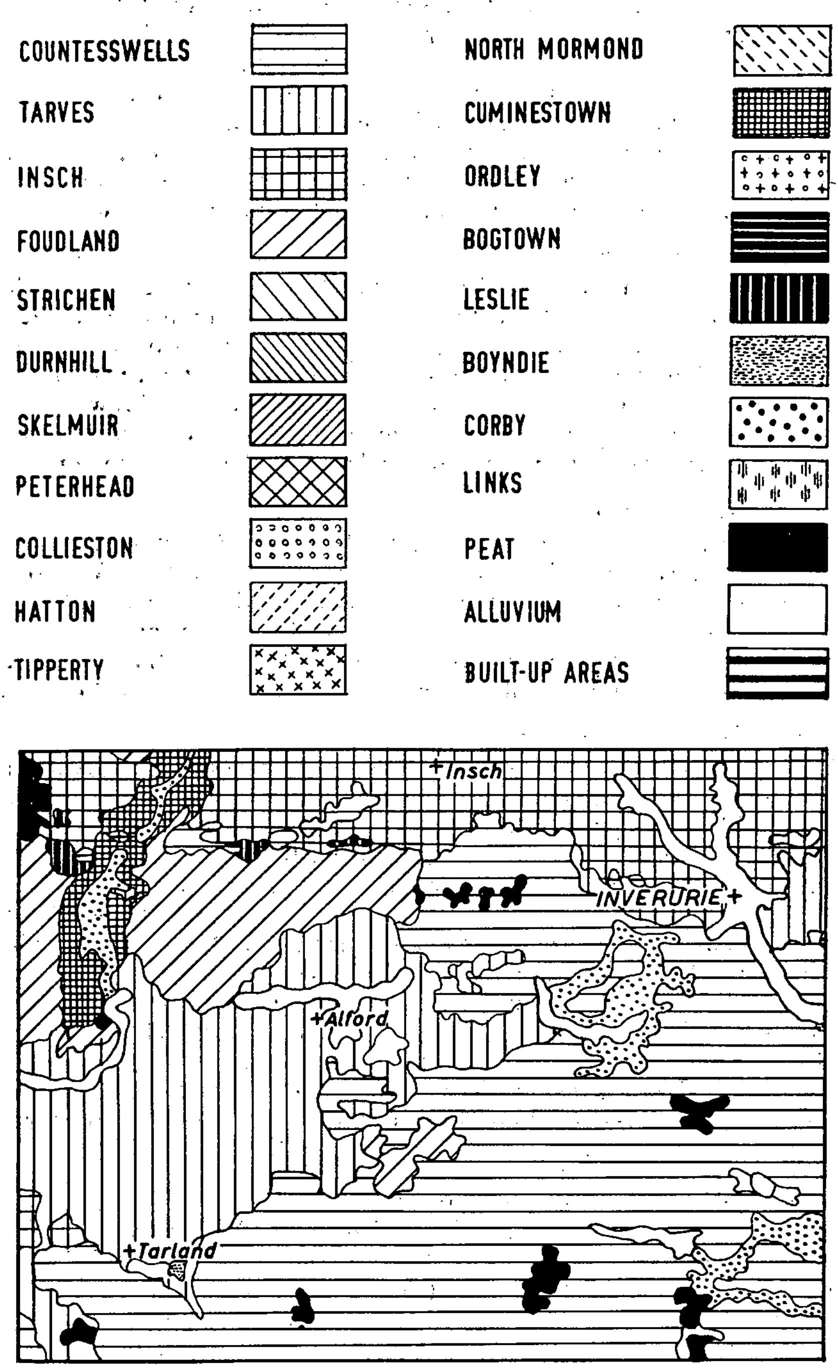



FIGURE 15A. Distribution of Soil Associations.

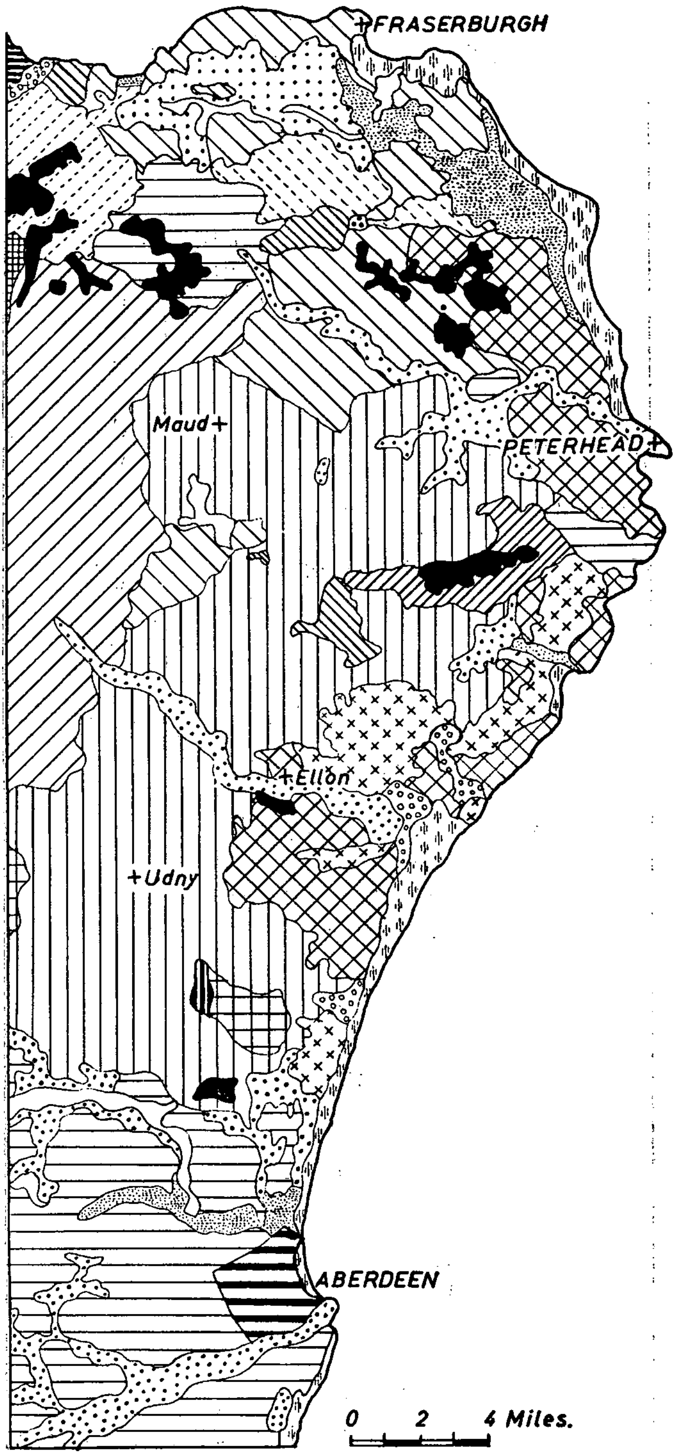



FIGURE 15B

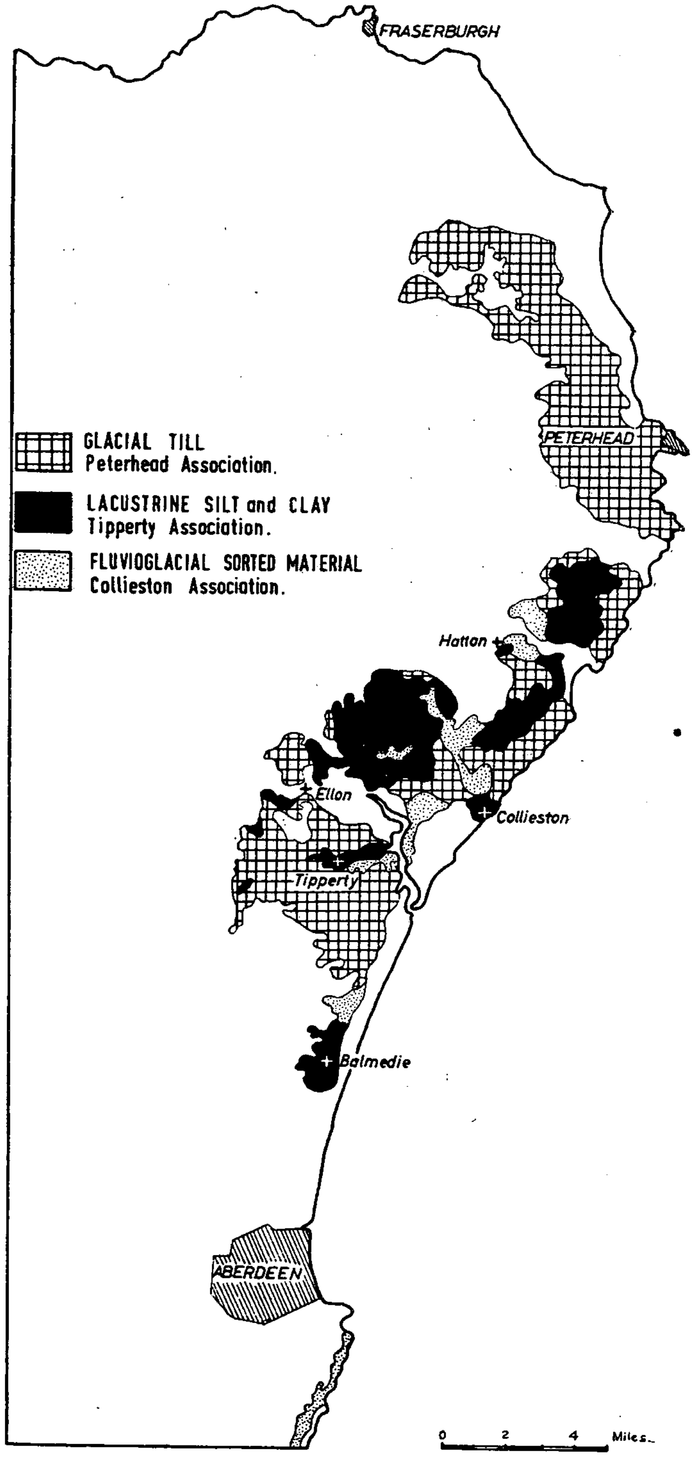



FIGURE 16. Distribution of the Red Strathmore Drift.

Included in the Collieston Association are areas below an altitude of 100 feet in which modified till overlies red clay till of a kind similar to that of the Peterhead Association. It is part of the raised beach and is extensive at Pettens, south of Balmedie.

*Lacustrine Sediments of the Tipperty Association*

Lacustrine silt and clay derived from Old Red Sandstone sediments occur in areas of flatter topography contiguous with the till of the Peterhead Association and the fluviatile materials of the Collieston Association (Fig. 16). In the clay pits of the Cruden Bay Brick and Tile Company at Cruden the red clay is about 40 feet thick and is poorly stratified. It contains some small pebbles throughout and a very occasional boulder. At Tipperty the clay is varved with layers one-eighth to one-quarter inches thick and is stone-free. Simpson (1955) considers the varved clay to have been laid down in salt water. Thin layers of sand do occasionally occur in the clay, but clay textures predominate over silt and sand. The clay is massive below 4 feet, but has a strong prismatic structure within soil depth. In depressions where drainage is poor there is a change of colour to pale grey to a depth of 4 feet—the level of the perched water-table; below this the colour is red. The clay is often calcareous below 4 feet.

The highest level at which the lacustrine clay has been found is at 300 feet in the Newton Hill sand pit.

*Fluviatile Deposits of the Auchinblae Association*

Water-sorted, red coarse sand and fine gravel with occasional bands of coarser gravel occur as sporadic mounds and ridges within the Strathmore Drift. Some exposures show only the upper few feet of the sand and gravel stained red, the underlying material having the brown colour characteristic of the Boyndie Association. The rock constituents are both igneous and metamorphic. Other exposures reveal red-stained material throughout. Rounded cobbles of reddish stained quartzite, porphyry and jasper, together with considerable amounts of limestone, occur in the gravels near Meikle Loch, indicating the inclusion of material from the Lower Old Red Sandstone conglomerate as well as from the sea bed. Some of the mounds are capped by a thin layer of red lacustrine clay. The Auchinblae soils are of coarser texture than the Collieston.

*Till of the Durnhill Association*

Quartzites of the Highland Schist formation which occur on Mormond Hill, Hill of Dudwick and Scotstown Moor are the parent rocks of the Durnhill Association. They give rise to a pale yellow, loamy, fine sandy till, which is very stony and generally shallow. The stones are angular and little worn by ice action.

*Till of the Skelmuir Association*

There is a lack of agreement among geologists as to the nature of the deposit which gives rise to the Skelmuir Association. Its appearance suggests that it is a till, but the presence of numerous flints and quartzite cobbles and the finding of spicules of Chalk fossils in the fine matrix support the contention that it is a residue from chalk weathered *in situ*. The flints and quartzites, however, are water-rounded, indicating transport by water after the chalk had weathered. As yet, no explanation deals adequately with these seemingly contradictory facts.

The deposit is a white clay loam with large contrasting ochreous mottles. Very large numbers of rounded quartzite and flint cobbles are embedded in it. The flints, considered to belong to the Cretaceous formation, are essentially spherical whereas the quartzites are flattened pebbles.

The deposit is about 4 feet thick. Towards its northern boundary, where the underlying rock is granite, coarse sandy granite material has been incorporated by later glacial action. In the south the deposit overlies quartz-schist, a substantial amount of which has become mixed with the original material.

*Fluvio-glacial Gravel of the Corby Association*

Morainic gravel mounds and fluvio-glacial terrace gravels give rise to soils of the Corby Association. The stones of the deposits are well rounded and derived mainly from Highland schists and granite. The deposits have been weakly sorted into layers varying from fine sand to coarse cobbles up to 9 inches in diameter. Normally the deposit is a yellow-brown, coarse sandy gravel, several feet thick.

*Fluvio-glacial Sand of the Boyndie Association*

The fluvio-glacial sand which gives rise to the Boyndie Association is often found in conjunction with the gravel of the Corby Association. It is similarly derived from granites and rocks of the Highland Schist formation. It is a yellow-brown sand or loamy sand with few stones.

*Marine Alluvium of the Blackwater Complex*

North of Peterhead, lying at an altitude of between 30 and 40 feet on the inland side of the links, there is a narrow belt of dark grey clay. In appearance it resembles the clays of the Carse of Stirling and the Carse of Gowrie. The deposit is stoneless, being overlain in parts by blown sand and by peat. Marginally, it has been observed to overlie sand and gravel. It is also known to occur beneath the sand dunes.

*Shelly Sand of the Fraserburgh Association*

In the north-east corner of Buchan, at a height of 25–30 feet, wind-blown shell fragments have accumulated in a narrow strip at Phingask where the deposit was of sufficient purity and thickness to be excavated for agricultural lime. South of Fraserburgh Bay an area of wet links is also shelly, and shell fragments mixed with mineral sand persist in the links between Inverallochy and St. Combs.

*Coastal Deposits of the Bogtown Association*

A deposit of lacustrine clay occurs in the north-west corner of Sheet 97 on the west side of Cullykhan Bay. It is a pale reddish brown silty clay, roughly stratified and variable in texture. Read (1923*a*, p. 203), applied to a similar deposit the term "coastal deposit". From a consideration of the black clay on which it lies and the red Strathmore Drift which has been seen to overlie it, he considered it to be an interglacial deposit laid down between the first and second glacial periods. The occurrence has been described by Glentworth (1954), who records from it a buried surface soil. A similar find was made in the present area.

*Alluvium of the Lochter Association*

In the vicinity of Inverurie there is a high terrace deposit, part of which has a fine-grained sandy texture. It is yellow-brown with few stones, and has a weak, medium, subangular blocky structure; it has been considered sufficiently distinctive for separation as the Lochter Association.

*Recent Alluvium*

Recent alluvium includes the deposits on the flood plains of streams and rivers. The texture is variable, but is usually loamy sand or sand. Layers of very recent deposition are commonly found.

*Sand of the Dunes and Links*

Dunes occur between Aberdeen and Collieston, and from Peterhead to Cairnbulg Point. Links are the relatively flat sandy areas on the landward side of dunes. Both are wind-blown deposits of sand, the dunes being unstable features shaped by wind, and the links flat expanses stabilised by a relatively close vegetation. Marram and lyme grasses are common plants on the dunes, many of which show signs of erosion or movement. The links have a sward of marram grass, fine grasses and herbs, which are sufficiently well established to prevent erosion. In places, the links are cultivated. In both dunes and links the sand is light brown and structureless. The links, however, are underlain at no great depth by boulder clay.

# CHAPTER V

# Methods and Definitions

THE primary aim of a soil survey is to identify and describe soils and to record their distribution on a map. In the field soils are identified on the basis of their morphology, that is by a comparative study of their appearance. The features considered are colour, texture, consistence, organic matter, roots, wetness, stoniness, lithology of the parent material, mottling and thickness of horizons. These characters are examined in profiles exposed in small pits dug at frequent intervals. Although each profile has an individual identity, some are so alike that they can be placed into the same category. The primary category for mapping is the soil series, which comprises soils with similar type and arrangement of horizons developed on similar parent material.

Identification of a soil series is made by reference to a number of established characters, and it is necessary to know the permissible range of characters for each series. Boundaries between series are not always sharp, and, although typical profiles show them to have widely differing morphological characters, two series occurring together in the field may merge over a considerable distance. An appreciation of the relationship between soil profile characters and topography and vegetation assists in delineating the boundary between series.

## CARTOGRAPHIC METHODS

The soil series is the primary mapping unit and it is also the primary unit of classification; its place in classification is discussed in Chapter VI. In order to relate soil series to their environment, and particularly to geology, they are grouped into a larger unit, the soil association. A soil association comprises series developed on parent materials derived from similar rocks but varying in profile morphology, mainly because of differences in hydrologic conditions. The usefulness of the association is in grouping together series which occur in a related pattern in a landscape; it is a flexible unit and can be modified to suit the needs of a particular area.

The Soil Survey of Scotland uses field maps with a scale of 1 : 25,000 (about 2½ inches to 1 mile) which are reduced to a scale of 1 : 63,360 (1 inch to 1 mile) for publication. On a scale of 1 inch to 1 mile the minimum size of area which can be delineated is about 5 acres. Therefore on the published maps any uniformly coloured area may contain within it an area less than 5 acres in extent of some other series. Any area where this happens repeatedly is mapped as a soil complex.

## DESCRIPTION OF SOIL PROFILES

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

A soil profile is described firstly by noting certain features of the site and then by giving the general characteristics of the profile. The constituent horizons are then described individually. It is usual to designate each horizon by a symbol, corresponding horizons in any profile of a series or major soil group being represented by the same symbol. It should be noted, however, that in different major soil groups the same symbol does not necessarily have the same significance.

## LABORATORY INVESTIGATIONS

A sample is taken from each soil horizon and subjected to a routine physico-chemical examination at the Macaulay Institute for Soil Research. The analyses carried out are shown in Appendix I.

Selected profiles are further analysed by mineralogical, differential thermal, spectrochemical and X-ray methods.

## DEFINITION OF STANDARD TERMS

When describing a soil profile standard terms are used for certain characteristics, either of site or of the profile itself. These terms are listed and defined below. First to be dealt with are the characteristics of site, namely, Relief and Slope, Aspect, Altitude and Vegetation, for the last three of which no definitions have been given as the terms used are self-explanatory. Drainage Class and Horizon Nomenclature concern the profile as a whole and the standard terms are defined under these headings. Finally there are the properties relating to the horizons, and standard terms are given for Colour, Texture, Structure, Consistence, Induration, Organic Matter Content, Stoniness, Mottling and Horizon Boundaries.

### RELIEF AND SLOPE CLASSES

A soil map shows relief by means of contours at 100 feet intervals. In addition it is usual to give a description of the area in terms of landform units. It is also useful to relate soil series to slope and this is facilitated by the single slope classes given below which are those used by the U.S. Soil Survey (U.S.D.A., 1951). The angle or degree of slope has to be considered in relation to the length of slope and to the frequency of undulation. Within a given horizontal distance high frequency relief has shorter slopes and more undulations than low frequency relief.

| Class A | | Single Slope Class | Relief Class |
|---|---|---|---|
| *Limits* | | | |
| Lower 0 per cent | (0°) | Name:—level | Depressional to flat |
| Upper 1–3 per cent | (½–1½°) | | Very gently undulating |

| Class B | | | |
|---|---|---|---|
| *Limits* | | | |
| Lower 1–3 per cent | (½–1½°) | Name:—gentle | Gently rolling slopes of low frequency |
| Upper 5–8 per cent | (3–4½°) | | Undulating slopes of higher frequency |

Class C

*Limits*

| | | | |
|---|---|---|---|
| Lower 5–8 per cent | (3–4½°) | Name:—moderate | Rolling slopes of low frequency |
| Upper 10–16 per cent | (6–9°) | | Strongly undulating slopes of high frequency |
| | | | Moundy slopes of very high frequency |

Class D

*Limits*

| | | | |
|---|---|---|---|
| Lower 10–16 per cent | (6–9°) | Name:—moderately steep | Strongly rolling to hilly |
| Upper 20–30 per cent | (12–17°) | | |

Class E

*Limits*

| | | | |
|---|---|---|---|
| Lower 20–30 per cent | (12–17°) | Name:—steep | Steep hilly or dissected |
| 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, S, 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 particular area.

The 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 preceding 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 either by a relatively high content of sesquioxides or clay or by a more or less blocky or prismatic structure. Quite often there are accessory characteristics such as a bright colour.

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

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

## HORIZON NOMENCLATURE OF THE MAJOR 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 gleying is slight or $A_2$g when gleying is strong. A concentration of roots may be present at the bottom of this layer and they may be partially decomposed. |
| $B_1$ | a thin iron pan about $\frac{1}{16}''$ 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 slight to moderate amount of gleying its symbol is modified by adding (g), for example $B_2$(g); when it is strong the symbol g is used, 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 in colour and rich in silica. |
| $B_2$ | brighter than A or C horizon. 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 | the relatively unweathered parent material. |

*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 greater clay content than A or C horizons. |
| $B_3(g)$ | less well-defined blocky or prismatic structure. Mottling within and sometimes on peds. |
| C(g) | structure usually massive, less mottled than B horizons. |

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

*Peaty Gley*

| | |
|---|---|
| L | undecomposed plant litter. |
| F | partially decomposed litter. |
| H | raw humus usually >2 ins. thick, black in colour. |
| $A_1g$ | mixed organic and mineral layer. A little ochreous mottling along roots, weak structure. |
| $A_2g$ | pale brown layer, humus stained, low in organic matter, weak structure. |
| $B_2g$ | pale-coloured with slight ochreous mottling and iron tubes surrounding root tracks, blocky structure. |
| $B_3g$ | grey to blue-grey with distinct iron tubes, no mottling, massive structure. |
| Cg | blue-grey, no iron tubes, massive. |

*Non-calcareous Gley*

| | |
|---|---|
| L | undecomposed plant litter. |
| F | partially decomposed litter. |
| H | trace of decomposed organic matter—often absent. |
| $A_1g$ | mixed mineral–organic layer. Some ochreous mottling associated with roots. Weak structure. |
| $A_2g$ | pale-coloured mineral layer, low in organic matter. Structure weak. May be some ochreous mottling. |
| $B_2g$ | well-defined blocky or prismatic structure. Peds coated with grey; ochreous and grey mottles within. |
| $B_3g$ | less well-defined blocky or prismatic structure. Peds coated with grey; ochreous and grey mottles within. |
| Cg | original colour of parent material more apparent. Structure more massive, although peds may still have grey coatings and ochreous and grey mottles within. |

*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. 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 mottles within. Calcareous. |
| Cg | original colour of parent material more apparent. Structure more massive, although peds may still have grey coatings and ochreous and grey mottles within. Calcareous. |

Surface-water gleys, which are of finer texture than ground-water gleys, become drier with depth and the lithochromic colour of the parent material appears beneath the Cg horizon. Ground-water gleys are waterlogged from the Cg horizon to bedrock.

## DRAINAGE CLASS

The word drainage has several meanings but in soil survey it refers usually 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 main characters to be observed in assessing the drainage class are given below. Precise descriptions of characters are possible only with individual series.

*Drainage: Excessive*

The soil horizons are much shallower than is normal and the B horizons are bright and uniform in colour. This type of profile is of only small extent and has not been shown on the soil maps.

*Drainage: Free*

The B horizons are bright and uniformly coloured; soils with B horizons showing only slight dullness and only a small number of mottles are included in this class.

*Drainage: Imperfect*

The B horizons are 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 freely and poorly drained soils, though it is generally rather closer in character to the freely drained.

The poorly drained and the very poorly drained soils require tile drainage before successful cultivation can be undertaken. Both may have an $A_2$g horizon, which is often a dull grey colour, but it is usually more evident in the very poorly drained soil. It seems that this horizon is one of maximum gleying.

## COLOUR

The colour of soil and the pattern of discrete colours within a soil horizon are important characteristics which help in distinguishing the drainage class more particularly. Colour is difficult to describe without reference to a standard colour chart and a system of colour assessment has been devised using colour charts. This system, the Munsell Soil Color Charts (Munsell Color Co. Inc., 1954), is now internationally used for the designation of soil colours.

Colour can be interpreted as the resultant of three components: Hue, Value and Chroma. Hue refers to the dominant spectral colour, e.g. whether red, yellow or blue. Value refers to the apparent lightness of the colour as compared with absolute white. Chroma refers to the purity of the Hue or the apparent departure from the Hue. In the Munsell system each colour or, in some cases, group of related colours is given a standard name in which Hue, Value and Chroma are designated. For instance, the standard name for 10YR6/3 is pale brown, the Hue being designated as 10YR, the Value as 6 and the Chroma as 3.

## 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 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 2000$\mu$ (or 2 mm.) and 200$\mu$ (or 0·2 mm.); the fine sand fraction of particles with effective diameters between 200$\mu$ and 20$\mu$; the silt fraction of particles with effective diameters between 20$\mu$ and 2$\mu$; and the clay fraction of particles with effective diameters less than 2$\mu$. 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. Department of Agriculture has a scheme which is also widely used. The main difference between the schemes, both of which are given below, is in the size limits of the silt fraction.

| U.S.D.A. Scheme | | International Scheme | |
|---|---|---|---|
| Name of Separate | Effective Diameter (range) $\mu$ | Fraction | Effective Diameter (range) $\mu$ |
| 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 now makes use of both schemes, and two sets of results are quoted in Appendix I for the recent profiles. Only values obtained by the U.S.D.A. scheme should be used with the triangular diagram (Fig. 17) to determine textural class.

*Textural Class Names*

In assigning textural class names to soil horizons the percentage of sand, silt and clay separates—the Soil Survey of Scotland combines all the sand separates into one with the general name sand—is plotted on a triangular diagram (Fig. 17) each section of which has a textural class name; the section of the diagram into which the soil fits is ascertained and the soil given the appropriate name. The various textural class sections on the diagram have

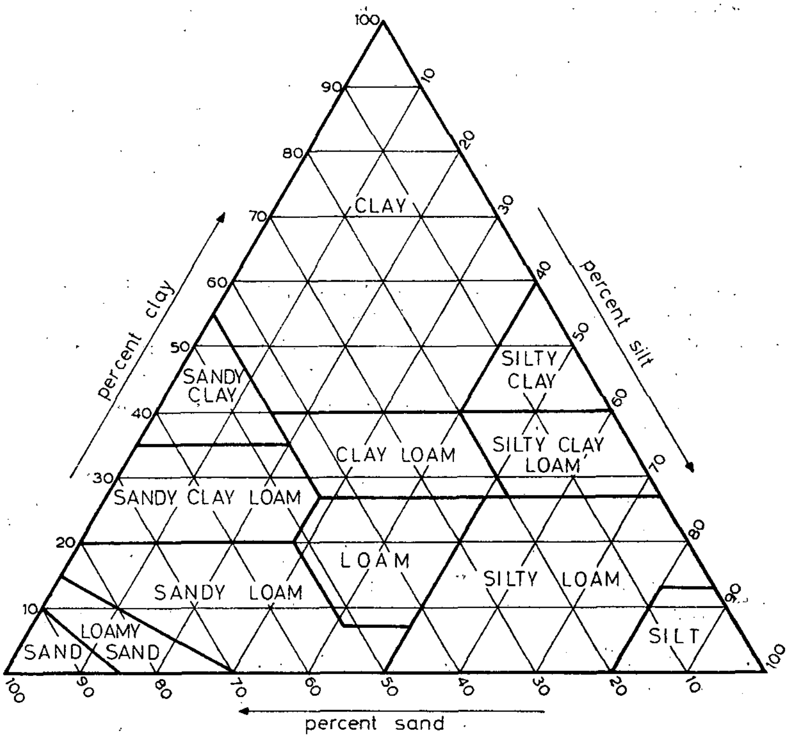



FIGURE 17. Percentages of Clay ($<2\mu$), Silt ($2$–$50\mu$) and Sand ($50$–$2000\mu$) in the Basic Soil Textural Classes.

been established after years of experience, especially in the United States, and the diagram should be used only in conjunction with the U.S.D.A. 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.

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<br>loamy sands |
| loamy soils — | moderately coarse-textured soils | sandy loams |
| | medium-textured soils | loams<br>silt loams<br>silts |
| | moderately fine-textured soils | clay loams<br>sandy clay loams<br>silty clay loams |
| clayey soils | — fine-textured soils | sandy clays<br>silty clays<br>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 space between aggregates, have easy permeability and are more productive than soils of comparable potential with massive or blocky structure.

Field descriptions of soil structure should record the (*i*) shape and arrangement, (*ii*) size and (*iii*) 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 soil structure terminology. The shape and arrangement is designated as type of soil structure; size as class; and degree of distinctness as grade. The terms used (U.S.D.A., 1951) are defined, and Table S shows the relationships of the various classes and types.

*Type.* There are four primary types of structure.

(I) Platy: with one dimension, the vertical, much less than the other two.

(II) Prismlike: with two dimensions (horizontal) much less than the vertical.

(III) Blocklike: with three dimensions of the same order of magnitude but having plane or curved surfaces that are casts of the moulds formed by 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 caps) and columnar (with rounded caps); angular blocky (with relatively sharp angles) and subangular 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.

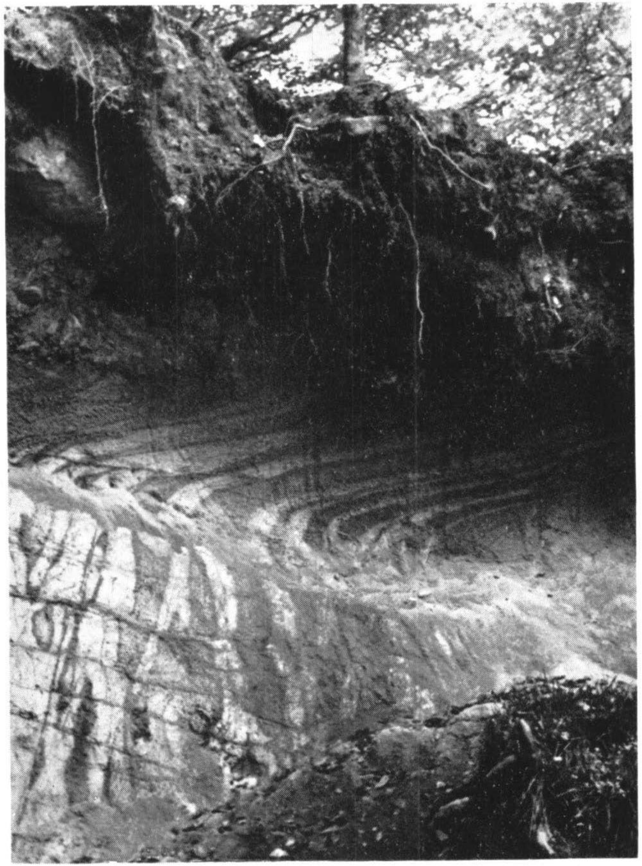


PLATE 14
Pre-glacial weathering and soil creep in rotten granite, Chapel of Garioch.

PLATE 15
Shallow till of the Foudland Association overlying shattered argillaceous schist.

PLATE 16
Clay pit, Tipperty ; excavating varved silty clay used in manufacture of agricultural tile drains.

PLATE 17
Flint and quartzite cobbles of the Skelmuir Association.

## TABLE S. 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 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. | |

Terms used for grade of structure are:

1. Weak —units barely observable *in situ*. When disturbed the soil material breaks into a mixture of a few unbroken units and many broken with much unaggregated material.
2. Moderate —well-formed units, but not distinct in undisturbed soil. When disturbed there are many unbroken units, some broken units and a little unaggregated material.
3. Strong —well-formed units, distinct in undisturbed soil; adhere only slightly to one another. When disturbed consist of entire units with few broken and very little unaggregated material.

When a 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 the 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 or adhesion. It is measured by the resistance of soil material to deformation or rupture. Structure and consistence are inter-related, the former being the resultant of forces within the natural soil and the latter being 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 only under strong pressure: sometimes not crushable between thumb and forefinger.

*Consistence when Dry*

To evaluate, break an air-dry mass in the hand.

0. Loose —non-coherent.
1. Soft —breaks to powder or individual grains under very slight pressure.
2. Hard —can be broken easily in the hands but only with difficulty 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, unlike consistence, appears not to be markedly affected by moisture content. Three terms are used to describe induration and they are defined below.

1. Weakly indurated —not usually detected when digging, but presence shown by stabbing a knife into 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. A horizon containing more than 20% organic matter is considered an organic horizon; containing less than 20% organic matter it is considered a mineral horizon. The varying amounts of organic matter in mineral horizons are usually indicated by the standard terms.

| | |
|---|---|
| high | —13%–20% |
| moderate | — 8%–13% |
| low | — <8% |

Organic horizons can often be subdivided into three 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 recognizable; and the H layer is the well-decomposed humus with very few recognizable constituents. When the H layer is more than 12 inches 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 indistinguishable by means of a lens. Silicate moder has an appearance similar to mull, but its constituent organic and mineral parts can be identified by the use of a good lens. The third type, raw humus or mor, is usually found where there are well developed L, F and H layers. 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 particular humus type is associated with each major soil group. The brown forest soils of low base status typically have silicate moder, but occasionally they 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 they can have a marked effect 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 emphasized that the perecentage of 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 its colour and pattern. Colour may be noted by Munsell Color Charts, but a general descriptive term "ochreous" is sometimes 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 mm. |
| medium | — 5–15 mm. |
| coarse | — >15 mm. |

3. Contrast

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

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

### HORIZON BOUNDARIES

Boundaries between horizons differ in distinctness and regularity. The terms used to describe distinctness are based 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 VI

# Soil Classification and Formation

THE system of classification used in this memoir is that adopted by the Soil Survey of England and Wales and the Soil Survey of Scotland which is at present under review. It is similar to that used in previous memoirs, Crompton and Osmond (1954), Avery (1955), Muir (1956), Mitchell and Jarvis (1956), Grant (1960) and Ragg (1960).

Soil series with very similar profiles are assigned to the same major soil group and sub-group (Fig. 18). Table T lists the series found in the area arranged in their appropriate division, major soil group and sub-group.

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

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

*Sub-group: Brown Forest Soils (low base status)*

Brown forest soils (low base status) have a moderately acid reaction and humus of the moder type. There is a gradual change from the A horizon to a uniformly coloured $B_2$, but a sharp change to a paler coloured indurated $B_3$ horizon.

*Sub-group: Brown Forest Soils with Gleyed B and C Horizons (imperfectly drained)*

Brown forest soils with gleyed B and C horizons are of moderate base status and moderately acid reaction. The B and C horizons show slight gleying. The soils are generally formed on parent material of moderately fine to fine texture. Those of fine texture sometimes have a near neutral reaction in the C horizon or may contain a small amount of free carbonate.

### MAJOR SOIL GROUP: PODZOLS

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

*Sub-group: Iron Podzols*

The iron podzol has a raw humus H horizon 1 to 3 inches thick. The $A_1$ horizon is thin, dark in colour and incorporates raw humus. The $A_2$ horizon

TABLE T. CLASSIFICATION OF SERIES

| Division | Major Soil Group | Sub-group | Series |
|---|---|---|---|
| Leached soils | Normal brown earths | Brown forest soils of low base status | Leslie, Insch, Tarves, Raemoir, Cairnrobin, Chapelden, Fraserburgh |
| | | Brown forest soils with gleyed B and C horizons | Thistlyhill, Blackhouse, Tipperty, Collieston, Middlehill, North Mormond, Auchiries, Baikies |
| | Podzols | Iron podzols | Tillypronie, Cuminestown, Hatton, Ordley, Denhead, Countesswells, Foudland, Strichen, Auchinblae, Boyndie, Corby, Bruntland, Lochter, Dess, Ferneybrae, Leys, Anniston, Glaschul, Mairlenden |
| | | Peaty podzols (with thin iron pan) | Windyheads, Charr, Suie, Gaerlie, Durnhill, Skelmuir, Pressendye, Tarbothill |
| Gleys | Surface-water gleys | Non-calcareous gleys | Marshmire, Peterhead, Birness |
| | Ground-water gleys | Non-calcareous gleys | Pitmedden, Culbyth, Blackrie, Boghead, Tophead, Terryvale, Fisherford, Anniegathel, Kilbady, Bogengarrie, Bogtown, Candy, Dallachy, Mulloch, Charleston, Myreton, Auchencleith |
| | | Calcareous gleys | Whitelinks |
| | | Peaty gleys | Pettymuck, Woodside, Garthfield, Blairmormond, Drumlasie, Shanquhar, Hythie, Balloch, Savock, Ballindarg, Mundurno, Mosstown, Pitburn, Dorbs |
| Organic soils | Blanket peat | Hill Peat | |
| | Basin peat | Low moor<br>Raised moss | |

has a low organic content and is pale coloured. The $B_2$ horizon is well developed and bright in colour; there may be strong humus/iron staining at the top. There is a sharp change into a paler, indurated $B_3$ horizon.

*Sub-group: Peaty Podzols (with thin iron pan)*

Peaty podzols have an H layer of raw humus up to 12 inches thick. The $A_2$ horizon may or may not be well defined; evidence of gleying and a narrow layer of humus accumulation is usually present in the lower part. The $B_1$ horizon is a thin iron pan, often continuous, which is impermeable to water and roots. The $B_2$ horizon is bright coloured, the $B_3$ horizon paler, and there is little or no evidence of gleying in either horizon.

## Division of Gleys

Gleys are mineral or peaty (H layer less than 12 inches) soils which have developed under conditions of intermittent or permanent waterlogging. A pale coloured $A_2g$ horizon is often prominent in the upper mineral horizons beneath which the horizons are grey with a greenish or bluish tinge and ochreous mottling is present. These are secondary colours which mask the colours inherited from the parent material.

### MAJOR SOIL GROUP: SURFACE-WATER GLEYS

Surface-water gleys are soils which exhibit strongly gleyed surface horizons; the intensity of gleying diminishes with depth. The soil colour inherited from parent material is more apparent in the $B_3g$ and Cg horizons than in the others.

*Sub-group: Non-calcareous Gleys*

These soils have no free calcium in the upper mineral horizons. The H layer is usually not more than 1 inch thick, and an $A_2g$ horizon, often well defined, is present in the semi-natural soils.

### MAJOR SOIL GROUP: GROUND-WATER GLEYS

Ground-water gleys are soils which have developed under the influence of a high ground-water table. In these soils the effect of gleying increases with depth and the colour inherited from the parent material is not apparent at depth.

*Sub-group: Non-calcareous Gleys*

These gleys have no free calcium in the upper mineral layers. The A horizon is seldom dark coloured and there is little development of a distinct organic-rich layer. Ochreous mottling on a grey base colour is pronounced in the Bg horizon. Grey colours become pronounced with depth as a result of waterlogging from the permanent ground-water-table.

*Sub-group: Peaty Gleys*

No free calcium occurs in the upper mineral horizons of these gleys. The H layer is well developed and over 2 inches thick. A humus stained $A_2g$ horizon forms the surface of the mineral soil and overlies an intensely gleyed grey mineral substratum which marks the level of the permanent water-table.

*Sub-group: Calcareous Gleys*

In the B and C horizons free calcium carbonate is present in higher amounts than in the upper horizon. Iron mottling in these horizons does not obscure the colour inherited from the parent material.

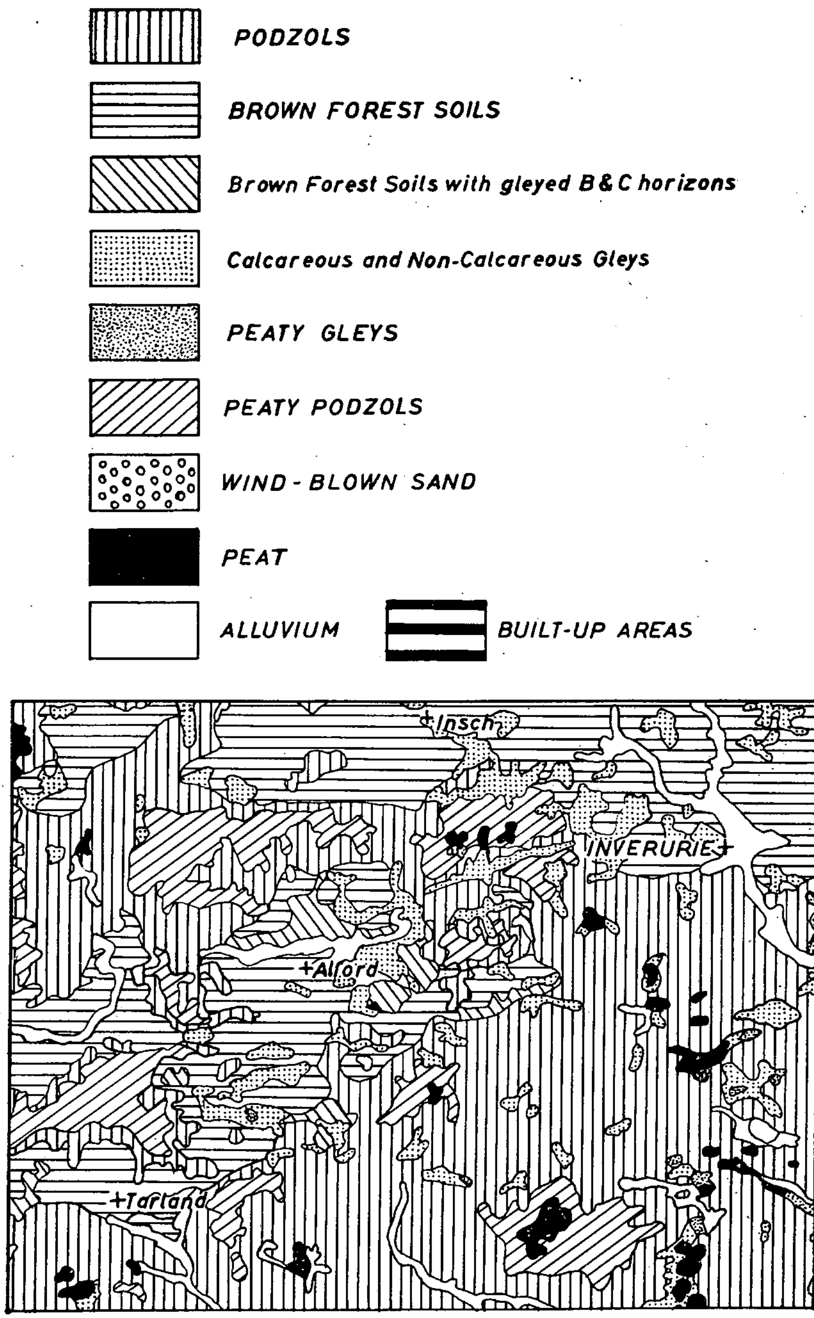



FIGURE 18A. Distribution of Major Soil Sub-Groups.

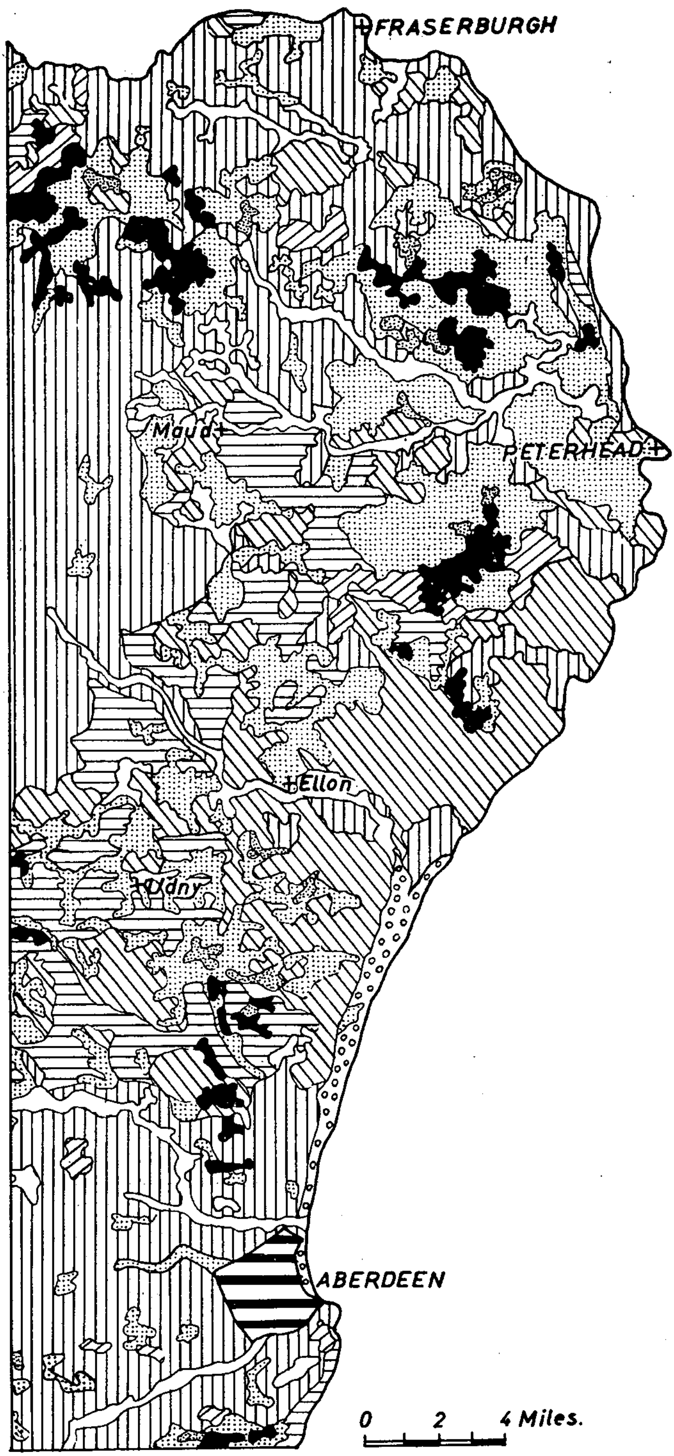



FIGURE 18B

### Division of Organic Soils

Organic soils are formed under waterlogged conditions. They have more than 12 inches organic matter overlying the mineral soil.

#### MAJOR SOIL GROUP: BLANKET PEAT

Blanket peat, sometimes called climatic or zonal peat, is an organic formation which develops on both convex and concave slopes, generally as a result of climatic conditions of high rainfall, low temperature and high humidity.

*Sub-group: Hill Peat*

Hill peat occurs at high elevations on high-lying plateaux and on gentle slopes at low elevations where parent materials are strongly acidic. The profile is of more uniform composition from top to bottom than that of basin peat.

#### MAJOR SOIL GROUP: BASIN PEAT

Basin peat develops initially under the influence of ground water in depressions or badly drained basins. The profile shows a vegetation sequence more complex than that of blanket peat.

*Sub-group: Low Moor*

Low moor is formed under marsh conditions where the level of the water is at or above the level of the formation. *Phragmites* sp. and sedges are the principal components of low moor, indicating that the water is relatively base-rich but acid in reaction (mesotrophic).

*Sub-group: Raised Moss*

Raised moss is a later development of the low moor stage occurring when the surface of the deposit rises above the influence of the standing water. These upper horizons consist of remains of *Sphagnum* spp., *Eriophorum* spp., *Trichophorum* spp. and *Calluna*, and are acidic (oligotrophic). The two stages of development—mesotrophic and oligotrophic—have not been shown on the soil map.

## SOIL FORMATION

Soil is a natural body containing mineral and organic matter which covers the earth's surface and supports life. The character of the soil in any one place is the result of the interaction of climate, parent material, relief, vegetation, time, and the influence of man. These factors operate gradually and continuously, and the variation in their influence is reflected in the morphological properties of the soil. Over a rolling landscape the soil cover forms a continuum. In soil classification and survey the continuum is separated into units—the soil series. Soil series are distinguished as conforming to various genetic soil groups. The main purpose of the genetic group is to relate differences in soil properties to the causal environmental factors.

### SOIL FORMING FACTORS

*Climate*

Two of the most important components of climate are precipitation and temperature, which affect the water supply and energy relationships in plant growth. The average monthly rainfall totals for this region are shown in Table E, and the calculated potential transpiration losses from an established turf surface are given in Table I. Comparison of these data shows that in the month of June potential transpiration exceeds precipitation and that there is approximately only one inch of surplus water over transpiration during the summer months of May to September. It must also be remembered that not all rainfall enters the soil, some is lost by run off. This small amount of surplus moisture in the growing season, combined with the relatively low moisture retention capacity of many of the soils, due to their moderately coarse texture, helps to explain the predominance in the north-east of soils with naturally free drainage.

With increasing altitude rainfall increases and temperature falls, a combination of circumstances which promotes the accumulation of organic matter, particularly on gently sloping or level sites at the higher altitudes. Thus, in the Grampian Foothills region, peaty podzol soils, viz., Charr, Suie and Pressendye series, are found on the summits of the hills. Hill peat, which might have been expected to occur, is relatively sparse in this region. On moderately steep south-facing slopes in the hill areas there is frequently only a thin accumulation of organic matter on the iron podzol soils, whereas peaty podzols extend far down the north-facing slopes. The temperature of a soil affects both the rate of chemical reaction and the degree of microbial activity, therefore the colder the soil, the slower is the breakdown of organic matter. The degree of base-richness of the parent material also affects the speed of breakdown of organic matter.

*Parent Material*

The main properties of parent material which affect soil formation are base-richness and texture. Fine textured, i.e. clayey, parent materials, are water retentive and less permeable than coarse textured material; they are therefore slower to drain, and more frequently show signs of gleying due to periodic waterlogging. Textural differences in soil parent material are related to the lithological composition of the parent rock or rocks and to glaciation. Granite, slate, schists and arenaceous sandstone rocks, together with fluvio-glacial sands and gravels, are some of the parent materials yielding moderately coarse to coarse textured soils. In the soil associations on these parent materials, gley soils with poor drainage occur in foot-slope positions and in concavities in the relief. In the Tipperty Association of silty clays and the Peterhead Association of clayey soils, gley soils are found on convex features of the relief. Generally the distribution of textures within an association is allied to relief, the shallow loamy textured material being found on hill tops and side slopes and the finer textured material on the gentle slopes of the valley bottoms.

One effect of base-rich parent material is to extend the range of brown forest soils into altitudes where they would not otherwise occur. This is illustrated by the presence of brown forest soils of the Insch Association at altitudes over 1000 feet in the Cabrach district. On acid parent materials at this altitude peaty podzols would occur, but the nutrient supply in basic igneous parent material enables microbial decomposition of organic matter to take place, thus preventing the peat forming tendency normally associated with the higher rainfall and lower temperature at altitudes of 1000 feet. Another effect attributable to the high iron content of basic igneous rocks is a structural one. A well-defined crumb structure is found in the A horizon of the brown forest soils and in the surface horizon of grass leys in arable land.

In the non-calcareous gleys of the Insch Association there is a striking preponderance of ochreous mottles, whereas in gleys on more acid parent materials grey mottles are dominant.

In the Buchan Platform and Upper Buchan Platform regions, which are at a comparatively low altitude, hill or blanket peat is more widespread and more extensively developed than in the Grampian Foothills region. This appears to be specifically due to the acidity of the parent materials on which it occurs.

*Relief*

The soil water regime and, to a considerable extent, the type of glacial parent material deposited is governed by relief. The steeper the slope the greater is the run-off and the smaller is the amount of water entering a soil. On flat sites, where water tends to lie, waterlogging and gleying are at a maximum. Under differing hydrologic conditions, differences in the extractability of certain constituents have been found. Consistently differing amounts of extractable calcium, magnesium, phosphate, iron and aluminium and of certain trace elements such as cobalt, nickel, vanadium, copper and manganese are found in the poorly drained gley soils as compared with freely drained iron podzols and brown forest soils in juxtaposition on the same hill slope on similar lithological parent material.

Deposits of till on the foot-slopes and valley bottoms are usually finer textured and thicker than on the sides and hill tops. This appears to be due to the original deposition of the glacial deposits, augmented by subsequent solifluction effects and the accumulation of the material further down-slope. With the exception of the Tipperty, Peterhead and Bogtown Associations, the present-day soils have developed on the products of the last glaciation when the direction of ice movement was largely determined by the existing valleys.

The effect of the interaction of relief, water movement and glacial deposits is to produce a hydrologic sequence of soils (Glentworth and Dion, 1949) with the freely drained soils occupying the convex slopes; passing down-slope the soils become imperfectly and then poorly drained, with very poorly drained soils in the depressions. In the north-east the complete sequence is frequently found but a partial sequence of three members is more common.

*Vegetation*

In the semi-natural state the relationship between vegetation and major soil group is quite marked and is described in Chapter VII. The relationship is complicated by relief and by accompanying alterations in climate, parent material and hydrologic conditions. The soil population of micro- and macro-organisms associated with the vegetation plays an important part in the decomposition of organic matter and in the formation of soil aggregates. Brown forest soils may carry deciduous trees, mainly birch, or an acid grassland type of vegetation in which *Agrostis tenuis*, *Festuca ovina* and *Anthoxanthum odoratum* predominate. Of the soil organisms associated with these plant communities, the earthworm is considered to be most important in aiding the decomposition of the litter to form humus of a mull type. In

PLATE 18
Fluvio-glacial sand, parent material of the Boyndie Association.

(*By courtesy of Geography Department University of Aberdeen*)

PLATE 19
The Mither Tap on Bennachie, a granite tor with encircling stone breastwork.

[*Facing page* 92]

PLATE 20
Manganese pan, Toll of Birness, 8 feet from surface in gravel pit.

PLATE 21
A glacial melt-water channel near Upper Towie.

this kind of humus the organic matter is intimately mixed with the mineral fabric.

Most of the semi-natural vegetation in this area is of a heath and moorland type; on some of these sites conifers have been planted. The soils are mainly peaty podzols or iron podzols and have a mat of raw humus at the surface carrying either an ericaceous or coniferous vegetation. Earthworms are not normally present in these soils and the decomposition of organic matter is the role of fungi and mites.

In the vegetation on the non-calcareous gleys a distinction can be made between vegetation on moderately acid and on acid soil types. The moderately acid gley is found in association with the more base-rich parent materials, e.g. Insch, Tarves, Peterhead and Tipperty Associations, and carries a vegetation dominated by *Deschampsia caespitosa*. This soil contains earthworms and has a mull type of humus. The uncultivated acid gleys found in association with the more acid parent materials, e.g. Countesswells, Corby, Durnhill and Skelmuir Associations, carry a vegetation dominated by *Polytrichum commune* and have 2 or 3 inches of mor humus; there are no earthworms. Earthworms do, however, come into these soils when cultivated.

*Influence of Man*

The result of man's activities has been to destroy the natural vegetation and to alter the soils by cultivation and drainage. Primarily, cultivation has changed heath and moorland soils—mainly iron podzols—into grassland soils, by mixing the various upper horizons and by enriching the soils with fertilizers and lime, so that now only the lower part of the podzolic profile—notably the indurated $B_3$ horizon—remains. In many places areas formerly occupied by basin peat and peaty gleys have been drained and the soils transformed into non-calcareous gleys.

Afforestation is mainly applied to iron podzol soils dominated by *Calluna*. It is frequently observed that under Callunetum a kind of mor humus develops which, on the flatter sites, induces the formation of an iron pan; ultimately the iron podzol changes into a peaty podzol. Planting halts this process of soil deterioration. By ploughing a peaty podzol soil at a spacing of 5 feet and subsequently planting with conifers, the iron pan is disrupted sufficiently to free the drainage; in time, the iron pan decomposes and the soil regrades into an iron podzol. Draining and planting peaty gley soils to Sitka spruce has, over the course of 40 to 50 years, raised the drainage class of such soils to the imperfect category, and resulted in a change in the colour of the subsoil from blue-grey to yellow-brown; the iron tubes surrounding roots which are characteristic of a peaty gley still remain as evidence of former wetness.

*Time*

Differences in the age of the soils, or the length of time the soil-forming processes have been operative, are not discernably of importance in this area. With the exception of the soils developed on Strathmore Drift, e.g. Peterhead and Tipperty Associations, the greater part of this region was freed from glaciation at the close of the Third Ice Age. The parent materials of the Tipperty and Peterhead Associations are known to be of Second Ice Age origin and the soils are therefore older. There is some reason to believe that the parent material of the Skelmuir Association is also of an earlier age. Alluvial soils, where deposition and erosion are still operative, are unstable and immature.

From a consideration of the soil-forming factors operative in soils from comparable and contrasting sites, general conclusions can be drawn concerning soil genesis. It is never easy, however, to assess the effect of a particular soil-forming factor; the influence of any one factor can differ widely from one soil to another depending on the extent to which it is affected by the action of other factors. In a given soil, differences in more than one genetic factor can usually be recognized and the influence of each factor is either diminished or increased by interaction with the others.

# CHAPTER VII

# The Soils

SEVENTY-EIGHT soil series have been distinguished in the area; 31 of these are also found on the adjacent Sheets 86 and 96 which have been described in a previous memoir (Glentworth, 1954). Series mapped since the publication of Sheets 86 and 96 and not shown on the earlier maps are (1) peaty podzol soils of the uncultivated moorlands, (2) iron podzols of the Foudland, Tarves and Insch Associations and (3) soils with imperfect drainage—included in the earlier maps in the freely drained series.

The area covered by the series is shown in square miles in Table U. Certain other categories viz., skeletal soils, peat, alluvium, mixed bottom land, links, dunes, and one soil complex, are also given. The various soil categories which make up a soil association are shown by the headings arranged horizontally; the associations are listed vertically. The table is self explanatory. Series are given place names; other soil categories are designated by symbols only. Each association bears the name of one of its series, usually that of the most characteristic series in the area in which the association was first described. Each vertical column relates the series within it to drainage class and major soil group. Skeletal soils are in a separate column. Not shown in Table U, but shown on the map, is a deep phase of the Insch series covering 8·5 square miles which is included in the value shown for the Insch freely drained series. These deep soils have a topsoil of 12 to 30 inches compared with the more usual depth of 7 to 11 inches.

The approximate percentage area of the major soil groups and sub-groups can readily be calculated, since the region is only slightly over 1000 square miles in extent. It will be seen that freely drained iron podzols predominate, occupying 36% of the area, with freely drained brown forest soils 18%. Therefore, 54% of the land is naturally well drained and requires no tile drainage. Imperfectly drained brown forest soils cover 8% and imperfectly drained iron podzols 3·7%. These soils require only occasional tile drains. Poorly drained gley soils take up some 14% and very poorly drained peaty gleys only 1%. These two groups require to be artificially drained if arable farming or silvicultural operations are to be successfully carried out. Basin peat is not extensive occupying some 3% of the area, while hill peat is comparatively insignificant with 0·6%. The organo-mineral peaty podzol soils account for 5·4% of the area and alluvium 5·5%. The remainder is taken up with mixed bottom land (1·3%), the Blackwater Complex (0·1%) links and dunes (0·7%), and towns, quarries, etc. (1·7%).

From these figures, in which the proportion of freely drained plus imperfectly drained soils is calculated to be 66% and of poorly drained and very poorly drained soils (excluding peat) 16%, it can be inferred that the north-east of Scotland is not a particularly wet area. The annual average

TABLE U. AREA OF SOIL CATEGORIES.

| | Brown Forest Soils | | Iron Podzols | | Peaty Podzols | Calcareous* and Non-Calc. Gleys | Peaty Gleys | | |
|---|---|---|---|---|---|---|---|---|---|
| | SERIES | | | | | | | | |
| ASSOCIATION | Freely Drained | Imperfectly Drained | Freely Drained | Imperfectly Drained | Freely Drained below Iron Pan | Poorly Drained | Very Poorly Drained | Skeletal Soils | Totals in Sq.Miles |
| AUCHINBLAE | | | Auchinblae 0.5 | | | Candy 0.1 | | | 0.6 |
| BOGTOWN | | | | | | Bogtown 0.2 | | | 0.2 |
| BOYNDIE | | | Boyndie 25.5 | Anniston 1.5 | | Dallachy 4.6 | Ballindarg 1.0 | | 32.6 |
| COLLIESTON | Cairnrobin 1.0 | Collieston 5.5 | | | | Marshmire 0.5 | | | 7.0 |
| CORBY | | | Corby 41.9 | Leys 0.8 | Tarbothill 0.4 | Mulloch 2.2 | Mundurno 0.4 | | 45.7 |
| COUNTESSWELLS | Raemoir 0.4 | | Countesswells 158.7 | Dess 30.9 | Charr 21.6 | Terryvale 25.9 | Drumlasie 1.7 | 1.4 | 240.6 |
| CUMINESTOWN | | | Cuminestown 7.7 | | | Culbyth 0.9 | Woodside 0.1 | | 8.7 |
| DURNHILL | | | | Ferneybrae 3.3 | Durnhill 1.7 | Kilbady 0.4 | Balloch 0.2 | 0.4 | 6.0 |
| FOUDLAND | | | Foudland 83.2 | Mairlenden 0.7 | Suie 14.6 | Fisherford 5.6 | Shanquhar 0.1 | 0.2 | 104.4 |
| FRASERBURGH | Fraserburgh 0.8 | | | | | Whitelinks* 0.2 | | | 1.0 |
| HATTON | Chapelden 0.8 | Middlehill 2.2 | Hatton 2.2 | | Windyheads 1.5 | Blackrie 2.8 | Garthfield 0.5 | | 10.0 |
| INSCH | Insch 48.5 | | Bruntland 1.7 | | | Myreton 6.7 | Mosstown 0.5 | | 57.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **LESLIE** | Leslie 3.1 | | | | | Charleston 0.4 | | | 3.5 |
| **LOCHTER** | | | Lochter 2.7 | | | Auchencleith 0.2 | | | 2.9 |
| **NORTH MORMOND** | | North Mormond 6.8 | | | | Tophead 1.7 | Blairmormond 0.1 | | 18.5 |
| | | Auchiries 9.5 | Denhead 0.4 | | | | | | |
| **ORDLEY** | | | Ordley 1.6 | Glaschul 0.1 | | Boghead 0.2 | | | 1.9 |
| **PETERHEAD** | | Blackhouse 21.9 | | | | Peterhead 21.7 | Pitburn 1.6 | | 45.2 |
| **SKELMUIR** | | | | | Skelmuir 4.1 | Bogengarrie 3.0 | Savock 0.7 | | 7.8 |
| **STRICHEN** | | Baikies 3.5 | Strichen 27.9 | | Gaerlie 0.4 | Anniegathel 11.1 | Hythie 1.3 | 0.2 | 44.4 |
| **TARVES** | Tarves 127.3 | Thistlyhill 21.4 | Tillypronie 8.7 | | Pressendye 10.0 | Pitmedden 50.9 | Pettymuck 2.5 | | 220.8 |
| **TIPPERTY** | | Tipperty 14.7 | | | | Birness 1.9 | Dorbs 0.2 | | 16.8 |
| **TOTALS in Sq. Miles** | 181.9 | 85.5 | 362.7 | 37.3 | 54.3 | 141.2 | 10.9 | 2.2 | **876.0** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **BASIN PEAT** | 29.2 | **HILL PEAT** | 6.3 | **BLACKWATER Complex** | 0.9 | 36.4 |
| **LINKS (Freely Drained)** | 6.9 | **LINKS (Poorly Drained)** | 0.8 | **DUNE SAND** | 6.5 | 14.2 |
| **ALLUVIUM** | 54.6 | **MIXED BOTTOM LAND** | 13.2 | **TOWNS, QUARRIES, etc.** | 16.6 | 84.4 |

| | |
|---|---|
| TOTAL AREA IN SQUARE MILES | 1011.0 |

rainfall varies between 28 and 35 inches, and the soils are mainly of medium to coarse texture. The non-calcareous gleys with poor drainage tend to be of finer texture than the brown forest soils and iron podzols with free and imperfect drainage. The Tipperty and Peterhead Associations have heavy, clayey textured soils.

The Countesswells Association is the most extensive, with 24% coverage, followed by Tarves with 22%, Foudland with 10·4%, Insch with 5·7% and Peterhead with 4·5%. Fluvio-glacial sand and gravel (Boyndie and Corby Associations) cover a surprisingly large area, 8%, or about 80 square miles.

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

## THE AUCHINBLAE ASSOCIATION

This association was first recognized in the vicinity of Auchinblae in Kincardineshire where there are extensive deposits of red sand or fine gravel. Developed on a part of the red Strathmore Drift, the association is confined, within the area described in this memoir, to the coastal plain between the 100 and 200 foot contours. It occurs mainly in the form of sporadic mounds and is represented only by the Auchinblae and Candy series. The association is of little significance in this region, its total area being slightly less than one square mile.

### DISTRIBUTION

The association is sparsely distributed over the coastal plain in the areas of Sheet 77 (Aberdeen) and 87 (Peterhead). The most northerly occurrence is inland from the Bullers of Buchan and the most southerly is at Menie House, 5 miles north of Aberdeen. Many of the areas are too small to be delineated on the 1 inch to 1 mile scale.

### PARENT MATERIAL

The parent material is red, water-sorted sand and fine gravel, with here and there a few bands of coarser gravel. Many of the stones are either igneous or metamorphic, but for the most part the fine material has been derived from Lower Old Red Sandstone sediments. Deep exposures frequently reveal the red colouring only in the upper few feet of the sand and fine gravels, the lower part having the brown colour characteristic of the Boyndie Association. Some of the mounds are capped by a few inches of lacustrine silt and clay which have also come from the red drifts. In the area to the north and east of Lochlundie Moss the gravel bands contain a proportion of pebbles from Lower Old Red Sandstone conglomerate—rounded reddish quartzite, porphyry and jasper quartz—and in the gravels near Meikle Loch fragments of chalk, possibly Cretaceous, are found.

*Series*

#### AUCHINBLAE SERIES

The main representative of the association in Aberdeenshire, the Auchinblae series, is freely drained and is a member of the major soil sub-group of iron podzols. It is almost entirely cultivated.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grassland |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–14″ | Dark brown (7·5YR4/2) sandy loam; weak, small sub-angular blocky; friable; organic matter moderate; fine roots abundant; few stones. Sharp change into |
| $B_3$ | 14–18″ | Red (2·5YR5/6) sand; moderately indurated; low organic matter; no stones; worm channels containing surface soil and roots; induration weakening with depth. Gradual change into |
| C | 18–36″ | Red (2·5YR5/6) sand; loose; single grain; no stones; low organic matter; a few roots persisting to 36 inches. |

This series is characterised by its free drainage, weak to moderate induration and the redness of the free-running sand in the C horizon. Roots are often checked by the induration and only penetrate to greater depths by means of cracks and worm channels. The depth of the surface soil is often shallow on the top of knolls.

### CANDY SERIES

The Candy series, a non-calcareous gley, covers only 0·1 square miles in this area. It is generally sited in hollows between mounds of sand. The S horizon is a very dark grey-brown (10YR3/2) loamy sand or sandy loam overlying a Bg horizon of pale brown (10YR6/3) coarse sand with yellowish brown (10YR5/6) mottles especially near roots. Often a silty or clayey layer near the base of the profile is the cause of the poor drainage.

### Note on Agriculture

With one exception, at Hatton of Cruden, the Auchinblae series is never sufficiently extensive to cover the whole area of a farm. Like most porous, free-draining soils this series requires generous applications of farmyard manure to increase its water- and nutrient-holding capacity. It is probably best left in grass as long as possible, although in a dry spell even the grass dries up and withers.

## THE BOGTOWN ASSOCIATION

The Bogtown Association covers only half a square mile on Sheet 87/97 (Peterhead/Fraserburgh), the area extending into the adjacent Sheet 96 (Banff). It is situated on the west side of Pennan Bay in the vicinity of Troup House, and is represented by only one series.

### Parent Material

The parent material is a lacustrine deposit, the strata of which vary in texture from clay to silt, with silty clay the most common. The material is referred to by Read (1923*a*) as a member of the Coastal Deposits, and is thought to have been laid down in the interglacial period between the First and Second Ice Ages. Buried surface horizon material, previously reported at Sandend Bay, has also been found in the Troup area.

### BOGTOWN SERIES

Developed on fine textured parent materials and with little variation in relief, the Bogtown Association is represented only by the poorly drained Bogtown series. In the original area near Sandend, Banffshire, one horizon has as much as 79% silt and another 64% clay, but in the Troup area the highest silt value is 26% and the highest clay value is 54%. The buried surface soil generally occurs at 2 feet, whereas in the other area it was found at a depth of 4 to 6 feet.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark grey-brown (10YR4/2) clay; weak, small sub-angular blocky breaking to crumb; friable; moderate organic matter; roots abundant; small faint rusty mottles especially along the root channels; occasional stone. Clear change into |
| Bg | 10–17″ | Dark grey-brown (10YR4/2) silty clay; weak medium prismatic; massive when wet; plastic; moderate organic matter; frequent roots; medium prominent ochreous mottles; dominant grey gleying. Clear change into |
| S/Bg | 17–30″ | Dark grey (2·5Y4/0) and dark grey-brown (2·5Y4/2) organic silt loam; massive; medium to high organic matter; some patches approaching peat; contemporary roots occasional, fossil remnants abundant; no stones; no mottles. Clear change into |
| Cg | 30″+ | Dark blue-grey silty clay loam; massive; plastic; low organic matter; occasional fossil roots ½ inch diameter; no mottling; no stones; wet; permanent water-table at 39 inches. |

The surface horizon, with 47% clay, is more clayey than that of the soils on Sheet 96 (Banff). The larger sub-angular peds break easily to crumbs in the drier upper 6 inches. Below this depth the wetness of the profile obscures the structure. Ochreous mottling is present in the cultivated surface horizon and in the Bg horizon, but grey colours tend to obscure the iron mottles towards the base. Below 18 inches no mottling occurs and the structure is massive with a plastic consistency. The fossil organic remains occur between 20 and 30 inches and are almost certainly a buried peaty surface horizon; a pH value of 6 in the surface horizon drops to 3 in the buried horizon.

## THE BOYNDIE ASSOCIATION

With a total area of 32·6 square miles, the Boyndie Association is one of the less extensive to be described in this memoir. Although four series, the Boyndie, Anniston, Dallachy and Ballindarg, have been mapped, the Boyndie series is by far the most important member of the association, most of which is cultivated. The parent material is a fluvio-glacial sand with sometimes a little gravel.

### DISTRIBUTION

Between Fraserburgh and Rattray Head, at an altitude of less than 150 feet, there is a belt of the association forming part of a gently sloping coastal plain. Another stretch, of about 7 square miles, occurs in the vicinity of

Longside at the confluence of the North and South Ugie Waters, and sizeable patches are found on terraces of the River Don from Hatton of Fintray to its mouth, and of the River Dee in the neighbourhood of Peterculter. There are many small bodies of the association scattered throughout the area, often lying near rivers and streams in the form of terraces. The relief is flat except where erosion has caused gullying, probably in immediate post-glacial times.

### Parent Material

Fluvio-glacial sand, generally over 4 feet thick and with little admixture of gravel, is the parent material of the Boyndie Association. The sand is derived mainly from acid igneous and metamorphic rocks and is highly siliceous. Most of the deposits are either glacial-outwash, raised beaches or river terraces, and on their margins the material thins out and merges with other formations. Some exposures have revealed gravel at depth and others till. The impedance of drainage in the Dallachy (poorly drained) and Ballindarg (very poorly drained) series is caused by the presence of relatively impermeable till just below the solum. In the vicinity of Fraserburgh, where the association occurs near the shelly sands which give rise to the Fraserburgh Association, the parent material is slightly calcareous.

### Soils

The soils of the Boyndie Association belong to four series, the Boyndie, Anniston, Dallachy and Ballindarg, the first of which is freely drained and accounts for some 80%, or 25·5 square miles, of the association. The prevalence of the freely drained series is due to the coarse texture of the parent material. The poorly drained Dallachy series is most widespread between Fraserburgh and St. Combs where till similar to that of the North Mormond Association underlies the sand. Both the imperfectly drained Anniston series and the very poorly drained Ballindarg series are of negligible extent.

*Series*

#### BOYNDIE SERIES

This is the dominant series of the association. As it is almost entirely under cultivation no characteristic natural vegetation can be given. The drainage class is free and the major soil sub-group is iron podzol.

##### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–9″ | Dark brown (10YR4/3) loamy sand; occasional gravel size pebbles; moderate fine crumb; soft; organic matter moderate; roots abundant; no mottles. Clear change into |
| A | 9–20″ | Dark yellowish brown (10YR4/4) loamy sand with occasional pebbles; weak, fine sub-angular blocky; organic matter low; roots numerous; few fine distinct ochreous and black mottles at base. Sharp change into |
| $B_3$ | 20–26″ | Brown (7·5YR5/4) sand, colour variable due to bands of water-sorted material; single grain; loose; organic matter low; roots frequent; few coarse distinct ochreous mottles. Sharp change into |

| | | |
|---|---|---|
| $B_3$ | 26–31″ | Yellowish brown (10YR5/6) sand; single grain; moderately indurated; roots few; low organic matter; no mottles; merging into |
| C | 31–54″+ | Alternating bands, 1 to 2 inches thick, of strong brown (7·5YR5/8) and light brown-grey (2·5Y6/2) sand; single grain; weakly indurated; no organic matter; no roots; no mottles. |

Throughout this series, whether formed on a river terrace or coastal deposit, the S or A horizon has a higher content of silt and clay than the lower horizons, and is relatively deep. Associated with the finer texture is a greater content of organic matter, and together these are responsible for the crumb structure and the soft consistence. In the lower horizons the structure is single grain and the consistence is either loose, as in the $B_2$ horizon, or indurated, as in the $B_3$ and C horizons. The $B_2$ horizon is coloured by layers of brown and grey sand and by irregular shaped large blotches of ochre staining. The general colour of each horizon is largely determined by that of the water-sorted band or bands on which the soil has been developed. Although most of this series is cultivated, in various localities there is evidence, such as the presence of an iron pan, that the natural soil was a peaty podzol. The limits of these areas are difficult to ascertain, and during the present survey no attempt has been made to map them. Instead, all the cultivated, freely drained soils have been placed in this series which is a member of the sub-group of iron podzols.

### ANNISTON SERIES

Developed on very gently sloping sites bordering the Dallachy series, the Anniston series has been distinguished in only two areas, one near Kinaldie and the other in the vicinity of Towie. With a moderate amount of mottling throughout, the profile is intermediate between the freely drained Boyndie series and the poorly drained Dallachy. Since most of the series is cultivated no characteristic natural vegetation can be given. The series belongs to the imperfect drainage class and the major soil sub-group of iron podzols.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark brown (10YR3/3) sandy loam with few small pebbles; moderate medium crumb; friable; moderate organic matter; roots abundant; few coarse faint ochreous mottles. Clear change into |
| $B_2$(g) | 10–17″ | Brown (10YR4/3) loamy sand; moderate fine blocky; friable; organic staining decreasing with depth; roots numerous; frequent medium distinct ochreous mottles; frequent fine distinct black mottles (probably manganese); black manganese concretions or rotten small stones at base. Sharp change into |
| $B_3$(g) | 17–30″ | Pale brown (10YR6/3) with patches of dark brown (7·5YR4/3) loamy sand; massive; moderately indurated; low organic matter; roots few; frequent medium distinct yellow (10YR7/5) mottles; and frequent medium distinct strong brown (7·5YR5/6) mottles. Sharp change into |
| C(g) | 30–64″+ | Bands of light yellowish brown (10YR6/4) sand alternating with bands of very dark grey (7·5Y3/1) fine sandy loam; massive, low organic matter; no roots; wet. |

The distinguishing feature of this series is the presence of ochreous mottling in the $B_2$(g) and $B_3$(g) horizons, together with some black manganese staining in the lower parts of the $B_2(g)$. The mottling occurs on a brown or pale brown background colour and is less extensive than in the poorly drained Dallachy series where the iron mottling on a grey background is also more contrasting.

The structure in the B(g) horizons is soft blocky, whereas in the B horizons of the Boyndie series it is single grain. Induration appears in the $B_3$ horizon, and this is also present in the Boyndie series but not in the Dallachy. At 30 inches the C(g) horizon has a layered appearance, with a massive structure caused by wetness.

### DALLACHY SERIES

Generally occurring in small patches throughout the association, the Dallachy series is located on the level or gentle slopes of depressions. The only sizeable areas—over 3 square miles—are found between Fraserburgh and Rattray Head on raised beach material. Till or alluvium underlies this series, causing water to concentrate in the sand and thus making the soil poorly drained. Most of the series, which belongs to the major soil sub-group of non-calcareous gleys, is cultivated.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–11″ | Dark brown (10YR4/3) sandy loam; moderate medium crumb; friable; moderate organic matter; roots abundant; frequent fine prominent yellowish red (5YR5/6) mottles. Sharp change into |
| $B_2g$ | 11–16″ | Dark grey (10YR4/1) and dark grey-brown (10YR4/2) sandy loam; marbled appearance; weak angular blocky; friable; low organic matter; roots few; few iron oxide pipes; frequent medium distinct ochreous mottles. Gradual change into |
| $B_3g$ | 16–26″ | Grey-brown (2·5Y5/2) sandy loam; weak angular blocky; friable; low organic matter; roots rare; few iron oxide tubes; few medium distinct ochreous mottles; some rotten stones; merging into |
| Cg | 26–38″ | Blue-grey (5B6/1) sandy loam; single grain; wet; non-plastic; low organic matter; no roots; occasional iron oxide pipe; occasional medium distinct ochreous mottles; occasional rotten stones; occasional pebbles occur throughout the profile. |

Due to the sandy texture, the structure of this profile is never strongly defined; this is especially noticeable in the $B_2g$, $B_3g$ and Cg horizons. Consistence is either friable or non-plastic. Although ochreous mottling is present throughout the profile it is most prevalent in the $B_2g$ and $B_3g$ horizons. In the Cg horizon there is often a water-table which effectively precludes extensive ochreous mottling. The presence of iron oxide pipes is indicative of a more waterlogged condition in the past, improvement probably having been effected by means of tile drains and open ditches at the field boundaries. Some pebbles occur throughout the profile and schistose stones in this soil are commonly found to be soft and thoroughly weathered.

### BALLINDARG SERIES

Throughout the area the Ballindarg series occupies less than 1 square mile and is widely distributed alongside the more extensive Dallachy series. The parent material is fluvio-glacial sand, underlain by an impervious stratum which is often a till. A level or gentle concave slope favours this series which is generally uncultivated. The drainage class is very poor and the major soil sub-group is peaty gley.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | old pasture with *Juncus effusus, Holcus lanatus, Ranunculus* sp., *Trifolium repens* |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–9″ | Very dark brown (10YR2/2) decomposed organic matter; slight content of sand and gravel; no definite structure; non-plastic; roots abundant. Sharp change into |
| $A_2g$ | 9–15″ | Grey-brown (10YR5/2) loamy sand; single grain; non-plastic; organic matter low but much organic staining; roots frequent; few distinct ochreous mottles; few iron oxide tubes and root channels; many coarse distinct grey mottles. Clear change into |
| $B_2g$ | 15–24″ | Grey (10YR5/1) loamy sand; single grain; non-plastic; low organic matter; roots rare; frequent medium distinct ochreous mottles; few iron oxide tubes round former root channels. Gradual change into |
| $B_3g$ | 24–32″ | Grey (10YR5/1) loamy sand with gravel sized pebbles; single grain; non-plastic; roots absent; low organic matter; no mottles; few iron oxide tubes round former root channels. Gradual change into |
| Cg | 32–40″ | Grey (7·5YR5/0) loamy sand; massive; non-plastic; roots absent; low organic matter; no mottles; level of permanent water-table. |

The surface horizon is well-decomposed organic matter with a small content of sand and gravel due to contamination from adjoining soil types. A sharp boundary marks the change to the $A_2g$ horizon, which is strongly stained from the organic matter above. Although very coarse in texture, it possesses a massive structure, due to the high content of moisture which causes the single mineral grains to adhere to each other. Ochreous mottling is not profuse, with the exception of the iron oxide tubes which encase former root channels. The $B_2g$ and $B_3g$ horizons are very much alike in colour, texture and structure, differing only in the absence of ochreous mottling and of roots in the $B_3g$ horizon. A permanent water-table is often present at about 3 feet, and in these cases the Cg horizon has a bluish tinge not seen in the other horizons.

## Note on Agriculture

While the gentle relief, the sandy nature of the soils and the comparatively small number of stones make cultivation easy at any season of the year, the Boyndie Association has nevertheless a number of disadvantages. The soils, which tend to be deeper than average—12 inches and over—have a low exchange capacity which allows nutrients to be leached out very easily. They also have a low water-holding capacity and this is responsible for premature ripening in a drought period, with burning of the crop on the shallower soils. Wind erosion can occur in a dry spring on cultivated land. Good management can mitigate these harmful effects. Generous applications of farmyard manure improve both resistance to drought and the nutrient-retention capacity of the soils.

Most of the association is cultivated and good crops of grass, oats, barley and turnips are generally to be found, the grass crop however tending to deteriorate from the third year onwards. In those parts of the association which consist of small tracts bordering rivers it is seldom that all the land on a farm belongs to one association. In the Longside and south Fraserburgh area, however, whole farms are contained within the association, and wire fences divide the fields. Except about the estates of Philorth and Cairness the country is bare and treeless. Exposure to offshore winds has an adverse effect on the growth of crops in this north-east corner and shelter belts would prove beneficial to both crops and stock.

The farms on this association are mostly concerned with feeding and fattening beef cattle, but farms which are situated near the links frequently carry a flock of sheep.

## THE COLLIESTON ASSOCIATION

The Collieston Association forms an enclave within the Peterhead and Tipperty Associations. All three are derived from Old Red Sandstone sediments, and all have been water-sorted to varying degrees. The Peterhead Association is essentially developed on till, the Tipperty on lacustrine clay and the Collieston on water-sorted material. The parent material of the Collieston Association can vary within a profile from gravel or sand to partially water-sorted till or lacustrine clay. The association occurs within the altitude range of 50 to 200 feet, and these textural variations can probably be related to geomorphological features such as raised beaches.

### DISTRIBUTION

The association covers 7 square miles and occurs in three areas (Fig. 16), one between Collieston and the Meikle Loch, another to the north-east and east of the Ythan estuary, with a small part on the west side, and a third about the farm of Pettens, north of Balmedie. The greater part of the association is found on gently rolling or moderately sloping land, with occasional knoll features.

### PARENT MATERIAL

The parent material consists of water-sorted strata derived from Old Red Sandstone sediments together with gravel layers composed mainly of local rocks—granite, gneiss, quartz-schist, knotted schist and quartzite. Water-sorted Old Red Sandstone till, derived from till similar to that of the Peterhead Association, can also be present. The greatest variation in the textural profile occurs on the convex slopes and knolls. On foot slopes and in depressional sites sandy colluvium consistently overlies clay. The gravel or sand layers are not always red. In places lumps of red clay have been found within the water-sorted strata, while some of the sand layers contain shelly fragments. The latter are considered to be evidence of the raised beach origin of this deposit. The association is underlain in places by gravel containing Cretaceous, Jurassic and perhaps older limestone which is probably of the First Ice Age and older than the Strathmore Drift.

### SOILS

Sand or gravel generally occurs in the lower horizons of the soils. Of equally common occurrence is a layer of lacustrine clay or water-modified red till in some part of the profile. On the steeper slopes, for example the belt east of the Newburgh estuary, or on knoll features which have a high gravel or sand content, the freely drained Cairnrobin series predominates. On the gentler slopes a layer of red lacustrine clay is commonly present and tends to cause a slight impedance to drainage. The dominant soil on these slopes is the imperfectly drained Collieston series. Some footslope and depressional sites have sandy colluvium overlying lacustrine clay, and here also Collieston series has been mapped. The Marshmire series, which is very poorly drained, is developed on flat or depressional sites. In certain areas the variation in strata and the presence or absence of the clay layer result in a complex of freely and imperfectly drained profiles. Such areas have been mapped as the imperfectly drained Collieston series as this series tends to be the dominant one.

*Series*

CAIRNROBIN SERIES

The Cairnrobin series, a brown forest soil, is freely drained and is developed on water-sorted material of variable texture. In places the profile consists of a water-sorted till for the top 18 inches of the profile underlain by strata of sand or gravel. The sand layers may be coarse or fine and reddish brown or yellowish brown. Layers of red lacustrine clay are occasionally present. Lacustrine clay in the form of cigar-shaped lumps has also been found in the sand layers as well as broken shelly fragments. The series is always found on moderately sloping ground.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–11″ | Dark reddish brown (5YR3/2) loam; medium crumb; friable; organic matter moderate; roots frequent; stones few to moderate. Sharp change into |
| $B_3$ | 11–16″ | Reddish brown (5YR4/4) stony coarse sandy loam; strongly indurated; organic matter low; organic matter and clay coating of cavities of removed pebbles. Sharp change into |
| $C_1$ | 16–36″ | Reddish brown (5YR5/3) stratified sand and gravel; single grain; pieces of rolled red clay incorporated with gravel. Sharp change into |
| $C_2$ | 36–39″ | Reddish brown (2·5YR4/4) lacustrine clay; highly plastic. Sharp change into |
| $C_3$ | 39–48″ | Yellowish red (5YR5/6) fine sand; mica flakes visible; single grain. |

The Cairnrobin series is freely drained and has a reddish brown loam-textured surface soil in which pebbles are present. A well-formed $B_3$ horizon of coarser texture with moderate to strong induration is usually present. A $B_2$ horizon can be sometimes found, but more often than not it has been incorporated into the S horizon by ploughing. Beneath the $B_3$ horizon it is usual to find strata of different, mainly water-sorted ,materials, whereas the surface and $B_3$ horizons appear to be a capping of water-sorted till.

COLLIESTON SERIES

The Collieston series is developed on the gentle slopes about Collieston village, on the land bordering the north bank of the Ythan estuary and about Pettens, north of Balmedie. The raised beach deposits in these localities are of varied composition. Exposed in the cliff sections at Collieston are stratified layers of red sand and fine sand 3 to 10 feet thick; inland from

Collieston, red lacustrine clay occurs as a layer 1 to 2 feet thick near the land surface. At the Mains of Slains, which is at a higher altitude, the parent material is water-sorted till overlying gravel. Despite the varied nature of the parent material the surface soils are nearly always loams, with a friable consistency. The series is a brown forest soil with gleyed B and C horizons. The water-table is maintained by an impervious clay till.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–12″ | Dark reddish brown (5YR3/2) loam; medium angular blocky breaking into very fine blocky; friable; organic matter moderate; roots very abundant; occasional pebbles; worms. Sharp change into |
| $B_2$ | 12–19″ | Reddish brown (2·5YR4/3) loam; admixture of surface soil, sandier than the S horizon; coarse sub-angular blocky; frequent fine ochreous mottles; worm channels filled with surface material; organic matter moderate; frequent fine roots; weakly indurated below, friable above. Sharp change into |
| $B_3$(g) | 19–32″ | Reddish brown (2·5YR4/4) clay loam; partially water-sorted till; coarse prismatic; firm; frequent medium ochreous mottles in upper part; black manganese coatings in lower part; worm holes; organic matter low; occasional roots at base; moderate stone and gravel content in pockets. Clear change into |
| C(g) | 32–48″ | Reddish brown (2·5YR4/4) sandy clay loam; massive; plastic; stones and gravel are rounded O.R.S. quartzites; sub-angular and rounded fragments of granite, gneiss, spotted schists and quartzite. |
| D | 48″+ | Gravel. |

The horizons of the Collieston series have a greater clay content than the corresponding horizons of the Cairnrobin series. In addition the B(g) horizons are, at most, weakly indurated, have reddish brown mottles (which indicate slight gleying), together with some black manganese staining, and have a coarse blocky or prismatic structure. In many features, such as texture and structure, the Collieston series is more closely related to the poorly drained Marshmire series.

## MARSHMIRE SERIES

The Marshmire series, a non-calcareous gley, is represented on the map by only one area, although several patches too small to delineate have been noted. The series is developed on flat sites generally associated with drainage channels. The drainage class is poor as a result of the high level at which the water-table is maintained by an impervious clay till.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–11″ | Dark reddish brown (5YR3/2) loam; coarse sub-angular blocky; compact; plastic; roots abundant; organic matter moderate; stones few; fine iron oxide staining along root tracks. Sharp change into |
| $A_2$g | 11–16″ | Grey-brown (10YR5/2) sandy loam; massive to weak coarse prismatic; firm; moist; organic matter low; fine roots; iron oxide coatings to old root channels; worm holes. Sharp change into |

| | | |
|---|---|---|
| $B_2g$ | 16–22″ | Grey-brown (10YR5/2) clay loam; stones frequent; coarse prismatic with sharp angles; interior of peds grey; many fine distinct reddish brown mottles in interior of units; root tracks and worm holes etching faces of peds; organic matter low; roots frequent. Clear change into |
| $B_3g$ | 22–32″ | Reddish brown (2·5YR4/4) clay; occasional stones and gravel; massive; many fine faint yellowish brown mottles; roots rare but many fine pores. Sharp change into |
| Cg | 32–44″ | Yellowish red (5YR4/6) silty, lacustrine clay; massive; plastic; few medium distinct reddish yellowish brown mottles; roots rare. |

In general morphology this series is very close to the Peterhead series. Its most notable features are the contrasting sandy texture and grey colour of the $A_2g$ and, to a lesser extent, of the $B_2g$ compared with the reddish brown clayey texture of the $B_3g$ and Cg horizons. Reddish brown mottling and prismatic structure are at a maximum in the $B_2g$ horizon, but the mottling is much less evident in the Cg horizon while the prismatic structure gives place to a massive structure in the $B_3g$ and Cg horizons. The presence of iron oxide tubes in the $A_2g$ horizon is an indication of strong gleying and permanently wet conditions.

### Note on Agriculture

The agricultural rating of the Collieston Association is moderately high. The Cairnrobin and Collieston series are, on the whole, not difficult to work but the Marshmire series is much more of a problem because of its wetness and its clayey texture. Most of the association is easterly lying, situated near the sea and unsheltered, with the result that strong or cold winds can have an adverse effect on crops. Stock rearing and fattening of both sheep and cattle are the main pursuits, although there is some dairying in the area about Balmedie.

## THE CORBY ASSOCIATION

The soils of the Corby Association are formed on gravels of fluvio-glacial and morainic origin and consequently have a very coarse texture. Frequently the areas of gravel merge into fluvio-glacial sand, the parent material of the Boyndie Association.

### Distribution

The association, 46 square miles in extent, is widespread throughout the area being distributed in the following localities.

*Area I.* On the plain between New Aberdour and Rathen. The relief is broken by low ridges running north-west to south-east with broad flat alluvial channels in between. Hummocky and moundy relief occurs in the Sinclair Hills and the Blackhills. This area merges into the spread of fluvio-glacial sands of the Boyndie Association on the east.

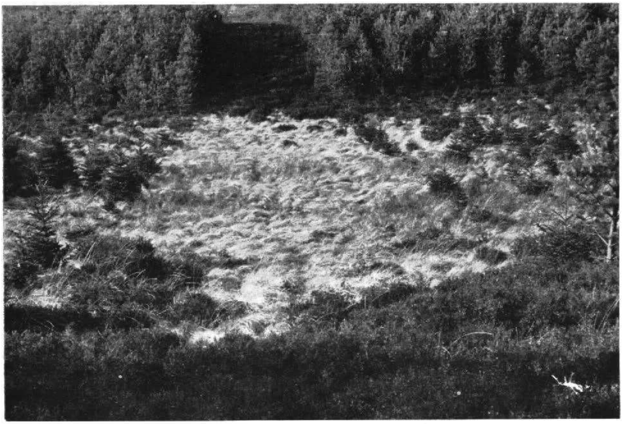
*Area II.* Gravel terraces about a quarter of a mile wide occur on the North Ugie Water from Strichen to the coast at Peterhead. They are less extensive on the South Ugie Water eastwards from Old Deer. Several tributaries entering the South Ugie Water from the south have gravel terraces such as that at Stuartfield.

*Area III.* About the Water of Cruden, and particularly in the area south of Hatton of Cruden, moundy gravel is extensive. Red lacustrine clay of the Tipperty Association occurs in the depressions between the mounds.

*(By courtesy of the Forestry Commission)*

PLATE 22

Stunted Scots pine over 80 years old on peaty podzol with iron pan.



*(By courtesy of the Forestry Commission)*

PLATE 23

Scots pine on dry slope (iron podzol), Norway spruce with *Deschampsia caespitosa* and *Juncus communis* in flush (gley soil).

[*Facing page* 108]

PLATE 24
Platy structure of indurated horizon.

PLATE 25
A clay soil of the Tipperty Association.

*Area IV.* In the valley of the River Ythan, from Auchterless to Newburgh, the terraces are in places half a mile wide, extending up to 1 mile east of Ellon. South of Ellon, at Cross-stone and Target Wood, ridges and mounds of morainic gravel occur. Smaller deposits are found at Hillhead of Fechil and at Cairnhill.

*Area V.* From the River Don at Aberdeen northwards to Belhelvie extensive and deep deposits of gravel occur in the form of prominent mounds and ridges which tend to lie in a north-east—south-west direction. The gravel is stratified and has thick bands of sand associated with it. It is being worked for building material and is exposed in many places. The aggregates are mainly of granite, schist, gneiss and quartzite. Thin bands of red fine sand, silt and clay occur in some of the cuttings. A capping of glacial till, of the same texture as the gravel, which has been thrust from the west, overlies some of the mounds and ridges. The area is discussed by Simpson (1955) who considers it to be part of a coastal kame belt.

*Area VI.* The gravel terraces of the River Dee from Peterculter to Aberdeen are at a height of about 180 feet. Aberdeen City east of a line from Broomhill Road to Powis School is underlain by gravel. Continuous terraces of gravel a quarter to a half mile wide occur on the banks of the river Don from Inverurie to its mouth. West of Inverurie the terraces are discontinuous, being confined to the Kemnay, Alford and Towie Basins. Many of the streams draining the Skene Lowlands have gravel terraces patchily distributed along them. North of Loch Davan, in the south-west corner of Sheet 76, both morainic and fluvio-glacial gravels occur.

*Area VII.* Deep deposits of gravel fill the Bogie Valley between Kildrummy and Rhynie; in the main the deposits are of morainic origin and have a moundy topography.

### Parent Material

The aggregates of the gravel are rounded or sub-angular and for the most part are of acid igneous or acid metamorphic rock, being derived from granite or from some representative of the Highland Schists. Below soil depth the gravel has little silt- and clay-sized fractions contained in it, but in the soil profile there is appreciably more fine material in the surface soil than in the subsoil. Where the Corby Association occurs within the general confine of the Insch Association there is a preponderance of basic-igneous material, while within the Foudland Association the gravel is largely composed of the weakly metamorphosed schists.

The gravel terraces along the rivers lie 25 to 100 feet higher than the recent alluvial flood plains and are fluvio-glacial deposits of end-glacial times. The terraces are essentially flat, although some have been dissected by gullies and now present a broken appearance. The influence of relief on agricultural use is very marked in this association: the terraces are generally cultivated, while the mounds, which may be moraines, kames or eskers, are more often uncultivated or have been planted with trees. Both terraces and mounds are of stratified material with bands of different-sized aggregates. The fluvio-glacial terraces of the main rivers are generally well defined and are easily recognized. Throughout the area however there are overflow channels which contained rivers in end-glacial times but are now dry or are occupied by insignificant streams. Several occur on Sheets 87/97 (Peterhead/Fraserburgh), running in a roughly north-south direction, and others cut across the angle of the River Don between Inverurie and Fintray. In these narrow overflow channels the terraces are not well defined and there is a gradual transition from terrace on the sides to alluvium on the floor. Frequently however there is a well-defined gravel terrace at the discharge end of the channels.

The scattered mounds of gravel in the coastal belt between Newburgh and Peterhead are sometimes capped by red clays of the Tipperty Association. This gravel, which contains a proportion of Old Red Sandstone conglomerates—lavas, porphyries, jasper quartz and reddish stained quartzites—is of First Ice Age origin.

## SOILS

Five series of the Corby Association are represented in this area, the Corby, Tarbothill, Leys, Mulloch and Mundurno. Because of the coarse texture and loose consistence of the parent material the freely drained Corby series is the most extensive. On land with a semi-natural vegetation, however, the Tarbothill series (freely drained below iron pan) is dominant. The imperfectly drained Leys series occurs where the gravel deposits are thin, and finer textured material, usually till, is within 4 feet of the surface. The poorly drained Mulloch series is located in hollows usually near a patch of basin peat. The very poorly drained Mundurno series is also commonly found in close proximity to basin peat and some of it is almost certainly a remnant from cut-over basin peat. The Corby and Leys series are iron podzols, the Tarbothill series a peaty podzol with iron pan, the Mulloch series a non-calcareous gley, and the Mundurno series a peaty gley.

*Series*

### CORBY SERIES

The Corby series is the most extensive soil in the association. The series belongs to the freely drained class and, in the uncultivated state, is an iron podzol. The freely drained cultivated soils are also mapped as iron podzols, but there is evidence that some of them were originally peaty podzols with iron pan. A dry heath community with *Calluna vulgaris*, *Erica cinerea*, *Deschampsia flexuosa*, *Festuca ovina* and *Agrostis canina* is the dominant semi-natural vegetation. Before the introduction of myxomatosis, however, rabbit infestation was severe and resulted in the disturbance of some of the soil horizons. On these disturbed sites, the vegetation is often dominated by *Ulex europaeus* and *Sarothamnus scoparius*.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Calluna vulgaris, Erica cinerea, Deschampsia flexuosa, Festuca ovina, Agrostis canina, Ulex europaeus* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 3–2″ | Litter |
| F | 2–1″ | Partially decomposed litter |
| H | 1–0″ | Very dark brown (10YR2/2) well-decomposed organic matter. Sharp change into |
| $A_2$ | 0–3″ | Dark grey-brown (10YR4/2) gravelly loamy coarse sand; very weak fine sub-angular blocky; loose; roots frequent. Sharp change into |

| | | |
|---|---|---|
| $B_2$ | 3–8″ | Yellowish brown (10YR5/4) loamy gravelly sand with organic staining near the top; weak medium sub-angular blocky; weakly indurated; roots frequent. Clear change into |
| $B_3$ | 8–18″ | Light olive-brown (2·5Y5/6) loamy gravelly sand; massive; strongly indurated; few roots penetrate. Gradual change into |
| C | 18″+ | Gravelly coarse sand; loose. |

The L, F and H horizons are not strongly developed. The $A_2$ horizon is easily recognisable and is usually 2 to 4 inches thick. A slight degree of induration and a little brown organic staining is superimposed on the yellowish brown colour of the $B_2$ horizon. The $B_3$ horizon has a massive structure with moderate to strong induration and is difficult to penetrate when digging a profile pit. Its colour has a lower chroma than that of the $B_2$ horizon.

### TARBOTHILL SERIES

Like the Corby series, the Tarbothill is developed on a thick gravel. This series, almost entirely uncultivated, is strongly podzolised and belongs to the group of peaty podzols with iron pan. Below the iron pan the drainage class is free; above the horizons are seasonally wet. The characteristic vegetation is a heath type, dominated by *Calluna vulgaris. Erica cinerea, Erica tetralix* or *Nardus stricta* are sometimes subsidiary species.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Erica cinerea, Calluna vulgaris, Anthoxanthum odoratum, Ulex europaeus* |
| DRAINAGE CLASS | | free below pan |
| *Horizon* | *Depth* | |
| L | 9–6″ | Litter |
| F | 6–4″ | Partially decomposed litter |
| H | 4–0″ | Black, well-decomposed organic matter; dries into hard cubic aggregates speckled with quartz grains. Clear change into |
| $A_2$ | 0–6″ | Grey-brown (2·5Y5/2) gravelly loamy coarse sand; dries grey; weak fine sub-angular blocky; loose; fine roots frequent; dark band of black organic matter at base. Sharp change into |
| $B_1$ | at 6″ | Thin ($\frac{1}{8}$″) iron pan, very variable in depth. Sharp change into |
| $B_2$ | 6–14″ | Strong brown (7·5YR5/6) gravelly loamy coarse sand; weak medium sub-angular blocky; weakly indurated; patches of dark brown organic staining; roots few. Clear change into |
| $B_3$ | 14–24″ | Brown (7·5YR5/4) gravelly coarse sand; massive; strongly indurated; no roots. Sharp change into |
| C | 24″+ | Gravel; single grain; loose. |

When thoroughly dry on an exposed face, the $A_2$ horizon is a striking feature with an almost white appearance. The iron pan is generally present but varies from being a prominent feature to being so inconspicuous that careful inspection is required to find it. It exhibits marked changes in depth and the convolutions of the pan can enclose pockets of the $A_2$ horizon which penetrate deeply into the C horizon. It is frequently found that a black concentration of organic matter occurs above the iron pan. This may be of one to ten or more inches in depth and is probably the feature responsible for the genetic group term of humus podzol being applied to these soils. Few roots penetrate a well-formed iron pan. The $B_2$ horizon is stained with organic matter and iron and shows some degree of induration. In the strongly developed peaty podzols of this association the $A_2$ passes directly into the strongly indurated $B_3$ horizon. On a long-exposed vertical face in a gravel pit the organic surface layers jut out, being bound by roots, the gravel in the $A_2$ and $B_2$ horizons falls away, the indurated $B_3$ horizon protrudes and the loose gravel of the C horizon tends to slump away.

## LEYS SERIES

Soils of the Leys series, which is imperfectly drained, have been mapped in a few localities. This series is generally found on moderate to gentle slopes on gravel deposits. Below the gravel there is usually a stratum with a finer texture which is responsible for the imperfect drainage. The Leys series, which belongs to the group of iron podzols, is almost always suitable for cultivation.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–9″ | Very dark brown (10YR2/2) gravelly sandy loam; weak structure, cloddy breaking into fine cloddy; friable; medium organic matter; roots abundant. Sharp change into |
| $B_2(g)$ | 9–17″ | Grey-brown (10YR5/2) gravelly coarse sandy loam; weak medium sub-angular blocky breaking into single grain; friable; low organic matter; worm channels containing surface material; few fine distinct ochreous and grey mottles on finer fractions and iron staining on the stones. Clear change into |
| $B_3(g)$ | 17–24″ | Brownish yellow (10YR6/8) gravelly coarse sand; massive; weakly indurated; low organic matter; few roots; frequent diffuse ochreous and grey mottles. Gradual change into |
| C(g) | 24–39″ | Dark yellowish brown (10YR4/4) sandy gravel; single grain; loose; no roots; few medium distinct ochreous mottles. |

All the horizons of this series contain a large number of cobbles, ranging in diameter from ½ inch to about 2 inches. Throughout the series the surface horizon is often a little finer in texture than the others. The $B_2(g)$ and $B_3(g)$ horizons show some mottling and the latter is also weakly indurated. This series can have characteristics resembling those of either the freely drained Corby series or the poorly drained Mulloch.

## MULLOCH SERIES

The Mulloch series, generally found alongside basin peat, belongs to the group of soils with poor drainage. An impervious layer at depth, together with the low topographical position, is responsible for the presence of the fluctuating water-table in the solum and the consequent mottling. The series, a non-calcareous gley, is found in small areas all of which cover only some 2 square miles.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–9″ | Very dark brown (10YR2/2) gravelly sandy loam; weak medium cloddy; loose; moderate organic matter; abundant roots; few fine faint ochreous mottles round roots. Sharp change into |

| | | |
|---|---|---|
| $A_2g$ | 9–13″ | Light brownish grey (10YR6/2) gravelly coarse sand; weak medium sub-angular blocky; loose; low organic matter; frequent roots; frequent medium prominent ochreous mottles and frequent medium distinct grey mottles; tongues of material from S horizon. Clear change into |
| $B_2g$ | 13–20″ | Pale brown (10YR6/3) coarse sandy fine gravel; single grain; loose; frequent medium distinct grey mottles and frequent medium prominent ochreous mottles. Gradual change into |
| $B_3g$ | 20–28″ | Pale brown (10YR6/3) coarse sandy gravel; single grain; loose; frequent medium grey mottles; horizontal bands of prominent ochreous staining. Sharp change into |
| Cg | 28–36″ | Coarse gravel with little fine material; single grain; loose; some stones soft and rotten; others stained with ochre. Sharp change into |
| D | 36″+ | Glacial till. |

Mottling is not pronounced in the S horizon but increases with depth, reaching a maximum in the $B_2g$ and $B_3g$ horizons. The colour of the $A_2g$ horizon has a slightly lower chroma than the others: on some sites the difference is quite marked. Strongly influenced by the coarse texture of the parent material, all the horizons have both a weak structure and a loose or non-coherent consistence. In the $B_3g$ horizon it is common to have horizontal bands of ochreous mottling, a feature which may be related to a fluctuating water-table.

### MUNDURNO SERIES

The Mundurno series is not extensive and is found near basin peat. Some of it was overlain by basin peat which has since been cut for fuel. Belonging to the very poorly drained class, this series is a peaty gley and is associated with a vegetation dominated by *Juncus* spp.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | nil |
| VEGETATION | | *Juncus effusus*, *Alopecurus geniculatus*, *Cardamine pratensis*, *Ranunculus repens*, *Ranunculus acris* |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–9″ | Black to dark olive-grey (5Y2/2) peaty sandy loam; weak medium cloddy; loose; high organic matter; roots abundant; few distinct fine ochreous mottles associated with roots. Sharp change into |
| $A_2g$ | 9–12″ | Dark grey-brown (2·5Y4/2) gravelly coarse sand; weak medium angular blocky; loose; moderate organic matter; roots frequent; few distinct fine ochreous mottles; patches of dark organic staining. Sharp change into |
| $B_2g$ | 12–16″ | Light yellowish brown (10YR6/4) gravelly coarse sand; moderate medium angular blocky; firm; roots few; frequent distinct medium ochreous mottles; patches of dark organic staining. Sharp change into |
| $B_3g$ | 16–20″ | Dark brown (10YR4/3) gravelly coarse sand; massive; moderately indurated; patches of dark organic staining; roots few; frequent medium distinct ochreous mottles. Gradual change into |
| Cg | 20–48″+ | Pale olive (5Y6/3) gravel; single grain; non-coherent; at the level of the permanent water-table the colour is blue. |

Characterised by dull colours and ochreous mottling in the B horizons and by organic matter in the S or $A_2g$ horizons, this series is a typical gley on coarse textured parent material. Its consistence is loose or non-plastic in most of the horizons and its structure is weak. Staining by organic matter in the B horizons is a noteworthy feature.

### Note on Agriculture

The soils are stony and cause severe wear and tear on implements. In a dry season crops grown on the Corby series suffer from drought, whereas those on the other series are less affected. In a normal year uneven ripening of cereals may occur; crops will be early on the Corby series, slower to ripen on the Leys and late on the Mulloch and Mundurno series. Pastures on the Corby series deteriorate comparatively quickly, and *Rumex acetosella* and *Viola tricolor* are common weed species which come in.

Nutrients are quickly lost through leaching and the fertility status of these soils is inherently low. Unless generous applications of fertiliser and lime are given, crops and pastures are poor. Farmyard manure is extremely beneficial, improving the moisture-holding capacity of the soil as well as its nutrient status. It is, however, less effective alone than when forming part of a manurial programme which includes liberal fertiliser applications.

On the Mulloch and Mundurno series tile draining is required before cropping can be successfully carried out. The nature of the parent material is such that deep draining is generally very effective.

The free drainage of the Corby series permits cultivation at almost any season of the year.

## THE COUNTESSWELLS ASSOCIATION

Developed on till from granite and granitic gneiss the Countesswells Association is 240 square miles in extent, most of it lying in Sheets 76 (Inverurie) and 77 (Aberdeen). A large part of the association is hill land under heath and coniferous plantation, with Bennachie (1,733 feet) the highest point. Arable land, which is seldom much above 800 feet, is more common in the eastern part of the area, especially in Sheet 77.

### Distribution

The Countesswells Association is one of the most extensive in the north-east of Scotland, covering about half the area of Sheets 76 and 77. A large triangular-shaped tract extends from Aberdeen in the east to Inverurie and Bennachie in the north-west and to Tarland in the west. A relatively large area occurs near New Pitsligo and there are several smaller areas about Gallow Hill and the Hill of Newleslie north of the Correen Hills, and around Stirling Hill, south of Peterhead. Very small occurrences are found at Tanglandford on the Ythan, at Pitscow and Blackfields north-west of Peterhead, and in the vicinity of Clatt, Kennethmont and Oldmeldrum.

### Parent Material

Throughout its area the Countesswells Association is developed on till derived from granite and, to a lesser extent, granitic gneiss, both of which are rich in quartz, orthoclase felspar and biotite. Some of the granite is grey, but pink granite is more widespread.

On well-drained areas with convex relief the till derived from grey granite is a light olive-brown (2·5Y5/4) while that derived from pink granite is a light reddish brown (10YR6/4). These tills, which are seldom more than 4 feet thick, have a stony coarse sandy loam texture. In localities where the relief is concave or flat and where drainage is poor, the tills are greyer in colour, being modified by gleying, and the texture is usually finer, being in some instances a sandy clay loam. Throughout the association the tills have a high content of coarse sand, gravel, stones and boulders. Stone dykes, built in the eighteenth century from boulders removed from the fields, are a characteristic feature of the arable land of this association. The uncultivated hill ground has a bouldery surface. Outcrops of rock occur throughout the association. On the summits of the granite hills the rock may appear as tors, together with a tumbled heap of joint blocks, as on Bennachie, or as bare rock pavements. These are mapped as skeletal soils.

Syenite underlies an area about Gallow Hill and the Hill of Newleslie, north of Leslie. The rock is pink and coarse textured with a high content of felspar, some biotite and hornblende. The summits of the hills are skeletal and the rock is decomposed. Soils on thin till derived largely from the decomposed syenite have been included in Countesswells Association.

The pink granite at Auchenhuive, south-east of Oldmeldrum, is deeply weathered and can be dug with a spade.

Thin till over partially decomposed rock covers much of the Stirling Hill area where there is a scatter of flint and quartzite cobbles through it. Both fresh and decomposed granite occur in the New Pitsligo basin. In the low-lying part, much of which is filled with basin peat, decomposed granite gives a very coarse textured till.

About Aberdeen, in the Airyhall, Craigiebuckler, Mastrick and Northfield districts, the till is generally deep and contains a higher proportion of silt and clay.

The decomposed or rotten granite is considered to be preglacially weathered material. Some measure of the weatherability of the rock is afforded by the boulders of coarse textured pink granite forming a stone circle, the Standing Stones of Echt, near Garlogie. Some 4 or 5 feet of these boulders appear above the ground which has recently been cleared of its peaty surface soil, revealing a marked constriction, about 3 inches deep, on each of the stones at the level of the former organic surface layer (Plate 40). If the stone circle is assumed to be between two and three thousand years old, then approximately 1 inch of the boulders has been weathered in one thousand years by the surface soil. Again, on Pitfichie Hill, fine-grained aplite dykes, some 2 or 3 inches higher than the general surface, can be seen on an exposed pavement of coarse-grained granite. Presumably this differential weathering has occurred since the time of the final glaciation when a relatively smooth surface would have been left.

## Soils

Most of the major soil groups and sub-groups found over the whole region are represented in the Countesswells Association. They include brown forest soils (low base status), iron podzols, peaty podzols with iron pan, non-calcareous gleys and peaty gleys. Unlike the brown forest soils, which are rare, the iron podzols and peaty podzols are very widespread and the gleys moderately extensive.

The L, F and H layers and the thin iron pan are key properties for distinguishing the peaty podzol from the iron podzol. Cultivation eliminates the L, F and H layers and also the thin iron pan when it is within plough depth. It is, therefore, difficult to be sure whether a particular cultivated soil has come from a peaty podzol or an iron podzol. Experience indicates that most freely drained and imperfectly drained cultivated soils of the Countesswells Association were formerly iron podzols, and in the circumstances it has been decided to map them all as such.

The Raemoir, Countesswells and Charr series, all of which are freely drained in the $B_3$ and C horizons at least, are developed on till with a stony coarse sandy loam texture. The other series, Dess, Terryvale and Drumlasie, which are respectively imperfectly, poorly and very poorly drained, are formed on till with a coarse sandy loam or sandy clay loam texture. There is a general relationship between relief and the distribution of these tills, the convex slopes being covered with the till of coarse texture and the concave postitions with the till of finer texture.

The three series on the parent material of coarse texture, Raemoir, Countesswells and Charr, are conveniently discussed together because their main differences lie in the horizons above the $B_3$. Similarly the Dess, Terryvale and Drumlasie series, developed on the finer till, form a convenient grouping for discussion and comparison.

*Series*

### RAEMOIR SERIES

One of the least extensive series in the Countesswells Association, the Raemoir series has been mapped on the lower south-facing slopes of the Hill of Fare, on Leschangie Hill near Kintore, and on Millstone Hill, due south of Bennachie. In these places it occurs under birch or birch with oak, both of which can have a ground vegetation containing bracken. From the $B_2$ horizon downwards it resembles the Countesswells series, but the upper horizon, a brown moder, is quite distinctive. This series is freely drained and belongs to the group of brown forest soils.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | birch woodland, with *Betula pubescens*, *B. verrucosa*, *Sorbus aucuparia*, *Pteridium aquilinum*, *Anthoxanthum odoratum*, *Agrostis tenuis*, *Holcus mollis*, *Oxalis acetosella*, *Anemone nemorosa*, *Hylocomium splendens*, *Pseudoscleropodium purum* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| A | 0–3″ | Dark brown (7·5YR3/2) sandy loam; strong medium crumb; friable; moderate organic matter, moder type; bleached sand grains present; roots abundant; earthworms present; no mottles. Gradual change into |
| $B_2$ | 3–15″ | Yellowish brown (10YR5/6) sandy loam; weak medium crumb; friable; low organic matter; roots numerous; no mottles. Sharp change into |
| $B_3$ | 15–23″ | Light yellowish brown (10YR6/4) stony coarse sandy loam; moderate coarse platy; moderately indurated; few roots; dark brown organic staining on underside of peds; numerous pin-sized holes; few fine distinct ochreous mottles. Clear change into |
| C | 23″+ | Pale brown (10YR6/3) stony sandy loam; no apparent structure due to high content of stones; weakly indurated; no mottles. |

This profile is rather more leached than the modal brown forest soil of low base status. The humus type is moder and there are a few bleached grains at the top of the A horizon. One of the salient features of this series is the thickness of the friable $B_2$ horizon, which is about 12 inches in a typical

(*By courtesy of Aberdeen Journals Ltd.*)

PLATE 26

Kintore and River Don with flat expanse of fluvio-glacial deposits. Alluvium, Corby and Boyndie Associations.

[*Facing page* 116]

PLATE 27
Gravel moraines at Blackhills near New Aberdour typical of the Corby Association.

PLATE 28
A stony, cultivated peaty podzol, Skelmuir Association.

profile. The $B_3$ horizon is characterised by induration and a coarse platy structure, with the peds stained on the underside by organic matter. Most of the stones throughout the profile are granitic and, as in many other series of the Countesswells Association, there is a noticeable increase in their number with depth.

### COUNTESSWELLS SERIES

Most of the arable land in this association belongs to the Countesswells series, situated as it is on the moderate slopes of the foothills and intermediate plateaux and on the low eminences within the wider valleys. Cultivation tends to disguise the former character of the soil and there is evidence, such as the presence of an iron pan below the S horizon, that some of the arable land was derived from peaty podzols. Since the distribution of the pan is erratic and mapping it wellnigh impossible, all the cultivated land belonging to the freely drained class has been placed in the Countesswells series, which is a member of the group of iron podzols. Under semi-natural conditions the Countesswells series has the H layer and $A_2$ horizon characteristic of the iron podzol but under cultivation these are also destroyed. A typical uncultivated member of the series carries a vegetation dominated by *Calluna vulgaris*.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Calluna vulgaris, Erica cinerea, Vaccinium myrtillus, V. vitis-idaea Betula* spp., *Sorbus aucuparia, Deschampsia flexuosa, Hypnum cupressiforme* var. *ericetorum* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 6–4″ | Litter |
| F | 4–1″ | Partially decomposed, fibrous litter; live roots abundant |
| H | 1–0″ | Black (5YR2/1), well-decomposed organic matter; bleached mineral grains throughout; roots abundant. Sharp change into |
| $A_2$ | 0–2″ | Dark grey-brown (10YR4/2) coarse sandy loam; weak medium sub-angular blocky; loose; roots abundant; low organic matter; few distinct fine ochreous mottles associated with fine roots; patches of organic staining. Clear change into |
| $B_2$ | 2–8″ | Yellowish brown (10YR5/6) sandy loam; weak medium sub-angular blocky; friable; roots numerous; low organic matter; no mottles; patches of dark brown organic staining; root concentration at base. Sharp change into |
| $B_3$ | 8–18″ | Light yellowish brown (10YR6/4) stony, loamy sand with some boulders; weak coarse platy, with dark brown staining on underside of peds; concentration of fine, sandy loam material round stones; numerous pin-sized holes in peds; strongly indurated; no roots; low organic matter; few fine prominent strong brown (7·5YR5/8) mottles. Gradual change into |
| C | 18–24″+ | Light olive-brown (2·5Y5/4) bouldery stony loamy coarse sand; no visible structure due to stoniness; compact; no roots; no mottles. |

The F and H layers and the $A_2$ horizon are seldom more than 3 inches thick and more often than not are less than 2 inches. When dried out, the $A_2$ horizon is a grey-brown colour (10YR5/2), much paler than the freshly exposed horizon. Its structure is ill-defined and its consistence is either loose or friable.

The surface layer of the cultivated soil, in which the $A_2$ and part of the $B_2$ horizon have been incorporated, is dark grey-brown (2·5Y4/2); beneath this both cultivated and uncultivated soils are identical except that dark brown organic staining found in the $B_2$ horizon of the uncultivated soils is not present in the cultivated soils. The thickness of the $B_2$ horizon is markedly less than in the Raemoir series although in many other respects, such as colour, structure and consistence, the horizons are similar. In the $B_3$ horizon the similarity to the Raemoir series is striking. The structure and the induration, particularly the latter, are such dominating features in the $B_3$ horizons of both the Raemoir and the Countesswells series, and indeed also of the Charr series, that there is no difficulty in appreciating how nearly identical these horizons are. Subsidiary properties such as a coating of finer material round stones, dark brown staining on the underside of peds and the presence of numerous pin-holes in the peds only serve to emphasise the similarity. In the C horizon the boulders and stones are so numerous that the finer material exists only as small infillings.

## CHARR SERIES

Extensively developed on hill ground, the Charr series is widespread on the high-level summit area of Bennachie, Cairn William, Hill of Fare and a number of other, less prominent, hills. It is also found on other sites throughout the area, but on these its profile is less strongly developed and its distribution more erratic. The parent material is a stony coarse sandy loam till mainly granitic or gneissic in origin and with numerous boulders and large stones embedded throughout. As a member of the group of peaty podzols this series is uncultivated and has a thin iron pan which is between a sixteenth and an eighth of an inch thick. Above the iron pan the drainage class is variable and can be anything from free to poor, whereas below the pan it is free. The most commonly associated vegetation is Callunetum.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Calluna vulgaris*, *Erica tetralix*, *Trichophorum caespitosum*, *Pleurozium scheberi*, *Cladonia* spp. |
| DRAINAGE CLASS | | poorly drained above and freely drained below the pan |
| *Horizon* | *Depth* | |
| L | 8–7″ | Litter |
| F | 7–4″ | Dark brown, partially decomposed, organic matter; fibrous; live roots abundant. Sharp change into |
| H | 4–0″ | Black (2·5Y2/0) well-decomposed organic matter; when wet, structureless and plastic; when dry, strong medium angular blocky and hard. Sharp change into |
| $A_2$ | 0–5″ | Greyish brown (2·5Y5/2) loamy coarse sand; weak fine sub-angular blocky; non-plastic; roots numerous; few distinct ochreous mottles associated with roots; irregular bands of black organic staining. Clear change into |
| $A_2g$ | 5–9″ | Olive-grey (5Y5/2) coarse sandy loam merging to coarse sandy clay loam at base; massive when wet, weak medium sub-angular blocky; slightly plastic; root concentration at base due to iron pan; thin band of black organic matter above pan. Sharp change into |
| $B_1$ | at 9″ | Thin iron pan $\frac{1}{16}$th-inch thick, continuous. Sharp change into |
| $B_3$ | 9–18″ | Light brown (7·5YR6/4) loamy coarse sand; weak coarse platy; strongly indurated; finer material round stones; no roots; dark brown staining on underside of peds; numerous pin-holes in peds; frequent distinct ochreous mottles. Gradual change into |
| C | 18″+ | Light reddish brown (5YR6/4), stony, loamy coarse sand; structure obscured by high stone content; no roots; no mottles. |

The clear-cut nature of the horizons and their contrasting colours make this profile one of the most striking in the region. The thin iron pan ($B_1$ horizon) seals off the surface horizons from those below, with the result that the drainage class in the two parts is quite different. The whole of the $A_2g$ horizon is gleyed and at its base there is a concentration of organic matter, a product of the decomposition of roots which have been unable to penetrate the thin iron pan into the soil below. The $B_3$ horizon, with its strong induration and coarse platy structure, is very similar to that of both the Raemoir and Countesswells series.

On more favourable sites at lower altitudes a variant of the above profile occurs with a $B_2$ horizon very similar to that of the Countesswells series, but it has not been mapped separately at this stage. In this variant the thin iron pan ($B_1$ horizon), now less strong and continuous, is located between the $B_2$ horizon and the $A_2$ above.

A relationship exists in this series between the thickness of the H layer and the position of the iron pan in the profile. When the H layer is from 2 to 6 inches thick the iron pan is generally between the $A_2$ and $B_2$ horizons, but when the H layer is from 6 to 12 inches thick, the iron pan is located at the top of the $B_3$ horizon. Other minor characteristics are related to the iron pan when in these positions. Normally the iron pan between the $A_2$ and $B_2$ horizons is not sufficiently continuous to prevent the penetration of roots and water into the horizons below. When located at the top of the $B_3$ horizon, however, the iron pan is so strongly developed that both roots and water are held up, the one causing a concentration of organic matter and the other gleying.

### DESS SERIES

The Dess series, developed on a loam or sandy clay loam till, is extensive at altitudes below 800 feet on moderate and gentle slopes, especially in the environs of Aberdeen. With very few exceptions it is cultivated, providing the most desirable farmland of the whole association.

With its imperfect drainage, this series provides the link between the freely drained Countesswells and the poorly drained Terryvale series. As its overall morphology is similar to that of the Countesswells series, it belongs to the group of iron podzols. On the other hand, like the Terryvale series, it is developed on till of rather finer texture than that of the Countesswells series, and is noticeably gleyed in the B and C horizons.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–11″ | Dark grey-brown (10YR4/2) loam; moderate medium cloddy; friable; moderate organic matter; roots abundant; no mottles. Sharp change into |
| $B_2(g)$ | 11–16″ | Yellowish brown (10YR5/6) loam; moderate medium angular blocky; friable; low organic matter; roots numerous; frequent faint, strong brown (7·5YR5/6) mottles often associated with roots. Sharp change into |
| $B_3(g)$ | 16–24″ | Light yellowish brown (10YR6/4) sandy loam; moderate coarse platy; moderately indurated; roots occasional; frequent fine distinct strong brown (7·5YR5/6) mottles associated with fine roots and surface of peds. Gradual change into |

| | | |
|---|---|---|
| C(g) | 24″+ | Yellowish brown (10YR5/4) stony sandy clay loam; weak coarse sub-angular blocky, becoming massive with depth; firm; few fine distinct grey (10YR6/0) mottles and few fine faint, strong brown (7·5YR5/6) mottles associated with roots. |

Although this soil has a strong morphological resemblance to the Countesswells series it is distinguished by a small amount of mottling in the B and C horizons. The S horizon is moderately thick providing a rather better medium for plant growth than is usually furnished by the other series of the Countesswells Association. In the $B_3$(g) horizon the degree of induration is significantly less than in the Raemoir, Countesswells and Charr series. The stony, sandy clay loam till of this series provides an important link with the Terryvale series which is developed on till of similar texture. As would be expected, the structure in the C(g) horizon is more massive than in any of the others.

### TERRYVALE SERIES

Developed on the gentle to moderate slopes of the low-ground, the Terryvale series is extensive in the south-eastern part of the area and in the vicinity of New Pitsligo. The parent material is a till of loam or sandy clay loam texture and is often more than 4 feet thick. Most of the series is under cultivation, but before this could be successfully carried out a tile drainage system had to be introduced to run off surplus water and so provide a medium suitable for root development. The drainage class of the series is poor and its major soil sub-group is non-calcareous gley.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | third year grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark grey-brown (10YR4/2) gritty sandy loam; moderate medium cloddy; friable; moderate organic matter; few fine distinct yellowish red (5YR4/8) mottles associated with fine roots. Clear change into |
| $A_2$g | 10–13″ | Grey (10YR5/1) coarse sandy loam; weak medium angular blocky; friable; low organic matter; roots numerous; frequent fine prominent strong brown (7·5YR5/8) mottles; tongues of surface soil penetrate into horizon. Sharp change into |
| $B_2$g | 13–20″ | Light brown-grey (10YR6/2) stony coarse sandy loam with irregular lenses of grey fine sand; weak coarse angular blocky; friable; roots few; frequent coarse distinct strong brown (7·5YR5/8) mottles. Gradual change into |
| $B_3$g | 20–28″ | Pale brown (10YR6/3) stony loam; moderate coarse angular blocky; firm; roots few; frequent coarse distinct strong brown (7·5YR5/8) mottles. Gradual change into |
| Cg | 28–38″ + | Light yellowish brown (10YR6/4) sandy clay loam; weak coarse angular blocky becoming massive with depth; plastic; roots rare; frequent coarse distinct strong brown (7·5YR5/8) mottles and frequent fine faint grey (10YR6/0) mottles. |

Below the S horizon there is an $A_2$g horizon with a typical grey colour and weak sub-angular blocky structure. The $B_2$g and $B_3$g horizons have a stronger chroma and appreciably more strong brown mottling than either the S or $A_2$g horizons. Both fineness of texture and size of structural unit increase with depth until in the Cg horizon the texture is a sandy clay loam and the structure is massive. In some of these soils the permanent water-table occurs at a depth

PLATE 1.

The Charr series, a peaty podzol with iron pan developed on granite till (Countesswells Association).

PLATE 2.

The Countesswells series, an iron podzol developed on granitic till (Countesswells Association).

of about 30 inches: the dominant colours of the horizon then become grey (5Y5/1) and olive-grey (5Y4/2).

### DRUMLASIE SERIES

One of the least extensive members of the Countesswells Association, the Drumlasie series occurs in small areas which are generally surrounded by the more important Terryvale series. Even with a drainage system, cultivation is difficult because of the depressional nature of the sites and the series is often left in pasture for long periods. The parent material is a till of loam or sandy loam texture, normally more than 4 feet thick and with numerous stones. The series belongs to the major soil sub-group of peaty gleys and its drainage class is very poor.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | old grass, with *Juncus effusus, Holcus lanatus, Ranunculus acris, Rumex acetosa, Agrostis canina, Cirsium palustre, Pseudoscleropodium purum, Rhytidiadelphus squarrosus* |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Black (2·5Y2/0) decomposed organic matter; fibrous and rooty in the top 2 inches; roots abundant; some mineral particles intermingled; wet. Sharp change into |
| $A_2g$ | 10–15″ | Pale olive (5Y6/4) coarse sandy loam; massive; wet; slightly plastic; roots numerous; low organic matter; olive-brown (2·5Y4/4) staining in patches and in vertical streaks associated with roots; few fine prominent yellowish brown (10YR5/8) mottles. Clear change into |
| $B_2g$ | 15–25″ | Pale yellow (5Y7/4) gritty sandy loam; massive; slightly plastic; few roots; frequent medium prominent yellowish brown mottles. Gradual change into |
| $B_3g$ | 25–36″ | Yellow (5Y7/6) gritty sandy loam; massive; slightly plastic; roots occasional; iron oxide tubes round cavities of dead roots. Sharp change into |
| Cg | 36–48″ | Grey (2·5Y6/0) gritty coarse sandy loam; massive; slightly plastic; no roots; no mottles; marked smell of $H_2S$; water seeping in at 36 inches. |

The structure of the S horizon, which is rich in organic matter, is easily damaged by cattle, especially in a wet season. Little mottling is exhibited in the $A_2g$ horizon where the predominant colour is grey but it increases with depth, reaching a maximum in the $B_2g$ and $B_3g$ horizons. The structure of all the horizons is weak and it becomes more massive with depth. A noticeable feature of the $B_3g$ horizon is the iron oxide tubes which preserve the channels formerly occupied by roots. The level of the ground-water often coincides with the upper boundary of the Cg horizon, which in this series has a coarse texture unlike that of the Dess and Terryvale series. The coarse texture may be explained by the fact that the Drumlasie series is commonly situated in depressions near small streams and the parent material has probably been water-worked to some extent.

*Skeletal Soils*

The skeletal soils are mapped in small patches throughout the area of the association. They are always in the vicinity of a rock outcrop. The profile consists of a thin mor humus layer over an A or $A_2$ horizon which rests on granite or granitic gneiss.

Breaking in the land of the Countesswells Association for arable agriculture must have been an arduous and difficult task involving Herculean labour in clearing the boulders. Most of this work was done during or before the beginning of the nineteenth century. The stone dykes now enclosing the land were built from the boulders removed, and some of these structures, known as "consumption dykes", were built to consume the over-plentiful supply of boulders. One runs for a quarter of a mile (Plate 42) and is 20 feet across and some 6 feet high. As a result of the removal of boulders, it is common to see patches of yellowish subsoil on the surface of a ploughed field. Many fast boulders still remain to be cleared and the process of blasting and extracting the pieces takes place with some regularity. When the land in the neighbourhood of Aberdeen was "taken in", there was a market for the boulders which were transported by sea to London for the construction of the docks. On land affected by waterlogging reclamation was effected by digging trenches and filling them with boulders and brushwood, and in this way the drainage was improved.

Today there are few large tracts of arable land in this association unbroken by stone dykes. In the less bouldery areas both field size, 10 to 20 acres, and farms are larger than in the more bouldery areas where an average field might approximate to 6 acres. Within the arable low ground region rock outcrops occur on many knolls and hill tops which are often planted with Scots pine.

Mixed farming based on the six or seven course rotation characteristic of the whole of the north-east region is practised. Oats is the principal cereal. Ten years ago virtually no wheat was grown and only a little barley; now, winter wheat following a potato crop, and a considerable amount of barley are grown. Sufficient roots, grass silage and/or hay are produced to provide, together with oatstraw, winter keep for fattening beef cattle. Concentrates are bought in only to provide the final finish to fatstock or the production ration for dairy cows. Dairying is practised about Aberdeen and Inverurie. Poultry, and to some extent pigs, play a significant part in the economy of many of the farms on this association. On the high-lying farms with access to hill land a flock of Blackface sheep is maintained.

Much of the land above 800 feet is now used for forestry. Extensive plantations of Scots pine, on the drier slopes which have iron podzol soils, and of Sitka spruce, on the non-calcareous gley soils, are established on the hill masses of the Hill of Fare, Bennachie, Cairn William and on many of the smaller hills. Iron podzol soils are the favoured soils for planting and have often carried previous crops of timber but, where ploughing has been undertaken to improve drainage by rupturing the iron pan, large expanses of the peaty podzol soil have been planted. "Notching in" is however the usual method of planting owing to the difficulty of ploughing the boulder-strewn surface. The indurated layer is strongly developed in both the iron podzols and peaty podzols in this association, but it does not prevent the successful growth of trees. Their root systems, however, are unable to penetrate this horizon and form a network on the surface of it. This was clearly seen after the gale early in 1953 which threw down a very large number of trees; all of them had shallow root systems flattening out across the top of the indurated layer. It is apparent that arable crops are subject to the same restriction of root development on the shallow soils and would no doubt benefit from a rupturing of the indurated layer by mechanical means.

Access to a water supply for stock watering purposes presents no problems on this association.

The fertility status of the soils of this association is inherently low, and while the overall standard of farming has markedly improved over the post-war years, there still remain many farms which are low in both lime and phosphate.

## THE CUMINESTOWN ASSOCIATION

The Cuminestown Association is one of the associations developed on till derived from Lower Old Red Sandstone sediments, in this case mainly sandstone. It is not a large association, occurring mostly on Sheet 76 (Inverurie). The main soil type is a freely drained iron podzol.

### DISTRIBUTION

There are two areas of the association, one of 8 square miles extending from Kildrummy Castle to Rhynie and the northern boundary of Sheet 76, and the other, of only three quarters of a square mile, is on the western border of Sheet 87/97 (Peterhead/Fraserburgh) at Newbyth.

### PARENT MATERIAL

On Sheet 76 the parent material is a till derived from Lower Old Red Sandstone sediments, mainly sandstones. The rock, which has been extensively quarried for building stone, while predominantly reddish brown sandstone, contains strata of purple, grey and yellow sandstone, together with gritty and pebbly bands. Thin shale bands and calcareous strata also occur. The till on Sheets 87/97 is derived from sandstones of Middle Old Red Sandstone age, but otherwise it greatly resembles that on Sheet 76. It is thick in the valleys and depressions and thin on the hills and convex slopes. Reddish brown, it has a variable texture, generally a sandy loam on the convex slopes and a clay loam in the hollows. Fragments of sandstones and schists and conglomerate cobbles are consistently present. In the Kildrummy–Rhynie area the association follows the Bogie Valley and lies at an altitude of between 700 and 1000 feet. The Newbyth area occupies a basin at an altitude of 400 to 500 feet. Both occurrences have high ground surroundings.

### SOILS

The dominant soil in the Kildrummy–Rhynie area is the Cuminestown series, which belongs to the major soil sub-group of freely drained iron podzols. The Culbyth and Woodside series, a non-calcareous gley and a peaty gley respectively are co-dominant with the Cuminestown series in the Newbyth area.

*Series*

#### CUMINESTOWN SERIES

The Cuminestown series is developed on a reddish brown sandy loam, occasionally loam, till which is found on the gentle convex slopes. It accounts for 90% of the association in the Kildrummy–Rhynie area and about 33% in the Newbyth area. Most of it is cultivated.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark reddish brown (2·5YR3/4) sandy loam; medium crumb; loose; organic matter moderate; roots abundant; stone content low to moderate, sandstones, quartzite pebbles and mica-schists. Sharp change into |
| $B_2$ | 10–16″ | Reddish brown (2·5YR5/4) loam; weak medium sub-angular blocky; friable; worms present; surface material down worm holes and cracks; roots frequent; few pebbles; fragments of sandstones and schists. Sharp change into |
| $B_3$ | 16–30″ | Reddish brown (2·5YR4/4) loam; medium sub-angular blocky; moderately indurated; roots occasional; moderate stone content with greater proportion of sandstones. Clear change into |
| C | 30″+ | Reddish brown (2·5YR4/4) sandy loam; coarse platy; weakly indurated; sandstone content increasing with depth; roots rare. |

This series is characterised by its reddish brown colour, especially in the $B_2$ and $B_3$ horizons, its free drainage and its weakly or moderately indurated $B_3$ horizon. The stone content increases with depth, in keeping with the proportion of red sandstone.

## CULBYTH SERIES

The Culbyth series occurs on the flatter positions at the foot of long catchment slopes. Its parent material is a loam or a sandy clay loam till, reddish brown with weak coarse prismatic structure. The surface horizon has been partially water-sorted in the Newbyth area, where it borders a broad drainage channel. The series is a poorly drained non-calcareous gley.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark brown (7·5YR4/2) loam; weak medium sub-angular blocky; friable; moderate organic matter; roots abundant; stones few, mainly sandstones, quartzite pebbles and sub-angular schists. Sharp change into |
| $B_2g$ | 10–18″ | Light reddish brown (5YR6/3) sandy clay loam; medium prismatic; firm; low organic matter; few stones; schists highly weathered; few roots; frequent distinct yellowish red (5YR5/8) mottles; prominent grey (5YR6/1) faces round stones and peds. Clear change into |
| $B_3g$ | 18–35″ | Reddish brown (5YR4/3) sandy clay loam; massive; firm; low organic matter; few stones; occasional roots; frequent distinct yellowish red (5YR5/6) mottles; distinct grey (5YR6/1) faces; to peds and stones. Gradual change into |
| Cg | 35–42″+ | Reddish brown (5YR4/3) and pinkish grey (5YR6/2) sandy clay loam; firm; coarse prismatic, occasionally massive; moderate stone content; roots rare; frequent medium distinct yellowish red (5YR5/6) mottles; distinct grey faces to peds and stones. |

This series by comparison with the Cuminestown series is characterised by paler colours, clayier texture and plastic massive clayey horizons. The grey and ochreous mottles are typical of a non-calcareous gley. When the series is uncultivated an $A_2g$ horizon is present, but this has usually been obliterated by cultivation.

### WOODSIDE SERIES

Situated near drainage channels and depressions, the Woodside series is a peaty gley with very poor natural drainage. Its parent material is a partially water-sorted loamy sand or sandy loam overlying a greyish brown sandy clay loam till. Much of the series has been improved for grazing by surface ditching.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | poor quality grass with *Juncus effusus*, *Alnus glutinosa*, *Salix atrocinerea* and *Carex* spp. |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Very dark brown (10YR2/2) peaty sandy loam; many medium rounded stones; fine angular blocky; high organic matter, staining the fingers; abundant roots. Sharp change into |
| $A_2g$ | 10–18″ | Grey-brown (10YR5/2) loamy sandy gravel; single grain; loose; low organic matter but dark brown humus staining in upper part; few medium distinct yellowish red (7·5YR5/6) mottles; abundant roots. Clear change into |
| $B_2g$ | 18–30″ | Light brown-grey (10YR6/2) sandy clay loam; medium prismatic; plastic; low organic matter and no humus staining; frequent roots; iron oxide coatings on old root channels. Gradual change into |
| $B_3g$ | 30–40″ | Pale brown (10YR6/3) sandy clay loam; massive; plastic; low organic matter and no humus staining; occasional roots; iron oxide coatings on old root channels. Gradual change into |
| Cg | 40–46″+ | Light brown (7·5YR6/4) sandy clay loam; massive; plastic; low organic matter; few roots; few iron oxide coatings to old root channels; thick light brown-grey (10YR6/2) coatings to peds—only the core of the ped is light brown. |

This is a very strongly gleyed soil with the top part of the profile developed on gravelly material. Gleying has removed the original reddish brown colour of the till which is completely bleached to a depth of 30 inches. The surface horizon is always high in organic matter. The uncultivated variant has a few inches of H layer. Iron tubes are a characteristic feature of the Bg horizons.

## NOTE ON AGRICULTURE

Many of the farms have access to hill grazings, and the type of farming followed is to a considerable extent determined by the proximity of hill ground. Rearing of both cattle and sheep is the main pursuit of the higher-lying farms with fattening on the lower farms. Cash cropping is not important, although some barley and potatoes are sold off the farm.

The freely drained Cuminestown series is not naturally fertile but it responds well to good fertiliser practice. The poorly drained Culbyth and the very poorly drained Woodside series require an adequate tile drainage system before they can be successfully brought into regular cultivation.

There are no handicaps to cultural operations such as boulderiness or excessive stoniness. Topographically most of the association has gentle slopes and regularly shaped fields divided by stone dykes built of quarried sandstone or in places by wire fences. Some restriction to farming is imposed by the altitude which for most of this association is around 700 feet.

## THE DURNHILL ASSOCIATION

The Durnhill, one of the smaller associations, occupies about 5 square miles (0·5% of the total area). The soils are developed on glacial till derived from rocks rich in quartz—mainly quartzite and quartz-schist. A large part of the association, especially over hilly ground, is covered by a wet moorland vegetation overlying thin till, probably covered in former times by hill peat which has since been used for fuel. The cultivated land lying below the moorland occupies slopes where the till is thicker and contains some admixture of rocks other than quartzite.

### DISTRIBUTION

The association occurs mainly on hill features or on areas of rising ground. A small occurrence is found on Scotstown Moor, north of Aberdeen. Four small areas are located near Auchnagatt. Longer and higher-lying tracts of the association cover the Hill of Dudwick and the adjacent Whitestone Hill, whilst the most extensive and highest-lying area is Mormond Hill (769 feet).

### PARENT MATERIAL

The parent material is a pale yellow till, a stony sandy loam less than 3 feet thick over upland areas and a thicker sandy clay loam on gentle slopes. The contributory rocks are mainly quartz-rich, for example quartzite and quartz-schist. The thicker deposit of till often contains other stones, indicating that the till is farther travelled and the product of a greater variety of rocks. It is nevertheless still very rich in quartz and has the colour and texture characteristic of the till elsewhere in the association.

### SOILS

The dominant soil, the Durnhill series, is a peaty podzol with gleying above a thin iron pan. It is probable that hill peat at one time covered most of this soil but it has been stripped off for fuel. Iron podzols (Ferneybrae series) are not extensive, occurring only on the steeper slopes of Mormond Hill. The remaining series, Kilbady, a non-calcareous gley, and Balloch, a peaty gley, are minor components of the association.

The most notable feature of the association is the dominance of peaty-topped soils. Even the Ferneybrae series, a cultivated iron podzol, was probably a peaty podzol in its natural state but cultivation has eliminated almost all trace of the peaty layers and the thin iron pan. It is only where the thin iron pan had been formed at a considerable depth that it still survives as proof of the natural soil type.

*Series*

#### FERNEYBRAE SERIES

The Ferneybrae series, a cultivated iron podzol with imperfect drainage, occupies moderate to gentle slopes. It is formed on a till of variable thickness which is rich in fragments of quartzite and quartz-schist. Its area amounts to 3·5 square miles, 70% of the association.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grassland |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–9″ | Dark brown (10YR3/4) stony sandy loam; weak medium crumb; loose; organic matter moderate; stones mainly angular pieces of quartzite; roots abundant. Sharp change into |
| $B_2$(g) | 9–18″ | Yellowish brown (10YR5/5) stony sandy loam; weak medium sub-angular blocky; friable; organic matter low; stones mainly angular quartzite; roots frequent; occasional large distinct ochreous mottles; some grey siliceous ($A_2$) material in upper 6 inches. Clear change into |
| $B_3$–C | 18–30″ | Dark yellowish brown (10YR4/4) stony loamy coarse sand; structureless; loose; stones mainly angular quartzite; occasional root penetrates to base of horizon. Sharp change into |
| D | 30″ | Shattered quartzite rock with interstitial filling of finer material. |

The S horizon of stony sandy loam, not particularly rich in organic matter, is predominantly dark grey—due to the mixing of calluna mor humus with the former $A_2$ horizon. A high content of quartzite fragments, which tend to be slightly sub-angular in the surface and sharply angular below, is found throughout the profile. The yellowish brown of the sandy loam $B_2$(g) horizon is in sharp contrast to the dark grey of the S horizon. Frequently large blotches of iron mottling and grey siliceous tongues of former $A_2$ material occur in the upper part. The structure of both these horizons is poorly defined, with a tendency to loose crumb in the surface few inches and, thereafter, to weak medium sub-angular blocky. The consistency of the S and $B_2$(g) horizons is friable. Roots penetrate the whole profile. There is little or no development of an indurated $B_3$ horizon. An increased stone content, with sandy interstitial filling, is found in the C horizon, and the depth at which this is encountered influences the agricultural quality of the land.

The most notable features of this profile are the dark colour of the S horizon and the bright brown of the $B_2$(g). The weakness, or even absence, of induration in the $B_3$–C horizon is often a consequence of the imperfect drainage.

## DURNHILL SERIES

The Durnhill series covers the greater part of the uncultivated moorland in the upland areas, much of which was previously covered with hill peat. Its parent material is a sandy quartz-rich till seldom as much as 3 feet thick. The series covers 2 square miles (40% of the association).

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Calluna vulgaris*, *Erica tetralix*, *Juncus squarrosus*, *Trichophorum caespitosum*, *Cladonia* spp. |
| DRAINAGE CLASS | | free below iron pan |
| *Horizon* | *Depth* | |
| L & F | 8–7″ | Variable thickness due to burning |
| H | 7–0″ | Black well-decomposed mor humus; greasy and plastic when wet; marked shrinkage cracks; medium angular blocky when dry; fine roots plentifully distributed. Sharp change into |
| $A_2$ | 0–4″ | Dark greyish brown (10YR4/2) stony loamy sand; very weak medium sub-angular blocky; friable; fine roots moderate; some dark brown humus staining; dries light grey. Sharp change into |

| | | |
|---|---|---|
| $A_2g$ | 4–8″ | Light olive-grey (5Y6/2) sandy clay loam; coarse platy to massive; plastic; vertical streaks of black humus; fine roots few; stones decomposing; wet. Sharp change into |
| $B_1$ | at 8″ | Thin iron pan |
| $B_2$ | 8–17″ | Yellowish brown (10YR5/6) sandy loam; weak medium subangular blocky; friable; stone content moderate—less than in $A_2$ horizon; a few old roots; organic matter low. Clear change into |
| C | 17–30″ | Brownish yellow (10YR6/6) very stony sandy till passing into shattered angular quartzite rock. |

This series has one of the most striking profiles encountered in the north-east of Scotland. The dull colours of the H and $A_2$ horizons contrast strongly with the bright reddish yellows of the $B_1$ and $B_2$. The thin iron pan ($B_1$) plays a key part in the profile. It forms a continuous sheet beneath the land surface and seals off the top horizons from the part beneath. Water is held up and caused to stagnate or move laterally. Where water is stagnant the consequent gleying of the lower part of the $A_2$ horizon (termed the $A_2g$) is marked. Roots concentrate just above the pan, seldom penetrating to the horizon beneath. Below the iron pan the colours of the horizons ($B_2$ and C) are characteristic of a freely drained soil, uniform and bright. In a few localities the till is deep enough for the $B_3$ indurated horizon to form. Where present, this is characterised by an olive-grey colour and a platy structure.

### KILBADY SERIES

Depressional areas surrounded by extensive stretches of higher ground are the typical sites of the Kilbady series. The only areas of any size occur on the northern slopes of Mormond Hill where ground-water affects the soils. The parent material, a stony till, is quite thick.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle to moderate |
| VEGETATION | | rotational grassland |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark brown (10YR3/3) sandy loam; medium to coarse subangular blocky; friable; stone content moderate; roots abundant; organic matter high; some rusty mottles along root channels. Sharp change into |
| $B_2g$ | 8–20″ | Pale brown (10YR6/3) sandy loam; friable; weak coarse prismatic; organic matter low; roots frequent; many small stones, quartzite and quartz-schist; frequent yellow and grey mottles; grey patches from decomposing quartz-schist. Clear change into |
| Cg | 20–36″ | Yellowish brown stony loamy coarse sand; structureless; wet; non-plastic; many coarse distinct ochreous mottles; fewer grey mottles; roots occasional; stones increasing with depth. |

The outstanding features of this profile are the grey and ochreous mottles, especially prominent in the $B_2g$ and Cg horizons, the quartz-rich stones which increase with depth, and the dark colour of the S horizon.

### BALLOCH SERIES

The Balloch series is found on the Hill of Dudwick, in three small areas affected by run-off and ground-water from adjacent higher ground. The profile is typical of the peaty gley group of soils, having a few inches of black

PLATE 3.

The Tipperty series, a brown forest soil with gleyed B and C horizons, developed on red lacustrine clay (Tipperty Association).

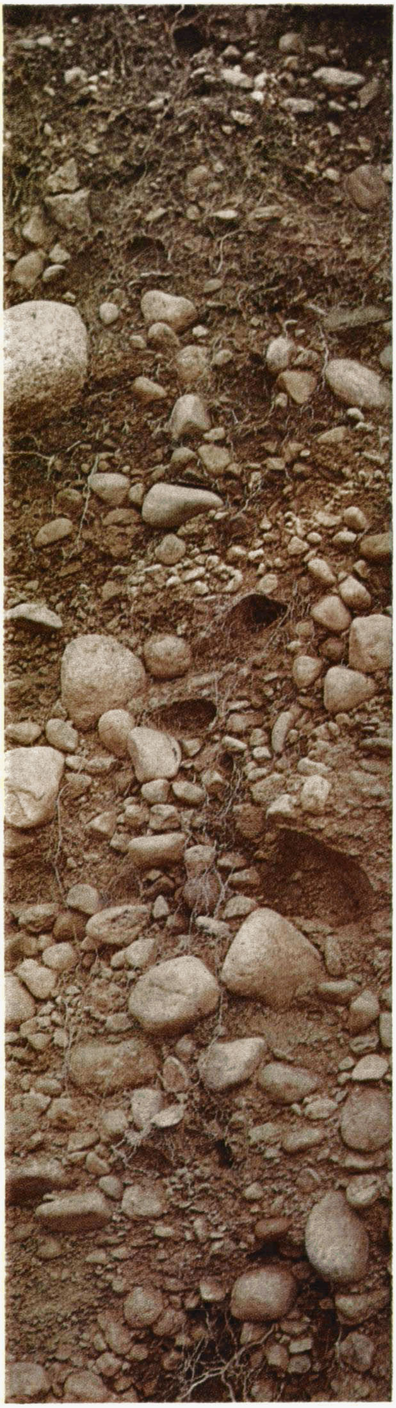


PLATE 4.

The Corby series, an iron podzol developed on water-sorted sand and gravel (Corby Association).

mor overlying grey (5Y5/1) sandy clay loam. The profile is normally wet and, consequently, the structure is weak. Iron oxide tubes go down to about 18 inches, below which the colour is a uniform shade of grey.

*Skeletal Soils*

Most of the skeletal soils of this association are found on Mormond Hill. They generally have an AC profile in which a relatively thin mor humus layer overlies shattered quartzite rock. There is virtually no trace of a B horizon.

### Note on Agriculture

The soils of the Durnhill Association are inherently very low in nutrients. Their texture is coarse, and regular applications of farmyard manure are required to increase their water-holding and exchange capacities. Lime and liberal applications of fertilizer are essential for good returns. Most of the farms on this association are small.

## THE FOUDLAND ASSOCIATION

One of the larger associations in north-east Scotland, the Foudland Association occupies 104 square miles, about 10% of the whole area. It is developed on till from argillaceous schist and slightly metamorphosed rocks of the Highland Schist formation. The soils, fine sandy loams, are predominantly freely drained, and occupy smooth gently to strongly rolling countryside.

### Distribution

The association occurs only on Sheets 76 (Inverurie) and 87 (Peterhead), in the former mainly as uncultivated hill land and in the latter mainly as arable land. The largest single body of the association on Sheet 76 is over the Correen Hills, of which Badingair Hill (1556 feet) is the highest point. These hills are heather-covered, except for rather high-lying marginal farms situated on their eastern slopes. Another large area, mostly hill ground, has been mapped on the west side of the Bogie Water at Lumsden, extending from Clayhooter Hill (1785 feet) in the north to Garlet Hill (1596 feet) in the south, and westwards beyond the margin of the map. A small body of the association occupies the summit of Corrennie Forest (1621 feet) in the central part of the sheet.

On Sheet 87 the association extends along the western side from the vicinity of Oldmeldrum to New Pitsligo in the north, and is an extension of the association from the adjacent Sheet 86 (Huntly).

Hilly topography is characteristic of the association on Sheet 76, and gently to strongly rolling topography on Sheet 87.

### Parent Material

The parent material is a till derived from weakly metamorphosed rocks of the Highland Schist formation, the constituent rocks varying from argillaceous schist through andalusite-schist (spotted schist) to a very fine grained mica-schist, coarse grained felspathic grits and quartzose pebbly grits. The till on the well-drained sites is yellowish brown and of fine sandy loam texture.

It contains a moderate to high content of flat, angular, rock fragments which generally measure about 4 inches long, 2 inches broad and less than 1 inch thick. The silt content (2–50$\mu$) of the till almost invariably exceeds the clay content.

Mechanical analysis shows the silt content of most of these soils to be just under 50%, the clay ($<2\mu$) about 20% and the sand (50–2000$\mu$) between 30% and 40%. The texture of the surface soil, as distinct from that of the till, ranges from fine sandy loam and loam in all the freely drained series to sandy clay loam in the poorly and very poorly drained series.

The Correen Hills and the hills west of the Bogie Water at Lumsden are mainly underlain by andalusite-schist rock, with lesser amounts of argillaceous schist and knotted schist. Though lithologically distinctive these rocks do not produce recognisably different tills as soil parent material. The average thickness of till over the hill areas is about 3 feet, although pockets occur where it is much thicker and likewise local eminences occur where it is very thin. The underlying rock is steeply folded and shattered, so that the till mantle rests on a very permeable substratum which allows surplus gravitational water to drain away.

Knotted schist is the major rock type contributing to the parent material of the association within Sheet 87, but north of a line drawn east and west through New Deer, and extending into Sheet 97 (Fraserburgh), felspathic grit rocks are dominant. When the felspathic grit influence is high the soils tend to have a coarser texture, of the order of sandy loam rather than fine sandy loam. Along the eastern margin of the association, where it abuts the Tarves Association, there is a band of soils (about half-a-mile wide) developed on schists which were contact-altered at the time of the intrusion of the Arnage and Maud basic igneous masses. These soils are most easily viewed in two localities, one east of Methlick, from Andet and Flinthills in the south to Castlehill in the north, and the other south and north of New Deer. They do not differ greatly from the soils developed on till from andalusite- or knotted schist, although the contact-altered schists themselves are harder and not so readily weathered.

## SOILS

As in the case of the Countesswells, Insch and Tarves Associations, the Foudland Association has a wide range of altitude, from 250 to 1750 feet. As well as skeletal soils, five series have been distinguished, comprising peaty podzols, iron podzols with free and imperfect drainage, non-calcareous gleys and peaty gleys. Soils with free drainage in the B and C horizons cover approximately 95% of the area and are distinguished as either the Foudland series (iron podzols) or the Suie series (peaty podzols). Brown forest soils of low base status have not been separated in this association, although those iron podzol profiles which are on the most favourable sites come very close to the brown forest soil in morphology. It is probable that all three major soil sub-groups (brown forest soils, iron podzols and peaty podzols) were at one time present in what is now farmland. Of these, the freely drained iron podzol was probably the most widespread. For this reason all the freely drained arable land belonging to this association has been mapped as iron podzols (Foudland series).

## FOUDLAND SERIES

The Foudland series is developed on a fine sandy loam till, often with a high content of schist chips and stones, especially in the lower horizons. It is the most extensive series of the Foudland Association accounting for about 80% of the association (83 square miles). Its drainage class is free, and it belongs to the major soil sub-group of iron podzols. As most of the series is under cultivation in this area, the characteristic vegetation is really a farm crop. On those parts which are uncultivated the vegetation is often *Calluna* heath.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderately steep to gentle |
| VEGETATION | | *Calluna vulgaris, Erica cinerea, Vaccinium vitis-idaea, V. myrtillus, Pteridium aquilinum, Teucrium scorodonia, Digitalis purpurea, Anemone nemorosa, Festuca ovina, Deschampsia flexuosa* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 3½–2½″ | Litter |
| F | 2½–½″ | Partially decomposed litter |
| H | ½–0″ | Black (10YR2/1) well-decomposed mor humus. Sharp change into |
| $A_2$ | 0–4½″ | Dark grey-brown (10YR4/2) sandy loam; weak fine sub-angular blocky; friable; roots frequent; moderate content of schistose chips. Sharp change into |
| $B_2$ | 4½–10″ | Brownish yellow (10YR6/8) silty fine sandy loam; weak sub-angular blocky; friable; moderately stony; low organic matter; frequent roots; no mottles. Sharp change into |
| $B_3$ | 10–30″ | Olive-yellow (5Y6/5) stony fine sandy loam; moderately indurated; moderate coarse platy; some ochre smears from weathered rocks; occasional roots; low organic matter. Gradual change into |
| C | 30″+ | Pale olive (5Y6/4) very stony fine sandy loam with fine material in the interstices; no organic matter; no roots; no mottles; structure indeterminate. |

The L, F and H layers together rarely exceed 5 inches and the H layer 2 inches. The $A_2$ horizon, which can vary from ½–5 inches, generally lacks the silty feel of the underlying layers. On drying it changes to grey (5Y6/1), in striking contrast to the brownish yellow (10YR6/8) of the $B_2$ horizon. The $A_2$ horizon has a weak fine sub-angular blocky structure and the $B_2$ horizon a medium sub-angular blocky structure, with a soft friable consistency. It has a comparatively low content of stones and these are coated with material more silty than the rest of the horizon. A sharp change in colour and structure marks the $B_3$ horizon, which is distinguished by a coarse platy structure and a weak or moderate degree of induration, significantly less than in the freely drained series of the Countesswells, Tarves and Insch Associations. Stones in this horizon tend to lie parallel to the land surface and often have a clean surface when pulled out although they leave silt-lined cavities. With depth, the induration decreases and the stone content increases, so that the C horizon consists of rock rubble with finer material in the interstices. The colour of the interstitial material is pale olive (5Y6/4) to yellow (5Y7/6).

The cultivated soil has a dark grey-brown (10YR4/2) S horizon, 8 inches thick, which is either a loam or a fine sandy loam. It contains a fairly high proportion of large (6 inch) flat stones but no boulders. From the $B_2$ horizon downwards the profile is similar to the above.

## MAIRLENDEN SERIES

The Mairlenden series is not extensive. It occurs only on Sheet 76 (Inverurie), in small scattered areas, notably on the formerly cultivated slopes west and south of the Hill of Millmedden, north-west of Alford about Tulloch Farm, and between the farms of Upper Balfour and Bogbraidy. Several minor occurrences are found in the Correen Hills.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | good rotational grassland |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–9″ | Dark grey-brown (10YR4/2) fine sandy loam; medium crumb; friable; moderate organic matter; moderate stones—small pieces of knotted schist; frequent roots. Gradual change into |
| $B_2$(g) | 9–15″ | Yellowish brown (10YR5/4) loam; weak coarse sub-angular blocky; friable; frequent roots; low organic matter; moderate stones; frequent medium distinct ochreous mottles. Sharp change into |
| $B_3$(g) | 15–25″ | Yellowish brown (10YR5/4) loam; moderate coarse blocky; compact; few roots; moderate stones weathered and some decomposing; frequent medium distinct ochreous and grey mottles. Gradual change into |
| C(g) | 25″+ | Yellowish brown (10YR5/4) stony loam; massive; firm; occasional roots; frequent medium distinct ochreous and grey mottles. |

The surface horizon varies between 9 and 12 inches and resembles that of the freely drained Foudland series. The change into the $B_2$(g) is a merging one, and were it not for a brightening of the colour, due to lower organic matter, the horizon might be considered a deep surface layer. Some mottling is associated with this horizon. A more pronounced structure, accompanied by a degree of induration, is noticeable in the $B_3$(g) horizon. Mottling of ochre and grey is marked, and many of the schistose stones can be crumbled with the fingers. There is little change with depth other than that the structure becomes more massive as wetness increases. The series is classed as an iron podzol with imperfect drainage.

## SUIE SERIES

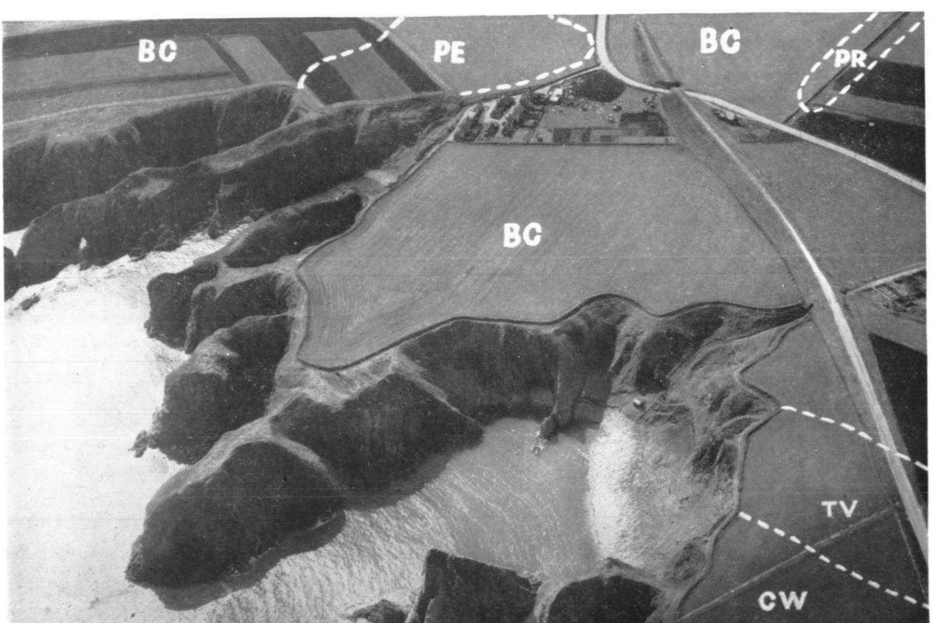
The Suie series is found on the summit of the Correen Hills and on the hills of Clayhooter, Clova, Broom, Garlet and Corrennie Forest, most of which are above 1500 feet. Situated on moderately sloping ground, which in the main is dominantly covered by heather, this series accounts for approximately 14% of the association (14·6 square miles). It is a member of the major soil sub-group of peaty podzols and is freely drained in the lower horizons.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Calluna vulgaris, Erica tetralix, Trichophorum ca spitosum, Cladonia* spp. |
| DRAINAGE CLASS | | free below the iron pan |
| *Horizon* | *Depth* | |
| L | 7½–7″ | Litter |
| F | 7–6″ | Partially decomposed litter |
| H | 6–0″ | Black (10YR2/1) greasy humus |

(*By courtesy of Geography Department, University of Aberdeen*)

PLATE 29
Characteristic topography of the Peterhead and Collieston Associations.




(*By courtesy of Aberdeen Journals Ltd.*)

PLATE 30
The Bullers of Buchan and North Haven with soil boundaries superimposed.

[*Facing page* 132]

(*By courtesy of Geography Department, University of Aberdeen*)

PLATE 31
Dunnideer Hill with remains of castle and vitrified fort; Foudland Hills in background.

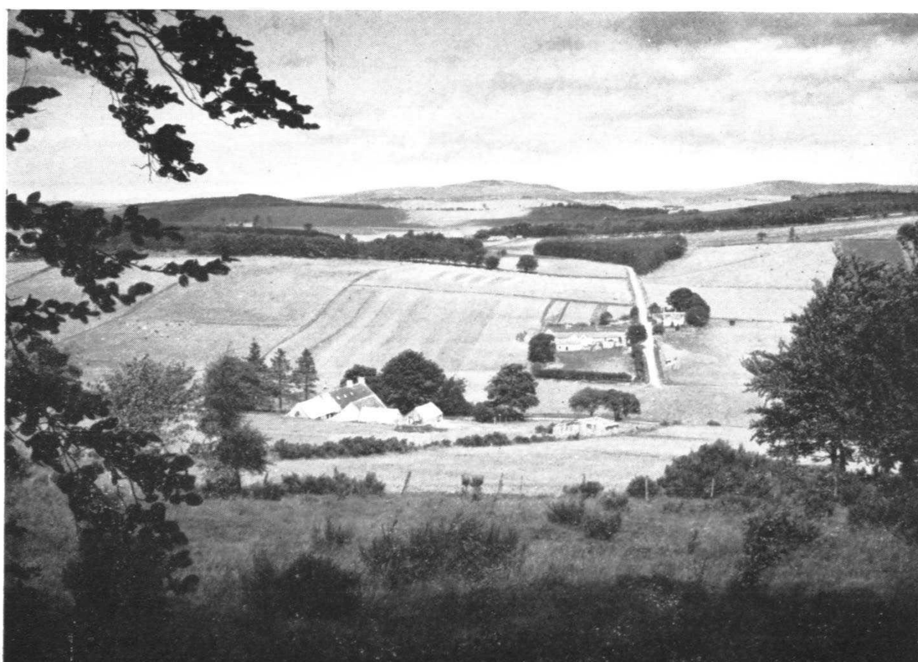


PLATE 32
The Howe of Alford, typical farmland of the Tarves Association.

| | | |
|---|---|---|
| $A_2$ | 0–3″ | Dark grey (10YR4/1) sandy loam; fine sub-angular blocky; friable; high organic matter; abundant roots; strongly bleached on drying out. Sharp change into |
| $B_1$ | at 3″ | Thin $\frac{1}{16}$ inch iron pan |
| $B_2$ | 3–8″ | Yellowish brown (10YR5/4) fine sandy loam; weak medium sub-angular blocky; friable; low organic matter; no roots; many schist stones. Sharp change into |
| $B_3$ | 8–15″ | Light olive-brown (2·5Y5/4) stony loamy sand; moderate medium platy; moderately indurated; low organic matter; no roots; high content of schist stones. Clear change into |
| C | 15–20″ | Light olive-brown (2·5Y5/4) stony loamy sand; structureless; friable; low organic matter; no roots; high content of schist stones. Sharp change into |
| D | 20″ | Shattered knotted schist rock, with interstitial filling of fine sand. |

Where the land has not been burned over for a long time the organic layers are about 12 inches thick and the vegetation an open stand of tall *Calluna vulgaris*, but where burning is practised, the organic layers are thinner and *Calluna vulgaris*, although it is still dominant, now forms a close mat less than 9 inches tall. The $A_2$ horizon, which has a gritty feel, is a prominent horizon, especially on exposure, when it dries to a light grey. If the thin iron pan ($B_1$) is impermeable the lower part is often gleyed. Most roots stop at the iron pan, unless the pan is rudimentary and not strong enough to act as a barrier. A brighter brown colour, almost an orange brown, marks the $B_2$ horizon. Moderate induration and a paler colour are characteristic features of the $B_3$ horizon. There is also a high stone content which increases with depth until shattered rock is reached at approximately 2 feet.

### FISHERFORD SERIES

The Fisherford series is developed on a loam till which, on the basis of the American silt values (2–50$\mu$), is almost a silt loam, with approximately 50% silt. It is located on the gentle to moderate foot-slopes of the valleys and is affected by the regional water-table. In Sheet 76 (Inverurie) a large part of this series is uncultivated, whereas, in Sheet 87 (Peterhead), it is almost all arable land. Compared with the Foudland series it is not extensive, amounting to only 5 to 6% of the association. The series belongs to the major soil sub-group of non-calcareous gleys.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–12″ | Very dark grey-brown (10YR3/2) loam; weak sub-angular blocky, breaking easily to crumb; friable; medium organic matter; abundant roots in top 6 inches—frequent in lower 6 inches; moderate stones; occasional small rusty mottle from decomposed stone. Sharp change into |
| $B_2g$ | 12–18″ | Grey-brown (2·5Y5/2) loam; weak angular blocky; firm; low organic matter; occasional roots; moderate stones; frequent distinct medium light brown-grey (2·5Y6/2) and few prominent medium yellowish red (5YR4/8) and strong brown (7·5YR5/6) mottles. Clear change into |

| | | |
|---|---|---|
| $B_3g$ | 18–28″ | Grey-brown (2·5Y5/2) loam; weak medium prismatic; firm; low organic matter; rare roots; moderate stones; occasional small boulder; few distinct medium light brown-grey (2·5Y6/2) and few fine prominent yellowish red (5YR4/8) and strong brown (7·5YR5/6) mottles. Gradual change into |
| Cg | 28–40″ + | Grey-brown (2·5Y5/2) loam; massive; no roots; moderate stones; mottling is only associated with decomposition of rock chips. |

Grey is the dominant colour from the surface down to the parent material. Against this background strong brown mottling, which is most prevalent in the $B_2g$ horizon, stands out. The S horizon has a blocky structure and is less inclined to form hard peds when dry than the S horizons of many of the cultivated, non-calcareous gley soils belonging to other associations. The structure of the $B_2g$ and $B_3g$ horizons is not strongly developed, partly because of their loamy texture, and partly because these horizons are mostly wet. The Cg horizon has either a weak coarse prismatic or a massive structure. A high silt content gives a smooth feel to the soil material of all the horizons which, moreover, cannot readily be removed from the fingers after texturing. Stones are common throughout the profile, most of them showing signs of decomposition in the $B_2g$ and $B_3g$ horizons. The depth to bedrock is probably from 8 to 12 feet.

### SHANQUHAR SERIES

This series, located in depressions and in the vicinity of water courses, has a scattered distribution and is generally too small in extent to be shown on the maps. In all, the area on the maps amounts to less than 0·1 square mile, and the series is, therefore, of slight practical importance, although a small part of it is under cultivation. It is a very poorly drained series and belongs to the major soil sub-group of peaty gleys.

#### PROFILE DESCRIPTION

SLOPE — gentle

VEGETATION — *Juncus effusus, Deschampsia caespitosa, Polytrichum commune*

DRAINAGE CLASS — very poor

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–11″ | Dark brown (7·5YR3/2) humose loam; abundant roots; low content of stones and mineral matter; frequent fine distinct rusty mottling along root channels. Sharp change into |
| $A_2g$ | 11–15″ | Dark brown (7·5YR4/2) loam; massive; plastic; patches of organic staining; moderate organic matter; abundant roots; few stones; few faint ochreous mottles. Sharp change into |
| $B_2g$ | 15–24″ | Grey-brown (2·5Y5/2) loam; massive; plastic; low organic matter; moderate stones; many well-formed iron oxide tubes round old root channels; few roots. Clear change into |
| $B_3g$ | 24–36″ | Grey-brown (2·5Y5/2) loam; massive; plastic; low organic matter; moderate stones; few iron oxide tubes round old root channels; very few roots. Gradual change into |
| Cg | 36–48″+ | Grey-brown (3·5Y5/2) loam; massive; plastic; low organic matter; moderate stones; very few iron oxide tubes round old root channels; no roots. |

The colour of the Bg horizons is similar to that of the Fisherford series. They exhibit a massive structure with only very slight ochreous mottling, the presence of iron tubes, especially in the $B_2g$ horizon, being characteristic.

*Skeletal Soils*

Skeletal soils are found on summit positions in the Correen Hills, about Suie Hill, Black Hill and Lord Arthur's Cairn. For the most part shattered schistose rock occurs near the surface, though occasionally a thin covering of black mor humus overlies the rock which is then strongly bleached.

### Note on Agriculture

On Sheet 76 (Inverurie), the greater part of the association consists of the uncultivated hill ground of the Correen Hills, and of the hills lying to the west of the Bogie Water. Extensive coniferous plantations once occupied the hill flanks (below 1500 feet) in the latter area. These were cut during the two world wars but have been largely replanted. Large plantations also occupy the eastern slopes of the Correen Hills and the western are about to be planted. The summits of some of these hills, however, are still heather moor, of use only for sheep and grouse.

Two properties of the hill soils in this association favour afforestation. On long moderate slopes they are both inherently freely drained and free from stones of a size to interfere with planting operations. Iron podzols are predominant on the lower slopes and peaty podzols with iron pan on the upper slopes. For afforestation purposes it is customary to plough at a spacing of 5 feet prior to planting, and, in so doing, to rupture any pan that may be present. This prevents surface waterlogging and allows roots to penetrate into the $B_2$ horizon. Those hills not devoted to forestry are used for hill sheep farming, the Blackface breed being the most popular.

On Sheet 87 (Peterhead) the association is all arable, with the exception of plantations on the Haddo Estate near the River Ythan. The whole of this part of the association lies between the 250 and 550 foot contours and has a marked rolling relief. Here again the soils are mainly freely drained, and consequently present few problems to the farmer as long as adequate amounts of lime and fertilizer are applied and organic matter is replaced.

The landscape is divided by wire fences into fields which are conveniently rectilinear.

This is an area of mixed farming with rather more emphasis on animals than crops. Both stock rearing and fattening are practised and are about equal in importance. Poultry husbandry also figures quite prominently in the economy of many of the farms. Grass and turnips are the principal crops used for the rearing and fattening of stock, and the six course rotation which is generally followed provides ample supplies of both. Half the farm is under grass for hay or pasture, one-third in grain, mostly oats, and the remaining sixth in turnips and potatoes. Barley, when grown, oats and potatoes are the principal cash crops.

A supply of water for stock is a problem over the upper slopes of many of the broad hills within this association.

Shelter belts were at one time a feature of the landscape of this association on Sheet 87 (Peterhead), but most of them have been felled and have not been replanted; in consequence the countryside looks bare, bleak and exposed.

## THE FRASERBURGH ASSOCIATION

This association is very small, amounting to only 1 square mile. Its main development is between Fraserburgh and Rosehearty and immediately to the south of Rattray Head. Two series, the Fraserburgh and the Whitelinks, have been mapped.

### Parent Material

The parent material is an aeolian shelly sand which occurs below an altitude of 100 feet. In the Rosehearty–Fraserburgh area the deposits lie adjacent to the shore, but south of Rattray Head they are separated from the shore by soils of the Links. Varying in thickness from 2 to 20 feet, the deposits are calcareous throughout. Where the sand is thin it is underlain by a silty, estuarine or marine deposit.

### Soils

The association has representatives of only two series, the freely drained Fraserburgh series and the poorly drained Whitelinks. The Fraserburgh series is developed on yellowish brown shelly sand which often remains unchanged to a depth of over 10 feet. Siliceous sand has sometimes been blown on to the calcareous deposit from the less stable dunes and links. The Whitelinks series is developed on shelly sand, between 2 and 3 feet thick, overlying a dark grey silty clay which holds up the ground water and is responsible for the series being poorly drained.

*Series*

#### FRASERBURGH SERIES

The Fraserburgh series in the immediate vicinity of the dunes is often uncultivated and has only a trace of silt and clay in the surface soil. Away from the dunes the series is cultivated, and although the sand content exceeds 75%, a small percentage of silt and clay is present throughout the profile. The series is a freely drained brown forest soil.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | free to excessive |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark brown (10YR4/3) shelly sand; weak fine crumb; loose; organic matter moderate; roots abundant; occasional pebbles. Sharp change into |
| $B_3$ | 17–29″ | Dark yellowish brown (10YR4/4) loamy sand; medium crumb; occasional roots; low organic matter; occasional pebbles. Clear change into |
| $B_3$ | 17–29″ | Dark yellowish brown (10YR4/4) loamy sand; medium crumb; slightly indurated; roots rare; low organic matter; occasional pebbles. Gradual change into |
| C | 29″+ | Yellowish brown (10YR5/4) shelly coarse sand; single grain; loose. |

The dark brown surface soil has a comparatively poor structure and a loose rather than friable consistency, although the organic matter appears to be average. There may be a few pebbles but this is not a common feature. The $B_2$ horizon has a similar texture to the S horizon but its brown colour is lighter and its structure is weaker. A slight induration, which appears to be correlated with a small increase in silt content, occurs in the $B_3$: the colour is a little darker than that of the $B_2$ horizon but not as dark as that of the S. A recognizable $B_3$ is not a consistent feature but is more common with increasing contamination of the shelly sand deposit with siliceous material.

On passing into the C horizon the pebble and gravel content sometimes increases, but it is more usual to find the shell sand continuing unchanged for 5 feet or more.

### WHITELINKS SERIES

The Whitelinks series has developed on sites underlain by a deposit of silty clay similar to that of the Blackwater Complex. This series occurs on level or depressed sites bordering the soils of the Links, south of Rattray Head. The drainage class is poor, due to the presence of a high water-table which in many instances is related to the presence of the impervious clay within 2 to 3 feet of the surface. The series belongs to the sub-group of calcareous gleys.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark grey-brown (10YR4/2) loamy shelly sand; weak medium sub-angular blocky, breaking to medium crumb; soft and friable; moderate organic matter; roots very abundant in top 3 inches, frequent below; no stones; no mottling. Clear change into |
| $B_2g$ | 8–18″ | Dark yellowish brown (10YR4/4) loamy sand; weak medium prismatic; low organic matter; roots frequent; occasional pebbles (1 cm.); frequent medium distinct ochreous mottles in lower part. Sharp change into |
| $B_3g$ | 18–24″ | Pale brown (10YR6/3) to dark grey (5Y4/1) sand with intercalations of silt; amorphous; plastic; very moist; low organic matter; roots rare; no stones; frequent distinct medium ochreous mottles. Gradual change into |
| Cg | 24–40″ | Dark grey (5Y4/1) clay; massive; plastic; wet; roots rare; low organic matter; mottling as in above horizon, fading with depth; occasional weakly-formed iron oxide tubes associated with fossil root channels. |

The series is a calcareous gley with free carbonate throughout. In the S horizon the colour is greyer than in the freely drained surface soil and the structure is weak, the peds breaking into crumbs. The $B_2g$ horizon has a similar texture to the S, but the horizon is moister and the lower part has a weak medium prismatic structure. It has a higher chroma than the S horizon and ochreous mottles occur and increase with depth. The $B_3g$ horizon has an amorphous structure and is wet. It is variable both in colour and texture having horizontal lenses of grey silt and frequent ochreous mottles. Dark grey silty clay, massive and plastic with some mottling and iron tubes, forms the Cg horizon.

### NOTE ON AGRICULTURE

The area of this association is small and most farms have only a part of their land on it. The porous nature of the soils of the Fraserburgh series makes them susceptible to drought; while this becomes an acute problem only once in every few years, nevertheless the low moisture retention capacity causes pastures to deteriorate rapidly. Manganese deficiency in oats has been found in this area.

In the eighteenth century shell sand was dug for liming purposes at Phingask and the inhabitants are said to have bartered one cart-load of shell sand for one of peats.

# THE HATTON ASSOCIATION

The Hatton Association, situated in the extreme north-west corner of Aberdeenshire and the adjacent part of Banffshire, is not extensive in the region dealt with in this account. It occurs only within the boundaries of Sheet 87/97 (Peterhead/Fraserburgh) to the extent of approximately 10 square miles. The parent material, a reddish brown till, imparts a reddish colour to the soils of which the dominant Hatton series is a freely drained iron podzol.

## DISTRIBUTION

The association occurs as a single area about Windyheads Hill which lies to the north of New Pitsligo. In just over 2 miles the country rises from the sandstone cliffs of the Moray Firth coast to a height of 750 feet. The high ground, on Windyheads Hill, is deeply dissected by meltwater drainage channels and the main one, known as the Tore of Troup, has steep sides which in places rise to 400 feet above the bed of the stream. East of this main channel are smaller but well-defined channels running both parallel and at right-angles to it, with the result that the country is rough and broken. South of Windyheads Hill the landscape becomes smoother and falls to a peat-filled basin drained by the Glaslaw and Gonar burns.

## PARENT MATERIAL

The parent material is glacial till derived from sediments of the Middle Old Red Sandstone formation. The rocks vary from coarse conglomerate to grey and red marl containing limestone nodules. The conglomerate bands, however, appear to exert the greatest influence on the parent material which on convex slopes is a stony sandy loam and on concave slopes a stony sandy clay loam. The influence of the high lime strata is observed only in patches along the steep sides of the Tore of Troup, where brown forest soils and plant species such as primrose and wild strawberry indicate more base-rich conditions.

## SOILS

The soil series represented in the association comprise brown forest soils of low base status, iron podzols, peaty podzols, non-calcareous gleys and peaty gleys. The uncultivated moorland occupying the summit of the Windyheads Hill and its south and west flanks is largely dominated by peaty podzols. The arable land is best considered an iron podzol, although some of it, judging by the remnants of iron pan still to be seen below the plough layer, was once a peaty podzol. Brown forest soils are developed on the most favourable sites, such as the steep slopes of the Tore of Troup where instability has a rejuvenating effect on the soil and occasional bands of marl give a higher base status. The poorly drained non-calcareous gleys are found in particular throughout the southern part of the association where there are gentle slopes and till with a clay loam texture. Very poorly drained peaty gleys with surface horizons rich in organic matter occur in depressions and channels receiving drainage water from the surrounding higher ground.

*Series*

### CHAPELDEN SERIES

The Chapelden series, a brown forest soil of low base status, is found on the steeply sloping banks of the Tore of Troup under a semi-natural vegetation containing birch, gorse and bracken. The angle of slope, between 30° and 40°, causes soil-creep and this has a rejuvenating effect, particularly on the surface horizons. Grazing by cattle and sheep is a further aid to soil movement. While the internal drainage of the soils is free, wet patches due to seepage appear intermittently along the slopes. Considerable variation of slope and stability of site occurs within the series.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | steep |
| VEGETATION | | *Betula pubescens/B. verrucosa, Sarothamnus scoparius, Ulex europaeus, Pteridium aquilinum, Scabiosa succisa, Teucrium scorodonia, Primula vulgaris* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 0–1″ | Loose fibrous litter |
| A | 1–7″ | Brown (7·5YR5/4) sandy loam; moderate medium to fine crumb; very friable; moderate organic matter; roots abundant; stones, mainly O.R.S. cobbles, moderate; no mottles. Gradual change into |
| $B_2$ | 7–18″ | Light brown (7·5YR6/4) sandy loam changing with depth into light reddish brown (2·5YR6/4) loam; weak, fine granular; friable; low organic matter; stoniness extremely variable; roots frequent. Gradual change into |
| C–D | 18″+ | Reddish brown (2·5YR5/4) decomposed rock (conglomerate, sandstone, or marl), variable in texture and hardness. |

In the S horizon there are no obvious signs of podzolization, but close inspection sometimes reveals individual bleached sand grains. Few mottles are present in any horizon of the profile, a characteristic in keeping with its free drainage. The $B_2$ horizon is relatively deep and is friable and well permeated with roots. Although most freely drained series have a $B_3$ horizon which exhibits induration, the Chapelden series is colluvial and does not have one, soft rock occurring immediately below the $B_2$ horizon.

## MIDDLEHILL SERIES

This series is a brown forest soil with gleyed B and C horizons. It is not very extensive (2·2 square miles) yet it accounts for approximately 20% of the association. Usually it occurs on the foot-slopes of small hills and plateaux and is suitable for cultivation.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–7″ | Dark brown (10YR3/3) sandy loam; moderate medium crumb; moderate organic matter; roots abundant; many stones, mainly O.R.S. cobbles; occasional boulders; occasional faint yellowish brown (10YR5/6) mottles. Sharp change into |
| $B_2(g)$ | 7–15″ | Brown (7·5YR4/4) sandy clay loam; fine sub-angular blocky breaking easily to crumbs; low organic matter; roots frequent; many stones, mainly O.R.S. cobbles; occasional boulders; frequent distinct yellowish brown (10YR5/6) mottles. Clear change into |
| $B_3(g)$ | 15–25″ | Brown (7·5YR5/4) sandy clay loam; medium sub-angular blocky; low organic matter; roots occasional; many stones, mainly O.R.S. cobbles; few faint yellowish brown (10YR5/6) mottles. Gradual change into |

| | | |
|---|---|---|
| C(g) | 25–38″ | Strong brown (7·5YR5/6) sandy clay loam; medium sub-angular blocky; low organic matter; roots absent; many stones, mainly O.R.S. cobbles; very few faint yellowish brown (10YR5/6) mottles. |

This series is developed on a thick deposit of till which has a sandy clay loam texture. Mottles are most frequent in the $B_2$(g) horizon and very rare or absent in the C(g) horizon. The structural units are larger and less rounded in the B(g) and C(g) horizons than in the S horizon. Unlike the Chapelden series, this series has a low permeability.

### HATTON SERIES

Developed on reddish brown, stony sandy loam till, the Hatton series generally occurs on moderate north-facing slopes. The quartzite cobbles from the underlying conglomerate rock are often sufficiently concentrated to interfere with cultivation and cause wear and tear on implements. The series is a freely drained iron podzol and most of it is under cultivation.

#### PROFILE DESCRIPTION

SLOPE moderate
VEGETATION rotational grass
DRAINAGE CLASS free

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–7″ | Dark brown (10YR3/3) stony sandy loam; medium crumb; organic matter moderate; high to excessive content of rounded cobbles mainly red-stained quartzites, occasional boulders; roots abundant in top 3 inches, thereafter frequent. Sharp change into |
| $B_2$ | 7–15″ | Brown (7·5YR4/4) stony sandy loam; fine sub-angular blocky; stones as above; moderate organic matter; roots frequent; few yellowish brown (10YR5/6) mottles toward base. Gradual change into |
| C | 15–40″+ | Strong brown (7·5YR5/6) stony, sandy clay loam; medium sub-angular blocky; stones slightly less frequent; very few yellowish brown (10YR5/6) mottles in top 3 inches; organic matter low; roots occasional to 24 inches. |

This series is notable for the substantial difference in clay content between the C horizon and the rest of the profile. This is believed to be a parent material difference and not one due to pedological processes. Sometimes an indurated $B_3$ horizon is present between the $B_2$ and C horizons. Stoniness is a marked feature of this series: on a volume basis the S horizon contains over 50% cobbles.

### WINDYHEADS SERIES

The Windyheads series, a peaty podzol, occurs on Windyheads Hill at an altitude of between 600 and 750 feet on the moderate slopes below the plateau-like summit of the hill. Hill peat has been removed from parts of this area. The series accounts for 15% of the association or 1·5 square miles.

#### PROFILE DESCRIPTION

SLOPE moderate
VEGETATION *Calluna vulgaris*, *Erica tetralix*, *Trichophorum caespitosum*, *Cladonia* spp.
DRAINAGE CLASS free below iron pan

| *Horizon* | *Depth* | |
|---|---|---|
| L | 9–8″ | Litter |
| F | 8–6″ | Partially decomposed litter. Sharp change into |

| | | |
|---|---|---|
| H | 6–0″ | Black (10YR2/1) greasy humus |
| $A_2$ | 0–6″ | Dark grey (10YR4/1) cobbly, coarse sandy loam; high content of quartz minerals; coarse sub-angular blocky; firm; dark brown organic staining in horizontal bands; roots abundant. Sharp change into |
| $A_2g$ | 6–9″ | As above but wet; cobbly sandy loam; weakly plastic; root concentration at base. Sharp change into |
| $B_1$ | at 9″ | Thin $\frac{1}{16}$ inch iron pan |
| $B_3$ | 9–20″ | Brown (7·5YR5/4) stony sandy loam; moderately indurated; organic matter low; roots absent; induration fading gradually with depth. Clear change into |
| C | 20–34″+ | Reddish yellow (5YR6/6) stony loam; massive; stone content decreasing with depth, mainly quartzose pebbles, cobbles and sub-rounded stones with occasional boulders. |

The H layer is generally about 4 to 6 inches thick and consists of black, almost completely decomposed raw humus. When wet it stains the fingers black and is plastic. When dry it shrinks into hard, medium-sized sharp-angled cubes between the faces of which is a mat of reddish brown fibrous roots. The thin iron pan is a barrier to water and causes gleying in the $A_2g$ horizon. Roots are unable to penetrate the $B_3$ horizon and are concentrated immediately above the iron pan. The top of the indurated $B_3$ horizon is noticeably enriched with iron oxide. The stony till, 3 to 4 feet thick, rests on conglomerate or upon rotten sandstone strata.

### BLACKRIE SERIES

The Blackrie series is developed on stony gritty clay loam till more particularly on gentle slopes in the southern and eastern part of the association. The series, a non-calcareous gley, is for the most part cultivated.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–7″ | Very dark brown (10YR2/3) stony loam; weak blocky breaking into well-developed medium crumb; slightly plastic; high organic matter; abundant roots; few distinct strong brown (7·5YR5/6) mottles at surface; high stone content. Sharp change into |
| $A_2g$ | 7–9″ | Light grey (10YR7/2) and very pale brown (10YR5/2) stony clay loam; stones as above; weak medium sub-angular blocky breaking into fine sub-angular blocky; plastic; low organic matter; frequent roots; few medium faint, strong brown (7·5YR5/6) mottles. Clear change into |
| $B_2g$ | 9–20″ | Light brown-grey (2·5YR6/2) to pale brown (10YR6/3) stony clay loam; weak medium sub-angular blocky; plastic; low organic matter; roots frequent to rare; frequent distinct medium dark red (2·5YR3/6) mottles; moist at top of horizon, wet at base. Gradual change into |
| $B_2g$ | 20–34″ | Grey-brown (10YR5/2) gritty clay loam; weak coarse sub-angular blocky; slightly plastic; moderately stony; roots frequent to rare sometimes forming mats around stones; many mottles dark red to red (2·5YR3/6 to 4/8) and frequent yellowish red mottles (5YR4/8) associated with root channels. Sharp change into |
| Cg | 34–40″+ | Dark grey-brown (2·5YR4/2) to grey (5/0) variable gritty sandy clay loam; massive; very frequent cobbles (some up to 20″); occasional roots round stones. |

Stones tend to obscure structure throughout this profile. The $A_2g$ horizon is not always present, depending on the thickness of the horizons in the natural soil and the subsequent depth of ploughing. When it is present it is a striking horizon, its colour contrasting with the reddish colours of the subsoil horizons. Mottling increases greatly in the $B_2g$ and $B_3g$ horizons; both dark red and yellowish red mottles occur, the latter being more particularly associated with root tracks. The colours of the Cg horizon indicate that it is almost permanently waterlogged.

### GARTHFIELD SERIES

The Garthfield series, situated in depressions and drainage channels is not extensive, amounting to only 5% of the association. It is developed on till which is often partially water-sorted, as indicated by a coarser texture in the upper part of the profile. The series is a very poorly drained peaty gley.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | old grass ley |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Very dark brown (10YR2/2) stony peat; greasy; amorphous; roots abundant. Sharp change into |
| Bg | 10–18″ | Light brown-grey (10YR6/2) stony coarse sandy loam; very weak medium sub-angular blocky; some humus staining in upper 3 inches; organic matter low; very stony; roots occasional, frequent in upper part; fine medium distinct brownish yellow (7·5YR5/6) mottles. Gradual change into |
| Cg | 18–30″+ | Light brown-grey (10YR6/2) stony sandy clay loam; massive; plastic; very wet; sticky; roots rare; organic matter low; moderately stony; well-defined iron oxide tubes down old root channels. |

The uncultivated profile has a thicker cover of peat than the cultivated profile given above. The whole of the profile is wet and the structure consequently poorly defined. The Bg and Cg horizons are intensely gleyed so that the original colour of the parent material has been lost.

### NOTE ON AGRICULTURE

A large part of this association is uncultivated moorland. Prior to the Second World War even the cultivated land had been allowed to revert to permanent grass which was only fit for extensive grazing. At the present day the greater part of the freely drained Hatton series is under cultivation and much drainage of the poorly drained Blackrie series has been carried out so that former *Juncus*-dominated old grassland is now under the plough. Within the last ten years or so extensive reclamation has taken place in the vicinity of the Tore of Troup and areas which reputedly carried no more than 200 sheep now graze 500 head of cattle as well as an increased number of sheep. Much of the association is of little value for arable land because of excessive stoniness, inherently low fertility, steep slopes in certain localities and poor drainage in others. Worked in conjunction with low ground farms the hill ground is being used very successfully as a stock-rearing area.

## THE INSCH ASSOCIATION

The Insch Association is approximately 60 square miles in extent, and is one of the more important associations in the north-east of Scotland. The parent material is a till of coarse to moderately fine texture derived from basic igneous rocks, which varies in thickness from 2 to 20 feet. Four series are represented, the brown forest soils of low base status of the Insch series and the non-calcareous gleys of the Myreton series being dominant. Most of the association is cultivated and crop yields are usually high.

### DISTRIBUTION

The association occurs mainly in the Insch Valley, the southern half of which lies within the region surveyed, and west of Rhynie in the Cabrach district. Separating these occurrences is an area of Old Red Sandstone which follows the Bogie Valley. Two smaller areas of the association have been mapped, one near Tarland and the other in the vicinity of Belhelvie.

### PARENT MATERIAL

There is some variation in the rock type which gives rise to the parent material of this association, but it is not sufficient to influence the character of the derived tills. The eastern part of the Insch Valley, east of Pitcaple, is underlain by hypersthene-gabbro, and both the western part and the Bogancloch Mass of the Cabrach are of olivine-norite. Near Tarland the rock is a gabbro and at Belhelvie, although variable, it is a contaminated igneous rock, predominantly a norite. The hypersthene-gabbro is a fine-grained greyish rock which on weathering acquires a thin skin of whitish decomposed material. The olivine-norite is a coarse-textured crystalline rock which decomposes in a typical fashion, with skins of weathered material, like the skins of an onion, enfolding fresh rock, each successive skin inwards less decomposed than its predecessors until the fresh core is reached. The constituents of the hypersthene-gabbro are labradorite, hypersthene, diallage and magnetite, and those of the norite are labradorite, olivine, hypersthene, augite, biotite, hornblende, magnetite and apatite.

The tills from these varieties of basic igneous rock are seldom pure and are indistinguishable from one another, their character remaining largely unaffected by the minor differences of the rocks. In the valleys near streams the till may be 20 feet thick, but it thins out on the hills often to less than 4 feet. On convex slopes where the soils are generally freely drained the till is yellowish brown (10YR5/6) and has a sandy loam or loam texture. Where the slopes are concave and the soils generally poorly drained, the till below soil depth is dark grey (2·5Y4/0) and a loam or sandy clay loam in texture. Unlike till derived from granite, the till from basic igneous rocks does not usually have a high content of stones and boulders. The stone dykes round fields have, however, been constructed from stones gathered during the initial reclamation. An exception to this is the Belhelvie area which is in places excessively bouldery.

### SOILS

In many ways the Insch Association is typical of the north-east of Scotland, containing as it does four series, each of which represents a different major soil sub-group—the Insch series (brown forest soil of low base status), the Bruntland series (iron podzol), the Myreton series (non-calcareous gley), and the Mosstown series (peaty gley). By far the most extensive are the Insch and Myreton series which constitute the bulk of the arable soils. Two phases of the Insch series have been mapped, an intermediate with a surface horizon 7 to 12 inches thick and a deep phase with a surface horizon 12 to 30 inches thick. Walton (1950) found that there is a positive correlation between the deep phase as reported by Glentworth (1944) and the infield of the Middle Ages. Between the Insch series, generally found below 1000 feet, and the Bruntland series, which occurs above this altitude, similarities exist in the $B_2$, $B_3$ and C horizons which are typical of freely drained leached soils, and only in the L, F, H and A horizons are there significant points of difference. In the same way the Myreton series and the Mosstown series, as gleys, have much in common, although the Mosstown series has a well-developed H layer and the Myreton has none. The Mosstown series, which is very poorly drained, occupies depressional sites, whereas the Myreton series, which is poorly drained, is commonly developed on moderate to gentle slopes.

Except in the hilly country of the Cabrach west of Rhynie, where it approaches 40 inches, rainfall for the association is between 30 and 35 inches.

*Series*

### INSCH SERIES

Located principally on moderate slopes below 1000 feet, the Insch series covers some 48·5 square miles or 85% of the association. The till on which the series is developed is sandy loam or loam in texture and is normally more than 4 feet thick, especially in the Insch Valley; the stone content is moderate and is unlikely to cause difficulty during cultivation. The series is freely drained and belongs to the group of brown forest soils of low base status. Under semi-natural conditions it carries an acid grassland type of vegetation dominated by *Agrostis* and *Festuca* spp. Two phases, based on the depth of the S or A horizon, have been delineated on the map.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | acid grassland with *Festuca rubra, Agrostis tenuis, Ulex europaeus, Anthoxanthum odoratum, Cynosurus cristatus, Trifolium repens* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| A | 0–10″ | Dark brown (10YR3/4) sandy loam; strong medium crumb; friable; moderate organic matter; roots plentiful; no mottles. Clear change into |
| $B_2$ | 10–18″ | Yellowish brown (10YR5/8) sandy loam; weak coarse crumb; friable; patches of dark brown organic staining, worm channels with A horizon filling; roots numerous; no mottles. Sharp change into |
| $B_3$ | 18–26″ | Yellowish brown (10YR5/4) sandy loam; moderate very coarse platy; strongly indurated at top becoming less so with depth; numerous pin-holes in peds; low organic matter; roots few; few distinct medium yellowish red (5YR5/8) mottles; merging into |
| C | 26–36″ | Yellowish brown (10YR5/6) sandy loam; moderate medium sub-angular blocky; firm; low organic matter; stones moderate; few distinct yellowish red (5YR5/8) mottles. |

A striking feature of this series is the well-developed crumb structure of the A horizon, which is related to the high iron content of the parent material. The change in colour from dark brown in the surface to yellowish brown in the $B_2$ is gradual, and the crumbs increase in size and are less well formed. Both horizons are very friable. In the $B_3$ horizon induration which is also found in the Bruntland series, results in a coarse platy structure with the peds coated with a brown organic staining on the underside. The peds have numerous pin-sized holes. The platiness and pin-sized cavities led Fitzpatrick (1956) to suggest that this horizon resembles the top of the present-day permafrost layer, and that the permafrost which is thought to have affected these soils in periglacial times has been partially responsible for its formation. Few roots penetrate the $B_3$ into the C horizon. No ochreous mottles are found until the $B_3$ and C horizons are reached. They are rare on sandy loam-textured soils but more common on sandy clay loam textures.

## BRUNTLAND SERIES

Developed on moderate slopes in the Cabrach, west of Rhynie, at altitudes over 1000 feet, the Bruntland series is not extensive and accounts for only 3% (1·72 square miles) of the association. The till on which the series is developed is less than 4 feet thick and is a sandy loam, but with a greater content of stones than the Insch series. The drainage class is free and the series belongs to the major soil sub-group of iron podzols. The typical vegetation is now dominated by *Calluna vulgaris* with, perhaps, some *Erica cinerea* and a little *Nardus stricta.*

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | Moderate |
| VEGETATION | | *Calluna vulgaris, Vaccinium myrtillus, V. vitis-idaea, Erica cinerea, Deschampsia flexuosa, Pleurozium schreberi, Hypnum cupressiforme* var. *ericetorum* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 3–2″ | Plant litter |
| F | 2–1″ | Fermented litter |
| H | 1–0″ | Well-decomposed organic matter |
| $A_2$ | 0–1″ | Dark grey (10YR4/1) loamy sand; high organic matter; weak very fine sub-angular blocky; loose; roots numerous; rich in bleached mineral matter. Sharp change into |
| $B_2$ | 1–5″ | Yellowish brown (10YR5/8) sandy loam; moderate medium crumb; friable; low organic matter; roots frequent; no mottles but much dark brown organic staining. Gradual change into |
| $B_2$ | 5–12″ | Yellowish brown (10YR5/8) sandy loam; moderate medium crumb; friable; low organic matter; roots frequent; no mottles. Sharp change into |
| $B_3$ | 12–20″ | Yellowish brown (10YR5/4) sandy loam; moderate very coarse platy; strongly indurated; low organic matter; roots rare; few fine distinct yellowish red (5YR5/8) mottles. Gradual change into |
| C | 20–32″ | Yellowish brown (10YR5/6) sandy loam; moderate medium sub-angular blocky; firm; low organic matter; few fine distinct yellowish red (5YR5/8) mottles. |

In this series the most notable features occur in the organic and A horizons; the $B_3$ and C horizons show great similarity to those of the Insch series, whilst the $B_2$ horizon differs only in the presence of some organic staining in the top few inches. The L, F and H layers are normally all about 1 inch thick, but the F layer can be up to 3 inches and the H layer up to 2 inches. Since this is a series developed on parent material low in quartz, it might be expected that the $A_2$ horizon would be absent or far from typical. It is found, however, that the $A_2$ horizon is often as much as 2 inches thick, with bleached mineral matter which is composed not of quartz but of silicates decolourised on the surface and can be clearly seen when the profile face has been allowed to dry.

## MYRETON SERIES

Widely distributed throughout the association, the Myreton series occurs mainly east of Insch in a fairly intricate pattern with the Insch series. West of Insch, where the relief is rolling rather than undulating, the Myreton series is not such an important component of the landscape. On the gentle slopes the till which gives rise to the Myreton series is often more than 4 feet thick and is clay loam in texture. The till is finer than that on which both the Insch and Bruntland series are developed. As most of the series is cultivated it is not possible to give a characteristic semi-natural vegetation, but it is noteworthy that *Polygonum persicaria* is a prominent member of the weed flora and that *Deschampsia caespitosa* is usually present in the margins of the fields. The series is poorly drained and a member of the sub-group of non-calcareous gleys.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark grey-brown (10YR4/2) loam; moderate medium angular blocky; firm; moderate organic matter; few distinct ochreous mottles. Sharp change into |
| $A_2g$ | 8–10″ | Light brown-grey (10YR6/2) loam; moderate medium angular blocky; firm; low organic matter; few distinct yellowish red (5YR5/8) mottles. Clear change into |
| $B_2g$ | 10–20″ | Strong brown (7·5YR5/6) clay loam; moderate medium prismatic, the peds often with acute angles; low organic matter; many distinct coarse yellowish red (5YR5/8) mottles inside peds; peds coated with grey; roots tend to grow between peds. Gradual change into |
| $B_3g$ | 20–36″ | Strong brown (7·5YR5/6) clay loam; moderate coarse prismatic; low organic matter; frequent distinct coarse yellowish red (5YR5/8) mottles inside peds; peds coated with grey but less so than in $B_2g$; moderate stone content, some basic igneous are decomposed; large worms penetrate to 30 inches. Sharp change into |
| Cg | 36″+ | Light olive-brown (2·5Y5/4) clay loam; massive; plastic; frequent prominent coarse yellowish red (5YR5/8) mottles. The permanent water-table is often about this depth. The material under the water-table shows no mottling. |

Unlike the pale coloured gleys developed on more siliceous parent material, this soil is characterised by strong browns from the profuse ochreous mottling caused by the high iron content of the parent material. The structure is medium blocky in the S and $A_2g$, becoming prismatic in the $B_2g$ and $B_3g$ and finally massive in the Cg horizon. The surfaces of the peds are strongly coated with grey which becomes a less noticeable blue in the lower horizons until, at the level of the water-table, blue-grey becomes the dominant colour. Roots usually grow between the peds and seldom penetrate into them. There is a notable increase in texture down the profile; whereas both the S and $A_2g$ horizons are loams the $B_2g$, $B_3g$ and Cg are clay loams, a distinction which is general throughout this series. The $A_2g$ horizon is seldom found in the cultivated profiles.

## MOSSTOWN SERIES

A minor component of the association, the Mosstown series is located in low-lying areas of flat relief invariably surrounded by the more extensive Myreton series. Developed on a clay loam till more than 4 feet thick, and often as much as 10 feet, the series belongs to the very poorly drained class and is a member of the sub-group of peaty gleys. It is generally kept in grass for long periods because of the difficulty experienced with cultivation.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | *Juncus effusus, Carex nigra, C. panicea, Ranunculus repens, Alopecurus geniculatus, Polytrichum commune* |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| L | 11–10″ | Litter |
| F | 10–8″ | Fermented litter |
| H | 8–0″ | Black (10YR2/1), well-decomposed mor. Sharp change into |
| $A_1g$ | 0–3″ | Very dark grey-brown (10YR3/2) loam, rich in organic matter; moderate medium angular blocky; plastic; few fine distinct thread-like ochreous mottles; roots numerous, few stones. Sharp change into |
| $A_2g$ | 3–9″ | Grey-brown (5Y5/2) sandy clay loam; weak medium angular blocky; plastic; some brown (10YR5/3) humus staining; few fine distinct strong brown (7·5YR5/8) mottles; roots frequent. Clear change into |
| $B_2g$ | 9–18″ | Olive (5Y5/3) clay loam; strong coarse prismatic; plastic; low organic matter; roots frequent; many coarse prominent strong brown (7·5YR5/8) mottles; frequent prominent iron oxide tubes associated with old root channels; grey faces to peds. Gradual change into |
| $B_3g$ | 18–32″ | Olive (5Y5/3) clay loam; strong coarse prismatic to massive; plastic; low organic matter; frequent prominent iron oxide tubes associated with old root channels; grey faces to peds but less grey than in the $B_2g$. Gradual change into |
| Cg | 32″+ | Olive (5Y5/3) clay loam; massive; plastic; low organic matter; few iron oxide tubes. This horizon marks the permanent level of the water-table. |

In contrast with the Myreton series, which has little or no H layer, the Mosstown series has an organic surface of between 2 and 12 inches thick. The $A_2g$ is well formed, with a pronounced grey colour and only a few ochreous mottles. Ochreous mottling reaches a maximum in the $B_2g$ horizon, below which, in the $B_3g$, mottles are few; iron oxide tubes encase former root channels in both the $B_2g$ and $B_3g$ horizons. There is no mottling and few iron oxide tubes in the Cg horizon. In the $A_1g$ and $A_2g$ horizons the structure is generally medium blocky, becoming prismatic in the $B_2g$ and $B_3g$ horizons and finally massive in the Cg. The faces of the peds are coated with grey in the B horizons and especially in the $B_2g$. A massive structure and uniform olive colour is associated with the level of the permanent water-table.

## Note on Agriculture

With its inherently fertile soils, the Insch Valley has a high reputation for the quality of its crops and stock. The principal cereal is oats followed closely by barley; wheat, which was not formerly grown, is now widespread. In the eastern part of the valley stock-fattening is the main livestock activity but west of Insch, at a somewhat higher elevation, stock-rearing is of more importance. The soils of the deep phase of the Insch series are particularly fertile, commonly yielding as much as thirteen quarters of oats per acre and occasionally more. Lodging is a hazard on these soils particularly in lea oats after third year grass; the final year's grass becomes dominated by clover and the supply of nitrogen to the following cereal crop is excessive. Great difficulty is experienced in getting the ploughs to clean on these soils.

West of Rhynie, in the hilly area of the Cabrach, where permanent grazings are common, stock-rearing is the principal type of farming. In a few localities breeding herds of Herefords are outwintered. Sheep graze the hills both in summer and winter, although in bad weather they are given supplementary feed. Most farms have both arable and hill land. The arable land provides winter keep for the stock and the hills have an abundance of grazing during the summer. Extensive areas of abandoned land have been ploughed and reseeded in the past decade.

## THE LESLIE ASSOCIATION

The Leslie Association is not extensive, its total area being approximately 3·5 square miles. It occurs in three widely separated areas with marked variations in altitude and climate. The greater part of the association is uncultivated. Certain peculiarities, thought to be due to uneven weathering of the underlying serpentine rock, are evident in the drainage pattern of the land surface and in the soils themselves.

### DISTRIBUTION

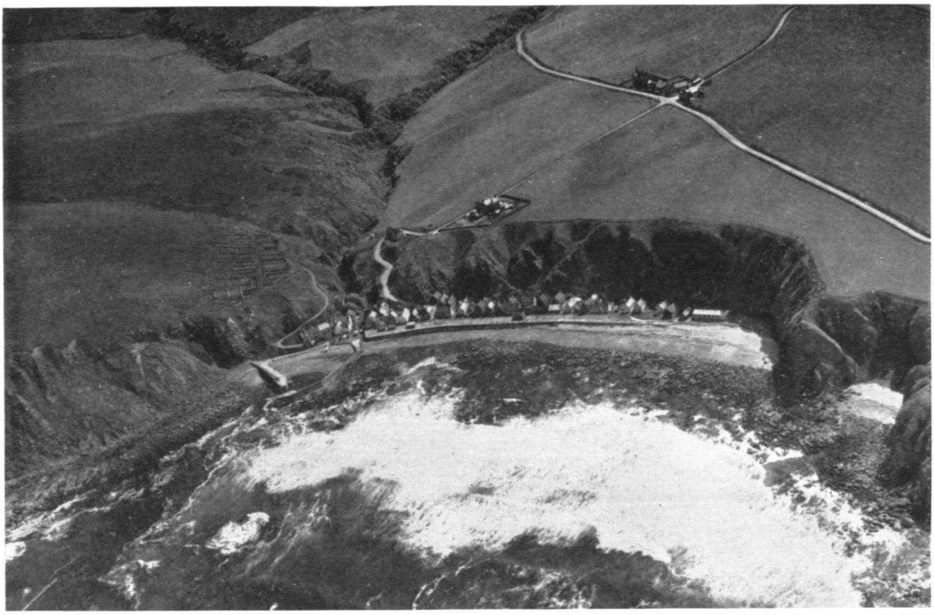
The association occurs in three areas, one over the Hills of Towanreef and Red Craig in the lower Cabrach, another around the village of Leslie and south of Kirkton of Clatt and the third in the Beauty Hill district, some 9 miles north of Aberdeen.

### PARENT MATERIAL

The parent material is a till, brown under well-drained conditions and grey and ochreous mottled under poor drainage. The content of weathered angular serpentine is high, the soils being virtually residual over parts of Towanreef and Beauty Hill. About Leslie, and round the western margins of the various parts of the association, local rocks are common in the surface horizons and to a lesser extent in the till. In hand specimen the rock varies from site to site. At Hawkhill Quarry a mile and a half west of Leslie "the rock is a beautiful variety being dark green in colour, veined and streaked with chrysotile and with the joint faces often coated with noble serpentine and asbestos". On the Hill of Towanreef it "is composed of dark green serpentine veined with steatite and containing crystals of enstatite—Red Craig is formed of a harder and more crystalline variety of the same rock with rusty ochreous weathering". (Wilson and Hinxman, 1890, p. 25.) The Beauty Hill rock is almost black, fine grained and breaking readily into small angular pieces; it is sometimes penetrated by threads of greenish chrysotile. All the serpentine rocks exposed to surface weathering have a creamy coloured skin, whereas many of the fragments weathered in the soil develop a black skin and have a soft very decomposed interior.

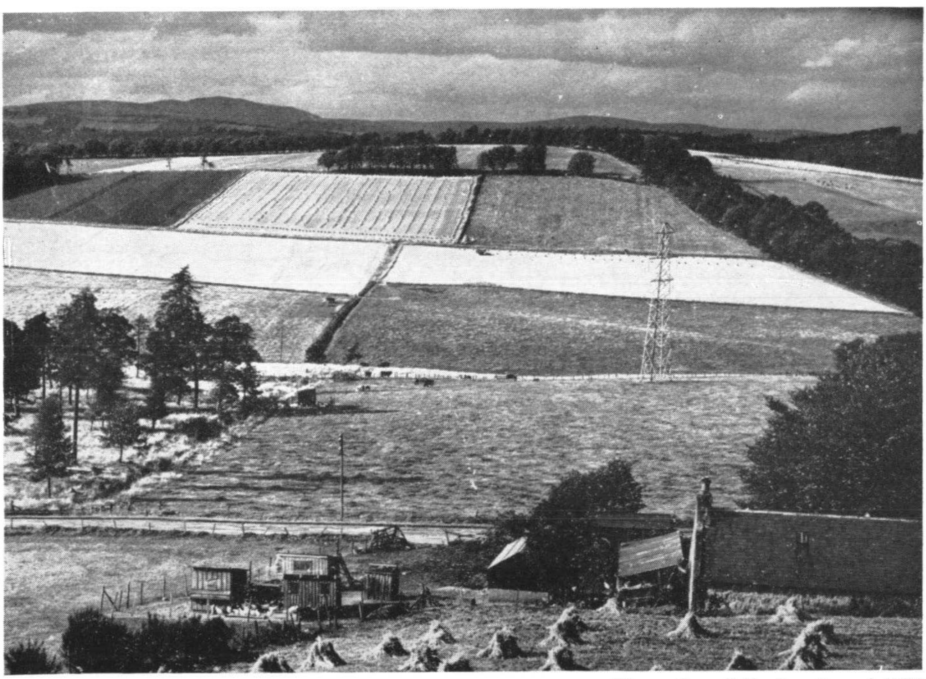
### SOILS

Only two soil series have been distinguished, a freely drained Leslie series and a poorly drained Charleston series. The Leslie series is developed on very thin till or residual shattered angular serpentine. The poorly drained



(*By courtesy of Aberdeen Journals Ltd.*)

PLATE 33
Pennan Village ; Old Red Sandstone rocks underlying soils of the Ordley Association.



(*By courtesy of Aberdeen Journals Ltd.*)

PLATE 34
Countesswells Association near Lumphanan.

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(*By courtesy of the Forestry Commission*)

PLATE 35

Typical farm and forest land on Countesswells Association near Aberdeen.

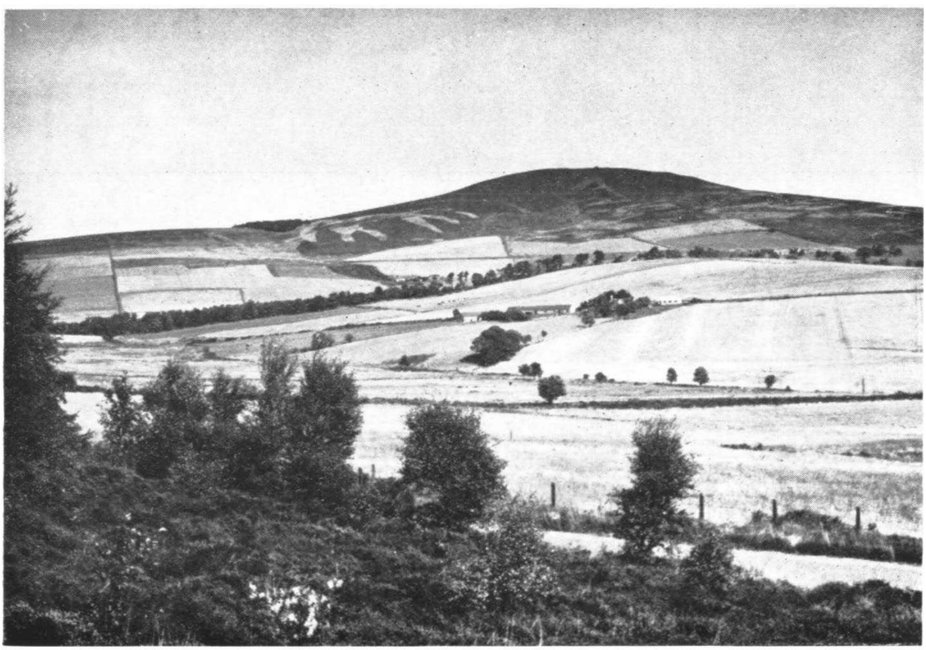


PLATE 36

Countesswells Association with Benaquhallie Hill in the background.

Charleston series is developed on a sandy clay loam till which can contain fragments of rock other than serpentine. The serpentine decomposes very readily under alternating oxidising and reducing conditions. Even in the well-drained soils, the serpentine fragments contained in the B horizon are soft and can be cut with a knife or scraped with the finger nail. Under poorly drained conditions the weathering is even greater.

Mention has been made of certain peculiarities in the drainage pattern. Both on the Hill of Towanreef (1409 feet) and on Beauty Hill (548 feet) drainage takes the form of small "flush" channels which continue for a short distance and end in a crater-like wet hollow, sometimes with a small fan of eroded material. The water then disappears, presumably into an underground channel, to reappear some distance down slope as a new flush channel. This drainage pattern gives an uneven pitted appearance to the hillsides.

Beauty Hill has been extensively ridged, with the result that on the crests the topsoil is deep, while the troughs between are denuded down to the bed rock. Surface drainage is channelled into the hollows so that gorse and grass, representative of dry conditions, occupy the crests while *Juncus* spp. representative of wet conditions occupy the troughs.

*Series*

### LESLIE SERIES

The Leslie series is the more extensive of the two series; it includes uncultivated moorland, as on the Hill of Towanreef and Red Craig (1400 feet), arable land in the area between Clatt and Leslie, and arable and abandoned ridged land on Beauty Hill. Rainfall over the Hill of Towanreef is between 35 and 40 inches and this favours the formation of humus. Rainfall in the other areas is between 30 and 35 inches. The series is a freely drained brown forest soil.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | old grass ley |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–16″ | Black (5YR2/1) humose sandy loam; moderate medium crumb; friable; organic matter high; roots numerous; few stones. Clear change into |
| $B_2$ | 16–24″ | Dark reddish brown (5YR2/2) loam; moderate fine crumb; friable; very stony with soft angular serpentine fragments which have a black coating on the outside and ochreous and green colours within, readily cut with a knife; organic matter moderate; roots numerous. Gradual change into |
| C | 16–24″+ | Brown (10YR5/3) stony fine sandy loam as interstitial filling between shattered, relatively soft angular serpentine fragments; friable; structureless; roots frequent; some ochreous staining from decomposing rock. |

The black or very dark brown highly organic surface is not found in regularly cultivated land where the colour is dark brown (7·5YR4/4). The texture of the surface horizon is a loam which gradually lightens to a fine sandy loam as the stone content increases with depth. Gradual changes, typical of the brown forest soil profile, occur between horizons. A fine crumb structure is well developed in the surface layer and extends into the B horizon. Horizon differentiation is more noticeable where the parent material includes a higher proportion of extraneous drift material, as on the western side of the Beauty Hills where an indurated $B_3$ horizon is sometimes present.

The majority of the Leslie soils are derived from residual serpentine rock. This weathers in a characteristic manner. While retaining the shape of the original rectangular fragments, the interior decomposes to give a light-weight fragment of rock with a spongy interior and a blackened and slightly harder outer skin. The rock is readily cut with the spade to expose a surface mottled with ochreous colours.

### CHARLESTON SERIES

Although the only large area of the Charleston series is on the western side of the Hill of Towanreef, patches of it occur near Leslie at Courteston, and on Hillbrae Farm at the northern end of the Beauty Hills. It is generally associated with more gentle slopes. The subsurface horizons are developed on a clay loam till which is frequently more than 6 feet thick and contains a proportion of rock constituents other than serpentine. *Juncus effusus* and *Deschampsia caespitosa* are two characteristic plant species found on the semi-natural Charleston series which is classed as a non-calcareous gley.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | *Juncus effusus, Anthoxanthum odoratum, Holcus lanatus, Agrostis tenuis; Potentilla erecta, Luzula* sp., *Pedicularis palustris, Plantago lanceolata, Ranunculus repens, Bellis perennis* |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| L | 3–2″ | Fibrous litter |
| H | 2–0″ | Black (5YR2/1) greasy humus; amorphous; plastic; roots numerous |
| $A_2g$ | 0–11″ | Dark grey-brown (10YR4/2) gritty loam; structureless; very slightly plastic; organic matter moderate; becoming low at base of horizon; stones few, mainly decomposed serpentine with occasional fragments of quartzite and granite; roots frequent with many strong brown (7·5YR5/6) mottles along the channels. Clear change into |
| $B_2g$ | 11–24″ | Grey (5Y5/1) on coarse prismatic faces, interior strongly stained with fine contrasting brownish yellow (10YR6/6) mottles and streaks; sandy clay loam; organic matter low; frequent roots between structural faces; stones moderate, mainly soft and decomposing serpentine, but acid rocks present. Gradual change into |
| Cg | 24–36″ | Light yellowish brown (10YR6/4) loam; massive; plastic; few roots; low organic matter; stone content mainly serpentine but granite and quartzite fragments present; many prominent coarse strong brown (7·5YR5/6) mottles. |
| Dg | 36–48″+ | As above with very high content of decomposing serpentine; water oozing in. |

The surface layer of the semi-natural soil is high in organic matter, but on cultivation this rapidly mineralises to give a yellowish brown (10YR5/4) friable loam. Herbs and grasses are the dominant constituents of the semi-natural vegetation. The upper mineral horizon is in the main grey, with humus staining, and much of it is incorporated into the S horizon when cultivated. It is somewhat coarser textured than the horizon below, and rusty mottling along the root channels shows up in the lower part. Structure is not much in evidence in the $A_2g$ horizon, but a pronounced prismatic structure develops in the $B_2g$ horizon. The faces of the peds are characteristically grey, their interior being profusely mottled with ochre, thus giving an overall yellowish brown colour to a profile face. The prismatic structure gives way to massive in the Cg. Accompanying this change is an increase in the content of rather soft serpentine rock. Angular serpentine *in situ* occurs at 4–5 feet, at the level of the permanent water-table.

### Note on Agriculture

On Towanreef in the Cabrach the vegetation is scanty and poor; extensive patches of bare ground occur which do not appear to have become colonised after burning. Beauty Hill has been ridged originally for arable crops and now carries a grassy heath type of vegetation of moderate quality.

The arable land in these districts tends to occur as small areas occupying only parts of farms. It has a high reputation for stock raising and fattening.

## THE LOCHTER ASSOCIATION

The Lochter Association is one of the smallest associations accounting for only 0·3% (2·9 square miles) of the area. Apart from a small area in Howe of Alford, it is confined to the lower reaches of the Don and the eastern extremity of the Insch Valley. It occurs on upper terraces of the River Don, the River Urie and the Lochter Burn. The Bass of Inverurie, situated in the angle between the Rivers Don and Urie, is a remnant of one of these terraces.

### Parent Material

Alluvial in origin, the parent material is either a loamy fine sand or a sandy loam, at least 3 feet thick. This alluvium is readily distinguished from that found alongside present-day rivers and streams and mapped as undifferentiated alluvium, since the high terrace which it forms is sufficiently above the river to be clear of flooding and erosion and in consequence its soils have had a comparatively long time to form mature profiles.

### Soils

There are two series within this association, the Lochter and the Auchencleith, both of which have clearly defined horizons. The Lochter series, freely drained and an iron podzol, is much more important than the Auchencleith which is a non-calcareous gley and found only in a few small areas.

*Series*

#### LOCHTER SERIES

The Lochter series, although it accounts for 96% of the association, is only 2·7 square miles in extent and is therefore of little importance in the area. It is good agricultural land and is fully utilized for mixed farming. The free drainage and sandy texture make cultivation easy. It belongs to the major soil sub-group of iron podzols.

PROFILE DESCRIPTION

SLOPE gentle
VEGETATION rotational grass
DRAINAGE CLASS free

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–14″ | Dark brown (10YR3/3) fine sandy loam; weak medium subangular blocky; friable; few stones; roots abundant; no mottles. |

| | | |
|---|---|---|
| | | Gradual change into |
| | 14–19″ | Brown (10YR4/3) gritty fine sandy loam; weak medium sub-angular blocky; friable; few stones; roots abundant; no mottles. Gradual change into |
| $B_2$ | 19–27″ | Yellowish brown (10YR5/5) loamy fine sand; weak fine crumb; loose; few stones; frequent roots; no mottles. Gradual change into |
| C | 27–36″ | Yellowish brown (10YR5/6) sand; single grain; loose; no stones; occasional roots; no mottles. |

This series, although it has better defined horizons than recent alluvium, is, nevertheless, essentially an immature profile. The boundaries between the horizons are gradual and the horizons themselves are striking neither in colour nor in structure.

### AUCHENCLEITH SERIES

The Auchencleith series, 0·2 square miles in extent, generally occurs in small areas within the larger Lochter series. It is poorly drained and is a non-calcareous gley.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–16″ | Dark brown (10YR3/3) fine sandy loam; moderate fine sub-angular blocky; friable; few stones; abundant roots; few fine distinct ochreous mottles. Sharp change into |
| $B_2g$ | 16–25″ | Light grey (7·5YR6/1) loam; weak medium prismatic; friable; few stones; frequent roots; frequent medium prominent strong brown (7·5YR5/6) mottles. Gradual change into |
| $B_3g$ | 25–32″ | Olive-grey (5Y5/2) sandy loam; weak coarse prismatic; friable; occasional roots; few medium prominent strong brown (7·5YR5/6) mottles. Gradual change into |
| Cg | 32–36″ | Grey-brown (10YR5/2) gravelly loamy coarse sand; single grain; loose; few roots. |

The Auchencleith series is a typical non-calcareous gley. It is, however, distinguished by its sandy nature and the weakness of its structure.

### NOTE ON AGRICULTURE

The Lochter Association is so small that its agriculture is, in practice, determined by that of the surrounding soils. It can be said, however, that it is very good, easily-worked land, capable of growing good crops of roots, grass and cereals.

## THE NORTH MORMOND ASSOCIATION

Almost the whole of the North Mormond Association, which is 18 square miles in extent, occurs within Sheet 97 (Fraserburgh). It adjoins the Peterhead Association at Crimond and extends westwards in a belt approximately 2 miles wide and 6 miles long on the north side of Mormond Hill. Part of the association has been developed on a till which has undergone a certain amount of re-working by water.

## Parent Material

The North Mormond Association is developed on a sandy clay loam till which is mainly derived from Old Red Sandstone sediments and acid metamorphic rocks. Stones are moderately plentiful, the commonest type being a quartzite cobble from the Old Red Sandstone sediments. Fragments of quartzite, quartz-schists, andalusite-schists and granites are also present. It is not possible to be certain about the source of this drift, since Old Red Sandstone material occurs both to the west and to the east, and schists and granites are very common throughout the area as a whole.

The till is reddish brown and generally at least 4 feet thick. Exposures at higher elevations often show it to overlie drifts from local rocks. For example, it occurs on Mormond Hill above a quartzite till, while at Whiterashes Farm the basal till is derived from quartz-schist. At lower elevations the till of the North Mormond Association is itself overlain by several feet of gravel, as can be seen at Whitewell Croft.

Below 150 feet the till is partially re-sorted by water. The re-sorting probably took place at the same time as the fluvio-glacial sands and gravels of the Boyndie and Corby Associations, which occur nearby, were laid down. The soils developed on the modified till are distinguished by a sandy, gritty layer under the cultivated horizon.

## Soils

Along the north side of Mormond Hill the relief of this association is moderately sloping, but near Rathen, Lonmay Station and Crimond it becomes gently rolling. Relief of this subdued character is favourable to the formation of imperfectly and poorly drained soils. The parent material, with a clay content of approximately 25%, is also conducive to imperfect and poor drainage, even if it has a cover of re-sorted material. Consequently, very little of the freely drained Denhead series occurs, the most widespread series being the imperfectly drained North Mormond and Auchiries.

*Series*

### NORTH MORMOND SERIES

Developed on a strong brown (7·5YR5/7) sandy clay loam till, the North Mormond series belongs to the imperfectly drained class of brown forest soils with gleyed B and C horizons. For the most part it is found on convex sites with moderate slopes above approximately 150 feet which is the limit of periglacial re-sorting.

#### PROFILE DESCRIPTION

SLOPE — moderate
VEGETATION — rotational grass
DRAINAGE CLASS — imperfect

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–8″ | Brown (10YR5/3) loam; weak crumb; loose; medium organic matter; roots abundant; frequent sub-angular stones, some Old Red Sandstone pebbles. Sharp change into |
| $B_2$(g) | 8–14″ | Yellowish brown (10YR5/5) sandy clay loam; medium moderate angular blocky; friable; low organic matter; roots frequent; stones moderate, some decayed; frequent distinct reddish yellow (7·5YR6/8) mottles, few distinct pinkish grey (7·5YR6/2) mottles. Clear change into |

| | | |
|---|---|---|
| $B_3(g)$ | 14–23″ | Yellowish brown (10YR5/4) sandy clay loam; moderate coarse angular blocky; firm; organic matter low; roots rare; stones moderate, some decayed; frequent distinct reddish yellow (7·5YR6/8) mottles. Gradual change into |
| C(g) | 23–42″ | Strong brown (7·5YR5/7) sandy clay loam; moderate coarse angular blocky to massive; firm; frequent stones, often decomposed; no roots; few faint reddish yellow (7·5YR6/8) mottles. |

The colour of the North Mormond series increases in redness down to the C(g) horizon where it is typically strong brown. Apart from the S horizon, which is a loam, the texture of the profile is a uniform sandy clay loam. Mottling and structure are most strongly expressed in the $B_2(g)$ horizon.

## AUCHIRIES SERIES

A brown forest soil with gleyed B and C horizons, the Auchiries series is developed on a stratified parent material. A layer of water-sorted material, up to approximately 15 inches thick, overlies the sandy clay loam till which is characteristic of the association as a whole. The series, most of which is cultivated, belongs to the class with naturally imperfect drainage.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate to gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–9″ | Brown (10YR4/3) sandy loam; weak medium sub-angular blocky; friable; moderate organic matter; moderate stone content, mostly rounded or sub-angular; roots abundant; few faint strong brown mottles. Sharp change into |
| $B_2(g)$ | 9–15″ | Grey-brown (10YR5/2) loamy sand; weak medium sub-angular blocky; friable; low organic matter; moderate stone content, mostly rounded or sub-angular; roots frequent; frequent distinct strong brown (7·5YR5/6) mottles; few faint grey (10YR6/1) mottles. Clear change into |
| $B_3(g)$ | 15–26″ | Yellowish brown (10YR5/4) sandy clay loam with pockets of grey-brown sandy loam; moderate coarse sub-angular blocky; firm; organic matter low; roots rare; stones moderate, some decayed; frequent distinct reddish yellow (7·5YR6/8) mottles. Gradual change into |
| C(g) | 26–42″+ | Strong brown (7·5YR5/7) sandy clay loam; moderate coarse angular blocky to massive; firm; frequent stones, often decomposed; no roots; few faint reddish yellow (7·5YR6/8) mottles. |

The character of this profile has been largely determined by its non-uniform parent material. The S and $B_2(g)$ horizons are developed on a sandy material and have the structure and consistence associated with it. The $B_3(g)$ and C(g) horizons are normally as encountered in the North Mormond series.

## DENHEAD SERIES

The Denhead series, a freely drained iron podzol, is not widespread. It is developed on a stratified deposit, water-sorted material having been laid down on the normal sandy clay loam till of the North Mormond series.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark grey-brown (10YR4/2) loamy sand; weak fine sub-angular blocky; loose; organic matter medium; roots abundant; frequent rounded and sub-angular stones; no mottles. Sharp change into |
| $B_2$ | 8–15″ | Reddish yellow (5YR6/6) loamy sand; weak fine sub-angular blocky; loose; organic matter low; roots frequent; frequent rounded and sub-angulaı stones; no mottles. Sharp change into |
| $B_3$ | 15–18″ | Pinkish grey (5YR6/2) loamy sand; indurated; few roots; organic matter low; frequent rounded and sub-angular stones; no mottles. Sharp change into |
| C(g)/ D(g) | 18″+ | Yellowish brown (7·5YR5/7) sandy clay loam with pockets of loamy sand; coarse angular blocky; firm; organic matter low; few fine distinct reddish yellow (7·5YR6/8) mottles. |

Generally speaking, if the water-sorted material is 18 inches or more thick, all the horizons down to at least the $B_3$ are developed in it. If it is shallower, the $B_3$ is missing, being replaced by a $B_3$(g) horizon developed on a sandy clay loam material. The $B_3$ horizon is typical of an iron podzol but the $B_3$(g) is more like that of a brown forest soil with gleyed B and C horizons, in particular the North Mormond series.

## TOPHEAD SERIES

Developed on a sandy clay loam till on gentle concave slopes, the Tophead series is a poorly drained non-calcareous gley. Most of it is arable land after first having been tile-drained. It is not an extensive series, amounting to approximately 1·5 square miles.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Very dark grey-brown (10YR3/2) loam; strong fine sub-angular blocky; friable; medium organic matter; abundant roots; frequent stones; faint yellowish red (5YR5/8) mottles round stones. Sharp change into |
| $B_2g$ | 10–17″ | Dark yellowish brown (10YR4/4) sandy clay loam; weak angular blocky; firm; organic matter low; roots frequent; frequent stones, mostly rounded especially at top; frequent prominent yellowish red (5YR4/6) mottles. Gradual change into |
| $B_3g$ | 17–36″ | Dark yellowish brown (10YR4/4) sandy clay loam; weak coarse prismatic; plastic; roots concentrated between peds; grey coating of clay on peds; abundant prominent yellowish red (5YR4/6) mottles inside peds; frequent rounded stones. Sharp change into |
| Cg | 36–42″+ | Grey (10YR5/1) sandy clay loam; massive; very plastic; abundant yellowish red (5YR4/8) mottles; abundant rounded stones. |

The texture of the profile becomes progressively finer with depth, varying from a loam in the surface to almost a clay loam in the Cg horizon. Rounded pebbles are plentiful throughout, but especially at the junction of the S and $B_2g$ horizons. Structure is most strongly expressed in the $B_2g$ where the peds have well-defined grey clay skins. The Cg horizon often marks the level of the water-table.

### BLAIRMORMOND SERIES

The Blairmormond series, a minor component of the association, is located in depressions which are generally a few acres in extent. It is a very poorly drained peaty gley.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle, concave |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–9″ | Very dark brown (10YR2/2) sandy clay loam; weak sub-angular blocky; friable; moderate organic matter; abundant roots; few fine distinct yellowish red (5YR4/6) mottles along root channels; few sub-angular stones. Sharp change into |
| Bg | 9–19″ | Grey-brown (2·5Y5/2) sandy clay loam; weak coarse angular blocky; plastic; low organic matter; roots rare; few rounded stones; frequent medium prominent yellowish red (5YR4/6) mottles. Gradual change into |
| Cg | 19–24″ | Olive-grey (5Y4/2) clay loam; weak coarse blocky to massive; plastic; low organic matter; roots rare; many coarse prominent yellowish red (5YR4/6) mottles; many coarse distinct grey (5Y5/1) mottles; moderate stone content, mostly sub-angular or rounded. |

The semi-natural series has an H layer 3 to 6 inches thick which on cultivation becomes mixed with an $A_2g$ horizon. The dominant colour through the profile is grey, indicating strongly gleying conditions. Ochreous mottling is also prominent.

### Note on Agriculture

The association, in general, is cultivated and crops are average to good. The least satisfactory soils are the freely drained Denhead series and the very poorly drained Blairmormond.

The principal grain crops are oats and to a lesser extent barley. Both rearing and fattening of stock are important, the latter on the better series. Most of the association is north-facing or near the sea and the cold north and east winds have an adverse effect on both crops and stock.

## THE ORDLEY ASSOCIATION

The Ordley Association has previously been described (Glentworth, 1954) for Sheets 86 and 96 (Huntly and Banff). Small extensions on to Sheet 97 (Fraserburgh), at the Tore of Troup, and on to Sheet 76 (Inverurie), in the vicinity of Rhynie and Towie, have been mapped. Together these areas amount to rather less than 2 square miles.

### Parent Material

The parent material consists of till derived from rocks of the basal conglomerate beds of the Old Red Sandstone formation. The pebbles of this rock consist almost wholly of rounded chips of the argillaceous schist rocks and, to a lesser extent, of the quartz-felspathic grits of the Banff Division of the Highland Schists. Sections of the beds are exposed on the west side of Pennan where free calcium carbonate, in the form of aragonite, is also a common constituent. The till varies in colour from yellowish brown faintly tinged with red to distinctly reddish brown. Its texture is normally a fine sandy loam to clay loam, but in the area in question it is mainly a loam to clay loam till in which there is a high proportion of sub-angular slaty chips. The till is more than 4 feet thick.

## SOILS

Because of the steeply sloping topography of the area on Sheet 97 only one series, the freely drained Ordley, is found; it is located near Pennan. On Sheet 76, in addition to the Ordley, the imperfectly drained Glaschul and the poorly drained Boghead series have been mapped in the Bogie Valley; both occupy only small areas.

*Series*

### ORDLEY SERIES

Developed on moderately sloping rolling topography, mainly on reddish brown parent material, the Ordley is the dominant series of the association. It is formed where the slate content, in the form of small sub-rounded chips, is high and where the texture is a loam. Freely drained, it belongs to the major soil sub-group of iron podzols.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grassland |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–9″ | Dark reddish brown (5YR3/4) loam; medium crumb; loose; organic matter moderate; roots abundant; many rounded chips of argillaceous schist. Sharp change into |
| $B_2$ | 9–15″ | Red (2·5YR5/6) to reddish yellow (5YR6/6) loam; high argillaceous schist content; weak, medium sub-angular blocky; friable; organic matter low; roots frequent. Sharp change into |
| $B_3$ | 15–24″ | Reddish brown (2·5YR4/4) sandy clay loam; very high stone content as above; weakly indurated; very coarse platy; organic staining between plates; roots occasional. Clear change into |
| C | 24–48″ | Red (2·5YR4/6) sandy loam; stony with small argillaceous schist chips; massive; roots rare. |

Except in their texture, which more often than not is a loam instead of a sandy loam, the S and $B_2$ horizons are typical of an iron podzol. The $B_3$ horizon is unusual in two respects, its high content of clay and the weakness of its induration. The character of the C horizon is in the main determined by the large number of schist fragments.

### GLASCHUL SERIES

The Glaschul series with imperfect drainage is similar to the above except for ochreous mottling in the $B_2$(g) and $B_3$(g) horizons.

### BOGHEAD SERIES

The Boghead series occurs only in very small areas, one north of Rhynie, another near Lumsden, and others to the north and to the south of Towie in Strathdon. It is a poorly drained non-calcareous gley and is developed in shallow depressions.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | old grass ley |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark reddish grey (5YR4/2) loam; moderate coarse granular; friable; moderate organic matter; stone content moderate, mainly argillaceous schist; few faint ochreous mottles increasing in intensity in lower part; roots abundant. Clear change into |
| $B_2g$ | 8–14″ | Reddish brown (5YR4/3) sandy clay loam; plastic; strong medium prismatic; moderate stone content; roots occasional; frequent medium distinct ochreous mottles inside peds; grey coating on exterior where roots concentrate. Gradual change into |
| $B_3g$ | 14–17″ | Reddish grey (5YR5/2) sandy clay loam; plastic; moderate coarse prismatic; moderate stone content; roots occasional; frequent medium distinct reddish yellow (7·5YR6/8) mottles and many grey (5/0) mottles. Gradual change into |
| Cg | 17–48″+ | Light reddish brown (5YR6/3) sandy clay loam; massive; very plastic; moderate stone content; many distinct reddish yellow (5YR6/8) and very pale brown (10YR7/3) mottles; water entering at 24 inches. |

The texture of the Bg and Cg horizons is characteristically a sandy clay loam. In the $B_2g$ horizon structure is very well defined, becoming less so in the lower horizons. The peds have distinct uniformly grey faces, and inside there is intense reddish yellow mottling. In the Cg horizon the grey mottles are replaced by mottles of a very pale brown colour.

### Note on Agriculture

In the Pennan area, where the largest units of the association occur, most of the land is so steep that it is kept permanently in grass. It is very suitable for sheep and, in the summer, for cattle. On the arable part of the association, west of the Tore of Troup, a high standard of farming is maintained and excellent crops of turnips, oats, barley, and even wheat, are grown. Grass grows well and most farms rear and fatten cattle.

## THE PETERHEAD ASSOCIATION

Along the coastal plain, from Balmedie to St. Fergus, reddish coloured soils derived from rocks of the Old Red Sandstone formation are found in an irregular belt which extends inland for distances up to 6 miles and occupies some 69 square miles (see Fig. 16). There are no solid formations of Old Red Sandstone age in the neighbourhood and the underlying rocks are granite, gneiss, andalusite-schist and quartzite. Jamieson (1906) considered the red drift to have been transported from the Vale of Strathmore during the second glaciation by ice moving in a northerly direction because the Scandinavian *mer de glace* blocked the way to the east. Three associations have been mapped on this deposit:

1. The Peterhead Association on a red clay till.
2. The Tipperty Association on red lacustrine deposits which vary from fine sand to clay, the latter predominating.
3. The Collieston Association on partially water-sorted till, generally of loam texture but frequently with a band of clay somewhere in the profile.

## Distribution

The Peterhead Association occurs in three areas on the eastern side of Sheets 87/97 (Peterhead/Fraserburgh) and 77 (Aberdeen) and covers about 45 square miles. The first is approximately 3 miles wide and extends from Crimond in the north to Boddam in the south. The second, which includes foot-slopes on the south side of Stirling Hill, continues southwards to the River Ythan, and at its widest part, at Ellon, is some 6 miles wide. Within this belt enclaves of red lacustrine clays occur which have been mapped as the Tipperty Association. From the Ythan the third area stretches as far south as Menie House (approximately 1 mile north of Balmedie). Isolated patches occur in the neighbourhood of Blackdog, 3 miles north of the Bridge of Don at Aberdeen.

The northern belt from Crimond to Boddam belongs to the coastal lowlands and is characterised by gently rolling topography. About St. Fergus however, the relief becomes more sharply undulating and is dissected by a number of deep channels. The central area between Stirling Hill and the River Ythan and the southern area, from the River Ythan to Blackdog, have a similar rolling landscape.

## Parent Material

The parent material of the Peterhead Association consists mainly of a reddish brown clay till derived from Old Red Sandstone sediments with a low content of stones. The stones are small, sub-angular and sub-rounded pieces of local rocks such as granite, quartz-schist and mica-schist together with a proportion of Old Red Sandstone conglomerate pebbles which are mostly quartzite, but include jasper-quartz, quartz-porphyry and lava. The clay content is generally above 30%, often reaching 40% in the basal layers. The highest content recorded is 72% clay. The thickness of the till cover varies with topography. Over the areas of gentle relief it probably exceeds 10 feet, but shallower and more contaminated tills occur around the margins of the association. In many places south of the Ythan the till contains a higher proportion of small stones, gravel and sand and has a sandy clay loam texture. The till of the Peterhead Association, as previously stated, is considered to have been laid down during the second glaciation (Jamieson, 1906; Bremner, 1916). Material of the third glaciation, coming from the west, has in many places along the western boundary been pushed on to and partially incorporated in the red clay till. Generally the surface soils are affected more than the subsurface horizons. This can be seen in the areas surrounding Stirling Hill (a granite boss) 1 mile west of Boddam, where granitic material is noticeably present in the surface horizons.

## Soils

Three series have been distinguished in the Peterhead Association, the Blackhouse series, an imperfectly drained brown forest soil, the Peterhead series, a poorly drained non-calcareous gley, and the Pitburn series, a very poorly drained peaty gley. The distribution of these series is allied to slope and to the texture of the parent material. The imperfectly drained soils tend to occupy the gentle to moderate slopes, the poorly drained soils areas of subdued relief and the very poorly drained soils flat or depressional sites.

## BLACKHOUSE SERIES

The Blackhouse series is extensive in the area from Peterhead southwards to Foveran, covering 22 square miles. It is developed on reddish brown clay loam to clay till with a low to moderate stone content. Moderate slopes favour its development. A member of the major soil sub-group of brown forest soils with gleyed B and C horizons, the series is imperfectly drained. Most of the series has been tile-drained however, and is now under arable agriculture.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–8″ | Reddish brown (5YR4/3) clay loam; medium and coarse crumb; plastic; roots abundant; organic matter moderate; frequent sub-rounded stones (1–4 in.); few fine faint ochreous mottles associated with root tracks and occasional decomposing stones. Sharp change into |
| $B_2$(g) | 8–14″ | Brown (7·5YR4/4) clay loam; plastic; worm holes filled with surface soil; medium prismatic with dull faces; roots frequent; organic matter low; stones frequent; frequent medium faint ochreous mottles. Clear change into |
| $B_3$(g) | 14–26″ | Reddish brown (2·5YR4/4) clay; plastic; strong coarse prismatic; acute angles to peds which have slightly paler and polished faces; roots occasional; organic matter low; frequent medium faint ochreous mottles in upper part; black manganese staining and aggregates (½ in.) throughout but concentrated towards base. Gradual change into |
| C(g) | 26–48″ | Reddish brown (2·5YR4/4) clay; plastic; prismatic, fading at 30 inches; massive below; moist; occasional live roots; organic matter very low; stones, as above; few faint ochreous mottles; large manganese stains and aggregates frequent in upper part, smaller and more rare at 40 inches. |

There is a conspicuous variation in colour from dark reddish brown (2·5YR2/4) to reddish brown (5YR4/3) in the surface soils of the Blackhouse series, the darker soils being richer in organic matter. Within the profile the change of colour into the B horizon is sharp and contrasting. The S horizon has a well-defined medium to coarse crumb structure, particularly under grassland, and this is easily destroyed if incorrectly managed. A medium prismatic structure in the upper $B_2$(g) passes into coarse prismatic in the $B_3$(g) and becomes massive in the C(g). Mottling in the S horizon is associated with the roots in older pastures; in the $B_2$(g) and $B_3$(g) horizons it is partially obscured by the colour of the parent material. Black manganese staining is usually present in the $B_3$(g) and C(g) horizons.

## PETERHEAD SERIES

The Peterhead series, 22 square miles in extent, is widespread in the Boddam, Peterhead, St. Fergus and Crimond districts where the topography is flat to gently undulating, and in smaller areas throughout the southern extension of the association to Balmedie. The red till has a high clay content of 45% or more, with few stones comprising Old Red Sandstone conglomerates and lava cobbles together with sub-rounded rock fragments of local derivation—granite, gneiss, quartzite, quartz-schist and spotted schist. The soils are surface-water gleys with poor drainage.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark grey-brown (10YR4/2) loam; strong angular blocky, breaking into medium crumb; slightly plastic; organic matter moderate; roots frequent; stones mainly small and sub-rounded; no mottling. Sharp change into |
| $B_2g$ | 8–16″ | Dark grey-brown (10YR4/2), brown (7·5YR5/4) and pale brown (10YR6/3) clay loam; mixing by worms; weak prismatic becoming stronger towards base; slightly plastic; low organic matter; roots frequent; frequent stones as above; moist; frequent yellow, medium, distinct mottles; grey sandy patches on structural planes. Clear change into |
| $B_3g$ | 16–24″ | Brown (7·5YR5/4) clay loam with patches of pale brown (10YR6/3) sandy clay loam; coarse prismatic; low organic matter; occasional roots growing between faces of peds; occasional large decomposing granite stones; moist; mottling as above with frequent black manganese staining. Gradual change into |
| Cg | 24–48″+ | Reddish brown (5YR4/4) clay; prismatic structure fading at 30 inches; massive below 36 inches; very plastic; no organic matter or roots; stones as in above horizon; fossil root channels to 46 inches; ochreous mottling and manganese staining frequent in upper part, infrequent at 48 inches. |

The Peterhead series has a strong resemblance to the Blackhouse series already described and the same variation in colour of the surface soils occurs. If anything the texture of the horizons, with the exception of the S horizon, is more clayey than in the Blackhouse series and the frequency and intensity of both grey and yellow or ochreous mottles is greater. The structure of both series is very similar but the peds of the $B_2g$ horizon in the Peterhead series have strongly gleyed faces.

## PITBURN SERIES

The Pitburn series is the least extensive in the association amounting to only 1·6 square miles. The parent material is a grey plastic clay till to a depth of 48 inches, but boring reveals the reddish brown till at lower depths. The subsoil is wet and the surface horizon is humose. Located in depressions, the series is a very poorly drained peaty gley.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Black (10YR2/1) humose clay loam; weak sub-angular blocky; greasy; organic matter high; stones frequent; roots abundant; no mottling. Sharp change into |
| $A_2g$ | 8–12″ | Dark grey-brown (10YR3/2) clay loam; massive; plastic; low organic matter; surface horizon material down worm holes; roots occasional; frequent small stones, many decomposing with faint ochreous mottling surrounding them; ochreous mottling along many old root channels. Clear change into |
| Bg | 12–22″ | Dark grey (5Y4/1) heavy clay; massive; very plastic; frequent stones of mixed origin; prominent ochreous and grey mottles; roots occasional; moist. Gradual change into |

| | | |
|---|---|---|
| Cg | 22–45″+ | Dark grey (5Y4/1) heavy clay; massive; plastic; many small stones, less decomposed than above; live roots rare; prominent yellowish brown (10YR3/4) mottles becoming confined to old root channels; mottling fading below 36 inches; wet. |

This series is mainly uncultivated. The S horizon is rich in organic matter and is underlain by a strongly bleached $A_2g$ horizon. The Bg horizon is similarly strongly gleyed, especially on the faces of the peds, the inside of which have been completely decolourised to grey from the original reddish brown by prolonged waterlogging. Only at considerable depths is the reddish brown colour found, at first in the centre of peds but, with greater depth, nearer the faces.

### Note on Agriculture

The Peterhead Association is situated in the coastal belt of Aberdeenshire which receives less than 30 inches of annual rainfall. Nevertheless, owing to the clayey texture of the soils and the prevalence of gentle slopes, excessive wetness hinders cultivation. Autumn ploughing is strongly recommended to allow time for frost action to reduce the furrows to a crumb structure. Difficulty is encountered in a wet spring in producing a tilth suitable for a seed-bed, more particularly for roots, and it is now common practice to grow turnips after lea, the grass sod being more easily converted into a seed-bed than the stubble furrow. A further reason for this is that the dominance of white clover in the sward of third-year grass produces too high a level of nitrogen, resulting in lodging if an oat crop follows lea. Caking of the surface soil following heavy rain often causes poor germination of turnip plants which are prevented from breaking through.

Tile drainage is widespread throughout the association particularly on the poorly drained Peterhead series. Excessive water in these soils is best removed by pipes placed so that the top of the pipe is not more than 2½ feet below the surface.

The association is used for stock fattening and cropping and the natural level of fertility is rather higher than is general for the north-east. Practically the whole association is cultivated, but prior to the Second World War, when prices for grain and agricultural products were low, large areas were allowed to revert to permanent pasture and became heavily infested with rushes. The tractor and other mechanical aids to speedy cultivation have greatly helped the working of these clay soils, since the speed of operation means that there is less temptation to commence working the land before it is in a fit state. Excellent grass, oats, barley and wheat are grown; turnips are least satisfactory.

One of the difficulties of farming in this area is the lack of shelter from the east winds. About Inverugie, some shelter has been provided for stock by planting hawthorn hedges on earth banks thrown up in the excavation of drainage ditches surrounding fields.

An interesting account of his experiences on farming clay soils of this association has been given by Cruickshank (1939).

## THE SKELMUIR ASSOCIATION

The Skelmuir Association covers an area of approximately 8 square miles. It occurs at altitudes between 200 and 450 feet to the south-west of Peterhead, in the vicinity of the Moss of Cruden, extending from Skelmuir Hill in the west almost to the coast at Boddam.

### Parent Material

The parent material of the Skelmuir Association is a stony sandy loam to stony clay loam till, the stones consisting of rounded pebbles of quartzite and flint varying in size from ½ to 6 inches. The flint and quartzite till bears no relation to the underlying solid rock which is granite to the east of the Mosses of Kinmundy, Savock and Cruden (as can be seen at Blackhills, north of the Hill of Longhaven) and schist to the west. A quarry at Smallburn Hill has exposed the till overlying the schist rock. On the higher convex slopes the till is shallow, about 2 feet thick, but on the lower slopes it is at least 4 feet thick.

The origin of the flint drift deposit is uncertain; the flints are from the Cretaceous Chalk formation, but no chalk has been found within the region. Limestone does occur, however, in the gravel deposits about the Kippet Hills, some 2 miles north of Collieston. The flint and quartzite pebbles are well rounded and obviously water worn, and it has been suggested that they are a remnant of a Pliocene shore line or littoral deposit. The degree of stoniness of the till decreases from east to west.

### Soils

It is probable that hill peat had at one time covered the greater part of this association. The Moss of Cruden, where land is being reclaimed for agriculture, covers the high ground in the centre of the association. Fields adjoining the moss on the north-east side have peat banks 4 feet high just outside the surrounding fences. The peat is being cut for fuel in many places, and inspection of the underlying mineral strata reveals some 12 inches of a grey waterlogged gleyed ($A_2g$) horizon overlying an iron pan. Beneath the iron pan the stony clay loam drift is very pale brown, with occasional large coarse distinct ochreous blotches.

Two soil series, the Skelmuir and the Bogengarrie, predominate in the arable land. The Skelmuir series, a peaty podzol, occupies convex slopes and is freely or imperfectly drained below the pan. Despite cultivation the $A_2$ horizon, or part of it, and the iron pan are frequently seen in this series, although in a few places cultivation has disrupted both and incorporated them in the surface soil. The Bogengarrie series tends to occupy concave slopes or flatter sites and is classed as poorly drained. It has a black surface with a grey and brown mottled subsoil and is considered to be a non-calcareous gley. Only a small area of peaty gley soils, the Savock series, has been mapped.

*Series*

#### SKELMUIR SERIES

The Skelmuir series, as can be seen from the map, tends to occupy positions near the boundaries of the association. As already stated, it is generally found on the convex slopes, on the thinner deposits in which material from the local rocks (particularly obvious in the lower horizons) is incorporated. South-west of Aldie Farm a proportion of the fine material in the till is derived from quartz-schist, but towards the margin of the association, in the same vicinity, in addition to the predominant flint and quartzite pebbles occasional erratics of basic-igneous, granite, quartz-grit and serpentine have been seen. Over the Hill of Aldie and the Hill of Dens the flint drift overlies weathered granite, some of which is incorporated in the profiles. The texture of the till is a sandy loam.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Calluna vulgaris, Erica tetralix, Cladonia* spp. |
| DRAINAGE CLASS | | poorly drained above iron pan; imperfect below |
| *Horizon* | *Depth* | |
| L | 10–8″ | Litter |
| F | 8–6″ | Fermented litter |
| H | 6–0″ | Black (2/0) well-decomposed, greasy, mor humus |
| $A_2$ | 0–4″ | Grey (10YR5/1) stony sandy loam; grey-brown (10YR5/2) humus staining; fine sub-angular blocky; organic matter moderate; roots abundant; locally strongly bleached on drying. Clear change into |
| $A_2g$ | 4–8″ | Olive-grey (5Y5/2) fine sandy clay loam; massive; wet; water running through; vertical tracks of decomposed roots; organic matter low; live roots few, concentration at base. Sharp change into |
| $B_1$ | at 8″ | Thin $\frac{1}{16}$ inch wavy iron pan, with amplitude of 2 feet |
| $B_2(g)$ | 8–22″ | Brownish yellow (10YR6/6) stony loam; massive; flint and quartzite pebbles abundant; few faint light grey (10YR6/1) mottles and frequent medium prominent yellowish brown (10YR5/6) mottles. Gradual change into |
| C(g) | 22–45″+ | As above; flints and quartzites increasing, occasional quartz-schist; mottling decreasing. |

The litter layers have redeveloped after peat cutting, as can readily be seen from the configuration of the land surface. The $A_2$ horizon is a two-storey layer with the lower half gleyed as a result of the hold-up of water by the iron pan. An increase in clay is noticeable in the gleyed lower half, and water runs laterally through it. The depth of the iron pan fluctuates and may occasionally dip to 36 inches. Beneath the iron pan the slightly gleyed condition of the $B_2(g)$ and C(g) horizons is unusual for a peaty podzol profile. The mottling is thought to be due to a rupturing of the iron pan and the subsequent flow of water into the horizon beneath. The parent material and $B_2$ horizons are, however, freely drained over the granite rock in the north-east of the association and over the quartz-schist rock in the south-west, but are imperfectly drained in localities near the Moss of Cruden.

The colour of the surface soils of arable land derived from the peaty podzol is black to very dark grey (5Y3/1–2/2).

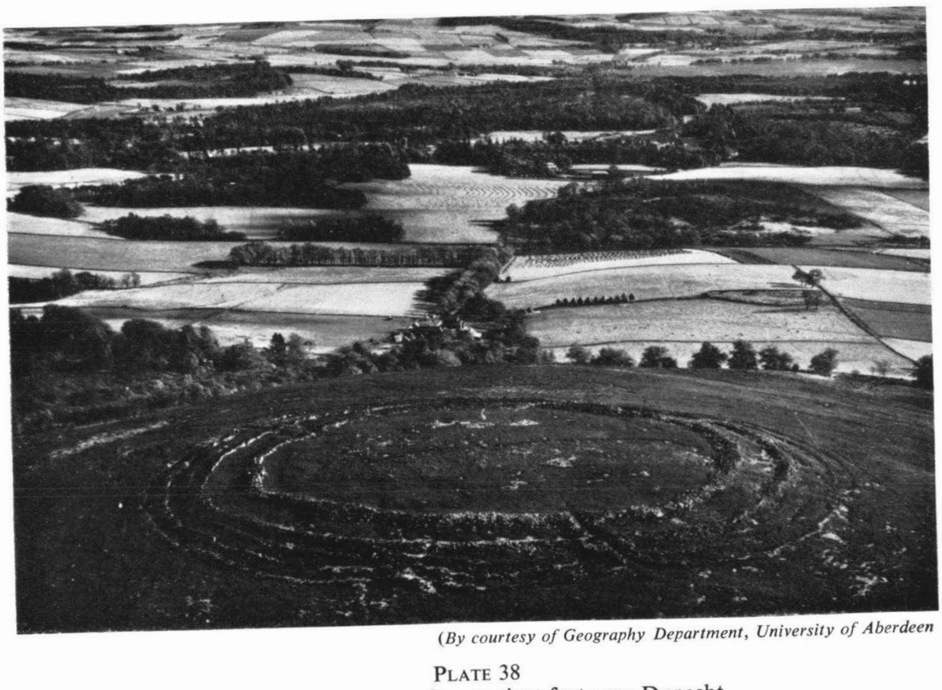
## BOGENGARRIE SERIES

The Bogengarrie series is developed on loam to clay loam till on the flat to gentle concave slopes. The soil tends to have a high organic matter content in the surface horizon and belongs to the poorly drained class.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–11″ | Black (5Y3/1) humose stony loam; roots abundant; no distinct structure; rounded quartz and flint pebble content high. Sharp change into |


PLATE 37
A soil map of Aberdeenshire published in 1811 by G. S. Keith in "A General View of the Agriculture of Aberdeenshire".



*(By courtesy of Geography Department, University of Aberdeen*

PLATE 38
Barmekin Hill, site of an ancient fort near Dunecht.

PLATE 39
The Maiden Stone, Crowmallie.

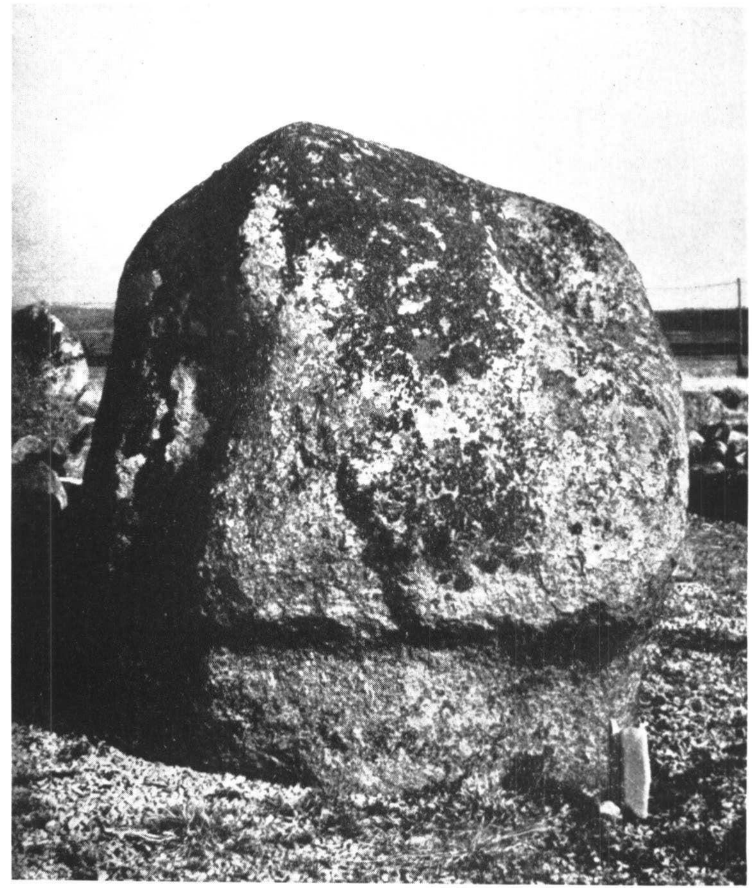


PLATE 40
One of the standing stones of Echt. Weathering at base corresponds to height of former peaty surface horizon.

| | | |
|---|---|---|
| $A_2g$ | 11–18″ | Pale olive (5Y6/4) stony fine sandy loam; moderate sub-angular coarse blocky; strongly stained with organic matter; surface material tonguing through; roots occasional; stone content high; many coarse prominent yellow-orange mottles, concentrated into broad band at base. Clear change into |
| $B_2g$ | 18–36″ | Pale yellow (2·5Y7/3) stony clay loam; moderate sub-angular blocky above, merging into massive below; many coarse prominent yellow-orange mottles; roots rare; stones moderate; plastic. Sharp change into |
| Cg | 36″+ | Variable depending on underlying rock. |

The surface horizon is rich in black organic matter and reflects its peaty origin. An $A_2g$ horizon is typically present, stained in the upper 4 inches by dark brown humus. At the base of the horizon there is a concentration of iron mottles. This is reminiscent of the $B_1$ iron pan horizon in the peaty podzol and may be a dissolving iron pan. Ochreous mottling is present throughout the $B_2g$ horizon. The Cg horizon is influenced by the nature of the underlying substratum. Adjacent to the red clay till of the Peterhead Association the Cg horizon may contain this material; elsewhere granite and quartz-schist are incorporated.

### SAVOCK SERIES

The Savock series has been mapped in only a few areas. The surface soil is black peat of 12 inches or less in depth. This is underlain by a grey $A_2g$ horizon stained with organic matter, as in the Bogengarrie series. The lower horizons are waterlogged and of a greenish grey colour with iron tubes around old root holes.

### NOTE ON AGRICULTURE

In general, the agricultural value of the soils of this association is low, and signs of low nutrient status are common in the cultivated soils. The size of farm tends to be small, and the excessive stoniness of the soils causes severe wear of implements. Steadings are often located on a slight convex rise in the local relief. All the streams and ditches emanating from the Moss of Cruden have an unusually large amount of bog iron ore in suspension.

Adequate drainage and liberal applications of fertilizers are the obvious steps towards obtaining satisfactory yields. Less obvious is the disrupting of the iron pan which is often present in the arable land. Some form of subsoiling which did not involve much mixing of sub-surface material with topsoils would cause a long-term improvement of many soils.

## THE STRICHEN ASSOCIATION

Approximately 45 square miles in extent, the Strichen Association occurs only within the boundaries of Sheets 87 and 97. Four series are represented, the Strichen, an iron podzol, the Baikies, a brown forest soil with gleyed B and C horizons, the Anniegathel, a non-calcareous gley, and the Hythie, a peaty gley. The Strichen, Baikies and Anniegathel series are co-dominant on Sheet 97 where gentle slopes prevail, but on Sheet 87 with its rolling topography only the Strichen and Anniegathel are widespread. The Hythie series is not extensive on either.

## Distribution

On Sheet 87 there are two comparatively large areas of the association, one in the vicinity of the Hills of Skelmonae and Skilmafilly 2 miles north-north-east of Methlick, and the second on either side the North Ugie Water extending from Old Deer in the south to Strichen in the north-west and reaching the foot of Mormond Hill in the north and Rora Moss in the east. A third small area lies on the eastern flanks of the Hill of Dudwick and Whitestone Hill. The topography of the two principal areas is gently rolling and of the third gently sloping. Extensive blocks of conifer plantations occupy the summits of the hills, notably at Loudon Wood, Drinnies Wood and White Cow Wood. On the northern side of the North Ugie Water the rolling topography east of Strichen gives place to smooth gently sloping relief which borders the extensive peat mosses, as at Rora and to the north of it.

On Sheet 97 much of the association occurs as isolated hills surrounded by extensive fluvio-glacial deposits, e.g. about Allanshill south and east of New Aberdour; in the vicinity of Mains of Boyndlie, Mill of Boyndlie and Kirktown; and south and north of the Water of Tyrie. Along the coast from New Aberdour to Fraserburgh there is an extensive belt of the soils of this association. In this area the higher ground occurs about a ½ to 1 mile inland, parallel to the coast in the form of an ill-defined broad ridge which slopes northwards to the coast and southwards to the fluvio-glacial deposits drained by the Water of Tyrie. The relief is gently to moderately sloping. Near the villages of Rosehearty, Pittulie and Sandhaven, deep (16–24 inches) surface soils occur.

## Parent Material

The parent rocks of the Strichen Association are quartz-schist and quartz-mica-schist of the Highland Schist formation. A derived till, which varies from a yellowish brown sandy loam to a brownish yellow sandy clay loam, is the parent material. In summit positions and on convex slopes the till is shallow and stony, except in a few places where the solid formation is deeply weathered and the overlying till is arenaceous with few stones. Concave slopes have a thick mantle of moderately stony till. The stones are mostly schists, but occasionally other types of stone are numerous, as for instance in the north-western parts of the association where relatively high contents of cobbles derived from the Old Red Sandstone conglomerate of the Gamrie–Turriff outlier are found. The finer material of the deposit is not seriously contaminated in these cases.

## Soils

In the four series, Strichen, Baikies, Anniegathel and Hythie, which belong to the Strichen Association, the genetic groups represented are respectively, iron podzol, brown forest soil with gleyed B and C horizon, non-calcareous gley and peaty gley. Very little peaty podzol (Gaerlie series) has been encountered, mainly because practically the whole association is cultivated and the characteristic humus layers and thin iron pan are readily destroyed by farm implements. The Strichen series is freely drained and is developed on a sandy loam till which covers the convex slopes of the undulating or rolling parts of the countryside. The Baikies, Anniegathel and Hythie series are derived from a sandy clay loam till on gentle convex or concave slopes and have imperfect, poor and very poor drainage respectively.

The Strichen and Foudland Associations are alike in many ways, the chief points of difference being that the Strichen Association is of coarser texture, has more sand and less silt, has a lower chroma on the $B_2$ horizon of the iron podzol (Strichen series) and more intense mottling in the gleys. The Strichen Association can also resemble the Tarves Association, especially where the acid parent rocks of the Tarves Association are schists. The Tarves iron podzol, however, has an even lower chroma in the $B_2$ horizon and more prominent mottling in the gleys.

*Series*

STRICHEN SERIES

The Strichen series is the largest of the association, covering approximately 28 square miles. Its drainage class is free and it belongs to the sub-group of iron podzols. The parent material is a sandy loam, generally shallow, with a moderate to high content of schist stones. Much of the series is cultivated and occurs on the rolling uplands of the north-western part of the area.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark grey-brown (10YR4/2) loam; weak medium crumb; friable; organic matter moderate; moderate to high stone content of small quartz-mica-schist and quartzite stones and Old Red Sandstone cobbles; roots abundant. Sharp change into |
| $B_2$ | 10–20″ | Strong brown (7·5YR5/8) fine sandy loam; soft; weak medium sub-angular blocky; organic matter low; fine roots frequent; fewer stones mainly mica-schist; worm holes with S horizon filling. Sharp change into |
| $B_3$ | 20–28″ | Brownish yellow (10YR6/6) sandy loam; poorly defined coarse platy; strongly indurated; very stony—mainly soft and occasionally hard mica-schist fragments; no roots; low organic matter. Clear change into |
| C | 28–40″ | Brownish yellow (10YR6/6) stony sandy loam till, stoniness increasing with depth. |

The S horizon, seldom more than 12 inches thick, varies in texture from loam to sandy loam, often with a high proportion of fine sand. The $B_2$ horizon is a bright uniform brown with no mottles. The structure is weak crumb in the S horizon, becoming medium sub-angular blocky in the $B_2$. The principal characteristics of the $B_3$ are its colour, paler than that of the $B_2$, and its induration which is stronger at the top of the horizon, weakening with depth. The till itself shows few signs of induration and is notable mainly for its high schist content.

BAIKIES SERIES

Developed on a loam or sandy clay loam, the Baikies series is found on gentle, concave slopes. Its drainage class is imperfect. One of the smaller series of the area it covers only 3·5 square miles, mainly in the vicinity of Fraserburgh. It belongs to the sub-group of brown forest soils with gleyed B and C horizons.

PROFILE DESCRIPTION

| | |
|---|---|
| SLOPE | gentle |
| VEGETATION | rotational grass |
| DRAINAGE CLASS | imperfect |

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–12" | Very dark grey-brown (10YR3/2) loam; weak medium sub-angular blocky; friable; organic matter moderate; roots abundant; small sub-angular schist stones plentiful. Sharp change into |
| $B_2(g)$ | 12–19" | Yellowish brown (10YR5/4) fine sandy loam; friable; medium sub-angular blocky; organic matter low; fine roots frequent; frequent medium faint yellowish brown (10YR5/8) mottles; streaks of very dark grey-brown (10YR3/2) along old root and worm tracks; stones larger than in S horizon. Clear change into |
| $B_3$–C | 19–40" | Yellowish brown (10YR5/4) loam; weakly indurated in upper 3 inches; low organic matter; roots occasional at base; frequent, yellowish brown and dark grey-brown, medium mottles; black manganese staining below 30 inches; structure weakly prismatic to massive below induration; high stone content, mainly small schists. |

The S horizon is a little darker and has larger peds than the S horizon of the Strichen series. The $B_2(g)$ horizon is not so brown as the $B_2$ of the Strichen series and it has characteristic yellowish brown mottles. This horizon has a very patchy appearance, due to frequent accumulations of dark brown organic matter from old roots and to worm tracks, filled with S horizon materials which occur at about 2-inch intervals. The schistose stones and occasional quartzite cobbles are larger in the $B_2(g)$ horizon than in the S. The change into the weakly indurated $B_3$ horizon does not appear to be accompanied by a marked colour change which is general in all well-drained soils, and where an increased clay content occurs there is no induration. Below the indurated part of the horizon, the mottling is ochreous with a little grey. Blue-black manganese staining appears below 30 inches.

## GAERLIE SERIES

The Gaerlie series is the least extensive of the association, accounting for only 1% of the association (0·4 square miles). It occurs as small scattered areas normally adjacent to the Strichen series. A peaty podzol with iron pan, it is always freely drained below the pan but can be gleyed above. The dominant vegetation is Callunetum.

PROFILE DESCRIPTION

| | |
|---|---|
| SLOPE | moderate |
| VEGETATION | *Calluna vulgaris, Erica cinerea, Hypnum cupressiforme* |
| DRAINAGE CLASS | free below iron pan |

| *Horizon* | *Depth* | |
|---|---|---|
| L/F | 3–2" | Litter and partially decomposed litter |
| H | 2–0" | Black (10YR2/1) humus, resilient |
| $A_2$ | 0–3" | Dark grey-brown (10YR4/2) loamy coarse sand; weak fine granular; friable; dark humus staining; many bleached quartz grains. Sharp change into |
| $B_1$ | at 3" | Iron pan $\frac{1}{16}$ inch thick; roots penetrate |
| $B_2$ | 3–9" | Strong brown (7·5YR5/6) fine sandy loam; fine crumb; soft; organic matter low, but some organic staining; fine roots frequent; moderate stone content, mainly schists. Sharp change into |

| | | |
|---|---|---|
| $B_3$ | 9–20″ | Brownish yellow (10YR6/6) sandy loam; weak coarse platy; strongly indurated; high stone content, mainly schists; low organic matter; occasional roots. Gradual change into |
| C | 20–40″+ | Brownish yellow (10YR6/6) stony sandy loam till, stoniness increasing with depth; weakly indurated; low organic matter; no roots. |

This series is very similar to the Strichen series in the $B_2$ and $B_3$ horizons. The upper horizons, however, are different. In this series there is an H layer, seldom more than 3 inches thick because of controlled burning of the moors, and an $A_2$ horizon which has prominent bleached quartz grains and some dark humus staining. On occasion, strong gleying is evident in the lower part of the $A_2$ horizon.

### ANNIEGATHEL SERIES

The Anniegathel series is formed on a sandy clay loam till and occurs on gently sloping ground. It is widespread over the low-lying tract alongside the North Ugie Water from Fetterangus to New Leeds and between Rosehearty and Fraserburgh. Almost all the land is cultivated and has been extensively tile-drained. The stone content of the till varies from moderate to low. Many of the schist stones are so weathered that they can be crushed with the fingers. The series is poorly drained and belongs to the sub-group of non-calcareous gleys.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Grey-brown (10YR5/2) loam; moderate coarse blocky; slightly plastic; organic matter moderate; roots abundant; stones moderate, mainly mica-schist and occasionally quartzite. Sharp change into |
| $A_2g$ | 8–12″ | Pale olive (5Y6/3) fine sandy loam; moderate coarse prismatic; plastic; organic matter low; roots occasional down faces of prisms; moderate stone content; frequent medium prominent ochreous mottles, particularly in lower half; occasional large worm holes with surface soil in-filling. Clear change into |
| $B_2g$ | 12–26″ | Yellowish brown (10YR5/8) sandy clay loam; strong coarse prismatic; plastic; few small mica-schist and quartz-schist stones mainly decomposed; high mica content; frequent medium distinct ochreous mottles; occasional iron tubes round old root channels; grey faces to the peds; occasional roots to 30 inches, rare below; Gradual change into |
| $B_3g/Cg$ | 26–44″ | Brownish yellow (10YR6/6) sandy clay loam; massive; plastic; increase in ochreous mottling; few medium distinct grey mottles; small schist stones mainly decomposed. |

The S horizon has the characteristic grey-brown colour of gley soils, a sub-angular blocky structure and either a firm or a plastic consistency, depending on the moisture condition. In the $A_2g$ the structure is coarse angular blocky for the first few inches which are dominantly grey, and beneath this, where ochreous mottling becomes prominent, it is prismatic. The ochreous mottling continues into the $B_2g$ and $B_3g/Cg$ horizons the former having a coarse prismatic and the latter a massive structure. The peds in the $B_2g$ horizon are coated with grey. The horizon $B_3g/Cg$ is generally of a brownish yellow colour with large ochreous mottles.

## HYTHIE SERIES

The Hythie series is a minor component of the association. It occupies small patches and narrow strips in low-lying, concave sites. The parent material is an olive-grey sandy clay loam which in channel areas can show signs of water-sorting. The series, a peaty gley, is very poorly drained.

### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | old pasture with *Alopecurus geniculatus, Holcus lanatus, Ranunculus acris, Bellis perennis, Phleum* sp. |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–9″ | Very dark grey-brown (10YR3/2) sandy loam; medium to coarse blocky; non-plastic; organic matter high; fine roots abundant; few stones, some decomposing giving yellowish red mottles; some rusty mottling along root channels. Sharp change into |
| $A_2g$ | 9–16″ | Light olive-brown (2·5Y5/4) sandy loam; massive; firm; organic matter low; roots few; moderately stony, many decomposing mica-schist and quartz-schist; iron tubes round root channels; few medium distinct ochreous mottles; many medium prominent grey mottles. Clear change into |
| $B_2g/B_3g$ | 16–40″ | Olive-grey (5Y5/2) sandy clay loam; massive; plastic; roots occasional; moderately stony; few distinct ochreous mottles; well-defined iron tubes along roots; black manganese stains from decomposing stone. Gradual change into |
| Cg | 40–48″ | Olive-grey (5Y4/2) sandy clay loam; massive; plastic; roots rare; no mottling; no iron tubes; stone content moderate, mainly mica-schist. |

The texture of the S horizon which is always rich in organic matter varies from sandy loam to loam. This horizon is nearly always wet and consequently its structure is weakly expressed. If allowed to dry out the horizon exhibits a coarse blocky structure which often breaks down further into a coarse crumb. The $A_2g$ horizon, in contrast to the S horizon, is low in organic matter (1·0%), but olive-brown organic staining is much in evidence in the top 2 or 3 inches. Grey colours predominate in the lower half of the horizon and continue into the horizons beneath. The texture, like that of the S horizon, is a sandy loam. Prominent iron tubes encasing roots extend from the lower part of the horizon into the olive-grey, massive $B_2g/B_3g$ horizon, but stop short of the Cg. The texture of both the $B_2g/B_3g$ and Cg horizons is, generally, a sandy clay loam. Ochreous mottling is much less prevalent in this series than in the poorly drained Anniegathel series.

### *Skeletal Soils*

A few small areas of skeletal soils belonging to this association have been mapped on Sheets 76 and one in the north of Sheet 87/97. In the area of Sheet 76 the soils have a thin mor humus layer overlying a rudimentary $A_1$ or $A_2$ horizon. This rests directly on shattered rock. In the area of Sheet 87/97, the skeletal soils do not, in general, have a mor humus horizon. The A horizon rests immediately on shattered rock.

## NOTE ON AGRICULTURE

On this association the range in farm size is considerable. Farms are small on the Anniegathel series bordering the peat mosses between New Leeds and Fetterangus and on the shallow Strichen series just inland from the coast between Fraserburgh and Rosehearty. They are large on the Strichen series of the rolling hills south of the North Ugie Water and on the Anniegathel and Baikies series between Fraserburgh and Rosehearty. The farms on these series in the latter area are said to be the highest yielding in the district. The frequent occurrence of shells in the soils indicates that heavy application of shell sand from the nearby sand dunes had once been made.

The small farms are chiefly engaged in the rearing and feeding of cattle; pigs and poultry are also of importance. The large farms are principally concerned with the fattening of both sheep and cattle. They also grow between 10 and 25 acres of cash crops such as potatoes and barley. Since the economy of most of the farms is based on livestock, grass is by far the most important single crop. As well as determining the numbers of livestock in summer, it contributes as hay or silage to their keep in winter. The other fodder crops grown in the area are oats and turnips.

## THE TARVES ASSOCIATON

The Tarves Association is one of the more extensive and agriculturally important associations in the north-east of Scotland. It covers 270 square miles, all but 49 being within the area described in this memoir. Sandy loam to sandy clay loam in texture, the parent material is a light yellowish brown till derived from both acid and basic rocks with the contribution from the basic rocks less than that from the acidic. The till, which is of variable thickness but normally less than 4 feet on the hill ground and more than 4 feet at lower elevations, especially where the slope is concave, has a moderate stone content and overlies many different types of solid formation. Six series belonging to six major soil sub-groups are present within the association, but it is the Tarves series which is of the greatest agricultural value.

### DISTRIBUTION

Stretching in a north-easterly direction from the vicinity of Tarland and Towie to within a few miles of the coast between Aberdeen and Peterhead, the association forms a 6 to 15 mile wide belt, broken only in the Bennachie–Cairn William district where a large area of Countesswells Association is located. The character of the terrain changes markedly from west to east. About Tarland the altitude of the arable land ranges from 500 to 1000 feet and the relief is strongly rolling to hilly. The mountainous land between Tarland and Towie, comprising the peaks of Pittendriech (1655 feet), Pressendye (2032 feet), Scar Hill (1723 feet), Baderonach (1557 feet) and Gallows Hill (1425 feet), much of which is planted, is part of the association, as is the hilly land in the neighbouring parish of Leochel Cushnie. To the north, in the Vale of Alford, the relief is gently rolling, and here conditions are more favourable for mixed arable farming. The Chapel of Garioch portion of the association is rolling to hilly with an altitudinal range from 200 to 800 feet. The major part of the association is contained in the very large area lying north of the Don between Inverurie and Aberdeen and extending in a continuous belt to the Ugie Water, west of Peterhead. Here the topography is gently rolling, with an altitudinal variation of between 200 and 400 feet.

## Parent Material

Unless affected by a water-table, the till on which the Tarves Association is developed is yellow. It is derived from many different rock types, but always with major contributions from both acid and basic rocks, with the influence of the acid rocks invariably the greater. Illustrative of the mixed stone content of the till, the following rocks were noted at Nether Aden, Mintlaw: chiastolite-schist, quartz-schist, biotite-schist, felsite, granite, diorite, olivine-norite, hypersthene-gabbro. At Tillycorthie, Pitmedden, phyllite, quartz-schist, argillaceous schist, granite, felsite, granitic gneiss, hornblendic gneiss, quartzite, quartz-grit, felspathic grit, hornfels, epidiorite, dolerite, gabbro and serpentine were identified. On the convex slopes of the rolling countryside and on the higher slopes of the hills the till is less than 4 feet thick and has a texture approximating to sandy loam, but on the concave slopes, especially at lower altitudes, it is more than 4 feet thick with a texture of sandy clay loam. Despite the variety of contributing rocks the till throughout the whole area is remarkably constant in colour and, if allowance is made for difference in site, in texture, but whenever it thins out on the hill slopes the till becomes strongly influenced by the underlying solid formation. For instance, in the Aberdeen–Tarves–Newmachar–Belhelvie area the soils developed on the thin till show the influence of the underlying gneiss, which varies in composition from granitic to hornblendic. Similarly, the thin till in the Arnage district contains a large proportion of stones from the underlying solid strata which Read (1923*a*, p. 77) has described as a contaminated igneous rock with a composition between gabbro and syenite. In the Stuartfield–Longside–Corse of Balloch district, quartz-schist, gneiss and granite are the underlying solid formations and they make an important contribution to the composition of the till. Granitic and hornblendic gneiss, with small areas of diorite, are the underlying rock types in the Tarland–Leochel Cushnie district and these are preponderant in the thin till as they are in the Chapel of Garioch–Bourtie section. Although a considerable mixture of rocks is seen in the till in the Howe of Alford, including gabbros from Glenbuchat and spotted schists from the Correen Hills, it is the more local hornblendic gneiss and granite which predominate wherever the till thins out.

## Soils

The soils of the Tarves Association are found over an altitudinal range from 100 to 2000 feet. Despite this, the amount of rainfall to which the soils are subjected is remarkably constant; most of the soils get between 30 and 35 inches, only those in the mountainous region just north of Tarland receiving more. Six major soil sub-groups are represented in the association, brown forest soils (low base status and gleyed B and C), iron podzols, peaty podzols, non-calcareous gleys and peaty gleys. The peaty podzols occur exclusively above 1000 feet in the vicinity of Tarland; elsewhere the brown forest soils, the iron podzols, or the gleys are dominant. Most of the arable land is thought to have been at one time either brown forest soils or non-calcareous gleys and in general is mapped as such. In one locality, however, at the edge of the mountainous country just north of Tarland, the arable land abuts iron podzols for a considerable distance and it is clear that some of it must formerly have been iron podzols. Owing to practical difficulties, however, this distinction has not been made in mapping, and all the cultivated land has been recorded as brown forest soils of low base status. The gleys are developed on a sandy clay loam till and the other soils on a sandy loam or loam till.

*Series*

TARVES SERIES

Located on moderate and steep convex slopes below 1000 feet, the Tarves series, with an area of 129 square miles, is the most extensive of the association. Its parent material is a moderately stony, sandy loam till seldom much more than 4 feet thick. Much of the series is cultivated, but where semi-natural conditions still prevail it supports an acid grassland type of vegetation. The drainage class is free and the major soil sub-group is brown forest soil of low base status.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | moderate |
| VEGETATION | | *Deschampsia flexuosa, Anthoxanthum odoratum, Agrostis tenuis, Galium saxatile, Sarothamnus scoparius, Rumex acetosa, Sorbus aucuparia* (scrub), *Pseudoscleropodium purum, Hypnum squarrosum* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 3–2″ | Litter |
| F | 2–0″ | Partially decomposed litter |
| A | 0–5″ | Dark brown (10YR4/3) sandy loam; moderate medium crumb; friable; moderate organic matter; abundant fine roots; no mottles. Gradual change into |
| $B_2$ | 5–13″ | Yellow-brown (10YR5/6) sandy loam; moderate fine sub-angular blocky; friable; organic matter low; roots plentiful; no mottles. Sharp change into |
| $B_3$ | 13–21″ | Light yellowish brown (10YR6/4) stony sandy loam; moderately coarse platy; strongly indurated, becoming less so with depth; organic matter low; roots few; few fine ochreous mottles; underside of peds stained with dark brown. Gradual change into |
| C | 21–33″ | Light yellowish brown (10YR6/4) to brown (10YR5/3) stony sandy loam; weak coarse sub-angular blocky; firm; passing into partially decomposed gneiss. |

The A horizon possesses a moder type of organic matter, with only an inch or so of L and F layers on top. It has a characteristic crumb structure which changes gradually to fine sub-angular blocky in the $B_2$ horizon. Strong induration is always present in the $B_3$ horizon, accompanied by a coarse platy structure and an absence of roots. The $B_3$ and C horizons are both quite stony, the latter often passing into weathered rock at less than 4 feet. Cultivation produces a dark brown (10YR4/3) surface horizon which, like that of the Insch Association, is much thicker (over 12 inches) than average in certain localities.

TILLYPRONIE SERIES

Developed on a stony sandy loam till, generally less than 4 feet thick, the Tillypronie series is not widespread, accounting for only some 4% of the association. This series is generally located on the moderate to steep slopes of the hills, with the Pressendye series on the flatter summits above and the Tarves series on the arable land below. The drainage class is free and the major soil sub-group is iron podzol. A characteristic vegetation is *Calluna vulgaris*, associated sometimes with *Nardus stricta* or *Deschampsia flexuosa.*

PROFILE DESCRIPTION

| | |
|---|---|
| SLOPE | moderately steep |
| VEGETATION | open scrub *Larix decidua, Pinus sylvestris,* and *Sorbus aucuparia* with *Calluna vulgaris, Vaccinium myrtillus, V. vitis-idaea, Deschampsia flexuosa* |
| DRAINAGE CLASS | free |

| *Horizon* | *Depth* | |
|---|---|---|
| L | 4–3″ | Litter |
| F | 3–1″ | Partially decomposed litter |
| H | 1–0″ | Black well-decomposed organic matter; soft; intermingled with silica grains. Gradual change into |
| $A_2$ | 0–2″ | Dark grey (10YR4/1) drying to light brownish grey (10YR6/2) sandy loam; weak fine sub-angular blocky; friable; high organic matter; roots abundant; patches of organic staining. Clear change into |
| $B_2$ | 2–6″ | Dark brown (10YR4/2) fine sandy loam; weak medium sub-angular blocky; friable; moderate organic matter; plentiful roots; low value of colour due to organic staining. Gradual change into |
| $B_2$ | 6–12″ | Yellowish brown (10YR5/8) fine sandy loam; weak medium sub-angular blocky; friable; low organic matter; roots frequent; no mottling. Sharp change into |
| $B_3$ | 12–22″ | Brownish yellow (10YR6/6) gritty stony sandy loam; moderate coarse platy; moderately indurated, becoming less so with depth; roots few; organic matter low; few medium distinct ochreous mottles. Clear change into |
| C | 22–33″ | Light yellowish brown (2·5Y6/4) stony sandy loam; weak medium angular blocky; firm. Sharp change into partially decomposed hornblendic gneiss. |

It is mainly in the upper horizons that this series differs from the Tarves and Pressendye series. The L and F layers are each about 1 inch thick, overlying a well-formed $A_2$ horizon which is quite dark when freshly exposed but grey when dried out. In the upper 4 inches or so of the $B_2$ horizon there is some organic staining which obscures the characteristic yellowish brown colour. The structure of the $A_2$ is weak sub-angular blocky, but in the $B_2$ the peds are better formed and more durable. Induration and platy structure are characteristic features of the $B_3$ horizon which is sufficiently dense to prevent roots growing into the C horizon beneath. There the structure is more massive and the content of stones is greater.

## PRESSENDYE SERIES

Although favoured by the gentle and moderate slopes of the hill-tops in the vicinity of Tarland, the Pressendye series is not extensive, accounting for only some 4·5% of the association. Its parent material, a till of a sandy loam texture less than 4 feet thick, is indistinguishable from those of both the Tarves and the Tillypronie series. Above the iron pan ($B_1$) the drainage class varies from free to poor, but below the pan it is always free. As a member of the major soil sub-group of peaty podzols the series carries a heath type of vegetation with *Calluna vulgaris* and *Erica tetralix* often abundant.

PROFILE DESCRIPTION

| | |
|---|---|
| SLOPE | gentle |
| VEGETATION | *Calluna vulgaris, Erica tetralix, Nardus stricta, Trichophorum caespitosum, Hypnum cupressiforme* |
| DRAINAGE CLASS | imperfect above the pan, free below |

| *Horizon* | *Depth* | |
|---|---|---|
| L | 7–6″ | Litter |
| F | 6–4″ | Partially decomposed litter |

| | | |
|---|---|---|
| H | 4–0″ | Black (10YR2/2) plastic humus. Sharp change into |
| $A_2$ | 0–4″ | Dark brown (7·5YR4/2) sandy loam; weak fine sub-angular blocky; friable; organic matter high; roots abundant; frequent fine distinct ochreous mottles at base; root concentration at base. Sharp change into |
| $B_1$ | at 4″ | Iron pan $\frac{1}{16}$th inch thick. Sharp change into |
| $B_2$ | 4–9″ | Light yellowish brown (10YR6/4) sandy loam; weak medium sub-angular blocky; organic matter low; few roots; no mottles. Sharp change into |
| $B_3$ | 9–15″ | Pale brown (10YR6/3) stony sandy loam; moderate medium coarse platy; moderately indurated; low organic matter; no roots; no mottles. Gradual change into |
| C | 15–24″ | Yellow (10YR7/6) stony sandy loam; weak coarse sub-angular blocky to massive; firm; low organic matter; no roots. Sharp change into |
| D | 24″+ | Weathered hornblendic gneiss. |

Of first importance in this profile are the upper horizons. The L, F and H layers are all well-formed, with the last over 3 inches thick—and often as much as 6 inches. The $A_2$ horizon, 2 to 4 inches thick, is rich in organic matter and is quite dark when freshly exposed, although on drying out it is much lighter and justifies its name of bleached layer. At the bottom of the horizon, just above the thin iron pan ($B_1$ horizon), there is an accumulation of organic matter which appears to be the product of decomposition of roots prevented by the hardness of the iron pan from penetrating into the horizons beneath. Below the iron pan the horizons resemble those of the Tarves and Tillypronie series, the $B_2$ horizon having a colour with a high chroma, a friable consistence and a crumb or sub-angular blocky structure, and the $B_3$ a paler colour, a platy structure and a moderate or strong degree of induration.

### THISTLYHILL SERIES

The Thistlyhill series, widespread on the lower ground, especially between Aberdeen and Maud, covers about 21 square miles, 2% of the surveyed area. It is a brown forest soil with gleyed B and C horizons. Its drainage however, is imperfect and it is developed on a sandy clay loam till, generally over 4 feet thick with only a moderate stone content. Practically all of the Thistlyhill series is cultivated and so it is not possible to give a characteristic natural or semi-natural vegetation.

PROFILE DESCRIPTION

| | |
|---|---|
| SLOPE | moderate |
| VEGETATION | rotational grass |
| DRAINAGE CLASS | imperfect |

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–10″ | Brown to dark brown (10YR4·5/3) loam; moderate fine sub-angular blocky; friable; moderate organic matter; roots plentiful. Sharp change into |
| $B_2(g)$ | 10–15″ | Yellowish brown (10YR5/6) loam; moderate fine sub-angular blocky; friable; low organic matter; roots frequent; few fine distinct ochreous mottles, more prevalent towards base; marked pockets of S horizon down worm holes. Sharp change into |
| $B_3(g)$ | 15–20″ | Light yellowish brown (10YR6/4) sandy loam; moderate coarse platy; moderately indurated; roots few; few medium distinct ochreous mottles. Gradual change into |
| C(g) | 20–26″ | Light yellowish brown (10YR6/4) sandy clay loam; weak coarse blocky; firm; frequent distinct ochreous mottles inside peds; faces of peds slightly grey. Gradual change into |

| | | |
|---|---|---|
| C(g) | 26–42″+ | Yellowish brown (10YR5/6) sandy clay loam; weak very coarse blocky to massive; firm; frequent distinct ochreous mottles inside peds; faces of peds slightly grey. |

An important feature of this soil is the mottling, slight in the $B_2$(g) and $B_3$(g) horizons and more extensive in the C(g) horizon where it is quite conspicuous. The induration in the $B_3$(g) horizon is not so marked as in the $B_3$ horizon of the Tarves series. With a sandy clay loam texture the C(g) horizon has a more massive structure than any of the other horizons, the peds being coated with grey material on the surfaces and having ochreous mottles inside. In general, this series, probably because of its less brightly coloured $B_2$(g) horizon, has a dull appearance compared with the freely drained Tarves series.

### PITMEDDEN SERIES

Although not as extensive as the Tarves series, the Pitmedden series is widely distributed throughout the association and is dominant in certain localities near Peterhead. With an area of 50 square miles it accounts for approximately 25% of the association. Situated on gentle to moderate foot-slopes where the relief is hilly or rolling, the series is developed on a sandy clay loam till more than 4 feet thick. Since most of the series is cultivated it is not possible to name a characteristic type of vegetation, but some of the weeds of the arable ground, such as *Polygonum persicaria*, are indicative of poor drainage. The series belong to the major soil sub-group of non-calcareous gleys.

#### PROFILE DESCRIPTION

SLOPE — gentle
VEGETATION — rotational grass
DRAINAGE CLASS — poor

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–9″ | Dark grey-brown (2·5Y4/2) loam; moderate coarse sub-angular blocky; plastic; moderate organic matter; roots plentiful; few fine ochreous mottles. Sharp change into |
| $A_2$g | 9–12″ | Grey-brown (2·5Y5/2) sandy loam; weak coarse blocky; plastic; low organic matter; roots numerous; pockets of S material; few fine distinct ochreous mottles. Clear change into |
| $B_2$g | 12–24″ | Light yellowish brown (2·5Y6/4) sandy clay loam; moderate medium prismatic; plastic; frequent roots, concentrated between peds; organic matter low; frequent distinct strong brown (7·5YR5/8) mottles inside peds; grey-brown (2·5Y5/2) coating on surface of peds. Clear change into |
| $B_3$g | 24–36″ | Light yellowish brown (2·5Y6/4) sandy clay loam; moderate coarse prismatic; plastic; few roots, concentrated between peds; organic matter low; frequent distinct strong brown (7·5YR5/8) mottles inside peds; grey-brown (2·5Y5/2) coating on surface of peds but not so definite as in $B_2$g. Sharp change into |
| Cg | 36″+ | Dark grey (2·5Y4/0) gritty sandy clay loam; massive; plastic; organic matter low; iron oxide tubes round former root holes; no roots; waterlogged. |

Sometimes the $A_2$g horizon is not represented, having been incorporated into the S horizon; at other times it is no more than 2 inches thick. Structure is more clearly expressed in the $B_2$g horizon, and becomes gradually more massive with depth until the Cg horizon is reached. The peds in the $B_2$g and $B_3$g horizons characteristically have a few millimetres of grey material on their surface and quite an amount of ochreous mottling within. In the

Cg horizon, which is often waterlogged, there are prominent iron oxide tubes lining old root channels and in some instances well-preserved woody roots are present.

### PETTYMUCK SERIES

A minor component of the association, the Pettymuck series is restricted to depressions where there was probably at one time a covering of peat, long since stripped off for fuel. Although tile drains now control the level of the water-table it is common practice not to cultivate this land any more than is necessary to maintain a satisfactory grass ley. Its parent material is a sandy clay loam till of considerable thickness, and the A and B horizons are frequently loam or even sandy loam. The drainage class is very poor and the major soil sub-group is peaty gley.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | old pasture |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Very dark brown (7·5YR3/1) peaty sandy loam; weak coarse sub-angular blocky; friable; roots plentiful; organic matter high; frequent fine distinct ochreous mottles along root channels. Sharp change into |
| $B_2g$ | 8–12″ | Light grey (2·5Y7/2) sandy clay loam; weak coarse sub-angular blocky; firm; low organic matter; roots numerous; many faint coarse pale yellow mottles (2·5Y7/4) especially round numerous root channels. Gradual change into |
| $B_3g$ | 12–22″ | Grey (2·5Y6/0) sandy clay loam; pockets of sandy loam and clay loam; massive; firm; roots frequent; most of the stones decomposed; many prominent medium ochreous mottles especially at the top of horizon; iron oxide tubes round former root channels. Gradual change into |
| Cg | 22–40″+ | Grey (2·5Y6/0) sandy clay loam; massive; plastic; roots few; most of stones decomposed; many well-defined iron oxide tubes along former root channels; few fine prominent ochreous mottles; level of permanent water-table. |

In some localities the S and $B_2g$ horizons have been developed on alluvial material which is not of sufficient thickness to warrant separation. In the Cg horizon there is much less mottling than in the $B_2g$ and $B_3g$ horizons, due to the presence of a water-table for most of the year. Instead there are iron oxide tubes formed on channels at one time occupied by roots. Nowhere in the profile is the structure well-defined, the most stable peds occurring in the $A_2g$, when present, and $B_2g$ horizons. In all the other horizons the tendency is towards massiveness.

### NOTE ON AGRICULTURE

With the land ranging from 250 to 2000 feet above sea level, farming practice naturally varies widely throughout the association. In the western hilly part sheep farming with subsidiary cattle rearing is the dominant activity. Where the terrain is more rolling, as in the eastern part of the parish of Leochel Cushnie, a considerable amount of grain is grown, but stock-rearing is still the principal enterprise. Pastures are down for quite long periods and few potato crops are grown. In the Vale of Alford and the eastern part of the association, climatic conditions allow a wider range of farming activities and stock-fattening becomes more important than rearing. Seed potatoes and dairying are additional interests in the Udny–Pitmedden district where severally internationally famous herds of beef cattle are located.

Most farms in the eastern part of the association include both Tarves and Pitmedden series in the rough proportion of two to one. The Tarves series seems to be of some practical importance in the successful feeding of fatstock, for in the few localities where the Pitmedden series is predominant little fattening is done and the principal enterprise is stock-rearing. The explanation may lie in the fact that the turnip crop, which is of prime importance in stock-fattening, is more successful on the Tarves series than on the Pitmedden. There is also some evidence that herbage grown on the Tarves series has a more satisfactory content of micro-nutrients than that on the Pitmedden. The six-course rotation, in conjunction with stock-fattening, is widely followed. If no livestock is kept, however, what is known locally as cross-cropping is practised. This is a rotation consisting of 4 years of grass, followed by 2 years of potatoes, then oats or barley for 4 or 5 consecutive years. The white crop is sown out with red clover which is ploughed down in preparation for the following white crop. All the grass is sold off the farm as hay. Between Aberdeen and Tarves dairying is of considerable importance.

Extensive felling of trees took place during the First and Second World Wars and it is only within the last 10 years that most of the replanting has taken place. In the hills of the west, large areas of the Tillypronie series and a few small areas of the Tarves series are being planted. Trees are found at 1750 feet on Callievar Hill and a little higher on The Top, but generally the upper limit is between 1250 and 1500 feet. Natural regeneration is extensive on the Loanend Plantation where solitary Scots pines have an apron of young trees, about 40 yards long, to the east. Felling often has the effect of accelerating erosion, and many drainage ditches on the lower ground have been plugged with material eroded from the felled areas.

## THE TIPPERTY ASSOCIATION

In an irregular belt along the coastal plain from Balmedie to St. Fergus, extending inland for distances up to 6 miles, three soil associations have been mapped on red drift derived from rocks of the Old Red Sandstone formation (Fig. 16). There are no solid formations of Old Red Sandstone age in the neighbourhood, and the explanation generally put forward is that the material on which these soils have been developed was transported northwards from Strathmore by ice during the second glaciation.

The Peterhead Association, on red clay till, and the Collieston Association, on partially water-sorted red till, have already been described. The third is the Tipperty Association which occurs below an altitude of 250 feet, on flat to gently rolling topography, and occupies an area of 17 square miles.

### DISTRIBUTION

The Tipperty Association has been mapped mainly between Stirling Hill and the Water of Cruden, to the south of the Water of Cruden in a belt extending as far as the east side of Lochlundie Moss, and north-east of Ellon from Auchmacoy in the south to the Toll of Birness in the north. Other patches occur at Blackdog, Balmedie, Belhelvie Lodge, Middle Ardo, Esslemont, Tipperty and Blackhillie.

## PARENT MATERIAL

At an altitude of between 100 and 250 feet the parent material is predominantly a massive red lacustrine clay which is calcareous below a depth of 3 feet, but there are areas, often too small to be delineated, of lacustrine silt or fine sand. The clay deposits occasionally have thin bands of sand or silt. Below the 100-feet contour the clay deposit is varved, with the laminae one-sixteenth to one-quarter inch thick. A layer of fine texture (clay or silt) alternates with one of coarser texture (silt or fine sand), each pair being considered by geologists to have been deposited within the same year. Soil forming processes have obscured the varving to a depth of approximately 3 feet.

The soil, as well as a considerable variety of varving, can be seen at Tipperty in a clay pit belonging to the Cruden Bay Brick and Tile Co. Ltd. There are few other good exposures, and it is not satisfactory to examine the deposit by means of auger cores because of mixing during the operation. The red clay has been seen buried beneath recent alluvium in many stream channels inland from the main deposits. Below the 100-feet contour the deposit is thick, more than 10 feet; above this level it is generally thinner.

## SOILS

Three soil series have been distinguished, the Tipperty, imperfectly drained, the Birness, poorly drained and the Dorbs, very poorly drained. The Tipperty series is the most extensive and occupies the gentle convex slopes while the Birness series is found in shallow depressions. Some of the Birness series comes near to the very poorly drained class. The Dorbs series, a peaty gley, is rare and is found in very small areas adjacent to one of the other two series. Permeability of all three series is poor owing to the high percentage of clay in the B and C horizons.

*Series*

### TIPPERTY SERIES

The Tipperty series is imperfectly drained and is developed on reddish brown lacustrine clay which shows minor stratification in the form of narrow bands of fine sand. A scatter of stones over the surface horizon is common, but the B(g) horizon is virtually stone-free. The series, generally cultivated, belongs to the major soil sub-group of brown forest soils with gleyed B and C horizons.

#### PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | imperfect |
| *Horizon* | *Depth* | |
| S | 0–12″ | Dark brown (7·5YR4/2) clay loam; fine crumb in top 3 inches passing into coarse crumb and into fine angular blocky; sticky; organic matter moderate; roots abundant; occasional small pebbles; worms present. Sharp change into |
| $A_2$(g)/ $B_2$(g) | 12–16″ | Brown (7·5YR5/4) clay; strong medium angular blocky; sticky; low organic matter; stone-free; frequent fine roots; worms present. Sharp change into |
| $B_2$(g) | 16–20″ | Reddish brown (2·5YR4/4) clay; strong medium prismatic breaking into medium angular blocky; sticky; low organic matter; stone-free; frequent roots between peds; peds coated with reddish brown (5YR5/3) clay; frequent fine strong brown (7·5YR5/8) mottles inside peds. Gradual change into |

| | | |
|---|---|---|
| $B_2(g)$ | 20–32″ | Yellowish red (5YR4/8) clay; coarse prismatic to columnar; frequent roots between peds; low organic matter; few fine strong brown (7·5YR5/8) mottles inside peds; frequent black manganese mottles on surface of peds. Gradual change into |
| C(g) | 32–48″+ | Red (2·5YR4/6) clay; massive; plastic; tendency to fine stratification; no roots; no mottles. |

The Tipperty series is characterised by its colour, structural and textural changes. The colour in the S horizon is dark brown, but in the $B_3(g)$ and C(g) horizons it is red. In the S horizon the structure is a fine crumb which progressively changes through fine to medium angular blocky in the $A_2(g)$ to prismatic in the $B_2(g)$ and $B_3(g)$ horizons and massive in the C(g). The faces of the peds in the $B_2(g)$ horizon are dull and exhibit slight gleying; the insides are mottled brown, especially near roots. With depth the peds become larger, have a polished coating of clay and are less gleyed. Black mottles of manganese oxide show up prominently on their surfaces in the $B_3(g)$ horizon. The high clay content of the $B_3(g)$ and C(g) horizons is responsible for a low permeability, and indirectly for the frequency and character of the mottling.

### BIRNESS SERIES

Formed in shallow depressions where sluggish outfall causes run-off water to accumulate, the Birness series is a poorly drained non-calcareous gley. Although the parent material is a red lacustrine clay, the S horizon and the greater part of the Bg horizon have a pronounced grey colour due to gleying. The relatively fresh parent material is present within approximately 3 feet of the surface. The series can be seen in and about the alder wood north-east of Leys Farm on the Fraserburgh road 3 miles north of Ellon.

Where it occurs as arable land the series has, without exception, been tile-drained, but the frequent presence of *Juncus effusus* indicates that even so the land is still wet.

#### PROFILE DESCRIPTION

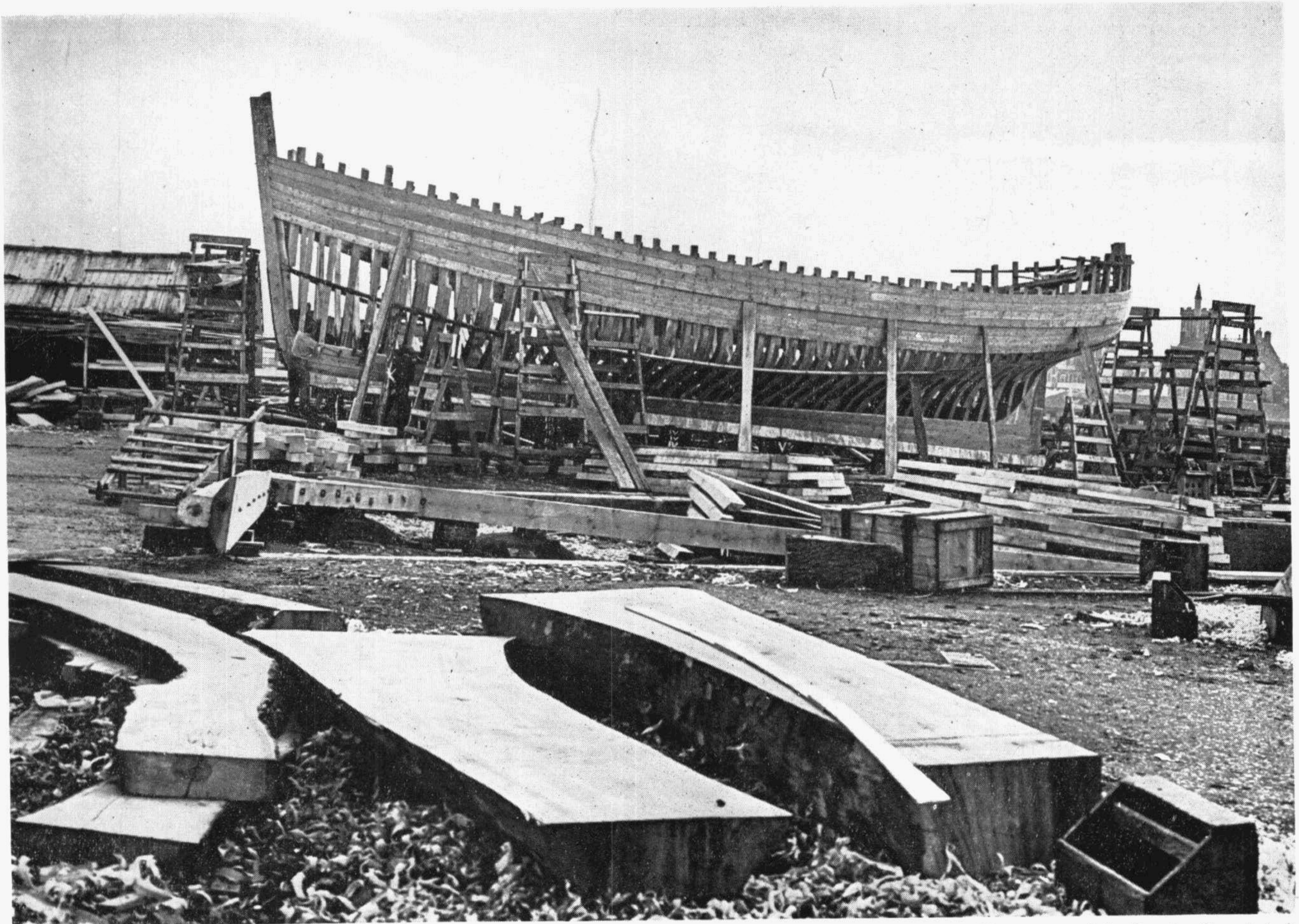
| | | |
|---|---|---|
| SLOPE | | very gentle |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–10″ | Dark grey (5Y4/1) clay loam; very fine blocky for 1 inch becoming medium sub-angular blocky; slightly plastic; organic mattet moderate; roots frequent; occasional rounded stones; rusty roor tracks along faces of peds. Sharp change into |
| $A_2g$ | 10–16″ | Olive-grey (5Y5/2) clay; moderate to strong medium to coarse angular blocky; plastic; organic matter low; roots frequent; few faint light yellowish brown (10YR6/4) smears on the faces of peds; more definite mottles in interior of peds. Clear change into |
| $B_2g$ | 16–26″ | Olive (5Y5/3) clay; strong coarse prismatic to columnar; occasional roots; low organic matter; increasing light yellowish brown (10YR6/4) staining on peds. Gradual change into |
| $B_3g$ | 26–40″ | Yellowish red (5YR5/6) clay; plastic; columnar to prismatic structure becoming massive; roots rare; few faint yellowish brown and grey mottles on faces of peds. Gradual change into |
| Cg | 40–48″+ | Yellowish red (5YR5/6) clay; massive; plastic; few yellowish brown and grey mottles. |

Gleying is very strong in this series. It is at a maximum in the $A_2g$ horizon, although it is probably equally intense in the S horizon but obscured by cultivation and organic matter. It becomes gradually less in the $B_2g$ and

PLATE 41
The standing stones of Echt.

PLATE 42
Kingswells consumption dyke, ¼ mile long, 20 feet wide and 6–8 feet high.

[*Facing page* 180]



*(By courtesy of the Forestry Commission)*

PLATE 43

$B_3g$ horizons, being confined in the main to the faces of the peds, and in the Cg horizon there is comparatively little. Structure is strongly expressed in the $A_2g$ horizon and even more so in the $B_2g$. Roots in the lower horizons are confined to the spaces between peds.

### DORBS SERIES

The Dorbs series is not extensive amounting to only 0·2 square miles. It has a well-defined H layer, approximately 6 inches thick, overlying an $A_2g$ horizon which consists of 6 inches of olive-grey (5Y4/2) clay with medium prismatic structure. The $B_2g$ horizon is an olive (5Y5/3) clay with a strong coarse prismatic structure. There are quite extensive organic stains on the surface of the peds in the $A_2g$ and $B_2g$ horizons; the latter also has frequent yellowish brown (10YR6/4) mottles on the ped surfaces. The $B_3g$ and Cg horizons are very similar to those of the Birness series.

### NOTE ON AGRICULTURE

Successful arable farming of this land is largely dependent on good drainage. Three-inch pipes are laid 10 feet apart at a depth of 2 feet 6 inches to the top of the pipe. In the neighbourhood of the Toll of Birness the old method of draining by rigs and furrows can still be seen, but these have generally been ploughed out. Similarly, many formerly open drains have been piped and filled in.

Cruickshank (1939), giving his lifetime experiences of farming this land, states that his main aim was to produce good grass. Grass seed was sown always with the first grain crop and grass was left down for long periods. Care was taken to ensure that young grass was not pastured in the autumn. Once pastures were well established they could stand any amount of grazing. Ploughing was to a depth of 10 to 12 inches and turning up of the red clay subsoil was offset by heavy manuring with phosphate. Tillage operations were carried out only when the land was comparatively dry with the result that wet weather often caused delays at critical times. No fixed rotation was followed. Turnips were grown after lea as also were potatoes and marrow stem kale. Too frequent cultivation was claimed to be responsible for poor turnip crops. Silage composed of peas, tares and oats was favoured in preference to hay, and the silage crop was followed by winter wheat. Liming was necessary; potassic fertiliser gave little response.

## THE BLACKWATER COMPLEX

The soils of the Blackwater Complex occupy approximately 1 square mile north of Peterhead in the vicinity of St. Fergus, on the relatively flat 30 foot raised beach which runs from north to south adjacent and parallel to the coast. The parent material, for the most part, is a marine silty clay which has been overlain in places by aeolian sand and by peat, making the soil pattern one of some complexity. On the landward side a 20-foot escarpment marks the old shoreline and the present boundary of the complex. On the seaward side the complex gives way to the soils of the links and dunes which are known from an inspection of gullies to be underlain at a considerable depth by the silty clay deposit. Since the deposit is of marine origin and forms part of the 30-foot raised beach, it appears to be related to the carse clays near Stirling and Perth.

## Parent Material

A dark grey clay or silty clay is always found in the soils of this complex, although not always at the same depth. It is reputed to be 6 to 9 feet thick. South of the Black Water this clay, or silty clay, material occurs at or near the surface, especially on the landward side of the area: as the links are approached a few inches of wind-blown sand from the neighbouring dunes overlies or is incorporated into the surface horizon. North of the Black Water the profiles of the complex have a much greater depth (1 to 3 feet) of sand overlying the clay material. A further complication is the formation of peat in hollows, which results in some profiles having a peaty top on sand overlying clay whilst others have alternate bands of peat and sand overlying a sandy subsoil, with the clay below. Drainage ditches surround most of the fields and these join a main drainage channel running from north to south into the Black Water.

## Soils

In the northern part of the complex the soils are cultivated and have surface horizons varying in texture from loamy sand to sandy peat. The soils belong to the poorly drained or very poorly drained classes, but the artificial drainage system runs off excess water and permits arable crops to be grown. The following two profiles are typical of this part of the complex. Horizon symbols have not been given.

### SOIL NO. 1

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | rotational grass |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Very dark brown (10YR2/2) loamy sand; weak medium blocky; friable; high organic matter; roots abundant; no stones; no mottles. Sharp change into |
| | 8–13″ | Black (10YR2/1) peat with some mineral matter; moderate medium sub-angular blocky; friable; roots abundant; no stones; no mottles. Sharp change into |
| | 13–15″ | Dark grey-brown (10YR4/2) sandy clay loam; massive; plastic; low organic matter; roots frequent; no stones; few distinct medium ochreous mottles. Sharp change into |
| | 15–18″ | Pale brown (10YR6/3) fine sand; single grain; non-plastic; low organic matter; but some organic staining; roots occasional; no stones; frequent distinct medium ochreous mottles. Clear change into |
| | 18–21″ | Pale brown (10YR6/3) fine sand with thin bands of silty clay; massive; slightly plastic; low organic matter; roots rare; frequent distinct medium ochreous mottles. Sharp change into |
| | 21–40″ | Dark grey (5Y4/1) silty clay; massive; plastic; low organic matter; live roots rare but fossil roots with surrounding iron tube concretions frequent; no stones; frequent distinct medium ochreous mottles decreasing with depth and disappearing at 40 inches. |

### SOIL NO. 2

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | long ley, with *Holcus lanatus*, *Agrostis tenuis*, *Festuca rubra*, *Cirsium palustre* |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| S | 0–8″ | Dark grey-brown (10YR4/2) loamy sand; weak fine blocky; moderate organic matter; rich in shell fragments; roots abundant; no stones; no mottles. Clear change into |

| | |
|---|---|
| 8–19″ | Dark yellowish brown (10YR4/4) loamy sand; weak medium prismatic; friable; moderate organic matter; roots frequent; no stones; no mottles. Sharp change into |
| 19–26″ | Very dark grey (10YR3/1) clay loam; moderate coarse prismatic; plastic; low organic matter; few stones; frequent distinct medium yellowish red (5YR5/8) mottles. Gradual change into |
| 26–32″ | Grey-brown (2·5Y5/2) silty clay; weak coarse prismatic; plastic; low organic matter; few stones; frequent distinct medium yellowish red (5YR5/8) and strong brown (7·5YR5/8) mottles. Gradual change into |
| 32–52″+ | Grey-brown (2·5Y5/2) silty clay; massive; plastic; low organic matter; few stones; few mottles, decreasing with depth. |

The profiles are similar in that the clay material in both is some 2 feet below the surface. The first profile, however, has a band of peat about 9 inches from the surface, as well as mineral layers of sandy and silty texture, whereas the second has only mineral layers of sandy texture. Mottles which are rare in the upper sandy horizons increase in number near the junction with the clay. The structure in the upper horizons is generally sub-angular blocky and in the horizons developed on the clay material it is frequently coarse prismatic or massive.

The southern part of the complex is also cultivated. The soils, however, are distinctive in that the clay material is much nearer the surface than in soils of the northern part, and the area is more fertile. The following profile is typical.

SOIL NO. 3

SLOPE: level
VEGETATION: rotational grass
DRAINAGE CLASS: poor

| *Horizon* | *Depth* | |
|---|---|---|
| S | 0–12″ | Very dark grey (5Y3/1) sandy clay loam; moderate medium sub-angular blocky; firm; moderate organic matter; roots abundant; few stones; frequent faint medium dark grey-brown (10YR3/2) mottles; few distinct yellowish red (5YR5/8) mottles associated with roots. Sharp change into |
| $B_2g$ | 12–13″ | Dark grey (2·5Y4/0) coarse sand; weak medium angular blocky; loose; low organic matter; roots frequent; frequent distinct yellowish red (5YR5.6) mottles associated with roots. Sharp change into |
| $B_2g$ | 13–25″ | Dark grey (2·5Y4/0) silty clay; strong coarse prismatic; grey skin to peds; firm; low organic matter; roots frequent especially between peds; yellowish red (5YR5·6) mottling associated with many fine root channels through peds. Clear change into |
| $B_3g$ | 25–30″ | Very dark grey (2·5Y3/0) clay; moderate coarse prismatic; firm; clay coatings to peds but less than in $B_2g$; low organic matter; many yellowish red (5YR5/6) mottles associated with fine root channels through peds. Gradual change into |
| Cg | 30–40″ | Very dark grey (2·5Y3/0) clay; massive; very plastic; low organic matter; many well-formed iron tubes associated with old root channels; water-table at 30 inches after 31-day drought. |

The S horizon contains a proportion of wind-blown sand, but the sandy $B_2g$ horizon appears to have been laid down at approximately the same time as the clay was settling out because sandy layers of this nature are encountered at various depths. The size of the peds, which are coated with clay, increases with depth, until in the Cg horizon the structure has become massive. Ochreous mottles are associated with root channels throughout and in the Cg horizon well-defined iron pipes are present.

### Note on Agriculture

Since the soils of the Blackwater Complex are poorly drained, the best yields are likely to be obtained in a dry season. The natural fertility of the clay land is high and good crops are grown, especially if the spring weather allows a proper seed bed to be prepared. The sandy peat land tends to be low in nutrients, but its texture makes it easy to cultivate in a wet season. The whole is an area of mixed farming, and when the soils of the nearby links form part of the holding sheep rearing and fattening become important. There is little protection from the strong winds off the North Sea for either crops or animals and planting of shelter belts is very desirable. The whole area is artificially drained, and proper maintenance of the drainage systems is essential.

## LINKS AND DUNE SAND

Along the eastern coast of Aberdeenshire between Aberdeen and Fraserburgh blown sand covers a total area of over 14 square miles. The dunes, which are moundy and unstable, occur next to the tidal sand and occupy about 6½ square miles. They are partially fixed by clumps and patches of marram grass (*Ammophila arenaria*), with lesser amounts of lyme grass (*Elymus arenarius*). The links, on the landward side of the dunes, are gently sloping to flat, with micro-undulations, and are tied down by a comparatively close sward of fine-leaved grasses or by heath. They cover an area of approximately 8 square miles, of which almost 1 square mile is affected by poor drainage.

Dunes, about one-eighth of a mile in width, extend northwards from Aberdeen in a continuous belt for a distance of 15 miles to Collieston. Links cover a wider belt of between one-quarter and half-a-mile on the landward of the dunes. North of the Ythan, dunes and links extend inland for about 1 mile and some 3 square miles of them, known as the Sands of Forvie, are now a bird sanctuary. It was here that the village and parish of Forvie were obliterated during a sandstorm at the beginning of the 18th Century. Five Bronze Age hut circles have also been discovered in this area. Between Collieston and the Bay of Cruden the coast is rocky, but surrounding the Bay of Cruden itself there is an isolated occurrence of both links and dunes, now used as a golf course. From the north bank of the River Ugie a continuous belt of dunes and links extends for 15 miles to Fraserburgh.

The farmland adjoining the links has not been greatly influenced by the blown sand except in the vicinity of St. Fergus where blown sand overlies a grey estuarine silty clay of the Blackwater Complex. On the landward side the links sand thins and grades into the adjacent soil series. The boundary between dunes and links is closely related to relief, the links being smoother with only micro-undulations. Having a more complete cover of vegetation, the links are relatively stable and have developed a soil profile. In the mobile dunes there are many areas of bare sand, while in the partially stabilized dunes a succession of buried $A_1$ horizons separated by layers of sand can be observed. The drainage class of the dunes is excessively free and such soils as exist are skeletal. The links, while having free to excessive drainage, normally have rudimentary iron podzol profiles. In the flat area known as Pettens Links there are extensive tracts with poor drainage and similar areas occur on the western side of the Sands of Forvie. Here, boulder clay, underlying the sand at depths of 3 to 4 feet, together with low situation and lack of outfall is responsible for the poor drainage. In some of these poorly drained parts *Erica tetralix, Calluna vulgaris, Nardus stricta* and *Polytrichum commune* are found. The profile consists of some 6 inches of mor humus overlying yellowish grey sand which is plentifully streaked with ferruginous colours following root tracks. In places, extensive ridging had at one time been carried out to improve the drainage.

The composition of the links and dune sand is mainly quartzose and felspathic, but in the vicinity of Fraserburgh there is a deposit of wind-blown shelly sand (Fraserburgh Association). The shelly character persists southwards from Fraserburgh down the St. Fergus links, but the shell content gradually decreases until it fades out about Scotstown Point. The following description is of a profile taken from the slightly shelly links in the vicinity of Rattray Head, now under poor permanent pasture; boulder clay occurs at a depth of 4 feet and the basal horizons are probably buried former surface horizons.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level with micro-undulations |
| VEGETATION | | *Agrostis–Poa* pasture with many herbs including *Carduus arvensis, Lotus corniculatus, Plantago maritima* and *P. coronopus* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| S | 0–5″ | Very dark grey-brown (10YR3/2) to very dark brown (10YR2/2) loamy sand; moderate platy structure in top 3 inches associated with well-developed root mat, becoming medium crumb below; organic matter high in top 2 inches; living and dead roots abundant throughout; no stones; moist. Clear change into |
| $B_2$ | 5–11″ | Brown (7·5YR5/3) sand; weak crumb structure around roots; single grain elsewhere; low organic matter except in worm channels containing S horizon material; roots abundant above, frequent below; no stones; no mottles. Clear change into |
| $B_2$ | 11–21″ | Pale brown (10YR6/3) sand; very weak coarse sub-angular blocky; soft to 14 inches becoming massive and compact below; organic matter low; roots frequent; no stones. Sharp change into |
| A (buried) | 21–24″ | Very dark grey-brown (10YR3/2) loamy sand; moderate medium crumb; organic matter high; roots frequent; small pebbles and sub-angular stones present; moist; no mottles. Gradual change into |
| A (buried) | 24–42″ | Very dark brown (7·5YR3/2) loamy sand becoming dark brown (10YR4/4) sand below 32 inches; weak coarse sub-angular blocky, breaking into loose crumb; organic matter medium above, low below; roots frequent at top rare at base of horizon; worms present; sub-angular stones, mostly decomposed; no mottles; moist. Clear change into |
| C | 42″+ | Strong brown (7·5YR5/6) sand with pockets of dark brown (7·5YR4/2) clay loam; no structure; occasional roots; no stones; moist; no mottles. |

This profile is a brown forest soil. It has essentially a crumb structure in the surface horizon with a gradual change into the $B_2$. The whole profile is shallow and obviously immature, overlying at 21 inches what would appear to be a fossil brown forest soil. The pH values are between 7 and 8 throughout.

From Cruden Bay southwards the links have no visible shelly material present, and under the *Calluna–Cladonia* vegetation which occurs spasmodically over the Sands of Forvie it is possible to find an iron podzol profile with 2 inches of black mor humus, overlying 3 inches of a white bleached sand $A_2$, above a 6-inch $B_2$ horizon of ochreous stained sand, on neutral-coloured sand. The following profile description is of an iron podzol, less strongly podzolised, overlying a peaty podzol profile.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | gentle |
| VEGETATION | | *Calluna vulgaris, Carex arenaria, Empetrum nigrum, Cladonia sylvatica, Hylocomium splendens, Pleurozium schreberi* |
| DRAINAGE CLASS | | free |
| *Horizon* | *Depth* | |
| L | 2½–2″ | Litter of mosses, lichens and *Calluna* twigs |
| F | 2–1½″ | Dark brown fibrous, partially decomposed organic matter |
| H | 1½–0″ | Very dark brown (5YR2/1) to black well-decomposed organic matter; mealy when crushed; weak crumb structure; abundant fine roots; moist. Sharp change into |
| $A_2$ | 0–2½″ | Dark grey-brown (10YR4/2) loamy sand; weak sub-angular blocky; medium organic matter; fine roots abundant; moist. Sharp change into |
| $B_2$ | 2½–20″ | Brown (7·5YR5/4) to light yellowish brown (10YR6/4) sand; single grain; slightly compacted; organic matter low; roots frequent; moist. Gradual change into |
| C | 20–34″ | Light yellowish brown (10YR6/4) sand; loose; occasional roots; moist. Sharp change into |
| A (buried) | 34–37″ | Dark reddish brown (5YR3/2) loam; weak fine sub-angular blocky; loose; occasional roots; moist. Sharp change into |
| $B_1$ | at 37″ | Iron pan ($\frac{1}{16}$th inch). Sharp change into |
| $B_2$ (buried) | 37″+ | Dark reddish brown (5YR3/2) loam; medium sub-angular blocky; loose; moist. |

This iron podzol profile is moderately to strongly acid; it overlies what appears to be a buried peaty podzol developed on parent material similar to that of the Collieston Association.

In the poorly drained areas variants of the following profile occur; some of the soils have a cover of recently blown sand.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | *Juncus effusus, Erica tetralix, Calluna vulgaris, Empetrum nigrum, Nardus stricta, Pleurozium schreberi, Polytrichum commune* |
| DRAINAGE CLASS | | poor |
| *Horizon* | *Depth* | |
| F/H | 2–0″ | Dark reddish brown (5YR2/2) moderately well-decomposed humus with some mineral grains; roots abundant; wet. Sharp change into |
| $A_1$ | 0–4″ | Very dark brown (10YR2/2) loamy sand, humus stained; very weak sub-angular blocky; medium to high organic matter; roots abundant; moist. Sharp change into |
| Bg | 4–20″ | Yellowish brown (10YR5/4) sand; single grain; roots frequent; organic matter low; moist to wet; frequent rusty-stained root channels. Sharp change into |
| Cg | 20″+ | Brown (10YR5/3) sand; low organic matter; roots occasional. |

The pH value of the surface horizon is between 3 and 4 and of the C horizon between 5 and 6. Buried peat at a depth of 3 to 4 feet occurs in some of the poorly drained links near Balmedie, and in this area peat is reported to have been washed up on the shore, presumably from deposits beneath the sea.

The very poorly drained areas occupy small depressions; the following profile was recorded from a very poorly drained area too small to record on the scale of 1 inch to 1 mile.

PROFILE DESCRIPTION

| | | |
|---|---|---|
| SLOPE | | level |
| VEGETATION | | *Empetrum nigrum, Carex nigra, Nardus stricta, Salix repens, Erica tetralix, Hylocomium splendens, Pleurozium schreberi* |
| DRAINAGE CLASS | | very poor |
| *Horizon* | *Depth* | |
| F/H | 3–0″ | Black (5YR2/1) humus, well-decomposed; abundant roots and rhizomes; wet. Sharp change into |
| H/A | 0–3″ | Very dark grey (5YR3/1) humus with some quartzose mineral grains present; abundant roots and rhizomes; wet. Sharp change into |
| Bg | 3–18″ | Brown (7·5YR5/4) sand; roots frequent; organic matter low; single grain; frequent iron oxide coatings to old root tracks; wet. Sharp change into |
| Cg | 18″+ | Light brownish grey (2·5Y6/2) sand; single grain; wet; roots frequent in upper part, occasional lower down. |

The well-developed F/H horizon is almost wholly organic and surprisingly free from mineral matter. In comparison with the corresponding horizons of the poorly drained soil, it is black rather than brown. The H/A horizon has a higher content of organic matter than the $A_1$ of the poorly drained soil and the Bg and Cg horizons are greyer.

### Note on Agriculture

The dunes are obviously of no agricultural value and are fenced off from the links which, because of their instability, low organic matter content in the upper horizon, excessive drainage and low moisture-retention capacity, are suitable for only limited agricultural application, mainly grazing. Attention has been drawn to the shelliness of the Fraserburgh links in the north and the acid nature of the links from Cruden Bay southwards; on the latter a small dressing of lime and fertiliser would help to improve the sward. The shelly links are extensively grazed by sheep, but it is said that sheep will not stay on the acid links although cattle favour them. Limited numbers of cattle are grazed all the year round on the links in the vicinity of Balmedie. Most of the links have been ploughed at one time or another, but regular ploughing is to be avoided because of the danger of wind erosion. Some areas of links are cropped once in 4 years and then sown down to grass. Controlled grazing and dunging by cattle is probably the best form of management.

Certain areas of the poorly drained links become flooded for periods in winter and possibly some improvement is derived from the addition of alluvial material. Old furrows and ridges are noticeable in many of these areas.

## ALLUVIUM

Alluvial land, locally referred to as haughland, is found alongside rivers and streams and in a number of concave topographical features scattered throughout the region. Its area totals 55 square miles. Almost all the alluvium in north-east Scotland has been deposited by fresh water, and can be differentiated into riverain and lacustrine. The soils developed on alluvium, especially riverain alluvium, are frequently sandy and imperfectly drained.

## Distribution and Parent Material

The alluvial terraces associated with the Rivers Dee and Don are from one-quarter to three-quarters of a mile wide in this area. Not so wide are the terraces of the River Ythan and the North and South Ugie Waters, whilst the terraces associated with small drainage channels, such as the Burns of Leuchar, Gadie, Tarland, Kinnernie, Ton, Lochter, Ebrie and Auchmacoy, and the Waters of Bogie, Fedderate, Cruden, Philorth and Tyrie, are all comparatively narrow.

The texture of the riverain alluvium is generally sandy, irrespective of the river with which it is associated, but a distinction can be made between the alluvium of the Dee and its tributaries and that of the others. Most of the rivers traverse a variety of rock types and the dominant fraction in the associated alluvium is fine sand. The River Dee, however, flows through granite or granitic gneiss for most of its length and consequently the predominating sand is coarse. The texture of the top 3 feet of the riverain alluvium is generally sandy, varying from coarse sand to very fine sandy loam. Below is a layer of gravel. Away from the river, often where the alluvium joins other types of deposits, the texture tends to be less sandy and more silty and clayey.

The lacustrine alluvium has been laid down in end-glacial times when temporary lakes occupied the hollows of the landscape. Deposits occur at Clatt, Duncanston, Pitcaple, Alford, Whitehouse, Auchlossan, Blackburn, Danestone, Nethermuir and extensively around the Loch of Skene. In general the texture of lacustrine alluvium is finer than that of riverain alluvium, varying from sandy loam to loam, and occasionally to silt loam.

## Soils

Alluvial soils can be grouped on the basis of texture, depth of surface horizon and drainage class, but on the present scale of mapping this is impracticable and all the soils have been included in one unit, undifferentiated alluvium.

Some riverain alluvial soils are periodically flooded and are therefore subjected to erosion and deposition. In consequence buried soil horizons and, conversely, truncated profiles are not uncommon.

A soil with imperfect drainage on the broad river alluvium has a surface horizon of brown fine sandy or very fine sandy loam, 12 to 18 inches thick, in which some ochreous mottling is present at the base. Beneath this there are frequently alternating bands of sand and top soil material, the whole showing ochreous mottling. Black manganese concretions are often prominent approximately 18 inches from the surface. There is a sharp change into gravel at 3 to 4 feet. About Kintore and Kemnay, on the Don, the depth of topsoil is approximately 24 inches. In the remnants of oxbow channels poorly and very poorly drained soils are found, in which buried peat layers are sometimes present.

The soils developed on lacustrine alluvium are obviously more mature and have a recognisable $B_2(g)$ or $B_2g$ horizon. Generally they are a fine sandy loam in the surface horizon and a coarse sandy loam or sandy loam at greater depth. The imperfectly drained soil is very similar to the imperfectly drained soil developed on riverain alluvium, except that its parent material is not so stratified. The poorly drained soil has a grey surface horizon and a Bg horizon with frequent ochreous and grey mottles.

### Note on Agriculture

The alluvial soils with free or imperfect drainage have a high natural fertility, are easily cultivated and do not require tile drains. The poorly and very poorly drained alluvial soils, on the other hand, must be satisfactorily drained before they can be used for arable agriculture. Where tracts of alluvium are not under rotational crops it is because they are difficult to drain, through lack of outfall, or are subject to flooding. Along certain stretches of the Rivers Don and Ugie levees have been constructed to afford some measure of protection from flooding, and these areas are periodically cultivated. From the vicinity of Culter to Cults on the River Dee and from Kintore to Pitmedden Station on the River Don flooding occurs after periods of high rainfall. Where flooding is a regular hazard the land is kept in permanent grass. The imperfectly drained soil carries a good quality permanent pasture, but the vegetation of the poorly drained soil is dominated by *Juncus effusus* and is indifferent grazing for stock.

## MIXED BOTTOM LAND

Mixed Bottom Land is a cartographic unit used to delineate the soils associated with narrow stream channels. The total area mapped as Mixed Bottom Land is approximately 13 square miles. The constituent soils occur in patches too small to be shown individually on the scale of 1 inch to 1 mile. Within the unit are soils on the sides—often steep—of the channel and those on the alluvium flanking the stream. There are marked differences in the age, drainage class, and texture of these soils.

# CHAPTER VIII

# Peat

PEAT may be defined in general terms as an accumulation of partially decayed plant remains formed under conditions of high rainfall or in badly drained hollows where excess moisture at the soil surface inhibits normal aerobic processes of decomposition. Other factors which favour the development of peat are low temperature, high acidity and nutrient deficiency, all of which reduce microbiological activity.

Peat differs from other soils in that it is either wholly or largely organic, whereas the latter are comprised chiefly of mineral matter with a varying organic content. No exact line of demarcation can logically or consistently be drawn between peats and mineral soils, but for practical purposes soils with a surface organic horizon greater than 12 inches in depth and exceeding 60% organic content are mapped as peat.

In the north-east of Scotland—essentially an agricultural area—peat was formerly a very important natural resource, and until a hundred years ago greatly influenced the way of life of the country people. Peat was then the principal fuel and much time and energy were spent in spring and summer securing the year's supply. By the middle of last century many of the best mosses were becoming depleted and peat had often to be carted great distances. In the Statistical Accounts of Scotland (1791–1799; 1845) many of the parish accounts mention this time-consuming operation and deplore the fact that it took men away from cultivating the land. The introduction of coal as an alternative fuel was therefore welcomed by many as a desirable innovation. In the early nineteenth century coal was heavily taxed, but even so progressive agriculturists recognised that a disproportionate effort went on peat cutting and saw that if this were reckoned in terms of money even taxed coal was an economic proposition. Today very little peat is cut for domestic fuel although near New Pitsligo several commercial firms produce moss litter and supply distilleries with sod peat.

Within the area covered by the maps two distinct types of peat deposit are recognisable, viz. basin peat (raised moss) and blanket bog (including hill peat). The typical basin-peat deposits occur in low-lying areas and both the low-moor and raised-moss stages are normally well developed. Low-moor peat formation is usually initiated under lacustrine or marsh conditions which range from eutrophic (mineral enriched) to oligotrophic (mineral deficient) according to the nature of the drainage water from the surrounding area. Peat accumulates under soligenous conditions until the level of the bog surface rises above the influence of ground water. At this stage peat formation continues under the influence of rainfall (ombrogenous conditions) with marked changes in vegetational character. Reedswamp and aquatic vegetation is replaced by slower growing species; sedges and grasses become less common and the most important peat formers of the raised-moss stage are *Sphagnum* spp. and *Eriophorum vaginatum* with varying amounts of *Calluna vulgaris*. The formation of high-level blanket bog or hill peat is not conditioned primarily by poor drainage but is climatically induced by high rainfall, high humidity and low temperature. In contrast to basin peat, hill peat is characterised by its uniformity, and throughout is composed mainly of remains of *Sphagnum* spp., *Eriophorum vaginatum* and *Calluna vulgaris*. Small areas of basin peat do however occur within the blanket bog complex.

A number of the larger deposits representative of the types occurring within the area were selected for detailed study. Many of the smaller bogs are only remnants of larger areas of peat which have been extensively cut for fuel.

Survey procedure for each selected deposit was to work along a line transect, usually the longest axis of the bog. At regular intervals along the transect lines complete cores of peat were extracted for field examination. This included an assessment of the degree of "humification" or decomposition (H value—according to scale of Von Post) and identification of macroscopic plant remains. The latter was supplemented by microscopic examination in the laboratory to determine the origin of the smaller fragments.

At regular intervals along the transect peat depths were recorded and the surface levelled back to a convenient Ordnance Survey bench mark. These data were used to prepare section diagrams of each bog (Fig. 19) and illustrated profiles are presented in Fig. 20. Results of chemical and physical analyses of profile samples are presented in Appendix IV .

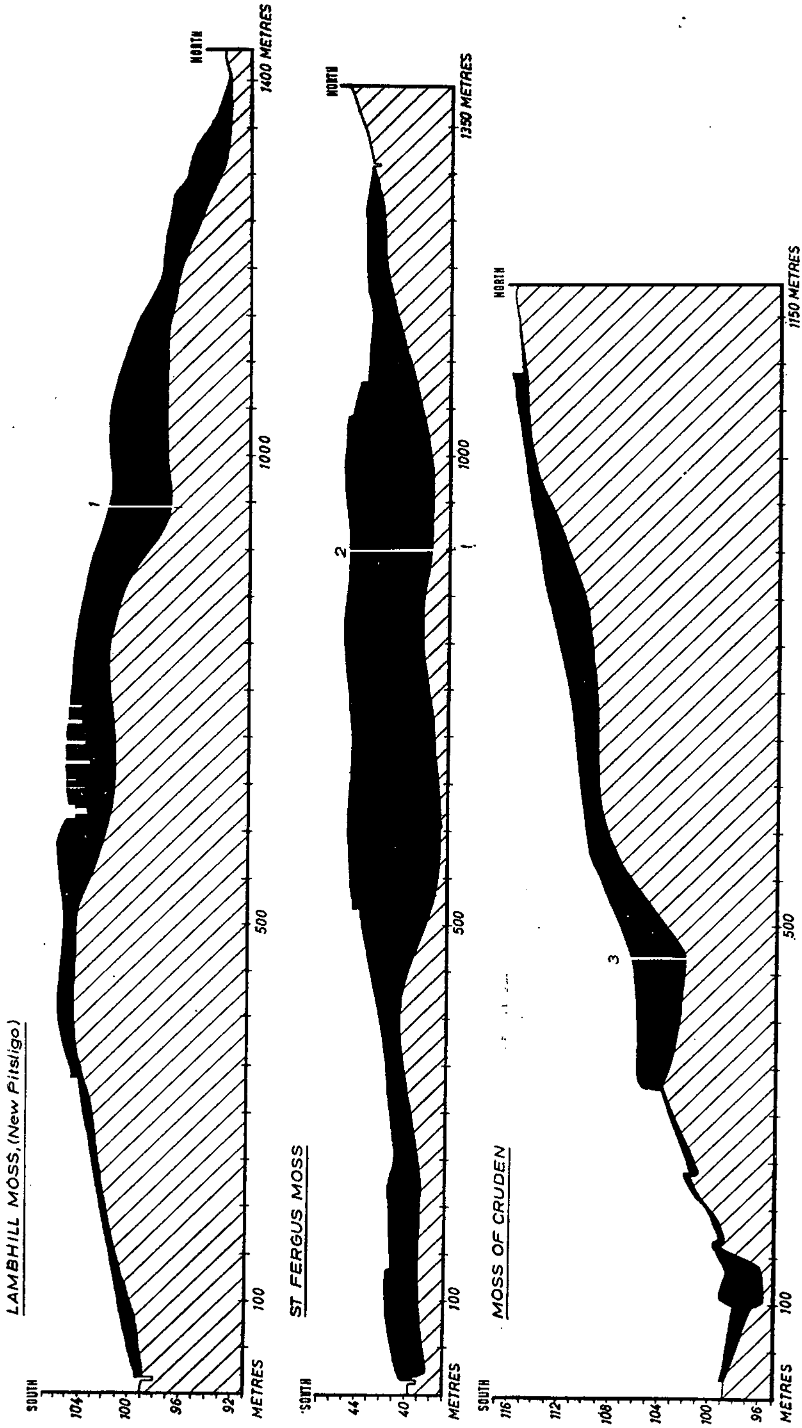
An account of the vegetational and climatic history of the area is based on pollen analysis of samples from St. Fergus Moss and Skene Moss.

*Lambhill Moss* (*New Pitsligo*)

This bog is the largest of a group centred round the village of New Pitsligo. At one time it probably formed part of a more extensive complex of blanket bog and basin peat, now isolated by cutting, erosion and reclamation.

The bog extends over approximately 450 acres and reaches a maximum elevation of 350 feet. South of the main Strichen Road (B9093), which traverses the bog, the surface is very rough, being dominated by a rank growth of heather (*Calluna vulgaris*) which conceals old ditches and disused cutting banks. The present cuttings, from which hand-cut sod peat is being extracted for fuel, lie parallel to the main road on its north side (Plate 46). Beyond these cuttings the surface is relatively unbroken and falls away to a small marshy area which forms the northern boundary of the deposit. The dry firm slopes are dominated by heather with varying proportions of cotton-grass (*Eriophorum vaginatum*) and *Sphagnum* spp.

The section (Fig. 19) runs from south to north crossing the main Strichen road at right-angles. Topographically this deposit appears, at first glance, to conform to a raised-moss basin-peat type with typical domed outline. Reference to the section shows, however, that the surface contours closely follow those of the underlying mineral soil. In this area it is unlikely that peat formation was initiated to any great extent under the influence of ground water or that soligenous conditions played a major part in the early stages of bog development. Although mapped as basin peat, the detailed survey has revealed that this deposit is more closely related to ombrogenous blanket bog. Its low elevation, however, would not justify its inclusion with high-level blanket bog or hill peat.



LAMBHILL MOSS, (New Pitsligo)
SOUTH
104
100
96
92
METRES
100
500
1000
1400 METRES
NORTH
1
ST FERGUS MOSS
SOUTH
44
40
METRES
100
500
1000
1350 METRES
NORTH
2
MOSS OF CRUDEN
SOUTH
116
112
108
104
100
96
METRES
100
500
1150 METRES
NORTH
3


FIGURE 19A

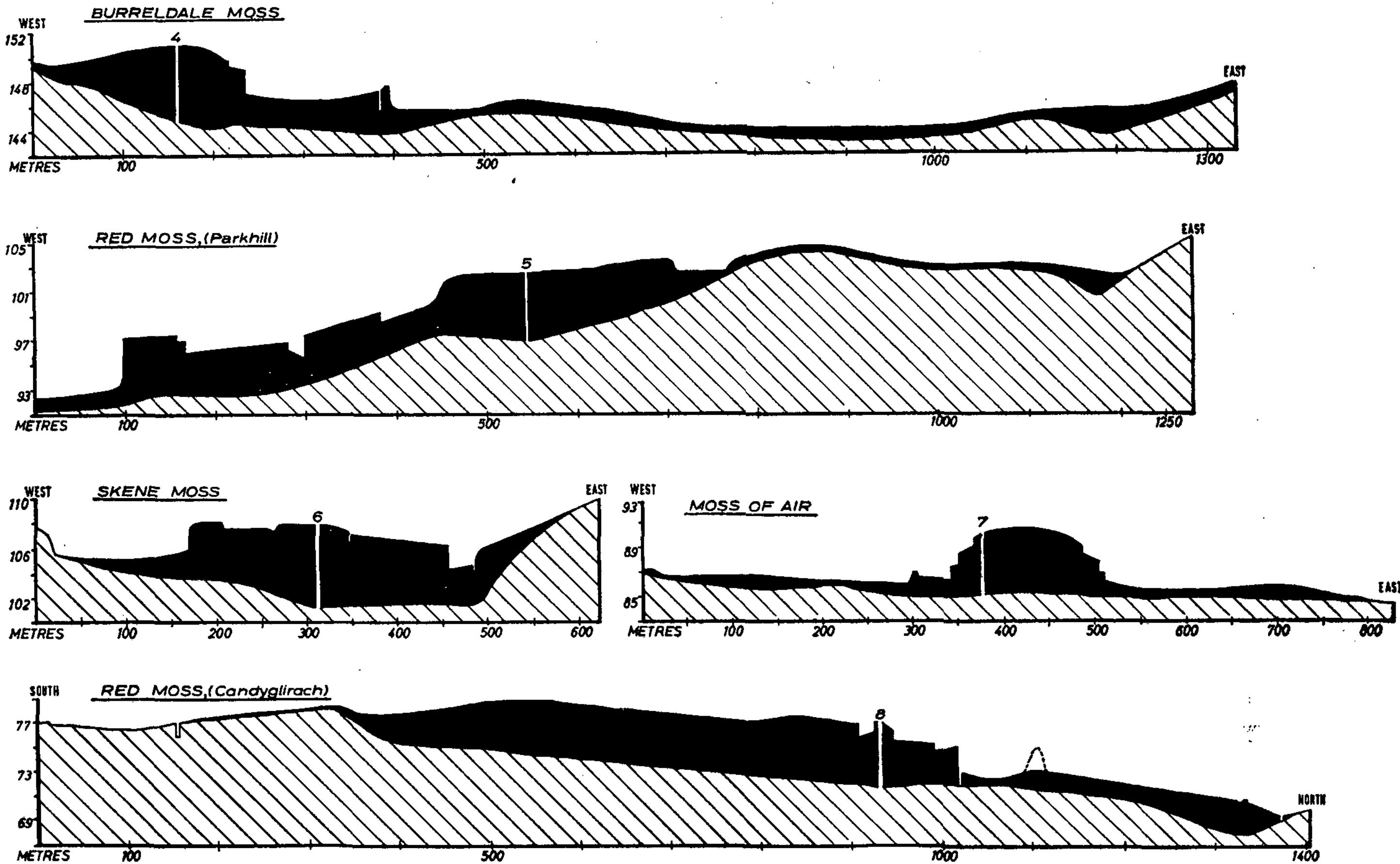



FIGURE 19B. Sections of Mosses showing Surface and Basal Topography.
(Typical profiles numbered 1–8 are illustrated in Fig. 20)

The maximum depth of peat recorded along the transect line was 16½ feet (Fig. 20, 1), with an average in the region of 8 feet. Samples extracted from a number of bore holes showed that, in terms of botanical origin, the profiles exhibit no marked stratification. Undoubtedly the two most important peat formers have been *Sphagnum* and *Eriophorum vaginatum* with smaller amounts of *Calluna* and other moorland species. Remains of *Carex* spp. (sedges) and *Betula* (birch) were recorded locally near the bottom of certain bore holes, but this horizon is not represented over the greater part of the area and appears to be associated with small depressions in the basal mineral soil. The sequence is thus more representative of blanket bog than of raised-moss basin peat, in which the changing environmental conditions from the saucer-shaped low-moor stage to oligotrophic raised bog are clearly reflected by and associated with marked variations in the botanical composition of the peat strata.

*St. Fergus Moss*

This deposit is one of a group comprising both blanket bog and basin peat which lies to the south and south-west of Crimond. The bog, half of which has been cut over, covers an area of about 420 acres and reaches a height of 150 feet. The maximum depth recorded was 24 feet, the average depth of the uncut portion being about 20 feet. Apart from changes in level which have resulted from previous cutting, the surface is relatively smooth and supports an almost heath-like type of vegetation dominated by vigorous heather associated with *Erica tetralix*, *Trichophorum caespitosum*, *Narthecium ossifragum*, *Eriophorum vaginatum* and *E. angustifolium*.

Reference to the section (Fig. 19) shows that this deposit originated in a large shallow depression in which peat formation initially took place under lacustrine conditions or in a semi-aquatic environment. Although now somewhat obscured by extensive cutting, the typical domed or convex outline of the younger raised-moss stage, which overlies older soligenous basin peat, is still clearly visible.

This interpretation of the section is supported by reference to the profile illustrated in Fig. 20, 2. The basal layers consist of black amorphous peat contaminated by mineral matter which dries to form dense, hard angular fragments. This type of peat is representative of extremely marshy, semi-lacustrine conditions associated with areas of open water in which sedimentation of finely divided organic matter has occurred. This horizon is followed by approximately 5 feet of typical low-moor sedge-grass peat which can be divided into a lower zone containing abundant seeds of *Menyanthes trifoliata* and a thicker upper zone in which a more highly decomposed sedge-grass peat is associated with abundant remains of birch and possibly alder (*Alnus*). Reed grass (*Phragmites*) was recorded in this horizon but its contribution to peat formation in the area has been relatively insignificant.

The lower horizons of mesotrophic soligenous peat are separated from the oligotrophic raised-moss peat by a transition zone of highly decomposed amorphous material which varies in depth and thickness along the transect line and contains, in places, remains of birch and hazel (*Corylus*). This horizon is overlain by a thick deposit of *Sphagnum-Eriophorum* peat which contains a well-defined layer of practically undecomposed pure *Sphagnum* peat at a depth of approximately 5 feet. The surface layer or top spit has been modified by recent draining and burning.

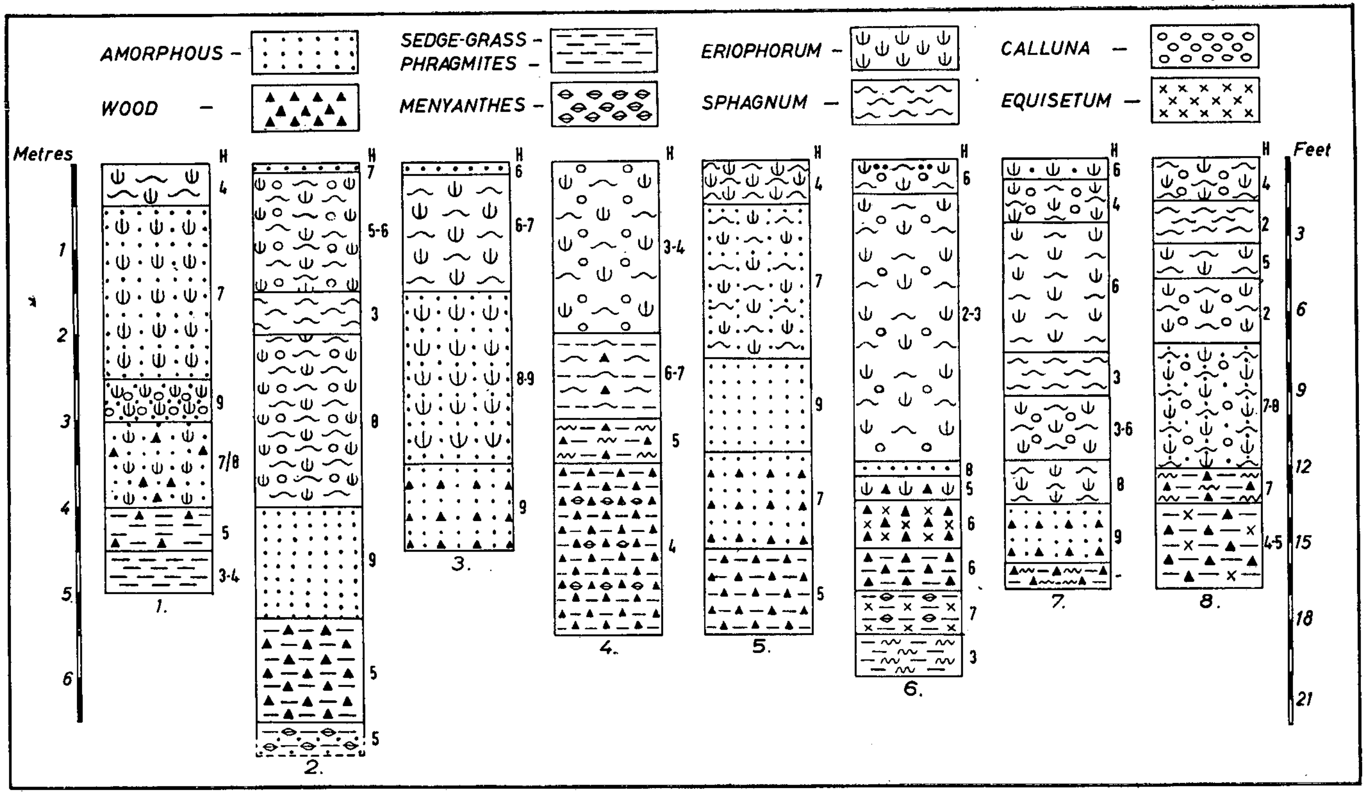



FIGURE 20. Eight Peat Profiles.

*Moss of Cruden*

Situated some 8 miles south-west of Peterhead, the moss covers about 1600 acres and is the largest area of peat examined. The highest part of the bog lies on a north-east to south-west ridge and reaches an elevation of 458 feet. About one-third of the total area has been cut over, although in places, especially at the northern end, replacement of top turves has been carried out so meticulously that it is by no means obvious from the surface that cutting has taken place. Where exposed, the basal soil in this area consists of pebbles and flints up to 5 inches in diameter (Plate 17). A certain amount of reclamation has been carried out on the lower ground at the southern end of the moss. The surface vegetation is dominated by heather and large tussocks of cotton-grass.

On the line examined (Fig. 19) the deepest bore was 15 feet with an average depth in the region of 7 feet. Profile samples show little variation in their botanical composition with depth, the peat being derived mainly from *Sphagnum* spp. and *Eriophorum*. The degree of decomposition, however, increases down the profile culminating in a basal layer of almost amorphous peat which contains small scattered fragments of birch (Fig. 20, 3).

Although stratification is not marked, thin horizons of *Carex* peat occur locally and are associated with small depressions in the mineral soil on the low ground at the southern end of the moss. The deposit is classified as blanket bog with local development of basin peat in the raised-moss stage.

*Burreldale Moss*

Burreldale Moss, 3½ miles east-north-east of Inverurie, covers approximately 170 acres of which about three-quarters has been severely cut over to the lower horizons. The highest part of the area lies at 500 feet on a small uncut section, where the peat reaches a maximum depth of 20 feet (Fig. 19). The surface of the virgin bog is very uneven and cracked due to shrinkage caused by the drainage effects of deep cuttings. Here the vegetation is dominated by a vigorous growth of heather and associated species. On the uncut portion heather or scrub birch and alder are dominant but a considerable area of bare peat remains uncolonised by plants, due to the inability of seedlings to establish themselves on an unstable surface.

Both the basal topography and the stratigraphy of the profile (Fig. 20, 4) indicate that this moss is a remnant of a raised-moss basin peat. The younger upper horizons consist of moderately decomposed *Sphagnum-Eriophorum-Calluna* peat which has developed above the influence of ground water. At about 7 feet this gives way to a horizon of well-decomposed *Sphagnum-Carex* peat which is followed by approximately 2 feet of *Carex-Phragmites* peat with birch remains. Below 12 feet the peat is dominantly sedge-grass in which remains of birch and seeds of *Menyanthes* are locally abundant. The latter species reflects the aquatic or semi-lacustrine conditions which prevailed at that level. Due to the compact nature of the peat it was not possible at this point to obtain samples below 19 feet.

*Red Moss (Parkhill)*

Red Moss, one of many mosses in the north-east of Scotland bearing this name, lies a few miles north of Aberdeen, near Dyce. About three-quarters of the total area (540 acres) has been cut-over and cutting is still taking place to a limited extent. The highest part of the bog lies at 350 feet and the average and

PLATE 44
Red Moss, Candyglirach, showing layer of pine stumps 7500 years old.

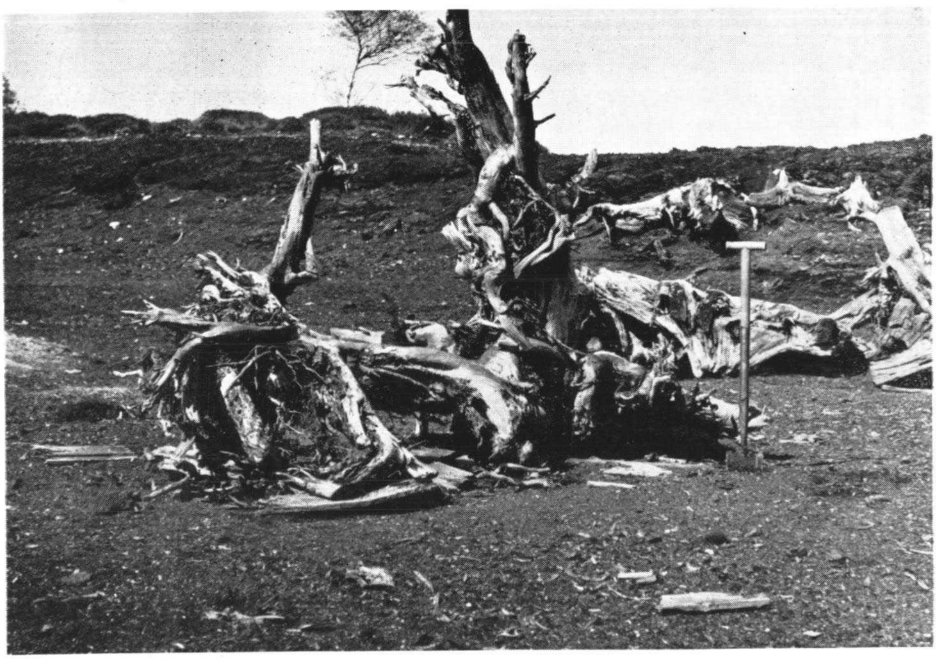


PLATE 45
Pine 7500 years old from Red Moss, Candyglirach.

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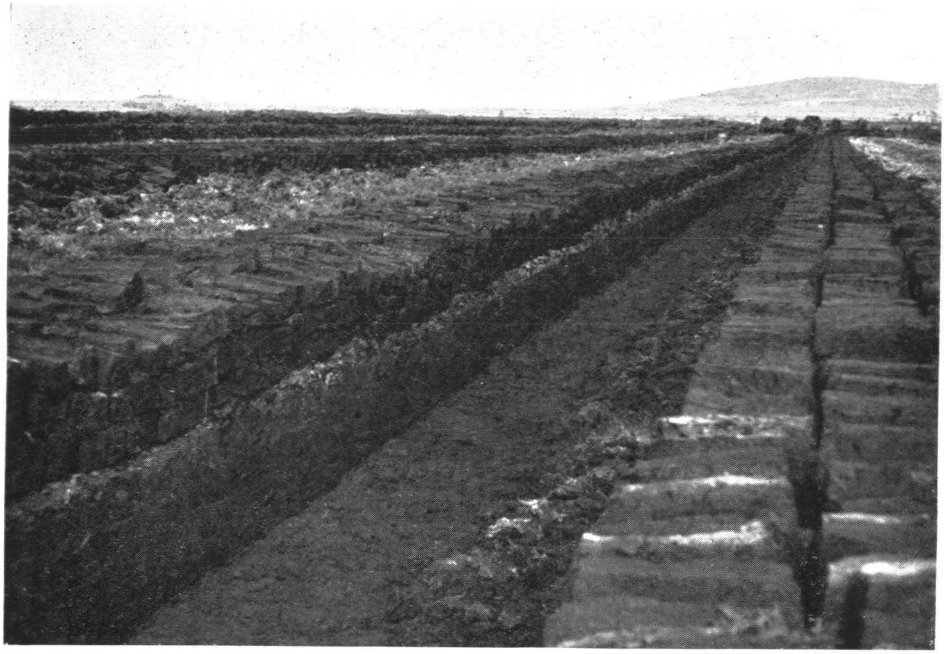


PLATE 46
Peat workings, Lambhill Moss, New Pitsligo.

PLATE 47
Red Moss, Candyglirach, cut peats laid out to dry.

maximum depths recorded on the uncut portion were 16 feet and 18½ feet respectively.

Topographically, the southern part of the bog is highly irregular due to the presence of numerous deep cutting banks (Fig. 19) above which the surface is dangerously fissured as a result of drying and subsequent shrinkage. The cut-over areas vary from dry to very wet depending on surface drainage and although *Calluna* is the most abundant species, scrub birch has also become established.

As can be seen from the section, this moss is situated on a gentle slope interrupted by peat-filled hollows now joined and obscured by younger shallow black fibrous peat derived from *Eriophorum* and *Calluna*. It appears that at one time much of the surrounding area was also covered by shallow peat but this has been removed and the ground brought into cultivation.

A profile (Fig. 20, 5) from the deepest part of the uncut portion of the bog shows the upper 8 feet to consist of *Sphagnum-Eriophorum* peat with smaller amounts of *Calluna* in an amorphous matrix. The degree of decomposition increases down the profile reaching a maximum (H9) between 8 and 11½ feet where the peat contains no recognisable plant remains. This horizon is followed by a layer of well-decomposed peat with birch remains which merges into a basal layer of typical, moderately decomposed, woody sedge-grass peat of the low-moor stage. The deposit is classified as a raised-moss basin peat extending over the higher ground as blanket bog.

*Skene Moss*

The several remnants of peat in the neighbourhood of Loch of Skene indicate another area where formerly peat had been much more extensive.

Skene Moss covers about 130 acres, at least four-fifths of which has been cut-over. The highest part of the bog is 350 feet and the maximum depth of peat recorded was 21½ feet with an average along the transect line of 11½ feet.

The surface of the bog is very uneven with numerous wet hollows. Little natural vegetation remains even on the relatively undisturbed portions which have suffered from periodic burning and drainage, but one small area supports a dense stand of pine and rank heather. The cut-over areas are being colonised by scrub birch and alder with a sparse covering of heather on the surface of the peat, much of which is still bare.

A short transect taken across the deepest part of the moss is illustrated in Fig. 19. This deposit has formed in a small poorly drained basin and its profile (Fig. 20, 6) clearly illustrates the stages of development from semi-aquatic conditions, through a reed-swamp phase, to oligotrophic raised moss. The upper 12 feet is dominated by relatively undecomposed *Sphagnum* peat with varying proportions of cotton-grass and heather which increase with depth. Around 12 feet there occurs a band of amorphous peat followed by a thin layer of birch wood remains and cotton-grass. Below this level the peat is predominantly a low-moor type in which the main constituents are *Carex* spp., *Betula*, *Equisetum* and *Menyanthes*, with traces of *Phragmites* near the base of the section where wood remains are absent. This bog is a typical example of a basin-peat deposit in the raised-moss stage.

*Moss of Air*

Situated on the western side of Loch of Skene, at an altitude of 275 feet, Air Moss extends to about 175 acres, three-quarters of which has been cut over. The undisturbed portion, 16½ feet deep, remains as an island surrounded by a shallow cut-over area seldom exceeding 3 feet in depth (Fig. 19).

Although much of the cut-over surface does not support any vegetation, moderately dense stands of birch with pine are developing in places. On the uncut portion vegetation is dominated by old *Calluna* with abundant *Eriophorum*.

The basal topography is flat rather than basin-shaped which probably accounts for the relatively small proportion of typical low-moor peat in the profile. Only the bottom 3 feet of the total 16½ feet is composed of the remains of *Carex*, *Phragmites* and *Menyanthes* while above this stratum the peat is mainly composed of *Sphagnum* and *Eriophorum* with varying amounts of *Calluna* and amorphous material (Fig. 20, 7).

*Red Moss* (*Candyglirach*)

This moss, some 280 acres in extent, is situated 4 miles from the Loch of Skene. Peat cutting has left only a quarter of the surface undisturbed. The greater part, lying south of the Aberdeen–Lumphanan road (B9125), was examined in detail.

The highest part of the bog is 250 feet and the deepest bore recorded 16½ feet of peat. The average depth of uncut peat is 13 feet and on the cut-over it varies between 0 and 8 feet.

The uncut bog surface is very uneven with rank heather dominating the vegetation except in very wet patches, where *Sphagnum* forms an almost continuous blanket. Much of the flatter cut-over part is bare except for isolated hummocks of heather and *Eriophorum*. At the edges and within the bog, stands of *Betula-Pinus* scrub occur but the trees on the central areas are stunted.

Many high banks show the stratigraphy of the peat in which, appearing vividly against the dark peat, are particularly striking large pine stumps bleached by exposure to the weather (Plates 44 and 45). Although this layer of pine occurs in the cutting faces at 2–5 feet from the top, its true position relative to the surface of the virgin bog lies at a depth of 10 feet. Many stumps removed by peat cutters have been piled on the cut-over areas. Above the pine-stump layer the peat consists mostly of *Sphagnum* and *Eriophorum* with variable amounts of *Calluna* and amorphous material. Below this the composition is mainly *Betula* and *Pinus*, together with *Carex*, *Phragmites* and *Equisetum*. Figure 20, 8 does not show the pine layer as this profile proved particularly favourable for sampling, a gap in the pine horizon allowing the peat borer to reach the bottom unimpeded by large wood remains.

## ANALYTICAL DATA

Analyses of profile samples from St. Fergus and Skene Mosses (basin peats) and Cruden Moss (hill peat) are presented in Appendix IV. In the course of bog development changing environmental conditions, which control the nature of the vegetation, can result in a variety of peat types. Thus trends in analytical data within a profile are generally inconsistent and difficult to interpret. Nevertheless the data do, to some extent, reflect conditions under which the peat originated and subsequently evolved. The tables also show a correlation between the analytical results and the main peat types as defined by botanical composition.

The values for percentage ash are extremely low in all profiles, although an increase can be noted in the surface and basal horizons. The latter are frequently contaminated by mineral matter during the early stages of paludification.

Bulk density shows no consistent trends with depth but low values are associated with the relatively undecomposed *Sphagnum* types of peat and the higher values with the darker more highly humified *Sphagnum-Eriophorum* peat and the dense more compact sedge-grass types in the lower horizons. The hill peat profile from Cruden shows little variation in bulk density apart from a slight rise in the lowest horizon which contains wood remains.

The pH values are all extremely low. In basin peat deposits there is a general tendency for the pH to increase with depth although in the two examples cited, this is not particularly pronounced. At Cruden, the very low and relatively restricted range of pH values (3·1–3·8) are typical of upland blanket bog.

In all three profiles, calcium largely follows the pattern of pH although no absolute correlation can be established. In the two basin peats the upper horizons contain little calcium but this increases with depth until, in the lower strata, the values are several times those at the top. The higher values in the lower horizons at St. Fergus and Skene correlate with the low-moor stage of bog development during which period peat was accumulating under the influence of ground water enriched from adjacent mineral soil. In other words the younger *Sphagnum* peat and its associates of the raised-moss stage are much lower in calcium than the older sedge-grass types. Owing to the higher density of the latter, this difference would be more pronounced if the comparison was made on a volume basis. At Cruden the calcium is extremely low throughout the profile.

The sodium, potassium and magnesium values are all extremely low and show no consistent trends.

The values for total phosphorus, though all low, show a marked drop from the surface to the underlying horizons, below which no obvious trends are apparent, except at St. Fergus where a small but significant increase occurs down the profile.

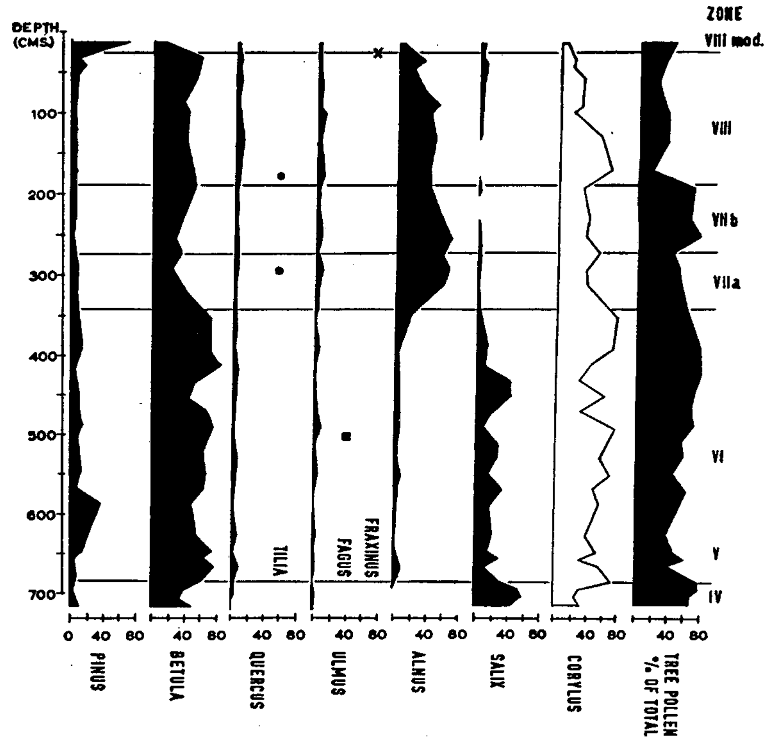
The figures for carbon generally exceed 50%, as would be expected in a highly organic soil, but no obvious trends are recorded.

Compared with the value for more eutrophic types of peat, nitrogen shows low to moderate values ranging from 0·66–1·65%. The only apparent trend is a tendency for values to fall from the surface to a minimum about the middle of the profiles and rise again in the lower horizons.

## Pollen Analysis and Vegetational History

The technique of pollen analysis enables the history of vegetational change to be studied and is based on the fact that pollen and spores have the property of remaining preserved in anaerobic deposits, such as peat and lake sediments, for many thousands of years. After suitable preparation pollen grains can be identified and quantitatively assessed thus giving a continuous record of vegetation from which major climatic changes can be deduced.

Pollen analyses from Aberdeenshire bogs have been used to give an outline of the vegetational history of the area. Data are presented in the form of pollen diagrams (Figs. 21, 22) which show the stratigraphy of the peat and



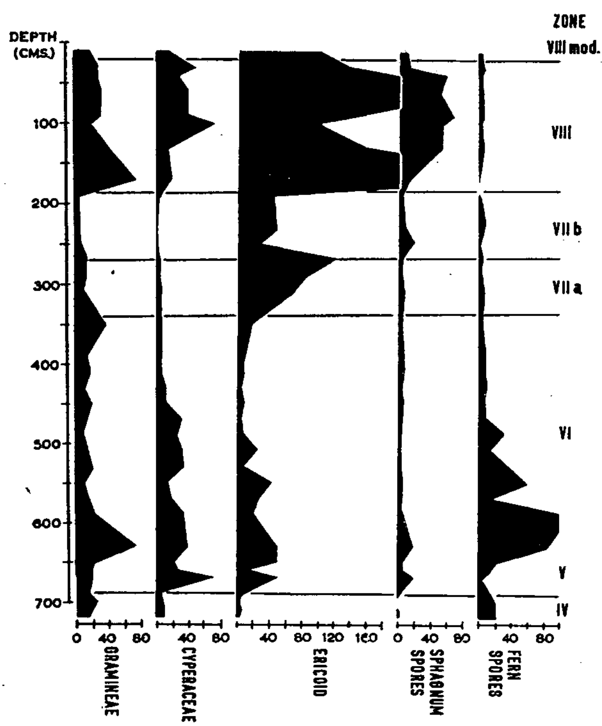
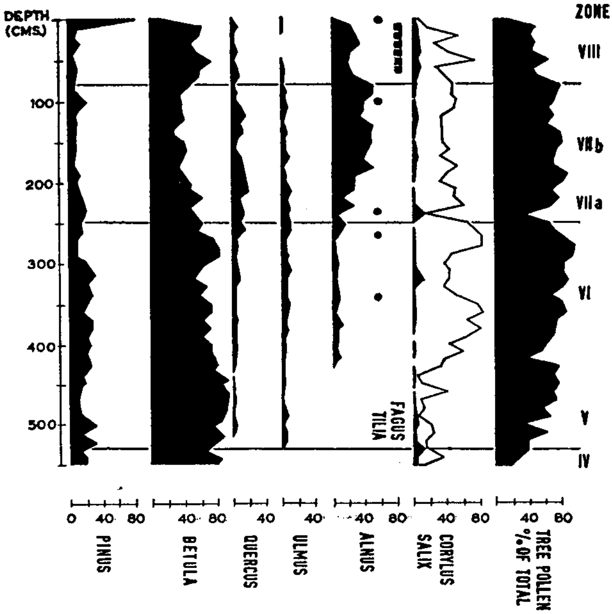




FIGURE 21. Pollen Diagrams, St. Fergus Moss.



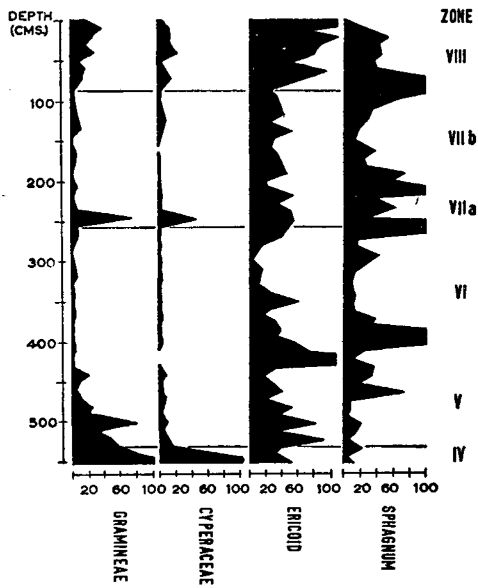




FIGURE 22. Pollen Diagrams, Skene Moss.

1. Corylus is excluded from arboreal and non-arboreal pollen totals.

2. Non-arboreal pollen is calculated as a percentage of arboreal pollen.

the percentage frequencies of pollen from trees and other species. The frequency curves of the various species exhibit certain fluctuations which have been shown to be generally common to all pollen diagrams from north and west Europe. It is now possible to devise a system of zones (numbered chronologically I–VIII) based on periods of relatively constant vegetation and believed to be contemporaneous. Transition from one zone to another is regarded as due to climatic change, human activity, or a combination of both. The results of radio-carbon dating carried out during the past decade have established the validity of chronology based on pollen analytical evidence.

## POLLEN ZONES

*Zones I–III.* The Late Glacial period: covers the time when ice was receding from most of the country. Neither of the profiles described in this investigation has horizons of this age.

*Zone IV.* The Pre-Boreal period: represents a period after the ice had retreated and during which climatic amelioration led to the initial spread of vegetation of a cool temperate type.

*Zone V.* The Early Boreal period: is dominated by birch with some Scots pine and possibly small amounts of other tree species. Hazel values tend to rise in this zone.

*Zone VI.* The Boreal period: commences with hazel increasing still further; this usually coincides with a small increase in elm. Birch remains high throughout the zone.

*Zone VII, sub-zone A.* The Atlantic period: at the transition from the previous period, alder increases rapidly and both birch and pine drop in frequency. The close of the Atlantic period is marked by a small but distinct fall in the values for elm. The change to sub-zone B, the Sub-Boreal period, which is not easy to delimit, may be placed where the total tree pollen curve starts a downwards trend. This may be gradual or sharp and may occur at or near the same level as maxima for hazel and alder. The decline in tree pollen may be interpreted as the first signs of human interference.

*Zone VIII.* The Sub-Atlantic period: birch gradually increases while alder remains constant or decreases slightly. During this period however the total tree pollen curve may show a decline. In recent centuries sudden changes in the frequency of certain species may occur, notably a marked increase in pine.

It will be observed that pollen zonation is governed mainly by the rise and fall of tree species as these were the dominant plants during the post-glacial period. The influence of man on his surroundings is indicated by the decline of total tree pollen and the corresponding increase of heath and herbaceous plants. Evidence of early agriculture is furnished by the presence of weeds of cultivation.

## DISCUSSION OF POLLEN DIAGRAMS

Simplified pollen diagrams from St. Fergus Moss in north-east Aberdeenshire and Skene Moss situated between the valleys of the Dee and Don are used to illustrate the vegetational history of the area. Peat formation started in these bogs in zone IV at the beginning of the pre-Boreal climatic amelioration.

The onset of zone V is indicated by a great increase in hazel, with smaller increases of oak, elm and pine, although birch remains the dominant tree species. The close of zone VI marks the end of the Boreal period and is clearly indicated by a rapid increase in alder and decrease in birch and pine.

From the Boreal–Atlantic transition onwards certain long-term trends are apparent. Birch, which never falls to low values, gradually increases and together with alder predominates until modern times. Oak and elm, which are represented by appreciable amounts of pollen, remain subsidiary species. The elm recession, marking the end of sub-zone VIIA, although not always obvious, is the last of the generally accepted features used in the pollen zonation of British profiles.

After the Atlantic period it appears that the efforts of early man to control his environment were taking effect. In the upper part of the diagrams the long-term changes of the dominant trees, birch and alder, may be due to factors other than those which cause the general pollen zonation. The gradual increase of birch, together with the downward trends of alder and hazel, may be due to the progressive leaching of mineral soils. Pine remains low until it rises to a peak which is undoubtedly due to modern planting. The decline of elm at the end of zone VIIB is thought to be connected with the infiltration of Neolithic agricultural communities and the forest clearances they initiated.

From this time onwards anthropogenic factors play an increasing part in the form of the diagrams. It is noticeable that the proportion of tree pollen shows an overall decrease with a significant drop at the beginning of zone VIII. Non-tree pollen, particularly the Ericoid group which is associated with grasses and sedges, increases substantially in the Sub-Atlantic period as it has in general since the Boreal period. This increase in non-arboreal pollen may be partly due to climatic deterioration, but is mainly attributed to the intensification of forest clearance for grazing and cultivation which took place in Britain about 1000 B.C. at the transition from the Bronze to the Iron Age. Further evidence of the practice of agriculture is found in the occurrence of cereals among the grass pollen, whilst certain plants regarded as weeds of cultivation, e.g. the plantains (*Plantago* spp.), are represented in the herbaceous pollen.

## HISTORY OF INDIVIDUAL TREE SPECIES

Birch exerts a dominating influence on the arboreal pollen diagram and during the whole of post-glacial time never falls to low values. In zone VII, during the period of maximum alder development, it falls to about 20%, otherwise it is invariably the most abundant tree pollen recorded. In the earlier periods, it is possible that some of the pollen grains counted belong to the dwarf birch (*Betula nana*), but no differentiation has been made.

Although alder does not attain its greatest importance until after the Boreal–Atlantic transition, it is present before this major climatic change took place. Reaching its maximum in zone VII, alder continues to contribute a high proportion of the pollen rain until the top of the profile.

Hazel (*Corylus*) is represented before the onset of zone V but only with low values. The elm (*Ulmus*) curve tends to rise gradually until the termiantion of zone VIIA: subsequently there is a small rise, but it never at any time accounts for more than a small proportion of the arboreal pollen. Together with oak (*Quercus*), elm forms the bulk of the mixed oak wood (*Quercetum mixtum*) which, judging from the pollen statistics, can never have flourished to any great extent. Oak is inconsistent and of little value in working out zonation.

Of the other tree species recorded, beech (*Fagus*)—once considered by many to have been introduced to Britain by the Romans—is infrequently noted and only from the post-Boreal period. In some diagrams, planting may account for its frequent occurrence high up in zone VIII. Ash (*Fraxinus*) is rarely represented and, like beech, occurs mainly in the upper zones. A few grains of lime (*Tilia*) are recorded mainly from zone VII and give an indication of the post-glacial climatic optimum which existed between the Boreal–Atlantic transition and the deterioration that set in at the beginning of zone VIII.

Pollen of willow (*Salix*) is abundant only in the basal horizons of the bog profiles and is presumably an indication of the pre-ombrogenous stage of development of the deposit. Sporadic willow pollen occurring throughout the profiles is regarded only as an indication of local conditions.

## NON-ARBOREAL GROUPS

The three principal non-arboreal groups are represented by the families *Gramineae* (the grasses), *Cyperaceae* (the sedges) and an assemblage called the Ericoids, which comprise the *Ericaceae* and allied plants. By far the greatest pollen contributor is the common heather (*Calluna vulgaris*). The trends of non-arboreal species are, on the whole, less constant than those of the trees, and they give an indication of conditions prevailing on the bog and its immediate surroundings rather than over a wider area. There is, however, something to be learned from the non-tree diagram, especially if it is studied together with the total tree curve. The great rise of the Ericoid group in zone VIIB or VIII coincides with the decline of the total tree curve and is probably due to the extension of heath after the destruction of forests in Neolithic times.

## SUMMARY OF VEGETATIONAL HISTORY

At the end of the Ice Age, about 8000–9000 B.C., when the glaciers in the Highland valleys had finally retreated, the land was colonised by tundra type vegetation. During the succeeding Pre-Boreal period, zone IV, scrub birch began to form the first woodland vegetation.

In the succeeding Boreal period, zones V–VI, woodland spread gradually. Birch predominated but pine constituted a considerable proportion of the woodland area in the north-east of Scotland. Small areas of mixed oakwood, alder and hazel existed on the better lowland sites. During this period the level of the sea relative to the land was lower than at present and eastern England was joined to the Continent by land now under the North Sea. The sea-level was gradually rising, however, and in the Atlantic period (zone VIIA), Britain became an island. Alder spread over areas which had a high water-table and mixed oakwoods also became much more extensive. Nevertheless birch and pine continued to be the dominant forest species in the north-east. The area of bog and marsh was increasing relative to forest, but in the ensuing Sub-Boreal period (zone VIIB), the bogs in the upland parts of Deeside and Speyside dried out and were colonised by pine, the stumps of which can still be seen.

At the beginning of historical time, birchwood was the most extensive woodland type, but pinewoods still existed, particularly on upland sites with northern aspects; remnants of their descendants still survive. Mixed oakwood occupied the more favourable lowland areas and alder was relatively extensive on wet land. The period was also one of active peat development during which time the land surface acquired the form it had prior to the extensive reclamation and drainage it has undergone in recent centuries.

TABLE V. TIME SCALE

| *Pollen Zones* | *Years before Present* | *Equivalent Climatic Period* | |
|---|---|---|---|
| VIII | | Sub-Atlantic | |
| | 2500 | | |
| VIIB | | Sub-Boreal | |
| | 5000 | | |
| VIIA | | Atlantic | |
| | 7500 | | Post-glacial |
| VI | | Boreal | |
| | 9000 | | |
| V | | Early Boreal | |
| | 9600 | | |
| IV | | Pre-Boreal | |
| | 10300 | | |
| III | | Upper Dryas clays | |
| | 10800 | | |
| II | | Allerod | Late glacial |
| | 12000 | | |
| I | | Lower Dryas clays | |
| | | | Full glacial |

# CHAPTER IX

# Vegetation

NATURAL or semi-natural vegetation is scarce in the extensively cultivated Aberdeenshire plain. In the hilly south-western parishes semi-natural communities of heath, hill peat vegetation and woodland are more common, and along the considerable line of coast there is an appreciable area of maritime vegetation, little modified by man. The highest point is Pressendye, 2032 feet, so that there is not a wide range in altitude, but the land does extend above the level of natural woodland and even towards the upper limit of heath dominated by *Calluna vulgaris* (Tansley, 1953).

Without man's influence the natural vegetation of the lowland region would be woodland and extensive stretches of moss vegetation on peat. Towards the edge of the peat deposits the woodland would perhaps be more open and heathy, especially if large herbivores were present to tilt the balance in favour of heath as soil conditions became less favourable to tree growth. Pollen records from the peat mosses (Durno, 1957) show that birch was the most abundant tree in the Boreal period of the post-glacial climate. Pine formed an appreciable proportion of the inland forest but was less common in the coastal districts. The wetter conditions of the Atlantic period were accompanied by a rapid increase in alder with a concomitant decrease in birch and pine. Oak and elm were present in the Boreal forests, and the records of the Atlantic period show an increase in their pollen in the coastal areas and a slight decrease inland. Numerous oak trunks were removed from the peat mosses of Buchan whilst they were being worked for fuel (Peter, 1875). This tree may be under-represented in the pollen records since it was growing in an area towards the northern limits of its range and its pollen production might have been reduced (Durno, 1957).

The first reliable evidence of man in Scotland can be assigned to the Atlantic period. The earliest colonists were hunters and food gatherers and their influence on the natural vegetation would be negligible (Childe, 1935). With the coming of the Neolithic farmers, tending flocks and growing a small amount of grain, forest clearance and grazing reduced the area of woodland in favour of heath and grassland. These peasants settled on the coastal plain of Aberdeen in the Sub-Boreal period. At about the same time Beaker-folk from England or Holland settled in the area (Childe, 1935). The increasing activity of the agriculturists after the late Bronze Age and Iron Age invasions is seen in the reduction of tree pollen laid down after the Sub-Boreal period (Durno, 1957). Climate change and leaching of the soil may, in part, have been responsible for the smaller extent of woodland after the Boreal and Atlantic periods, but after the Sub-Boreal the activity of man in re-shaping his environment has been the dominant factor. This is borne out by the more rapid diminution of tree pollen in the upper layers of the coastal peat deposits as compared with those inland; the coastal areas were the first to be colonised (Durno, 1957). With the reduction in forest there is a large increase in Ericoid pollen in the peat. Extension of heath on mineral soils and not merely the lateral spread of the peat deposits must have been responsible for this increase, since the stratigraphy of the more recent peat shows that it was built up mainly from *Eriophorum* and *Sphagnum*.

The use of timber for building and as fuel, both for domestic purposes and for metal smelting, must have made large inroads into the stands of natural forest, after the land had been intensively settled by the time of the Roman invasion under Agricola. This probably became increasingly more important in the historical period until, by the time of the writing of the first Statistical Account of Scotland (Sinclair, 1791–1799) the only natural woodland recorded in the area is pinewood in Aboyne parish, birchwood in Kildrummy and plots of natural birch, oak, ash and alder in Glenmuick and Tullich. The birchwood in Kildrummy was in the vicinity of Kildrummy Castle and was most probably secondary.

Pollen analysis of two buried A horizons collected from soils in the vicinity of Aberdeen shows a very high proportion of birch pollen with some alder (Durno, unpublished). The date of turning down of these topsoils is not known, but it was probably during the period of agricultural improvement in the eighteenth century or even earlier. The vegetation at or near these sites was birchwood, with a fair proportion of hazel as well as the alder already noted. Because of the proximity of Aberdeen this woodland was almost certainly secondary and may have been associated with open heath. The parish accounts in the first Statistical Account indicate that heath was very wide-spread and extensive, and woodland in the coastal parishes was negligible and, where present, was planted and mainly of Scots fir (pine). In some of the inland parishes woodland, both planted and naturally regenerated, was more extensive. In the parish of Peterculter uncultivated land near the River Dee was covered with furze and broom, and in many parishes a coarse type of grass, as well as heath, grew on the hills.

At the time of the writing of the New Statistical Account, about the middle of the nineteenth century, a great deal of re-afforestation had been achieved. The trees planted were mainly Scots pine and larch, but in the policies of mansion houses hardwoods also were planted. The Buchan parishes are reported as being generally unfavourable to the growth of Scots pine and larch, both of which decline after 40 years, and other species such as beech, plane (sycamore), elm, ash and alder were considered to be more suited to the conditions.

In the present century there has been a decline in the area afforested, and this is now being offset by planting carried out by the Forestry Commission. Reclamation of former heath- and gorse-infested permanent pasture has been undertaken in recent years in such areas as the neighbourhood of the Tore of Troup.

## TYPES OF VEGETATION

### WOODLAND

The greater part of the woodland is coniferous plantations where Scots pine (*Pinus sylvestris*), larch (*Larix* spp.) and spruce (*Picea* spp.) predominate. This woodland, when the canopy has closed, differs from natural woodland not only in the tree species present but also in the even age of the trees and the intensity of shade cast over the ground vegetation The fall of needles is a concomitant factor and the planting of coniferous species on a fertile brown forest soil may suppress exacting species of the field and ground layers. Removal of the tree crop on maturity may not result in the re-entry of these species because of the acidity of the raw humus surface layer and the absence of nearby parent plants.

Under the closed canopy of the younger plantations the ground vegetation is usually open and consists of shade tolerant and mainly oxyphilous species. As a tree crop matures, especially in the case of Scots pine and larch, the canopy opens under thinning operations and the ground vegetation becomes closed. The vegetation of the forest floor then contains a higher proportion of species of open heath and acid grassland. The canopy of spruce, which up to the present century was almost entirely Norway spruce but now includes a large proportion of Sitka spruce, remains dense even under a mature crop and the ground vegetation is open throughout the growth of the trees.

Selection of sites for the planting of the different coniferous species is influenced by the vegetation already on the ground, so that the differential effects of the species on the ground vegetation are difficult to determine. Only the effect of the denser canopy of spruce can be readily assessed.

Woodland planted around mansion houses is largely of deciduous species but includes the coniferous species already mentioned and others such as *Abies* and *Sequoia*. The most common deciduous species are *Ulmus glabra*, *Fraxinus excelsior*, *Acer pseudoplatanus*, *Quercus robur* and *Fagus sylvatica*. In addition to these policies woods there are small plantations of oak and beech often planted as pure crops.

Secondary woodland of birch (*Betula* spp.) is perhaps the most natural in the area, but as it often succeeds the felling of a coniferous plantation the trees are more even-aged than in natural woodland and in their juvenile stages may cast as dense a shade as young coniferous plantations. Birchwood has also been a source of firewood and many woods have regenerated from the stumps of felled trees. Associated with the dominant birch are occasional to frequent trees of rowan (*Sorbus aucuparia*). Both birch and rowan are present in coniferous plantations and the birch trees are the parent seed source for regeneration after felling. In some of the wetter sites subsidiary alder is present along with the birch and in these situations natural woodland was probably dominated by alder with birch subsidiary.

Alderwood, with *Alnus glutinosa* dominant, occurs in certain localities but is of lesser extent than birchwood. Natural regeneration from seed does occur and some of the woodland has arisen in this way. Other woods, such as the one at Auchmacoy near Ellon where *Alnus incana* is dominant along with *A. glutinosa*, are obviously planted.

The ground vegetation of the major part of the woodland contains a large proportion of oxyphilous species and species indicative of high base status of the soil are not common. Along the sides of narrow dens and in the vicinity of some of the mansion houses small areas of woodland with species such as *Mercurialis perennis*, *Circaea lutetiana*, *Brachypodium sylvaticum*, *Allium ursinum* and *Melandrium rubrum*, are to be found. In shelterbelts also there occur species of fertile conditions but the influence of high light intensity and of disturbance by man and his grazing animals are often evident. Species which commonly occur in shelterbelts and are usually absent from other woodland are *Dactylis glomerata*, *Heracleum sphondylium* and *Arrhenatherum elatius*.

Ground vegetation with a marked heath character occurs in coniferous plantations and birchwood. Where the canopy is fairly light *Calluna vulgaris* is dominant and *Vaccinium myrtillus* and *Deschampsia flexuosa* abundant. With increasing shade there is a greater abundance of the last two species, which may be the dominants, and shade tolerant species such as *Dryopteris austriaca* and *Oxalis acetosella* are prominent. On hill slopes which extend from a low altitude to the upper limit of trees there is often a sequence from *Calluna*-dominated ground vegetation in the open woodland at the upper levels to *Vaccinium*-dominated in the middle zone and grass-dominated towards the base of the slopes. The dominant grass of the lower slopes is commonly *Holcus mollis* or *H. mollis* is co-dominant with *Agrostis tenuis*, *A. canina* and *Deschampsia flexuosa*. Bracken, *Pteridium aquilinum*, occurs locally as dominant of the field layer, especially at the lower levels where the canopy is fairly open.

After felling, lowland areas are often invaded by *Chamaenerion angustifolium* or sometimes by a flush of *Deschampsia flexuosa*. Broom, *Sarothamnus scoparius*, and gorse, *Ulex europaeus*, may also invade the sites of felled woodland.

The ground vegetation of lowland woods contains a high proportion of plants typical of waste places. The planting of much of this woodland, in particular around mansion houses, on former agricultural land may be partly responsible, as well as continued interference by man and the proximity of arable land. The species are *Poa trivialis*, *Dactylis glomerata*, *Holcus lanatus*, *Cerastium vulgatum*, *Galium aparine* and *Veronica serpyllifolia*, and agricultural weeds such as *Senecio jacobaea*, *Poa annua* and *Stellaria media*. Some species of the former group, for example *Holcus lanatus*, do occur in natural woodland but not in the abundance in which they are found in these disturbed woods.

The influence of the different species of deciduous trees on the ground vegetation is not apparent, except in the case of the beech, *Fagus sylvatica*. Where the canopy of this tree is heavy the ground vegetation is open, and if the woodland floor is exposed to wind and thus swept bare of fallen leaves bryophytic species are established (Watt, 1923). The commonest mosses in such beech woodland are *Hypnum cupressiforme*, *Mnium hornum*, *Dicranum scoparium*, *Isopterygium elegans* and *Plagiothecium undulatum*.

## GRASSLAND

One half of the arable land is under temporary ley, but the extent of permanent pasture is not large. The hill grazings are mainly heath and only the lower hill slopes and small hills are grass covered. Gorse and, to some extent, broom infest quite an area of the permanent pasture, but bracken is seldom the noxious weed of grassland that it is in more southerly and westerly areas of Scotland. The higher proportion of cattle on the north-east pasture is probably an important factor in keeping bracken in check. The gorse scrub is often burned when its growth so dominates the vegetation that the grazing value is negligible, and succession to woodland, where there is a nearby source of parent trees, is thus prevented.

The dominant grasses are *Agrostis tenuis*, *Festuca ovina* and *F. rubra*.

Where gorse is abundant or dominant *F. ovina* is less abundant and *F. rubra* relatively more abundant. Where there is a fairly strong heath component in the vegetation, indicated by the undershrubs *Calluna vulgaris* and *Vaccinium myrtillus*, there is a greater abundance of *Deschampsia flexuosa* and *Agrostis canina*. The former occurs in areas of felled woodland also as a locally dominant or co-dominant species, and the latter is locally abundant. The two grasses *Anthoxanthum odoratum* and *Holcus lanatus* are frequent or abundant but are seldom dominant species. In pasture laid down after cultivation *Holcus lanatus* may occur as co-dominant along with *Agrostis tenuis*. In such grassland the dominance of *Agrostis* is very marked and *Festuca ovina* is infrequent in the early stages of the succession. *Holcus mollis* is often locally abundant on the sites of former woodland and certain areas of sown-out pasture. It is less common in the permanent pasture.

Another feature of pasture established after woodland is the presence of the woodland species, *Anemone nemorosa*, *Oxalis acetosella* and *Trientalis europaea*. They do occur locally in grassland where no trace of former woodland is evident but are far less common. *Trientalis* is recorded as occurring locally in permanent pasture where there is a strong heath element in the vegetation. Its occurrence may be governed by the nature of the upper humus layer of the soil as well as by the intensity of grazing.

Other dicotyledonous herbs which are frequent, except in recently laid down pasture, are *Galium saxatile*, *Potentilla erecta* and *Viola riviniana*. Species which invade the sown out grassland more rapidly are *Veronica chamaedrys* and *Lotus corniculatus*. Their presence may be a measure of the higher base status or general fertility of the soil after cultivation as well as of their ability to invade this pasture. *Trifolium repens* is abundant after sowing out, since it forms part of the seed mixture, and the grassy community is favourable to its continued presence in the vegetation. Agricultural weeds, *Ranunculus repens*, *Bellis perennis* and *Cirsium arvense*, as well as the sown out grasses *Dactylis glomerata*, *Poa trivialis* and *Lolium perenne*, persist for a considerable time on the more moist and fertile sites.

The most common bryophyte is *Rhytidiadelphus squarrosus* which occurs throughout the grassland but is less common in areas recently sown out. Other species which are often abundant are *Hylocomium splendens* and *Pseudoscleropodium purum* and, in some of the more heathy pastures, *Pleurozium schreberi*.

Where bracken dominates the vegetation the grassy understorey shows kinship with the community developed under grazing after the felling of woodland. *Festuca ovina* is less abundant than in the absence of bracken and *Holcus mollis* may be locally abundant. Woodland species, *Rubus idaeus* and *Oxalis acetosella*, are occasional or locally present.

The bulk of the above grassland can be assigned to the *Agrostis–Festuca* grassland described by Tansley (1953). The sown-out pastures, from the abundance of *Trifolium repens* and the presence in considerable amount of *Plantago lanceolata*, *Achillea millefolium* and the grasses *Cynosurus cristatus* and *Poa pratensis*, can be assigned to Neutral Grassland (Tansley, 1953).

Minor areas are dominated by moor mat-grass, *Nardus stricta*: this community is intermediate between heath and *Agrostis–Festuca* grassland. *Nardus* often occurs as a locally frequent species in both these communities, but it is seldom a dominant species. The most commonly associated grass is *Deschampsia flexuosa* and other frequent grasses are *Festuca ovina* and

*Agrostis tenuis.* Where these *Nardus*-dominated areas are marginal to heath *Calluna vulgaris* and *Vaccinium myrtillus* are present in varying amounts, and where soil drainage is impeded *Molinia caerulea* is locally frequent.

### HEATH

The heath formation is strongly developed on the hills, in the vicinity of some of the lowland mosses and on certain lowland spreads of gravel and poorly drained stony till. Heather, *Calluna vulgaris,* is the main dominant, and where careful burning is carried out this species may be the only flowering plant to occur in any abundance. Although the intensity of grazing is of great importance, it is, basically, the fertility of the soil that determines the stock-carrying potential of untreated land. The coarse textured nature of the hill soils and their low base status are important factors, encouraging the establishment of heath rather than acidic grassland. A division between heath and grassland is often marked by a fence but this sharp line usually indicates a transition from upper to lower slope soils.

In addition to the suitability of the soil the climate of moderate rainfall is favourable to the establishment of dry heath, when compared with areas of higher rainfall in western Scotland.

The greater part of the heath, if there were no grazing and burning, would be forest. Birch and pine, the potential dominants of such forest, do occasionally establish themselves in open heath, but they are almost invariably prevented from reaching maturity by the periodic burning. Burning is carried out about once in every twelve years, although this varies slightly, depending on whether the land is reserved for grouse or for sheep. As only a portion of the heath is burned each year, the result is a series of even-height patches of heather at various stages of growth. The vagaries of the wind during burning and accidental fires usually prevent strict rotation of burning, so that the hills present an irregular patchwork of *Calluna*-dominant areas and subsidiary areas where grasses and *Vaccinium myrtillus* have been favoured by too short or too long a period between fires. In addition to these areas of burning unfavourable to *Calluna* there is a succession where lichens and orthotropic mosses are prominent in the early stages and, under certain conditions of soil and exposure, grasses and *Vaccinium* may be abundant before heather completely covers the ground.

Associated with the dominant *Calluna* in the dry heath are the under-shrubs *Erica cinerea, Vaccinium myrtillus* and *V. vitis-idaea.* These three species tend to recover from burning more quickly than *Calluna,* and for a few years after burning one of the *Vaccinia,* or a combination of the two, may dominate the vegetation. On dry slopes of southern exposure *Erica cinerea* tends to be more abundant, and on boulder-strewn slopes *Vaccinium myrtillus* is often abundant. Other low shrubby species which occur are *Arctostaphylos uva-ursi*—at the higher levels, *Empetrum nigrum*—occasional or locally frequent at all levels but more abundant at the higher near areas of hill peat, and *Erica tetralix*—infrequent, being much more common in wet heath. The needle furze, *Genista anglica,* also is locally frequent, and both *Ulex europaeus* and *Sarothamnus scoparius* may be present, but usually in areas marginal to the main heath communities.

The grasses of acidic grassland occur in dry heath and become more abundant as intensity of grazing increases; they are also more abundant where podzolisation is less marked. The most widespread grass is *Des-*

*champsia flexuosa* but other species encountered are *Nardus stricta, Festuca ovina, Agrostis canina* and *A. tenuis. Juncus squarrosus* may be locally frequent, especially where grazing is heavy. Dicotyledonous herbs are not common and the most prevalent species are *Potentilla erecta* and *Galium saxatile.* Their abundance increases as the grassy element becomes more important.

Bryophytes often form a continuous layer under the dominant undershrubs. The most abundant species are *Hypnum cupressiforme* var. *ericetorum, Hylocomium splendens* and *Pleurozium schreberi.* These occur under the canopy of older heather or after burning where the fire has not destroyed the surface mat of mosses. Where there has been a severe burn lichens and orthotropic mosses, such as *Dicranum scoparium* and *Pohlia nutans,* invade the area and persist under the canopy of heather, though becoming less abundant as the plagiotropic mosses become re-established. Species of the lichen genus *Cladonia* are common and are conspicuous in the young communities after burning and in old heath which has escaped burning. In the latter case *C. impexa* is often abundant and *Hypogymnia physodes,* growing epiphytically on the old stems and branches of *Calluna,* is very common.

Wet heath is often found on poorly drained sites and on gentle convex slopes in upland regions. *Calluna vulgaris* is again the dominant plant, but the main subordinate species are different from those of the dry heath. *Erica tetralix* is the most abundant undershrub associated with the heather and *Erica cinerea* is often absent. The two species of *Vaccinium* are less frequent than on the drier areas, but *Empetrum nigrum* is equally as abundant. Deer grass, *Trichophorum caespitosum,* is typical of upland wet heath and lowland wet heath in the vicinity of peat deposits. It is absent from lowland heaths which have been influenced by fairly recent planting and subsequent felling. The bryophytic species are the same as those of the dry heath, with the addition of species of *Sphagnum, S. compactum* and *S. plumulosum,* and *Aulacomnium palustre* and a greater abundance of *Polytrichum commune.*

Heath dominated by *Vaccinium myrtillus* occurs after felling of certain plantations where the canopy has been fairly heavy. There is also on Tap o' Noth a small area of Vaccinietum above the general Callunetum; the exposure and the rocky nature of the ground favour *Vaccinium myrtillus* rather than *Calluna* as the dominant species. In the Vaccinietum there is a greater abundance of the subordinate species *Deschampsia flexuosa, Festuca ovina, Nardus stricta, Agrostis canina* and *A. tenuis,* when compared with the surrounding area of low wind-cut Callunetum.

## MARSH VEGETATION

Extensive areas of marsh were cleared and drained during the eighteenth and nineteenth centuries. A certain proportion of this had probably been secondary marsh formed by the removal of peat but much of it may have developed on the site of former alderwood on mineral soil or soil with a deep humose top. Present-day marsh is not extensive and is mainly confined to the margins of small lochs, to water courses and to the beds of water channels cut by glacial meltwater. In addition there are flushes in the hills and a secondary marsh community which has arisen from degeneration of land formerly drained for agricultural use. Other areas had been planted with deciduous and coniferous trees and when abandoned after felling these are often re-colonised by birch and alder.

PLATE 48
An upland farm on the Tarves Association, iron podzol soils developed on heathland, Langgadlie Hill.

*(By courtesy of The Scotsman Publications Ltd.)*

PLATE 49
Bishopstone Farm on the western side of Tyrebagger Hill.

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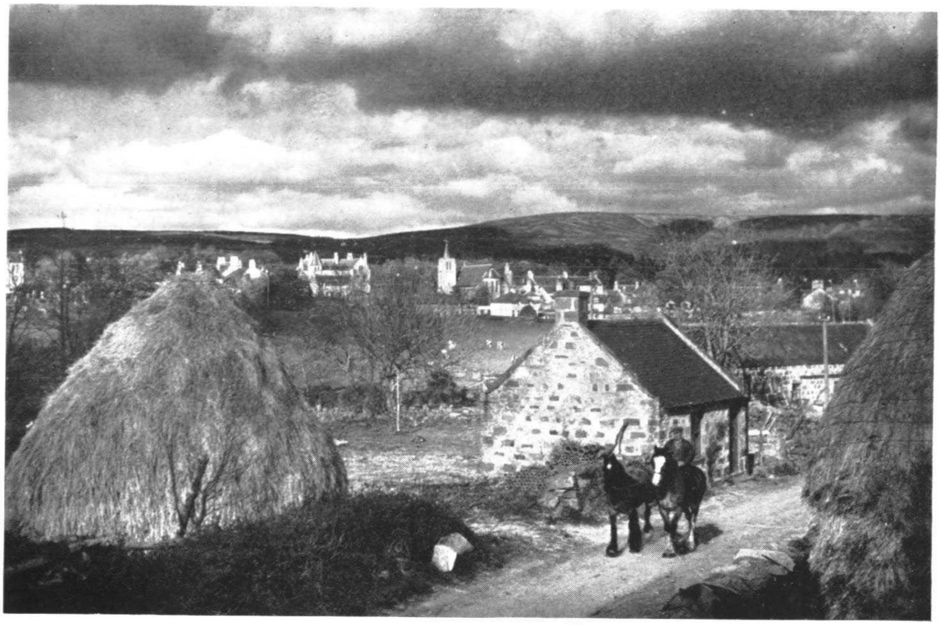

(*By courtesy of The Scotsman Publications Ltd.*)

PLATE 50

Torphins Village in the Dee Valley, looking towards Hill of Fare.

(*By courtesy of Aberdeen Journals Ltd.*)

PLATE 51

The Tarland Basin with Lochnagar in the distance.

A fairly large area of reedswamp on a recently silted-up portion of the Loch of Strathbeg is dominated by *Phalaris arundinacea*. Its chief associates are *Heracleum sphondylium, Galium palustre, Filipendula ulmaria* and *Potentilla palustris*. The other marsh communities noted are the wet marshy pastures and flushes. *Juncus effusus* is usually the dominant species of the pastures and the main subordinate species are *Agrostis canina* var. *canina*. *Holcus lanatus, Cirsium palustre, Rumex acetosa* and *Epilobium obscurum*, Where grazing is fairly heavy other grass species, such as *Agrostis tenuis* and *Anthoxanthum odoratum* are common and *Trifolium repens* and *Ranunculus repens* are more abundant than in the tall communities where grazing is negligible.

The dominant of flushes is often *Juncus acutiflorus*, although where deposition of mineral material is active the dominant may be *J. effusus*. *J. acutiflorus* does not have the dense tussock habit of *J. effusus* so that there is often a greater abundance of the subordinate species. This flush community is very similar to that dominated by *J. effusus* on formerly improved land. Certain marsh species, *Ranunculus flammula, Caltha palustris, Potentilla palustris* and *Galium uliginosum* which are absent from the latter are present in the older community.

## PEAT VEGETATION

The area of peat on the Aberdeenshire plain was greatly reduced at the time when peat was the main domestic fuel. The Rev. James Peter, reading a paper to the Club of Deir in 1875, reported that, over a period of thirty years, 4914 out of 11479 acres had been stripped of peat or converted to agricultural land by cultivation of the peat. Arable land had been increased to the extent of 3132 acres. Not only peat from lowland deposits was used for fuel but also the hill peat from Hill of Fare and Bennachie. Peats are still cast in some localities for fuel and from one moss peat is extracted for agricultural uses.

The peat-cutting operations and their abandonment has greatly modified the type of vegetation growing on the peat. On the lowland deposits, where the upper layers of acid oligotrophic peat have been removed to expose the more eutrophic peat for plants to root in, there has been a backward displacement of the plant succession. Early stages of a hydrosere are in evidence although modified from those of an undisturbed hydrosere. The communities are similar to marsh vegetation in very wet situations. *Carex rostrata* and *Carex nigra* are very common in the early stages of rebuilding the peat, and associated species are *Potentilla palustris, Menyanthes trifoliata* and *Equisetum fluviatile*. Small areas also of reedswamp dominated by *Phalaris arundinacea* occur. A later stage of succession shows the development of a "carr" vegetation dominated by the sallow, *Salix atrocinerea*. The field layer of the carr contains a large number of marsh or fen species, but there are also oxyphilous species, *Calluna vulgaris, Erica tetralix* and *Galium saxatile*, on the remnants of more acid peat.

Secondary birchwood has invaded many areas of cut-over and drained peat, often after felling of coniferous woodland planted on the peat. The even-aged community of trees casts a heavy shade on the lower layers of vegetation and these consist almost entirely of shade tolerant oxyphilous species. The dominant vascular plant is often the fern *Dryopteris austriaca* and associated species are *Deschampsia flexuosa, Oxalis acetosella* and *Galium saxatile. Rumex acetosella* is common in certain woods and sets seed where the canopy is fairly light. The more abundant mosses are those which occur under dense canopy of beech, but there is a greater abundance of *Polytrichum commune* than in beechwood.

Where the vegetation on peat has been less drastically modified *Calluna vulgaris* is dominant or co-dominant with *Eriophorum vaginatum.* Lowland deposits of deep peat in many cases have the outward structure of raised mosses, with the central portion slightly higher than the edges. The surface, however, shows little development of the hummock and hollow sequence typical of Irish raised mosses. The dominance of heather marks the drying out of many of these deposits which has resulted from the cutting of surface drains and the removal of peat, especially towards the edge of the mosses. Climatic change also may have influenced drying out and there is the possibility that some of the deposits may have reached the limit of their upward growth, but the overwhelming factor has undoubtedly been disturbance by man.

The co-dominance of *Eriophorum vaginatum* with *Calluna* is evident on areas less affected by drying out of the surface peat. There is, at the same time, a greater abundance of species of *Sphagnum—S. plumulosum, S. rubellum, S. cuspidatum* and, to a lesser extent, *S. papillosum* and *S. magellanicum.*

*Erica tetralix* is generally distributed throughout these lowland communities and is often abundant. The occurrence of *Empetrum nigrum* is less constant and less frequent and *Vaccinium myrtillus* is seldom present.

The cotton grass, *Eriophorum angustifolium,* is highly constant in the vegetation and occurs particularly in the wetter hollows and where active building of the peat is still taking place. It is abundant where removal of a section of peat has lowered the level of an area and effectively raised the water-table. Slight hollows are occupied by *Narthecium ossifragum* and occasionally by *Drosera rotundifolia,* but the deeper hollows and pools are usually dominated by *Sphagnum cuspidatum* and may be colonised by *Eriophorum angustifolium.*

Towards the edge of some of the mosses, or where cutting has uncovered a rather more eutrophic peat, *Myrica gale* may be abundant. Along with it *Calluna* and *Erica tetralix* are abundant and *Molinia caerulea* can be abundant although it is not invariably present.

Birch and pine frequently invade areas of open moss, but the development of mature woodland is often prevented by periodic fires. Tree growth, especially in the case of the pine, is very poor on the wetter peat.

The upland peat deposits are not extensive and are largely eroded and hagged. A considerable amount of the peat on Bennachie and on Mormond Hill has been destroyed by recent disastrous fires. *Calluna vulgaris* is the dominant plant on the eroding peat and common associates are *Rubus chamaemorus, Vaccinium myrtillus, Eriophorum vaginatum* and *Empetrum nigrum.* Peat on saddles and in depressions may still be actively building and can easily be distinguished from the surrounding eroded peat by its smooth surface and the greater abundance of *Eriophorum vaginatum* and *E. angustifolium.* Peat on slightly elevated areas with very gentle slopes, such as the Moss of Cruden, is not susceptible to erosion and the vegetation is very similar to that of the saddle peat on the hills or the lowland peat in depressions.

The area has a long coast line and maritime communities are thus fairly extensive. Vegetation on the cliffs was investigated at one point only, since the horizontal extent of these is limited on a small scale soil map. The grassy cliffs at New Aberdour have abundant *Festuca rubra* and *Holcus lanatus*. Other grasses which are common are *Agrostis tenuis, Dactylis glomerata* and *Cynosurus cristatus*. The two clovers *Trifolium repens* and *T. pratense* are the most abundant of the dicotyledonous herbs, but the list of these is long and varied and includes maritime species, *Plantago maritima* and *Armeria maritima*, and species of local seepages, *Parnassia palustris* and *Juncus articulatus*.

The areas of wind-blown sand show a sequence from colonisation of the mobile sand at the seaward side to the closed communities on a stable substratum on the landward. The main dune fixing species is *Ammophila arenaria*, although locally both *Elymus arenarius* and *Agropyron junceiforme* are present.

At Rattray Head the early dunes are colonised by seedlings of *Ammophila arenaria*, and the later building stages, with the active accumulation of sand around the growing plants, show the marked dominance of this species. At first the drift line species, *Cakile maritima* (cf. Gimingham, 1951), is locally frequent, and other species associated with *Ammophila* are *Festuca rubra* var. *arenaria, Cirsium arvense* and *Senecio jacobaea*. Where the dunes become more stable *Cakile maritima* is absent and the vegetation becomes more closed with a greater abundance of *Festuca rubra* var. *arenaria. Senecio jacobaea* and *Cirsium arvense* are still present, but a greater proportion of the vegetation is formed by other species, such as *Galium verum, Campanula rotundifolia, Trifolium repens* and *Poa pratensis*. The orthotropic moss *Tortula ruraliformis* is locally frequent at this stage.

The dominance and vigour of *Ammophila* decline in the later closed communities on the more or less fixed dunes and *Festuca rubra* (forms other than var. *arenaria*) is often dominant. The grass species *Agrostis tenuis* and *Poa pratensis* and the sedge *Carex arenaria* may be abundant. *Senecio jacobaea* and *Cirsium arvense* are still prominent, but a large number of the species found are typical of grassland growing on a stable soil. The mosses characteristic of mobile and younger dunes, *Tortula ruraliformis, Ceratodon purpureus* and species of *Bryum*, are still present, but the plagiotropic species *Rhytidiadelphus triquetrus, R. squarrosus* and *Hylocomium splendens* are far more abundant. At the same time lichens, *Peltigera canina* and species of *Cladonia*, including *C. sylvatica, C. furcata* and *C. fimbriata*, are locally present and may be abundant.

Where the dune system is narrow it gives way to a flat area of grassy vegetation in which *Ammophila* forms only a minor part or is absent. Deposition of fresh sand is less important than leaching of the soil, and species characteristic of acidic grassland become prominent; *Galium saxatile* and *Nardus stricta* are fairly common, and the heath undershrubs *Calluna vulgaris* and *Empetrum nigrum* may locally occur.

On the wider dune systems, as at Collieston, there is a transition to heath. In the transitional stages *Ammophila* is often abundant with *Calluna vulgaris* which is becoming the dominant plant. *Empetrum nigrum* and *Carex arenaria* are fairly abundant, and the mosses *Pleurozium schreberi, Dicranum scoparium, Rhytidiadelphus triquetrus* and *Hypnum cupressiforme* are common.

The lichens *Cladonia sylvatica, Cetraria aculeata, Peltigera canina* and *Hypogymnia physodes* are particularly prominent. In the fully developed heath community *Ammophila* persists but locally; *Carex arenaria,* however, may still be quite abundant, but apart from this the vegetation is similar to inland heath on dry exposed sites.

## VEGETATION IN RELATION TO MAJOR SOIL GROUPS

There is a clear correlation between the vegetation and the major soil groups, although it is often obscured by man's past and present use of the land. Drainage of a poorly drained soil produces a fairly rapid response in the vegetation, with species of drier situations becoming more abundant, but the soil characteristics change only slowly. Cultivation of a podzol and its subsequent abandonment to grazing may maintain a grassland characteristic of a brown forest soil. The soil itself retains the modified morphology for a considerable time, but the removal of intensive grazing and the invasion by heath plants initiates the re-establishment of the upper horizons of a podzolic profile.

### BROWN FOREST SOILS

*(i) Freely Drained*

Freely drained brown forest soils occur on the more base-rich parent materials in the lowland area, on small hills and on the lower slopes of the larger hills. There are also limited areas on the more acid parent materials and these usually occur on the lower hill slopes. The range in base status of these soils reflects the level of bases in the parent materials and the topographic situation of the soils in relation to leaching.

Deciduous woodland around mansion houses has been planted and the tree species are seldom indicative of soil condition, except in so far as species suitable to the site have been chosen. The ground vegetation, however, does give a measure of the drainage and fertility of the soil, although there is usually a considerable ruderal element present. *Holcus mollis* and *Agrostis tenuis* are the most abundant species and occur locally as dominants, but in this varied and disturbed community other species, *Pteridium aquilinum, Poa trivialis, Urtica dioica* and *Dryopteris austriaca,* can be locally dominant. Local areas of soil, as on the north bank of the River Ythan at Gight, are of fairly good base status and *Mercurialis perennis* is locally dominant whilst other species characteristic of the more fertile soils, *Melandrium rubrum, Stachys sylvatica* and the moss *Eurhynchium striatum,* are quite common.

Woodland on the lower hill slopes is a more natural community dominated by planted oak or secondary birch. The soils are more acid and grade into podzols at higher altitudes. The planted oak is *Quercus robur,* with a lesser proportion of *Q. petraea* and intermediate forms, and the birch includes both *Betula pubescens* and *B. verrucosa,* with intermediates. *Sorbus aucuparia* is frequent in some of the woods and the shrub *Corylus avellana* is present locally in others although it is not widespread.

Dominant species of the field layer are the grasses *Holcus mollis* and *Deschampsia flexuosa,* with *Holcus* the more common on the deeper soil at the base of the slopes. *Vaccinium myrtillus* is locally dominant, particularly farther up the slopes where the tree canopy is lighter and the soils are more shallow with numerous boulders. Bracken, *Pteridium aquilinum,* is abundant in many of the woods and locally dominates areas of more open canopy.

The woodland species *Oxalis acetosella* is frequent throughout and is abundant in some woods. Other fairly constant and frequent species are *Anthoxanthum odoratum, Galium saxatile, Viola riviniana* and *Luzula pilosa*. The birchwoods have suffered more interference than the woods with a long established crop of oak trees and this is reflected in the ground vegetation. *Agrostis tenuis* is often abundant, and may be dominant where grazing is permitted and *Holcus lanatus* is common. Certain of the bryophytes, in particular two species of *Rhytidiadelphus, R. loreus* and *R. squarrosus*, are associated with the two types of woodland. *R. loreus* occurs in the oakwoods while *R. squarrosus* is more common in the more frequently disturbed birchwoods.

The greater area of permanent grassland occurs on the freely drained brown forest soils. The composition of this grassland and its variation in relation to past use of the land have already been described. Variations due to differences in the base status of the soil remain to be indicated. Communities on the rather more base-rich soils have a greater number of species than those on the more acid soils, and there are certain species which are fairly reliable indicators of the more fertile soils. These species are *Galium verum, Koeleria gracilis, Helianthemum chamaecistus, Thymus drucei* and, on some of the hill pastures, *Viola lutea*. The relative abundance of the more common constituents of the grassland vegetation varies. On the acid soils *Potentilla erecta, Deschampsia flexuosa* and *Agrostis canina* are more abundant, and on the more basic soils there is a greater abundance of *Poa pratensis, Plantago lanceolata, Festuca rubra* and *Trifolium repens*. The two species *Veronica chamaedrys* and *Achillea millefolium* also tend to be more common on the less acid soils. The mosses *Pseudoscleropodium purum* and *Pleurozium schreberi* show different relative abundance on the range of acidity which occurs under grassland on the brown forest soils. *P. purum* is more abundant on the more base-rich soils and *P. schreberi* where acid conditions prevail.

Vegetation on soils derived from ultrabasic rocks is very similar to that on the basic rocks. *Festuca rubra* is dominant, or co-dominant with *Agrostis tenuis*, but the high frequency of the grasses *Helictotrichon pratense* and *Deschampsia caespitosa* in some communities on the Leslie series is not encountered on the Insch series.

(*ii*) *Imperfectly Drained*

The bulk of the imperfectly drained soils is cultivated, and where semi-natural vegetation does exist it is as shelterbelts, policies woodland and pasture laid down after cultivation. The woodland is similar to that on the freely drained soils, with a greater proportion of "exacting" species. *Allium ursinum* and *Geum urbanum* are more common than on the freely drained soils and species of more moist conditions, *Deschampsia caespitosa, Ranunculus repens, Cirsium palustre* and *Juncus effusus*, are often frequent. The bryophytes present give similar evidence of more moist and rather more base-rich conditions—*Eurhynchium praelongum, E. striatum, Mnium undulatum, Cirriphyllum piliferum, Thuidium tamariscinum* and species of *Fissidens* are fairly common.

Little difference exists between the vegetation of the sown-out pastures of the imperfectly and freely drained soils. There is one area of old pasture on the imperfectly drained soil of the Cruden Association which shows a great abundance of *Juncus effusus* var. *compactus* and *Deschampsia caespitosa*, but in most cases the communities are similar.

The greater area of semi-natural vegetation occurs on the podzolic soils. It ranges from woodland (usually secondary birchwood and coniferous plantations but including oakwood of the upper slopes) to open heath and grassy heath.

*(i) Freely Drained Iron Podzols*

Woodland on the freely drained iron podzols has a heathy ground vegetation. The influence of increasing shade of a growing plantation has already been described, and the felling of a mature pine or larch plantation results in a rapid spread of *Calluna vulgaris*. Under the more dense canopy of old spruce heather is generally absent and *Deschampsia flexuosa* is the dominant after felling, with heather invading more slowly.

As in brown forest soils there is a range in soil properties and the two groups, brown forest soils and iron podzols, grade into each other. Towards the brown forest end of the range in the iron podzol podzolisation is less obvious and the heathy component of the vegetation is less marked. *Holcus mollis* is quite common and is locally dominant. Other grass species, such as *Agrostis tenuis* and *Anthoxanthum odoratum*, are frequent and, where grazing or other disturbance of the woodland community takes place, *Agrostis tenuis*, *Festuca ovina* and *Holcus lanatus* are often abundant.

The main dominants on the more strongly podzolised soils are *Deschampsia flexuosa* and *Vaccinium myrtillus*. The most commonly associated species are *Dryopteris austriaca*, *Oxalis acetosella* and *Galium saxatile*. Other species which frequently occur in these woods are *Luzula pilosa*, *Trientalis europaea*, *Viola riviniana* and, under lighter canopy, *Potentilla erecta*. *Digitalis purpurea* is common in certain plantations with an open ground vegetation, especially on sites which appear to have had a succession of crops of coniferous trees.

Under light canopy, and particularly towards the upper limit of woodland, *Calluna vulgaris* is the dominant of the field layer. Associated with it are *Vaccinium myrtillus*, *V. vitis-idaea* and *Deschampsia flexuosa*. On dry stony sites *Erica cinerea* is frequent, and on certain coarse textured soils, which may formerly have been the site of natural pinewood rather than of birchwood, *Goodyera repens* is locally frequent.

Bryophytes which are common in woodland with a grassy field layer are *Rhytidiadelphus squarrosus* and *Pseudoscleropodium purum*, and where *Calluna* is dominant *Hylocomium splendens*, *Hypnum cupressiforme* var. *ericetorum* and *Pleurozium schreberi* are abundant. Under fairly heavy coniferous canopy *Plagiothecium undulatum* and *Lophocolea bidentata* are locally abundant.

Open heath is the vegetation on the hills where burning and grazing or severe exposure have prevented the establishment of trees. The exposure factor in the past would have prevented tree growth in only a few localities, since the flatter hill-tops had a capping of peat and not freely drained podzolic soils on them so that nearly all the freely drained podzols are potentially capable of carrying forest.

The description of dry heath already given applies to the vegetation on these soils. Variations in the heath community reflect only in a very slight degree the influence of the soil parent material, since past and present use of the land is the dominant factor. *Lathyrus montanus*, *Lotus corniculatus* and *Antennaria dioica* occur in certain areas of heath on podzols of the Insch

Association and are not recorded in other heaths. There is little evidence of an $A_2$ horizon in these soils and the species are perhaps relicts of a more grassy vegetation. The community is richer in the number of species present, when compared with heath at the same altitude on soils derived from more acid rocks, and *Helianthemum chamaecistus*, which in the southern half of Britain is a calcicolous species (Procter, 1958), occurs locally.

Heath occurs on residual soils derived from serpentine and, although the upper humus horizon of these soils appears similar to that of a podzol, the presence of weathering serpentine in the lower horizons has a considerable effect on the species present. *Calluna vulgaris* may be the dominant species, but a low-growing form of *Juniperus communis* is often dominant and the grasses *Festuca rubra*, *Deschampsia caespitosa* and *Helictotrichon pratense* are locally frequent. A small area of heathy vegetation on Beauty Hill is heavily grazed by cattle and the main dominant is *Erica cinerea*; *Molinia caerulea* and *Ulex europaeus* are abundant and *Calluna vulgaris* and *Succisa pratensis* are frequent to abundant. Occasional plants of *Plantago maritima* also occur in this community.

(*ii*) *Imperfectly Drained Iron Podzols*

Woodland vegetation on the imperfectly drained iron podzols is very similar to that on the freely drained. As in the case of the imperfectly drained brown forest soils a large area is cultivated land. Secondary birchwood occurs locally, but the woodland is mainly of planted conifers. *Sorbus aucuparia* is frequent, sometimes forming a second storey under the dominant birch, and *Salix atrocinerea* is occasionally present. Dominant species of the field layer are usually the grass species *Agrostis tenuis*, *Deschampsia flexuosa*, *Holcus mollis* and *Agrostis canina*, but *Calluna vulgaris* is locally dominant. *Vaccinium myrtillus* is present locally but seldom as a dominant. Occasional plants of wet acid conditions, such as *Erica tetralix*, are found and one of the main distinctions from the vegetation on the freely drained soils is the abundance of the moss *Polytrichum commune*. The vegetation in the plantations is substantially the same as on the freely drained soil and the influence of the canopy outweighs that of the impedance in soil drainage.

Imperfectly drained podzols are sometimes marginal to hill peat and the heath vegetation is intermediate between dry and wet heath. *Calluna vulgaris* is the dominant plant and associated are the same species as on the freely drained soils with *Vaccinium myrtillus* and *V. vitis-idaea* less abundant. *Erica cinerea*, a species often typical of dry stony situations, is a frequent member of the community and its presence is perhaps due to the stony nature of these imperfectly drained soils. The wet heath species *Trichophorum caespitosum* and *Erica tetralix* are locally frequent and the heath rush, *Juncus squarrosus*, is occasional or locally frequent. There is little evidence of the effect of soil drainage on the bryophytes present. Species of *Sphagnum* may occur locally and the liverwort, *Gymnocolea inflata*, is more frequent than in the dry heaths.

The heath community on the imperfectly drained soils of the Hill of Towanreef shows the same anomalies as that on the freely drained soils. The soil is perhaps more nearly related to the brown forest soil, but the vegetation is akin to that on the iron podzols. The dominants are *Calluna vulgaris* and *Juniperus communis*, except after burning when the grass *Festuca ovina* may temporarily be the dominant.

### (*iii*) *Peaty Podzols with Iron Pan*

Peaty podzols with iron pan are usually the soils on the upper hill slopes, but they do occur at low altitudes and south of Aberdeen local areas of these soils are now cultivated land. The mode of formation of the iron pan and the conditions under which it forms are not clear. Where there is a strong iron pan a deep humus top horizon is almost invariably present and wet heath species are often frequent in the vegetation. On the other hand, iron pans do occur in soils where the upper humus horizon is similar to that of a freely drained iron podzol and no wet indicator species are present. In such cases it may be that the conditions for iron pan formation perhaps no longer exist or that the iron pan is at an early stage of development.

Heath vegetation on the well-developed peaty podzols with iron pan is similar to that on the imperfectly drained iron podzols with sometimes a greater abundance of wet heath species.

## GLEYS

### (*i*) *Non-calcareous Gleys*

The main area of non-calcareous gleys is poorly drained and has been mapped as such but, locally, very poorly drained soils do occur. The vegetation of the very poorly drained sites differs from that of the poorly drained in the greater proportion of marsh species; the soil water regime is inimical to trees other than the species *Alnus glutinosa* and *Betula pubescens*.

Woodland on the poorly drained soils is secondary birchwood, in which *Betula pubescens* is the dominant and *B. verrucosa* of minor occurrence, alderwood and mixed policies woodland. In the birchwood *Alnus glutinosa* is occasional and repeated felling has probably brought about the replacement of alder as the dominant by the birch. Alderwood, especially the narrow strip of woodland along water courses, has arisen from natural regeneration of alder, but it has also been planted, either as shelterbelt or as part of policies woodland. The mixed policies woodland often has *Ulmus glabra* as the dominant—undoubtedly planted, yet this species was an important constituent in the natural woodland on these soils. Other frequent species in these woods are *Fraxinus excelsior*, *Acer pseudoplatanus* and *Fagus sylvatica*. Drainage has been artificially improved to enable some of these species, and others, such as *Tilia vulgaris*, *Quercus* spp. and *Aesculus hippocastanum*, to grow vigorously.

Shrubs present in some of the birchwoods are *Salix atrocinerea*, *S. caprea* and *S. aurita* and, in the policies woodland, the exotic species *Rhododendron ponticum* and *Sambucus racemosa*.

The field layer is often dominated by the grass *Deschampsia caespitosa* or the two species of *Holcus*, *H. mollis* and *H. lanatus*. Species indicating wet conditions, *Cirsium palustre*, *Juncus effusus*, *J. conglomeratus*, *Stellaria alsine* and *Epilobium obscurum*, are fairly common and a considerable number of species indicate a moist not highly acid soil. These species include *Ranunculus repens*, *Poa trivialis* and *Ajuga reptans*. There are also present indicators of a moderately high base status, such as *Circaea lutetiana*, *Geum urbanum* and *Fragaria vesca*. The most abundant bryophytes are *Eurhynchium praelongum* and *Thuidium tamariscinum*.

Drainage of old pasture land had previously been improved but is often deteriorating through neglect. *Agrostis tenuis* and *Festuca rubra* are the dominants of the better quality pasture, with abundant *Trifolium repens* and *Holcus lanatus*. *Plantago lanceolata*, *Cynosurus cristatus* and *Achillea millefolium* are often frequent, but with invasion and dominance of the pasture by *Juncus effusus*, *Trifolium repens* becomes less abundant and *Plantago lanceolata* and *Achillea millefolium* are absent.

The more natural community which has been established by the removal of trees and maintained by grazing is often dominated by *Juncus acutiflorus*. Abundant associated grasses are *Holcus lanatus*, *Festuca rubra*, *Poa trivialis*, *Deschampsia caespitosa*, *Anthoxanthum odoratum*, *Agrostis canina* var. *canina* and, in some situations, *Holcus mollis*. Dicotyledonous herbs commonly associated with it are *Ranunculus acris*, *R. repens*, *Rumex acetosa*, *Galium palustre*, *Cirsium palustre* and *Trifolium repens*.

(*ii*) *Peaty Gleys*

Very poorly drained peaty gley soils are not extensive and usually occur in the vicinity of basin peat deposits. In many instances the peaty humus topsoil is the basal layer of former cut-over peat and the vegetation varies from marsh to wet-heath and acid-peat vegetation.

The communities with a marsh character are often dominated by *Juncus effusus* with abundant *Deschampsia caespitosa*. *Calluna vulgaris* and the moss *Polytrichum commune* are locally abundant, indicating the transitional nature of the vegetation between marsh vegetation and wet heath. In other localities the wet heath or acid basin peat element is the stronger and *Erica tetralix*, *Eriophorum angustifolium*, *Calluna vulgaris* and *Deschampsia flexuosa* are abundant while *Juncus effusus* may still be prominent.

A second series of communities occurs on poorly drained soils which are associated with the non-calcareous gleys but which differ from them in the deep acid raw humus layer. These soils are included with the non-calcareous gleys with mineral topsoils because of their small area and the broad transitions between this type of gley and the non-calcareous gley.

Birchwood occurs on these soils and, with the cutting of surface drains, Scots pine and spruce plantations are established. Where the canopy is open the ground vegetation is wet heath and *Polytrichum commune* is abundant. Under heavier canopy *Polytrichum commune* is often the dominant species and forms a dense hummocky community with other bryophytes, such as *Rhytidiadelphus triquetrus* and species of *Sphagnum*.

When trees are absent the vegetation is a wet heath dominated by *Calluna vulgaris* and *Erica tetralix*, *Trichophorum caespitosum* and *Juncus squarrosus* are conspicuous. *Sphagnum compactum*, *S. girgensohnii* and *S. plumulosum* are locally abundant along with *Polytrichum commune* and the more widespread hypnaceous heath bryophytes.

On poorly drained soils derived from serpentine wet heath has frequent to locally abundant *Festuca rubra*, *Deschampsia caespitosa* and *Molinia caerulea*, a vegetation similar to that on other soils transitional between non-calcareous and peaty gleys.

# CHAPTER X

# Agriculture

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## HISTORICAL

ABERDEENSHIRE today is widely known for its quality beef cattle, its high output of oats and its heavy poultry population. What many people not too familiar with the north-east perhaps fail to appreciate, however, is that its fame as an agricultural county lies not in the quality of its soil but in the almost unbelievable improvement of land and livestock brought about by the Herculean efforts of its farmers during the 18th and 19th centuries. In few other areas in Britain can the initiative of early improvers and the results of sheer physical endeavour be more clearly demonstrated.

Livestock in general, and cattle in particular, take pride of place in the annals of this large county. Not content with the improvement of the small indigenous black polled cattle, Aberdeenshire, and its neighbouring counties of Banff and Kincardine, were responsible for the founding of the Aberdeen–Angus breed and for development of the Beef Shorthorn. To McCombie of Tillyfour and MacPherson Grant of Ballindalloch on the one hand, and Amos Cruickshank of Sittyton and Duthie of Collynie on the other, will always go the main credit for the development of these two world-famous breeds.

A less glamorous task, but of fundamentally greater importance, was the improvement of soil and the production of crops. Much of the land was wet and boggy, peaty in character or rocky and generally of a low productive potential. Ample evidence of the creation of arable land out of rock and peat is apparent from the number of accommodation or "consumption" dykes to be seen in Skene and other districts throughout Aberdeenshire. Early land improvement in the late 18th century can be attributed mainly to landlords of that time who had studied developments further south and were determined to achieve equal success. As in the case of livestock improvement certain names, such as Silver of Netherley, Barclay of Ury and Grant of Monymusk, will be remembered as the great pioneers of land improvement in the north-east. In more recent times, tribute must be paid to the treatment of clay soils by Cruickshank of Cruden Bay, the teachings of W. M. Findlay of Craibstone in the use of wild white clover and the value, as a cash crop, of seed potatoes, and the improvement in method and practice throughout the area as a result of the pioneering and progressive efforts of well-known Aberdeenshire farming families acknowledged.

## CLIMATE

In conjunction with soil variations, topography and elevation, climatic conditions obviously can exert a considerable influence on agricultural practice and on systems of farming.

Whilst the Aberdeenshire climate may not be deemed the most delectable, it is sufficiently suitable to justify fairly extensive arable, as well as livestock, farming in many parts of the county.

As a whole, the county has a moderately low rainfall averaging between 30 inches and 35 inches per annum. The narrow coastal strip between Peterhead and Fraserburgh has, in an average year, only some 25 inches, the area between Inverurie and Echt 28 inches, the Insch valley and the Alford and Tarland basins 30 inches, with over 35 inches on the upland areas in the west and south-west of the county. Of even greater importance to agriculture is the rainfall distribution. Long-term records show that April and June, followed by January, February, May and September, are the driest months of the year. Thus, while spring work is not normally affected by long periods of adverse weather, lack of rain may occur in May and June, while the hay, grain and potato harvests run the risk of delay and spoilage due to rain.

Similarly, June is normally the sunniest month but periods of dull weather during July and August are common. Temperature varies by some 20°F from a winter average of 35°F–38°F to a mid-summer average of 57°F. Of considerable significance is the fact that due to the prevalence of cold south and south-easterly winds and the flat, treeless coastal area—particularly in the north-east—most springs tend to be cold and commencement of growth is late. The growing season varies between districts and according to elevation, but it is estimated at 241 days in Buchan, 222 at Craibstone (300 feet) and 207 at Logie Coldstone (600 feet).

The haar coming in from the North Sea—and most prevalent in the spring and summer months—inhibits drying of crops and causes delay in the daily harvesting operations on farms near the coast. Most of the county experiences reasonably open winter weather with frost and some snow but more severe weather is sustained in the west and south-west areas where the night temperature during the winter months may rarely exceed freezing point and where ploughing can be seriously delayed for long periods by the soil remaining frozen for the greater part of the day.

## LAND TENURE

A feature of Aberdeenshire is the number of large estates. In the past, large tracts of land were granted for services rendered to the Crown, while the occupation of Balmoral Estate in 1840 by Royalty no doubt influenced industrialists to acquire landed properties in the county. In Scotland during the past 20 years few landlords have been able, through increased taxation and death duties, to exist solely on the revenue obtained from rented farms and have had either to take up farming on their own account or sell part or whole of the estate.

Official sources reveal that whereas in 1939 the percentage of rented farms was 68%, by 1959 the figure had dropped to 45%. While this may be taken as a fairly general occurrence throughout the county, the rate of change has been by no means uniform. For instance, and typical of many north-eastern and east-central parishes, the percentage of owner-occupied farms in Aberdour and Pitsligo has increased over the 20-year period from 26 and 42 to 90 and 86 respectively. On the other hand there has been practically no change in status of farms in the south-western parishes of Glenbuchat, Strathdon, Crathie and Braemar, Glenmuick, Aboyne and Birse, in which the large percentage are rented.

Many sitting tenants have been offered, and have accepted, the opportunity of buying their farms. On rented farms much of the renovation and modernisation of farm steadings has been undertaken by the tenant, with the permission of the landlord. Thus, during the period since the Second World War—with agriculture enjoying a fair measure of prosperity—extensive improvements to farm property have been achieved, mainly by the owner-occupier and the more progressive tenant farmer.

Under the Agriculture (Scotland) Act, 1947, tenant farmers were granted a security of tenure which could be revoked only on the grounds of bad husbandry. In the Agriculture Act, 1958, the tenure clause was amended to the extent that a landlord now had the opportunity of refusing to accept, at the expiry of a lease, the heir-at-law on the decease of a tenant. Since it is the exception rather than the rule not to have close and long-standing landlord-tenant relationships, most landlords will rarely consider exercising this privilege.

Leases have tended to become of shorter duration, the common length of lease nowadays being either 14 years with a mutual break at 7 years, or 10 years with a break at 5 years. Whilst Martinmas is the common date of entry to farms further south, Whitsunday is the normal date in Aberdeenshire. Within the past five years there has been a general revision of farm rentals. In many cases, rents of long standing have been increased by 100% and today average rents in the county vary from £2 to £4 per acre of arable land. Since the war the value of land has increased considerably and today a purchase price ranging from £80 to £110 per acre may be regarded as normal for a low-ground arable farm. While the price for less desirable holdings may be considerably less, there is comparatively little difference nowadays in prices paid for upland holdings in receipt of Hill Cattle Subsidy or, to a lesser extent, in receipt of Marginal Agricultural Production assistance. During 1961 the rating system applied to agricultural holdings has been radically altered. In the past, farm rates were based on an eighth of the rateable value of the land; henceforth, the rating will be assessed on the full rateable value of the houses and buildings on the farm.

## FARM SIZE AND SOIL ASSOCIATION

Aberdeenshire, with some 614,178 acres of arable land and 390,000 acres of rough grazings, is not only one of the largest counties in Scotland but, with over 8000 farms, is also one of the more populous agricultural areas.

Official agricultural statistics for 1959 also reveal that the average size of holding in the county consists of 76·5 acres arable and 48·5 acres rough grazing. A truer picture is obtained, however, if the seven south-western parishes embracing the upper reaches of the Don and the Dee and the forests of Balmoral and Birse—an area of large estates and deer forests—are discounted. Within the remaining 76 parishes of Aberdeenshire, the average size of farm is composed of 77·5 acres arable and only 11·7 acres rough grazing.

Aberdeenshire is typified, therefore, by its large number of small family farms of between 50 and 80 acres arable land and with a relatively small acreage of permanent pasture and rough grazing. Such farms are essentially responsible for the intensive rearing of beef cattle and the large poultry population in the county. As one might expect, the smaller arable farms are to be found mainly in the south and south-western parishes, including Crathie and Braemar, Kemnay, Newhills, and Lumphanan in which the average acreage of arable land varies from 38 to 55 acres. The larger farms on which fattening—in some cases as well as rearing—is practised are to be found generally on the better land. Parishes with the largest average arable acreage per farm include Gartly, Bourtie, Logie–Buchan, St. Fergus and Foveran, the acreage in these cases varying from 120 to 132 arable acres.

Whilst there are many individual and parochial instances of land improvement, it is of considerable interest to observe that the larger farms on the better land are generally found on soils of superior inherent fertility belonging to the Insch, Tarves, Strichen, Ordley and, to a lesser extent, the Foudland Associations, and on the clayey soils of the Peterhead and Tipperty Associations. On the other hand many of the smaller and inherently poorer farms lie on the Countesswells, Skelmuir, Durnhill and Corby Associations, soils characterised in many instances by stony, coarse textured and strongly acidic parent materials.

## SOIL FERTILITY

The parent material from which a large number of the soils in Aberdeenshire is derived cannot be regarded as having a high productive capacity. At the same time, the yield of crops and livestock products today compares very favourably, in terms of output per acre, with those of other counties in Great Britain. It can be concluded, therefore, that the high state of fertility to be found throughout Aberdeenshire is attributable essentially to the industry and husbandry of the Aberdeenshire farmer, who for centuries has sought to create favourable cropping conditions from considerable areas of poorly drained, shallow, stony soils.

It must be recorded, too, that a number of Government-aided schemes have contributed a great deal towards the over-all improvement in soil fertility. In this connection, the Agricultural Lime Subsidy Scheme, introduced in Scotland in 1936, the Grassland Ploughing Subsidy Scheme (1938) and the Marginal Agricultural Production Scheme (1943) are worthy of particular mention. Liming, for example, has now become routine practice and, as a consequence, marked improvement in yields of barley and grass have been obtained. Using the newer, high-yielding varieties of barley, which are highly susceptible to lime deficiency, yields of barley now frequently exceed those of oats by 2–3 cwt. per acre—in a county famed for the yield and quality of its oats. Improvement in the productiveness of rotation grass is exemplified by the fact that, in the 1930's, it was common practice to feed a supplement to fattening cattle on grass whereas recent investigations have indicated that no increase in liveweight or improvement in condition is obtained from this practice.

With regard to land reclamation and the ploughing up of old permanent pasture, the achievements throughout Aberdeenshire are striking. A flight by aeroplane over the county will reveal that the plough has been taken to the top of all but the higher hills. Statistics, too, substantiate such visual observations, since Aberdeenshire, with only 37% of its land under rough grazings—including large tracts of hill in the Crathie and Braemar districts—has a higher percentage of arable land than any other county in the north of Scotland. This fact, perhaps more than any other, characterises the north-east farmer and his determination to improve his lot and his holding.

Largely from the influence of the Marginal Agricultural Production Scheme, soil fertility in upland areas has markedly improved in recent years. Crop production and stock-carrying capacity in such areas have both increased to the extent that there is now comparatively little difference in output per acre compared with low-ground farms.

While the lime status of most farms throughout Aberdeenshire has been raised to a satisfactory level, it is true to say that an increased use of fertilisers has produced in many cases an increase in crop yield. Most farmers recognise the need for adequate phosphate and, in fact, commonly apply additional phosphate in the form of basic slag or ground mineral phosphate to the sow-out shift or to young grass. Potash deficiency, although induced to some extent by insufficient supplies during the last war, is comparatively unimportant. With the improvement in the standing properties and the grain potential of the more recently introduced cereal varieties, the use of additional nitrogen can be justified economically without adversely affecting harvesting operations. Similarly, on soils with optimum supplies of lime and phosphate, a greater use of nitrogen would no doubt prove beneficial on grass for both cutting and grazing. Results from a recent survey of fertiliser usage tend to bear out these contentions. Whilst the average annual rate per acre of application of phosphates in four districts of Aberdeenshire was 0·78 cwts. $P_2O_5$ compared with a United Kingdom figure of 0·44 cwts. $P_2O_5$, the average rate per acre of application of nitrogen was only 0·29 cwts. N against 0·33 cwts. N for the United Kingdom; the more northerly latitude and higher rainfall must of course be borne in mind in relation to nitrogen requirement. Concurrent with the increased use of lime and fertilisers, certain trace element troubles affecting crops and livestock have arisen. In the majority of cases, however, the addition of the requisite element in appropriate quantities, whether to the soil, in the feed, or by dosing, has restored the balance.

With the high stock-carry which is a feature of Aberdeenshire farms, and the increased use of fertilisers, there is little doubt that soil fertility will continue to improve. Present-day yields of crops range from 24–32 cwts. per acre of oats, 24–38 cwts. barley, 22–36 cwts. wheat and 7–11 tons of potatoes, while rotation pastures carry ¾–1¼ adult cattle per acre and yield 2–2½ tons hay or 6–8 tons silage. The upper limits of the range may be taken as above average yields on the better low-ground farms and the lower limits as average yields on the less fertile upland farms.

## SYSTEMS OF FARMING

The six-course rotation—oats, roots including potatoes, oats and three years in grass—is traditional in Aberdeenshire. Such a rotation, with its flexibility, has enabled farmers to weather successfully periods of depression through the years. Variations, such as the "easy" seven-course, with 4 years grass or the "hard" seven-course, with a yaval cereal crop, are fairly common in upland and low-ground areas respectively. Financial returns have caused a marked change in the choice of cereal on many farms. The oat crop—the traditional cereal of the north-east—has fallen from grace in recent years mainly because of a diminishing demand and consequent reduction in price. In its place the acreage of wheat has risen markedly, while the popularity of barley is such that on some farms no oats are now grown. Despite such changes, oats are still the most widely grown cereal, particularly on the beef-fattening farms growing a large acreage of turnips. Seed potatoes represent the chief cash crop on many low-ground farms, though it is of interest to record that last year peas for canning were grown on a number of Buchan farms for the first time. Some carrot and other vegetable crops are grown in small amounts as cash crops. With two enterprising firms engaged in food processing, at Peterhead and Fraserburgh, it is conceivable that the acreage of such crops may be extended in the future.

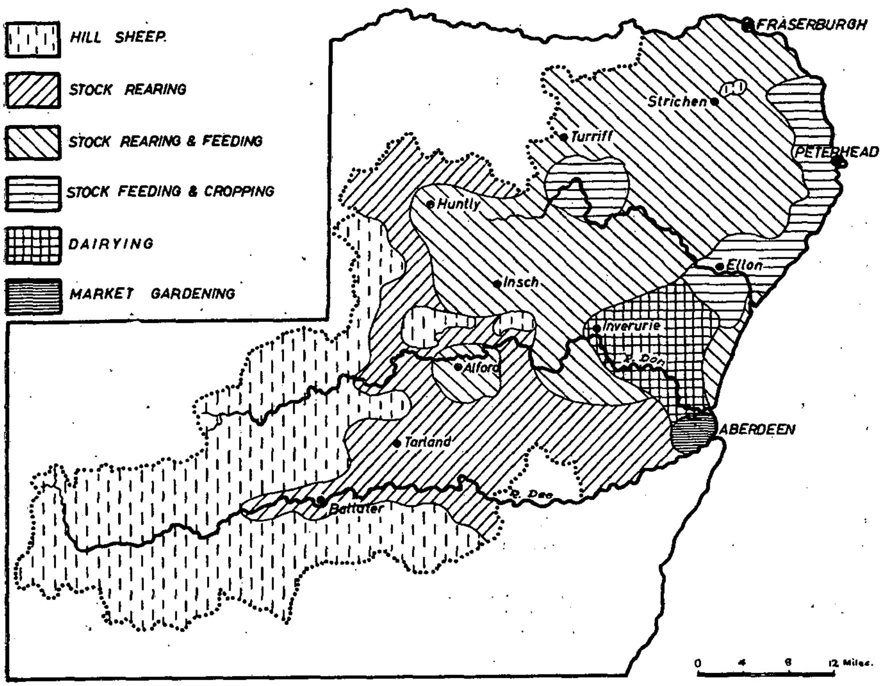


FIGURE 23. Systems of Farming in Aberdeenshire.

Turnips for both cattle and sheep feeding are still widely grown. Whilst this crop has been replaced in varying degree by grass silage—for cattle particularly—the high food value per acre obtainable from a good crop of turnips is still of considerable moment, especially on the smaller family farm where the high labour cost of the crop is of less importance. Recent mechanical advances in the sowing and harvesting of the crop have materially arrested the reduction in acreage of turnips.

Grass, however, is the crop which has received most attention over the past 10–15 years. The fact that it has now achieved the status of a "crop" in the minds of farmers and others, bears testimony to the importance with which it is regarded. By a higher degree of management a longer grazing season has been obtained and greater productivity secured, and silage-making has meant the production of a cheaply-made, high-quality, winter feed, together with improved grazing over the farm throughout the season. While silage has completely replaced turnips on only a few of the larger dairy farms, many farmers today feed a proportion of both turnips and silage. No material change in the rotation of crops has therefore been effected, the only adjustment being in the root shift where, in addition to the normal acreage of potatoes grown for seed, part of the turnip acreage is replaced by a one-year silage mixture from which two cuts per year are taken in conjunction with grass from the normal rotation pastures.

The Aberdeenshire farmers' forte, however, is livestock—in particular the breeding, rearing and fattening of beef cattle. Breeding and rearing are essentially carried out on the smaller family farms throughout the county and in the upland districts of Deeside, Donside and Huntly, while typical feeding farms stretch from Alford and Insch to Turriff and Buchan. The introduction of the Hill Cattle Subsidy Scheme has, over recent years, effected a fairly sharp increase in the number of breeding cows. At the same time, the high price of weaned calves and the success of artificial rearing has increased the popularity of rearing young calves, though the supply of good quality calves is becoming more and more difficult.

Not only does Aberdeenshire have a reputation for commercial beef production, but the fame and show successes of its long-established herds of pedigree Shorthorn and Aberdeen-Angus cattle stand as high as ever. Pedigree beef farms, while found throughout the county, predominate in the Alford-Upper Donside area, with the Aberdeen-Angus the most popular breed.

Since the establishment of the Aberdeen and District Milk Marketing Board in 1934 dairy farming has increased, notably in the Aberdeen, Inverurie and Udny areas. Replacing the flying-stock herds of Irish cows and materially assisting in the establishment of tubercle free herds, the Ayrshire breed has for long been the popular dairy breed. In recent years, however, with the desire to obtain a more suitable bullock for fattening, many Friesian herds have made their appearance.

While sheep in the past have always been an integral—though less important—part of Aberdeenshire farming, numbers have risen in recent years, partly through a temporary lack of confidence in beef production and partly because of improved prices for lamb and mutton. In the hill and upland districts of West Aberdeenshire Blackface flocks are carried. Greyface ewe hoggs from the Huntly district and Half-breds from the Inverurie, Turriff and Buchan areas are today in demand as breeding stock by south buyers, while large numbers of lambs are bought at the autumn sales and fattened on turnips. The number of Cheviot and Half-bred flocks, crossed respectively with Border Leicester and Suffolk tups for fat lamb production, has also increased, while well-known pedigree flocks of North Country Cheviots and Border Leicesters have been established throughout the county.

Around an enterprising bacon factory at Dyce a considerable pig population has grown since the war. Pigs are produced predominantly from a large number of farms carrying moderate numbers; there are comparatively few large-scale enterprises. On many farms, and particularly the smaller ones, pigs have proved a profitable side-line in the post-war period. As might be expected from an area which specialises in livestock, herds of pedigree pigs of both the Large White and Landrace breeds have established reputations as herds from which first-quality stock can be obtained.

The most important side-line, however, on practically every farm in Aberdeenshire, is poultry. Despite a heavy stock-carry of other livestock

*(By courtesy of the Forestry Commission)*

PLATE 54
30-year-old larch on Raemoir series, brown forest soils.

PLATE 52
Boulders turned up by the plough in soil of the Countesswells Association.

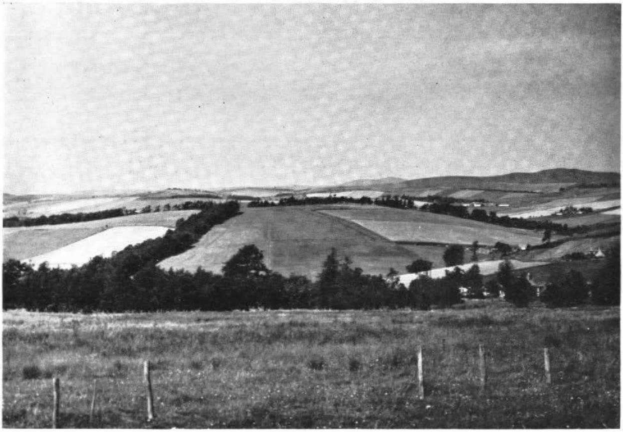

PLATE 53
Shelterbelts near Echt in the Skene Lowlands.

[*Facing page* 228]

room is always found for 200–300 head of poultry. In 1958, numbers of poultry and turkeys in Aberdeenshire were, respectively 2,384,000 and 33,000, representing in each case 25% of total numbers in Scotland. On cattle-rearing or feeding-farms the receipt of the weekly egg money—small though the amount may be—serves effectively to bridge the lengthier periods between cheques for sales of cattle. Broiler groups—and currently rabbit-meat groups—are being formed within the county, but, given the service of regular egg collection and cash payment by return, the majority of the family farms of Aberdeenshire will continue without doubt to maintain their moderate-sized poultry units.

## LABOUR AND MACHINERY

Much of the success attained by Aberdeenshire farmers in both land improvement and quality of livestock can be attributed to the skill and diligence of farm workers. With the considerably increased value of livestock and the high cost of purchase and maintenance of agricultural machinery, farm staff carry a heavy responsibility. In this connection it is worthwhile to record the interest and desire to acquire knowledge of their job shown by the attendance of agricultural workers at classes conducted by the North of Scotland College of Agriculture.

A further point of note is that farm workers are today staying for considerably longer periods with one employer. Undoubtedly the reasons for this change are firstly, that cottar houses on most farms—even in moderately remote areas—have been modernised and equipped with all public services and, secondly, that the wages of farm staff have improved markedly. Including the value of perquisites, most wages paid today exceed the statutory minimum agricultural rates. Whereas shepherds, grieves and tractormen were paid a minimum of 35s. 6d. for a normal 50-hour working week in 1939, the present rates for the above categories are 188s. 9d., 184s. 9d. and 182s. 9d. respectively for a 45-hour week and with increased holidays with pay. Fewer perquisites are now being supplied, especially in the case of coal and milk. "Bothying" of single men has largely disappeared, although a few large farms provide hostels.

As in other counties, the number of agricultural workers is showing a steady decline. For example, in Aberdeenshire, the decline in numbers from 1939 to 1958 represents a reduction of approximately 20% to just over 10,000. The fact, however, that the overall production of farm produce has, over the same period, shown an increase, reveals that increased use and improvement of agricultural machinery has fully compensated for the fall in the supply of labour.

Many improvements in farm machinery have taken place during the past 20 years. The pneumatic lift on tractors, the mechanical dung loader, the combine seed and fertiliser drill, the automatic hammer-mill, the combine harvester, grain- and hay-drying systems and, most recently, the forage harvester, are among the more important innovations during this period. Not only has such machinery served to reduce considerably costs of production on the larger farms, it has also removed much of the drudgery on the smaller, family farms. With the extensive development of rural electrification throughout the county in the past 10 years mechanisation of many indoor steading operations has been effected, while the use of heat lamps for stock, such as pigs and poultry, and the adequate lighting of farm buildings have been of considerable benefit. While water for cattle can be scarce in some areas during dry summers, mains water supplies are being extended and it is of interest to record that some farmers are installing field irrigation systems for both water and liquid manure.

AGRICULTURAL STATISTICS FOR ABERDEENSHIRE

(D.O.A.F.S. Census, June, 1958)

| | | |
|---|---|---|
| *Crops* | | |
| Acreage of Oats | 166,895 | |
| " " Barley | 27,528 | |
| " " Wheat | 8,183 | |
| " " Potatoes | 11,341 | |
| " " Turnips | 60,030 | |
| " " All Crops | | 277,675 |
| " " Rotational Grass | | 312,749 |
| " " Permanent Grass | | 23,887 |
| " " Total Crops and Grass | | 614,311 |
| " " Rough Grazings | | *390,000 |
| *Livestock* | | |
| Total Cattle | | 256,357 |
| Breeding Cows and Heifers (Beef and Dairy) | 56,704 | |
| Total Sheep | | 407,146 |
| Breeding Ewes | 143,317 | |
| Total Pigs | | 82,993 |
| Breeding Sows and Gilts | 8,856 | |
| Total Poultry | | 2,441,029 |
| Hens | 1,188,186 | |
| Horses (working) | | 876 |
| *Agricultural Workers* | | |
| Male | 9,204 | |
| Female | 1,126 | |
| Total Regular Workers | | 10,330 |

* Including deer forests.

FARM BUILDINGS, FENCING AND DRAINAGE

Well-built but out-moded farm buildings, together with the inability of many landlords to meet the cost of extensive renovation, have materially retarded the efficiency obtainable from the remarkable development in farm machinery. Reduction in costs of production as a result of labour-saving devices in the feeding and housing of cattle and the handling of produce within the farm steading have also been largely nullified.

However, with the reasonably prosperous period during, and subsequent to, the Second World War and the introduction of the Farm Buildings Improvement Scheme in 1957, steady, if not spectacular improvements have been made. Present-day farm buildings—as occasioned by the fluctuating demands of the industry—require a high degree of flexibility and adaptability which, unless careful planning is exercised, is not always obtained.

In a county in which fattening cattle have been traditionally tied up in byres, change to courts or loose housing has naturally been slow. Because of the saving in labour, however, most farmers are changing over whenever circumstances permit. Of current interest is the use of slatted flooring for all types of stock, including cattle. By this system a higher stock holding capacity per unit of area together with a 100% saving in straw for bedding is secured. In the case of pigs and poultry, housing has made tremendous advances, particularly in relation to insulation and ventilation. For storage of fodder, the Dutch barn type of building has been widely adopted.

Consistent with increased values of livestock, fencing of farm lands has also improved. The character of the fencing has, perhaps unhappily, radically altered. Disappearing fast are the sheltering stone dykes and the picturesque hawthorn hedges, to be replaced by commonplace but effective post-and-wire fencing. Allied to fencing is the question of shelterbelts. Whilst the benefits from such shelter are admitted, farmers are reluctant, possibly by nature, to plant trees, with the result that much of the north-east corner of Aberdeenshire remains bare, with few wind breaks.

In land drainage, too, considerable advances have been made. Deep drainage systems on a field scale have proved beneficial where conditions permitted while, with a great advance in the design and capability of mechanical diggers, many low-lying pockets of wet land have been eliminated and small-gradient water-courses improved. On the hill, the introduction of a caterpillar-drawn drainage plough has proved of enormous benefit in draining unproductive, unhealthy and dangerous boggy areas.

# CHAPTER XI

# Forestry

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*Forestry Commission* (*Scotland*)

AT the present time about 6% of the area covered by Sheets 76, 77, 87 and 97 is under productive woodland, virtually all of which has been planted. The examination of fossil plant remains, archaeological relics and historical accounts has revealed, however, that from post-glacial times until a few centuries ago, a very much greater proportion of the region under review carried extensive forests. In general terms, broadleaved species such as oak, elm, alder, birch, and hazel were most widespread, but Scots pine also occurred locally on the more freely drained iron podzols and peaty podzols and particularly so inland.

The decline in the area of woodland in this region and in the status of some of its constituents since about 2000 B.C. has for long been ascribed to the impact of man, but it is now known that changes in climate have also played an important part. Thus, the Sub-Atlantic period, which has lasted from about 500 B.C. until the present day and is typified by an oceanic climate with high humidities and low summer temperatures, has been accompanied by an increase in the area of bog and marshland and a general deterioration in the fertility of the soil: this, in turn, has led to a reduction in the area under trees and changes in the representative species. Nevertheless, the importance of the influence of man should not be underestimated. From Neolithic until quite recent times vast tracts of woodland were cleared to make way for the cultivation of food and fodder crops and the grazing of domestic animals. Further calls were made upon the natural forest for timber for building and wood for fuel and, over and above the destruction that all these activities entailed, large areas of woodland were set on fire to drive out game and predatory animals and in the incessant warring of the clans.

The cumulative effect of these destructive processes was such that by the 17th century, according to the chroniclers of that period, the lowland parts of Scotland were virtually bereft of trees and the only areas of extensive woodland which had survived were locked up in the remoter glens. Scotland's growing dependency upon other countries for timber had not escaped the notice of her legislators and various Acts aimed at protecting or even expanding her dwindling woodland area were passed by the Scottish Parliaments from time to time. Nevertheless, despite the severe penalties which these Acts provided for against "them that be night stealis greene woodde, or pealis the bark off trees", they did little to check the process of denudation.

It was left to some of the landowners of the 18th century, a time o enthusiastic improvers, to take the first active steps to re-forest this north-east corner of Scotland. Notable amongst these "Planting Lairds", as they came to be known, was Sir Alexander Grant of Monymusk who is said to have planted 50,000,000 trees during his long life. Some of the trees he caused to be planted are still growing in Paradise Wood on the banks of the River Don. One of the reasons for this upsurge in tree planting lay in the return from exile of many Scottish lairds. They brought with them from the continent new ideas on forestry and species of conifers such as European silver fir, European larch and Norway spruce which were not indigenous to this country. The last two species, together with the native Scots pine, were to form the backbone of the new plantations. By and large, at this time only the more favourable sites were tackled. Thus the parklands and policy woods, which tended to be on brown forest soils, were planted with broad-leaved species (prominent amongst these, beech, oak, lime and sycamore), often with a sprinkling of European silver fir, European larch and Norway spruce, and the lower hill sides, whose soils were generally moderately podzolised but freely drained, were planted with Scots pine, European larch and Norway spruce, frequently in intimate mixture.

As a result of the efforts of a few, the formation of woods, if not their systematic management, became fashionable amongst all sorts and conditions of landowners. Extensive areas had been planted by the middle of the 19th century when the introduction of hitherto unknown conifer species from north-west America by great Scottish explorers and plant collectors, such as Douglas and Menzies, gave a fresh impetus to the work. Principal among these species were Douglas fir, Sitka (or Menzies) spruce, Western hemlock, Western red cedar and various silver firs, many of which still figure prominently in the woodlands of this region. The knowledge gained on the behaviour and correct culture of these species was to prove invaluable when the time came to repair the ravages wrought by the massive clear fellings of the two World Wars.

The Great War of 1914–18 brought great destruction to the woodlands of this region in common with the rest of the country. During this period approximately 30% of the total woodland area of this part of north-east Scotland was felled and a much higher proportion of the most productive stands. As has been noted, the fact that the timber was there to cut at all was almost entirely due to the enterprise of the "Planting Lairds", and it soon became evident that with the changing economic and social structure the rehabilitation of the devasted woodlands and the afforestation of additional land to lay down a strategic reserve of timber against possible future emergencies could not be left again to private enterprise alone. It was for that reason that the Forestry Commission was brought into being in 1919 with funds and powers to survey, acquire and plant land, to undertake forest research and to advise and assist with grants private landowners in the replanting of felled woodland and the afforestation of bare ground. Subsequent large-scale destruction of an already inadequate reserve of timber due to demands of the Second World War and the great gale of 31st January, 1953, further underlined the need for a State Forest Service, by that time firmly established.

It is estimated that today there are approximately 60,000 acres in the region under review which may be classed as woodland. Of this area just over 60% is productive, the remainder being felled woodland and bare ground which it is intended to plant within the near future. Classified by type of ownership, private woodlands account for approximately 60% of the total woodland area and 80% of the area scheduled for replanting. From this it will be seen that planting on privately owned land will be largely confined to traditional techniques and species and it will be left to the Forestry Commission to tackle the more difficult ground and employ new methods of ground preparation and species which have not been extensively used until comparatively recent times.

While there are no really large private woodland estates in this region, the average size of private woodlands which are under systematic management is roughly some 600 acres. Most of these are run efficiently and it would not be appropriate to single out any for especial mention. Under the Forestry Commission there are nine State forests. The largest of these are Pitfichie, Bennachie, Forest of Deer and Kirkhill, with 5247 acres, 3875 acres, 3473 acres and 2834 acres respectively, already under plantations.

Whilst climatic factors such as rainfall and humidity, temperature (ranges and seasonal means), exposure (particularly to sea winds), etc. play as important a part as the nature of the soil in dictating the type of species to plant or whether, in fact, any tree species should be planted at all, it is true to say that within any one climatic region the soil type is the chief determining factor. Within the region under review there are virtually no soils of adequate depth (more than 10 inches) which are, *per se*, too inimical to tree growth to be made capable of growing adequate timber crops by intensive preparation of the site. The expense of the work entailed may, of course, rule out such operations in many cases.

Of the soils which occur in this part of Scotland the freely drained brown forest soils are those most sought after by the forester. They are also the most difficult to come by since the agriculturists are equally aware of their value. Such soils require little or no preparation and will grow almost any tree species, both broadleaved and coniferous, which are climatically at home. The imperfectly drained brown forest soils, although intrinsically as fertile, require to be drained to a greater or less degree. On extensive sites this work is now carried out by large hill-drainage ploughs drawn by crawler tractors. Where the soil is likely to retain its moisture, such as in water-receiving areas, Norway and Sitka spruces are commonly planted on the upturned turves.

The next most valuable soils for forestry are the freely drained iron podzols. These, again, may frequently be planted without any preparation and the chief species used are Scots pine and the three larches, European, Japanese and hybrid. Douglas fir and species of silver fir may also be planted in sheltered sites and a small measure of Sitka spruce on moister areas and near to the coast.

The imperfectly drained iron podzols are much more difficult to afforest successfully. They call for intensive preparation and the use of less exacting species. Nowadays such soils are ploughed with specially constructed hill ploughing tackle giving furrows 14 inches wide, 6 to 8 inches deep and with a sub-soiler penetrating to 18 inches depth in the bottom of the furrow. The furrows are 5 feet to 5 feet 6 inches apart and the trees are planted either on the upturned turves or in the bottom of the trench, depending on the wetness of the site. Where planted in the bottom of the furrow the trees often tend to develop a unilateral root system and recent investigations indicate that ploughing at 5 feet spacing may prove inadequate. It has, for this reason, been suggested that better balanced and more stable trees will be obtained if such soils are completely ploughed with a sub-soiler and this matter is now receiving consideration. The species planted on soils of this type are frequently intended as pioneer or nurse crops and Japanese and hybrid larch and contorta pine have been largely used for this purpose. Sitka spruce has been extensively planted in admixture with these and locally this species and Scots pine have been planted pure. The application of ground mineral phosphate to the planting stations at the time of planting is standard practice on the poorer sites and with the more exacting species.

The peaty podzols, gleys and peaty gleys all call for drainage to a greater or less extent before they can be planted. In the wetter areas up to 120 chains of drains per acre may be required. Modern hill-drainage ploughs drawn by crawler tractors are now invariably used for this work. Planting is also invariably carried out on the upturned turves and manuring with ground mineral phosphate is a *sine qua non*. Species used are Norway and Sitka spruce on the richer, better drained sites, but Norway spruce alone in frost hollows. As drainage gets poorer and site quality deteriorates an increasing proportion of contorta pine is mixed throughout the spruce until on the poorest sites of all contorta pine is planted pure.

From the foregoing it will be seen that a great variety of soil types have been successfully afforested in this region. With an increasingly prosperous and vigorous agricultural industry using improved techniques to bring marginal land into full production the forester has been forced more and more on to ground which a few decades ago would have been considered unplantable. This, in turn, has led to improved techniques in soil cultivation and drainage which, coupled with the use of fertilisers and "new" coniferous species, have clothed many long standing deserts in this part of Scotland with flourishing plantations. The process is still continuing and it seems likely that few large tracts of wasteland in this region where the climatic factors are not too extreme cannot be made to grow satisfactory crops of trees. How much, in fact, of any such land which the agricultural and sporting interests are prepared to release for forestry will eventually be planted will be determined largely by considerations of expense.

The foregoing account has been written largely from the point of view of tree crops devoted to the production of timber. It should not be overlooked, however, that woodland, particularly where it is closely associated with agriculture or rural or urban communities, has other important functions to perform. Not least amongst these is the provision of shelter, the lack of which is so often a critical factor on many upland farms. In many areas the plantations which have been formed with the prime object of timber production in view furnish valuable shelter as an incidental service, but elsewhere belts of trees have been planted aimed solely at the provision of shelter. Although these belts are not such a feature of the landscape in this region as they are, for example, of the Border country, there are few north-east farmers nowadays who would agree with their old Buchan counterpart who objected to shelterbelts in that rigorous climate on the grounds that they would make his out-wintered stock too soft. Old shelterbelts, many of which have now outgrown their usefulness, and younger ones laid down under hill farming schemes, or even with the aid of Forestry Commission planting grants, occur all through the region. How to obtain the maximum shelter throughout the life of a belt and how to replace it before it becomes ineffective and still preserve the shelter during the conversion period are problems which require much further study.

The amenity which well planned and skilfully sited woodland can confer is of particular importance in the open lowlands of this area which are so devoid of trees. The parks and pleasances laid down in the 18th and 19th centuries in the policies of the big estates were planted primarily with this object in view. It is also true to say that much other planting was done in the interests of sport, to provide cover for game and to present driven birds well to the guns, any timber which might be produced being regarded as purely incidental. Nevertheless, whatever the original intention, there is little doubt that the woodlands of the region are a source of profit to many and of pleasure to all sections of the community.

*Species referred to in the Text*

| | |
|---|---|
| Alder | Alnus glutinosa *Gaert.* |
| Beech | Fagus sylvatica *L.* |
| Birch | Betula verrucosa *Ehrh.* and B. pubescens *Ehrh.* |
| Contorta pine | Pinus contorta *Dougl.* |
| Douglas fir | Pseudotsuga taxifolia *Britt.* |
| Elm | Ulmus glabra *Stokes.* |
| European larch | Larix decidua *Mill.* |
| European silver fir | Abies alba *Mill.* |
| Hazel | Corylus avellana *L.* |
| Hybrid larch | X Larix eurolepis *Henry* |
| Japanese larch | Larix leptolepis *Murray* |
| Lime | Tilia europaea *L.* |
| Norway spruce | Picea abies *Karst.* |
| Oak | Quercus petraea *Lieb.* and Q. robur *L.* |
| Sitka spruce | Pisea sitchensis *Carr* |
| Scots pine | Pinus sylvestris *L.* |
| Sycamore | Acer pseudoplatanus *L.* |
| Western American silver fir | Abies grandis *Lindl.* and A. procera *Rehd.* |
| Western hemlock | Tsuga heterophylla *Sarg.* |
| Western red cedar | Thuja plicata *D. Don* |

# CHAPTER XII

# Discussion of Analytical Data

WHEN this area was being surveyed, samples were taken of soil profiles representative of the different soil series mapped. Standard analytical determinations, which include loss on ignition, soil separates, exchangeable cations, percentage base saturation, pH, carbon, nitrogen, total and readily soluble phosphorus, have been carried out on each sample. In addition certain of the profiles, most typical of the series concerned, have been subjected to more detailed investigations by 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 analysis methods; the minerals in the fine sand fractions have been identified and their frequencies estimated by specific gravity and optical methods; and the amounts of trace elements have been determined by spectrochemical methods.

## STANDARD DATA

Standard analytical data for 199 profiles from this area are given in Appendix I, and for ease of reference in this chapter each profile has been given a number. Many of the variations in the values of the constituents result from inherent differences in the lithological composition of the parent material, but a study of each constituent frequently reveals that certain trends are common to the members of a major soil group and others to the components, especially the drainage classes, of an association. These trends are discussed below in relation to the standard determinations listed above.

### LOSS ON IGNITION

In Scotland semi-natural uncultivated soils have higher organic matter, and consequently higher loss on ignition values, than the surface horizons of the derived cultivated soils. In peaty podzols loss on ignition values are frequently 75 to 90% in the L/F horizons (profiles 106 and 108), although tramping and burning reduce the values to 10 to 30% (profiles 105, 109 and 110). Reduction in values caused by cultivation may be seen in the comparison of the iron podzol profiles Nos. 64 and 65. For the cultivated iron podzols and the brown forest soils, both freely and imperfectly drained, loss on ignition values usually decrease with depth. Cultivated surface horizons of the non-calcareous gleys tend to have lower values than the cultivated surface horizons of the iron podzols and brown forest soils. The peaty gleys have high loss on ignition values in the surface horizons and low values in the mineral horizons.

## SOIL SEPARATES

The soil separates of sand, silt and clay are determined by mechanical analysis. The size limits are those adopted by the International Scheme of Mechanical Analysis (sand 20–2000$\mu$, silt 2–20$\mu$ and clay $<2\mu$) and by the U.S.D.A. (sand 50–2000$\mu$, silt 2–50$\mu$ and clay $<2\mu$).

It is generally recognised that relationships exist between the proportions of the three soil separates and members of both associations and major soil groups. Most of the tills of Aberdeenshire are of moderately coarse to medium texture. Moderately fine and fine textures are found only in the Peterhead Association, derived from till, and in the water-sorted deposits on which are developed the Tipperty and Bogtown Associations and the Blackwater Complex. The coarse textured soils are those of fluvio-glacial origin, the Corby, Boyndie and Fraserburgh Associations. The Countesswells till is notably high in the coarse sand separate (e.g. profiles 65, 66 and 107), while the till of the Foudland Association is high in silt (e.g. profiles 75 and 78). Generally the silt size separate is lower in amount than clay in most soils, but the Tarves Association is variable in this respect. Certain soils of the Tarves series (e.g. profiles 19, 20 and 28) have lower silt than clay, while others (e.g. profiles 18 and 21) are higher in silt than clay. This variation appears to be due to a high proportion of mica-schist rocks in the till of the more silty profiles. In the brown forest soils with free drainage the commonest surface textures are loams and sandy loams but a small number of soils have a sandy clay loam texture. The majority of the B and C horizons are sandy loams, but some have textures in the sand, loamy sand and loam classes. In the imperfectly drained brown forest soils with gleyed B and C horizons, the majority of the surface horizons have a loam or clay loam texture, while the B and C horizons are mainly sandy clay loams and clays and are therefore higher in the finer fractions than the well-drained counterparts. The freely drained iron podzols are predominantly sandy loams, with a number of loamy sands and sandy clay loams: a few of the surface and $B_2$ horizons have loam textures and a few of the $B_3$ and C horizons sand textures. The iron podzols with gleyed B and C horizons have mainly sandy loam and loam textures with a few sandy clay loams and sands. The peaty podzol group is also centred around the sandy loam class as are the peaty gleys. In the non-calcareous gleys, however, the majority of the soils lie in textural classes between sandy clay loam and sandy loam, with a few soils having textures in the clay loam and clay classes. The variation in the proportions of the separates in the horizons of soils on till tends to be erratic.

## EXCHANGEABLE CATIONS

### *Exchangeable Calcium*

The values for exchangeable calcium, as has been previously observed, vary with major soil group, association and drainage class.

In the peaty podzols the values are low (i.e. $<3{\cdot}0$ m.e./100 g.) with the highest values occurring in the litter layer. Only in one profile (No. 107) does the value exceed 8. With the exception of the H horizon in profile 91, the uncultivated iron podzols also have low values. Cultivated iron podzols generally show the effect of liming, values on the surface being mostly in the medium range (3–8 m.e./100 g.) with some high ($>8$ m.e./100 g.) and some low. Values in the $B_2$, $B_3$ and C horizons, however, are nearly all low. The majority of the iron podzols (e.g. Nos. 62, 80 and 84) show a decrease in exchangeable calcium down the profile but in some (profiles 69 and 97) the minimum is reached in the $B_2$ or $B_3$ horizon. The cultivated brown forest soils and the brown forest soils with gleyed B and C horizons generally have medium to high values in the surface horizon; the majority of the $B_2$, $B_3$ and C horizons have medium values, but in both groups there is a marked tendency for the minimum value to occur in the $B_2$ or $B_3$ horizon. The values recorded for the non-calcareous gley group tend to be rather higher throughout the profile, being mainly in the medium range (3–8) for all horizons, although there are quite a number of high values in the S horizon (e.g. Nos. 114 and 153) and low in the C horizon (Nos. 123 and 165). The gleys show either a decrease down the profile (e.g. Nos. 149 and 169) or a minimum value in the $A_2g$ or $B_2g$ horizon (Nos. 117 and 160), although there are examples of an increase down the profile (No. 140) or of a maximum value in the $A_2g$ or $B_2g$ horizon (Nos. 114 and 122).

Variations also occur with the association, those from base-rich parent materials exhibiting higher values throughout the component genetic soil groups and drainage classes. Extremely high values are recorded for the Fraserburgh Association (profiles 5 and 173), the Bogtown Association (profile 114) and the Blackwater Complex (profile 193). At the opposite extreme low values are obtained for the Countesswells (profiles 4, 67 and 127), Corby (profiles 57 and 119) and Durnhill (profiles 108 and 109) Associations.

*Exchangeable Magnesium*

In the brown forest and iron podzol soils the values for exchangeable magnesium are generally considerably lower than those for exchangeable calcium. An exception is the Leslie Association, derived from serpentine, where the Mg values are 20 to 30 m.e./100 g. while those of Ca are 0·3 to 6 (e.g. profiles 16 and 17). In the iron podzol soils there is a marked tendency for the maximum values to occur in the surface horizon and for values to decrease gradually with depth. Generally the values are $<1$ throughout the profile and only in two profiles (Nos. 85 and 89) do they rise to 2 in the surface horizon. The brown forest soils show somewhat higher values, with the minimum value almost invariably in the $B_2$ horizon. The brown forest soils with gleyed B and C horizons have notably higher amounts, particularly in the slightly gleyed horizons, and the main trends are either an increase down the profile (e.g. Nos. 36 and 47) or a minimum value in the $B_2(g)$ horizon (e.g. Nos. 30 and 35). An increase in value may be noted in the C horizon of brown forest soils derived from basic-igneous parent material. Values in the peaty podzol group are generally very low, except in the top organic layer, and there does not appear to be any definite trend down the profile. In the non-calcareous gley soils the values are medium to high throughout the profiles, but exceptionally high values are found in two soils of the Leslie Association (profiles 143 and 144) where the surface horizons have values of 66 and 42 m.e./100 g. respectively. An outstanding trend in this genetic group is the increase in value with depth to a maximum in either the Bg horizon (Nos. 166 and 171) or the Cg horizon (Nos. 117 and 142). In a number of profiles in addition to the Leslie Association soils Mg values exceed those for Ca in the basal horizons (profiles 149, 169 and 171), but more commonly the values are considerably lower. The peaty gleys have low to moderate values, and the only consistent trend appears to be for the minimum value to occur beneath the peaty surface in the $A_2g$ or Bg horizon.

*Exchangeable Potassium*

The highest values for this constituent are found in the mor humus layers of the uncultivated iron podzol, peaty podzol and peaty gley profiles (Nos. 91, 113 and 180). The freely drained brown forest soils tend to have low values throughout the profile, generally with a minimum in the $B_2$ or $B_3$ horizons though a few show a decrease down the profile (e.g. Nos. 15 and 24). Values for the brown forest soils with gleyed B and C horizons are mostly in the medium range (0·1 to 1·0 m.e./100 g.), and again the majority have a minimum value in the $B_2(g)$ or $B_3(g)$ horizon with two (Nos. 43 and 44) showing a decrease. In the iron podzols values vary from low to medium, with about half the freely drained members showing a decrease down the profile and the other half a minimum in the $B_2$ or $B_3$ horizon, while the imperfectly drained members almost invariably have the minimum value in the $B_2(g)$ or $B_3(g)$ horizon. Apart from the litter and humus layers, values in the peaty podzols tend to be rather low; the minimum value occurs in the $A_2$, $B_2$ or $B_3$ horizon, although the increase in the C horizon is very slight. In the non-calcareous gley group the range is again low to moderate with the majority having a minimum value in the $A_2g$ or Bg horizon, though here again a few (e.g. Nos. 145 and 154) show a decrease down the profile. The peaty gleys, almost without exception, show a minimum in the $A_2g$ horizon, and here too the values are from low to moderate. The content of this cation is related to clay content, and it is significant that the clayey soils of the Peterhead and Tipperty Associations tend to have somewhat higher values than the other associations. This is in accord with the high content of illitic clay minerals in these soils. Coarse textured parent materials tend to have low values.

*Exchangeable Sodium*

The highest value recorded in a mineral horizon for this cation is in the $B_2g$ layer of a non-calcareous gley of the Bogtown Association (profile 114) where a value of 1·21 m.e./100 g. was recorded for a horizon with 54% clay and a loss of ignition of 14·6%. Comparatively high values are found throughout the profiles of the brown forest soils with gleyed B and C horizons and the non-calcareous gleys of the Peterhead and Tipperty Associations (profiles 35, 48 and 152) all of which have high clay contents. Both these associations are adjacent to the sea board. High values (i.e. $>$0·5 m.e./100 g.) are common in the highly organic surface layers of the peaty gley soils and are followed by minimum values in the underlying $A_2g$ layers sometimes with a rise in the Cg horizon. Similar high values are also shown in the surface organic layers of the peaty podzols, but the minimum values in this case are normally in the $B_2$ or $B_3$ horizons. In the freely drained brown forest soils, the highest value is in the surface horizon, and there is either a decrease down the profile or a minimum in the $B_2$ or $B_3$ horizon. The highest value in the brown forest soils with gleyed B and C horizons is generally in the C horizon, with a minimum almost invariably in the $B_2(g)$. In the iron podzols, with both free and imperfect drainage, the maximum value is usually in the surface horizon and values decrease down the profile or reach a minimum in the $B_2$. Values in the non-calcareous gleys vary considerably and there appears to be no definite trend.

*Exchangeable Hydrogen*

For exchangeable hydrogen the general tendency in all the major soil groups is for the values to decrease with depth. Variations are found when the soil is calcareous, e.g. Fraserburgh Association (profiles 5 and 173) where no exchangeable hydrogen occurs; where an increase in organic matter occurs, e.g. in the $B_1$ horizon of profile 106, the Ag horizon of profile 114, and the Bg horizon of profile 134; in the non-calcareous gleys of the Leslie Association (profiles 143 and 144) where the surface horizons have a low value and there is no exchangeable hydrogen below; and in profiles low in clay where the soil has no exchangeable hydrogen below the surface horizon, e.g. non-calcareous gley profiles of the Boyndie and Corby Associations (profiles 116 and 118) and the freely drained iron podzol of the Corby Association (profile 55).

In the freely drained brown forest soils there are some profiles (e.g. Nos. 7 and 26) which show a rise in exchangeable hydrogen values in the C horizon. Although the majority of the brown forest soils with imperfect drainage follow the general trend of a decrease in values down the profile, some (e.g. Nos. 31 and 43) show a minimum in the $B_2$(g) or $B_3$(g) and in profile 46 a maximum value is found in the $B_2$(g) horizon which is also very high in clay. The freely and imperfectly drained iron podzols also have examples of values falling to a minimum in the $B_2$ or $B_3$ horizon (Nos. 60 and 102) or rising to a maximum in the $B_2$ (Nos. 71 and 97). A few of the non-calcareous gleys (e.g. profiles 132 and 133) exhibit two minimum values, one in the $A_2$g or Bg and the second in the Cg. The peaty gleys also show this in some profiles (Nos. 175 and 180), while others have only one minimum value which is in the $A_2$g (Nos. 184 and 185).

*Exchange Capacity*

The exchange capacity, as assessed by the sum of cations, is generally shown to be highest in the S horizon. In the brown forest soils, the Insch series (Nos. 7–15) frequently shows a decrease down the profile to the $B_3$, with a distinct increase in the C horizon. This trend is also evident in the imperfectly drained brown forest soils, although the minimum value is very often in the $B_2$(g). In the iron podzols the freely drained soils show either a decrease down the profile or a minimum in the $B_2$ or $B_3$ horizon. This minimum in the $B_3$ horizon is also found frequently in the imperfectly drained iron podzols and occasionally in the peaty podzols. The non-calcareous gleys show either a decrease down the profile or have a minimum in the $A_2$g or $B_2$g horizon. Some of those with a minimum in the $A_2$g show a decrease again in the Cg (e.g. Nos. 132, 157 and 168). The peaty gleys have an extremely high exchange capacity in the organic surface horizon, but have a marked decrease in capacity below this, the minimum value often occurring in the $A_2$g horizon.

PERCENTAGE BASE SATURATION AND pH

The percentage saturation in the brown forest soils with free drainage is generally at a minimum in the $B_2$ (e.g. profiles 8 and 10), though in a few profiles (e.g. profile 23) the minimum value is in the $B_3$. In those soils which do not have a minimum value in the $B_2$ or $B_3$ the value increases down the profile (e.g. profiles 1 and 16). The brown forest soils with imperfect drainage either show an increase in value with depth (e.g. Nos. 30 and 35) or a minimum in the $B_2$ horizon (e.g. profiles 34 and 47). The iron podzols with free drainage have no consistent trend in the percentage saturation; there are examples of a decrease down the profile (Nos. 60 and 86), an increase down the profile (Nos. 65 and 78), a minimum in the $B_2$ or $B_3$ (Nos. 59 and 68) and a maximum in the $B_2$ (Nos. 70 and 73). The iron podzols with imperfect drainage also show no consistent trends. Values are very low in the peaty podzols, with a tendency towards a minimum value in the $B_2$. The non-calcareous gleys generally have increasing percentage base saturation with increasing depth, but quite a number of them (e.g. profiles 115 and 130) show a slight decrease in the Cg horizon. The peaty gleys generally show either an increasing value with depth (Nos. 179 and 191) or a minimum value in the $B_2$g or $A_2$g (Nos. 177 and 178), although these trends are not consistent.

Except in the Fraserburgh and Leslie series where it rises well above 7, the majority of the freely drained brown forest soils, have a pH value between 5 and 6. The value tends to increase with depth although a number of soils show a decrease in the C. The brown forest soils with imperfect drainage have slightly higher pH values than the freely drained. Some show an increase down the profile (e.g. Nos. 40 and 44), whilst others show a decrease (Nos. 33 and 43). Values in the iron podzols, both freely and imperfectly drained, are again mainly between 5 and 6; there is a tendency for a minimum to occur in the $B_2$ of the freely drained, but no very definite trend in the imperfectly drained. Peaty podzols are the most acid of all the major soil groups, the majority having pH values between 3·5 and 5. In general the value increases with depth though in some profiles there is a decrease again in the C horizon. The majority of the non-calcareous gley group have values between 5·5 and 6·5, but some, e.g. profiles 154–156 (Skelmuir Association) are considerably more acid, while profiles 143 and 144 (Leslie Association) and the lower layers of profile 117, which have high clay contents, are distinctly more alkaline. The main trend in this group is an increase down the profile with frequently a decrease again in the Cg horizon, but there are quite a few (e.g. Nos. 157 and 169) which show a decrease right down the profile. The peaty gleys tend to be more uniform throughout the profile, except for Nos. 179 and 180 which have a fairly wide range and increase in pH value with depth.

### CARBON AND NITROGEN

There is a decrease in the percentages of carbon and of nitrogen down the profiles of all major soil groups.

In Table W the average percentages of carbon and nitrogen, together with the carbon/nitrogen ratio, is given for the cultivated surface horizon of the major soil groups. The values for these constituents in the middle and lower horizons have not been determined.

There is a tendency in the surface horizon for the percentage value for carbon to be higher in the brown forest soils with imperfect drainage, the iron podzols with imperfect drainage and the non-calcareous gleys than in the brown forest soils and iron podzols with free drainage, whilst the peaty gleys have the highest values of all. The values for percentage nitrogen are higher in the brown forest soils with both free and imperfect drainage than in the iron podzols with free and imperfect drainage. The non-calcareous gleys have values mid-way between those for the brown forest soils and iron podzols, whilst in the peaty gleys the values are more than twice as high as in any of the other groups. The average carbon/nitrogen ratios show the brown forest soils and iron podzols with free drainage to have the lowest ratio, while the imperfectly drained and poorly drained have a higher ratio, and the peaty gleys the highest ratio. The L, F and H layers of the uncultivated peaty podzols have, of course, much higher values for carbon and nitrogen than the surface layers of the cultivated soils. The C/N ratio is generally in the region of 30 or 40 to 1, which is in keeping with that generally found in plant remains.

TABLE W. AVERAGE PERCENTAGE CARBON AND NITROGEN AND CARBON/NITROGEN RATIO IN S HORIZON

| Major Soil Group | Average %C | Average %N | Average C/N |
|---|---|---|---|
| B.F.S.—freely drained (22 profiles) | 3·77 | 0·302 | 12·5 |
| Iron podzols—freely drained (32 profiles) | 3·97 | 0·278 | 14·3 |
| B.F.S. with gleyed B and C—imperfectly drained (18 profiles) | 4·39 | 0·293 | 15·0 |
| Iron podzols—imperfectly drained (11 profiles) | 4·30 | 0·257 | 16·7 |
| Non-calcareous gleys—poorly drained (55 profiles) | 4·33 | 0·286 | 15·1 |
| Peaty gleys—very poorly drained (13 profiles) | 16·03 | 0·710 | 22·6 |

## PHOSPHORUS

### *Total Phosphorus*

The average value for total phosphorus in the surface soil of cultivated brown forest soils and peaty gleys is higher (310 mg./100 g.) than in the other genetic groups. This is followed by an average of 245 mg./100 g. for the surface horizons of the freely drained iron podzols, while brown forest soils and iron podzols with imperfect drainage, and non-calcareous gleys all have approximately the same average value of 220–230 mg./100 g. There are two main trends in the distribution of total phosphorus throughout the cultivated profiles of the major soil groups, the first a straight decrease with depth and the second showing a minimum value somewhere down the profile followed by an increase. Of the freely drained members of both brown forest soils and iron podzols about half show a decrease right down the profile and the other half show a minimum. In the brown forest soils the minimum is most often found in the $B_3$ horizon (e.g. profiles 7 and 19) while in the iron podzols it is more frequently in the $B_2$ (e.g. profiles 63 and 68). In the majority of the imperfectly drained members of both groups a minimum value occurs in the $B_2$(g) although in each group there are a few (e.g. Nos. 41 and 95) with a straight decrease down the profile. Both the non-calcareous and the peaty gleys have their minimum value in the $A_2$g horizon in most cases, though here again there are examples (Nos. 135 and 184) of a decrease right down the profile.

Of the uncultivated soils the peaty podzol has its highest percentage of total phosphorus in the L/F horizons, with low values in both the $A_2$ and $B_3$ horizons. This same tendency to low values in the $A_2$ and $B_3$ horizons is found in the freely drained iron podzol group (profile 81). Uncultivated iron podzols are generally considerably lower in total phosphorus than the cultivated profiles.

*Acetic Acid or Readily Soluble Phosphorus*

The values for acetic soluble phosphorus in cultivated brown forest soils almost invariably fall to a minimum in the $B_2$ or $B_3$ horizon, although there are a few examples (Nos. 7 and 28) of a maximum in these horizons. The absolute values vary widely, with the soils of the Insch Association being highest, particularly in the $B_3$ and C horizons (Nos. 8 and 10). Very low values occur in certain profiles in the Countesswells, Leslie and Tarves Associations (Nos. 4, 17 and 18). As previously noted (Mitchell and Jarvis, 1956), in the imperfectly drained brown forest soils a minimum value nearly always occurs in the B(g) horizon, although there are examples of an increase (No. 42) and a decrease (No. 43) down the profile. Widely varying values are a feature of the non-calcareous gley soils the majority of which show a minimum in the Bg horizon (or the $A_2$g where present), but in this group too there are profiles showing an increase (No. 172), a decrease (No. 156), or a maximum (No. 120). In the peaty podzols with iron pan the values for acetic soluble phosphorus are very low, with minimum values in the $A_2$ and $B_2$ horizons, while there is an appreciable rise in the C horizon of the Corby (No. 105) and Countesswells (No. 107) profiles. The cultivated iron podzols of both free and imperfect drainage have low to moderate values, and the majority show a decrease in value in the $B_2$ horizon. Compared with the uncultivated freely drained iron podzol and the peaty podzol, both of which have very low amounts of acetic soluble phosphorus, it would appear that the cultivated soils have enhanced values which are no doubt due to cultural practices. Values in the peaty gleys vary considerably and the two main trends are a maximum (Nos. 175 and 190) or a minimum (Nos. 179 and 187) in the $A_2$g or Bg.

Investigations on the phosphorus relationships of soils in north-east Scotland (Williams, 1959), in which comparisons of freely drained and poorly drained soils from the same field were made, showed marked differences depending on drainage conditions and the nature of the parent material.

## SILICA-SESQUIOXIDE RATIOS OF THE CLAY FRACTION

Silica, iron and aluminium determinations were carried out on the clay fraction ($<1{\cdot}4\mu$) of certain typical profiles. The procedures followed are listed in the summary of analytical methods at the end of the chapter. The percentages of silica, iron oxide and aluminium oxide and the 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 II, Tables 10–16. 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.

Representative soils of several major soil groups from this area have been

*(By courtesy of the Forestry Commission)*

PLATE 55

100-year-old Scots pine, regenerating naturally on Countesswells series.

*(By courtesy of the Forestry Commission)*

PLATE 56

Ploughing preparatory to tree planting.

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studied and trends in the differential movement of silica and sesquioxides are apparent which to some extent reflect their weathering processes.

A gradual rise in the silica-sesquioxide ratio may be interpreted as indicating that weathering and soil formation are taking place without marked horizon differentiation. Similarly a constant value for this ratio is considered characteristic of the brown forest group of soils, indicating little or no leaching of sesquioxides. When, however, a low value of the silica-sesquioxide ratio occurs, this may be interpreted as due to either a loss of silica or an accumulation of sesquioxides.

The majority of soils studied show a minimal percentage of $SiO_2$ in the $B_2$ horizon. The percentage $Fe_2O_3$ shows a tendency for the maximum value to occur most frequently in the $B_2$ horizon, while the percentage of $Al_2O_3$ indicates an accumulation in the B or C horizon.

Cultivated brown forest soils of low base status and iron podzol soils have been so altered in their upper horizons that it is impossible to differentiate them. They have therefore been considered together. In this area the cultivated freely drained brown forest soils and the cultivated iron podzols studied all show a morphological $B_2$ and $B_3$ horizon. An $A_2$ horizon is absent or weakly developed in the semi-natural brown forest soils. In the cultivated soils studied the percentage $SiO_2$ is at a minimum in the $B_2$ horizon in most cases. There is however no very definite trend in the percentage $Fe_2O_3$, with the lowest values possibly occurring in the basal horizons, while the percentage of $Al_2O_3$ is at a maximum in the $B_2$ or $B_3$ horizon. The slight podzolic tendency in these soils is indicated by the clay ratios where $SiO_2/R_2O_3$ is at a minimum value in the $B_2$ (sometimes in the $B_3$) with the $SiO_2/Fe_2O_3$ and $SiO_2/Al_2O_3$ ratios also lowest in the $B_2$ horizon. From a comparison of the percentage values for iron and aluminium in the freely drained cultivated brown forest soils and iron podzols it appears that aluminium is translocated to the lower B horizons, while iron is customarily present in the surface and B horizons in amounts greater than in the C horizon.

In profile 81, a freely drained uncultivated iron podzol, the percentage of $SiO_2$ has a very definite maximum in the bleached $A_2$ horizon, while the percentage $Fe_2O_3$ shows a definite maximum in the $B_2$ horizon and minimum in the $A_2$. The $Al_2O_3$ is at a minimum value in the $B_2$ horizon. The clay ratios have a minimum value for $SiO_2/R_2O_3$ in the $B_2$ horizon, while the $SiO_2/Fe_2O_3$ value is very high in the $A_2$, thus exhibiting that the profile has a marked eluvial ($A_2$) horizon and an illuvial ($B_2$) horizon. The trend for $SiO_2/Al_2O_3$ is less definite, but the highest value is found in the $A_2$ (eluvial) horizon. The podzolic nature of this profile is considered to be typical of the iron podzol group which occurs extensively on the heather-covered moorland of Sheet 76 (Inverurie).

Brown forest soils with gleyed B and C horizons on moderately base-rich and moderately clayey textured parent materials show little variation in the silica-sesquioxide ratios throughout the profile. This is a generally accepted characteristic of brown forest soils. In their morphological characters they resemble the grey-brown podzolics of the U.S.A. in tending to have a clay accumulation layer in the B(g) horizons. With the exception of profile 45 where there is a maximum in the $B_2$(g) horizon there is little variation in the percentage $SiO_2$ or in the percentage $Fe_2O_3$. This absence of variation also applies to the percentage of $Al_2O_3$. The ratios $SiO_2/R_2O_3$, $SiO_2/Fe_2O_3$ and

$SiO_2/Al_2O_3$ vary little throughout, except in profile 45 where there is a minimum $SiO_2/Fe_2O_3$ value in the $B_2$(g) horizon.

Iron podzols with imperfect drainage differ from the brown forest soils with gleyed B and C in that they have recognisable B horizons which are yellow-brown in colour indicating enrichment by iron oxides. In these soils the percentage $SiO_2$ is at a minimum in the $B_2$(g), whilst the percentage $Fe_2O_3$ is at a maximum in the $B_2$(g) and the percentage $Al_2O_3$ tends to increase with depth. The ratios of $SiO_2/R_2O_3$ and $SiO_2/Fe_2O_3$ are at a minimum in the $B_2$(g); $SiO_2/Al_2O_3$ is also at a minimum in the $B_2$(g) horizon of profile 101 but is lowest in the C(g) horizon of the uncultivated profile (No. 103).

The non-calcareous gley soils show no definite trends in the percentage values for silica, iron and aluminium, although there is a slight tendency for the percentage of $Fe_2O_3$ to be at a maximum in the Bg or Cg horizons. This absence of a definite trend is reflected in the clay ratios with the exception of profiles 124 and 168 where the $SiO_2/Fe_2O_3$ values decrease slightly to a minimum value in the Bg horizon, indicating a leaching of iron from the surface. The absolute values for the percentage of $Fe_2O_3$ differ widely as a result of the lithological origin of the parent material. Profile 142 from the Insch Association, derived from basic igneous rocks, has values between 15 and 20% $Fe_2O_3$, whereas profile 171 of the Tipperty Association, on red lacustrine clay of Old Red Sandstone origin, has values between 6 and 8·5%. The irregularity in value of the clay ratios and percentages of silica and sesquioxides has been previously noted by Glentworth (1954, p. 136) and Ragg (1960, p. 144). Mitchell and Jarvis (1956, p. 170) on the other hand, in reporting on non-calcareous surface-water gley soils on clayey textured parent materials in Ayrshire, find an obvious leaching of iron from the surface horizon with a zone of accumulation in the $B_3$g or Cg horizon.

Of the peaty gley group, results for profile 185 (Table 15) provide evidence of the movement of iron from the surface horizon with an accumulation layer in the Bg horizon and again in the Cg horizon. Aluminium has also moved into the basal $B_3$g and Cg horizons.

As has been previously observed (Muir, 1956, p. 118; Mitchell and Jarvis, 1956, p. 170; Ragg, 1960, p. 144), the striking differential movement of silica and sesquioxides is most pronounced in the peaty podzol profile with its marked horizon differentiation. Table 16 shows that the highest percentage of silica occurs in the $A_2$ horizon, whilst the percentage of iron in this horizon is extremely low. The lowest percentage of silica occurs in the $B_2$ which, apart from the thin iron pan immediately above it, has also the highest content of iron. The highest value for percentage aluminium is found in the $A_2$ horizon, although the differential movement of this element is not so pronounced. Muir (1956, p. 116) previously reported consistently high percentages of $Al_2O_3$ in both the $A_1$ and $A_2$ horizons, attributing the cause to the probable accumulation of plant residues. The ratios also demonstrate the marked differential movement of silica and sesquioxides, being highest in the $A_2$ horizon and lowest in the $B_2$.

## TRACE ELEMENTS

The soils of the area covered by this memoir and the adjacent sheets 86 and 96 are of very varied trace element status. The total content of trace elements in a soil depends almost entirely on the nature of the rock from which the soil parent material was derived, and igneous, metamorphic and sedimentary rocks of many different types occur. Parent materials originating from ultrabasic and basic igneous rocks contain relatively large amounts of cobalt, nickel and chromium, as well as magnesium, and more molybdenum than most other igneous rocks except some granites. Some soils derived from acid igneous rocks may be low in cobalt and possibly also in selenium, the importance of which in animal nutrition is now being realised; these elements and copper are generally least abundant in soils derived from arenaceous sediments. The soils derived from argillaceous sediments and the corresponding metamorphic rocks are seldom deficient in any trace elements; on occasion quite high contents of molybdenum may occur.

Many of the associations are formed on materials derived from a mixture of different parent rocks in variable proportions and are seldom as uniform as those derived from a single parent rock. There is therefore always the possibility of deficiencies of certain trace elements, notably copper and cobalt, occurring on some soils within such associations although normally adequate amounts are present. This is particularly the case with parent materials containing an arenaceous rock constituent, and is one reason why the application of trace elements should always be based on the advice of a qualified advisory officer with access to laboratory facilities. In an area such as this, trace elements should not be applied on a regional geographical basis, as even adjoining farms may have quite different requirements. An exception to this may be made in the case of boron. Boron deficiency occurs spasmodically in soils from many of the associations, and boronated fertilizers should be applied before turnips, swedes or sugar beet whenever there has been a previous occurrence of boron deficiency on the farm. Little reliable information on the true boron status of the soils of the area is at present available, as both determination and interpretation raise problems which have yet to be satisfactorily solved.

The availability of trace elements to plants depends not on the total content in the soil, although this is important in providing a reserve supply, but on the extent and nature of the pedological processes and also to some extent on biological factors such as vegetational history. These effects are demonstrated by variations in trace element status between series within an association. Deficiencies of essential trace elements are most likely to occur in freely drained series, and excesses of noxious elements in very poorly drained series, particularly in association with accumulations of organic material in peaty gleys. The essential trace elements which may be present in inadequate amount in certain of the soils of the area are cobalt, copper, manganese, boron and selenium, while those possibly present in excess include molybdenum and nickel. The trace element status of a soil is best assessed by the extractable amount in the surface horizon. It is impossible to quote definite figures, as the interpretation of analytical results depends on a number of factors, but generally contents below 0·3 p.p.m. acetic acid soluble cobalt and 0·7 p.p.m. copper extracted by E.D.T.A. indicate deficiency levels. For molybdenum, the best extractant is probably ammonium acetate, while excesses of most other trace elements can be detected by acetic acid extraction.

*Cobalt*

Adequate amounts of cobalt are always present in soils of the Leslie, Insch and Strichen Associations, with total contents between 100 and

25 p.p.m., and acetic acid extractable contents in the surface horizons varying from over 10 p.p.m. in poorly drained to around 1 p.p.m. in typical freely drained profiles. Although the Tarves Association contains some basic igneous material the amount is very variable; total cobalt contents range between 60 and 7 p.p.m., with extractable cobalt in the surface horizons falling to 0·6 p.p.m. in some of the samples examined. The Countesswells Association, derived from granite or granitic gneiss, is generally adequately supplied with cobalt, with up to 20 p.p.m. total cobalt, presumably in soils from the gneiss, but as little as 2 p.p.m. in some areas. The more widespread type contains 0·5 p.p.m. extractable cobalt in the surface horizons, but contents as low as 0·1 p.p.m. occur and the pasture herbage may then be cobalt-deficient as far as ruminant nutrition is concerned. Other soils containing rocks of acid igneous origin are those of the North Mormond Association. These mixed tills, markedly influenced by arenaceous strata of the Old Red Sandstone, are quite low in cobalt with <3–10 p.p.m. total and 0·4 p.p.m. extractable in one of the samples examined. Cobalt deficiency in stock may occur on some of these soils. The Foudland Association derived from andalusite-schist carries the normal trace constituents of an argillaceous sediment and is therefore generally adequately supplied with cobalt (6–20 p.p.m. total; 0·5–2 p.p.m. extractable).

A number of associations are derived mainly from Old Red Sandstone sediments. The Peterhead and Tipperty Associations usually contain sufficient clay to ensure adequate cobalt contents (6–15 p.p.m. total; 0·5–1·5 p.p.m. extractable), but the arenaceous soils of the Hatton and Ordley Associations may be cobalt deficient (<3 p.p.m. total; <0·3 p.p.m. extractable), as might those of the Cuminestown Association, no profiles of which have been examined. The quartzites on which the Durnhill Association is developed are exceedingly low in cobalt (<3 p.p.m.) and the freely drained soils of this association will carry cobalt deficient herbage (<0·3 p.p.m. extractable cobalt) unless there is, as occasionally occurs, some admixture of basic igneous or argillaceous rocks in the parent material.

The remaining associations are derived from alluvial, fluvioglacial or raised beach deposits. The sandy soils of the Fraserburgh Association and Blackwater Complex contain calcareous shells and are very low in total (<3 p.p.m.) and extractable (<0·25 p.p.m.) cobalt, being therefore liable to carry herbage low in cobalt. Similar considerations apply to the lighter arenaceous fluvio-glacial and morainic deposits.

The effect of drainage conditions is well illustrated in the set of profiles from the Tarves Association at Upper Crichie, where the acetic acid soluble cobalt ranges from 0·62 p.p.m. in the surface horizon of the freely drained Tarves series and 0·64 p.p.m. in the imperfectly drained Thistlyhill series to 2·4 p.p.m. in the poorly drained Pitmedden series and 9·1 p.p.m. in the very poorly drained Pettymuck series.

*Copper*

Low yields of oats and barley attributable to copper deficiency occur on several soil types, generally light arenaceous soils with quite low organic matter contents.

The associations containing ultrabasic and basic rocks (Leslie and Insch) and that derived from quartz-mica-schist (Strichen) contain 20–40 p.p.m. total copper and are unlikely ever to be copper deficient, as the E.D.T.A.

extractable contents in the surface horizons are generally from 3 p.p.m. upwards, although one freely drained soil of the Strichen Association showed only 1·2 p.p.m. The total copper contents of the soils of the Tarves Association (mixed till) are, like the cobalt, very variable, but the lowest extractable copper found was over 1 p.p.m. and values up to 7·7 p.p.m. occurred.

The total copper contents of the soils derived from granite and granitic gneiss (Countesswells Association) vary from $<5$ p.p.m. upwards to 50 p.p.m., with extractable amounts from the deficiency level (0·6 p.p.m.) upwards to 3 p.p.m. or more; low copper may be expected to occur in the same soils as show low cobalt contents. The selected profiles of the North Mormond Association (mixed acid igneous/Old Red Sandstone till) contain about 10 p.p.m. total copper, and from 1 p.p.m. upwards of E.D.T.A. extractable copper in the surface horizons.

The total contents of the soils of the Foudland Association generally lie within the 10–20 p.p.m. range, with extractable contents of 1·5–8 p.p.m., although somewhat lower values have occasionally been found. Similar contents occur in the Peterhead and Tipperty Associations, the higher extractable values always being found in the poorly drained series.

In the area north-east of Turriff, severe copper deficiency of cereals has been encountered on soils of the Ordley and Hatton Associations, with total contents which may be as high as 15 p.p.m. but which are normally somewhat lower. These soils have very low E.D.T.A. extractable copper contents of 0·5 p.p.m. or less in the surface horizons.

Although the parent material of the Durnhill Association is derived from quartzite, it appears generally to be adequately supplied with copper, total contents of 20 p.p.m. upwards being recorded, with as much as 200 p.p.m. in the poorly drained lower-lying soils which appear to contain some Tarves or Strichen material.

Soils derived from alluvial, fluvio-glacial, morainic and raised beach deposits must be considered possibly low in copper unless there is a considerable proportion of argillaceous material in the parent material. Thus the samples from the Fraserburgh Association which have been examined all contain less than 10 p.p.m. total copper and around 1 p.p.m. E.D.T.A. extractable copper. Similar contents have been found in the surface horizons of Boyndie and Corby soils, and locally lower contents are to be anticipated.

*Manganese*

The total manganese contents vary from less than 200 p.p.m. in the soils derived from arenaceous sediments and acidic igneous rocks to over 5000 p.p.m. in the soils of the Insch Association derived from basic igneous rocks. Only in the light soils of acid igneous or fluvio-glacial origin and particularly in the lime-rich Fraserburgh Association is manganese deficiency of cereals to be suspected. In these soils the dangers of induced deficiency due to overliming must be kept in mind.

*Molybdenum*

There has been no evidence of molybdenum deficiency in any of the soils of the area. In the soils examined, the highest total molybdenum contents, of 20–30 p.p.m., occur in soils of the Foudland and Tarves Associations in the Ythan Valley. Several instances of Black Scour in cattle attributable to excess molybdenum occur here on localised areas of poorly drained soils that have probably been influenced by organic matter accumulation. In such areas ammonium acetate extractable molybdenum in the surface horizons may rise to nearly 1 p.p.m. and clover in pasture herbage may contain more than 50 p.p.m.

*Selenium*

No selenium determinations have been made on the soils of this area, but veterinary work on cattle and sheep suggests that slight deficiency may possibly occur on arenaceous soils, particularly of Old Red Sandstone origin. The use of selenium as a soil additive is not at present recommended because of the dangers to stock arising from excessive uptake by plants, the range between deficiency and excess being quite narrow, and the levels in question considerably below 1 p.p.m.

*Nickel*

The only other element regarding which particular comment is necessary is nickel, as several small areas, for instance on the Tarves Association a few miles north of Ellon, and on the Leslie Association on the Beauty Hills, 10 miles north of Aberdeen, contain excess nickel. In these areas, where growth of cereals and other crops is severely restricted unless the pH is raised to around 7, very high contents of extractable nickel (up to 100 p.p.m.) occur. The nickel is probably derived from ultrabasic material, from which it has been mobilised in conditions of poor drainage and peat development, although the peat may since have been removed.

## MINERALOGY OF THE CLAY FRACTION

In the mechanical analysis of soil the clay fraction is defined as that made up of particles with effective diameter less than $2\mu$. The fraction commonly used for the study of clay minerals is, however, that with particles less than $1{\cdot}4\mu$ effective spherical diameter. This fraction of the soil contains a distinct group of crystalline minerals with characteristic properties. Chemically clay minerals are hydrated silicates of aluminium, and frequently they may also contain magnesium, iron, potassium, etc. Most of these minerals form thin plate-like crystals and from a structural aspect are referred to in general as layer silicates. Crystalline clay minerals do not constitute the whole of the clay fraction. Oxides and hydroxides of iron and aluminium, for example, goethite $\alpha$-FeO.OH, haematite $\alpha$-$Fe_2O_3$ and gibbsite $\gamma$-$Al(OH)_3$ are often present, as are amorphous forms of these compounds and alumina-silica gels. These compounds of iron, alumina and silica may occur as discrete particles or as coatings on the surface of the crystalline material, and exert especially in the latter form a considerable influence on the properties of the soil. Colloidal organic matter is also present in varying amounts in the soil clay fraction and may form complexes with the crystalline and the amorphous inorganic components.

The clay fractions of the principal soils encountered in the area were examined by X-ray diffraction and by differential thermal analysis methods and the approximate quantitative mineralogical composition was determined. Most Scottish soil clays examined to date are illitic in character. The predominant clay mineral in most of the soil clays from this area is also illite: however, there are notable exceptions and these will be discussed below.

The clays from the freely and poorly drained soils of the extensive Countesswells Association, derived from granite and granitic gneiss, consist essentially of illite. In the freely drained members of the association there is a tendency for the illite to be replaced by vermiculite in the upper horizons of the profile. This transition is not, however, evident in the clays from the poorly drained series.

In the soils of the Tarves Association, derived from mixed acid igneous, acid metamorphic and basic igneous rocks, kaolin accounts for approximately 40% of the clay fraction, the remainder being trioctahedral illite and vermiculite. There is very little difference in the clay mineralogy of the freely, poorly and very poorly drained soils of the association, except that the kaolin content of the freely drained soil is slightly higher than that of the wetter soils.

The Foudland Association soils, developed on a coarse textured till derived from slate, andalusite-schist and schistose grit, exhibit marked differences in mineralogy which are allied to variations in the internal soil-water relations. The clays examined from freely drained soils appear, from the considerable background on the X-ray film, to contain a high proportion of amorphous material. There is much less evidence of amorphous material in the soils with poor drainage. Illite and kaolin are the principal clay minerals in both series, the ratio of illite to kaolin varying from about 4 : 1 in the freely drained soil to 3 : 1 in the poorly drained soil.

The mineralogy of the clays from the Insch Association derived from basic igneous rocks, is closely similar to that quoted for Insch soils in Sheets 86 and 96 (Glentworth, 1954). That is, they contain between 40 and 60% trioctahedral illite, together with montmorillonite and vermiculite. The kaolin mineral tends to be halloysitic and there is an unusually high proportion of sesquioxides.

The soils of the Peterhead, Tipperty and Hatton Associations (Appendix III) are all derived from Old Red Sandstone sediments. The parent material of the Peterhead Association is a fine textured glacial till, while that of the Tipperty Association is lacustrine clay of even finer texture. The Hatton Association soils are, on the other hand, developed on a stony coarse textured glacial till. Clays from the Peterhead and Tipperty soils contain upwards of 60% illite, with minor amounts of montmorillonite and vermiculite, and the very close similarity in mineralogical composition of the clays from the C horizons of soils of these two associations substantiates the claim made by some glaciologists that these parent materials are derived from the same drift. In contrast, the Hatton Association soils with their coarse texture and free drainage contain much less illite. The surface horizon clays consist of equal amounts of illite and vermiculite, while 25% of montmorillonite has been observed in the basal horizons of these soils, this being the highest montmorillonite content recorded in soil clays from the area.

Soil clays from the Skelmuir, Durnhill and Strichen Associations are unusual in that irrespective of drainage class kaolin is the predominant mineral. A very poorly drained soil of the Skelmuir Association, derived from a drift with a large proportion of flint and quartzite cobbles, has a kaolin content in excess of 70% (Appendix III). The clays from the freely drained soils of the Strichen and Durnhill Associations situated to the west of Auchnagatt also have high kaolin contents—up to 75% in certain instances.

This kaolin-rich area was found not to coincide with any particular rock formation. Consequently the kaolin is probably a product of hydrothermal action.

The most extensive coarse textured soils of the area, those of the Boyndie Association developed on fluvio-glacial sand, of the Corby Association derived from water-sorted and morainic gravel, and of the Fraserburgh Association on coastal shelly sand, are in the main illitic: kaolin and vermiculite are also present in varying but small amounts. The only calcareous soils encountered are those of the Fraserburgh Association. A maximum of 15% calcium carbonate has been noted in the clay from the surface horizons of these soils, and the percentage invariably decreases on passing down the profile. This high concentration of carbonate in the surface may be due to heterogeneity in the parent material, but it is more likely to be a result of the local agricultural practice of adding lime in the form of marine shells.

Clays from the poorly and very poorly drained soils of the North Mormond Association are illitic, the material from the basal horizons, in particular, having between 60 and 70% illite and the remainder of the clay fraction consisting essentially of kaolin, with only traces of vermiculite and montmorillonite.

X-ray diffraction indicates that the clay from the surface horizon of the poorly drained members of the North Mormond Association has a low content of crystalline minerals. A low crystalline mineral content was also observed in the clay fraction of the freely drained soils of the Foudland and Fraserburgh Associations. Differential thermal analysis results suggest that the amorphous material in the Foudland and Fraserburgh soils is of the allophanic type. The amorphous material in the soil clays of the North Mormond Association is not clearly defined and requires further detailed study. From thermal analysis evidence it is considerably less hydrated than allophane.

## 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 colorimetrically (Hunter, 1950), or 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 phosphorus was determined by a colorimetric method using hydrazine sulphate, after fusing the soil with sodium carbonate (Muir, 1952).

7. Acetic soluble phosphorus was determined colorimetrically in a 2·5% acetic acid extract (Williams and Stewart, 1941).
8. Silica-sequioxide determinations of the clay fraction:—approximately 0·5 gm. of 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.
9. The trace element determinations were made spectrochemically according to the methods described by Mitchell (1948).
10. The mineralogy of the clay fractions was determined by differential thermal analysis and X-ray diffraction. Differential thermal curves were determined according to methods described by Mitchell and Mackenzie (1959). Diffraction patterns of the soil clays were obtained on film with a Raymax 60 X-ray generator.

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# APPENDIX I

## Standard Analytical Data

### TABLE 1. BROWN FOREST SOILS, FREELY DRAINED

| 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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | | | | | | | COLLIESTON ASSOCIATION; Cairnrobin Series. Southfolds, Balmedie, 40536–40541 | | | | | | | | | | | |
| S | 0-8 | 4·73 | N.D. | N.D. | 75·9 | 7·6 | 16·5 | 4·06 | 1·16 | N.D. | 0·26 | 5·84 | 48·7 | 5·53 | 1·78 | 0·154 | 150 | 3·6 | High sand content in C. |
| $B_2$ | 10-14 | 1·55 | N.D. | N.D. | 89·8 | 3·9 | 6·3 | 2·78 | 0·84 | N.D. | 0·11 | 1·46 | 71·8 | 5·98 | 0·17 | 0·030 | 110 | 9·4 | High clay content in D. |
| $B_2$ | 18-24 | 1·98 | N.D. | N.D. | 84·5 | 4·3 | 11·2 | 5·73 | 1·43 | N.D. | 0·06 | 1·10 | 86·8 | 6·85 | | | 120 | 7·7 | High exchangeable Mg in |
| C | 36-42 | 1·23 | N.D. | N.D. | 94·8 | 1·2 | 5·0 | 2·71 | 2·18 | N.D. | 0·13 | 0·73 | 93·8 | 8·00 | | | 130 | 17·0 | D. |
| D | 54-56 | 4·55 | N.D. | N.D. | 27·6 | 8·2 | 59·7 | 7·74 | 8·04 | N.D. | 0·34 | Nil | 100 | 7·14 | | | 110 | 3·6 | High pH in C. |
| D | 57-60 | 2·27 | N.D. | N.D. | 67·8 | 11·4 | 14·5 | 3·23 | 3·44 | N.D. | 0·22 | Nil | 100 | 7·10 | | | 120 | 19·0 | |
| 2. | | | | | | | | COLLIESTON ASSOCIATION; Cairnrobin Series. Petten's Farm, Balmedie, 40940–40944 | | | | | | | | | | | |
| S | 0-8 | 8·05 | N.D. | N.D. | 64·2 | 11·3 | 18·5 | 5·78 | 0·68 | N.D. | 0·09 | 8·97 | 42·2 | 5·52 | 3·90 | 0·263 | 260 | 4·2 | High clay content in C. |
| S | 20-24 | 7·46 | N.D. | N.D. | 63·5 | 13·0 | 19·8 | 2·63 | 0·21 | N.D. | 0·07 | 11·10 | 20·0 | 5·30 | 3·48 | 0·195 | 280 | 4·7 | High exchangeable Ca in C. |
| $B_3$ | 24-32 | 3·43 | N.D. | N.D. | 86·4 | 6·3 | 7·3 | 2·17 | 0·18 | N.D. | 0·12 | 6·44 | 27·9 | 5·36 | | | 220 | 9·9 | Low exchangeable K in S. |
| C | 40-44 | 4·56 | N.D. | N.D. | 29·5 | 15·0 | 53·2 | 8·56 | 4·14 | N.D. | 0·32 | 3·76 | 77·6 | 5·77 | | | 130 | 1·0 | |
| D | 48-52 | 1·88 | N.D. | N.D. | 80·9 | 4·7 | 14·4 | 4·43 | 1·15 | N.D. | 0·16 | 1·97 | 74·5 | 5·86 | | | 120 | 15·0 | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3. | COLLIESTON ASSOCIATION; Cairnrobin Series. Mains of Slains, 112217–112223 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 7·97 | 42·4 | 29·1 | 56·2 | 15·3 | 24·5 | 7·09 | 1·86 | 0·32 | 0·21 | 9·90 | 48·9 | 5·81 | 3·00 | 0·251 | 220 | 6·3 | High exchangeable Ca and Mg in D. |
| $B_3$ | 9-13 | 5·48 | 65·6 | 16·8 | 72·6 | 9·8 | 14·9 | 3·52 | 0·85 | 0·18 | 0·08 | 5·50 | 45·7 | 6·01 | 1·14 | 0·092 | 147 | 3·9 | |
| C | 15-18 | 3·13 | 58·6 | 26·7 | 72·8 | 12·5 | 11·6 | 3·04 | 0·80 | 0·16 | 0·07 | 3·18 | 56·2 | 6·09 | 0·48 | 0·075 | 114 | 10·3 | |
| C | 21-25 | 2·20 | 78·8 | 14·2 | 85·5 | 7·5 | 4·8 | 3·03 | 0·79 | 0·13 | 0·05 | Nil | 100 | 6·27 | | | 85 | 9·8 | |
| C | 34-38 | 2·36 | 81·2 | 7·9 | 84·2 | 4·9 | 8·5 | 4·40 | 1·82 | 0·27 | 0·13 | 0·22 | 97·0 | 6·35 | | | 113 | 12·8 | |
| C | 34-38 | 3·06 | 74·9 | 10·1 | 78·5 | 6·5 | 11·9 | 4·10 | 1·44 | 0·24 | 0·13 | Nil | 100 | 6·40 | | | 134 | 9·9 | |
| D | 50-54 | 4·34 | 16·8 | 54·2 | 37·3 | 33·7 | 26·8 | 8·60 | 6·89 | 0·47 | 0·38 | Nil | 100 | 7·00 | | | 80 | 2·7 | |
| 4. | COUNTESSWELLS ASSOCIATION; Raemoir Series. Upper Woodend, 111628–111631 | | | | | | | | | | | | | | | | | | |
| $A_1$ | 1-3 | 12·70 | 65·9 | 17·2 | 74·6 | 8·5 | 10·6 | 2·80 | 0·90 | 0·21 | 0·34 | 12·78 | 25·0 | 4·88 | 6·35 | 0·380 | 121 | 1·9 | Low exchangeable bases except in $A_1$. Low total $P_2O_5$ in $B_2$ and $B_3$-C. Low readily soluble $P_2O_5$. |
| $B_2$ | 9-13 | 7·33 | 60·8 | 18·5 | 70·9 | 8·4 | 17·0 | 0·16 | 0·18 | 0·10 | 0·10 | 8·63 | 5·9 | 4·82 | 2·78 | 0·155 | 66 | 1·0 | |
| $B_3$ | 16-21 | 1·76 | 77·6 | 15·3 | 85·1 | 7·8 | 5·3 | Nil | Nil | 0·05 | 0·02 | 0·68 | 9·3 | 5·12 | | | 133 | 1·4 | |
| $B_3$-C | 22-26 | 3·12 | 76·4 | 11·2 | 81·7 | 5·9 | 9·3 | 0·15 | 0·13 | 0·09 | 0·05 | 2·84 | 12·9 | 5·02 | | | 67 | 1·2 | |
| 5. | FRASERBURGH ASSOCIATION; Fraserburgh Series. Kirkton Links, 118301–118304 | | | | | | | | | | | | | | | | | | |
| S | 3-7 | 12·90 | 96·1 | 1·8 | 96·7 | 1·2 | 0·4 | 26·43 | 1·62 | 0·38 | 0·07 | Nil | 100 | 8·32 | 1·01 | 0·121 | 58 | 13·8 | Very high sand content. High exchangeable Ca and readily soluble $P_2O_5$. Low exchangeable K and total $P_2O_5$. Very high pH and % saturation. |
| $B_2$ | 12-16 | 11·20 | 100 | Nil | 100 | Nil | Nil | 20·80 | 1·21 | 0·27 | 0·04 | Nil | 100 | 9·05 | 0·22 | 0·012 | 44 | 11·6 | |
| $B_2$ | 20-24 | 10·30 | 100 | Nil | 100 | Nil | Nil | 21·70 | 1·23 | 0·27 | 0·04 | Nil | 100 | 8·98 | | | 41 | 12·7 | |
| C | 30-34 | 12·10 | 100 | Nil | 100 | Nil | Nil | 22·00 | 1·26 | 0·25 | 0·04 | Nil | 100 | 8·61 | | | 31 | 14·8 | |
| 6. | FRASERBURGH ASSOCIATION; Fraserburgh Series. Glenbuchty Cottage, 118050–118055 | | | | | | | | | | | | | | | | | | |
| S | 1-5 | 17·30 | 79·9 | 4·7 | 80·9 | 3·7 | 2·4 | 29·70 | 2·33 | 0·42 | 0·15 | Nil | 100 | 8·31 | 1·93 | 0·177 | 79 | 36·0 | High exchangeable Ca in S and $B_2$. Very high pH and % saturation. Low total $P_2O_5$. High readily soluble $P_2O_5$ except in lower part of $B_2$. |
| $B_2$ | 10-14 | 8·52 | 90·5 | 2·2 | 91·1 | 1·6 | 3·0 | 26·70 | 1·65 | 0·30 | 0·12 | Nil | 100 | 8·96 | 0·57 | 0·062 | 52 | 24·2 | |
| $B_2$ | 20-24 | 2·67 | 71·2 | 18·6 | 80·9 | 8·9 | 7·5 | 10·94 | 0·79 | 0·33 | 0·18 | Nil | 100 | 8·89 | 0·39 | 0·042 | 94 | 4·5 | |
| C | 30-34 | 2·16 | 62·4 | 22·2 | 74·1 | 10·5 | 13·2 | 7·29 | 0·85 | 0·30 | 0·18 | Nil | 100 | 8·53 | | | 67 | 11·3 | |
| C | 37-41 | 2·80 | 55·0 | 29·6 | 73·2 | 11·4 | 12·6 | 8·36 | 0·93 | 0·37 | 0·18 | Nil | 100 | 7·99 | | | 117 | 43·6 | |
| C | 48-52 | 2·35 | 61·8 | 23·7 | 76·5 | 8·9 | 12·2 | 7·60 | 0·85 | 0·35 | 0·17 | Nil | 100 | 8·32 | | | 82 | 13·5 | |

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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7. | | | | | | | | INSCH ASSOCIATION; Insch Series. Pitellachie, 54520–54524 | | | | | | | | | | | |
| S | 0-6 | 11·00 | N.D. | N.D. | 50·8 | 21·1 | 22·6 | 4·67 | 0·20 | N.D. | 0·08 | 10·20 | 32·3 | 5·66 | 4·84 | 0·323 | 395 | 3·8 | Low exchangeable Mg except in C. Low exchangeable K. High total $P_2O_5$ in S and $B_2$. High readily soluble $P_2O_5$ in $B_3$. |
| S | 8-13 | 9·99 | N.D. | N.D. | 49·5 | 23·8 | 21·8 | 2·90 | 0·13 | N.D. | 0·05 | 10·04 | 20·7 | 5·55 | 3·93 | 0·302 | 389 | 2·1 | |
| $B_2$ | 15-18 | 6·49 | N.D. | N.D. | 64·0 | 16·3 | 16·5 | 1·61 | 0·12 | N.D. | 0·06 | 6·75 | 20·7 | 5·60 | | | 319 | 3·7 | |
| $B_3$ | 22-27 | 2·95 | N.D. | N.D. | 67·5 | 13·9 | 15·7 | 3·42 | 0·29 | N.D. | 0·06 | 2·58 | 56·0 | 5·71 | | | 130 | 24·1 | |
| C | 36-42 | 3·84 | N.D. | N.D. | 50·7 | 18·9 | 26·6 | 6·15 | 0·99 | N.D. | 0·05 | 3·18 | 69·4 | 5·24 | | | 187 | 9·4 | |
| 8. | | | | | | | | INSCH ASSOCIATION; Insch Series. Inschfield, 33491–33497 | | | | | | | | | | | |
| S | 0-6 | 11·97 | N.D. | N.D. | 58·8 | 15·7 | 20·7 | 9·64 | 1·08 | N.D. | 0·06 | 12·70 | 46·0 | 5·51 | 4·37 | 0·400 | 590 | 11·6 | High exchangeable Ca in S and C(g). Low exchangeable Mg in $B_2$. Low exchangeable K. High total $P_2O_5$. High readily soluble $P_2O_5$ in S and $B_3$, very high in C(g). |
| S | 18-24 | 12·30 | N.D. | N.D. | 56·7 | 16·0 | 33·0 | 5·55 | 0·34 | N.D. | 0·05 | 14·45 | 29·0 | 5·52 | 4·62 | 0·360 | 640 | 4·6 | |
| $B_2$ | 27-30 | 8·00 | N.D. | N.D. | 76·3 | 10·4 | 11·0 | 1·46 | 0·06 | N.D. | 0·01 | 9·03 | 14·5 | 5·63 | 1·88 | 0·180 | 520 | 5·3 | |
| $B_3$ | 32-34 | 4·35 | N.D. | N.D. | 83·7 | 9·5 | 9·9 | 1·39 | 0·91 | N.D. | 0·01 | 4·34 | 35·0 | 5·70 | | | 520 | 36·2 | |
| C(g) | 38-40 | 4·60 | N.D. | N.D. | 81·1 | 10·7 | 11·3 | 8·56 | 0·92 | N.D. | 0·05 | 4·52 | 68·0 | 5·81 | | | 650 | 85·4 | |
| C(g) | 46-50 | 4·78 | N.D. | N.D. | 74·8 | 14·1 | 13·8 | 13·50 | 2·06 | N.D. | 0·07 | 4·57 | 77·0 | 6·04 | | | 590 | 82·8 | |
| C(g) | 54-58 | 5·72 | N.D. | N.D. | 73·5 | 13·6 | 14·2 | 19·11 | 3·84 | N.D. | 0·10 | 5·30 | 81·0 | 6·13 | | | 490 | 68·8 | |

9. INSCH ASSOCIATION; Insch Series. Harthill, 83699–83704

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-4 | 15·30 | N.D. | N.D. | 38·5 | 23·9 | 26·0 | 2·09 | 0·22 | N.D. | 0·07 | 20·60 | 10·3 | 5·41 | 5·28 | 0·335 | 653 | 0·6 | High exchangeable Ca in C(g), otherwise low. |
| S | 6-11 | 11·50 | N.D. | N.D. | 43·5 | 22·0 | 28·8 | 2·89 | 0·15 | N.D. | 0·09 | 12·95 | 19·7 | 5·96 | 3·85 | 0·295 | 431 | 3·0 | Low exchangeable Mg and K except in C(g). |
| $B_2$(g) | 13-16 | 3·51 | N.D. | N.D. | 66·0 | 10·2 | 20·3 | 1·78 | 0·13 | N.D. | 0·09 | 8·68 | 18·7 | 5·75 | 1·66 | 0·167 | 402 | 2·7 | High total $P_2O_5$. |
| $B_3$(g) | 18-22 | 3·60 | N.D. | N.D. | 63·6 | 14·9 | 18·8 | 1·29 | 0·10 | N.D. | 0·07 | 5·58 | 20·9 | 6·10 | | | 346 | 11·1 | Low readily soluble $P_2O_5$ in S and $B_2$(g), high in $B_3$(g) and C(g). |
| C(g) | 27-31 | 4·35 | N.D. | N.D. | 58·9 | 14·0 | 24·9 | 11·89 | 1·38 | N.D. | 0·16 | 4·15 | 76·7 | 6·16 | | | 322 | 47·8 | |
| C(g) | 37-41 | 3·67 | N.D. | N.D. | 57·9 | 16·7 | 21·8 | 13·55 | 2·10 | N.D. | 0·17 | 2·59 | 86·2 | 6·76 | | | 341 | 56·8 | |

10. INSCH ASSOCIATION; Insch Series. Drumrossie, 12286–12292A

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-4 | 10·12 | N.D. | N.D. | 57·1 | 15·2 | 24·2 | 12·16 | 0·71 | N.D. | 0·07 | 9·50 | 58·0 | 5·68 | 3·78 | 0·315 | 580 | 10·6 | High exchangeable Ca in S and C(g). |
| S | 4-8 | 9·88 | N.D. | N.D. | 58·5 | 15·4 | 23·8 | 12·40 | 0·57 | N.D. | 0·05 | 8·45 | 62·0 | 5·81 | N.D. | N.D. | N.D. | N.D. | Low exchangeable Mg in $B_2$ and $B_3$. |
| S | 10-14 | 9·16 | N.D. | N.D. | 58·0 | 15·3 | 24·0 | 11·20 | 0·32 | N.D. | 0·02 | 8·73 | 57·0 | 5·78 | 3·20 | 0·300 | N.D. | N.D. | Low exchangeable K. |
| S | 22-26 | 11·61 | N.D | N.D. | 55·4 | 16·7 | 24·4 | 4·80 | 0·08 | N.D. | 0·02 | 14·39 | 26·0 | 5·70 | N.D. | N.D. | 580 | 3·7 | High total $P_2O_5$. |
| $B_3$ | 28-30 | 9·70 | N.D. | N.D. | 67·6 | 12·2 | 18·0 | 2·60 | 0·07 | N.D. | 0·01 | 10·65 | 20·0 | 5·64 | 2·38 | 0·260 | 496 | 4·6 | High readily soluble $P_2O_5$ in $B_3$, very high in C(g). |
| $B_3$ | 32-36 | 6·03 | N.D. | N.D. | 78·4 | 10·5 | 11·5 | 3·56 | 0·03 | N.D. | 0·03 | 6·32 | 24·0 | 5·81 | | | 527 | 29·2 | |
| C(g) | 38-42 | 5·20 | N.D. | N.D. | 76·1 | 10·7 | 13·5 | 9·05 | 0·43 | N.D. | 0·03 | 5·26 | 65·0 | 5·85 | | | 527 | 87·7 | |
| C(g) | 46-50 | 4·63 | N.D. | N.D. | 70·2 | 14·1 | 16·5 | 17·70 | 2·95 | N.D. | 0·06 | 3·71 | 85·0 | 5·96 | | | 526 | 81·3 | |

11. INSCH ASSOCIATION; Insch Series. Newton of Ardoyne, 3521–3526

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 16·54 | N.D. | N.D. | 66·8 | 11·1 | 14·2 | 5·81 | 2·10 | N.D. | N.D. | 16·85 | 32·1 | 5·32 | 5·56 | 0·520 | N.D. | N.D. | High sand content in D. |
| $B_2$ | 6-10 | 8·65 | N.D. | N.D. | 80·5 | 7·3 | 9·6 | 2·08 | 0·74 | N.D. | N.D. | 8·02 | 26·0 | 5·42 | 2·94 | 0·240 | N.D. | N.D. | High exchangeable Ca in $B_3$, C and D. |
| $B_3$ | 28-32 | 3·69 | N.D. | N.D. | 80·6 | 10·6 | 11·3 | 9·56 | 3·01 | N.D. | N.D. | 3·63 | 77·6 | 6·63 | | | N.D. | N.D. | |
| C | 32-36 | 4·74 | N.D. | N.D. | 85·8 | 4·8 | 7·6 | 11·25 | 3·33 | N.D. | N.D. | 2·93 | 83·3 | 6·59 | | | N.D. | N.D. | |
| D | 40-44 | 3·84 | N.D. | N.D. | 93·8 | 4·0 | 4·9 | 12·30 | 3·20 | N.D. | N.D. | 1·35 | 92·0 | 7·05 | | | N.D. | N.D. | |
| D | 64-72 | 4·04 | N.D. | N.D. | 92·3 | 2·5 | 6·0 | 20·00 | 4·43 | N.D. | N.D. | Nil | 100 | 7·19 | | | N.D. | N.D. | |

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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12. | | | | | | | | INSCH ASSOCIATION; Insch Series. Wester Fingask, 15278–15282 | | | | | | | | | | | |
| S | 0-4 | 12·82 | N.D. | N.D. | 61·0 | 13·6 | 19·8 | 4·27 | 0·58 | N.D. | 0·12 | 14·30 | 25·6 | 5·48 | 3·84 | 0·430 | N.D. | N.D. | Low exchangeable Ca in $B_2$ and $B_3$, high in C(g). High exchangeable Mg in C(g). Low exchangeable K in $B_2$ and $B_3$. |
| S | 8-12 | 12·63 | N.D. | N.D. | 63·9 | 14·8 | 21·7 | 2·61 | 0·36 | N.D. | 0·08 | 13·80 | 18·0 | 5·37 | 3·78 | 0·330 | N.D | N.D. | |
| $B_2$ | 14-17 | 8·03 | N.D. | N D | 84·2 | 9·3 | 6·7 | 2·11 | 0·32 | N.D. | 0·07 | 10·20 | 19·6 | 5·17 | | | N.D. | N.D. | |
| $B_3$ | 23-27 | 4·91 | N.D. | N.D. | 82·9 | 11·0 | 8·2 | 1·63 | 0·69 | N.D. | 0·06 | 4·60 | 33·0 | 5·48 | | | N.D. | N.D. | |
| C(g) | 42-44 | 4·72 | N.D. | N.D. | 70·5 | 13·1 | 18·1 | 16·45 | 5·40 | N.D. | 0·19 | 2·90 | 88·1 | 6·26 | | | N.D. | N.D. | |
| 13. | | | | | | | | INSCH ASSOCIATION; Insch Series. Logie, Pitcaple, 3536–3541 | | | | | | | | | | | |
| S | 0-10 | 14·86 | N.D. | N.D. | 53·9 | 15·3 | 22·2 | 7·00 | 0·57 | N.D. | N.D. | 12·65 | 37·4 | 5·09 | N.D. | N.D. | N.D. | N.D. | High sand content in lower horizons. High exchangeable Ca in C(g) and D. |
| $B_2$ | 10-14 | 8·61 | N.D. | N.D. | 76·9 | 10·7 | 11·7 | 3·44 | 0·27 | N.D. | N.D. | 8·80 | 29·6 | 5·60 | N.D. | N.D. | N.D. | N.D. | |
| $B_3$ | 20-24 | 4·44 | N.D. | N.D. | 74·5 | 13·0 | 13·4 | 4·47 | 0·46 | N.D. | N.D. | 2·40 | 67·4 | 5·68 | | | N.D. | N.D. | |
| C(g) | 30-34 | 4·76 | N.D. | N.D. | 68·0 | 16·5 | 14·7 | 14·50 | 4·90 | N.D. | N.D. | 2·68 | 87·8 | 5·72 | | | N.D. | N.D. | |
| C(g) | 36-40 | 4·06 | N.D. | N.D. | 93·4 | 4·5 | 4·9 | 10·65 | 2·82 | N.D. | N.D. | 1·85 | 87·8 | 5·62 | | | N.D. | N.D. | |
| D | 56-60 | 2·66 | N.D. | N.D. | 94·9 | 3·8 | 4·2 | 11·05 | 2·52 | N.D. | N.D. | 1·34 | 91·0 | 5·89 | | | N.D. | N.D. | |
| 14. | | | | | | | | INSCH ASSOCIATION; Insch Series. Hillhead of Lethenty, 15251–15255 | | | | | | | | | | | |
| S | 0-4 | 14·40 | N.D. | N.D. | 54·3 | 17·2 | 19·6 | 5·47 | 1·20 | N.D. | 0·27 | 13·87 | 33·3 | 5·75 | 5·13 | N.D. | N.D. | N.D. | Low exchangeable Ca in $B_2$ and $B_3$, high in C. Low exchangeable K in $B_3$. |
| $B_2$ | 14-17 | 11·48 | N.D. | N.D. | 57·2 | 19·9 | 21·0 | 4·00 | 0·44 | N.D. | 0·09 | 14·25 | 25·5 | 5·75 | 4·35 | N.D. | N.D. | N.D. | |
| $B_2$ | 18-22 | 8·65 | N.D. | N.D. | 70·4 | 11·8 | 17·1 | 1·99 | 0·23 | N.D. | 0·12 | 10·56 | 18·1 | 5·55 | | | N.D. | N.D. | |
| $B_3$ | 23-26 | 4·25 | N.D. | N.D. | 77·3 | 9·7 | 12·8 | 1·61 | 0·34 | N.D. | 0·06 | 5·14 | 28·1 | 5·87 | | | N.D. | N.D. | |
| C | 30-36 | 4·15 | N.D. | N.D. | 63·1 | 15·8 | 21·0 | 11·10 | 3·80 | N.D. | 0·11 | 3·16 | 82·8 | 6·59 | | | N.D. | N.D. | |

15. INSCH ASSOCIATION; Insch Series. Glack, 150572–150575

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 1-3 | 20·80 | 61·4 | 19·2 | 74·2 | 6·4 | 3·8 | 11·62 | 3·84 | 0·35 | 0·69 | 14·06 | 54·0 | 5·92 | 9·45 | 0·507 | 110 | 0·5 | High exchangeable Ca in top horizon. |
| A | 5-8 | 14·80 | 68·0 | 18·1 | 78·0 | 8·1 | 6·5 | 7·04 | 2·15 | 0·25 | 0·36 | 10·31 | 48·7 | 5·95 | 5·65 | 0·317 | 157 | 0·2 | Low readily soluble $P_2O_5$ except in $B_3$. |
| $B_2$ | 12-17 | 8·71 | 80·5 | 12·0 | 83·6 | 8·9 | 3·1 | 4·19 | 1·41 | 0·16 | 0·16 | 6·18 | 48·9 | 6·15 | | | 157 | 0·6 | |
| $B_3$ | 21-25 | 3·72 | 72·7 | 19·8 | 82·3 | 10·2 | 7·6 | 2·14 | 0·88 | 0·16 | 0·12 | 1·29 | 71·9 | 6·37 | | | 218 | 6·5 | |

16. LESLIE ASSOCIATION; Leslie Series. Beauty Hill, 111494–111498

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L/F | 3-0 | 31·70 | N.D. | N.D. | N.D. | N.D. | N.D. | 6·22 | 30·40 | 0·64 | 0·60 | 6·85 | 84·7 | 5·79 | 16·50 | 1·090 | 162 | 5·5 | Low exchangeable Ca except in L/F. |
| $B_2$ | 0-3 | 16·40 | 47·2 | 26·8 | 60·6 | 13·4 | 13·7 | 3·02 | 27·46 | 0·39 | 0·16 | 3·56 | 90·0 | 6·52 | 5·26 | 0·110 | 82 | 4·0 | Very high exchangeable Mg. |
| $B_3$ | 4-8 | 11·30 | 40·5 | 34·0 | 54·8 | 19·7 | 19·8 | 1·43 | 27·55 | 0·37 | 0·07 | 0·12 | 99·6 | 6·96 | | | 56 | 1·0 | Low total $P_2O_5$ except in L/F. |
| C | 11-15 | 8·28 | 55·3 | 23·2 | 63·9 | 14·6 | 17·4 | 0·79 | 24·65 | 0·28 | 0·07 | Nil | 100 | 7·52 | | | 49 | 4·1 | Low readily soluble $P_2O_5$ in $B_2$ and D. |
| D | 19-23 | 9·03 | 55·8 | 23·7 | 65·9 | 13·6 | 16·0 | 0·79 | 27·15 | 0·23 | 0·11 | Nil | 100 | 7·90 | | | 54 | 1·1 | |



17. LESLIE ASSOCIATION; Leslie Series. Towanreef, 109758–109760

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 4-8 | 9·40 | 45·5 | 26·8 | 58·3 | 14·0 | 23·0 | 0·79 | 22·25 | 0·12 | 0·24 | 3·36 | 87·5 | 6·78 | 2·43 | 0·240 | 94 | 0·6 | Low exchangeable Ca. |
| $B_2$ | 14-22 | 6·12 | 69·7 | 16·4 | 75·9 | 10·2 | 10·8 | 0·31 | 27·33 | 0·11 | 0·03 | 1·27 | 95·5 | 7·18 | 1·01 | 0·129 | 75 | 0·6 | Very high exchangeable Mg. |
| C | 26-32 | 5·80 | 77·2 | 11·9 | 81·6 | 7·5 | 8·0 | 0·31 | 21·90 | 0·09 | 0·03 | 1·06 | 95·5 | 6·68 | | | 83 | 1·8 | Low exchangeable K in $B_2$ and C. Low total and readily soluble $P_2O_5$. |

18. TARVES ASSOCIATION; Tarves Series. Nethermuir, 47431–47434

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 22·40 | N.D. | N.D. | 47·9 | 20·5 | 16·3 | 6·70 | 0·82 | N.D. | 0·22 | 21·30 | 26·1 | 5·75 | N.D. | N.D. | 300 | 1·5 | Low exchangeable Ca and Mg in $B_3$ and C. |
| $B_2$ | 7-10 | 16·90 | N.D. | N.D. | 55·4 | 23·6 | 14·9 | 3·19 | 0·41 | N.D. | 0·15 | 17·60 | 16·1 | 5·90 | N.D. | N.D. | 170 | 0·6 | Low total $P_2O_5$ in C. |
| $B_3$ | 12-14 | 9·29 | N.D. | N.D. | 75·2 | 17·3 | 7·4 | 2·88 | 0·18 | N.D. | 0·15 | 6·73 | 32·0 | 6·02 | N.D. | N.D. | 100 | 0·3 | Low readily soluble $P_2O_5$. |
| C | 16-20 | 4·95 | N.D. | N.D. | 61·6 | 27·4 | 8·5 | 2·64 | 0·20 | N.D. | 0·26 | 3·58 | 46·5 | 6·16 | N.D. | N.D. | 90 | 0·7 | |

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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19. | | | | | | | | TARVES ASSOCIATION; Tarves Series. Upper Crichie, 118409–118413 | | | | | | | | | | | |
| S | 2-6 | 8·37 | 47·0 | 26·4 | 58·5 | 14·9 | 22·4 | 4·66 | 0·36 | 0·11 | 0·16 | 8·10 | 39·4 | 5·52 | 2·99 | 0·195 | 313 | 8·2 | Low exchangeable Ca, Mg and K except in S. High total $P_2O_5$ in S. Low readily soluble $P_2O_5$ except in S. |
| $B_2$ | 10-14 | 5·82 | 58·3 | 22·4 | 67·1 | 13·6 | 16·4 | 1·69 | 0·12 | 0·08 | 0·09 | 4·63 | 30·1 | 5·42 | 0·98 | 0·069 | 161 | 1·4 | |
| $B_3$ | 17-21 | 4·55 | 63·3 | 20·6 | 72·3 | 11·6 | 13·8 | 1·22 | 0·19 | 0·07 | 0·07 | 3·11 | 33·3 | 5·81 | | | 102 | 0·7 | |
| C | 26-30 | 3·64 | 60·0 | 27·2 | 75·2 | 12·0 | 9·2 | 1·38 | 0·18 | 0·04 | 0·09 | 0·79 | 68·1 | 5·54 | | | 144 | 0·9 | |
| C | 36-40 | 3·69 | 64·9 | 20·2 | 75·3 | 9·8 | 11·2 | 1·07 | 0·19 | 0·05 | 0·07 | 0·79 | 63·7 | 5·57 | | | 138 | 1·9 | |
| 20. | | | | | | | | TARVES ASSOCIATION; Tarves Series. Nether Aden, 111393–111396 | | | | | | | | | | | |
| S | 3-7 | 10·00 | 45·6 | 28·3 | 60·7 | 13·2 | 21·1 | 5·44 | 0·50 | 0·16 | 0·10 | 8·70 | 41·6 | 5·65 | 4·17 | 0·286 | 343 | 4·2 | High sand content in C. Low exchangeable Ca in $B_2$ and $B_3$. Low exchangeable Mg in C. Low exchangeable K in $B_2$. High total $P_2O_5$ in S. |
| $B_2$ | 14-18 | 5·64 | 55·0 | 21·3 | 65·1 | 12·2 | 20·9 | 2·32 | 0·30 | 0·10 | 0·07 | 6·59 | 29·7 | 5·68 | 1·18 | 0·090 | 210 | 3·8 | |
| $B_3$ | 23-28 | 4·32 | 54·2 | 23·6 | 62·0 | 13·8 | 20·0 | 2·32 | 0·64 | 0·09 | 0·10 | 4·27 | 42·4 | 5·74 | | | 109 | 2·9 | |
| C | 36-42 | 2·99 | 82·6 | 9·3 | 87·9 | 4·0 | 5·1 | 7·48 | 0·07 | 0·10 | 0·14 | 1·48 | 83·9 | 5·41 | | | 134 | 4·7 | |
| 21. | | | | | | | | TARVES ASSOCIATION; Tarves Series. Balwearie, 47337–47340 | | | | | | | | | | | |
| S | 0-8 | 8·97 | N.D. | N.D. | 46·5 | 39·8 | 19·2 | 3·80 | 0·54 | N.D. | 0·07 | 10·59 | 29·5 | 5·25 | 3·37 | 0·278 | 240 | 0·8 | Low exchangeable K in S and $B_3$. Low total $P_2O_5$ in C. Low readily soluble $P_2O_5$ in S and $B_2$. |
| $B_2$ | 12-16 | 4·37 | N.D. | N.D. | 77·3 | 11·3 | 11·4 | 5·70 | 0·34 | N.D. | 1·06 | 11·92 | 37·3 | 5·39 | 0·57 | 0·062 | 170 | 0·1 | |
| $B_3$ | 22-26 | 3·97 | N.D. | N.D. | 69·3 | 17·1 | 9·7 | 7·35 | 2·11 | N.D. | 0·07 | 4·37 | 68·5 | 5·68 | | | 110 | 8·9 | |
| C | 38-42 | 4·47 | N.D. | N.D. | 67·7 | 20·3 | 9·8 | 5·23 | 2·26 | N.D. | 0·17 | 3·97 | 65·8 | 5·96 | | | 80 | 6·9 | |

22. TARVES ASSOCIATION; Tarves Series. Balquhain, 47359–47364

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 12·10 | N.D. | N.D. | 47·0 | 22·5 | 24·5 | 6·24 | 0·52 | N.D. | 0·15 | 12·80 | 28·6 | 5·54 | 3·87 | 0·342 | 340 | 2·2 | Low exchangeable Ca in $B_3$. Low exchangeable Mg and K in $B_2$ and $B_3$. High total $P_2O_5$ in S and $B_2$. Low readily soluble $P_2O_5$ in S and $B_2$, high in $B_3$, C and D. |
| $B_2$ | 11-15 | 9·57 | N.D. | N.D. | 50·1 | 26·8 | 18·3 | 6·77 | 0·25 | N.D. | 0·07 | 9·40 | 43·0 | 6·06 | 3·15 | 0·271 | 320 | 1·3 | |
| $B_2$ | 16-20 | 6·91 | N.D. | N.D. | 61·3 | 19·3 | 16·0 | 2·28 | 0·16 | N.D. | 0·09 | 7·67 | 24·8 | 5·98 | | | 270 | 3·4 | |
| $B_3$ | 22-26 | 4·36 | N.D. | N.D. | 70·4 | 11·9 | 15·5 | 1·33 | 0·09 | N.D. | 0·08 | 4·63 | 24·5 | 6·06 | | | 230 | 19·0 | |
| C | 32-36 | 4·33 | N.D. | N.D. | 61·4 | 15·6 | 20·9 | 6·47 | 1·21 | N.D. | 0·22 | 3·79 | 67·5 | 5·89 | | | 200 | 20·0 | |
| D | 44-48 | 5·32 | N.D. | N.D. | 60·9 | 18·9 | 17·6 | 6·53 | 2·19 | N.D. | 0·16 | 5·09 | 64·7 | 5·86 | | | 180 | 12·0 | |

23. TARVES ASSOCIATION; Tarves Series. Drumwhindle Mains, 47442–47446

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 11·40 | N.D. | N.D. | 53·1 | 25·2 | 16·5 | 9·57 | 0·66 | N.D. | 0·19 | 7·82 | 57·3 | 6·08 | 4·38 | 0·353 | 280 | 2·6 | High exchangeable Ca in S, low in $B_3$, B–C and C. Low exchangeable Mg in $B_3$, B–C and C. Low readily soluble $P_2O_5$ in S, $B_2$ and B–C. |
| $B_2$ | 10-14 | 9·28 | N.D. | N.D. | 64·2 | 17·6 | 13·6 | 6·29 | 0·38 | N.D. | 0·13 | 7·61 | 47·2 | 6·12 | 3·15 | 0·272 | 220 | 0·7 | |
| $B_3$ | 16-20 | 5·60 | N.D. | N.D. | 74·7 | 13·2 | 12·1 | 1·27 | 0·05 | N.D. | 0·10 | 3·95 | 26·5 | 5·90 | | | 180 | 7·9 | |
| B–C | 24-28 | 4·83 | N.D. | N.D. | 69·3 | 15·4 | 12·9 | 1·01 | 0·08 | N.D. | 0·15 | 1·98 | 38·4 | 6·06 | | | 130 | 1·6 | |
| C | 40-44 | 4·13 | N.D. | N.D. | 82·1 | 7·9 | 10·0 | 1·19 | 0·22 | N.D. | 0·09 | 1·98 | 43·1 | 5·79 | | | 110 | 4·2 | |

24. TARVES ASSOCIATION; Tarves Series. Millhill, 110430–110434

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 9·87 | 48·5 | 26·8 | 58·8 | 16·5 | 19·8 | 6·57 | 0·46 | 0·16 | 0·40 | 13·43 | 36·0 | 5·79 | 4·04 | 0·277 | 277 | 10·2 | Low exchangeable Ca except in S. Low exchangeable Mg and K in C and D. High readily soluble $P_2O_5$ in S, otherwise low. |
| $B_2$ | 12-18 | 5·86 | 54·7 | 23·2 | 62·6 | 15·3 | 19·2 | 2·33 | 0·32 | 0·12 | 0·23 | 8·10 | 27·0 | 5·74 | 1·48 | 0·067 | 158 | 1·4 | |
| $B_3$ | 20-24 | 4·37 | 52·2 | 25·9 | 64·9 | 13·2 | 19·7 | 2·17 | 0·49 | 0·16 | 0·15 | 4·83 | 38·1 | 5·75 | | | 114 | 1·3 | |
| C | 30-34 | 2·49 | 72·8 | 14·9 | 78·4 | 9·3 | 9·8 | 0·92 | 0·18 | 0·09 | 0·07 | 1·14 | 52·5 | 5·82 | | | 102 | 1·7 | |
| D | 36-42 | 2·38 | 85·4 | 7·1 | 88·1 | 4·5 | 5·1 | 0·77 | 0·12 | 0·06 | 0·05 | 3·98 | 20·1 | 5·73 | | | 134 | 1·7 | |

25. TARVES ASSOCIATION; Tarves Series. Tillycorthie, 40978–40981

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-7 | 10·75 | N.D. | N.D. | 54·7 | 17·7 | 22·2 | 4·50 | 0·34 | N.D. | 0·22 | 10·60 | 32·3 | 5·44 | 4·23 | 0·320 | 310 | 6·5 | Low exchangeable Ca and Mg except in S. High total $P_2O_5$ in S. |
| $B_3$ | 9-12 | 3·67 | N.D. | N.D. | 59·0 | 17·3 | 20·0 | 1·77 | 0·27 | N.D. | 0·24 | 5·00 | 31·3 | 5·66 | 0·41 | 0·044 | 126 | 4·6 | |
| $B_3$ | 18-22 | 4·36 | N.D. | N.D. | 62·9 | 14·5 | 20·4 | 1·37 | 0·31 | N.D. | 0·20 | 4·23 | 30·6 | 5·80 | | | 123 | 3·5 | |
| C | 30-34 | 3·44 | N.D. | N.D. | 62·7 | 10·9 | 23·0 | 1·55 | 0·22 | N.D. | 0·18 | 4·93 | 28·4 | 5·53 | | | 125 | 3·6 | |

TABLE 1—Continued

| Horizon | Depth in. | % Loss on | Soil Separates % Sand U.S.D.A. | % Silt U.S.D.A. | % Sand Inter. | % Silt Inter. | % Clay | Exchangeable Cations m.e./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26. | TARVES ASSOCIATION; Tarves Series. Cairnbrogie, 25531–25535 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 10·00 | N.D. | N.D. | 57·2 | 13·2 | 24·6 | 3·69 | 0·49 | N.D. | 0·14 | 11·34 | 27·6 | 5·26 | 3·53 | 0·310 | 369 | 3·8 | Low exchangeable Ca in $B_2$ and $B_3$. |
| S | 10-16 | 9·61 | N.D. | N.D. | 52·3 | 18·9 | 23·8 | 5·00 | 0·36 | N.D. | 0·05 | 9·72 | 35·9 | 5·59 | 2·77 | 0·270 | 338 | 2·0 | Low exchangeable Mg in $B_2$. |
| $B_2$ | 18-20 | 6·33 | N.D. | N.D. | 60·4 | 17·3 | 19·3 | 2·38 | 0·21 | N.D. | 0·06 | 6·75 | 28·2 | 5·58 | | | 210 | 2·7 | Low exchangeable K in S and $B_2$. |
| $B_3$ | 24-30 | 4·49 | N.D. | N.D. | 66·3 | 13·5 | 17·7 | 2·78 | 0·33 | N.D. | 0·13 | 4·59 | 37·5 | 5·93 | | | 80 | 2·0 | High total $P_2O_5$ in S, low in $B_2$. |
| C | 40-48 | 5·41 | N.D. | N.D. | 89·5 | 4·0 | 6·5 | 5·40 | 0·53 | N.D. | 0·23 | 15·39 | 28·5 | 5·10 | | | 197 | 15·0 | High readily soluble $P_2O_5$ in C, otherwise low. |
| 27. | TARVES ASSOCIATION; Tarves Series. Craigies, 28116–28119 | | | | | | | | | | | | | | | | | | |
| S | 0-6 | 12·91 | N.D. | N.D. | 59·7 | 18·3 | 15·5 | 6·85 | 0·51 | N.D. | 0·13 | 13·78 | 36·0 | 5·68 | 5·52 | 0·394 | 320 | 3·3 | Low exchangeable Ca and Mg except in S. |
| $B_2$ | 12-16 | 8·11 | N.D. | N.D. | 54·0 | 16·8 | 24·7 | 1·01 | 0·16 | N.D. | 0·09 | 12·05 | 9·5 | 5·05 | 2·47 | 0·207 | 270 | N.D. | Low exchangeable K in $B_2$ and $B_3$. |
| $B_3$ | 20-22 | 4·90 | N.D. | N.D. | 55·8 | 35·3 | 6·4 | 0·70 | 0·10 | N.D. | 0·08 | 6·02 | 12·5 | 5·09 | | | 90 | N.D. | High total $P_2O_5$ in S, low in $B_3$. |
| C | 34-36 | 5·12 | N.D. | N.D. | 77·2 | 8·4 | 14·4 | 1·00 | 0·06 | N.D. | 0·10 | 5·03 | 18·9 | 5·12 | | | 180 | N.D. | Low readily soluble $P_2O_5$. |

28. TARVES ASSOCIATION; Tarves Series. Allathan, 28019–28023

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-4 | 11·25 | N.D. | N.D. | 49·2 | 19·3 | 25·7 | 5·44 | 0·75 | N.D. | 0·05 | 15·21 | 29·0 | 5·24 | 5·22 | 0·370 | 380 | 7·0 | Clay content above average for Tarves series.<br>Low exchangeable Ca and Mg in $B_2$ and $B_3$.<br>Low exchangeable K except in C.<br>High total $P_2O_5$ in S, low in $B_3$.<br>Low readily soluble $P_2O_5$ in C. |
| S | 10-14 | 10·30 | N.D. | N.D. | 51·1 | 19·6 | 24·1 | 2·52 | 0·25 | N.D. | 0·03 | 17·34 | 19·0 | 5·27 | 5·05 | 0·300 | 420 | 7·8 | |
| $B_2$ | 16-20 | 5·04 | N.D. | N.D. | 60·0 | 13·3 | 24·1 | 1·14 | 0·20 | N.D. | 0·03 | 8·40 | 14·0 | 5·27 | | | 140 | 10·0 | |
| $B_3$ | 22-26 | 3·88 | N.D. | N.D. | 61·1 | 8·7 | 26·3 | 2·42 | 0·26 | N.D. | Nil | 7·19 | 27·2 | 5·05 | | | 90 | 3·3 | |
| C | 40-44 | 3·36 | N.D. | N.D. | 60·5 | 11·7 | 24·4 | 5·83 | 1·48 | N.D. | 0·11 | 4·08 | 64·6 | 5·90 | | | 130 | 0·8 | |

29. TARVES ASSOCIATION; Tarves Series. Pittenderich, 150636–150640

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2-6 | 17·20 | 61·2 | 15·5 | 69·8 | 6·9 | 10·4 | 0·64 | 0·39 | 0·14 | 0·37 | 19·90 | 7·2 | 4·87 | 7·20 | 0·440 | 213 | 0·6 | Very low exchangeable Ca.<br>Low exchangeable Mg except in A.<br>Low exchangeable K except in A.<br>Low readily soluble $P_2O_5$ in A. |
| $B_2$ | 9-13 | 6·69 | 57·5 | 26·8 | 67·8 | 16·5 | 12·4 | Nil | Nil | 0·10 | 0·05 | 10·82 | 1·4 | 5·18 | 1·60 | 0·107 | 194 | 4·7 | |
| $B_3$ | 15-20 | 4·57 | 55·4 | 24·9 | 68·1 | 14·5 | 17·4 | Nil | 0·06 | 0·07 | 0·07 | 4·86 | 4·0 | 5·26 | | | 146 | 5·8 | |
| C | 24-28 | 4·80 | 60·4 | 25·1 | 70·6 | 14·9 | 12·1 | Nil | Nil | 0·07 | 0·07 | 6·26 | 2·2 | 5·05 | | | 200 | 11·2 | |
| C | 34·38 | 6·51 | 63·5 | 26·9 | 76·0 | 14·4 | 6·3 | Nil | 0·07 | 0·13 | 0·27 | 5·62 | 7·7 | 5·47 | | | 190 | 7·0 | |

## TABLE 2. 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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **30.** | | | | | | | | COLLIESTON ASSOCIATION; Collieston Series. Mains of Slains, 109692–109696 | | | | | | | | | | | |
| S | 0-8 | 7·70 | 41·1 | 26·5 | 50·1 | 17·5 | 28·5 | 6·33 | 1·65 | 0·29 | 0·15 | 8·42 | 50·0 | 5·73 | 3·76 | 0·271 | 229 | 5·7 | High clay content in $B_3(g)$ and D. High exchangeable Ca in $B_3(g)$ and D. High exchangeable Mg in $B_3(g)$, C(g) and D. Low readily soluble $P_2O_5$ in $B_3(g)$ and C(g), high in D. Low total $P_2O_5$ in $B_3(g)$ and C(g). |
| $B_2(g)$ | 12-17 | 3·08 | 40·4 | 36·5 | 65·9 | 11·0 | 20·0 | 4·60 | 1·46 | 0·25 | 0·10 | 3·33 | 65·8 | 6·06 | 1·31 | 0·067 | 119 | 8·2 | |
| $B_3(g)$ | 20-25 | 3·96 | 23·0 | 31·0 | 31·2 | 22·8 | 42·0 | 9·24 | 5·67 | 0·46 | 0·34 | 2·46 | 86·5 | 6·15 | | | 56 | 0·2 | |
| C(g) | 34-38 | 2·48 | 42·3 | 26·8 | 50·5 | 18·6 | 28·4 | 6·67 | 6·10 | 0·36 | 0·27 | 1·29 | 91·4 | 6·01 | | | 65 | 1·0 | |
| D | 44-48 | 4·08 | 21·0 | 33·5 | 27·5 | 27·0 | 43·5 | 8·48 | 12·30 | 0·52 | 0·42 | 1·09 | 95·2 | 6·53 | | | 112 | 20·0 | |
| **31.** | | | | | | | | COLLIESTON ASSOCIATION; Collieston Series. North Loirston, 125874–125878 | | | | | | | | | | | |
| S | 2-6 | 9·68 | 45·2 | 28·8 | 57·9 | 16·1 | 21·2 | 9·18 | 1·36 | 0·27 | 0·19 | 6·03 | 64·7 | 5·56 | 4·27 | 0·251 | 234 | 5·6 | High exchangeable Ca in S. Low total $P_2O_5$ in $B_2(g)$. High readily soluble $P_2O_5$ in C(g). |
| S | 9-13 | 6·56 | 50·2 | 23·8 | 60·6 | 13·4 | 22·7 | 9·44 | 1·38 | 0·24 | 0·14 | 4·90 | 69·8 | 6·22 | 2·60 | 0·169 | 150 | 3·3 | |
| $B_2(g)$ | 16-19 | 2·59 | 47·6 | 30·7 | 63·9 | 14·4 | 19·1 | 5·19 | 1·00 | 0·21 | 0·13 | Nil | 100 | 6·60 | | | 62 | 6·5 | |
| C(g) | 28-32 | 2·93 | 44·8 | 30·3 | 58·2 | 16·9 | 22·0 | 5·35 | 1·63 | 0·33 | 0·20 | 0·40 | 95·0 | 6·66 | | | 77 | 9·9 | |
| C(g) | 38-42 | 2·64 | 48·9 | 28·6 | 61·8 | 15·7 | 19·9 | 3·97 | 1·59 | 0·21 | 0·17 | 1·18 | 83·5 | 5·64 | | | 152 | 12·5 | |

32. COLLIESTON ASSOCIATION; Collieston Series. Blackhill of Cairnrobin, 125879–125883

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3-7 | 14·60 | 45·0 | 32·0 | 59·6 | 17·4 | 15·7 | 4·88 | 1·28 | 0·27 | 0·15 | 14·38 | 32·4 | 5·74 | 7·95 | 0·389 | 194 | 4·2 | Low total and readily soluble $P_2O_5$ in $B_2$(g). |
| $B_2$(g) | 12-16 | 3·36 | 42·3 | 32·4 | 55·0 | 19·7 | 21·9 | 3·54 | 1·42 | 0·22 | 0·13 | 1·59 | 77·0 | 5·36 | 0·50 | 0·037 | 76 | 1·6 | |
| $B_2$(g) | 20-24 | 2·83 | 52·7 | 24·6 | 61·9 | 15·4 | 19·9 | 3·38 | 2·54 | 0·22 | 0·15 | 2·39 | 72·5 | 5·34 | | | 107 | 2·5 | |
| C(g) | 28-32 | 2·83 | 48·0 | 28·1 | 60·3 | 15·8 | 21·1 | 3·54 | 4·16 | 0·27 | 0·21 | 1·50 | 84·5 | 5·56 | | | 115 | 3·8 | |
| C(g) | 36-40 | 2·65 | 55·6 | 23·5 | 64·7 | 14·4 | 18·2 | 4·15 | 4·77 | 0·33 | 0·27 | 2·79 | 77·2 | 5·82 | | | 118 | 6·6 | |

33. HATTON ASSOCIATION; Middlehill Series. Windyheads Hill, 118400–118404

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1-5 | 10·50 | 43·6 | 32·7 | 59·4 | 16·9 | 18·4 | 11·72 | 1·14 | 0·18 | 0·28 | 6·82 | 66·3 | 6·10 | 4·92 | 0·287 | 160 | 10·4 | High exchangeable Ca in S. Low total $P_2O_5$ except in S. High readily soluble $P_2O_5$ in S, otherwise low. |
| $B_2$(g) | 9-13 | 4·72 | 43·8 | 26·3 | 58·2 | 11·9 | 27·5 | 2·97 | 0·60 | 0·08 | 0·12 | 11·19 | 25·2 | 5·39 | 0·84 | 0·059 | 65 | 0·8 | |
| C(g) | 17-21 | 3·97 | 48·8 | 20·0 | 57·8 | 11·0 | 27·2 | 1·40 | 0·42 | 0·07 | 0·10 | 11·26 | 15·0 | 5·16 | | | 58 | 0·8 | |
| C(g) | 26-30 | 3·63 | 49·9 | 19·9 | 60·3 | 9·5 | 26·6 | 1·09 | 0·33 | 0·06 | 0·10 | 8·69 | 15·4 | 5·15 | | | 58 | 0·6 | |
| C(g) | 34-38 | 3·67 | 51·0 | 21·6 | 60·2 | 12·4 | 23·7 | 1·25 | 0·40 | 0·08 | 0·12 | 10·20 | 15·4 | 4·97 | | | 52 | 0·7 | |

34. NORTH MORMOND ASSOCIATION; North Mormond Series. Denhead, 119064–119068

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3-7 | 7·42 | 51·1 | 25·9 | 62·2 | 14·8 | 19·3 | 5·09 | 0·91 | 0·22 | 0·20 | 6·08 | 51·2 | 6·00 | 3·84 | 0·231 | 149 | 2·7 | Low exchangeable Ca in $B_3$(g) and C(g). Low total $P_2O_5$ in $B_2$(g) and $B_3$(g). Low readily soluble $P_2O_5$. |
| $B_2$(g) | 12-16 | 4·36 | 47·7 | 24·5 | 58·0 | 14·2 | 25·6 | 4·16 | 0·93 | 0·24 | 0·22 | 5·84 | 48·7 | 5·94 | 0·93 | 0·059 | 69 | 0·5 | |
| $B_3$(g) | 20-24 | 3·30 | 50·5 | 23·8 | 62·2 | 12·1 | 22·4 | 2·93 | 1·07 | 0·19 | 0·22 | 3·55 | 55·4 | 5·58 | | | 80 | 1·0 | |
| C(g) | 28-32 | 3·77 | 50·9 | 21·1 | 60·5 | 11·5 | 24·2 | 2·16 | 1·58 | 0·20 | 0·24 | 3·26 | 56·3 | 5·25 | | | 99 | 0·8 | |
| C(g) | 39-43 | 2·99 | 52·7 | 19·8 | 60·4 | 12·1 | 24·5 | 1·99 | 1·68 | 0·17 | 0·15 | 2·87 | 58·3 | 5·35 | | | 109 | 2·5 | |

35. PETERHEAD ASSOCIATION; Blackhouse Series. St. Fergus, 117573–117578

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 9·56 | 40·6 | 23·7 | 50·7 | 13·6 | 30·9 | 12·98 | 1·53 | 0·42 | 0·24 | 3·78 | 80·0 | 6·17 | 4·56 | 0·323 | 245 | 11·4 | High clay content. High exchangeable Ca in S and C(g). High exchangeable Mg in $B_3$(g) and C(g). High readily soluble $P_2O_5$ except in lower part of $B_2$(g). |
| $B_2$(g) | 9-13 | 4·05 | 50·4 | 23·0 | 60·4 | 13·0 | 24·6 | 6·16 | 0·90 | 0·54 | 0·15 | 0·81 | 90·5 | 6·69 | 0·97 | 0·072 | 166 | 21·8 | |
| $B_2$(g) | 17-21 | 3·41 | 41·0 | 20·8 | 48·4 | 13·4 | 34·8 | 6·85 | 3·75 | 0·38 | 0·24 | 1·06 | 91·5 | 6·54 | 0·17 | 0·027 | 67 | 1·0 | |
| $B_3$(g) | 28-32 | 3·13 | 31·7 | 26·5 | 40·2 | 18·0 | 38·7 | 6·99 | 6·00 | 0·46 | 0·29 | 0·59 | 95·8 | 6·80 | | | 106 | 17·8 | |
| $B_3$(g) | 36-40 | 3·63 | 20·9 | 31·1 | 30·8 | 21·2 | 44·4 | 8·96 | 6·64 | 0·50 | 0·37 | Nil | 100 | 7·10 | | | 138 | 32·8 | |
| C(g) | 43-48 | 3·84 | 18·4 | 28·2 | 26·6 | 20·0 | 49·6 | 9·55 | 8·90 | 0·49 | 0·44 | Nil | 100 | 7·59 | | | 147 | 42·8 | |

TABLE 2—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **36.** | | | | | | | | | | | | | | | | | | | |
| | PETERHEAD ASSOCIATION; Blackhouse Series. St. Fergus, 117968–117973 | | | | | | | | | | | | | | | | | | |
| S | 2-6 | 11·20 | 43·0 | 25·6 | 52·7 | 15·9 | 25·8 | 11·31 | 1·14 | 0·32 | 0·16 | 6·07 | 68·1 | 6·74 | 4·20 | 0·326 | 199 | 4·4 | High clay content. |
| $B_2(g)$ | 9-13 | 4·53 | 32·7 | 34·5 | 48·5 | 18·9 | 30·5 | 6·45 | 1·71 | 0·28 | 0·13 | 3·36 | 71·7 | 6·24 | 0·80 | 0·072 | 84 | 3·2 | High exchangeable Ca in S. |
| $B_2(g)$ | 18-22 | 4·38 | 30·0 | 27·7 | 39·3 | 18·4 | 40·1 | 6·02 | 3·51 | 0·25 | 0·24 | 3·37 | 75·0 | 5·99 | 0·21 | 0·041 | 81 | 0·9 | High exchangeable Mg in C(g). |
| $B_3(g)$ | 29-33 | 3·65 | 40·5 | 23·2 | 48·3 | 15·4 | 32·6 | 4·45 | 4·13 | 0·30 | 0·23 | 3·12 | 74·5 | 5·69 | | | 81 | 1·4 | Low total $P_2O_5$ in $B_2(g)$ and $B_3(g)$. |
| $B_3(g)$ | 37-41 | 3·76 | 34·2 | 25·6 | 43·4 | 16·4 | 36·4 | 4·63 | 4·96 | 0·36 | 0·25 | 4·88 | 67·7 | 5·51 | | | 103 | 1·4 | Low readily soluble $P_2O_5$ except in S. |
| C(g) | 46-50 | 4·02 | 35·7 | 23·4 | 43·3 | 15·8 | 38·9 | 6·05 | 5·70 | 0·48 | 0·32 | 4·21 | 75·0 | 5·60 | | | 123 | 1·4 | |
| **37.** | | | | | | | | | | | | | | | | | | | |
| | PETERHEAD ASSOCIATION; Blackhouse Series. Hillhead of Cocklaw, 35006–35010 | | | | | | | | | | | | | | | | | | |
| S | 0-6 | 13·60 | N.D. | N.D. | 44·3 | 17·9 | 31·0 | 13·35 | 1·48 | N.D. | 0·08 | 10·29 | 59·2 | 5·69 | 5·71 | 0·392 | 210 | 2·9 | High clay content. |
| $B_2$ | 8-14 | 10·00 | N.D. | N.D. | 25·1 | 21·0 | 48·9 | 17·30 | 1·77 | N.D. | 0·15 | 7·82 | 71·1 | 5·87 | 3·90 | 0·207 | 200 | 1·8 | High exchangeable Ca except in C(g). |
| $B_3(g)$ | 16-22 | 6·17 | N.D. | N.D. | 17·8 | 18·6 | 60·5 | 7·79 | 1·41 | N.D. | Nil | 4·36 | 67·7 | 5·47 | | | 120 | 1·7 | High exchangeable Mg in C(g). |
| $B_3(g)$ | 26-34 | 5·32 | N.D. | N.D. | 18·7 | 20·3 | 58·3 | 11·48 | 4·30 | N.D. | 0·15 | 3·10 | 83·7 | 5·52 | | | 140 | 2·0 | Low exchangeable K in S and $B_3(g)$. |
| C(g) | 40-48 | 4·24 | N.D. | N.D. | 32·1 | 20·2 | 45·2 | 6·01 | 8·87 | N.D. | 0·16 | 1·86 | 89·0 | 4·07 | | | 220 | 3·6 | Low readily soluble $P_2O_5$ except in C(g). |

38. PETERHEAD ASSOCIATION; Blackhouse Series. South Burnhead, 117567–117572

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 7·79 | 43·9 | 27·0 | 54·5 | 16·4 | 25·2 | 10·06 | 2·25 | 0·23 | 0·22 | 3·74 | 77·3 | 6·34 | 3·63 | 0·238 | 140 | 3·5 | High clay content.<br>High exchangeable Ca.<br>High exchangeable Mg in $B_3$(g) and C(g).<br>High % saturation.<br>Low total $P_2O_5$ in $B_2$(g) and $B_3$(g).<br>Low readily soluble $P_2O_5$ in $B_2$(g), high in lower half of profile. |
| $B_2$(g) | 10-14 | 4·56 | 37·6 | 25·5 | 47·6 | 15·5 | 34·6 | 9·59 | 3·69 | 0·23 | 0·22 | 1·28 | 91·6 | 6·72 | 1·20 | 0·089 | 69 | 0·8 | |
| $B_3$(g) | 16-20 | 4·46 | 17·2 | 27·4 | 23·5 | 21·1 | 53·2 | 12·66 | 7·53 | 0·42 | 0·33 | Nil | 100 | 7·15 | 0·32 | 0·038 | 81 | 3·8 | |
| $B_3$(g) | 24-28 | 5·32 | 24·0 | 24·1 | 30·2 | 17·9 | 49·2 | 10·55 | 7·79 | 0·41 | 0·39 | Nil | 100 | 7·38 | | | 110 | 26·8 | |
| C(g) | 32-36 | 3·74 | 24·9 | 23·4 | 31·3 | 17·0 | 48·0 | 9·38 | 7·38 | 0·44 | 0·40 | Nil | 100 | 7·61 | | | 120 | 29·6 | |
| C(g) | 42-46 | 3·59 | 27·3 | 21·3 | 33·3 | 15·3 | 47·8 | 10·13 | 7·88 | 0·46 | 0·44 | Nil | 100 | 7·77 | | | 140 | 32·7 | |

39. STRICHEN ASSOCIATION; Baikies Series. Skillymarno, 118157–118161

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 4-8 | 9·99 | 43·8 | 30·5 | 55·4 | 18·9 | 20·7 | 7·08 | 0·65 | 0·21 | 0·13 | 6·75 | 54·3 | 6·21 | 3·85 | 0·315 | 292 | 3·6 | Low exchangeable Ca except in S.<br>Low exchangeable Mg in $B_2$(g).<br>Low exchangeable K in $B_2$(g) and $B_3$(g).<br>High readily soluble $P_2O_5$ in $B_2$(g). |
| $B_2$(g) | 14-18 | 5·63 | 59·1 | 24·2 | 69·8 | 13·5 | 13·9 | 1·71 | 0·27 | 0·16 | 0·07 | 5·62 | 28·2 | 5·77 | 1·93 | 0·067 | 250 | 10·2 | |
| $B_3$(g) | 21-25 | 5·22 | 54·4 | 21·9 | 62·4 | 13·9 | 21·1 | 1·71 | 0·48 | 0·18 | 0·09 | 4·11 | 37·4 | 5·50 | | | 165 | 2·9 | |
| C(g) | 28-32 | 5·06 | 56·0 | 20·0 | 63·0 | 13·0 | 21·5 | 2·17 | 0·61 | 0·18 | 0·12 | 5·37 | 36·4 | 5·40 | | | 170 | 2·6 | |
| C(g) | 36-40 | 4·76 | 46·0 | 28·9 | 60·0 | 14·9 | 22·7 | 2·48 | 1·19 | 0·18 | 0·15 | 3·86 | 51·0 | 5·52 | | | 191 | 6·4 | |

40. TARVES ASSOCIATION; Thistlyhill Series. Balwearie, 47346–47349

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 10·40 | N.D. | N.D. | 57·6 | 21·6 | 16·6 | 2·17 | 0·19 | N.D. | 0·14 | 13·42 | 15·6 | 5·22 | 4·18 | 0·323 | 250 | 2·0 | Low exchangeable Ca except in C(g).<br>Low exchangeable Mg in S and $B_2$.<br>Low exchangeable K in $B_2$.<br>High readily soluble $P_2O_5$ in C(g), otherwise low. |
| $B_2$ | 10-12 | 5·97 | N.D. | N.D. | 61·2 | 16·3 | 19·6 | 1·54 | 0·17 | N.D. | 0·05 | 9·03 | 15·1 | 5·32 | 0·99 | 0·102 | 160 | 1·1 | |
| $B_3$(g) | 24-28 | 3·88 | N.D. | N.D. | 55·8 | 14·3 | 26·0 | 2·87 | 1·30 | N.D. | 0·13 | 4·20 | 50·6 | 5·76 | | | 140 | 0·1 | |
| C(g) | 40-44 | 3·52 | N.D. | N.D. | 56·4 | 14·8 | 26·1 | 7·05 | 4·17 | N.D. | 0·17 | 3·14 | 78·4 | 6·26 | | | 210 | 19·0 | |

TABLE 2—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41. | | | | | | | TARVES ASSOCIATION; Thistlyhill Series. Upper Crichie, 118414–118418 | | | | | | | | | | | | |
| S | 3-7 | 9·81 | 48·3 | 29·2 | 60·4 | 17·1 | 17·6 | 4·50 | 0·32 | 0·12 | 0·32 | 10·25 | 33·9 | 5·52 | 3·96 | 0·289 | 389 | 10·7 | Low clay content in $B_3$(g). |
| $B_2$(g) | 11-15 | 6·02 | 64·3 | 22·0 | 73·4 | 12·9 | 10·7 | 2·17 | 0·12 | 0·09 | 0·15 | 5·14 | 32·9 | 5·76 | 1·60 | 0·122 | 213 | 3·9 | Low exchangeable Ca in $B_2$(g) and $B_3$(g). |
| $B_3$(g) | 17-21 | 3·71 | 74·7 | 16·5 | 80·7 | 10·1 | 5·1 | 0·92 | 0·05 | 0·10 | 0·10 | 0·80 | 59·5 | 6·14 | | | 201 | 3·0 | Low exchangeable Mg in $B_2$(g) and $B_3$(g). |
| C(g) | 25-29 | 4·19 | 64·0 | 19·5 | 72·8 | 10·6 | 14·6 | 3·88 | 0·73 | 0·18 | 0·12 | 0·80 | 86·0 | 5·99 | | | 129 | 1·2 | High total and readily soluble $P_2O_5$ in S. |
| C(g) | 35-39 | 3·95 | 55·0 | 23·0 | 66·6 | 11·4 | 18·0 | 4·47 | 1·32 | 0·17 | 0·13 | 1·17 | 84·0 | 5·85 | | | 108 | 0·6 | Low readily soluble $P_2O_5$ in C(g). |
| 42. | | | | | | | TARVES ASSOCIATION; Thistlyhill Series. Balquhain, 47365–47369 | | | | | | | | | | | | |
| S | 0-8 | 12·00 | N.D. | N.D. | 46·4 | 28·5 | 19·1 | 3·85 | 0·19 | N.D. | 0·07 | 13·70 | 15·5 | 5·41 | 4·32 | 0·363 | 350 | 2·3 | High exchangeable Ca and Mg in $B_3$(g) and C(g). |
| $B_2$(g) | 12-16 | 4·58 | N.D. | N.D. | 54·6 | 15·2 | 21·3 | 4·82 | 0·51 | N.D. | 0·09 | 5·26 | 50·8 | 5·80 | 0·33 | 0·062 | 160 | 9·0 | Low exchangeable Mg in S. |
| $B_3$(g) | 24-28 | 4·38 | N.D. | N.D. | 45·9 | 20·6 | 31·3 | 13·60 | 5·64 | N.D. | 0·18 | 3·85 | 83·4 | 6·14 | | | 230 | 17·0 | Low exchangeable K in S and $B_2$(g). |
| C(g) | 40-44 | 4·22 | N.D. | N.D. | 55·3 | 13·8 | 29·1 | 14·19 | 6·08 | N.D. | 0·21 | 2·77 | 88·1 | 6·57 | | | 270 | 43·0 | High total $P_2O_5$ in S. |
| C(g) | 44-48 | 3·26 | N.D. | N.D. | 70·7 | 11·8 | 15·9 | 8·76 | 2·82 | N.D. | 0·14 | 2·31 | 83·6 | 6·40 | | | 160 | 50·0 | Low readily soluble $P_2O_5$ in S, high in $B_3$(g) and C(g). |

43. TARVES ASSOCIATION; Thistlyhill Series. Millhill, 110435–110439

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 10·61 | 46·5 | 27·9 | 56·7 | 17·7 | 20·3 | 7·72 | 0·47 | 0·25 | 0·37 | 11·14 | 44·1 | 6·33 | 4·55 | 0·274 | 304 | 16·9 | Low exchangeable Ca except in S. |
| $B_2(g)$ | 9-13 | 6·32 | 51·7 | 18·6 | 58·0 | 12·3 | 26·5 | 1·72 | 0·30 | 0·09 | 0·20 | 6·32 | 26·8 | 5·77 | 1·14 | 0·054 | 120 | 1·3 | High total $P_2O_5$ in S, low in $B_3(g)$ and C(g). |
| $B_3(g)$ | 14-18 | 4·64 | 55·0 | 21·1 | 62·1 | 14·0 | 21·6 | 1·70 | 0·42 | 0·09 | 0·19 | 4·03 | 37·4 | 5·74 | | | 69 | 1·0 | High readily soluble $P_2O_5$ in S, otherwise low. |
| C(g) | 20-26 | 4·43 | 50·6 | 25·4 | 62·3 | 13·7 | 21·8 | 2·00 | 0·62 | 0·14 | 0·11 | 5·20 | 35·6 | 5·30 | | | 73 | 0·8 | |
| C(g) | 36-42 | 2·75 | 60·5 | 20·3 | 70·3 | 10·5 | 16·5 | 1·53 | 1·01 | 0·10 | 0·13 | 4·60 | 37·5 | 5·15 | | | 69 | 0·8 | |

44. TARVES ASSOCIATION; Thistlyhill Series. Woodlands, 28088–28092

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 13·18 | N.D. | N.D. | 32·7 | 38·7 | 22·1 | 9·89 | 0·89 | N.D. | 0·10 | 10·88 | 49·9 | 5·54 | N.D. | N.D. | 280 | N.D. | High exchangeable Ca. |
| S | 14-18 | 10·47 | N.D. | N.D. | 60·0 | 17·5 | 17·3 | 8·73 | 1·24 | N.D. | 0·09 | 8·53 | 54·0 | 5·73 | N.D. | N.D. | 210 | N.D. | High exchangeable Mg in C(g). |
| $B_3(g)$ | 20-24 | 4·67 | N.D. | N.D. | 70·9 | 2·1 | 27·0 | 9·20 | 2·01 | N.D. | 0·09 | 3·01 | 80·0 | 5·98 | | | 140 | N.D. | Low exchangeable K. |
| C(g) | 28-32 | 4·17 | N.D. | N.D. | 56·2 | 11·8 | 27·8 | 10·80 | 10·42 | N.D. | 0·05 | 1·44 | 93·7 | 6·66 | | | 70 | N.D. | Low total $P_2O_5$ in C(g). |
| C(g) | 40-44 | 3·78 | N.D. | N.D. | 67·1 | 10·3 | 18·8 | 9·85 | 9·87 | N.D. | 0·04 | 0·62 | 97·0 | 6·86 | | | 60 | N.D. | |

45. TIPPERTY ASSOCIATION; Tipperty Series. Auchmacoy, 48093–48097

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 9·01 | N.D. | N.D. | 41·1 | 23·3 | 31·1 | 11·10 | 0·97 | N.D. | 0·10 | 4·68 | 72·2 | 5·97 | 3·00 | 0·226 | 210 | 5·2 | High clay content. |
| $B_2(g)$ | 9-13 | 4·30 | N.D. | N.D. | 48·4 | 19·1 | 30·4 | 6·16 | 2·90 | N.D. | 0·19 | 2·24 | 80·5 | 6·27 | 0·38 | 0·062 | 120 | 0·7 | High exchangeable Ca in S. |
| $B_3(g)$ | 18-23 | 4·04 | N.D. | N.D. | 32·6 | 22·3 | 43·1 | 5·70 | 6·56 | N.D. | 0·33 | 2·86 | 80·9 | 6·81 | | | 130 | 0·6 | High exchangeable Mg in $B_3(g)$ and C(g). |
| C(g) | 40-44 | 4·37 | N.D. | N.D. | 39·3 | 25·5 | 32·9 | 3·95 | 6·78 | N.D. | 0·22 | 1·81 | 85·8 | 6·11 | | | 140 | 6·8 | Low readily soluble $P_2O_5$ in $B_2(g)$ and $B_3(g)$. |

46. TIPPERTY ASSOCIATION; Tipperty Series. Southfolds, Balmedie, 40542–40545

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 7·26 | N.D. | N.D. | 44·0 | 17·5 | 35·4 | 9·23 | 3·98 | N.D. | 0·34 | 5·85 | 69·8 | 5·79 | 2·37 | 0·200 | 179 | 4·4 | High clay content. |
| $B_2(g)$ | 12-18 | 6·71 | N.D. | N.D. | 6·0 | 21·5 | 72·5 | 9·12 | 5·47 | N.D. | 0·51 | 8·82 | 63·1 | 5·71 | 0·29 | 0·052 | 60 | 6·4 | High exchangeable Ca in upper part of profile. |
| $B_2(g)$ | 24-30 | 5·65 | N.D. | N.D. | 28·9 | 15·6 | 53·2 | 5·42 | 9·43 | N.D. | 0·55 | 7·57 | 67·1 | 5·64 | | | 70 | 6·3 | High exchangeable Mg in $B_2(g)$ and C(g). |
| C(g) | 36-42 | 5·24 | N.D. | N.D. | 17·1 | 21·7 | 58·4 | 4·53 | 8·77 | N.D. | 0·35 | 3·69 | 78·7 | 5·94 | | | 40 | 1·2 | Low total $P_2O_5$ except in S. Low readily soluble $P_2O_5$ in C(g). |

TABLE 2—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **47.** | | | | | | | | TIPPERTY ASSOCIATION; Tipperty Series. Toll of Birness, 109667–109671 | | | | | | | | | | | |
| S | 0-6 | 10·60 | 26·2 | 38·7 | 41·7 | 23·2 | 29·8 | 7·80 | 2·00 | 0·36 | 0·37 | 8·87 | 54·4 | 5·87 | 6·48 | 0·325 | 146 | 3·5 | High clay content. |
| $B_2$(g) | 12-14 | 4·92 | 26·0 | 34·1 | 40·0 | 20·1 | 37·4 | 4·04 | 2·94 | 0·29 | 0·23 | 7·55 | 49·7 | 5·56 | 1·62 | 0·084 | 168 | 3·0 | High exchangeable Mg in $B_3$(g) and C(g). |
| $B_3$(g) | 18-24 | 4·00 | 19·5 | 41·1 | 34·0 | 26·6 | 37·4 | 4·06 | 5·50 | 0·31 | 0·33 | 5·63 | 64·5 | 5·48 | | | 106 | 3·5 | |
| $B_3$(g) | 26-34 | 3·70 | 19·4 | 39·8 | 33·4 | 25·2 | 36·3 | 5·15 | 7·98 | 0·41 | 0·39 | 3·76 | 78·9 | 5·58 | | | 138 | 8·3 | |
| C(g) | 42-48 | 3·57 | 17·9 | 43·5 | 36·3 | 25·1 | 35·0 | 6·72 | 9·51 | 0·43 | 0·42 | 2·59 | 86·9 | 5·87 | | | 149 | 9·2 | |
| **48.** | | | | | | | | TIPPERTY ASSOCIATION; Tipperty Series. Tipperty Clay Pit, 111407–111410 | | | | | | | | | | | |
| S | 2-6 | 10·00 | 18·5 | 37·8 | 34·6 | 21·7 | 38·7 | 12·00 | 3·48 | 0·45 | 0·33 | 2·64 | 86·0 | 6·25 | 3·47 | 0·258 | 215 | 14·1 | Very high clay content. High exchangeable Ca. |
| $B_2$(g) | 12-16 | 6·82 | Nil | 40·0 | 3·6 | 33·1 | 59·9 | 12·35 | 6·70 | 0·74 | 0·43 | Nil | 100 | 7·06 | 0·43 | 0·035 | 82 | 1·3 | High exchangeable Mg except in S. |
| $B_3$(g) | 23-27 | 6·26 | Nil | 34·5 | 0·3 | 32·1 | 64·5 | 12·99 | 7·30 | 0·63 | 0·42 | Nil | 100 | 7·19 | | | 84 | 1·1 | High % saturation. Low total and readily soluble $P_2O_5$ in $B_2$(g) and $B_3$(g). |
| C(g) | 36-40 | 5·41 | Nil | 35·7 | 5·5 | 30·2 | 64·3 | 11·20 | 8·72 | 0·63 | 0·48 | Nil | 100 | 7·10 | | | 162 | 20·8 | High readily soluble $P_2O_5$ in S and C(g). |

## TABLE 3. IRON PODZOLS, FREELY DRAINED

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 49. | | | AUCHINBLAE ASSOCIATION; Auchinblae Series. Hatton of Cruden, 147849–147852 | | | | | | | | | | | | | | | | |
| S | 0-6 | 6·04 | 62·3 | 18·6 | 70·6 | 10·3 | 16·1 | 10·83 | 0·68 | 0·21 | 0·22 | Nil | 100 | 7·06 | 2·56 | 0·178 | 212 | 14·7 | High sand content in $B_3$ and C. High exchangeable Ca in S, otherwise low. Low exchangeable Mg and K in $B_3$ and C. High readily soluble $P_2O_5$ in S. |
| $B_3$ | 15-18 | 2·40 | 91·3 | 2·8 | 92·5 | 1·6 | 5·9 | 1·69 | 0·16 | 0·05 | 0·08 | 2·81 | 41·3 | 6·32 | 0·39 | 0·064 | 137 | 9·6 | |
| C | 24-30 | 1·61 | 92·5 | 5·8 | 93·8 | 4·5 | 1·7 | 0·76 | 0·09 | 0·04 | 0·06 | 1·21 | 44·0 | 6·31 | | | 81 | 3·8 | |
| C | 30-36 | 2·33 | 70·9 | 24·0 | 85·7 | 9·2 | 5·1 | 1·83 | 0·31 | 0·09 | 0·06 | 2·35 | 49·4 | 6·50 | | | 104 | 5·3 | |
| 50. | | | BOYNDIE ASSOCIATION; Boyndie Series. Philorth, 118280–118285 | | | | | | | | | | | | | | | | |
| S | 3-7 | 5·88 | 70·0 | 13·1 | 75·3 | 7·8 | 14·0 | 5·80 | 0·89 | 0·16 | 0·13 | 3·06 | 69·5 | 5·51 | 2·38 | 0·194 | 143 | 2·8 | High sand content. Low exchangeable Ca except in surface layers. Low exchangeable Mg in C. Low exchangeable K except in S. Low total $P_2O_5$ except in surface layers. Low readily soluble $P_2O_5$ in S and $B_2$. |
| $B_2$ | 11-15 | 4·66 | 72·6 | 11·4 | 77·3 | 6·7 | 13·7 | 5·65 | 0·84 | 0·14 | 0·10 | 2·08 | 76·4 | 5·41 | 1·91 | 0·106 | 126 | 1·3 | |
| $B_2$ | 21-25 | 1·30 | 87·0 | 3·8 | 89·4 | 1·4 | 7·9 | 2·57 | 0·54 | 0·10 | 0·05 | 1·48 | 69·0 | 5·91 | 0·23 | 0·040 | 45 | 2·9 | |
| $B_3$ | 28-31 | 1·51 | 81·5 | 9·9 | 88·0 | 3·4 | 7·5 | 2·57 | 0·52 | 0·11 | 0·07 | 1·03 | 76·0 | 6·15 | | | 45 | 3·6 | |
| $B_3$ | 38-42 | 1·02 | 88·3 | 5·1 | 93·0 | 0·4 | 5·6 | 1·36 | 0·34 | 0·10 | 0·04 | 0·91 | 67·0 | 6·30 | | | 48 | 6·0 | |
| C | 50-54 | 0·72 | 89·8 | 5·0 | 92·9 | 2·0 | 4·4 | 0·69 | 0·14 | 0·07 | 0·05 | Nil | 100 | 6·57 | | | 50 | 9·9 | |

TABLE 3—Continued

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 51. | | | | | | | | BOYNDIE ASSOCIATION; Boyndie Series. Whitehillock, 125888–125892 | | | | | | | | | | | |
| S | 3-7 | 6·83 | 73·3 | 16·1 | 83·1 | 7·4 | 6·2 | 1·85 | 0·65 | 0·17 | 0·25 | 6·65 | 30·5 | 5·16 | 3·02 | 0·187 | 153 | 4·9 | High sand content. |
| $B_2$ | 11-15 | 3·92 | 78·3 | 15·8 | 89·1 | 4·9 | 2·0 | 1·07 | 0·27 | 0·22 | 0·07 | 3·86 | 29·7 | 5·76 | 0·86 | 0·086 | 117 | 4·8 | Low exchangeable Ca. |
| $B_2$ | 24-28 | 1·87 | 92·2 | 5·7 | 94·0 | 3·9 | 0·2 | 0·91 | 0·16 | 0·15 | 0·07 | Nil | 100 | 5·95 | | | 98 | 8·4 | Low exchangeable Mg and |
| C | 34-38 | 1·61 | 95·4 | 3·0 | 97·6 | 0·8 | Nil | 0·91 | 0·19 | 0·15 | 0·07 | 0·69 | 65·8 | 5·90 | | | 107 | 7·6 | K except in S. |
| C | 45-49 | 1·66 | 93·9 | 3·8 | 94·7 | 3·0 | 0·6 | 0·69 | 0·20 | 0·11 | 0·05 | Nil | 100 | 6·05 | | | 97 | 9·5 | |
| 52. | | | | | | | | BOYNDIE ASSOCIATION; Boyndie Series. Glenhead, 112433–112437 | | | | | | | | | | | |
| S | 2-6 | 7·28 | 61·3 | 25·7 | 74·5 | 12·5 | 9·4 | 5·85 | 0·15 | 0·11 | 0·17 | 4·70 | 57·2 | 5·97 | 3·35 | 0·178 | 242 | 19·4 | High sand (Inter.). |
| $B_2$ | 8-11 | 2·96 | 78·9 | 14·0 | 88·1 | 4·8 | 4·1 | 1·22 | 0·05 | 0·05 | 0·05 | 3·75 | 26·8 | 5·66 | 0·71 | 0·032 | 148 | 8·1 | Low exchangeable Ca and |
| $B_2$ | 14-18 | 2·99 | 68·7 | 23·2 | 82·8 | 9·1 | 5·1 | 1·83 | 0·07 | 0·07 | 0·07 | 3·64 | 35·9 | 5·76 | | | 130 | 5·4 | K except in S. |
| $B_2$ | 23-27 | 2·63 | 75·0 | 16·5 | 85·8 | 5·7 | 5·9 | 1·67 | 0·07 | 0·07 | 0·07 | 3·29 | 36·4 | 5·82 | | | 133 | 5·9 | Low exchangeable Mg. |
| C | 38-42 | 1·83 | 80·3 | 15·9 | 92·5 | 3·7 | 2·0 | 1·21 | 0·07 | 0·07 | 0·07 | 5·53 | 20·4 | 6·00 | | | 209 | 16·4 | High readily soluble $P_2O_5$ in S and C. |
| 53. | | | | | | | | CORBY ASSOCIATION; Corby Series. Memsie, 35024–35027 | | | | | | | | | | | |
| S | 0-6 | 9·50 | N.D. | N.D. | 67·7 | 14·4 | 13·1 | 8·52 | 0·10 | N.D. | 0·13 | 11·70 | 42·8 | 5·31 | 4·78 | 0·302 | 200 | 4·9 | Low exchangeable Ca in $B_2$ and C. |
| $B_2$ | 10-12 | 6·15 | N.D. | N.D. | 66·2 | 13·8 | 16·9 | 2·13 | 0·24 | N.D. | 0·04 | 8·20 | 22·8 | 5·55 | 1·64 | 0·117 | 130 | 2·8 | Low exchangeable Mg. |
| $B_3$ | 22-26 | 4·43 | N.D. | N.D. | 63·7 | 13·5 | 20·6 | 3·79 | 0·23 | N.D. | 0·05 | 5·73 | 41·5 | 5·60 | | | 120 | 3·5 | Low exchangeable K except in S. |
| C | 40-44 | 2·95 | N.D. | N.D. | 80·4 | 9·3 | 7·3 | 0·82 | 0·03 | N.D. | 0·01 | 3·54 | 19·5 | 5·43 | | | 140 | 5·8 | Low readily soluble $P_2O_5$ in $B_2$. |

54. CORBY ASSOCIATION; Corby Series. Fiddie Mains, 48432–48435

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 10·40 | N.D. | N.D. | 81·5 | 12·6 | 5·9 | 4·32 | 0·19 | N.D. | 0·13 | 0·51 | 90·1 | 5·37 | 1·22 | 0·333 | 240 | 2·4 | High sand content. Low exchangeable Ca and K except in S. Low exchangeable Mg. Low readily soluble $P_2O_5$ in S. |
| $B_2$ | 10-14 | 4·15 | N.D. | N.D. | 91·0 | 4·3 | 4·7 | 1·45 | 0·10 | N.D. | 0·07 | 3·31 | 32·9 | 5·86 | 0·94 | 0·087 | 170 | 3·6 | |
| $B_2$ | 20-24 | 2·10 | N.D. | N.D. | 96·3 | 0·7 | 3·0 | 0·63 | Nil | N.D. | 0·09 | 3·05 | 19·1 | 6·00 | | | 160 | 8·1 | |
| C | 32-36 | 2·08 | N.D. | N.D. | 94·5 | 2·1 | 3·4 | 0·63 | 0·08 | N.D. | 0·08 | 3·16 | 20·0 | 6·05 | | | 140 | 5·5 | |

55. CORBY ASSOCIATION; Corby Series. Moss-side, Fetternear, 112166–112169

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1-5 | 11·30 | 57·2 | 28·9 | 70·6 | 15·5 | 8·2 | 9·11 | 0·55 | 0·14 | 0·18 | 11·11 | 47·3 | 5·70 | 5·98 | 0·314 | 189 | 8·5 | High sand content in $B_2$ and C. High exchangeable Ca in S, otherwise low. Low exchangeable Mg and K except in S. |
| $B_2$ | 9-15 | 1·90 | 93·9 | 2·4 | 94·1 | 2·2 | 1·8 | 1·21 | 0·08 | 0·03 | 0·08 | Nil | 100 | 6·02 | 0·79 | 0·200 | 101 | 5·1 | |
| $B_2$ | 23-29 | 1·04 | 96·6 | 1·0 | 96·6 | 1·0 | 1·4 | 0·60 | 0·06 | 0·03 | 0·03 | Nil | 100 | 6·01 | | | 109 | 4·4 | |
| C | 30-34 | 1·35 | 95·6 | 1·6 | 96·3 | 0·9 | 1·4 | 0·90 | 0·08 | 0·04 | 0·03 | Nil | 100 | 5·95 | | | 117 | 3·4 | |

56. CORBY ASSOCIATION; Corby Series. Foggieton, 41324–41329

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 13·20 | N.D. | N.D. | 72·0 | 17·6 | 10·6 | 2·60 | 0·09 | N.D. | 0·12 | 9·87 | 22·0 | 5·58 | 4·78 | 0·350 | 190 | N.D. | High sand content in $B_3$ and C. Low exchangeable Ca, Mg and K. |
| S | 10-12 | 9·18 | N.D. | N.D. | 70·2 | 19·4 | 10·4 | 3·24 | 0·16 | N.D. | 0·08 | 10·10 | 25·7 | 5·43 | 4·44 | 0·255 | 150 | N.D. | |
| $B_3$ | 13-16 | 4·13 | N.D. | N.D. | 80·3 | 10·9 | 8·8 | 0·62 | Nil | N.D. | 0·08 | 4·16 | 14·1 | 5·40 | | | 210 | N.D. | |
| $B_3$ | 22-26 | 3·89 | N.D. | N.D. | 81·9 | 9·9 | 8·2 | 0·65 | Nil | N.D. | 0·06 | 3·64 | 16·1 | 5·40 | | | 160 | N.D. | |
| C | 32-36 | 3·42 | N.D. | N.D. | 89·4 | 6·6 | 4·0 | 0·62 | Nil | N.D. | 0·06 | 3·64 | 15·9 | 5·43 | | | 120 | N.D. | |
| C | 44-48 | 1·54 | N.D. | N.D. | 99·1 | 6·7 | 4·2 | 0·65 | Nil | N.D. | 0·06 | 1·56 | 31·4 | 5·81 | | | 160 | N.D. | |

57. CORBY ASSOCIATION; Corby Series. Mundurno, 41113–41116

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 8·46 | N.D. | N.D. | 79·7 | 13·1 | 7·2 | 1·42 | 0·49 | N.D. | 0·22 | 10·30 | 17·1 | 5·12 | 4·10 | 0·249 | N.D. | N.D. | High sand content in $B_3$ and C. Low exchangeable Ca. Low exchangeable Mg and K in $B_3$. |
| $B_3$ | 10-14 | 2·32 | N.D. | N.D. | 93·5 | 1·8 | 4·7 | 0·07 | Nil | N.D. | 0·07 | 4·21 | 3·3 | 5·13 | 0·69 | 0·033 | 117 | N.D. | |
| $B_3$ | 22-26 | 2·43 | N.D. | N.D. | 91·7 | 3·7 | 4·6 | 0·07 | Nil | N.D. | 0·11 | 3·53 | 5·1 | 5·10 | | | N.D. | N.D. | |
| C | 44-48 | 1·01 | N.D. | N.D. | 94·6 | 2·6 | 3·4 | 0·03 | 0·58 | N.D. | 0·29 | 1·91 | 32·0 | 5·27 | | | N.D. | N.D. | |



T

TABLE 3—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58. | COUNTESSWELLS ASSOCIATION; Countesswells Series. Westside, Maryculter, 61606–61610 | | | | | | | | | | | | | | | | | | |
| A | 3-5 | 16·80 | N.D. | N.D. | 59·6 | 11·2 | 16·6 | 0·55 | 0·72 | N.D. | 0·17 | 38·98 | 3·6 | 4·12 | 9·75 | 0·410 | 110 | 1·3 | Low exchangeable cations, % saturation and pH. |
| $B_2$ | 7-11 | 6·44 | N.D. | N.D. | 61·1 | 16·0 | 19·7 | 0·07 | Nil | N.D. | Nil | 9·60 | 0·7 | 4·84 | 2·39 | 0·073 | 125 | 0·6 | Low readily soluble $P_2O_5$ in A and $B_2$. |
| $B_2$ | 15-19 | 7·70 | N.D. | N.D. | 68·5 | 15·5 | 11·9 | 0·07 | Nil | N.D. | Nil | 8·46 | 0·8 | 4·55 | | | 159 | 1·0 | |
| $B_3$ | 20-36 | 4·74 | N.D. | N.D. | 70·9 | 14·2 | 12·5 | 0·20 | Nil | N.D. | Nil | 5·75 | 3·4 | 4·60 | | | 140 | 3·7 | |
| C | 28-36 | 4·79 | N.D. | N.D. | 72·2 | 14·8 | 10·6 | Nil | Nil | N.D. | 0·05 | 5·75 | 0·9 | 4·63 | | | 206 | 8·5 | |
| 59. | COUNTESSWELLS ASSOCIATION; Countesswells Series. Ballogie, 54537–54541 | | | | | | | | | | | | | | | | | | |
| S | 0-9 | 11·60 | N.D. | N.D. | 74·0 | 6·5 | 18·4 | 7·34 | 0·54 | N.D. | 0·12 | 11·25 | 41·5 | 5·64 | 5·41 | 0·345 | 334 | 11·8 | Low exchangeable Ca in $B_3$ and C. |
| $B_2$ | 11-18 | 6·15 | N.D. | N.D. | 62·4 | 16·3 | 18·3 | 3·24 | 0·20 | N.D. | 0·05 | 6·35 | 35·3 | 5·76 | 2·13 | 0·173 | 225 | 1·8 | Low exchangeable Mg and K except in S. |
| $B_2$ | 20-26 | 7·65 | N.D. | N.D. | 76·4 | 6·5 | 13·3 | 3·47 | 0·17 | N.D. | 0·06 | 9·06 | 29·0 | 5·73 | | | 243 | 2·2 | High total $P_2O_5$ in S. |
| $B_3$ | 29-34 | 4·50 | N.D. | N.D. | 77·3 | 3·5 | 13·7 | 1·37 | 0·05 | N.D. | 0·07 | 7·86 | 16·0 | 5·66 | | | 164 | 2·0 | High readily soluble $P_2O_5$ in S, otherwise low. |
| C | 36-40 | 4·86 | N.D. | N.D. | 82·0 | 3·8 | 9·4 | 2·52 | 0·09 | N.D. | 0·09 | 6·61 | 29·0 | 5·61 | | | 185 | 2·0 | |
| 60. | COUNTESSWELLS ASSOCIATION; Countesswells Series. Borrohill, 119405–119408 | | | | | | | | | | | | | | | | | | |
| S | 3-7 | 11·10 | 50·8 | 27·1 | 61·3 | 16·6 | 16·5 | 9·25 | 1·01 | 0·21 | 0·22 | 8·19 | 56·5 | 5·74 | 4·65 | 0·298 | 254 | 12·4 | High exchangeable Ca in S, otherwise low. |
| $B_2$ | 10-13 | 4·23 | 50·8 | 26·7 | 63·1 | 14·4 | 20·4 | 2·60 | 0·40 | 0·12 | 0·22 | 3·58 | 48·2 | 5·65 | 0·57 | 0·043 | 88 | 2·0 | Low exchangeable Mg and K in C. |
| $B_3$ | 14-18 | 4·06 | 51·8 | 23·8 | 63·0 | 12·6 | 22·4 | 2·14 | 0·38 | 0·13 | 0·14 | 3·73 | 42·8 | 5·55 | | | 89 | 1·7 | Low total $P_2O_5$ except in S. |
| C | 21-25 | 3·72 | 53·6 | 22·2 | 63·8 | 12·0 | 20·5 | 1·83 | 0·27 | 0·11 | 0·09 | 4·60 | 33·3 | 5·64 | | | 83 | 3·3 | High readily soluble $P_2O_5$ in S, low in $B_2$ and $B_3$. |

61. COUNTESSWELLS ASSOCIATION; Countesswells Series. Ardmurdo, 47374–47378

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-7 | 15·00 | N.D. | N.D. | 59·2 | 21·6 | 14·2 | 15·65 | 0·61 | N.D. | 0·47 | 8·48 | 66·8 | 6·26 | 5·37 | 0·380 | 330 | 9·6 | High exchangeable Ca in S and $B_2$, low in $B_3$ and C. Low exchangeable Mg in $B_3$ and C. High total $P_2O_5$ in S. Low readily soluble $P_2O_5$ in $B_3$, high in $B_3$ and C. |
| $B_2$ | 7-12 | 7·60 | N.D. | N.D. | 68·9 | 17·2 | 10·9 | 9·36 | 0·46 | N.D. | 0·79 | 5·11 | 67·5 | 6·69 | 2·58 | 0·190 | 240 | 2·0 | |
| $B_3$ | 12-16 | 2·75 | N.D. | N.D. | 67·6 | 16·2 | 13·5 | 2·78 | 0·12 | N.D. | 0·20 | 1·68 | 64·6 | 6·67 | | | 200 | 24·0 | |
| $B_3$ | 22-26 | 2·93 | N.D. | N.D. | 76·9 | 3·4 | 16·8 | 2·28 | 0·08 | N.D. | 0·15 | 2·71 | 48·0 | 6·76 | | | 150 | 11·0 | |
| C | 36-40 | 2·43 | N.D. | N.D. | 75·0 | 8·9 | 14·9 | ·173 | 0·05 | N.D. | 0·15 | 2·28 | 45·9 | 6·44 | | | 140 | 12·0 | |

62. COUNTESSWELLS ASSOCIATION; Countesswells Series. Cairntradlin, 47423–47426

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 9·66 | N.D. | N.D. | 59·9 | 22·4 | 12·9 | 6·67 | 0·30 | N.D. | 0·04 | 8·12 | 46·3 | 5·77 | 3·60 | 0·310 | 330 | 7·8 | Low exchangeable Ca in C. Low exchangeable Mg. Low exchangeable K in S and $B_2$. High total $P_2O_5$ in S. High readily soluble $P_2O_5$, except in S. |
| $B_2$ | 7-10 | 6·42 | N.D. | N.D. | 65·4 | 18·0 | 11·9 | 3·62 | 0·20 | N.D. | 0·05 | 6·08 | 39·0 | 5·74 | 2·01 | 0·178 | 270 | 15·0 | |
| $B_3$ | 10-14 | 3·52 | N.D. | N.D. | 57·7 | 17·2 | 21·6 | 3·25 | 0·19 | N.D. | 0·10 | 2·83 | 55·5 | 6·04 | | | 160 | 14·0 | |
| C | 16-20 | 2·28 | N.D. | N.D. | 61·5 | 15·7 | 22·6 | 1·48 | 0·23 | N.D. | 0·13 | 2·19 | 45·5 | 5 90 | | | 140 | 13·0 | |

63. COUNTESSWELLS ASSOCIATION; Countesswells Series. Cluny, 47383–47386

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 9·15 | N.D. | N.D. | 68·9 | 10·5 | 15·0 | 7·38 | 0·44 | N.D. | 0·22 | 7·78 | 50·5 | 5·92 | 3·19 | 0·270 | 270 | 9·5 | Low exchangeable Ca in C. Low exchangeable Mg except in S. High readily soluble $P_2O_5$, except in S. |
| $B_2$ | 10-14 | 2·98 | N.D. | N.D. | 69·2 | 13·6 | 14·3 | 3·16 | 0·06 | N.D. | 0·15 | 3·71 | 47·6 | 5·84 | 0·50 | 0·052 | 170 | 19·0 | |
| $B_3$ | 20-24 | 2·20 | N.D. | N.D. | 79·7 | 5·2 | 11·9 | 4·47 | 0·08 | N.D. | 0·18 | 2·91 | 62·0 | 5·88 | | | 190 | 27·0 | |
| C | 40-44 | 2·57 | N.D. | N.D. | 81·4 | 4·7 | 12·4 | 1·49 | 0·14 | N.D. | 0·17 | 3·54 | 34·0 | 5·78 | | | 190 | 17·0 | |

64. COUNTESSWELLS ASSOCIATION; Countesswells Series. Drumlasie (uncultivated), 117158–117163

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_1$ | 0-3 | 19·05 | 59·8 | 21·7 | 74·7 | 6·8 | 4·2 | 1·43 | 0·84 | 0·18 | 0·29 | 21·01 | 11·5 | 4·73 | 9·62 | 0·503 | 106 | 1·9 | Low clay content. Low exchangeable Ca. Low exchangeable Mg and K except in $A_1$. Low readily soluble $P_2O_5$ in $A_1$ and $B_2$, high in $B_3$ and D. |
| $B_2$ | 4-8 | 12·15 | 59·7 | 26·1 | 74·4 | 11·4 | 8·1 | 0·16 | 0·13 | 0·11 | 0·05 | 17·15 | 2·6 | 5·07 | 5·06 | 0·232 | 129 | 2·1 | |
| $B_2$ | 11-15 | 9·40 | 63·1 | 27·1 | 75·8 | 14·4 | 5·1 | 0·16 | Nil | 0·07 | 0·05 | 13·76 | 2·0 | 5·16 | 3·43 | 0·100 | 148 | 2·0 | |
| $B_2$ | 18-24 | 2·44 | 78·1 | 19·5 | 88·2 | 9·4 | Nil | Nil | 0·03 | 0·06 | Nil | 1·82 | 4·7 | 5·08 | | | 186 | 4·3 | |
| $B_3$ | 30-34 | 1·67 | 73·6 | 24·7 | 87·0 | 11·3 | Nil | Nil | Nil | 0·06 | Nil | 1·36 | 4·2 | 5·09 | | | 135 | 13·1 | |
| D | 36-40 | 1·37 | 80·7 | 17·9 | 88·7 | 9·9 | Nil | Nil | 0·02 | 0·05 | Nil | Nil | 100 | 5·93 | | | 137 | 14·6 | |

TABLE 3—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 65. | | | | | | | COUNTESSWELLS ASSOCIATION; Countesswells Series. Drumlasie (cultivated), 117176–117182 | | | | | | | | | | | | |
| S | 2-6 | 6·20 | 60·1 | 23·4 | 71·4 | 12·1 | 13·4 | 4·78 | 0·10 | 0·10 | 0·13 | 4·50 | 53·2 | 6·02 | 2·73 | 0·178 | 310 | 26·2 | Low exchangeable Ca in $B_2$, $B_3$ and C. Low exchangeable Mg except in D. Low exchangeable K in C. High total $P_2O_5$ in S. Very high readily soluble $P_2O_5$. |
| $B_2$ | 9-13 | 3·62 | 73·4 | 13·4 | 81·0 | 5·8 | 9·6 | 2·61 | 0·01 | 0·08 | 0·10 | 1·61 | 63·5 | 5·98 | 0·88 | 0·067 | 276 | 32·6 | |
| $B_3$ | 16-20 | 2·39 | 82·8 | 10·1 | 88·3 | 4·7 | 4·7 | 1·68 | 0·03 | 0·05 | 0·10 | 0·68 | 73·2 | 6·03 | 0·32 | 0·025 | 202 | 72·2 | |
| $B_3$ | 22-26 | 2·21 | 80·5 | 13·2 | 86·6 | 7·1 | 4·1 | 1·98 | 0·12 | 0·05 | 0·10 | 0·22 | 91·2 | 6·20 | | | 208 | 42·0 | |
| C | 30-34 | 2·26 | 83·7 | 10·1 | 89·2 | 4·6 | 3·9 | 1·83 | 0·12 | 0·11 | 0·09 | Nil | 100 | 6·42 | | | 197 | 48·0 | |
| C | 37-41 | 2·12 | 88·0 | 6·2 | 92·0 | 2·2 | 3·7 | 1·98 | 0·17 | 0·11 | 0·07 | Nil | 100 | 5·99 | | | 161 | 37·8 | |
| D | 49-53 | 2·02 | 87·3 | 5·6 | 92·1 | 0·8 | 5·1 | 3·35 | 0·44 | 0·05 | 0·10 | Nil | 100 | 5·95 | | | 220 | 68·1 | |
| 66. | | | | | | | COUNTESSWELLS ASSOCIATION; Countesswells Series. Hillhead of Auchenhuive, 28108–28111 | | | | | | | | | | | | |
| S | 0-6 | 14·35 | N.D. | N.D. | 60·4 | 21·2 | 11·2 | 1·90 | 0·25 | N.D. | 0·44 | 18·81 | 12·1 | 5·27 | 5·69 | 0·400 | 360 | N.D. | Low exchangeable Ca and Mg. Low exchangeable K in C. High total $P_2O_5$ in S, low in C. |
| $B_2$ | 10-14 | 17·09 | N.D. | N.D. | 78·6 | 13·3 | 8·1 | 0·51 | 0·01 | N.D. | 0·21 | 15·09 | 4·6 | 5·25 | 2·92 | 0·175 | 140 | N.D. | |
| $B_3$ | 16-18 | 7·36 | N.D. | N.D. | 84·6 | 6·0 | 9·4 | 0·42 | Nil | N.D. | 0·16 | 10·95 | 5·0 | 5·15 | | | 130 | N.D. | |
| C | 30-34 | 2·60 | N.D. | N.D. | 91·5 | 4·9 | 3·6 | 0·48 | Nil | N.D. | 0·04 | 2·00 | 20·6 | 5·28 | | | 70 | N.D. | |
| 67. | | | | | | | COUNTESSWELLS ASSOCIATION; Countesswells Series. Sunhoney, 48103–48108 | | | | | | | | | | | | |
| S | 0-6 | 8·97 | N.D. | N.D. | 66·5 | 2·3 | 26·8 | 2·07 | 0·10 | N.D. | 0·08 | 10·49 | 18·4 | 5·35 | 1·80 | 0·260 | 200 | 3·9 | Low exchangeable Ca and Mg. Low exchangeable K in S and $B_3$. High readily soluble $P_2O_5$ in $B_3$ and C. |
| $B_2$ | 8-12 | 6·22 | N.D. | N.D. | 80·8 | 9·6 | 9·6 | 1·26 | 0·08 | N.D. | 0·10 | 8·87 | 14·0 | 5·57 | 1·59 | 0·155 | 220 | 6·2 | |
| $B_3$ | 12-16 | 2·72 | N.D. | N.D. | 82·1 | 12·7 | 5·2 | 0·19 | 0·17 | N.D. | 0·10 | 3·18 | 12·7 | 5·38 | | | 260 | 50·0 | |
| $B_3$ | 18-22 | 3·30 | N.D. | N.D. | 68·0 | 12·6 | 16·1 | 1·01 | 0·11 | N.D. | 0·08 | 4·00 | 23·0 | 5·71 | | | 230 | 29·0 | |
| C | 26-30 | 3·97 | N.D. | N.D. | 68·5 | 12·4 | 15·5 | 0·84 | 0·09 | N.D. | 0·13 | 4·38 | 19·7 | 5·81 | | | 240 | 25·0 | |
| C | 40-44 | 2·80 | N.D. | N.D. | 69·0 | 7·2 | 21·0 | Nil | 0·27 | N.D. | 0·13 | 4·76 | 7·8 | 5·03 | | | 220 | 36·0 | |

68. COUNTESSWELLS ASSOCIATION: Countesswells Series. West Mains, Auchenhove, 48413–48417

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 11·60 | N.D. | N.D. | 68·8 | 14·8 | 10·6 | 2·43 | 0·18 | N.D. | 0·11 | 13·50 | 17·0 | 5·35 | 5·45 | 0·375 | 270 | 1·9 | Low exchangeable Ca and Mg. Low exchangeable K in $B_3$. Low readily soluble $P_2O_5$ in S, very high in $B_3$ and C. |
| $B_2$ | 10-16 | 7·00 | N.D. | N.D. | 82·2 | 10·0 | 7·8 | 1·32 | 0·07 | N.D. | 0·10 | 12·10 | 10·9 | 5·60 | 2·74 | 0·185 | 200 | 3·0 | |
| $B_3$ | 18-22 | 1·81 | N.D. | N.D. | 81·3 | 9·4 | 9·3 | 1·25 | Nil | N.D. | 0·07 | 2·84 | 31·8 | 5·80 | | | 210 | 43·0 | |
| C | 24-28 | 1·66 | N.D. | N.D. | 73·1 | 13·4 | 13·5 | 0·87 | Nil | N.D. | 0·11 | 2·31 | 29·8 | 5·76 | | | 210 | 62·0 | |
| C | 36-40 | 1·65 | N.D. | N.D. | 71·0 | 14·3 | 14·7 | 2·86 | 0·64 | N.D. | 0·20 | 0·89 | 81·5 | 6·13 | | | 220 | 86·0 | |

69. COUNTESSWELLS ASSOCIATION; Countesswells Series. Parkhead, 128770–128774

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 13·20 | 52·5 | 27·7 | 64·8 | 15·4 | 13·2 | 6·10 | 0·20 | 0·11 | 0·14 | 14·62 | 31·0 | 5·55 | 6·57 | 0·333 | 274 | 10·4 | Low exchangeable Ca in $B_3$ and C. Low exchangeable Mg. Low exchangeable K, except in S. High readily soluble $P_2O_5$ in S and C, low in $B_2$. |
| $B_2$ | 9-12 | 8·38 | 59·0 | 22·7 | 69·5 | 12·2 | 14·1 | 3·42 | 0·08 | 0·09 | 0·07 | 10·70 | 35·5 | 5·60 | 3·23 | 0·166 | 158 | 2·1 | |
| $B_3$ | 13-17 | 3·69 | 61·8 | 19·5 | 69·8 | 11·4 | 15·0 | 0·46 | 0·05 | 0·07 | 0·08 | 3·65 | 15·3 | 5·45 | | | 162 | 4·0 | |
| C | 21-25 | 3·08 | 61·8 | 17·6 | 71·7 | 9·7 | 17·5 | 1·07 | 0·13 | 0·05 | 0·07 | 4·26 | 23·6 | 5·20 | | | 151 | 20·7 | |
| C | 28-32 | 2·97 | 49·1 | 32·7 | 69·6 | 12·2 | 15·2 | 1·67 | 0·42 | 0·06 | 0·08 | 4·97 | 31·0 | 5·40 | | | 162 | 19·1 | |

70. COUNTESSWELLS ASSOCIATION; Countesswells Series. Tulloch, 130476–130479

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 7·99 | 60·0 | 20·8 | 68·4 | 12·4 | 15·2 | 4·79 | 0·21 | 0·12 | 0·11 | 8·10 | 39·2 | 5·61 | 3·92 | 0·319 | 269 | 7·0 | Low exchangeable Ca, except in S. Low exchangeable Mg. Low exchangeable K in $B_3$ and C. High readily soluble $P_2O_5$ in C. |
| $B_2$ | 10-14 | 6·05 | 56·1 | 24·7 | 66·7 | 14·1 | 16·2 | 2·30 | 0·13 | 0·06 | 0·07 | 3·83 | 59·9 | 5·30 | 2·12 | 0·159 | 190 | 3·5 | |
| $B_3$ | 18-22 | 3·06 | 61·1 | 20·9 | 70·7 | 11·3 | 14·9 | 2·29 | 0·23 | 0·06 | 0·14 | 2·73 | 50·1 | 5·15 | | | 113 | 3·1 | |
| C | 29-33 | 1·71 | 72·0 | 17·4 | 79·5 | 9·9 | 8·9 | 0·46 | 0·04 | 0·04 | 0·08 | 2·07 | 22·8 | 5·45 | | | 122 | 17·0 | |

71. CUMINESTOWN ASSOCIATION; Cuminestown Series. Lumsden, 54512–54515

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 7·75 | N.D. | N.D. | 62·0 | 14·1 | 20·1 | 3·57 | 0·43 | N.D. | 0·20 | 8·20 | 23·9 | 5·37 | 3·16 | 0·236 | 176 | 1·9 | Low exchangeable Ca in lower-half of profile. Low exchangeable Mg in C. Low total $P_2O_5$ except in S. Low readily soluble $P_2O_5$. |
| $B_2$ | 12-18 | 4·02 | N.D. | N.D. | 62·9 | 12·0 | 21·1 | 3·10 | 0·40 | N.D. | 0·15 | 8·93 | 29·0 | 5·13 | 0·08 | 0·058 | 99 | 0·7 | |
| $B_2$ | 24-30 | 2·92 | N.D. | N.D. | 70·1 | 8·2 | 18·8 | 0·83 | 0·34 | N.D. | 0·15 | 9·20 | 12·5 | 5·07 | | | 92 | 2·4 | |
| C | 38-44 | 3·56 | N.D. | N.D. | 89·3 | 9·9 | 10·8 | 0·63 | 0·21 | N.D. | 0·16 | 8·08 | 11·0 | 4·88 | | | 74 | 0·9 | |

TABLE 3—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72. | CUMINESTOWN ASSOCIATION; Cuminestown Series. Cot Hill, 110272–110276 | | | | | | | | | | | | | | | | | | |
| S | 3-7 | 6·97 | 72·8 | 13·6 | 78·4 | 8·0 | 10·1 | 0·62 | 0·39 | 0·07 | 0·18 | 16·35 | 7·2 | 4·50 | 3·26 | 0·266 | 138 | 1·4 | High sand content in $B_2$ and C. Low exchangeable Ca. Low exchangeable Mg and K except in S. Low total $P_2O_5$ in C. Low readily soluble $P_2O_5$ in top layers. |
| $B_2$ | 12-16 | 4·33 | 76·9 | 10·7 | 80·8 | 6·8 | 10·2 | 0·15 | 0·14 | 0·06 | 0·03 | 10·83 | 3·4 | 4·70 | 2·15 | 0·179 | 113 | 1·0 | |
| $B_2$ | 22-36 | 1·93 | 92·8 | 2·6 | 93·7 | 1·7 | 2·7 | 0·15 | 0·04 | 0·06 | 0·02 | 2·74 | 9·0 | 4·98 | | | 118 | 6·1 | |
| C | 32-36 | 2·50 | 73·2 | 17·8 | 82·8 | 8·2 | 6·5 | 0·15 | 0·13 | 0·04 | 0·02 | 4·46 | 7·1 | 4·99 | | | 67 | 2·5 | |
| C | 39-43 | 0·98 | 95·0 | 4·0 | 96·4 | 2·6 | Nil | 0·45 | 0·08 | 0·03 | 0·02 | 5·52 | 9·7 | 5·10 | | | 44 | 4·2 | |
| 73. | CUMINESTOWN ASSOCIATION; Cuminestown Series. Templeton, 48089–48092 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 13·50 | N.D. | N.D. | 61·0 | 16·2 | 16·6 | 6·58 | 0·44 | N.D. | 0·18 | 7·30 | 49·6 | 5·58 | 1·83 | 0·260 | 320 | 2·8 | High total $P_2O_5$ in S. Low readily soluble $P_2O_5$. |
| $B_2$ | 10-14 | 4·37 | N.D. | N.D. | 63·7 | 12·5 | 21·6 | 6·24 | 0·45 | N.D. | 0·10 | 2·42 | 71·7 | 5·92 | 0·70 | 0·088 | 180 | 2·7 | |
| $B_3$ | 20-24 | 3·48 | N.D. | N.D. | 63·1 | 13·6 | 21·9 | 3·28 | 0·37 | N.D. | 0·10 | 3·98 | 48·5 | 5·49 | | | 130 | 1·8 | |
| C | 40-44 | 2·86 | N.D. | N.D. | 74·0 | 9·1 | 16·9 | 3·65 | 0·72 | N.D. | 0·12 | 5·29 | 46·0 | 5·35 | | | 110 | 1·3 | |
| 74. | FOUDLAND ASSOCIATION; Foudland Series. Balquhindachy, 119387–119389 | | | | | | | | | | | | | | | | | | |
| S | 4-8 | 12·70 | 33·1 | 49·0 | 60·2 | 21·9 | 11·5 | 11·29 | 0·60 | 0·21 | 0·58 | 7·92 | 61·5 | 6·12 | 6·03 | 0·369 | 368 | 11·3 | High exchangeable Ca in S, otherwise low. Low exchangeable Mg in $B_2$ and C. High total and readily soluble $P_2O_5$ in S. Low readily soluble $P_2O_5$ in $B_2$. |
| $B_2$ | 14-18 | 9·10 | 42·9 | 47·7 | 73·8 | 16·8 | 4·8 | 2·35 | 0·06 | 0·17 | 0·18 | 10·77 | 20·4 | 5·54 | 2·94 | 0·152 | 189 | 2·1 | |
| C | 22-26 | 3·99 | 48·0 | 39·9 | 72·1 | 15·8 | 8·1 | 0·77 | Nil | 0·13 | 0·12 | 3·32 | 23·6 | 5·62 | | | 103 | 4·4 | |

75. FOUDLAND ASSOCIATION; Foudland Series. Hardgate, 35015–35019

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 11·10 | N.D. | N.D. | 55·7 | 22·8 | 15·9 | 3·18 | 0·49 | N.D. | 0·17 | 12·65 | 23·4 | 5·36 | 4·31 | 0·260 | 165 | 1·3 | Low exchangeable Ca, Mg |
| $B_2$ | 10-12 | 6·47 | N.D. | N.D. | 56·9 | 20·9 | 19·0 | 1·14 | 0·22 | N.D. | 0·08 | 5·98 | 19·3 | 5·68 | 1·08 | 0·070 | 119 | 0·2 | and K except in S. |
| $B_3$ | 20-24 | 6·31 | N.D. | N.D. | 60·3 | 23·6 | 12·9 | 0·55 | 0·13 | N.D. | 0·07 | 4·92 | 13·2 | 5·30 | | | 137 | 0·1 | Low readily soluble $P_2O_5$. |
| $B_3$ | 30-34 | 6·25 | N.D. | N.D. | 60·5 | 28·4 | 8·0 | 0·55 | 0·06 | N.D. | 0·01 | 4·45 | 12·2 | 4·99 | | | 127 | Nil | |
| C | 44-48 | 5·66 | N.D. | N.D. | 62·6 | 26·4 | 8·2 | 1·20 | 0·12 | N.D. | 0·01 | 4·45 | 23·1 | 5·00 | | | 147 | N.D. | |

76. FOUDLAND ASSOCIATION; Foudland Series. Auchmullen, 105151–105155

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_1$ | 3-6 | 12·60 | 43·0 | 36·5 | 65·8 | 13·7 | 14·2 | 0·78 | 0·36 | 0·09 | 0·29 | 14·62 | 9·4 | 5·62 | 4·55 | 0·249 | 213 | 0·4 | High sand content in C. |
| $B_2$ | 9-14 | 6·26 | 43·4 | 40·5 | 70·2 | 13·7 | 13·0 | 0·31 | 0·10 | 0·05 | 0·08 | 10·05 | 5·1 | 5·12 | 1·54 | 0·123 | 296 | 0·3 | Low exchangeable Ca. |
| $B_2$ | 16-21 | 5·89 | 50·2 | 37·4 | 74·5 | 13·1 | 9·5 | 0·31 | 0·07 | 0·06 | 0·05 | 9·00 | 5·2 | 5·00 | | | 239 | 0·4 | Low exchangeable Mg and |
| C | 23-29 | 3·82 | 68·2 | 25·6 | 88·7 | 5·1 | 2·4 | 0·30 | 0·04 | 0·03 | 0·03 | 3·88 | 9·3 | 5·22 | | | 202 | 1·6 | K except in $A_1$. |
| C | 36-41 | 4·31 | 71·7 | 22·8 | 90·1 | 4·4 | 3·3 | 0·30 | 0·42 | 0·03 | 0·03 | 3·99 | 16·4 | 5·21 | | | 201 | 1·0 | Low % saturation. |
| | | | | | | | | | | | | | | | | | | | Low readily soluble $P_2O_5$. |

77. FOUDLAND ASSOCIATION; Foudland Series. Tulloch (cut woodland), 47311–47314

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_1$ | 0-8 | 13·70 | N.D. | N.D. | 53·6 | 21·5 | 18·0 | 3·19 | 1·59 | N.D. | 0·50 | 1·31 | 80·1 | 5·93 | 5·97 | 0·308 | 190 | 0·9 | Low exchangeable Ca and |
| $B_2$ | 10-20 | 5·00 | N.D. | N.D. | 62·0 | 21·2 | 12·2 | 0·27 | 0·22 | N.D. | 0·16 | 0·90 | 41·8 | 5·65 | 2·11 | 0·148 | 180 | 0·4 | Mg except in $A_1$. |
| $B_3$ | 26-30 | 3·59 | N.D. | N.D. | 74·3 | 25·2 | 10·5 | 0·01 | 0·04 | N.D. | 0·14 | 1·07 | 15·1 | 5·69 | | | 130 | 1·3 | Low readily soluble $P_2O_5$. |
| C | 40-44 | 3·67 | N.D. | N.D. | 83·5 | 9·7 | 6·8 | 0·66 | 0·10 | N.D. | 0·16 | 1·06 | 46·5 | 5·22 | | | 120 | 0·9 | |

78. FOUDLAND ASSOCIATION; Foudland Series. Tulloch (grass), 47315–47318

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-5 | 8·87 | N.D. | N.D. | 54·3 | 21·5 | 19·8 | 3·75 | 0·79 | N.D. | 0·26 | 13·44 | 26·4 | 5·80 | 3·01 | 0·312 | 220 | 0·6 | Low exchangeable Ca in $B_2$ |
| $B_2$ | 8-12 | 5·99 | N.D. | N.D. | 59·1 | 22·5 | 15·5 | 2·36 | 0·76 | N.D. | 0·20 | 9·05 | 26·6 | 5·96 | 1·12 | 0·131 | 170 | 0·5 | and $B_3$. |
| $B_3$ | 20-24 | 6·23 | N.D. | N.D. | 53·7 | 17·4 | 25·8 | 2·85 | 1·65 | N.D. | 0·19 | 2·06 | 69·4 | 5·79 | | | 140 | 0·2 | Very low readily soluble |
| C | 40-44 | 5·36 | N.D. | N.D. | 43·2 | 32·0 | 22·1 | 3·90 | 2·52 | N.D. | 0·25 | 1·95 | 77·4 | 5·40 | | | 140 | 0·3 | $P_2O_5$. |

TABLE 3—Continued

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 79. | | FOUDLAND ASSOCIATION; Foudland Series. Benaquhallie, 113636–113639 | | | | | | | | | | | | | | | | | |
| $A_1$ | 3-6 | 12·60 | 52·4 | 28·2 | 69·6 | 11·0 | 13·1 | 1·87 | 0·24 | 0·10 | 0·38 | 12·52 | 17·2 | 4·98 | 5·80 | 0·238 | 145 | 2·3 | Low exchangeable Ca and Mg. |
| $B_2$ | 11-15 | 8·68 | 51·9 | 34·1 | 69·8 | 16·2 | 9·7 | 0·93 | 0·10 | 0·10 | 0·29 | 8·08 | 15·2 | 5·40 | 2·41 | 0·155 | 146 | 3·7 | Low exchangeable K in C. |
| $B_2$-C | 18-23 | 6·40 | 56·4 | 25·8 | 72·9 | 9·3 | 14·6 | 0·46 | 0·01 | 0·07 | 0·10 | 7·37 | 8·0 | 5·19 | | | 132 | 3·1 | Low readily soluble $P_2O_5$ in $A_1$ and C. |
| C | 26-29 | 6·57 | 59·9 | 25·9 | 74·8 | 10·9 | 10·9 | 0·46 | 0·05 | 0·07 | 0·07 | 9·79 | 6·2 | 5·15 | | | 138 | 2·1 | |
| 80. | | FOUDLAND ASSOCIATION; Foudland Series. Andet, 83709–83712 | | | | | | | | | | | | | | | | | |
| S | 0-8 | 9·50 | N.D. | N.D. | 51·3 | 19·0 | 25·0 | 9·10 | 0·84 | 0·05 | 0·22 | 10·25 | 49·8 | 5·83 | 2·97 | 0·271 | 312 | 3·6 | High exchangeable Ca in S, low in $B_3$ and C. |
| $B_2$ | 11-16 | 7·25 | N.D. | N.D. | 67·9 | 25·6 | 2·9 | 3·48 | 0·42 | 0·05 | 0·14 | 8·64 | 32·1 | 5·86 | 1·45 | 0·173 | 183 | 1·2 | Low exchangeable Mg in C. |
| $B_3$ | 22-29 | 4·20 | N.D. | N.D. | 72·8 | 11·5 | 13·6 | 1·12 | 0·40 | Nil | 0·02 | 5·81 | 21·0 | 5·93 | | | 92 | 0·9 | Low exchangeable K in $B_3$ and C. |
| C | 30-34 | 3·73 | N.D. | N.D. | 79·5 | 5·1 | 11·7 | 0·71 | 0·24 | Nil | Nil | 2·43 | 28·1 | 5·85 | | | 74 | 0·8 | High total $P_2O_5$ in S, low in $B_3$ and C. Low readily soluble $P_2O_5$ except in S. |

81. FOUDLAND ASSOCIATION; Foudland Series. Suie, 150662–150668

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_2$ | 1-4 | 14·40 | 50·7 | 33·5 | 68·7 | 15·5 | 8·6 | 0·61 | 0·59 | 0·14 | 0·37 | 17·19 | 9·0 | 4·21 | 7·39 | 0·296 | 81 | 0·4 | Low exchangeable Ca. Low exchangeable Mg and K except in $A_2$. Low % saturation. Low total $P_2O_5$ in $A_2$ and $B_3$. Very low readily soluble $P_2O_5$. |
| $B_2$ | 6-10 | 11·90 | 38·6 | 43·7 | 61·0 | 21·2 | 11·8 | Nil | 0·10 | 0·07 | 0·09 | 15·48 | 1·7 | 4·89 | 3·08 | 0·136 | 153 | Nil | |
| $B_2$ | 12-15 | 7·35 | 41·2 | 45·1 | 63·3 | 23·0 | 10·0 | Nil | Nil | 0·04 | 0·09 | 8·47 | 1·5 | 5·10 | 1·55 | 0·077 | 109 | Nil | |
| $B_3$ | 17-21 | 5·66 | 35·2 | 50·3 | 59·6 | 25·9 | 11·7 | Nil | Nil | 0·03 | 0·05 | 4·37 | 1·8 | 5·06 | | | 85 | 0·4 | |
| C | 24-27 | 6·41 | 52·3 | 34·2 | 67·6 | 19·5 | 10·3 | Nil | Nil | 0·04 | 0·09 | 4·15 | 3·0 | 5·12 | | | 126 | 0·6 | |
| C | 28-30 | 4·46 | 64·9 | 24·9 | 77·2 | 12·6 | 8·0 | Nil | Nil | 0·05 | 0·10 | 5·27 | 2·8 | 5·14 | | | 171 | 0·6 | |

82. INSCH ASSOCIATION; Bruntland Series. Glack, 150576–150580

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_1$ | 2-6 | 29·20 | N.D. | N.D. | N.D. | N.D. | N.D. | 1·63 | 0·89 | 0·28 | 0·52 | 34·94 | 8·0 | 4·87 | 16·87 | 0·602 | 236 | 0·4 | Low exchangeable Ca. Low exchangeable Mg except in $A_1$. Low % saturation. Very low readily soluble $P_2O_5$ except in C. |
| $B_2$ | 8-11 | 16·90 | 64·6 | 21·0 | 77·4 | 8·2 | 1·7 | 0·47 | 0·27 | 0·16 | 0·16 | 19·08 | 5·3 | 5·29 | 6·28 | 0·269 | 223 | Nil | |
| $B_2$ | 14-17 | 10·30 | 66·6 | 25·6 | 80·0 | 12·2 | 2·7 | 0·31 | 0·10 | 0·13 | 0·15 | 9·76 | 6·6 | 5·41 | | | 224 | 0·1 | |
| C | 21-25 | 4·54 | 74·5 | 20·7 | 82·9 | 12·3 | 2·5 | 0·31 | 0·08 | 0·12 | 0·13 | 3·84 | 14·3 | 5·58 | | | 217 | 4·4 | |

83. LOCHTER ASSOCIATION; Lochter Series. Keith Hall Farm, 113640–113644

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 10·80 | 49·6 | 25·7 | 60·1 | 15·2 | 19·3 | 7·64 | 0·49 | 0·18 | 0·34 | 9·80 | 46·8 | 6·10 | 3·80 | 0·151 | 354 | 8·2 | Low exchangeable Ca in $B_2$ and C. Low exchangeable Mg in $B_2$. High total $P_2O_5$ in S. Low readily soluble $P_2O_5$ in lower part of S. |
| S | 8-12 | 9·67 | 48·8 | 25·8 | 60·7 | 13·9 | 20·6 | 4·21 | 0·33 | 0·09 | 0·19 | 10·11 | 32·2 | 5·56 | 3·35 | 0·270 | 341 | 2·8 | |
| S | 14-18 | 9·15 | 43·0 | 32·6 | 62·8 | 12·8 | 19·8 | 4·38 | 0·24 | 0·08 | 0·19 | 9·60 | 33·7 | 6·00 | | | 317 | 1·5 | |
| $B_2$ | 22-26 | 4·41 | 75·7 | 11·5 | 81·7 | 5·5 | 10·6 | 2·00 | 0·12 | 0·11 | 0·13 | 2·52 | 48·3 | 6·05 | | | 249 | 10·2 | |
| C | 32-36 | 3·94 | 74·3 | 13·4 | 82·6 | 2·1 | 8·4 | 2·46 | 0·37 | 0·08 | 0·19 | 1·61 | 65·8 | 6·20 | | | 228 | 9·2 | |

TABLE 3—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84. | | | | | | | | NORTH MORMOND ASSOCIATION; Denhead Series. Denhead, 119060–119063 | | | | | | | | | | | |
| S | 2-6 | 6·86 | 51·4 | 21·8 | 61·6 | 11·6 | 23·4 | 4·60 | 0·78 | 0·19 | 0·33 | 5·75 | 50·6 | 5·76 | 2·75 | 0·261 | 193 | 1·7 | Low exchangeable Ca in $B_3$(g) and C(g). |
| $B_2$ | 9-13 | 5·44 | 55·8 | 21·4 | 65·9 | 11·3 | 20·1 | 3·86 | 0·67 | 0·27 | 0·14 | 5·47 | 47·3 | 6·27 | 1·31 | 0·078 | 108 | 0·5 | Low total $P_2O_5$ in $B_3$(g). |
| $B_3$(g) | 16-20 | 4·21 | 49·4 | 26·8 | 63·3 | 12·9 | 21·7 | 2·45 | 0·51 | 0·19 | 0·14 | 3·39 | 49·3 | 6·00 | | | 90 | 0·4 | Low readily soluble $P_2O_5$. |
| C(g) | 25-29 | 4·80 | 60·3 | 20·1 | 70·9 | 9·5 | 17·2 | 1·38 | 0·35 | 0·11 | 0·14 | 3·31 | 37·5 | 5·62 | | | 130 | 0·3 | |
| 85. | | | | | | | | ORDLEY ASSOCIATION; Ordley Series. Goryhill, 109761–109765 | | | | | | | | | | | |
| S | 2-6 | 13·50 | 60·6 | 18·1 | 67·9 | 10·8 | 14·5 | 2·69 | 2·06 | 0·13 | 0·90 | 17·30 | 25·0 | 5·22 | 6·27 | 0·403 | 163 | 0·7 | Low exchangeable Ca. |
| $B_2$ | 9-13 | 6·65 | 49·7 | 23·6 | 60·1 | 13·2 | 23·4 | 0·94 | 1·30 | 0·16 | 0·24 | 15·59 | 14·4 | 5·14 | 1·41 | 0·138 | 98 | 0·4 | Low exchangeable K in D. |
| $B_2$ | 17-21 | 6·55 | 49·0 | 21·7 | 59·7 | 11·0 | 26·0 | 0·16 | 2·33 | 0·17 | 0·16 | 20·60 | 12·0 | 5·52 | | | 81 | 0·8 | Low total $P_2O_5$ in $B_2$ and C. |
| C | 25-29 | 6·16 | 59·9 | 19·5 | 68·5 | 11·9 | 17·5 | 0·63 | 1·96 | 0·16 | 0·14 | 19·02 | 13·2 | 5·23 | | | 95 | 0·8 | Low readily soluble $P_2O_5$ except in D. |
| D | 33-36 | 4·25 | 69·8 | 14·3 | 77·1 | 7·0 | 13·7 | 0·47 | 1·52 | 0·12 | 0·07 | 11·61 | 15·8 | 5·38 | | | 155 | 5·7 | |
| 86. | | | | | | | | ORDLEY ASSOCIATION; Ordley Series. Boghead, Lumsden, 105131–105135 | | | | | | | | | | | |
| S | 1-5 | 6·81 | 49·7 | 25·6 | 62·2 | 13·1 | 21·3 | 4·62 | 0·42 | 0·12 | 0·15 | 7·58 | 41·2 | 5·29 | 2·65 | 0·224 | 212 | 4·7 | Low exchangeable Ca except in S. |
| $B_2$ | 8-13 | 3·14 | 53·1 | 17·2 | 61·3 | 9·0 | 26·6 | 2·42 | 0·58 | 0·09 | 0·13 | 5·86 | 35·5 | 5·22 | 0·37 | 0·053 | 70 | Nil | Low total $P_2O_5$ except in S. |
| $B_2$ | 13-16 | 2·09 | 66·0 | 9·5 | 71·8 | 3·7 | 22·4 | 1·53 | 0·24 | 0·07 | 0·10 | 4·67 | 29·4 | 5·06 | | | 46 | Nil | Low readily soluble $P_2O_5$ in $B_2$. |
| C | 19-24 | 2·02 | 78·1 | 9·1 | 82·9 | 4·3 | 10·8 | 1·68 | 0·64 | 0·08 | 0·13 | 7·13 | 26·2 | 5·25 | | | 78 | 5·1 | |
| C | 28-31 | 1·88 | 78·4 | 10·0 | 82·5 | 4·9 | 9·7 | 1·06 | 0·41 | 0·07 | 0·08 | 5·60 | 22·4 | 5·07 | | | 74 | 4·2 | |

87. STRICHEN ASSOCIATION; Strichen Series. Touxhill, 110640–110644

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 9·58 | 44·9 | 31·8 | 58·3 | 18·4 | 18·5 | 3·54 | 0·41 | 0·11 | 0·13 | 7·25 | 36·6 | 5·36 | 3·37 | 0·244 | 147 | 1·8 | Low exchangeable Ca except in S. Low exchangeable Mg in $B_3$, C and D. Low exchangeable K in $B_2$, $B_3$ and D. Low total $P_2O_5$ in $B_3$, C and D. Low readily soluble $P_2O_5$. |
| $B_2$ | 10-14 | 6·86 | 52·1 | 27·0 | 72·6 | 6·5 | 17·5 | 2·45 | 0·31 | 0·10 | 0·07 | 4·14 | 41·5 | 5·62 | 1·19 | 0·110 | 129 | 0·9 | |
| $B_3$ | 16-21 | 6·22 | 49·2 | 26·9 | 57·9 | 18·2 | 20·8 | 1·68 | 0·27 | 0·10 | 0·07 | 1·37 | 60·8 | 5·71 | | | 93 | 0·7 | |
| C | 28-34 | 4·61 | 64·9 | 16·8 | 70·9 | 10·8 | 16·0 | 0·91 | 0·18 | 0·08 | 0·11 | 0·11 | 92·0 | 5·68 | | | 70 | 0·6 | |
| D | 38-42 | 3·82 | 72·0 | 16·2 | 81·0 | 7·2 | 8·0 | 0·76 | 0·06 | 0·05 | 0·04 | 0·23 | 79·7 | 5·36 | | | 44 | 0·7 | |

88. STRICHEN ASSOCIATION; Strichen Series. Skillymarno, 117980–117983

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3-7 | 10·20 | 58·3 | 22·0 | 67·9 | 12·4 | 14·6 | 5·40 | 0·43 | 0·13 | 0·10 | 11·28 | 35·0 | 6·00 | 4·26 | 0·232 | 268 | 3·1 | Low exchangeable Ca and K except in S. 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 S. |
| $B_2$ | 11-15 | 6·64 | 56·9 | 24·6 | 67·2 | 14·3 | 15·2 | 2·32 | 0·34 | 0·10 | 0·07 | 7·56 | 27·2 | 5·60 | 2·33 | 0·093 | 157 | 0·8 | |
| $B_3$ | 17-21 | 3·74 | 77·3 | 13·3 | 82·4 | 8·2 | 5·7 | 0·76 | 0·09 | 0·07 | 0·05 | 2·29 | 29·7 | 5·71 | | | 99 | 1·6 | |
| C | 24-28 | 3·14 | 80·6 | 11·2 | 85·2 | 6·6 | 5·1 | 0·15 | 0·04 | 0·04 | 0·04 | 2·28 | 10·6 | 5·51 | | | 89 | 1·0 | |

89. TARVES ASSOCIATION; Tillypronie Series. Balwearie, 47331–47336

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L/F | 2-0 | 40·80 | N.D. | N.D. | N.D. | N.D. | N.D. | 3·89 | 2·71 | N.D. | 1·20 | 56·60 | 12·2 | 4·21 | 15·95 | 0·865 | 240 | 7·3 | Low exchangeable Ca except in L/F. Low exchangeable Mg in $A_2$, $B_2$ and $B_3$. High exchangeable K in L/F Low readily soluble $P_2O_5$ except in L/F and $B_3$. |
| $A_2$ | 3-6 | 13·30 | N.D. | N.D. | 63·9 | 16·4 | 14·5 | 0·70 | 0·26 | N.D. | 0·20 | 22·30 | 4·7 | 4·73 | 5·40 | 0·287 | 150 | Nil | |
| $B_2$ | 10-12 | 9·12 | N.D. | N.D. | 61·3 | 22·4 | 11·8 | 0·17 | 0·03 | N.D. | 0·14 | 15·30 | 2·1 | 5·03 | | | 200 | 0·2 | |
| $B_3$ | 16-19 | 4·19 | N.D. | N.D. | 66·0 | 14·8 | 17·8 | 0·47 | 0·18 | N.D. | 0·10 | 6·78 | 9·8 | 5·03 | | | 180 | 3·7 | |
| C | 20-24 | 4·42 | N.D. | N.D. | 70·4 | 11·1 | 14·5 | 0·78 | 0·49 | N.D. | 0·13 | 6·14 | 18·8 | 5·20 | | | 160 | 0·4 | |
| C | 36-40 | 3·43 | N.D. | N.D. | 78·1 | 10·6 | 11·3 | 1·03 | 0·43 | N.D. | 0·14 | 4·82 | 24·7 | 5·53 | | | 210 | 1·1 | |

TABLE 3—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90. | TARVES ASSOCIATION; Tillypronie Series. Rowrandle, 63312–63316 | | | | | | | | | | | | | | | | | | |
| $A_2$ | 3-6 | 10·04 | N.D. | N.D. | 72·0 | 10·9 | 12·1 | 0·34 | 0·45 | N.D. | 0·23 | 18·04 | 5·4 | 4·22 | 5·18 | 0·247 | 122 | 1·1 | Low exchangeable Ca. |
| $B_2$ | 8-11 | 8·76 | N.D. | N.D. | 73·0 | 12·0 | 10·6 | 0·06 | 0·30 | N.D. | 0·15 | 16·20 | 3·1 | 4·69 | 3·02 | 0·189 | 144 | 0·7 | Low exchangeable Mg in $B_3$ and C. |
| $B_3$ | 13-17 | 3·71 | N.D. | N.D. | 67·4 | 15·5 | 13·4 | 0·07 | 0·13 | N.D. | 0·11 | 6·92 | 4·2 | 4·83 | 0·95 | 0·082 | 140 | 2·1 | Low readily soluble $P_2O_5$ |
| $B_3$ | 24-30 | 2·60 | N.D. | N.D. | 64·1 | 15·7 | 17·6 | 0·07 | 0·20 | N.D. | 0·12 | 5·02 | 7·2 | 4·98 | | | 124 | 2·3 | |
| C | 36-42 | 3·23 | N.D. | N.D. | 60·8 | 15·1 | 20·9 | Nil | 0·13 | N.D. | 0·24 | 5·95 | 5·9 | 4·92 | | | 112 | 1·8 | |
| 91. | TARVES ASSOCIATION; Tillypronie Series. Pittenderich, 150641–150646 | | | | | | | | | | | | | | | | | | |
| H | 1-0 | 83·10 | N.D. | N.D. | N.D. | N.D. | N.D. | 11·07 | 7·31 | 1·04 | 1·96 | 96·42 | 18·1 | 3·78 | 53·06 | 1·217 | 171 | 9·8 | High exchangeable Ca and Mg in H, otherwise low. |
| $A_2$ | 0-2 | 10·30 | 68·6 | 20·6 | 78·3 | 10·9 | 5·7 | 0·46 | 0·30 | 0·09 | 0·28 | 20·59 | 5·2 | 4·31 | 5·80 | 0·169 | 73 | 0·2 | High exchangeable K in H, low in $B_3$ and C. |
| $B_2$ | 4-8 | 11·75 | 65·3 | 22·0 | 74·9 | 12·4 | 6·8 | Nil | 0·07 | 0·07 | 0·10 | 16·05 | 1·5 | 4·90 | | | 150 | Nil | Low % saturation, except in H. |
| $B_3$ | 11-15 | 5·10 | 68·5 | 25·5 | 80·9 | 13·1 | 3·5 | Nil | Nil | 0·05 | 0·05 | 5·36 | 1·8 | 5·10 | | | 118 | 2·9 | Low total $P_2O_5$ in $A_2$. |
| C | 25-33 | 5·40 | 64·8 | 29·2 | 80·3 | 13·7 | 3·3 | Nil | Nil | 0·07 | 0·05 | 5·14 | 2·3 | 5·14 | | | 116 | 0·8 | Low readily soluble $P_2O_5$ except in H. |

TABLE 4. IRON PODZOLS, IMPERFECTLY DRAINED

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 92. | | | BOYNDIE ASSOCIATION; Anniston Series. Pictillum, 112418–112422 | | | | | | | | | | | | | | | | |
| S | 1-5 | 12·30 | 80·3 | 8·4 | 84·0 | 4·2 | 5·1 | 7·21 | 0·54 | 0·11 | 0·14 | 11·25 | 41·5 | 5·44 | 7·17 | 0·287 | 148 | 3·1 | High sand content. |
| $B_2(g)$ | 8-12 | 0·97 | 90·4 | 7·0 | 93·4 | 4·0 | 1·6 | 1·50 | 0·24 | 0·06 | 0·07 | Nil | 100 | 5·79 | 0·12 | 0·015 | 79 | 11·2 | Low exchangeable Ca and |
| $B_2(g)$ | 14-18 | 0·79 | 95·0 | 4·2 | 96·2 | 3·0 | Nil | 1·20 | 0·18 | 0·05 | 0·13 | Nil | 100 | 5·75 | | | 68 | 8·2 | Mg except in S. |
| C(g) | 20-25 | 0·84 | 91·8 | 7·4 | 95·8 | 3·4 | Nil | 1·20 | 0·18 | 0·04 | 0·13 | Nil | 100 | 5·53 | | | 100 | 9·6 | Low total $P_2O_5$ except in S. |
| C(g) | 32-36 | 0·87 | 92·4 | 2·7 | 95·0 | 1·1 | 3·0 | 0·75 | 0·24 | 0·04 | 0·10 | Nil | 100 | 5·66 | | | 95 | 11·7 | |
| 93. | | | BOYNDIE ASSOCIATION; Anniston Series. Philorth, 118286–118291 | | | | | | | | | | | | | | | | |
| S | 3-7 | 6·35 | 69·2 | 12·9 | 75·0 | 7·1 | 14·7 | 5·83 | 0·79 | 0·17 | 0·10 | 4·52 | 60·2 | 5·85 | 2·70 | 0·179 | 153 | 3·0 | High sand content in $B_3(g)$ and C(g). |
| $B_2(g)$ | 11-15 | 4·91 | 74·7 | 9·8 | 79·4 | 5·1 | 13·0 | 5·50 | 0·78 | 0·14 | 0·04 | 3·85 | 62·6 | 6·40 | 1·91 | 0·138 | 170 | 1·3 | Low exchangeable Ca in $B_3(g)$ and C(g). |
| $B_3(g)$ | 18-22 | 1·86 | 85·6 | 5·0 | 88·0 | 2·6 | 7·5 | 2·57 | 0·47 | 0·08 | 0·02 | 0·34 | 90·5 | 6·34 | 0·64 | 0·055 | 69 | 4·0 | Low exchangeable K except in S. |
| $B_3(g)$ | 24-28 | 0·55 | 97·0 | 0·4 | 97·4 | Nil | 2·0 | 0·83 | 0·20 | 0·04 | 0·02 | Nil | 100 | 6·12 | | | 36 | 10·4 | Low total $P_2O_5$ in $B_3(g)$ and C(g). |
| C(g) | 36-40 | 1·16 | 80·7 | 8·4 | 84·9 | 4·2 | 9·7 | 2·42 | 0·47 | 0·10 | 0·07 | 0·23 | 92·0 | 6·10 | | | 52 | 16·7 | Low readily soluble $P_2O_5$ in $B_2(g)$, high in C(g). |
| C(g) | 50-54 | 0·72 | 94·7 | 2·2 | 96·7 | 0·2 | 2·4 | 1·51 | 0·24 | 0·10 | 0·09 | Nil | 100 | 6·52 | | | 45 | 13·6 | |

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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 94. | | COUNTESSWELLS ASSOCIATION; Dess Series. Westside, Maryculter, 61588–61593 | | | | | | | | | | | | | | | | | |
| H | 3-6 | 38·00 | N.D. | N.D. | N.D. | N.D. | N.D. | 1·58 | 1·04 | N.D. | 0·46 | 110·60 | 2·7 | 4·06 | 22·50 | 0·658 | 173 | 2·8 | Low exchangeable Ca. Low exchangeable Mg except in H and C(g). Low readily soluble $P_2O_5$ in H, $B_2$ and $B_2$(g). |
| $B_2$ | 8-12 | 7·91 | N.D. | N.D. | 62·1 | 18·8 | 15·1 | 0·20 | Nil | N.D. | 0·12 | 12·90 | 2·4 | 4·71 | 2·59 | 0·123 | 102 | 1·0 | |
| $B_2$(g) | 17-21 | 4·09 | N.D. | N.D. | 72·3 | 16·6 | 8·9 | 0·27 | Nil | N.D. | 0·10 | 5·80 | 6·0 | 4·95 | 1·07 | 0·061 | 146 | 2·7 | |
| $B_3$(g) | 24-30 | 2·19 | N.D. | N.D. | 71·6 | 13·3 | 12·9 | 0·26 | Nil | N.D. | 0·13 | 2·33 | 14·7 | 5·23 | 0·28 | 0·030 | 137 | 4·5 | |
| C(g) | 36-41 | 1·60 | N.D. | N.D. | 66·8 | 15·0 | 16·6 | 0·66 | 0·68 | N.D. | 0·18 | 2·99 | 33·8 | 5·04 | | | 145 | 2·1 | |
| C(g) | 42-46 | 2·00 | N.D. | N.D. | 66·9 | 13·8 | 17·3 | 0·79 | 0·81 | N.D. | 0·24 | 2·16 | 46·0 | 5·19 | | | 145 | 6·5 | |
| 95. | | COUNTESSWELLS ASSOCIATION; Dess Series. Baads, Culter, 48361–48365 | | | | | | | | | | | | | | | | | |
| S | 0-6 | 7·30 | N.D. | N.D. | 73·8 | 14·1 | 12·1 | 3·78 | 0·18 | Nil | 0·13 | 9·76 | 29·6 | 5·39 | 3·72 | 0·274 | 270 | 10·0 | Low exchangeable Ca and K except in S. Low exchangeable Mg. High readily soluble $P_2O_5$. |
| $B_3$ | 9-11 | 1·66 | N.D. | N.D. | 77·4 | 12·3 | 10·3 | 0·55 | Nil | Nil | Nil | 2·39 | 18·7 | 5·63 | 0·37 | 0·096 | 220 | 39·0 | |
| C(g) | 14-18 | 1·63 | N.D. | N.D. | 77·4 | 10·1 | 12·3 | 1·41 | Nil | Nil | Nil | 2·40 | 36·9 | 5·75 | | | 200 | 43·0 | |
| C(g) | 30-34 | 1·00 | N.D. | N.D. | 74·4 | 8·3 | 16·3 | 1·05 | Nil | Nil | Nil | 2·59 | 28·9 | 5·46 | | | 190 | 38·0 | |
| 96. | | COUNTESSWELLS ASSOCIATION; Dess Series. Borrohill, 119402–119404 | | | | | | | | | | | | | | | | | |
| S | 2-6 | 11·30 | 46·9 | 31·4 | 61·3 | 17·0 | 16·0 | 11·20 | 1·10 | 0·19 | 0·32 | 7·62 | 62·6 | 6·04 | 5·52 | 0·280 | 222 | 5·5 | High exchangeable Ca in S, low in $B_3$(g) and C(g). Low exchangeable Mg in C(g). Low total and readily soluble $P_2O_5$ in $B_3$(g). |
| $B_3$(g) | 12-16 | 3·73 | 55·6 | 20·5 | 64·2 | 11·8 | 20·3 | 2·90 | 0·62 | 0·11 | 0·21 | 2·56 | 60·3 | 5·81 | 0·53 | 0·036 | 82 | 2·6 | |
| C(g) | 22-26 | 3·72 | 66·4 | 16·7 | 74·6 | 8·5 | 13·2 | 1·52 | 0·26 | 0·08 | 0·24 | 2·19 | 49·0 | 5·86 | | | 134 | 5·5 | |

97. COUNTESSWELLS ASSOCIATION; Dess Series. Cairntradlin, 47408–47412

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 8·31 | N.D. | N.D. | 66·9 | 16·2 | 12·9 | 7·52 | 0·33 | N.D. | 0·16 | 5·55 | 59·0 | 6·24 | 3·36 | 0·262 | 300 | 3·8 | Low exchangeable Ca and Mg in $B_2$ and $B_3$(g). Low exchangeable K in $B_2$, $B_3$(g) and upper part of C(g). High readily soluble $P_2O_5$ in $B_3$(g) and lower part of C(g). |
| $B_2$ | 8-11 | 6·29 | N.D. | N.D. | 75·6 | 13·9 | 10·5 | 1·90 | 0·12 | N.D. | 0·07 | 7·05 | 22·9 | 5·74 | 1·74 | 0·200 | 260 | 4·5 | |
| $B_3$(g) | 12-16 | 3·02 | N.D. | N.D. | 63·7 | 16·4 | 16·9 | 2·25 | 0·26 | N.D. | 0·06 | 2·83 | 47·6 | 5·77 | | | 170 | 11·0 | |
| C(g) | 22-26 | 2·97 | N.D. | N.D. | 58·7 | 8·8 | 29·6 | 4·76 | 1·88 | N.D. | 0·05 | 2·84 | 70·0 | 5·99 | | | 150 | 5·4 | |
| C(g) | 40-44 | 2·34 | N.D. | N.D. | 60·3 | 10·0 | 27·4 | 6·30 | 4·62 | N.D. | 0·16 | 1·10 | 91·0 | 6·47 | | | 170 | 31·0 | |

98. COUNTESSWELLS ASSOCIATION; Dess Series. Standingstones, Dyce, 40884–40887

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 7·75 | N.D. | N.D. | 60·6 | 15·2 | 20·4 | 1·80 | 0·25 | N.D. | 1·31 | 12·10 | 21·8 | 5·10 | 3·27 | 0·250 | 216 | 2·3 | Low exchangeable Ca and Mg in S and $B_3$(g). High exchangeable K in S, low in $B_3$(g). Low readily soluble $P_2O_5$ except in $B_3$(g). |
| $B_3$(g) | 14-20 | 3·03 | N.D. | N.D. | 59·7 | 23·7 | 13·6 | 1·53 | 0·28 | N.D. | 0·08 | 3·47 | 35·2 | 5·76 | 0·29 | 0·025 | 133 | 6·2 | |
| C(g) | 22-26 | 2·50 | N.D. | N.D. | 72·0 | 9·9 | 18·1 | 3·94 | 0·82 | N.D. | 0·18 | 1·92 | 72·0 | 6·21 | | | 240 | 0·8 | |
| C(g) | 36-40 | 2·81 | N.D. | N.D. | 65·8 | 12·9 | 18·5 | 3·89 | 1·68 | N.D. | 0·25 | 1·76 | 77·8 | 6·67 | | | 120 | 1·7 | |

99. COUNTESSWELLS ASSOCIATION; Dess Series. Parkhead, 128775–128779

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 11·00 | 59·0 | 23·5 | 69·3 | 13·2 | 12·0 | 5·50 | 0·26 | 0·10 | 0·17 | 9·23 | 39·4 | 5·75 | 5·32 | 0·254 | 228 | 18·3 | Low exchangeable Ca except in S. Low exchangeable Mg except in lower part of C(g). Low exchangeable K except in S and lower part of C(g). High readily soluble $P_2O_5$ in S and $B_3$(g). |
| $B_2$(g) | 9-12 | 5·62 | 68·3 | 19·9 | 78·5 | 9·7 | 9·0 | 2·62 | 0·15 | 0·10 | 0·07 | 6·47 | 31·2 | 5·99 | 1·98 | 0·107 | 154 | 4·6 | |
| $B_3$(g) | 16-20 | 2·78 | 63·0 | 26·7 | 75·3 | 14·4 | 7·5 | 0·61 | 0·03 | 0·05 | 0·08 | 4·95 | 13·5 | 5·35 | | | 186 | 21·8 | |
| C(g) | 26-30 | 2·14 | 66·9 | 21·5 | 76·7 | 11·7 | 9·5 | 0·61 | 0·09 | 0·05 | 0·07 | 2·91 | 21·9 | 5·31 | | | 151 | 7·1 | |
| C(g) | 33-36 | 2·32 | 66·0 | 16·4 | 72·5 | 9·9 | 15·3 | 2·14 | 0·98 | 0·07 | 0·18 | 4·11 | 4·1 | 5·23 | | | 117 | 4·7 | |

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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **100.** | | | | | | | | **COUNTESSWELLS ASSOCIATION; Dess Series. Tulloch, 128788–128792** | | | | | | | | | | | |
| S | 2-6 | 14·25 | 57·1 | 22·9 | 67·3 | 13·7 | 12·9 | 14·47 | 0·51 | 0·17 | 0·14 | 7·68 | 66·7 | 6·31 | 7·60 | 0·396 | 248 | 12·5 | High exchangeable Ca in S, low in upper part of $B_3$(g). Low exchangeable K except in S. Low total $P_2O_5$ in $B_3$(g) and C(g). High readily soluble $P_2O_5$ in S and upper part of $B_3$(g), low in $B_2$(g) and lower part of $B_3$(g). |
| $B_2$(g) | 12-16 | 10·88 | 67·8 | 16·5 | 76·0 | 8·3 | 10·3 | 4·55 | 0·38 | 0·10 | 0·01 | 12·50 | 28·7 | 5·91 | 4·42 | 0·181 | 104 | 1·1 | |
| $B_3$(g) | 22-26 | 2·17 | 73·3 | 16·8 | 81·8 | 8·3 | 7·7 | 1·06 | 0·34 | 0·04 | 0·02 | 0·62 | 70·3 | 6·01 | | | 148 | 14·3 | |
| $B_3$(g) | 30-34 | 2·13 | 63·6 | 21·5 | 73·3 | 11·8 | 12·8 | 3·19 | 1·04 | 0·07 | 0·07 | 0·60 | 84·8 | 6·01 | | | 57 | 2·2 | |
| C(g) | 36-40 | 1·93 | 71·0 | 15·7 | 78·1 | 8·6 | 11·4 | 3·15 | 1·31 | 0·07 | 0·07 | 0·36 | 92·6 | 6·11 | | | 64 | 4·3 | |
| **101.** | | | | | | | | **FOUDLAND ASSOCIATION; Mairlenden Series. Balquhindachy, 119390–119393** | | | | | | | | | | | |
| S | 4-8 | 8·92 | 29·7 | 46·7 | 53·9 | 22·5 | 19·1 | 3·72 | 0·24 | 0·12 | 0·18 | 10·61 | 28·7 | 5·32 | 3·60 | 0·274 | 285 | 4·9 | Low exchangeable Ca and K except in S. Low exchangeable Mg except in C(g). Low total $P_2O_5$ in $B_2$(g) and C(g). Low readily soluble $P_2O_5$ in $B_2$(g), high in $B_3$(g). |
| $B_2$(g) | 14-18 | 2·51 | 61·3 | 29·7 | 78·7 | 12·3 | 6·5 | 1·06 | 0·05 | 0·07 | 0·06 | 1·46 | 46·0 | 5·43 | 0·45 | 0·037 | 56 | 0·8 | |
| $B_3$(g) | 22-27 | 3·28 | 40·2 | 47·6 | 70·9 | 16·9 | 8·9 | 1·37 | 0·12 | 0·08 | 0·08 | 2·63 | 38·6 | 5·65 | | | 109 | 10·2 | |
| C(g) | 29-33 | 2·59 | 42·4 | 46·3 | 72·4 | 16·3 | 8·7 | 1·98 | 0·33 | 0·08 | 0·06 | 2·04 | 54·6 | 5·80 | | | 86 | 7·7 | |

102. FOUDLAND ASSOCIATION; Mairlenden Series. Tulloch, 121140–121143

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 7·85 | 21·6 | 53·1 | 52·7 | 22·0 | 21·4 | 4·51 | 0·26 | 0·08 | 0·13 | 8·36 | 37·4 | 5·85 | 2·65 | 0·211 | 264 | 1·5 | Low exchangeable Ca except in S. |
| $B_2$(g) | 10-14 | 6·33 | 33·3 | 41·1 | 51·2 | 23·1 | 22·4 | 2·95 | 0·25 | 0·07 | 0·10 | 5·92 | 36·3 | 6·15 | 1·81 | 0·168 | 285 | 1·1 | Low exchangeable Mg. |
| $B_3$(g) | 17-21 | 4·58 | 39·7 | 36·6 | 56·4 | 19·9 | 21·4 | 1·54 | 0·16 | 0·07 | 0·08 | 1·15 | 61·8 | 5·81 | | | 158 | 1·8 | Low exchangeable K in $B_3$(g). |
| C(g) | 28-32 | 4·29 | 34·4 | 40·5 | 55·8 | 19·1 | 23·0 | 1·39 | 0·12 | 0·05 | 0·10 | 3·34 | 33·3 | 5·69 | | | 162 | 1·4 | Low readily soluble $P_2O_5$. |

103. FOUDLAND ASSOCIATION; Mairlenden Series. Suie, 150669–150773

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 2-6 | 16·10 | 29·0 | 35·3 | 45·5 | 18·8 | 23·6 | 0·47 | 0·52 | 0·11 | 0·77 | 18·92 | 9·0 | 4·90 | 6·39 | 0·397 | 195 | Nil | Low exchangeable Ca. |
| $B_1$ | 10-14 | 9·90 | 35·6 | 41·1 | 54·5 | 22·2 | 18·4 | Nil | 0·10 | 0·06 | 0·32 | 8·57 | 5·3 | 5·10 | 1·85 | 0·145 | 169 | Nil | Low exchangeable Mg except in A. |
| C(g) | 22-26 | 6·67 | 42·7 | 40·9 | 64·9 | 18·5 | 13·3 | Nil | 0·08 | 0·06 | 0·07 | 5·57 | 3·6 | 5·25 | | | 150 | Nil | Low exchangeable K in C(g). |
| C(g) | 31-35 | 7·55 | 54·0 | 26·3 | 66·4 | 13·9 | 15·9 | Nil | 0·16 | 0·05 | 0·07 | 6·67 | 4·0 | 5·27 | | | 277 | Nil | Low % saturation. |
| D | 45-47 | 7·56 | 40·5 | 48·2 | 76·4 | 12·4 | 7·5 | Nil | 0·23 | 0·07 | 0·12 | 6·00 | 6·5 | 5·39 | | | 259 | Nil | No readily soluble $P_2O_5$. |

104. ORDLEY ASSOCIATION; Glaschul Series. Boghead, Lumsden, 105136–105140

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 7·14 | 44·9 | 33·9 | 63·7 | 15·1 | 17·6 | 2·93 | 0·23 | 0·20 | 0·11 | 8·00 | 30·2 | 5·11 | 2·43 | 0·161 | 148 | 2·8 | Low exchangeable Ca. |
| B(g) | 11-15 | 3·02 | 45·9 | 31·0 | 60·0 | 16·9 | 20·1 | 2·92 | 0·50 | 0·09 | 0·11 | 4·33 | 45·5 | 5·20 | 0·19 | 0·047 | 72 | 0·8 | Low exchangeable Mg in S. |
| B(g) | 20-24 | 2·89 | 41·9 | 27·9 | 50·5 | 19·3 | 27·3 | 2·16 | 1·05 | 0·11 | 0·22 | 6·10 | 36·7 | 5·06 | | | 68 | 2·3 | Low total $P_2O_5$ except in S. |
| B(g) | 27-31 | 2·81 | 42·1 | 28·4 | 52·3 | 18·2 | 26·7 | 1·84 | 1·44 | 0·12 | 0·19 | 5·86 | 38·0 | 5·15 | | | 69 | 1·8 | Low readily soluble $P_2O_5$ except in C(g). |
| C(g) | 33-37 | 2·63 | 46·5 | 28·2 | 58·0 | 16·7 | 22·7 | 1·84 | 1·76 | 0·11 | 0·19 | 6·22 | 38·5 | 5·13 | | | 70 | 3·4 | |

# TABLE 5. PEATY PODZOLS WITH IRON PAN

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| **105.** | | | | | | | | **CORBY ASSOCIATION; Tarbothill Series. Loirston, 63361–63366** | | | | | | | | | | | |
| H | 6-1 | 29·60 | N.D. | N.D. | N.D. | N.D. | N.D. | 0·13 | 1·19 | N.D. | 0·25 | 52·50 | 2·9 | 4·95 | 16·93 | 0·532 | 117 | 1·6 | Low exchangeable Ca. |
| $A_2$(g) | 2-7 | 11·40 | N.D. | N.D. | 74·5 | 11·4 | 8·4 | 0·06 | 0·84 | N.D. | 0·20 | 27·20 | 3·9 | 5·22 | 4·65 | 0·178 | 133 | 0·8 | Low exchangeable Mg in |
| $A_2$(g) | 9-11 | 2·78 | N.D. | N.D. | 71·9 | 10·1 | 13·2 | 0·06 | 0·45 | N.D. | 0·12 | 4·40 | 12·5 | 5·57 | 0·53 | 0·041 | 113 | 1·4 | lower part of C. |
| $B_3$ | 11-15 | 2·32 | N.D. | N.D. | 73·4 | 13·2 | 11·1 | 0·99 | 1·17 | N.D. | 0·12 | 1·81 | 55·8 | 6·00 | | | 126 | 9·2 | Low exchangeable K in C. |
| C | 19-24 | 1·82 | N.D. | N.D. | 78·5 | 11·4 | 8·3 | 0·91 | 0·56 | N.D. | 0·09 | 1·03 | 60·2 | 6·10 | | | 163 | 29·0 | Low readily soluble $P_2O_5$ |
| C | 29-35 | 1·36 | N.D. | N.D. | 86·9 | 9·3 | 3·4 | 0·19 | 0·23 | N.D. | 0·07 | 0·77 | 38·7 | 6·00 | | | 186 | 43·8 | in H and $A_2$(g), high in C. |
| **106.** | | | | | | | | **COUNTESSWELLS ASSOCIATION; Charr Series. Hill of Fare, 48119–48125** | | | | | | | | | | | |
| F | 7-3 | 92·70 | N.D. | N.D. | N.D. | N.D. | N.D. | 5·41 | 8·38 | N.D. | 0·87 | 128·20 | 10·2 | 3·91 | 41·50 | 1·375 | 130 | 9·5 | Low exchangeable Ca except |
| H | 3-0 | 23·60 | N.D. | N.D. | 53·5 | 23·1 | 5·7 | 0·69 | 1·30 | N.D. | 0·27 | 37·00 | 5·7 | 3·88 | 14·00 | 0·397 | 90 | 2·8 | in F. |
| $A_2$ | 1-4 | 2·92 | N.D. | N.D. | 64·9 | 21·8 | 10·4 | 0·31 | 0·06 | N.D. | 0·08 | 4·97 | 8·3 | 4·04 | 1·16 | 0·058 | 60 | 0·8 | High exchangeable Mg in F, |
| $B_1$ | 4-5 | 12·90 | N.D. | N.D. | 62·7 | 19·8 | 11·1 | 2·05 | 0·24 | N.D. | 0·14 | 28·73 | 7·8 | 4·51 | 5·78 | 0·202 | 110 | 0·7 | low in $A_2$, $B_1$, $B_2$ and D. |
| $B_2$ | 9-13 | 9·60 | N.D. | N.D. | 66·0 | 21·2 | 8·0 | 1·15 | Nil | N.D. | 0·14 | 15·72 | 8·0 | 4·50 | | | 130 | 0·8 | Low exchangeable K in $A_2$, |
| $B_2$ | 17-21 | 11·92 | N.D. | N.D. | 66·9 | 18·4 | 8·7 | 1·09 | Nil | N.D. | 0·07 | 21·50 | 5·3 | 4·61 | | | 110 | 0·9 | $B_2$ and D. |
| D | 21-25 | 2·63 | N.D. | N.D. | 70·9 | 14·8 | 11·7 | 1·42 | Nil | N.D. | 0·09 | 5·82 | 20·7 | 4·73 | | | 130 | 8·8 | Low total $P_2O_5$ in H and $A_2$. |
| | | | | | | | | | | | | | | | | | | | Low readily soluble $P_2O_5$ |
| | | | | | | | | | | | | | | | | | | | except in F and D. |

107. COUNTESSWELLS ASSOCIATION; Charr Series. Blacktop, 150610–150616

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L | 8-7 | 95·00 | N.D. | N.D. | N.D. | N.D. | N.D. | 16·44 | 5·64 | 1·37 | 1·76 | 60·75 | 29·3 | 4·54 | 59·59 | 1·958 | 218 | 22·5 | High exchangeable Ca, Mg and K at top of profile, low otherwise. |
| F | 7-4 | 93·50 | N.D. | N.D. | N.D. | N.D. | N.D. | 11·72 | 4·28 | 1·08 | 1·03 | 108·28 | 14·3 | 3·51 | 57·47 | 1·592 | 161 | 11·8 | Low total $P_2O_5$ in $A_2$. |
| H | 4-3 | 92·10 | N.D. | N.D. | N.D. | N.D. | N.D. | 12·40 | 5·97 | 1·29 | 0·94 | 137·77 | 13·0 | 3·51 | 59·47 | 1·510 | 140 | 9·4 | High readily soluble $P_2O_5$ in L, F, $B_3$ and C; low in $A_2$, $B_2$ and lower part of H. |
| H | 3-0 | 52·40 | N.D. | N.D. | N.D. | N.D. | N.D. | 2·61 | 1·61 | 0·70 | 0·30 | 91·24 | 5·4 | 3·60 | 32·70 | 0·907 | 167 | 0·1 | |
| $A_2$ | 0-3 | 14·60 | 68·5 | 15·3 | 75·7 | 8·1 | 8·9 | 0·46 | 0·30 | 0·15 | 0·10 | 40·48 | 2·4 | 3·92 | | | 78 | Nil | |
| $B_2$ | 5-9 | 9·36 | 48·3 | 42·7 | 70·9 | 20·1 | 4·3 | Nil | 0·04 | 0·11 | 0·05 | 12·81 | 1·5 | 4·66 | | | 114 | Nil | |
| $B_3$ | 13-19 | 2·40 | 70·7 | 22·8 | 80·6 | 12·9 | 6·5 | Nil | Nil | 0·05 | Nil | 2·87 | 1·7 | 4·70 | | | 141 | 24·4 | |
| C | 23-29 | 1·97 | 80·1 | 16·9 | 88·6 | 8·4 | 3·0 | Nil | Nil | 0·05 | Nil | 1·96 | 2·5 | 4·63 | | | 117 | 16·8 | |

108. DURNHILL ASSOCIATION; Durnhill Series. Hill of Dudwick, 147853–147858

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L/F | 4-0 | 76·80 | N.D. | N.D. | N.D. | N.D. | N.D. | 1·72 | 2·46 | 0·69 | 0·39 | 99·94 | 5·0 | 4·29 | 46·18 | 1·091 | 155 | 0·6 | Low exchangeable Ca. |
| $A_2$(g) | 1-5 | 7·72 | 43·2 | 31·5 | 56·3 | 18·4 | 21·4 | 0·15 | 0·30 | 0·07 | 0·11 | 13·84 | 4·4 | 4·49 | 2·05 | 0·066 | 52 | Nil | Low exchangeable Mg in $B_2$. |
| $B_2$ | 7-11 | 4·99 | 42·3 | 31·4 | 53·1 | 20·6 | 23·8 | Nil | 0·14 | 0·04 | 0·10 | 6·25 | 4·3 | 4·85 | | | 66 | Nil | Low total $P_2O_5$ except in L/F. |
| $B_3$ | 20-26 | 7·96 | 30·6 | 39·0 | 48·1 | 21·5 | 26·4 | 0·15 | 0·35 | 0·17 | 0·13 | 7·76 | 9·3 | 5·19 | | | 78 | Nil | Low readily soluble $P_2O_5$. |
| C | 36-42 | 6·10 | 56·1 | 30·6 | 67·8 | 18·9 | 10·2 | 0·15 | 0·42 | 0·17 | 0·11 | 1·31 | 39·4 | 5·17 | | | 78 | Nil | |

109. DURNHILL ASSOCIATION; Durnhill Series. Hill of Dudwick, 147864–147868

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L/F | 2-0 | 18·70 | 59·2 | 21·4 | 72·2 | 8·4 | 5·4 | 1·89 | 1·30 | 0·43 | 0·61 | 29·34 | 12·6 | 4·40 | 8·52 | 0·296 | 112 | Nil | Low exchangeable Ca. |
| $A_2$ | 3-7 | 8·31 | 56·8 | 24·9 | 70·1 | 11·6 | 14·1 | 0·39 | 0·33 | 0·19 | 0·15 | 17·93 | 5·6 | 4·67 | 3·17 | 0·099 | 90 | Nil | Low exchangeable Mg and K in $B_2$, $B_3$ and C. |
| $B_2$ | 10-12 | 4·14 | 61·8 | 22·2 | 73·5 | 11·5 | 12·9 | Nil | 0·13 | 0·08 | 0·08 | 5·49 | 5·0 | 5·05 | | | 119 | Nil | Low total $P_2O_5$ in $A_2$, $B_3$ and C. |
| $B_3$ | 18-22 | 3·11 | 77·2 | 19·8 | 88·3 | 8·7 | 3·0 | Nil | 0·06 | 0·04 | 0·04 | 3·49 | 3·9 | 5·20 | | | 54 | Nil | No readily soluble $P_2O_5$. |
| C | 28-34 | 3·66 | 71·8 | 21·9 | 81·4 | 12·3 | 6·3 | 0·15 | 0·13 | 0·07 | 0·06 | 3·76 | 9·8 | 5·02 | | | 80 | Nil | |

110. DURNHILL ASSOCIATION; Durnhill Series. Mormond Hill, 118056–118058

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_2$ | 1-4 | 11·10 | 59·6 | 21·6 | 69·3 | 11·9 | 13·2 | 0·15 | 0·06 | 0·09 | 0·04 | 20·15 | 1·7 | 4·36 | 4·92 | 0·165 | 73 | 0·9 | Very low exchangeable Ca, Mg, K and % saturation. |
| C-D | 6-10 | 3·77 | 61·1 | 22·5 | 70·0 | 13·6 | 12·6 | Nil | 0·02 | 0·05 | 0·04 | 7·55 | 1·4 | 4·73 | 0·79 | 0·039 | 92 | 1·8 | Low total and readily soluble $P_2O_5$. |

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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **111.** | | | | | | | | **FOUDLAND ASSOCIATION; Suie Series. Suie, 150655–150661** | | | | | | | | | | | |
| $H/A_1$ | 2-0 | 66·70 | N.D. | N.D. | N.D. | N.D. | N.D. | 2·34 | 2·02 | 0·51 | 1·11 | 82·56 | 6·8 | 4·01 | 46·32 | 1·107 | 177 | 2·0 | Low exchangeable Ca. |
| $A_2$ | 0-2 | 16·30 | 43·5 | 35·9 | 63·0 | 16·4 | 8·4 | 0·15 | 0·32 | 0·09 | 0·22 | 30·65 | 2·5 | 4·28 | 6·83 | 0·261 | 127 | Nil | Low exchangeable Mg and |
| $B_2$ | 3-7 | 8·25 | 29·6 | 53·3 | 54·5 | 28·4 | 13·0 | Nil | 0·06 | 0·05 | 0·09 | 12·86 | 1·5 | 4·92 | | | 180 | Nil | K in $B_2$, $B_3$ and C. |
| $B_2$ | 9-12 | 5·25 | 42·7 | 43·3 | 65·6 | 20·4 | 11·4 | Nil | 0·04 | 0·04 | 0·09 | 6·53 | 2·5 | 5·08 | | | 106 | Nil | Low total $P_2O_5$ in $B_3$. |
| $B_3$ | 14-18 | 3·87 | 43·4 | 51·2 | 72·5 | 22·1 | 5·4 | Nil | Nil | 0·03 | 0·05 | 4·66 | 1·7 | 5·09 | | | 78 | 0·8 | Very low readily soluble |
| C | 29-33 | 4·78 | 41·6 | 42·6 | 61·8 | 22·4 | 13·4 | Nil | 0·07 | 0·04 | 0·09 | 6·85 | 2·8 | 5·10 | | | 103 | Nil | $P_2O_5$. |
| **112.** | | | | | | | | **SKELMUIR ASSOCIATION; Skelmuir Series. Moss of Cruden, 109672–109678** | | | | | | | | | | | |
| L | 8-7 | 95·00 | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | N.D. | 84·50 | N.D. | 4·01 | 63·60 | 1·473 | 110 | 8·6 | Low exchangeable Ca |
| F | 6-4 | 84·00 | N.D. | N.D. | N.D. | N.D. | N.D. | 6·19 | 9·38 | 1·98 | 1·07 | 121·10 | 13·3 | 3·67 | 60·10 | 1·600 | 107 | 9·0 | except in F. |
| H | 3-0 | 30·40 | N.D. | N.D. | N.D. | N.D. | N.D. | 0·47 | 1·57 | 0·39 | 0·07 | 41·20 | 5·3 | 3·89 | 24·90 | 0·636 | 57 | 1·6 | High exchangeable Mg in |
| $A_2$ | 1-5 | 7·40 | 43·5 | 26·6 | 56·8 | 13·3 | 26·2 | Nil | 0·24 | 0·11 | Nil | 17·15 | 2·0 | 4·45 | | | 53 | 1·4 | F, low in $A_2$. |
| $B_2(g)$ | 7-12 | 4·05 | 48·0 | 24·0 | 57·0 | 15·0 | 26·0 | 0·15 | 0·59 | 0·07 | 0·03 | 7·80 | 9·7 | 4·81 | | | 90 | 1·0 | High exchangeable K in F, |
| $B_2(g)$ | 20-26 | 3·80 | 49·2 | 18·0 | 57·2 | 10·0 | 29·0 | 0·31 | 1·20 | 0·07 | 0·07 | 5·58 | 22·8 | 4·99 | | | 92 | 1·6 | otherwise low. |
| C(g) | 31-37 | 3·32 | 46·4 | 21·3 | 55·5 | 12·2 | 29·0 | 0·61 | 1·36 | 0·10 | 0·10 | 6·11 | 26·7 | 4·77 | | | 78 | 1·5 | Low total and readily soluble $P_2O_5$, except in L and F. |

113. TARVES ASSOCIATION; Pressendye Series. Pittenderich, 150647–150654

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $H/A_1$ | 3-0 | 51·00 | N.D. | N.D. | N.D. | N.D. | N.D. | 4·93 | 3·16 | 0·59 | 1·56 | 67·08 | 13·2 | 3·99 | 28·50 | 0·932 | 180 | 7·7 | Low exchangeable Ca and |
| $A_2$ | 0-4 | 13·00 | 57·5 | 25·6 | 66·3 | 16·8 | 10·4 | 0·47 | 0·25 | 0·13 | 0·16 | 25·17 | 3·9 | 4·61 | 6·59 | 0·212 | 119 | Nil | Mg except in $H/A_1$. |
| $A_2(g)$ | 4-8 | 16·10 | 49·6 | 31·6 | 67·2 | 14·0 | 6·7 | 0·31 | 0·20 | 0·10 | 0·16 | 28·91 | 2·6 | 4·82 | 6·63 | 0·260 | 138 | 0·1 | High exchangeable K in |
| $B_2(g)$ | 8-12 | 8·91 | 49·7 | 34·8 | 66·0 | 18·5 | 11·0 | Nil | 0·06 | 0·09 | 0·05 | 11·27 | 1·7 | 4·90 | | | 128 | Nil | $H/A_1$, low in $B_2(g)$ and $B_3$. |
| $B_3$ | 12-15 | 4·40 | 56·1 | 33·4 | 67·2 | 22·3 | 8·3 | Nil | 0·03 | 0·05 | 0·02 | 3·12 | 3·1 | 5·16 | | | 85 | 0·5 | Low total $P_2O_5$ in $B_3$ and C. |
| C | 24-29 | 4·52 | 63·9 | 23·1 | 71·4 | 15·6 | 10·7 | Nil | Nil | 0·06 | 0·12 | 3·44 | 5·0 | 5·20 | | | 81 | Nil | Very low readily soluble |
| | | | | | | | | | | | | | | | | | | | $P_2O_5$ except in $H/A_1$. |

## TABLE 6. 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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 114. | | | | | | | | BOGTOWN ASSOCIATION; Bogtown Series. Cullykhan Bay, 118059–118063 | | | | | | | | | | | |
| S | 2-6 | 13·10 | 13·1 | 33·3 | 20·2 | 26·2 | 47·0 | 16·96 | 4·94 | 0·92 | 0·40 | 9·33 | 71·5 | 6·11 | 4·79 | 0·453 | 245 | 2·0 | High clay content in S and $B_2g$.<br>High exchangeable Ca.<br>Low readily soluble $P_2O_5$ in S, $B_2g$ and Ag, high in lower part of C. |
| $B_2g$ | 11-15 | 14·60 | 7·5 | 30·9 | 13·9 | 24·5 | 54·3 | 22·60 | 4·55 | 1·21 | 0·49 | 10·90 | 72·7 | 6·24 | 5·42 | 0·441 | 223 | 1·5 | |
| Ag | 21-25 | 20·50 | 45·9 | 37·0 | 64·5 | 18·4 | 1·7 | 18·60 | 3·28 | 0·57 | 0·19 | 37·60 | 37·6 | 3·19 | | | 143 | 1·1 | |
| Cg | 31-35 | 6·83 | 34·5 | 47·7 | 56·7 | 25·5 | 14·4 | 14·26 | 4·41 | 0·38 | 0·37 | 6·28 | 75·8 | 4·99 | | | 114 | 4·4 | |
| Cg | 41-45 | 4·42 | 33·6 | 42·9 | 58·1 | 18·4 | 21·3 | 9·05 | 2·47 | 0·36 | 0·36 | 2·20 | 84·8 | 5·96 | | | 105 | 23·5 | |
| 115. | | | | | | | | BOYNDIE ASSOCIATION; Dallachy Series. Philorth, 118292–118296 | | | | | | | | | | | |
| S | 2-6 | 11·50 | 68·9 | 12·8 | 73·5 | 8·2 | 12·5 | 7·92 | 0·76 | 0·17 | 0·09 | 7·85 | 53·1 | 6·28 | 5·26 | 0·301 | 195 | 2·0 | High sand content in lower part of S.<br>Low exchangeable Ca and Mg in lower part of S.<br>Low exchangeable K except in Cg.<br>Low total $P_2O_5$ in $B_3g$, Cg and lower part of S.<br>Low readily soluble $P_2O_5$ in upper part of S, high in $B_3g$ and Cg. |
| S | 9-11 | 0·66 | 95·3 | 3·6 | 96·3 | 2·6 | 0·4 | 0·68 | 0·10 | 0·05 | Nil | 0·57 | 59·2 | 6·22 | 0·22 | 0·015 | 40 | 3·7 | |
| $B_3g$ | 12-15 | 2·89 | 60·5 | 23·6 | 71·3 | 12·8 | 13·0 | 3·36 | 0·76 | 0·16 | 0·04 | 1·84 | 70·3 | 5·88 | | | 111 | 5·9 | |
| $B_3g$ | 20-24 | 1·92 | 66·1 | 21·7 | 76·8 | 11·0 | 10·3 | 3·94 | 1·09 | 0·18 | 0·07 | 0·23 | 95·8 | 6·02 | | | 84 | 15·6 | |
| Cg | 34-38 | 2·06 | 66·7 | 19·9 | 78·0 | 8·6 | 11·3 | 3·34 | 0·98 | 0·27 | 0·13 | 1·14 | 80·5 | 5·51 | | | 82 | 17·7 | |

116. BOYNDIE ASSOCIATION; Dallachy Series. Fordtown, 111623–111627

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_2g$ | 3-6 | 4·95 | 72·7 | 17·3 | 80·6 | 9·4 | 7·5 | 0·76 | 0·50 | 0·13 | 0·03 | 5·23 | 21·4 | 5·25 | 2·77 | 0·125 | 61 | 1·2 | High sand content.<br>Low exchangeable Ca and K.<br>Low exchangeable Mg in Bg.<br>Low total and readily soluble $P_2O_5$ in $A_2g$.<br>High readily soluble $P_2O_5$ in lower part of profile. |
| Bg | 8-12 | 2·90 | 82·9 | 8·7 | 86·8 | 4·8 | 5·5 | 0·61 | 0·26 | 0·10 | 0·02 | Nil | 100 | 5·66 | 0·91 | 0·039 | 126 | 4·8 | |
| Bg | 15-19 | 1·63 | 92·0 | 5·6 | 94·0 | 3·6 | 0·8 | 0·61 | 0·21 | 0·12 | 0·03 | Nil | 100 | 5·81 | | | 188 | 15·0 | |
| Bg | 24-28 | 1·19 | 90·3 | 8·3 | 94·4 | 4·2 | 0·2 | 0·45 | 0·17 | 0·10 | 0·03 | Nil | 100 | 5·80 | | | 176 | 21·4 | |
| Cg | 31-35 | 1·51 | 82·2 | 13·3 | 89·6 | 5·8 | 3·0 | 0·60 | 0·39 | 0·11 | 0·05 | Nil | 100 | 5·80 | | | 226 | 24·2 | |

117. COLLIESTON ASSOCIATION; Marshmire Series. Mains of Slains, 109687–109691

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 8·00 | 52·6 | 21·4 | 61·5 | 12·5 | 22·0 | 5·54 | 1·15 | 0·23 | 0·07 | 8·50 | 45·2 | 5·52 | 4·23 | 0·264 | 218 | 7·2 | High clay content in $B_3g$ and Cg.<br>High exchangeable Ca and Mg in $B_3g$ and Cg.<br>Low exchangeable K in S and $A_2g$.<br>Low total $P_2O_5$ in $A_2g$.<br>Low readily soluble $P_2O_5$ in $A_2g$, high in $B_2g$, $B_3g$ and Cg. |
| $A_2g$ | 12-16 | 2·56 | 64·4 | 15·3 | 73·6 | 6·1 | 17·7 | 4·12 | 1·73 | 0·13 | 0·05 | 2·12 | 74·0 | 5·62 | 1·18 | 0·074 | 85 | 2·0 | |
| $B_2g$ | 17-21 | 3·28 | 32·7 | 30·5 | 43·1 | 20·1 | 32·5 | 7·90 | 4·97 | 0·23 | 0·27 | 1·64 | 89·0 | 6·27 | | | 119 | 32·9 | |
| $B_3g$ | 28-32 | 7·00 | 7·0 | 42·3 | 14·2 | 35·1 | 47·0 | 16·58 | 14·25 | 0·32 | 0·52 | Nil | 100 | 8·09 | | | 215 | 29·4 | |
| Cg | 40-44 | 8·55 | Nil | 47·8 | 1·0 | 46·8 | 52·2 | 17·17 | 14·56 | 0·27 | 0·60 | Nil | 100 | 8·33 | | | 147 | 25·2 | |

118. CORBY ASSOCIATION; Mulloch Series. Moss-side, Fetternear, 112170–112173

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 17·00 | 66·4 | 15·0 | 72·5 | 8·9 | 5·8 | 11·00 | 1·11 | 0·10 | 0·13 | 13·50 | 47·8 | 5·49 | 6·10 | 0·519 | 175 | 1·3 | High sand content in Bg and Cg.<br>High exchangeable Ca in S, otherwise low.<br>Low exchangeable Mg and K except in S.<br>Low readily soluble $P_2O_5$ in top half of profile. |
| Bg | 9-12 | 1·65 | 91·1 | 5·2 | 92·7 | 3·6 | 2·0 | 3·02 | 0·42 | 0·07 | 0·03 | Nil | 100 | 5·75 | 0·62 | 0·029 | 100 | 1·2 | |
| Bg | 15-19 | 1·68 | 90·1 | 8·0 | 92·9 | 5·2 | 0·2 | 1·65 | 0·18 | 0·04 | 0·03 | Nil | 100 | 5·78 | | | 131 | 6·0 | |
| Cg | 24-28 | 1·37 | 93·8 | 4·6 | 95·2 | 3·4 | 0·2 | 1·66 | 0·22 | 0·04 | 0·05 | Nil | 100 | 5·95 | | | 121 | 6·0 | |

TABLE 6—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 119. | CORBY ASSOCIATION; Mulloch Series. Foggieton, 41330–41334 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 7·35 | N.D. | N.D. | 61·8 | 19·4 | 15·6 | 2·83 | 0·34 | N.D. | 0·12 | 6·24 | 34·5 | 5·50 | 3·13 | 0·182 | N.D. | N.D. | Low exchangeable Ca except in top part of Bg. |
| Bg | 9-13 | 2·65 | N.D. | N.D. | 64·9 | 15·5 | 16·9 | 3·64 | 0·68 | N.D. | 0·13 | 2·08 | 68·1 | 5·82 | 0·27 | 0·048 | N.D. | N.D. | |
| Bg | 20-24 | 1·54 | N.D. | N.D. | 76·7 | 8·7 | 15·6 | 2·00 | 0·60 | N.D. | 0·12 | 2·08 | 56·8 | 5·68 | | | N.D. | N.D. | |
| Bg | 28-32 | 1·28 | N.D. | N.D. | 73·3 | 9·9 | 15·8 | 1·38 | 0·60 | N.D. | 0·11 | 1·85 | 53·2 | 5·53 | | | N.D. | N.D. | |
| Cg | 40-44 | 1·45 | N.D. | N.D. | 80·0 | 7·6 | 12·4 | 1·69 | 0·52 | N.D. | 0·18 | 1·56 | 60·5 | 5·22 | | | N.D. | N.D. | |
| 120. | COUNTESSWELLS ASSOCIATION; Terryvale Series. Westside, Maryculter, 60772–60776 | | | | | | | | | | | | | | | | | | |
| S | 0-6 | 11·10 | N.D. | N.D. | 55·2 | 15·5 | 23·3 | 8·91 | 0·76 | N.D. | 0·17 | 2·32 | 80·9 | 5·57 | 5·84 | 0·381 | 291 | 6·4 | Low exchangeable Ca except in S. High readily soluble $P_2O_5$ except in S. |
| $A_2g$ | 8-12 | 1·75 | N.D. | N.D. | 68·2 | 14·7 | 15·4 | 2·04 | 2·78 | N.D. | 0·14 | 0·82 | 85·9 | 5·69 | 0·27 | 0·050 | 132 | 30·0 | |
| $B_2g$ | 18-24 | 1·68 | N.D. | N.D. | 62·6 | 16·0 | 20·2 | 2·45 | 1·31 | N.D. | 0·11 | 1·11 | 77·9 | 6·00 | | | N.D. | 16·0 | |
| $B_2g$ | 27-30 | 1·77 | N.D. | N.D. | 60·1 | 14·0 | 24·2 | 1·97 | 1·46 | N.D. | 0·19 | 0·22 | 94·2 | 6·75 | | | 148 | 12·4 | |
| Cg | 34-39 | 1·81 | N.D. | N.D. | 58·0 | 16·3 | 23·9 | 1·84 | 1·35 | N.D. | 0·23 | 0·44 | 88·6 | 5·42 | | | 133 | 13·1 | |
| 121. | COUNTESSWELLS ASSOCIATION; Terryvale Series. Ballogie, 54542–54546 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 4·81 | N.D. | N.D. | 69·2 | 9·8 | 16·2 | 2·50 | 0·10 | N.D. | 0·08 | 6·57 | 29·0 | 5·19 | 2·34 | 0·187 | 142 | 9·4 | Low exchangeable Ca in S, $A_2g$ and $B_2g$. Low exchangeable Mg in S. Low exchangeable K in S and $A_2g$. Low total $P_2O_5$ in $A_2g$, $B_2g$ and $B_3g$. High readily soluble $P_2O_5$ in $B_3g$, low in Cg. |
| $A_2g$ | 10-15 | 2·24 | N.D. | N.D. | 63·1 | 15·4 | 19·3 | 2·43 | 0·37 | N.D. | 0·07 | 2·28 | 55·8 | 5·32 | 0·31 | 0·067 | 71 | 5·5 | |
| $B_2g$ | 20-23 | 0·95 | N.D. | N.D. | 79·6 | 6·4 | 13·1 | 1·08 | 0·41 | N.D. | 0·10 | 0·85 | 65·0 | 5·35 | | | 85 | 9·7 | |
| $B_3g$ | 25-30 | 1·86 | N.D. | N.D. | 58·8 | 12·2 | 27·2 | 3·52 | 0·96 | N.D. | 0·14 | 0·57 | 89·0 | 5·75 | | | 99 | 16·2 | |
| Cg | 37-43 | 1·79 | N.D. | N.D. | 62·9 | 12·5 | 22·9 | 3·20 | 0·77 | N.D. | 0·14 | 0·53 | 88·5 | 5·71 | | | 106 | 2·7 | |

122. COUNTESSWELLS ASSOCIATION; Terryvale Series. Baads, Culter, 48357–48360B

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-10 | 6·49 | N.D. | N.D. | 67·5 | 15·6 | 13·7 | 7·44 | 0·72 | N.D. | 0·08 | 14·72 | 56·0 | 5·63 | 2·62 | 0·215 | 280 | 7·9 | High exchangeable Ca in $A_2g$. |
| $A_2g$ | 12-16 | 4·59 | N.D. | N.D. | 75·7 | 8·4 | 15·9 | 8·39 | 0·79 | N.D. | 0·12 | 12·73 | 73·1 | 6·03 | 1·49 | 0·188 | 230 | 9·9 | Low exchangeable K in S. |
| $B_2g$ | 16-20 | 1·63 | N.D. | N.D. | 85·7 | 3·8 | 10·5 | 3·77 | 0·51 | N.D. | 0·12 | 4·80 | 91·7 | 6·48 | | | 140 | 39·0 | High readily soluble $P_2O_5$ in $B_2g$, very high in Cg. |
| Cg | 20-28 | 1·36 | N.D. | N.D. | 71·9 | 16·3 | 12·8 | 3·64 | 0·75 | N.D. | 0·10 | 4·69 | 95·7 | 6·57 | | | 230 | 110·0 | |
| Cg | 40-44 | 1·97 | N.D. | N.D. | 67·6 | 12·1 | 18·3 | 4·82 | 0·92 | N.D. | 0·11 | 6·45 | 90·7 | 6·02 | | | 220 | 86·0 | |

123. COUNTESSWELLS ASSOCIATION; Terryvale Series. Borrohill, 119398–119401

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 12·90 | 42·9 | 36·1 | 57·9 | 21·1 | 14·5 | 10·56 | 1·07 | 0·19 | 0·23 | 10·95 | 52·4 | 5·76 | 6·81 | 0·310 | 195 | 5·2 | High exchangeable Ca in S, low in Cg and lower part of $A_2g$. |
| $A_2g$ | 10-14 | 4·10 | 49·0 | 31·4 | 63·8 | 16·6 | 17·5 | 3·20 | 0·67 | 0·10 | 0·12 | 2·70 | 60·1 | 5·48 | 0·53 | 0·041 | 63 | 2·1 | Low total and readily soluble $P_2O_5$ except in S. |
| $A_2g$ | 17-21 | 3·58 | 52·4 | 26·7 | 65·5 | 13·6 | 17·3 | 1·82 | 0·62 | 0·10 | 0·14 | 2·34 | 53·4 | 5·25 | | | 69 | 1·6 | |
| Cg | 25-29 | 3·68 | 51·2 | 26·4 | 65·6 | 12·0 | 18·7 | 1·37 | 0·78 | 0·09 | 0·19 | 2·20 | 52·5 | 5·24 | | | 66 | 1·7 | |

124. COUNTESSWELLS ASSOCIATION; Terryvale Series. Ardmurdo, 47379–47382

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 8·90 | N.D. | N.D. | 55·9 | 18·6 | 21·1 | 10·00 | 0·77 | N.D. | 0·19 | 6·98 | 61·0 | 5·92 | 3·10 | 0·259 | 270 | 6·9 | High exchangeable Ca in S. |
| Bg | 12-16 | 2·93 | N.D. | N.D. | 77·0 | 8·0 | 15·6 | 6·65 | 0·67 | N.D. | 0·11 | 1·73 | 81·0 | 6·68 | 0·46 | 0·063 | 150 | 16·2 | High readily soluble $P_2O_5$ in Bg and Cg. |
| Bg | 22-26 | 2·46 | N.D. | N.D. | 83·1 | 4·8 | 9·7 | 6·13 | 0·77 | N.D. | 0·11 | 1·05 | 87·0 | 6·79 | | | 140 | 16·0 | |
| Cg | 36-40 | 2·90 | N.D. | N.D. | 73·7 | 4·7 | 21·7 | 5·05 | 1·07 | N.D. | 0·16 | 1·00 | 86·5 | 6·69 | | | 160 | 38·0 | |

125. COUNTESSWELLS ASSOCIATION; Terryvale Series. Cairntradlin, 47413–47417

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 7·65 | N.D. | N.D. | 56·7 | 19·5 | 20·9 | 7·95 | 0·61 | N.D. | 0·13 | 5·94 | 59·2 | 5·87 | 3·15 | 0·246 | 220 | 6·5 | Low exchangeable K in upper part of Bg. |
| S | 8-11 | 8·44 | N.D. | N.D. | 60·7 | 15·8 | 21·0 | 5·79 | 0·69 | N.D. | 0·10 | 7·04 | 48·2 | 5·78 | 3·18 | 0·213 | 160 | 1·6 | Low total $P_2O_5$ in upper part of Bg. |
| Bg | 12-16 | 3·00 | N.D. | N.D. | 59·0 | 20·7 | 17·3 | 5·75 | 1·67 | N.D. | 0·08 | 1·97 | 79·4 | 5·88 | | | 80 | 0·2 | Low readily soluble $P_2O_5$ except in S. |
| Bg | 22-26 | 2·99 | N.D. | N.D. | 60·0 | 12·0 | 26·0 | 8·09 | 4·56 | N.D. | 0·12 | 0·87 | 93·5 | 6·86 | | | 130 | 2·3 | |
| Cg | 40-44 | 2·22 | N.D. | N.D. | 60·4 | 11·5 | 25·9 | 4·14 | 2·95 | N.D. | 0·14 | 0·87 | 89·5 | 6·70 | | | 170 | 2·0 | |

TABLE 6—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 126. | | | | | | | | COUNTESSWELLS ASSOCIATION; Terryvale Series. Cluny, 47387–47390 | | | | | | | | | | | |
| S | 0-8 | 6·94 | N.D. | N.D. | 57·6 | 22·9 | 16·1 | 5·62 | 0·36 | N.D. | 0·12 | 7·76 | 44·0 | 5·58 | 3·10 | 0·248 | 220 | 8·7 | Low exchangeable Ca in upper part of Bg. |
| Bg | 10-14 | 3·84 | N.D. | N.D. | 61·6 | 15·3 | 19·3 | 2·94 | 0·50 | N.D. | 0·13 | 4·05 | 47·0 | 5·72 | 0·74 | 0·076 | 120 | 3·9 | Low readily soluble $P_2O_5$ in lower part of Bg. |
| Bg | 20-24 | 3·12 | N.D. | N.D. | 61·6 | 17·1 | 18·2 | 4·86 | 1·90 | N.D. | 0·15 | 1·96 | 78·0 | 6·35 | | | 120 | 0·7 | |
| Cg | 38-42 | 2·34 | N.D. | N.D. | 67·8 | 11·0 | 18·9 | 5·26 | 1·61 | N.D. | 0·16 | 8·56 | 82·0 | 6·07 | | | 140 | 6·4 | |
| 127. | | | | | | | | COUNTESSWELLS ASSOCIATION; Terryvale Series. Standingstones, 40888–40891 | | | | | | | | | | | |
| S | 0-8 | 8·45 | N.D. | N.D. | 65·3 | 19·9 | 14·8 | 1·41 | 0·20 | N.D. | 0·15 | 13·10 | 11·8 | 5·08 | 3·78 | 0·264 | 280 | 6·2 | Low exchangeable Ca. |
| Bg | 14-18 | 3·39 | N.D. | N.D. | 76·9 | 11·7 | 11·4 | 1·48 | 0·20 | N.D. | 0·15 | 5·70 | 24·3 | 5·62 | 0·47 | 0·061 | 180 | 18·7 | Low exchangeable Mg except in Cg. |
| Bg | 22-26 | 2·83 | N.D. | N.D. | 77·0 | 8·2 | 14·8 | 1·40 | 0·26 | N.D. | 0·15 | 5·95 | 23·3 | 5·80 | | | 160 | 28·5 | High readily soluble $P_2O_5$ except in S. |
| Cg | 36-40 | 2·09 | N.D. | N.D. | 74·9 | 2·8 | 12·8 | 1·95 | 0·79 | N.D. | 0·20 | 2·13 | 58·0 | 6·02 | | | 147 | 15·4 | |
| 128. | | | | | | | | COUNTESSWELLS ASSOCIATION; Terryvale Series. Sunhoney, 48109–48114 | | | | | | | | | | | |
| S | 0-6 | 6·15 | N.D. | N.D. | 73·8 | 14·8 | 11·4 | 0·60 | 0·48 | N.D. | 0·12 | 4·66 | 20·4 | 6·61 | 2·07 | 0·215 | 240 | 6·5 | Low exchangeable Ca in S. |
| Bg | 8-10 | 3·21 | N.D. | N.D. | 63·9 | 16·1 | 16·7 | 5·71 | 1·03 | N.D. | 0·13 | Nil | 100 | 8·00 | 0·28 | 0·066 | 180 | 1·2 | Low readily soluble $P_2O_5$ in upper part of Bg, very high in lower part and in Cg. |
| Bg | 10-12 | 3·42 | N.D. | N.D. | 63·7 | 13·2 | 19·7 | 5·69 | 1·20 | N.D. | 0·10 | 2·61 | 73·0 | 6·64 | | | 110 | 0·4 | |
| Bg | 14-18 | 1·77 | N.D. | N.D. | 80·6 | 11·0 | 8·4 | 4·26 | 1·09 | N.D. | 0·10 | 0·41 | 93·0 | 6·62 | | | 240 | 78·4 | |
| Bg | 18-22 | 2·17 | N.D. | N.D. | 67·2 | 10·5 | 20·0 | 5·57 | 1·37 | N.D. | 0·13 | 1·61 | 81·5 | 6·74 | | | 220 | 44·6 | |
| Cg | 40-44 | 2·18 | N.D. | N.D. | 60·8 | 11·7 | 25·4 | 3·78 | 1·02 | N.D. | 0·27 | 0·60 | 89·5 | 5·86 | | | 270 | 49·6 | |

129. COUNTESSWELLS ASSOCIATION; Terryvale Series. West Mains, Auchenhove, 48418–48421

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-10 | 8·44 | N.D. | N.D. | 74·9 | 15·9 | 9·2 | 2·45 | 0·14 | N.D. | 0·13 | 11·10 | 19·6 | 5·35 | 2·15 | 0·352 | 240 | 11·0 | Low exchangeable Ca. Low exchangeable Mg except in Cg. Low exchangeable K in $A_2g$ and Bg. High readily soluble $P_2O_5$ in S, very high in rest of profile. |
| $A_2g$ | 11-13 | 1·99 | N.D. | N.D. | 77·8 | 7·8 | 12·5 | 1·43 | 0·14 | N.D. | 0·08 | 1·06 | 60·8 | 5·61 | 0·60 | 0·111 | 180 | 49·0 | |
| Bg | 16-20 | 1·07 | N.D. | N.D. | 75·8 | 14·9 | 9·3 | 0·62 | 0·24 | N.D. | 0·08 | Nil | 100 | 5·96 | | | 200 | 95·0 | |
| Cg | 28-34 | 1·25 | N.D. | N.D. | 71·4 | 13·9 | 14·7 | 1·98 | 0·55 | N.D. | 0·13 | 0·18 | 94·4 | 6·24 | | | 210 | 91·0 | |

130. COUNTESSWELLS ASSOCIATION; Terryvale Series. Upper Woodend, 111637–111641

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $A_2g$ | 5-8 | 14·00 | 46·4 | 25·9 | 57·5 | 14·8 | 20·7 | 1·09 | 0·94 | 0·12 | 0·32 | 15·26 | 13·9 | 4·86 | 6·42 | 0·301 | 135 | 0·8 | Low exchangeable Ca. Low exchangeable K in lower layers. Low total $P_2O_5$ except in $A_2g$. Low readily soluble $P_2O_5$. |
| Bg | 10-12 | 8·02 | 29·8 | 31·8 | 42·6 | 19·0 | 34·4 | 1·08 | 1·07 | 0·09 | 0·34 | 11·41 | 18·4 | 5·10 | 2·77 | 0·152 | 73 | 0·6 | |
| Bg | 14-19 | 2·93 | 54·5 | 28·4 | 66·3 | 16·6 | 14·2 | 0·46 | 0·31 | 0·04 | 0·10 | 2·72 | 25·0 | 5·04 | | | 45 | 0·6 | |
| Bg | 28-33 | 1·91 | 81·4 | 10·5 | 86·2 | 5·7 | 6·2 | 0·45 | 0·34 | 0·06 | 0·02 | 0·56 | 60·8 | 5·19 | | | 45 | 0·6 | |
| Cg | 38-42 | 1·77 | 74·9 | 16·9 | 80·9 | 10·9 | 6·4 | 0·76 | 0·49 | 0·03 | 0·03 | 1·36 | 49·1 | 5·09 | | | 44 | 0·6 | |

131. COUNTESSWELLS ASSOCIATION; Terryvale Series. Parkhead, 128780–128783

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 10·10 | 58·1 | 25·0 | 70·8 | 12·3 | 11·9 | 4·45 | 0·43 | 0·09 | 0·10 | 10·97 | 31·6 | 5·30 | 5·15 | 0·250 | 195 | 8·1 | Low exchangeable Ca except in S. Low exchangeable Mg in Cg. Low exchangeable K in Bg. |
| Bg | 10-14 | 2·03 | 81·9 | 10·4 | 86·1 | 6·2 | 5·7 | 1·66 | 0·25 | 0·04 | 0·04 | 3·77 | 34·5 | 5·55 | 0·37 | 0·029 | 110 | 10·3 | |
| Bg | 17-21 | 2·92 | 64·5 | 20·8 | 73·4 | 11·9 | 11·8 | 2·58 | 0·76 | 0·07 | 0·08 | 4·30 | 44·8 | 5·56 | | | 123 | 7·1 | |
| Cg | 24-28 | 2·56 | 69·0 | 18·3 | 77·1 | 10·2 | 10·1 | 2·43 | 0·10 | 0·09 | 0·13 | 4·19 | 39·6 | 5·30 | | | 129 | 7·8 | |

132. COUNTESSWELLS ASSOCIATION; Terryvale Series. Tulloch, 128793–128797

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 10·29 | 60·0 | 23·2 | 70·5 | 12·7 | 11·7 | 10·95 | 0·64 | 0·11 | 0·11 | 4·82 | 71·0 | 6·55 | 5·65 | 0·351 | 220 | 14·9 | High exchangeable Ca in S. Low exchangeable K in $A_2g$. Low total $P_2O_5$ in upper part of Bg. Low readily soluble $P_2O_5$ in Bg, otherwise high. |
| $A_2g$ | 10-14 | 2·18 | 62·2 | 25·7 | 74·2 | 13·7 | 9·9 | 2·72 | 0·53 | 0·09 | 0·04 | 1·89 | 64·2 | 6·36 | 0·49 | 0·033 | 106 | 19·2 | |
| Bg | 18-22 | 2·54 | 55·0 | 19·1 | 63·9 | 10·2 | 23·4 | 3·98 | 2·31 | 0·13 | 0·17 | 2·02 | 76·6 | 5·73 | | | 69 | 2·0 | |
| Bg | 26-30 | 1·99 | 65·7 | 16·0 | 73·6 | 8·1 | 16·3 | 2·74 | 1·71 | 0·13 | 0·11 | 2·47 | 65·5 | 5·75 | | | 117 | 1·5 | |
| Cg | 34-38 | 1·63 | 69·2 | 11·3 | 75·4 | 5·1 | 17·9 | 3·80 | 1·88 | 0·17 | 0·13 | 0·34 | 94·8 | 6·61 | | | 114 | 15·6 | |

TABLE 6—Continued

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 133. | CUMINESTOWN ASSOCIATION; Culbyth Series. Lumsden, 54516–54519 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 8·75 | N.D. | N.D. | 63·1 | 14·1 | 18·5 | 3·56 | 0·42 | N.D. | 0·28 | 7·40 | 36·5 | 5·53 | 6·52 | 0·253 | 193 | 1·7 | Low exchangeable Ca except in S. |
| Bg | 13-18 | 2·68 | N.D. | N.D. | 67·3 | 15·2 | 14·8 | 2·26 | 0·32 | N.D. | 0·11 | 2·79 | 49·0 | 5·51 | 1·20 | 0·047 | 102 | 1·1 | Low total $P_2O_5$ in lower part of Bg. |
| Bg | 24-30 | 2·42 | N.D. | N.D. | 57·2 | 19·9 | 20·5 | 1·97 | 0·31 | N.D. | 0·12 | 7·13 | 25·1 | 5·30 | | | 75 | 0·8 | Low readily soluble $P_2O_5$ except in Cg. |
| Cg | 38-44 | 2·18 | N.D. | N.D. | 55·4 | 24·4 | 18·1 | 1·52 | 0·41 | N.D. | 0·13 | 6·63 | 23·8 | 5·20 | | | 123 | 4·6 | |
| 134. | CUMINESTOWN ASSOCIATION; Culbyth Series. Templeton, Kildrummy, 48084–48088 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 8·15 | N.D. | N.D. | 62·5 | 15·8 | 17·6 | 4·64 | 0·32 | N.D. | 0·14 | 7·35 | 41·0 | 5·67 | 2·88 | 0·247 | 290 | 1·9 | Low exchangeable Ca and Mg except in S. |
| Bg | 9-17 | 6·37 | N.D. | N.D. | 67·1 | 11·7 | 18·0 | 2·58 | 0·21 | N.D. | 0·09 | 3·28 | 46·8 | 5·87 | 1·11 | 0·127 | 220 | 1·2 | High total $P_2O_5$ in bottom part of Bg. |
| Bg | 18-21 | 4·25 | N.D. | N.D. | 76·8 | 7·4 | 15·8 | 2·64 | 0·13 | N.D. | 0·10 | 3·08 | 48·4 | 5·81 | | | 210 | 1·9 | High readily soluble $P_2O_5$ in Cg, otherwise low. |
| Bg | 22-25 | 29·1 | N.D. | N.D. | 50·1 | 10·4 | 17·7 | 4·20 | 0·20 | N.D. | 0·14 | 19·28 | 19·1 | 5·66 | | | 440 | 1·0 | |
| Cg | 40-44 | 2·97 | N.D. | N.D. | 82·3 | 6·8 | 10·9 | 1·81 | 0·14 | N.D. | 0·11 | 1·52 | 57·6 | 5·67 | | | 150 | 13·0 | |
| 135. | FOUDLAND ASSOCIATION; Fisherford Series. Balquhindachy, 119394–119397 | | | | | | | | | | | | | | | | | | |
| S | 3-7 | 10·30 | 29·5 | 49·3 | 56·4 | 22·4 | 16·0 | 4·20 | 0·20 | 0·12 | 0·15 | 11·50 | 28·9 | 5·40 | 4·91 | 0·314 | 307 | 9·3 | High U.S.D.A. silt content. |
| $B_2g$ | 13-17 | 2·91 | 38·4 | 49·3 | 70·3 | 17·4 | 9·4 | 0·76 | 0·03 | 0·05 | 0·08 | 1·76 | 34·3 | 5·41 | 0·53 | 0·037 | 103 | 4·6 | Low exchangeable Ca and K except in S. |
| $B_3g$ | 22-26 | 2·56 | 36·2 | 52·3 | 71·5 | 17·0 | 8·9 | 1·67 | 0·15 | 0·07 | 0·08 | 1·46 | 57·5 | 5·57 | | | 86 | 6·9 | Low exchangeable Mg except in Cg. |
| Cg | 34-38 | 1·84 | 38·0 | 52·9 | 74·0 | 16·9 | 7·3 | 1·82 | 0·31 | 0·06 | 0·08 | 1·02 | 69·0 | 5·62 | | | 76 | 9·1 | High total $P_2O_5$ in S, low in $B_3g$ and Cg. |

136. FOUDLAND ASSOCIATION; Fisherford Series. Tulloch, 47319–47322

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 10·80 | N.D. | N.D. | 53·9 | 20·3 | 20·4 | 3·81 | 0·82 | N.D. | 0·65 | 8·38 | 38·6 | 5·72 | 4·50 | 0·364 | 230 | 1·4 | Low exchangeable Ca except in S. Low total $P_2O_5$ except in S. Low readily soluble $P_3O_5$ except in Cg. |
| $B_2g$ | 12-16 | 3·58 | N.D. | N.D. | 69·8 | 14·3 | 13·3 | 2·28 | 1·13 | N.D. | 0·19 | 5·58 | 39·2 | 5·65 | 0·28 | 0·071 | 80 | 0·8 | |
| $B_2g$ | 20-24 | 3·60 | N.D. | N.D. | 74·2 | 12·6 | 13·2 | 1·35 | 1·51 | N.D. | 0·18 | 3·83 | 44·3 | 5·79 | | | 90 | 1·9 | |
| Cg | 38-42 | 3·27 | N.D. | N.D. | 59·3 | 14·4 | 23·0 | 1·89 | 1·81 | N.D. | 0·26 | 4·94 | 44·5 | 5·71 | | | 70 | 4·4 | |

137. FOUDLAND ASSOCIATION; Fisherford Series. Andet, 83713–83717

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 9·31 | N.D. | N.D. | 41·9 | 41·6 | 11·9 | 8·65 | 0·38 | 0·03 | 0·21 | 11·25 | 45·2 | 5·81 | 3·40 | 0·240 | 179 | 2·5 | High clay content in Bg. High exchangeable Ca in S, low in Cg. Low exchangeable K in $A_2g$ and Cg. Low total $P_2O_5$ except in S. Low readily soluble $P_2O_5$. |
| $A_2g$ | 11-16 | 2·29 | N.D. | N.D. | 47·1 | 26·6 | 24·0 | 4·80 | 0·74 | Nil | 0·06 | 6·43 | 46·4 | 5·88 | 0·60 | 0·061 | 67 | 4·0 | |
| Bg | 26-30 | 4·00 | N.D. | N.D. | 47·7 | 19·3 | 31·0 | 7·00 | 2·00 | 0·03 | 0·16 | 5·56 | 62·2 | 5·79 | | | 22 | 0·5 | |
| Bg | 35-37 | 3·09 | N.D. | N.D. | 48·4 | 13·8 | 34·8 | 4·54 | 2·52 | 0·03 | 0·25 | 8·14 | 47·4 | 5·44 | | | 30 | 0·5 | |
| Cg | 40-45 | 2·46 | N.D. | N.D. | 70·2 | 14·2 | 13·1 | 2·34 | 1·32 | Nil | 0·09 | 6·00 | 38·4 | 5·54 | | | 32 | 0·4 | |

138. HATTON ASSOCIATION; Blachrie Series. Upper Glasslaw, 118405–118408

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 31·50 | N.D. | N.D. | N.D. | N.D. | N.D. | 11·10 | 1·84 | 0·26 | 0·78 | 37·80 | 27·0 | 5·15 | 20·85 | 0·925 | 265 | 2·0 | High exchangeable Ca in S and $B_3g$. Low total $P_2O_5$ except in S. Low readily soluble $P_2O_5$ except in Cg. |
| $B_2g$ | 12-16 | 3·66 | 43·3 | 31·2 | 57·7 | 16·8 | 21·8 | 5·55 | 1·33 | 0·13 | 0·34 | 7·20 | 50·5 | 4·82 | 0·65 | 0·050 | 45 | 0·9 | |
| $B_3g$ | 23-27 | 3·65 | 56·3 | 20·3 | 64·0 | 12·6 | 19·7 | 9·30 | 2·98 | 0·18 | 0·47 | 3·27 | 80·0 | 5·36 | | | 51 | 1·9 | |
| Cg | 38-42 | 2·02 | 76·3 | 15·0 | 84·0 | 7·3 | 6·7 | 4·26 | 1·15 | 0·08 | 0·15 | 1·47 | 79·1 | 4·24 | | | 64 | 9·7 | |

139. INSCH ASSOCIATION; Myreton Series. Pitellachie, 54525–54528

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-10 | 5·31 | N.D. | N.D. | 50·6 | 21·4 | 25·4 | 5·60 | 0·37 | N.D. | 0·06 | 8·81 | 40·4 | 5·69 | 4·07 | 0·306 | 326 | 4·2 | High exchangeable Ca in Cg. Low exchangeable K. High total $P_2O_5$ in S. High readily soluble $P_2O_5$ in $B_3g$, very high in Cg. |
| $B_2g$ | 12-17 | 2·85 | N.D. | N.D. | 57·7 | 18·9 | 20·6 | 7·18 | 1·24 | N.D. | 0·05 | 2·03 | 80·7 | 6·36 | 0·39 | 0·027 | 143 | 4·0 | |
| $B_3g$ | 22-28 | 3·28 | N.D. | N.D. | 56·3 | 16·6 | 23·9 | 7·84 | 2·50 | N.D. | 0·03 | 2·30 | 81·9 | 6·69 | | | 187 | 15·4 | |
| Cg | 36-40 | 2·53 | N.D. | N.D. | 58·2 | 15·9 | 23·4 | 8·16 | 2·60 | N.D. | 0·08 | Nil | 100 | 7·21 | | | 276 | 59·8 | |

TABLE 6—Continued

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 140. | INSCH ASSOCIATION; Myreton Series. Inschfield, 33498–33501 | | | | | | | | | | | | | | | | | | |
| S | 0-6 | 6·53 | N.D. | N.D. | 65·4 | 12·9 | 21·9 | 11·33 | 2·86 | N.D. | 0·08 | 6·66 | 68·0 | 5·62 | 1·74 | 0·180 | 400 | 42·0 | High sand content in Cg and D. High exchangeable Ca. Low exchangeable K. High total and readily soluble $P_2O_5$ in S and $B_2g$, low in Cg and D. |
| $B_2g$ | 18-22 | 5·15 | N.D. | N.D. | 70·9 | 14·7 | 14·9 | 13·12 | 3·26 | N.D. | 0·03 | 4·44 | 79·0 | 5·99 | 0·63 | 0·070 | 310 | 28·6 | |
| Cg | 22-26 | 3·76 | N.D. | N.D. | 90·0 | 4·1 | 8·3 | 12·36 | 3·28 | N.D. | Nil | 2·22 | 87·6 | 6·38 | | | 20 | 0·1 | |
| D | 38-42 | 2·65 | N.D. | N.D. | 92·4 | 2·2 | 6·1 | 8·07 | 3·24 | N.D. | Nil | 2·22 | 83·6 | 6·49 | | | 10 | 0·1 | |
| 141. | INSCH ASSOCIATION; Myreton Series. Harthill, 83705–83708 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 8·95 | N.D. | N.D. | 42·0 | 19·9 | 33·7 | 14·18 | 0·94 | 0·05 | 0·15 | 11·19 | 57·8 | 5·76 | 2·88 | 0·251 | 507 | 14·7 | Rather high clay content for Myreton series. High exchangeable Ca. High to very high total and readily soluble $P_2O_5$. |
| $B_2g$ | 12-18 | 5·24 | N.D. | N.D. | 51·9 | 16·0 | 29·5 | 18·80 | 2·03 | 0·11 | 0·15 | 5·68 | 78·9 | 6·32 | 0·56 | 0·084 | 331 | 34·9 | |
| $B_3g$ | 24-30 | 3·63 | N.D. | N.D. | 52·3 | 14·6 | 29·5 | 17·00 | 2·56 | 0·21 | 0·16 | 1·21 | 94·6 | 6·76 | | | 346 | 83·5 | |
| Cg | 36-42 | 3·32 | N.D. | N.D. | 51·3 | 16·0 | 29·4 | 17·70 | 2·28 | 0·25 | 0·18 | Nil | 100 | 7·03 | | | 320 | 83·0 | |
| 142. | INSCH ASSOCIATION; Myreton Series. Hatton of Ardoyne, 3504–3507 | | | | | | | | | | | | | | | | | | |
| S | 0-16 | 11·22 | N.D. | N.D. | 51·3 | 17·4 | 23·8 | 5·65 | 1·48 | N.D. | N.D. | 11·20 | 38·8 | 5·93 | N.D. | N.D. | N.D. | N.D. | High exchangeable Ca and Mg in $B_3g$ and C. |
| $B_2g$ | 16-20 | 6·73 | N.D. | N.D. | 64·6 | 15·2 | 19·3 | 5·61 | 2·11 | N.D. | N.D. | 5·55 | 58·2 | 6·18 | N.D. | N.D. | N.D. | N.D. | |
| $B_3g$ | 32-36 | 4·30 | N.D. | N.D. | 67·9 | 14·3 | 19·5 | 15·05 | 5·45 | N.D. | N.D. | 2·79 | 92·0 | 6·78 | | | N.D. | N.D. | |
| C | 56-60 | 7·94 | N.D. | N.D. | 59·4 | 15·5 | 25·4 | 16·20 | 6·71 | N.D. | N.D. | 1·46 | 94·0 | 7·10 | | | N.D. | N.D. | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 143. | LESLIE ASSOCIATION; Charleston Series. Beauty Hill, 111592–111596 | | | | | | | | | | | | | | | | | | |
| A | 1-5 | 27·50 | N.D. | N.D. | N.D. | N.D. | N.D. | 4·98 | 66·60 | 0·63 | 0·50 | 1·24 | 98·4 | 6·76 | 11·30 | 0·770 | 189 | 3·1 | Low exchangeable Ca except in A. |
| $A_{2}g$ | 7-11 | 4·37 | 42·4 | 44·1 | 64·2 | 22·3 | 11·3 | 0·61 | 26·16 | 0·17 | 0·10 | Nil | 100 | 7·47 | 0·38 | 0·058 | 49 | 5·9 | High to very high exchangeable Mg. |
| $B_{2}g$ | 15-19 | 4·43 | 54·2 | 32·8 | 72·5 | 14·5 | 10·8 | 0·46 | 13·39 | 0·20 | 0·11 | Nil | 100 | 7·47 | | | 79 | 15·1 | Low total $P_2O_5$ in $A_{2}g$ and $B_{2}g$. |
| $B_{2}g$ | 22-26 | 4·38 | 70·7 | 15·5 | 76·6 | 9·6 | 11·6 | 0·61 | 13·72 | 0·17 | 0·13 | Nil | 100 | 7·79 | | | 101 | 12·0 | High readily soluble $P_2O_5$ in $B_{2}g$ and Cg. |
| Cg | 33-39 | 3·66 | 64·4 | 20·2 | 64·1 | 10·5 | 11·7 | 0·46 | 27·50 | 0·18 | 0·15 | Nil | 100 | 8·17 | | | 136 | 22·0 | |
| 144. | LESLIE ASSOCIATION; Charleston Series. Towanreef, 109754–109757 | | | | | | | | | | | | | | | | | | |
| A | 4-7 | 18·20 | 37·1 | 25·4 | 50·3 | 12·2 | 23·8 | 1·66 | 41·90 | 0·24 | 0·34 | 7·90 | 86·8 | 6·71 | 9·71 | 0·754 | 244 | 0·8 | Low exchangeable Ca. |
| Bg | 9-12 | 4·85 | 55·6 | 26·8 | 68·2 | 14·2 | 15·2 | 0·16 | 16·78 | 0·10 | 0·03 | Nil | 100 | 7·12 | 1·04 | 0·157 | 74 | 0·8 | High to very high exchangeable Mg. |
| Bg | 14-17 | 4·75 | 63·4 | 20·0 | 71·6 | 11·8 | 14·2 | 0·16 | 17·20 | 0·08 | 0·03 | Nil | 100 | 7·29 | | | 84 | 3·4 | Low exchangeable K except in A. |
| Cg | 19-22 | 4·50 | 55·2 | 27·3 | 68·7 | 13·8 | 15·2 | 0·16 | 14·88 | 0·08 | Nil | Nil | 100 | 7·58 | | | 87 | 9·2 | Low total $P_2O_5$ except in A. Low readily soluble $P_2O_5$ except in Cg. |
| 145. | LOCHTER ASSOCIATION; Auchencleith Series. Keithhall, 113645–113649 | | | | | | | | | | | | | | | | | | |
| S | 2-6 | 9·19 | 52·5 | 23·6 | 64·6 | 11·5 | 19·3 | 6·83 | 1·29 | 0·12 | 0·13 | 7·07 | 54·1 | 5·86 | 3·09 | 0·264 | 298 | 4·5 | High sand content in Cg. |
| S | 10-14 | 7·18 | 52·5 | 18·2 | 61·8 | 8·9 | 25·7 | 4·80 | 0·90 | 0·08 | 0·08 | 6·83 | 46·9 | 5·95 | 2·22 | 0·093 | 333 | 5·5 | Low exchangeable K. |
| Bg | 18-22 | 3·12 | 58·5 | 22·3 | 73·2 | 7·6 | 16·1 | 6·11 | 1·68 | 0·08 | 0·07 | 3·32 | 70·5 | 6·24 | | | 142 | 4·2 | High total $P_2O_5$ in S. |
| Bg | 26-30 | 2·40 | 66·3 | 24·8 | 83·6 | 7·5 | 6·5 | 5·33 | 1·41 | 0·07 | 0·07 | 1·59 | 81·2 | 6·26 | | | 231 | 40·0 | High readily soluble $P_2O_5$ in lower layers. |
| Cg | 32-36 | 1·64 | 84·4 | 9·5 | 90·5 | 3·4 | 4·5 | 4·25 | 1·25 | 0·07 | 0·05 | 1·13 | 83·3 | 6·18 | | | 195 | 29·9 | |
| 146. | NORTH MORMOND ASSOCIATION; Tophead Series. Blairmormond, 119073–119076 | | | | | | | | | | | | | | | | | | |
| S | 3-7 | 9·76 | 55·4 | 24·1 | 65·2 | 14·3 | 15·6 | 3·40 | 0·29 | 0·08 | 0·36 | 13·08 | 24·0 | 5·14 | 4·93 | 0·263 | 207 | 12·6 | Low total $P_2O_5$ in $B_{2}g$ and $B_{3}g$. |
| $B_{2}g$ | 12-16 | 3·24 | 50·6 | 24·3 | 62·4 | 12·5 | 21·9 | 3·37 | 0·99 | 0·08 | 0·21 | 2·14 | 68·5 | 5·25 | 0·31 | 0·043 | 65 | 1·5 | High readily soluble $P_2O_5$ in S and Cg, low in $B_{2}g$ and $B_{3}g$. |
| $B_{3}g$ | 24-28 | 3·06 | 50·7 | 23·0 | 60·7 | 13·0 | 23·2 | 4·00 | 1·64 | 0·10 | 0·15 | 2·80 | 67·8 | 5·22 | | | 95 | 1·8 | |
| Cg | 36-40 | 3·39 | 45·0 | 25·0 | 54·5 | 15·5 | 26·6 | 4·60 | 3·45 | 0·17 | 0·28 | 0·83 | 91·2 | 5·28 | | | 106 | 24·1 | |

TABLE 6—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 147. | | | | | | | ORDLEY ASSOCIATION; Boghead Series. Goryhill, 109766–109769 | | | | | | | | | | | | |
| S | 3-7 | 10·51 | 48·9 | 29·1 | 64·0 | 14·0 | 16·7 | 2·67 | 2·61 | 0·24 | 0·42 | 13·10 | 31·2 | 5·16 | 4·28 | 0·308 | 114 | 0·6 | Low exchangeable Ca in S and $A_2$, high in Cg. Low total $P_2O_5$ in Bg and Cg. Low readily soluble $P_2O_5$ except in Cg. |
| $A_2g$ | 9-13 | 5·89 | 57·8 | 21·1 | 67·3 | 11·7 | 18·1 | 2·08 | 1·88 | 0·18 | 0·19 | 10·75 | 28·8 | 5·50 | 1·47 | 0·145 | 105 | 0·4 | |
| Bg | 14-16 | 5·14 | 57·6 | 21·5 | 66·8 | 12·3 | 18·3 | 3·90 | 3·64 | 0·19 | 0·18 | 9·95 | 44·3 | 5·35 | | | 78 | 0·7 | |
| Cg | 22-26 | 3·98 | 65·2 | 18·4 | 72·0 | 11·6 | 12·4 | 9·48 | 3·83 | 0·22 | 0·19 | 3·20 | 81·2 | 5·40 | | | 95 | 8·1 | |
| 148. | | | | | | | ORDLEY ASSOCIATION; Boghead Series. Boghead, 105145–105150 | | | | | | | | | | | | |
| S | 2-6 | 6·85 | 50·7 | 29·1 | 62·8 | 17·0 | 16·8 | 4·01 | 0·22 | 0·09 | 0·10 | 7·18 | 38·1 | 5·47 | 2·44 | 0·183 | 160 | 1·1 | Low total $P_2O_5$ except in S. Low readily soluble $P_2O_5$. |
| $A_2g$ | 12-16 | 3·37 | 50·0 | 24·5 | 63·1 | 11·4 | 22·1 | 3·07 | 0·65 | 0·09 | 0·10 | 3·92 | 50·0 | 5·37 | 0·28 | 0·045 | 53 | 0·5 | |
| $A_2g$ | 18-22 | 3·22 | 48·7 | 24·2 | 61·8 | 11·1 | 23·9 | 3·07 | 1·22 | 0·11 | 0·14 | 4·67 | 49·3 | 5·15 | 0·14 | 0·032 | 51 | 0·4 | |
| Bg | 24-28 | 3·04 | 46·5 | 29·0 | 59·8 | 15·7 | 21·5 | 2·92 | 1·93 | 0·13 | 0·17 | 3·89 | 57·0 | 5·27 | | | 57 | 0·4 | |
| Bg | 30-34 | 2·74 | 55·5 | 19·6 | 61·7 | 13·0 | 22·2 | 3·07 | 2·59 | 0·11 | 0·17 | 2·53 | 70·1 | 5·41 | | | 54 | 0·3 | |
| Cg | 38-42 | 2·34 | 64·9 | 17·9 | 71·2 | 11·6 | 14·9 | 3·36 | 2·04 | 0·08 | 0·16 | 1·08 | 84·0 | 5·85 | | | 63 | 0·3 | |
| 149. | | | | | | | PETERHEAD ASSOCIATION; Peterhead Series. Westfield, Foveran, 40945–40950 | | | | | | | | | | | | |
| S | 0-8 | 8·86 | N.D. | N.D. | 45·6 | 21·3 | 28·7 | 8·45 | 1·13 | N.D. | 0·21 | 7·73 | 56·0 | 5·94 | 3·70 | 0·249 | 199 | 4·9 | High exchangeable Ca in S, low in Cg. High exchangeable Mg in lower part of $B_2g$. Low total $P_2O_5$ in lower part of $B_2g$. Low readily soluble $P_2O_5$ in $B_2g$ and lower part of Cg. |
| $B_2g$ | 10-13 | 5·56 | N.D. | N.D. | 48·6 | 15·8 | 32·8 | 5·67 | 1·35 | N.D. | 0·17 | 5·88 | 55·0 | 5·96 | 1·70 | 0·109 | 115 | 1·4 | |
| $B_2g$ | 13-18 | 3·96 | N.D. | N.D. | 43·8 | 20·0 | 32·2 | 4·68 | 2·61 | N.D. | 0·21 | 3·89 | 65·8 | 5·53 | | | 85 | 0·4 | |
| $B_2g$ | 20-24 | 3·35 | N.D. | N.D. | 44·9 | 18·5 | 33·2 | 3·93 | 5·31 | N.D. | 0·25 | 4·28 | 68·9 | 5·63 | | | 90 | 1·1 | |
| Cg | 30-34 | 2·59 | N.D. | N.D. | 57·0 | 14·3 | 26·1 | 2·99 | 3·38 | N.D. | 0·22 | 2·93 | 69·1 | 6·21 | | | 120 | 5·5 | |
| Cg | 46-50 | 3·57 | N.D. | N.D. | 50·2 | 38·6 | 7·6 | 2·38 | 4·87 | N.D. | 0·16 | 2·04 | 78·4 | 6·49 | | | 147 | 1·6 | |

150. PETERHEAD ASSOCIATION; Peterhead Series. Ednie, 34998–35001

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 11·60 | N.D. | N.D. | 41·7 | 20·9 | 31·6 | 6·33 | 1·21 | N.D. | 0·21 | 9·16 | 45·8 | 5·30 | 5·43 | 0·348 | 150 | 4·0 | High clay content. High exchangeable Ca except in S. High exchangeable Mg in Cg. Low exchangeable K in $B_3g$. Low total and readily soluble $P_2O_5$ in $B_2g$ and $B_3g$. |
| $B_2g$ | 8-14 | 5·32 | N.D. | N.D. | 24·0 | 20·3 | 53·1 | 10·14 | 4·47 | N.D. | 0·53 | 3·60 | 80·7 | 5·76 | 0·67 | 0·053 | 50 | 2·5 | |
| $B_3g$ | 14-16 | 5·24 | N.D. | N.D. | 29·8 | 15·1 | 52·5 | 8·93 | 0·33 | N.D. | Nil | 4·74 | 66·1 | 5·50 | | | 80 | 2·0 | |
| Cg | 40-48 | 4·29 | N.D. | N.D. | 41·6 | 17·1 | 39·2 | 12·43 | 6·14 | N.D. | 0·12 | 2·88 | 86·6 | 5·67 | | | 100 | 6·0 | |

151. PETERHEAD ASSOCIATION; Peterhead Series. St. Fergus, 117974–117979

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 12·30 | 49·0 | 28·9 | 60·2 | 17·7 | 15·9 | 13·20 | 1·64 | 0·32 | 0·20 | 5·85 | 72·6 | 6·63 | 5·48 | 0·374 | 297 | 5·4 | High clay content in $B_3g$ and Cg. High exchangeable Ca in S. High exchangeable Mg in $B_3g$ and Cg. Low total $P_2O_5$ except in S. Low readily soluble $P_2O_5$ in $B_3g$ and lower part of $B_2g$. |
| $B_2g$ | 10-14 | 4·07 | 41·6 | 30·6 | 52·9 | 19·3 | 25·8 | 5·35 | 1·75 | 0·19 | 0·12 | 3·34 | 69·0 | 6·30 | 1·03 | 0·071 | 73 | 6·3 | |
| $B_2g$ | 20-24 | 3·82 | 39·6 | 26·7 | 49·9 | 16·4 | 29·9 | 6·14 | 3·49 | 0·28 | 0·21 | 1·85 | 84·8 | 6·10 | 0·24 | 0·043 | 59 | 1·7 | |
| $B_3g$ | 30-34 | 3·73 | 34·8 | 28·3 | 45·2 | 17·9 | 33·2 | 6·16 | 4·83 | 0·38 | 0·27 | 2·55 | 82·1 | 5·83 | | | 59 | 1·0 | |
| $B_3g$ | 37-41 | 4·01 | 38·7 | 22·3 | 46·7 | 14·3 | 37·0 | 7·28 | 5·60 | 0·43 | 0·36 | 3·62 | 79·0 | 5·84 | | | 91 | 2·5 | |
| Cg | 44-48 | 3·78 | 34·7 | 23·1 | 42·2 | 15·6 | 38·4 | 7·42 | 5·18 | 0·43 | 0·32 | 3·95 | 77·2 | 5·66 | | | 94 | 4·1 | |

152. PETERHEAD ASSOCIATION; Peterhead Series. St. Fergus, 117956–117961

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 9·43 | 42·0 | 27·6 | 50·9 | 18·7 | 25·7 | 9·80 | 1·77 | 0·36 | 0·28 | 9·72 | 55·7 | 6·21 | 4·38 | 0·316 | 194 | 6·2 | High clay content in $B_3g$ and Cg. High exchangeable Ca except in $B_2g$. High exchangeable Mg in $B_3g$ and lower part of Cg. Low total $P_2O_5$ in $B_3g$ and upper part of $B_2g$. High readily soluble $P_2O_5$ in Cg. |
| $B_2g$ | 10-14 | 3·78 | 39·6 | 26·6 | 51·5 | 14·7 | 30·0 | 6·63 | 2·09 | 0·32 | 0·15 | 1·19 | 88·4 | 6·78 | 0·32 | 0·041 | 53 | 3·4 | |
| $B_2g$ | 18-22 | 4·75 | 42·3 | 29·6 | 54·9 | 17·0 | 25·7 | 5·86 | 1·69 | 0·25 | 0·13 | 3·19 | 71·2 | 6·40 | 0·64 | 0·068 | 110 | 6·2 | |
| $B_3g$ | 26-30 | 3·79 | 25·6 | 28·0 | 37·5 | 16·1 | 42·6 | 9·10 | 6·15 | 0·58 | 0·28 | Nil | 100 | 7·21 | | | 87 | 4·1 | |
| Cg | 33-37 | 3·81 | 26·0 | 27·0 | 34·5 | 18·5 | 43·2 | 9·25 | 4·42 | 0·60 | 0·33 | Nil | 100 | 7·33 | | | 102 | 15·7 | |
| Cg | 40-44 | 3·48 | 34·1 | 25·0 | 43·3 | 15·8 | 37·4 | 7·78 | 5·75 | 0·48 | 0·29 | Nil | 100 | 7·55 | | | 101 | 18·9 | |



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TABLE 6—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 153. | | | | | | | | PETERHEAD ASSOCIATION; Peterhead Series. Shielhill, 117481–117486 | | | | | | | | | | | |
| S | 2-6 | 13·09 | 36·1 | 32·1 | 49·1 | 19·1 | 25·3 | 16·18 | 2·88 | 0·28 | 0·38 | 11·85 | 62·6 | 5·65 | 7·21 | 0·342 | 185 | 6·9 | High clay content in $B_3g$ and Cg. High exchangeable Ca in S and $B_3g$. High exchangeable Mg in $B_3g$. Low total $P_2O_5$ in $B_2g$ and $B_3g$. Low readily soluble $P_2O_5$ in $B_3g$. |
| $B_2g$ | 8-10 | 2·81 | 58·2 | 23·8 | 66·5 | 15·5 | 15·2 | 4·11 | 1·28 | 0·20 | 0·15 | 2·87 | 66·6 | 6·31 | 0·48 | 0·043 | 62 | 8·7 | |
| $B_3g$ | 12-16 | 4·48 | 19·1 | 22·7 | 25·3 | 16·5 | 56·0 | 10·41 | 5·42 | 0·58 | 0·43 | 5·95 | 74·2 | 5·64 | 0·41 | 0·038 | 56 | 0·9 | |
| $B_3g$ | 20-24 | 4·45 | 42·6 | 20·5 | 49·4 | 13·7 | 34·7 | 10·94 | 7·06 | 0·78 | 0·63 | 7·76 | 71·6 | 4·53 | | | 78 | 1·4 | |
| Cg | 30-34 | 2·80 | 20·0 | 24·2 | 28·2 | 16·0 | 53·0 | 6·21 | 3·35 | 0·41 | 0·41 | 5·25 | 66·5 | 5·31 | | | 110 | 3·7 | |
| Cg | 38-42 | 2·67 | 43·5 | 21·1 | 51·6 | 13·0 | 32·7 | 5·43 | 2·95 | 0·36 | 0·42 | 3·39 | 73·0 | 5·35 | | | 119 | 5·3 | |
| 154. | | | | | | | | SKELMUIR ASSOCIATION; Bogengarrie Series. Bogengarrie, 47439–47441 | | | | | | | | | | | |
| S | 0-8 | 18·50 | N.D. | N.D. | 45·9 | 1·5 | 38·9 | 6·91 | 1·55 | N.D. | 0·23 | 22·40 | 29·8 | 4·99 | 9·50 | 0·418 | 210 | 1·0 | High clay content in S. Low exchangeable Ca in C. Low readily soluble $P_2O_5$. |
| Bg | 10-14 | 6·20 | N.D. | N.D. | 52·2 | 17·5 | 27·2 | 3·23 | 0·83 | N.D. | 0·17 | 10·37 | 29·0 | 4·99 | 1·27 | 0·107 | 150 | 0·7 | |
| Cg | 20-24 | 4·74 | N.D. | N.D. | 47·2 | 25·0 | 25·2 | 2·16 | 0·72 | N.D. | 0·16 | 10·03 | 23·2 | 4·93 | | | 120 | 0·5 | |
| 155. | | | | | | | | SKELMUIR ASSOCIATION; Bogengarrie Series. Dens, 35032–35035 | | | | | | | | | | | |
| S | 0-7 | 10·60 | N.D. | N.D. | 65·1 | 13·4 | 16·2 | 5·84 | 0·59 | N.D. | 0·11 | 10·94 | 37·3 | 5·35 | 5·87 | 0·311 | 160 | 4·1 | Low exchangeable Ca and K except in S. Low total $P_2O_5$ in $B_2g$ and $B_3g$. Low readily soluble $P_2O_5$ except in S. |
| $B_2g$ | 8-14 | 4·44 | N.D. | N.D. | 47·0 | 14·4 | 34·2 | 2·41 | 0·52 | N.D. | 0·05 | 7·49 | 28·5 | 5·18 | 0·97 | 0·077 | 80 | 2·5 | |
| $B_3g$ | 16-24 | 4·18 | N.D. | N.D. | 53·3 | 12·5 | 30·0 | 2·53 | 0·52 | N.D. | 0·09 | 7·70 | 29·0 | 5·09 | | | 60 | 0·2 | |
| D | 26-40 | 3·65 | N.D. | N.D. | 62·2 | 11·2 | 22·9 | 2·33 | 1·59 | N.D. | 0·04 | 7·18 | 35·6 | 4·97 | | | 110 | 1·7 | |

156. SKELMUIR ASSOCIATION; Bogengarrie Series. Skelmuir, 35002–35005

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 11·10 | N.D. | N.D. | 51·5 | 15·3 | 27·6 | 8·52 | 0·07 | N.D. | Nil | 8·11 | 50·9 | 5·52 | 3·90 | 0·242 | 230 | 3·4 | High exchangeable Ca in S, otherwise low. |
| $B_2g$ | 10-14 | 5·63 | N.D. | N.D. | 51·9 | 12·4 | 32·9 | 2·72 | 0·28 | N.D. | Nil | 6·45 | 31·7 | 4·99 | 3·26 | 0·057 | 50 | 2·1 | Low exchangeable Mg and K. |
| $B_3g$ | 22-26 | 5·25 | N.D. | N.D. | 49·7 | 14·9 | 32·9 | 1·49 | 0·20 | N.D. | 0·01 | 6·83 | 20·0 | 4·93 | | | 90 | 1·7 | Low total and readily soluble $P_2O_5$ except in S. |
| Cg | 44-48 | 5·24 | N.D. | N.D. | 53·8 | 11·2 | 32·4 | 1·83 | 0·06 | N.D. | Nil | 6·83 | 21·8 | 4·68 | | | 80 | 1·5 | |

157. STRICHEN ASSOCIATION; Anniegathel Series. Touxhill, 110630–110634

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 14·10 | 43·7 | 29·6 | 57·1 | 16·2 | 19·6 | 12·05 | 0·74 | 0·18 | 0·24 | 5·79 | 69·6 | 5·98 | 6·52 | 0·511 | 188 | 4·6 | High exchangeable Ca in S, low in $B_3g$ and Cg. |
| $A_2g$ | 7-11 | 5·34 | 49·2 | 26·7 | 59·6 | 16·3 | 21·4 | 3·37 | 0·80 | 0·07 | 0·07 | 3·44 | 55·6 | 5·60 | 0·39 | 0·041 | 85 | 3·0 | Low exchangeable K in $A_2g$. |
| $B_2g$ | 18-24 | 6·80 | 37·1 | 29·0 | 45·8 | 20·3 | 30·5 | 4·17 | 1·49 | 0·09 | 0·13 | 4·98 | 54·1 | 5·25 | | | 167 | 3·1 | Low total $P_2O_5$ in $A_2g$. |
| $B_3g$ | 30-34 | 6·31 | 38·6 | 40·2 | 47·2 | 31·6 | 18·0 | 1·99 | 1·26 | 0·07 | 0·11 | 4·84 | 41·5 | 5·10 | | | 193 | 2·8 | Low readily soluble $P_2O_5$ in $B_3g$ and Cg. |
| Cg | 40-44 | 7·19 | 32·5 | 33·3 | 45·1 | 20·7 | 30·6 | 1·53 | 0·77 | 0·07 | 0·11 | 3·45 | 41·9 | 5·05 | | | 256 | 1·8 | |

158. STRICHEN ASSOCIATION; Anniegathel Series. Skillymarno, 118162–118166

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3-7 | 8·76 | 38·1 | 33·8 | 55·7 | 16·2 | 23·7 | 5·62 | 0·88 | 0·16 | 0·10 | 7·75 | 46·6 | 5·86 | 3·41 | 0·244 | 239 | 4·8 | Low exchangeable K in upper part of Bg. |
| Bg | 12-16 | 6·34 | 42·3 | 32·4 | 58·1 | 16·6 | 22·1 | 4·03 | 0·91 | 0·14 | 0·06 | 5·25 | 49·5 | 5·80 | 1·93 | 0·162 | 147 | 1·9 | High total $P_2O_5$ in Cg. |
| Bg | 21-25 | 3·47 | 74·7 | 14·1 | 83·1 | 6·7 | 6·7 | 3·65 | 0·99 | 0·14 | 0·07 | 2·88 | 62·8 | 6·01 | | | 130 | 19·6 | Low readily soluble $P_2O_5$ at top of Bg, high in lower layers. |
| Bg | 30-34 | 3·74 | 70·3 | 16·6 | 78·7 | 8·2 | 9·4 | 5·22 | 2·19 | 0·25 | 0·14 | 2·77 | 73·8 | 6·31 | | | 214 | 24·3 | |
| Cg | 40-44 | 4·24 | 48·8 | 25·6 | 62·4 | 12·0 | 23·5 | 7·48 | 4·25 | 0·31 | 0·23 | 2·24 | 84·5 | 6·62 | | | 308 | 44·7 | |

159. TARVES ASSOCIATION; Pitmedden Series. Nethermuir, 47427–47430

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 12·50 | N.D. | N.D. | 48·3 | 22·3 | 23·2 | 7·22 | 1·46 | N.D. | 0·18 | 11·80 | 42·8 | 5·89 | 5·54 | 0·318 | 260 | 3·4 | Low readily soluble $P_2O_5$ in $B_3g$ and Cg. |
| $B_2g$ | 8-12 | 4·33 | N.D. | N.D. | 60·8 | 16·4 | 20·7 | 4·56 | 1·43 | N.D. | 0·10 | 3·28 | 65·0 | 6·06 | 0·66 | 0·064 | 170 | 9·5 | |
| $B_3g$ | 16-20 | 4·31 | N.D. | N.D. | 52·0 | 19·4 | 26·2 | 5·19 | 2·27 | N.D. | 0·17 | 3·53 | 68·4 | 6·02 | | | 110 | 1·8 | |
| Cg | 42-46 | 3·30 | N.D. | N.D. | 61·1 | 16·6 | 19·0 | 3·82 | 2·05 | N.D. | 0·18 | 3·06 | 66·4 | 5·80 | | | 170 | 2·5 | |

TABLE 6—Continued

| Horizon | Depth in. | % Loss on Ignition | Soil Separates | | | | | Exchangeable Cations m.e./100 g. | | | | | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. 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 | | | | | | | |
| 160. | TARVES ASSOCIATION; Pitmedden Series. Upper Crichie, 119051–119054 | | | | | | | | | | | | | | | | | | |
| S | 4-8 | 14·96 | 52·6 | 26·5 | 64·5 | 14·6 | 13·4 | 6·48 | 0·92 | 0·22 | 0·20 | 13·30 | 37·0 | 5·62 | 7·98 | 0·355 | 239 | 8·1 | Low clay content in Cg. Low total and readily soluble $P_2O_5$ except in S. |
| $B_2g$ | 13-17 | 3·72 | 61·9 | 22·4 | 71·9 | 12·4 | 12·0 | 3·52 | 1·80 | 0·12 | 0·13 | 1·54 | 78·5 | 6·02 | 0·46 | 0·046 | 89 | 1·1 | |
| $B_3g$ | 20-24 | 4·17 | 55·2 | 24·3 | 68·0 | 11·5 | 18·4 | 4·15 | 3·17 | 0·22 | 0·18 | 1·41 | 84·5 | 5·84 | | | 53 | 0·5 | |
| Cg | 32-36 | 3·51 | 72·7 | 17·9 | 82·4 | 9·2 | 5·9 | 5·06 | 4·30 | 0·33 | 0·27 | 1·70 | 85·4 | 5·23 | | | 75 | 1·9 | |
| 161. | TARVES ASSOCIATION; Pitmedden Series. Nether Aden, 111388–111392 | | | | | | | | | | | | | | | | | | |
| S | 2-6 | 9·00 | 48·5 | 28·3 | 61·2 | 15·6 | 18·7 | 4·62 | 0·34 | 0·07 | 0·10 | 6·68 | 43·4 | 5·59 | 3·19 | 0·234 | 194 | 4·1 | Low exchangeable Ca in Cg. Low exchangeable K at top of Bg. Low total and readily soluble $P_2O_5$ in lower layers. |
| Bg | 7-10 | 4·20 | 66·4 | 19·4 | 75·0 | 10·8 | 10·4 | 3·06 | 0·45 | 0·06 | 0·07 | 2·51 | 59·3 | 5·77 | 0·87 | 0·068 | 154 | 7·6 | |
| Bg | 12-16 | 5·05 | 44·8 | 27·7 | 59·4 | 13·1 | 25·0 | 6·19 | 1·99 | 0·06 | 0·13 | 1·73 | 83·0 | 6·24 | | | 68 | 1·1 | |
| Bg | 23-26 | 3·89 | 59·6 | 19·9 | 68·3 | 11·2 | 16·6 | 4·15 | 2·89 | 0·24 | 0·13 | 0·58 | 92·6 | 6·06 | | | 59 | 1·5 | |
| Cg | 33-36 | 3·55 | 60·0 | 19·0 | 68·8 | 10·2 | 17·5 | 2·75 | 2·64 | 0·14 | 0·11 | 0·57 | 90·9 | 6·01 | | | 94 | 1·6 | |
| 162. | TARVES ASSOCIATION; Pitmedden Series. Balwearie, 47341–47345 | | | | | | | | | | | | | | | | | | |
| S | 0-8 | 5·73 | N.D. | N.D. | 55·8 | 19·3 | 20·4 | 4·00 | 0·23 | N.D. | 0·10 | 10·69 | 28·8 | 5·48 | 2·90 | 0·290 | 260 | 3·7 | Low exchangeable Mg in S. Low exchangeable K in $A_2g$. Low total $P_2O_5$ in Bg. Low readily soluble $P_2O_5$ in $A_2g$ and Bg, high in Cg. |
| $A_2g$ | 10-12 | 4·39 | N.D. | N.D. | 63·6 | 15·0 | 19·2 | 4·86 | 0·79 | N.D. | 0·09 | 4·37 | 56·4 | 5·86 | 0·57 | 0·075 | 110 | 1·2 | |
| Bg | 18-22 | 4·08 | N.D. | N.D. | 59·9 | 12·8 | 24·3 | 6·04 | 2·15 | N.D. | 0·13 | 3·14 | 72·6 | 6·11 | | | 90 | 1·0 | |
| Bg | 24-28 | 3·64 | N.D. | N.D. | 63·8 | 14·6 | 21·2 | 4·08 | 1·73 | N.D. | 0·13 | 2·51 | 70·3 | 6·11 | | | 100 | 8·5 | |
| Cg | 40-44 | 2·74 | N.D. | N.D. | 73·8 | 9·2 | 16·3 | 4·07 | 1·77 | N.D. | 0·14 | 2·73 | 68·6 | 6·14 | | | 200 | 14·0 | |

163. TARVES ASSOCIATION; Pitmedden Series. Balquhain, 47355–47358

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 8·54 | N.D. | N.D. | 48·0 | 24·7 | 23·0 | 9·37 | 1·31 | N.D. | 0·20 | 8·26 | 56·8 | 5·85 | 3·06 | 0·255 | 290 | 10·0 | High exchangeable Ca. High exchangeable Mg in $A_2g$ and Bg. Low readily soluble $P_2O_5$ in $A_2g$, otherwise high. |
| $A_2g$ | 10-14 | 4·54 | N.D. | N.D. | 45·9 | 15·9 | 36·4 | 12·20 | 5·28 | N.D. | 0·19 | 2·97 | 85·2 | 6·63 | 0·38 | 0·038 | 100 | 1·1 | |
| Bg | 22-26 | 3·51 | N.D. | N.D. | 48·5 | 16·9 | 31·1 | 10·05 | 5·66 | N.D. | 0·23 | 2·55 | 86·2 | 6·95 | | | 260 | 33·0 | |
| Cg | 40-44 | 3·43 | N.D. | N.D. | 59·4 | 14·4 | 22·8 | 8·22 | 4·84 | N.D. | 0·18 | 2·56 | 83·8 | 6·93 | | | 290 | 33·0 | |

164. TARVES ASSOCIATION; Pitmedden Series. Drumwhindle Mains, 47447–47450

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 8·80 | N.D. | N.D. | 60·9 | 21·0 | 13·7 | 3·34 | 2·18 | N.D. | 0·25 | 5·72 | 50·2 | 5·58 | 3·18 | 0·291 | 240 | 5·7 | High exchangeable Ca in $A_2g$ and Cg. High readily soluble $P_2O_5$ in $A_2g$ and Bg. |
| $A_2g$ | 12-16 | 4·56 | N.D. | N.D. | 64·9 | 17·3 | 15·5 | 10·21 | 3·53 | N.D. | 0·20 | 0·22 | 91·8 | 6·16 | 0·23 | 0·051 | 120 | 15·0 | |
| Bg | 20-24 | 4·25 | N.D. | N.D. | 62·7 | 17·4 | 17·8 | 7·67 | 3·96 | N.D. | 0·23 | 0·66 | 94·8 | 6·57 | | | 130 | 15·0 | |
| Cg | 40-44 | 4·17 | N.D. | N.D. | 55·9 | 17·0 | 24·4 | 9·50 | 4·62 | N.D. | 0·23 | Nil | 100 | 7·27 | | | 160 | 4·8 | |

165. TARVES ASSOCIATION; Pitmedden Series. Millhill, 110440–110444

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 10·28 | 45·7 | 28·1 | 59·6 | 14·2 | 21·1 | 13·94 | 0·57 | 0·20 | 0·64 | 3·94 | 79·7 | 6·46 | 4·63 | 0·239 | 223 | 12·5 | Low clay content in Cg. High exchangeable Ca in S, low in Cg. Low exchangeable K in Cg. Low total $P_2O_5$ in Cg and upper part of Bg. High readily soluble $P_2O_5$ in S, otherwise low. |
| Bg | 9-12 | 4·20 | 58·8 | 18·8 | 65·3 | 12·3 | 20·3 | 3·52 | 0·57 | 0·09 | 0·10 | 3·89 | 52·4 | 0·54 | 0·54 | 0·114 | 68 | 0·8 | |
| Bg | 18-24 | 3·95 | 45·9 | 27·0 | 58·9 | 13·9 | 23·2 | 3·84 | 1·48 | 0·13 | 0·14 | 2·30 | 70·9 | 5·36 | | | 69 | 0·7 | |
| Bg | 30-34 | 3·85 | 51·7 | 20·4 | 60·3 | 11·8 | 24·0 | 2·92 | 2·37 | 0·10 | 0·13 | 2·30 | 70·6 | 5·36 | | | 111 | 0·7 | |
| Cg | 42-46 | 2·45 | 75·1 | 14·3 | 80·2 | 9·2 | 8·1 | 1·36 | 1·08 | 0·05 | 0·08 | 1·14 | 69·3 | 5·18 | | | 74 | 0·9 | |

166. TARVES ASSOCIATION; Pitmedden Series. Tillycorthie, 40982–40986

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 7·70 | N.D. | N.D. | 49·3 | 18·5 | 28·3 | 7·51 | 0·69 | N.D. | 0·11 | 5·87 | 58·6 | 6·08 | 3·04 | 0·212 | 180 | 8·8 | High exchangeable Mg in lower part of Bg. Low total $P_2O_5$ in $A_2g$ and Bg. High readily soluble $P_2O_5$ in $A_2g$ and Cg, low in upper part of Bg. |
| $A_2g$ | 8-12 | 3·79 | N.D. | N.D. | 51·8 | 19·7 | 24·8 | 4·93 | 2·09 | N.D. | 0·16 | 3·04 | 70·3 | 6·22 | 0.31 | 0·051 | 80 | 15·0 | |
| Bg | 16-20 | 4·19 | N.D. | N.D. | 66·3 | 6·6 | 24·8 | 5·59 | 4·78 | N.D. | 0·22 | 2·85 | 78·7 | 6·11 | | | 60 | 1·5 | |
| Bg | 28-32 | 4·78 | N.D. | N.D. | 52·4 | 16·0 | 29·2 | 5·63 | 6·36 | N.D. | 0·15 | 3·13 | 79·6 | 6·41 | | | 100 | 6·8 | |
| Cg | 44-48 | 4·28 | N.D. | N.D. | 48·4 | 27·1 | 22·4 | 4·45 | 2·49 | N.D. | 0·22 | 2·21 | 76·4 | 6·69 | | | 145 | 10·0 | |

TABLE 6—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 167. | | | | | | | | TARVES ASSOCIATION; Pitmedden Series. Rowrandle, 63317–63321 | | | | | | | | | | | |
| S | 0-6 | 9·05 | N.D. | N.D. | 65·8 | 14·0 | 15·7 | 1·95 | 1·17 | N.D. | 0·17 | 11·40 | 22·6 | 5·24 | 5·67 | 0·278 | 146 | 1·2 | Low exchangeable Ca |
| $A_2g$ | 8-12 | 2·36 | N.D. | N.D. | 64·9 | 17·3 | 15·4 | 0·47 | 1·06 | N.D. | 0·11 | 2·81 | 36·7 | 5·33 | 0·43 | 0·050 | 85 | 0·6 | except in Cg. |
| Bg | 16-21 | 2·74 | N.D. | N.D. | 57·1 | 15·7 | 24·5 | 2·02 | 3·65 | N.D. | 0·13 | 4·90 | 54·2 | 5·77 | | | 92 | Nil | Low total $P_2O_5$ in $A_2g$ and |
| Bg | 28-33 | 2·98 | N.D. | N.D. | 60·8 | 13·1 | 23·1 | Nil | 3·96 | N.D. | 0·11 | 3·16 | 56·4 | 6·46 | | | 102 | Nil | upper part of Bg. |
| Cg | 39-45 | 2·69 | N.D. | N.D. | 58·0 | 14·1 | 25·2 | 3·34 | 3·84 | N.D. | 0·17 | 2·84 | 72·3 | 6·38 | | | 134 | 0·5 | Low readily soluble $P_2O_5$. |
| 168. | | | | | | | | TARVES ASSOCIATION; Pitmedden Series. Cairnbrogie, 25522–25525 | | | | | | | | | | | |
| S | 0-4 | 9·32 | N.D. | N.D. | 48·3 | 21·4 | 25·8 | 5·88 | 0·80 | N.D. | 0·30 | 7·56 | 48·0 | 5·37 | 3·01 | 0·270 | 209 | 5·8 | High exchangeable Ca and |
| $A_2g$ | 8-12 | 3·07 | N.D. | N.D. | 60·8 | 19·2 | 18·0 | 7·92 | 1·11 | N.D. | 0·08 | 2·43 | 78·9 | 6·70 | 0·27 | 0·050 | 40 | 2·1 | Mg in Bg. |
| Bg | 24-28 | 3·69 | N.D. | N.D. | 71·3 | 13·0 | 15·7 | 14·40 | 5·34 | N.D. | 0·13 | 1·89 | 91·3 | 7·11 | | | 60 | 9·1 | Low exchangeable K in |
| Cg | 44+ | 3·85 | N.D. | N.D. | 66·0 | 8·9 | 21·7 | 6·90 | 4·12 | N.D. | 0·20 | 1·08 | 91·2 | 6·68 | | | 80 | 7·6 | $A_2g$. |
| | | | | | | | | | | | | | | | | | | | Low total $P_2O_5$ except in S. |
| | | | | | | | | | | | | | | | | | | | Low readily soluble $P_2O_5$ |
| | | | | | | | | | | | | | | | | | | | in $A_2g$. |
| 169. | | | | | | | | TARVES ASSOCIATION; Pitmedden Series. Craigies, 28120–28123 | | | | | | | | | | | |
| S | 0-6 | 7·48 | N.D. | N.D. | 56·6 | 18·3 | 21·4 | 9·29 | 1·42 | N.D. | 0·15 | 2·01 | 84·4 | 6·17 | 2·74 | 0·214 | 130 | N.D. | High exchangeable Ca in S, |
| $A_2g$ | 8-12 | 3·34 | N.D. | N.D. | 56·9 | 20·4 | 19·4 | 3·34 | 1·93 | N.D. | 0·16 | 0·80 | 87·2 | 5·46 | 0·21 | 0·031 | 40 | N.D. | low in Bg and Cg. |
| Bg | 20-24 | 3·85 | N.D. | N.D. | 63·1 | 8·9 | 24·1 | 2·40 | 2·72 | N.D. | 0·37 | 5·06 | 47·0 | 5·19 | | | 60 | N.D. | Low total $P_2O_5$ in $A_2g$ and |
| Cg | 34-38 | 3·66 | N.D. | N.D. | 54·4 | 15·1 | 27·1 | 1·39 | 1·95 | N.D. | 0·38 | 5·86 | 38·7 | 4·93 | | | 180 | N.D. | Bg. |

170. TARVES ASSOCIATION; Pitmedden Series. Allathan, 28024–28027

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-4 | 9·35 | N.D. | N.D. | 37·2 | 32·6 | 25·5 | 4·95 | 0·52 | N.D. | 0·04 | 13·62 | 28·6 | 5·40 | 4·35 | 0·269 | 180 | 5·0 | Low exchangeable Ca except in S. Low exchangeable K. Low total $P_2O_5$ in $A_2g$. |
| $A_2g$ | 8-12 | 3·37 | N.D. | N.D. | 62·7 | 11·7 | 22·2 | 2·82 | 0·93 | N.D. | 0·05 | 5·36 | 41·5 | 5·19 | 2·48 | 0·050 | 70 | 5·4 | |
| Bg | 20-24 | 3·06 | N.D. | N.D. | 67·6 | 8·7 | 20·6 | 2·85 | 2·19 | N.D. | 0·09 | 3·32 | 60·7 | 5·82 | | | 120 | 5·8 | |
| Cg | 40-44 | 3·05 | N.D. | N.D. | 60·9 | 6·6 | 29·4 | 2·66 | 1·70 | N.D. | 0·09 | 3·66 | 55·0 | 5·55 | | | 110 | 8·2 | |

171. TIPPERTY ASSOCIATION; Birness Series. Auchmacoy, 48098–48102

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-8 | 10·70 | N.D. | N.D. | 38·5 | 27·0 | 29·2 | 13·60 | 2·73 | N.D. | 0·18 | 6·71 | 71·2 | 6·15 | 4·93 | 0·264 | 180 | 6·0 | High clay content except in S. High exchangeable Ca in S. High exchangeable Mg in $B_2g$, $B_3g$ and Cg. Low total $P_2O_5$ in $A_2g$ and Bg. Low readily soluble $P_2O_5$ in $A_2g$ and $B_2g$, high in $B_3g$ and Cg. |
| $A_2g$ | 10-14 | 4·11 | N.D. | N.D. | 40·8 | 17·3 | 41·0 | 6·59 | 4·04 | N.D. | 0·23 | 5·33 | 67·1 | 5·57 | 0·49 | 0·050 | 70 | 0·2 | |
| $B_2g$ | 16-20 | 3·58 | N.D. | N.D. | 33·0 | 21·5 | 43·8 | 4·45 | 5·50 | N.D. | 0·24 | 5·92 | 63·3 | 5·37 | | | 80 | 0·3 | |
| $B_3g$ | 24-28 | 4·41 | N.D. | N.D. | 22·4 | 24·4 | 52·0 | 5·19 | 9·68 | N.D. | 0·34 | 3·29 | 82·3 | 5·78 | | | 130 | 13·0 | |
| Cg | 40-44 | 4·00 | N.D. | N.D. | 52·6 | 11·1 | 34·3 | 3·72 | 6·74 | N.D. | 0·33 | 2·63 | 80·4 | 5·80 | | | 120 | 13·8 | |

172. TIPPERTY ASSOCIATION; Birness Series. Toll of Birness, 109662–109666

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 10·50 | 26·3 | 37·7 | 41·0 | 23·0 | 30·8 | 3·59 | 2·17 | 0·31 | 0·52 | 10·90 | 37·7 | 5·28 | 6·12 | 0·313 | 134 | 1·0 | High clay content. High exchangeable Ca and Mg in $B_2g$, $B_3g$ and Cg. Low total $P_2O_5$ in $A_2g$ and $B_2g$. Low readily soluble $P_2O_5$ in S and $A_2g$, high in $B_3g$ and Cg. |
| $A_2g$ | 12-14 | 4·15 | 21·9 | 36·8 | 38·9 | 19·8 | 39·2 | 6·56 | 4·53 | 0·34 | 0·25 | 3·94 | 74·7 | 5·41 | 1·22 | 0·064 | 47 | 2·0 | |
| $B_2g$ | 18-24 | 4·25 | 16·4 | 40·9 | 30·4 | 26·9 | 40·6 | 9·90 | 6·14 | 0·43 | 0·35 | 1·67 | 91·0 | 5·92 | | | 75 | 6·2 | |
| $B_3g$ | 26·34 | 3·72 | 17·1 | 46·9 | 36·1 | 27·9 | 34·1 | 12·82 | 7·47 | 0·43 | 0·65 | 0·65 | 97·0 | 6·68 | | | 123 | 21·4 | |
| Cg | 40-46 | 4·85 | 3·6 | 39·5 | 11·1 | 32·0 | 54·5 | 10·43 | 6·32 | 0·39 | 0·43 | 1·10 | 94·2 | 6·86 | | | 129 | 36·1 | |

## TABLE 7. 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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **173.** | | | | | | | | FRASERBURGH ASSOCIATION; Whitelinks Series. Blackwater, 111411–111413 | | | | | | | | | | | |
| S | 2-8 | 7·42 | 90·8 | 3·9 | 93·6 | 1·1 | 1·6 | 21·60 | 0·63 | 0·14 | 0·15 | Nil | 100 | 7·42 | 4·28 | 0·173 | 100 | 3·9 | Very high sand content. |
| $B_2g$ | 12-16 | 3·39 | 94·3 | 1·1 | 94·6 | 0·8 | 1·2 | 20·80 | 0·32 | 0·18 | 0·10 | Nil | 100 | 8·52 | 0·21 | 0·011 | 45 | 4·6 | High exchangeable Ca, pH and % saturation. |
| Cg | 30-33 | 3·64 | 94·6 | 0·6 | 94·6 | 0·6 | 1·2 | 22·75 | 0·32 | 0·18 | 0·10 | Nil | 100 | 9·12 | | | 49 | 5·2 | Low total $P_2O_5$ except in S. |
| **174.** | | | | | | | | FRASERBURGH ASSOCIATION; Whitelinks Series. Pittenheath, 119415–119419 | | | | | | | | | | | |
| S | 2-6 | 6·52 | 83·3 | 8·3 | 88·0 | 3·7 | 5·1 | 12·31 | 1·40 | 0·27 | 0·22 | 3·51 | 80·3 | 6·66 | 3·32 | 0·244 | 74 | 4·9 | High clay content in $B_3g$ and Cg. |
| $B_2g$ | 12-16 | 1·89 | 79·6 | 8·6 | 83·0 | 5·2 | 9·9 | 9·53 | 0·83 | 0·23 | 0·09 | Nil | 100 | 7·46 | 0·57 | 0·061 | 61 | 4·7 | High exchangeable Ca and % saturation. |
| $B_3g$ | 20-24 | 4·96 | 34·5 | 32·8 | 51·0 | 16·3 | 30·2 | 20·00 | 1·07 | 0·43 | 0·17 | Nil | 100 | 8·00 | | | 119 | 2·5 | Low total $P_2O_5$ except in upper part of $B_3g$. |
| $B_3g$ | 28-32 | 4·31 | 22·9 | 36·0 | 39·2 | 19·7 | 38·9 | 20·53 | 2·16 | 0·60 | 0·33 | Nil | 100 | 7·91 | | | 97 | 10·2 | High readily soluble $P_2O_5$ in lower layers. |
| Cg | 38-42 | 4·54 | 20·2 | 34·0 | 30·0 | 24·2 | 43·5 | 18·97 | 2·88 | 0·60 | 0·37 | Nil | 100 | 7·81 | | | 76 | 20·7 | |

## TABLE 8. 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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 175. | | | | | | | | BOYNDIE ASSOCIATION; Ballindarg Series. Pictillum, 112428–112432 | | | | | | | | | | | |
| S | 2-6 | 63·40 | N.D. | N.D. | N.D. | N.D. | N.D. | 21·86 | 6·48 | 0·74 | 0·48 | 72·70 | 24·9 | 5·01 | 39·10 | 1·110 | 159 | 1·8 | Low clay content.<br>High exchangable Ca and Mg in S.<br>Low exchangeable Ca in lower layers.<br>Low exchangeable K except in S.<br>Low total $P_2O_5$ in $A_2g$ and Cg.<br>Low readily soluble $P_2O_5$ in S. |
| $A_2g$ | 9-13 | 1·99 | 88·3 | 6·7 | 91·4 | 3·6 | 3·0 | 2·12 | 0·34 | 0·12 | 0·05 | 0·34 | 88·5 | 5·40 | 0·54 | 0·021 | 85 | 5·2 | |
| Bg | 16-20 | 5·32 | 68·9 | 16·2 | 79·4 | 5·7 | 12·2 | 3·82 | 1·98 | 0·20 | 0·05 | 5·94 | 50·4 | 5·44 | | | 186 | 6·4 | |
| Bg | 28-32 | 2·92 | 83·1 | 9·3 | 87·4 | 5·0 | 4·7 | 2·43 | 0·84 | 0·12 | 0·07 | 5·23 | 39·8 | 5·05 | | | 157 | 7·5 | |
| Cg | 33-37 | 2·88 | 83·3 | 7·9 | 87·2 | 4·0 | 5·9 | 2·13 | 0·76 | 0·17 | 0·05 | 1·36 | 69·7 | 4·70 | | | 95 | 5·3 | |
| 176. | | | | | | | | CORBY ASSOCIATION; Mundurno Series. Fiddie Mains, 48436–48439 | | | | | | | | | | | |
| S | 0-10 | 15·13 | N.D. | N.D. | 86·2 | 10·7 | 3·1 | 6·70 | 0·64 | N.D. | 0·18 | 16·65 | 31·1 | 5·25 | 1·89 | 0·398 | 170 | 1·7 | Low clay content.<br>Low exchangeable Ca, Mg and K except in S.<br>Low readily soluble $P_2O_5$ in S and $A_2g$, high in Bg and Cg. |
| $A_2g$ | 11-16 | 2·60 | N.D. | N.D. | 89·8 | 5·0 | 5·2 | 1·44 | 0·09 | N.D. | 0·07 | 3·54 | 31·1 | 5·37 | 1·11 | 0·086 | 120 | 2·8 | |
| Bg | 18-24 | 2·36 | N.D. | N.D. | 80·8 | 12·5 | 6·7 | 0·75 | 0·08 | N.D. | 0·08 | 2·27 | 28·6 | 5·36 | | | 160 | 10·0 | |
| Cg | 34-38 | 1·24 | N.D. | N.D. | 85·7 | 8·0 | 6·3 | 0·50 | 0·15 | N.D. | 0·08 | 1·52 | 29·3 | 5·26 | | | 190 | 36·0 | |

TABLE 8—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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **177.** | | | | | CORBY ASSOCIATION; Mundurno Series. Mundurno, 41122–41125 | | | | | | | | | | | | | | |
| S | 0-6 | 14·20 | N.D. | N.D. | 73·4 | 16·2 | 9·4 | 4·47 | 0·26 | N.D. | 0·09 | 19·20 | 20·2 | 5·02 | 6·54 | 0·386 | 320 | 9·5 | Low exchangeable Ca except in S.<br>Low exchangeable Mg except in $A_2g$.<br>Low exchangeable K in S and $A_2g$.<br>Low total $P_2O_5$ in $A_2g$ and Cg.<br>High readily soluble $P_2O_5$ in Bg. |
| $A_2g$ | 8-12 | 4·58 | N.D. | N.D. | 86·4 | 8·3 | 5·3 | 2·55 | 0·37 | N.D. | 0·08 | 10·20 | 22·7 | 5·19 | 2·69 | 0·105 | 50 | 3·2 | |
| Bg | 16-20 | 8·30 | N.D. | N.D. | 81·7 | 9·8 | 8·5 | 1·94 | 0·15 | N.D. | 0·12 | 16·10 | 12·2 | 5·20 | | | 269 | 16·0 | |
| Cg | 32-36 | 2·74 | N.D. | N.D. | 66·1 | 16·2 | 15·0 | 0·89 | 0·19 | N.D. | 0·11 | 5·60 | 17·5 | 5·15 | | | 90 | 7·7 | |
| **178.** | | | | | COUNTESSWELLS ASSOCIATION; Drumlasie Series. New Pitsligo, 35020–35023 | | | | | | | | | | | | | | |
| S | 0-8 | 27·90 | N.D. | N.D. | 45·6 | 12·2 | 14·3 | 10·19 | 0·92 | N.D. | 0·07 | 25·90 | 30·4 | 5·28 | 17·40 | 0·360 | 230 | N.D. | High exchangeable Ca in S, low in $A_2g$ and Cg.<br>Low exchangeable Mg in $A_2g$.<br>Low exchangeable K.<br>Low total $P_2O_5$ except in S. |
| $A_2g$ | 12-14 | 6·80 | N.D. | N.D. | 54·4 | 12·9 | 29·3 | 2·38 | 0·10 | N.D. | Nil | 8·80 | 22·9 | 5·34 | 1·70 | 0·103 | 90 | N.D. | |
| $B_3g$ | 20-30 | 3·91 | N.D. | N.D. | 66·2 | 13·9 | 16·0 | 3·25 | 0·48 | N.D. | 0·02 | 4·52 | 45·3 | 5·35 | | | 30 | N.D. | |
| Cg | 36-42 | 3·50 | N.D. | N.D. | 60·6 | 13·3 | 22·6 | 2·57 | 1·22 | N.D. | 0·09 | 2·84 | 57·8 | 5·38 | | | 40 | N.D. | |

179. COUNTESSWELLS ASSOCIATION; Drumlasie Series. Cairntradlin, 47418–47422

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-4 | 21·20 | N.D. | N.D. | 48·2 | 29·5 | 6·9 | 4·27 | 0·88 | N.D. | 0·25 | 51·00 | 9·2 | 4·25 | 22·60 | 0·965 | 240 | 2·5 | Low exchangeable Ca in $A_2g$ and lower part of S. Low exchangeable Mg in lower part of S. Low exchangeable K except in S. Low total $P_2O_5$ in $A_2g$. Low readily soluble $P_2O_5$ in $A_2g$ and Bg, high in Cg. |
| S | 4-10 | 6·35 | N.D. | N.D. | 63·0 | 19·3 | 13·9 | 1·71 | 0·26 | N.D. | 0·06 | 10·53 | 16·2 | 5·09 | 1·96 | 0·102 | 190 | 3·1 | |
| $A_2g$ | 12-16 | 3·25 | N.D. | N.D. | 60·4 | 10·9 | 25·5 | 1·61 | 1·12 | N.D. | 0·09 | 3·04 | 48·5 | 5·54 | | | 90 | 0·4 | |
| Bg | 18-22 | 3·29 | N.D. | N.D. | 60·4 | 10·3 | 26·1 | 4·86 | 3·06 | N.D. | 0·08 | 1·97 | 80·3 | 5·95 | | | 140 | 0·4 | |
| Cg | 40-44 | 2·64 | N.D. | N.D. | 60·7 | 10·9 | 25·8 | 6·11 | 2·65 | N.D. | 0·09 | 1·31 | 87·1 | 6·77 | | | 170 | 31·0 | |

180. COUNTESSWELLS ASSOCIATION; Drumlasie Series. Roquharold, 3381–3385

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | 4-0 | 90·00 | N.D. | N.D. | N.D. | N.D. | N.D. | 8·85 | 8·19 | N.D. | 1·59 | 84·00 | 18·1 | 3·91 | N.D. | N.D. | N.D. | N.D. | High exchangeable Ca and K in H, otherwise low. High exchangeable Mg in H, low in $A_2g$ and Bg. Low % saturation in $A_2g$ and Bg. |
| $A_2g$ | 0-4 | 3·09 | N.D. | N.D. | 80·2 | 11·3 | 8·2 | 0·25 | 0·12 | N.D. | 0·05 | 8·25 | 4·8 | 4·54 | N.D. | N.D. | N.D. | N.D. | |
| Bg | 8-12 | 10·30 | N.D. | N.D. | 66·1 | 12·6 | 17·8 | 0·15 | 0·06 | N.D. | 0·07 | 24·90 | 1·1 | 4·95 | | | N.D. | N.D. | |
| Bg | 12-16 | 3·55 | N.D. | N.D. | 69·8 | 12·3 | 17·5 | 0·34 | 0·13 | N.D. | 0·08 | 9·24 | 5·6 | 5·25 | | | N.D. | N.D. | |
| Cg | 60-68 | 2·09 | N.D. | N.D. | 67·0 | 14·1 | 16·6 | 2·56 | 2·04 | N.D. | 0·07 | 3·06 | 60·5 | 6·10 | | | N.D. | N.D. | |

181. COUNTESSWELLS ASSOCIATION; Drumlasie Series. Parkhead, 128784–128787A

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3-7 | 12·10 | 58·9 | 20·5 | 67·4 | 12·0 | 14·5 | 8·23 | 1·64 | 0·18 | 0·39 | 8·87 | 54·1 | 5·61 | 6·75 | 0·343 | 251 | 2·3 | High exchangeable Ca in S and A. High exchangeable Mg in A. Very high total $P_2O_5$ in A. Low readily soluble $P_2O_5$. |
| $A_2g$ | 10-12 | 11·09 | 59·4 | 22·3 | 68·3 | 13·4 | 12·8 | 6·30 | 1·03 | 0·21 | 0·22 | 9·02 | 45·6 | 5·61 | 6·32 | 0·280 | 283 | 2·3 | |
| A | 14-17 | 73·60 | N.D. | N.D. | N.D. | N.D. | N.D. | 28·60 | 5·53 | 0·56 | 0·12 | 74·88 | 31·7 | 4·10 | 39·70 | 1·785 | 999 | 3·1 | |
| A | 21-24 | 64·90 | N.D. | N.D. | N.D. | N.D. | N.D. | 35·60 | 10·78 | 0·76 | 0·16 | 79·79 | 37·2 | 4·03 | 42·80 | 1·983 | 415 | 1·2 | |
| Cg | 27-31 | 4·90 | 73·3 | 14·2 | 79·8 | 7·7 | 10·0 | 3·96 | 0·82 | 0·12 | 0·10 | 6·52 | 43·4 | 4·49 | | | 151 | 2·2 | |

TABLE 8—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **182.** | | | | | COUNTESSWELLS ASSOCIATION; Drumlasie Series. Tulloch, 128798–128801 | | | | | | | | | | | | | | |
| S | 3-7 | 41·00 | N.D. | N.D. | N.D. | N.D. | N.D. | 31·95 | 2·35 | 0·21 | 0·38 | 29·40 | 54·3 | 6·06 | 26·46 | 1·210 | 376 | 12·0 | High clay content in Cg. Very high exchangeable Ca in S and A. High exchangeable Mg except in S. High total $P_2O_5$ in surface layers. High readily soluble $P_2O_5$ in S. |
| A | 12-16 | 74·10 | N.D. | N.D. | N.D. | N.D. | N.D. | 31·44 | 5·61 | 0·52 | 0·31 | 82·68 | 31·4 | 5·20 | 52·79 | 1·810 | 380 | 1·7 | |
| A | 21-25 | 71·60 | N.D. | N.D. | N.D. | N.D. | N.D. | 19·39 | 5·02 | 0·73 | 0·32 | 91·16 | 21·8 | 5·20 | | | 115 | 4·4 | |
| Cg | 35-39 | 11·70 | 27·7 | 31·0 | 42·9 | 15·8 | 35·4 | 7·24 | 6·66 | 0·40 | 0·49 | 8·20 | 64·4 | 5·51 | | | 136 | 4·2 | |
| **183.** | | | | | COUNTESSWELLS ASSOCIATION; Drumlasie Series. Drumlasie, 117164–117169 | | | | | | | | | | | | | | |
| A | 0-2 | 44·20 | N.D. | N.D. | N.D. | N.D. | N.D. | 14·88 | 6·26 | 0·62 | 0·79 | 30·20 | 42·8 | 5·20 | 29·22 | 1·228 | 276 | 4·4 | High exchangeable Ca in A, otherwise low. High exchangeable Mg in A. Low exchangeable K except in S. Low total $P_2O_5$ in $A_2g$. Low readily soluble $P_2O_5$ in lower part of A, high in $A_2g$, very high in Bg and Cg. |
| A | 4-8 | 44·90 | N.D. | N.D. | N.D. | N.D. | N.D. | 16·16 | 4·72 | 0·53 | 0·22 | 37·15 | 23·9 | 5·42 | 24·75 | 0·705 | 185 | 1·3 | |
| $A_2g$ | 11-16 | 1·24 | 82·9 | 12·3 | 89·6 | 5·6 | 3·6 | 1·36 | 0·66 | 0·08 | 0·03 | Nil | 100 | 5·29 | 0·25 | 0·017 | 78 | 19·7 | |
| Bg | 20-24 | 1·25 | 74·8 | 18·5 | 81·8 | 11·5 | 5·4 | 1·81 | 0·95 | 0·10 | 0·05 | Nil | 100 | 6·17 | | | 131 | 43·5 | |
| Bg | 28-34 | 1·45 | 67·6 | 21·6 | 77·9 | 11·3 | 9·3 | 2·41 | 1·11 | 0·10 | 0·07 | Nil | 100 | 6·50 | | | 162 | 57·5 | |
| Cg | 38-44 | 1·22 | 78·1 | 13·9 | 86·3 | 5·7 | 6·8 | 1·81 | 0·86 | 0·08 | 0·07 | Nil | 100 | 6·43 | | | 171 | 49·7 | |

184. NORTH MORMOND ASSOCIATION; Blairmormond Series. Blairmormond, 119069–119072

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 3-7 | 11·10 | 37·1 | 33·4 | 51·2 | 19·3 | 23·9 | 11·70 | 1·58 | 0·19 | 0·52 | 7·10 | 66·4 | 6·00 | 5·44 | 0·296 | 201 | 8·3 | High clay content in Cg. High exchangeable Ca in S and $B_2g$. Low total $P_2O_5$ except in S. High readily soluble $P_2O_5$ in $A_2g$. |
| $A_2g$ | 11-15 | 2·97 | 44·7 | 28·6 | 57·6 | 15·7 | 23·7 | 7·22 | 1·37 | 0·18 | 0·12 | 1·33 | 86·8 | 6·32 | 0·50 | 0·038 | 60 | 11·5 | |
| $B_2g$ | 22-26 | 3·91 | 37·8 | 30·8 | 50·8 | 17·8 | 27·5 | 8·18 | 2·22 | 0·25 | 0·22 | 1·63 | 86·8 | 6·19 | | | 55 | 6·9 | |
| Cg | 33-37 | 3·72 | 33·0 | 29·4 | 44·7 | 17·7 | 33·9 | 7·88 | 2·59 | 0·21 | 0·25 | 1·85 | 85·8 | 5·82 | | | 51 | 4·2 | |

185. STRICHEN ASSOCIATION; Hythie Series. Touxhill, 110645–110650

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 17·10 | 41·9 | 27·6 | 53·3 | 16·2 | 17·7 | 8·13 | 0·85 | 0·25 | 0·25 | 10·70 | 46·6 | 5·65 | 8·54 | 0·407 | 228 | 1·5 | High exchangeable Ca in S, otherwise low. Low total $P_2O_5$ in $A_2g$. Low readily soluble $P_2O_5$. |
| $A_2g$ | 11-15 | 3·84 | 60·5 | 23·6 | 72·4 | 11·7 | 12·1 | 0·91 | 0·38 | 0·05 | 0·13 | 1·36 | 52·0 | 5·25 | 0·19 | 0·032 | 73 | 1·0 | |
| $B_2g$ | 20-24 | 5·17 | 51·3 | 25·7 | 64·4 | 12·6 | 20·4 | 1·06 | 0·52 | 0·12 | 0·22 | 1·48 | 56·5 | 5·12 | 0·19 | 0·027 | 144 | 0·7 | |
| $B_3g$ | 30-36 | 5·55 | 50·0 | 24·4 | 60·4 | 14·0 | 22·8 | 1·06 | 0·51 | 0·19 | 0·23 | 1·71 | 53·9 | 5·05 | | | 169 | 0·7 | |
| Cg | 40-46 (1) | 5·42 | 51·1 | 27·2 | 64·9 | 13·4 | 19·0 | 1·53 | 1·24 | 0·12 | 0·21 | 2·18 | 58·7 | 5·52 | | | 147 | 0·6 | |
| Cg | 40-46 (2) | 5·18 | 54·8 | 24·7 | 65·7 | 13·8 | 17·9 | 1·37 | 0·69 | 0·12 | 0·19 | 2·18 | 52·2 | 5·12 | | | 133 | 1·0 | |

186. STRICHEN ASSOCIATION; Hythie Series. Skillymarno, 118167–118171

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 2-6 | 10·90 | 44·9 | 17·3 | 57·8 | 14·4 | 22·3 | 8·98 | 1·20 | 0·27 | 0·19 | 6·49 | 62·1 | 6·41 | 4·72 | 0·340 | 255 | 4·5 | High exchangeable Ca in S. Low total $P_2O_5$ in upper part of Bg. High readily soluble $P_2O_5$ in $A_2g$ and Cg. |
| $A_2g$ | 9-13 | 3·47 | 70·3 | 16·6 | 77·2 | 9·7 | 9·6 | 3·66 | 1·25 | 0·20 | 0·14 | 1·15 | 82·0 | 6·30 | 0·23 | 0·021 | 121 | 17·1 | |
| Bg | 17-21 | 4·07 | 53·3 | 25·7 | 65·7 | 13·3 | 19·0 | 5·20 | 2·44 | 0·29 | 0·21 | 0·70 | 92·0 | 6·59 | | | 72 | 3·6 | |
| Bg | 28-32 | 4·17 | 55·1 | 23·3 | 66·1 | 12·3 | 19·5 | 5·85 | 2·71 | 0·34 | 0·28 | 1·63 | 84·6 | 6·34 | | | 107 | 4·5 | |
| Cg | 40-44 | 4·58 | 59·1 | 18·4 | 66·1 | 11·4 | 20·2 | 6·33 | 3·06 | 0·38 | 0·30 | 1·05 | 90·5 | 6·63 | | | 155 | 10·3 | |

187. TARVES ASSOCIATION; Pettymuck Series. Upper Crichie, 119055–119059

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 1-5 | 41·30 | N.D. | N.D. | N.D. | N.D. | N.D. | 10·08 | 1·86 | 0·41 | 0·40 | 53·80 | 19·2 | 4·89 | 24·38 | 1·218 | 406 | 1·5 | High exchangeable Ca in S, low in $A_2g$ and $B_2g$. High total $P_2O_5$ in S. Low readily soluble $P_2O_5$ in S and $A_2g$, high in $B_2g$ and $B_3g$. |
| S | 6-10 | 51·10 | N.D. | N.D. | N.D. | N.D. | N.D. | 12·05 | 2·87 | 0·60 | 0·47 | 62·50 | 21·3 | 4·76 | 33·75 | 1·703 | 350 | 1·3 | |
| $A_2g$ | 10-14 | 3·96 | 72·5 | 15·2 | 80·0 | 7·7 | 8·3 | 2·18 | 0·61 | 0·14 | 0·18 | 4·53 | 40·7 | 4·86 | | | 100 | 1·1 | |
| $B_2g$ | 16-20 | 2·99 | 66·5 | 22·4 | 77·2 | 11·7 | 8·1 | 2·88 | 1·24 | 0·16 | 0·18 | 2·18 | 67·3 | 4·80 | | | 112 | 11·0 | |
| $B_3g$ | 24-28 | 1·98 | 70·4 | 19·3 | 78·7 | 11·0 | 8·3 | 3·04 | 1·54 | 0·16 | 0·19 | 1·02 | 83·0 | 5·28 | | | 110 | 16·9 | |

TABLE 8—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **188.** | | | | | | | | | | | | | | | | | | | **TARVES ASSOCIATION; Pettymuck Series. Balquhain, 47350–47354** |
| S | 0-6 | 15·50 | N.D. | N.D. | 50·1 | 24·5 | 19·7 | 8·50 | 0·87 | N.D. | 0·18 | 20·28 | 32·0 | 5·12 | 6·80 | 0·460 | 320 | 1·5 | High exchangeable Ca in S and lower part of Bg. High exchangeable Mg in lower part of Bg. High total $P_2O_5$ in S. Low readily soluble $P_2O_5$ in S, high to very high in Bg and Cg. |
| $A_2g$ | 7-11 | 2·97 | N.D. | N.D. | 63·6 | 16·7 | 16·7 | 3·20 | 0·97 | N.D. | 0·13 | 8·52 | 33·7 | 4·73 | 0·66 | 0·057 | 240 | 6·5 | |
| Bg | 16-20 | 2·81 | N.D. | N.D. | 53·1 | 15·6 | 28·7 | 5·32 | 2·04 | N.D. | 0·16 | 5·90 | 56·1 | 4·99 | | | 250 | 17·0 | |
| Bg | 30-34 | 3·20 | N.D. | N.D. | 50·9 | 15·3 | 30·6 | 8·34 | 5·09 | N.D. | 0·26 | 2·12 | 86·6 | 5·67 | | | 280 | 75·0 | |
| Cg | 40-44 | 2·23 | N.D. | N.D. | 69·2 | 12·5 | 16·1 | 7·54 | 2·03 | N.D. | 0·14 | 1·70 | 85·0 | 5·97 | | | 280 | 69·0 | |
| **189.** | | | | | | | | | | | | | | | | | | | **TARVES ASSOCIATION; Pettymuck Series. Millhill, 110424–110429** |
| S | 0-6 | 42·10 | N.D. | N.D. | N.D. | N.D. | N.D. | 23·35 | 1·70 | 0·50 | 0·32 | 52·80 | 32·9 | 5·44 | 26·75 | 1·112 | 355 | 2·1 | High exchangeable Ca in S and A, low in $A_2g$. High exchangeable Mg in A. High total $P_2O_5$ in S, low in $A_2g$ and Bg. Low readily soluble $P_2O_5$ in S, A and Bg. |
| A | 9-14 | 73·70 | N.D. | N.D. | N.D. | N.D. | N.D. | 13·29 | 5·10 | 1·06 | 0·26 | 26·90 | 42·3 | 4·51 | 47·20 | 1·881 | 214 | 0·7 | |
| $A_2g$ | 16-20 | 3·33 | 55·0 | 25·2 | 65·7 | 14·5 | 16·5 | 2·90 | 1·81 | 0·17 | 0·14 | 5·47 | 47·8 | 4·92 | | | 75 | 3·3 | |
| Bg | 25-30 | 3·31 | 55·9 | 22·4 | 65·4 | 12·9 | 18·4 | 4·15 | 3·52 | 0·25 | 0·19 | 5·15 | 61·6 | 4·93 | | | 59 | 1·7 | |
| Cg | 34-40 | 4·50 | 34·6 | 36·1 | 47·8 | 22·9 | 27·1 | 4·49 | 2·38 | 0·28 | 0·31 | 6·13 | 54·9 | 5·32 | | | 123 | 5·1 | |

190. TARVES ASSOCIATION; Pettymuck Series. Mains of Cairnbrogie, 25526–25530

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-4 | 27·70 | N.D. | N.D. | 32·0 | 20·9 | 22·8 | 8·75 | 1·60 | N.D. | 0·38 | 24·03 | 31·9 | 5·27 | 10·93 | 0·770 | 360 | 3·5 | High exchangeable Ca in S. |
| S | 10-12 | 29·40 | N.D. | N.D. | 36·9 | 15·3 | 25·8 | 10·30 | 2·53 | N.D. | 0·20 | 25·38 | 34·0 | 5·31 | 13·32 | 0·802 | 388 | 6·6 | High total $P_2O_5$ in S. |
| $A_2g$ | 12-16 | 3·14 | N.D. | N.D. | 63·8 | 14·6 | 18·5 | 3·90 | 1·98 | N.D. | 0·11 | 1·35 | 81·8 | 5·95 | | | 125 | 16·6 | High readily soluble $P_2O_5$ |
| Bg | 24-28 | 3·19 | N.D. | N.D. | 72·0 | 11·7 | 13·1 | 5·12 | 2·12 | N.D. | 0·17 | 1·08 | 87·3 | N.D. | | | 136 | 12·2 | except in S. |
| Cg | 44+ | 4·64 | N.D. | N.D. | N.D. | N.D. | N.D. | 6·40 | 3·56 | N.D. | 0·29 | 2·70 | 79·2 | N.D. | | | 168 | 10·9 | |

191. TARVES ASSOCIATION; Pettymuck Series. Woodlands, 28084–28087

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | 0-6 | 57·80 | N.D. | N.D. | N.D. | N.D. | N.D. | 17·90 | 1·46 | N.D. | 0·18 | 61·15 | 24·2 | 5·23 | N.D. | N.D. | 580 | N.D. | High exchangeable Ca in S. |
| $A_2g$ | 10-14 | 3·61 | N.D. | N.D. | 84·1 | 6·7 | 9·2 | 4·58 | 0·48 | N.D. | Nil | 3·92 | 56·4 | 5·89 | N.D. | N.D. | 150 | N.D. | Low exchangeable K |
| Bg | 18-22 | 3·19 | N.D. | N.D. | 66·3 | 17·2 | 13·3 | 7·48 | 2·72 | N.D. | 0·08 | 2·03 | 83·1 | 6·08 | | | 170 | N.D. | except in S. |
| Cg | 34-42 | 2·51 | N.D. | N.D. | 74·3 | 9·5 | 16·2 | 5·10 | 2·67 | N.D. | 0·09 | Nil | 100 | 5·73 | | | 140 | N.D. | High total $P_2O_5$ in S. |

# TABLE 9, MISCELLANEOUS SOILS

| 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./100 g. Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **192.** | | | | | | | | BLACKWATER COMPLEX ASSOCIATION; Pittenheath, 119409–119414 | | | | | | | | | | | |
| S | 2-6 | 7·60 | 91·1 | 4·3 | 92·5 | 2·9 | 0·8 | 25·20 | 0·59 | 0·20 | 0·14 | Nil | 100 | 7·50 | 4·15 | 0·257 | 98 | 10·0 | Low clay content in S and $B_2g$, very high in D. |
| S | 9-12 | 19·40 | 75·3 | 8·0 | 78·2 | 5·1 | 2·1 | 43·75 | 1·57 | 0·36 | 0·19 | Nil | 100 | 7·16 | 11·69 | 0·694 | 99 | 3·5 | High exchangeable Ca in S, $A_2g$ and D. |
| $A_2g$ | 13-15 | 4·53 | 54·6 | 22·4 | 65·2 | 11·8 | 20·7 | 12·98 | 0·90 | 0·17 | 0·18 | Nil | 100 | 7·45 | 1·75 | 0·079 | 68 | 2·5 | Low exchangeable Mg and K in $B_2g$. |
| $B_2g$ | 16-18 | 0·93 | 83·2 | 12·5 | 91·4 | 4·2 | 3·4 | 3·62 | 0·22 | 0·07 | 0·06 | Nil | 100 | 7·31 | | | 67 | 13·7 | Low total $P_2O_5$. |
| C | 19-21 | 1·47 | 76·7 | 9·9 | 81·5 | 5·1 | 11·9 | 6·05 | 0·56 | 0·10 | 0·14 | Nil | 100 | 7·45 | | | 62 | 12·3 | Low readily soluble $P_2O_5$ in $A_2g$, high in $B_2g$, C and D. |
| D | 31-35 | 6·19 | 3·6 | 28·2 | 10·3 | 21·5 | 65·1 | 24·60 | 3·99 | 0·44 | 0·71 | Nil | 100 | 7·58 | | | 85 | 15·0 | |
| **193.** | | | | | | | | BLACKWATER COMPLEX ASSOCIATION; Blackwater, 111414–111418 | | | | | | | | | | | |
| S | 2-6 | 7·09 | 47·8 | 22·3 | 57·8 | 12·3 | 26·4 | 11·12 | 1·56 | 0·28 | 0·50 | 4·50 | 75·0 | 6·00 | 3·00 | 0·224 | 160 | 6·0 | Very high clay content in D. |
| S | 7-11 | 5·55 | 54·7 | 17·9 | 62·6 | 10·0 | 24·6 | 10·40 | 1·64 | 0·29 | 0·40 | 0·57 | 95·8 | 6·08 | 2·02 | 0·122 | 105 | 5·8 | High exchangeable Ca. |
| Dg | 15-20 | 7·96 | Nil | 36·7 | 6·0 | 28·2 | 61·8 | 18·50 | 6·60 | 0·77 | 0·77 | 0·47 | 98·4 | 6·71 | | | 106 | 34·1 | High exchangeable Mg in D. |
| Dg | 28-32 | 8·84 | Nil | 33·3 | 3·6 | 27·8 | 64·2 | 18·25 | 7·19 | 0·60 | 0·84 | Nil | 100 | 6·65 | | | 145 | 33·8 | High readily soluble $P_2O_5$ in D. |
| Dg | 36-39 | 8·74 | Nil | 42·3 | 9·1 | 30·1 | 56·4 | 16·43 | 5·85 | 0·55 | 0·84 | Nil | 100 | 6·75 | | | 160 | 14·2 | |

194. LINKS (ACID) ASSOCIATION; Newburgh, 150557–150560

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2-4 | 2·73 | 97·2 | 2·2 | 98·2 | 1·2 | 0·6 | 0·45 | 0·40 | 0·15 | 0·07 | 3·75 | 22·2 | 5·30 | 1·54 | 0·084 | 50 | 1·2 | Very high sand content. Low exchangeable Ca, Mg and K. Low total and readily soluble $P_2O_5$. |
| 7-12 | 0·62 | 98·4 | 1·6 | 98·6 | 1·4 | Nil | Nil | 0·05 | 0·07 | 0·02 | 0·42 | 25·0 | 5·61 | 0·23 | 0·020 | 64 | 1·3 | |
| 21-27 | 0·47 | 99·2 | 0·8 | 99·6 | 0·4 | Nil | Nil | 0·05 | 0·07 | 0·02 | Nil | 100 | 5·75 | | | 61 | 1·8 | |

195. LINKS (ACID) ASSOCIATION; Newburgh, 150565–150571

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-1½ | 3·90 | 97·2 | 2·6 | 97·4 | 2·4 | 0·2 | 0·45 | 0·27 | 0·15 | 0·14 | 5·74 | 15·0 | 3·93 | 2·53 | 0·104 | 34 | 1·6 | Very high sand content. Low exchangeable Ca, Mg and K except in lower layers. Low total and readily soluble $P_2O_5$. |
| 2-5 | 1·27 | 98·0 | 2·0 | 98·4 | 1·6 | Nil | Nil | 0·09 | 0·07 | 0·02 | 1·09 | 14·1 | 4·73 | 0·59 | 0·032 | 46 | 1·9 | |
| 9-14 | 0·49 | 98·4 | 1·6 | 98·6 | 1·4 | Nil | Nil | 0·02 | 0·07 | Nil | Nil | 100 | 5·09 | 0·19 | 0·012 | 28 | 2·4 | |
| 22-28 | 0·37 | 98·4 | 1·6 | 98·6 | 1·4 | Nil | Nil | 0·03 | 0·05 | Nil | 0·90 | 8·2 | 5·49 | | | 36 | 2·0 | |
| 32-35 | 7·60 | 63·6 | 20·9 | 70·6 | 13·9 | 11·7 | 6·30 | 2·66 | 0·40 | 0·17 | 8·98 | 51·5 | 6·51 | | | 68 | 0·7 | |
| 41-45 | 3·73 | 68·0 | 18·6 | 77·4 | 9·2 | 13·4 | 5·35 | 1·34 | 0·24 | 0·17 | 3·33 | 60·5 | 6·41 | | | 71 | 1·2 | |

196. LINKS (CALCAREOUS) ASSOCIATION; Rattray Head, 118375–118377

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-7 | 4·72 | 95·8 | 0·8 | 96·2 | 0·4 | 1·0 | 17·89 | 0·50 | 0·23 | 0·10 | Nil | 100 | 7·79 | 2·24 | 0·157 | 54 | 3·3 | Very high sand content. High exchangeable Ca. Low exchangeable K. Low total $P_2O_5$. |
| 8-11 | 3·51 | 96·5 | Nil | 96·5 | Nil | Nil | 16·10 | 0·48 | 0·19 | 0·07 | Nil | 100 | 8·02 | 0·37 | 0·025 | 42 | 3·6 | |
| 16-20 | 3·67 | 96·3 | Nil | 96·3 | Nil | Nil | 16·85 | 0·63 | 0·21 | 0·07 | Nil | 100 | 8·65 | | | 40 | 4·2 | |

197. LINKS (CALCAREOUS) ASSOCIATION; Rattray Head, 118378–118384

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-5 | 10·68 | 85·7 | 7·0 | 90·2 | 2·5 | 2·0 | 7·38 | 1·41 | 0·24 | 0·25 | 3·48 | 73·5 | 5·88 | 6·59 | 0·374 | 74 | 6·2 | High sand content. High exchangeable Ca in middle layers. Low total $P_2O_5$. Low readily soluble $P_2O_5$ in middle layers. |
| 6-10 | 1·49 | 95·9 | 1·4 | 96·5 | 1·4 | 0·6 | 7·48 | 0·32 | 0·09 | 0·07 | Nil | 100 | 6·88 | 0·67 | 0·060 | 42 | 4·5 | |
| 14-18 | 1·84 | 96·4 | 1·2 | 96·4 | 1·2 | 0·6 | 12·17 | 0·23 | 0·13 | 0·09 | Nil | 100 | 7·41 | 0·33 | 0·035 | 40 | 2·8 | |
| 21-24 | 4·47 | 79·4 | 12·0 | 83·7 | 7·7 | 6·4 | 14·60 | 0·81 | 0·17 | 0·19 | Nil | 100 | 7·57 | | | 96 | 1·5 | |
| 26-30 | 3·12 | 85·7 | 5·9 | 86·9 | 4·7 | 5·3 | 11·18 | 0·67 | 0·13 | 0·13 | Nil | 100 | 7·52 | | | 63 | 1·2 | |
| 36-40 | 1·46 | 93·3 | 2·8 | 93·7 | 2·4 | 2·4 | 5·46 | 0·25 | 0·08 | 0·12 | Nil | 100 | 7·87 | | | 61 | 3·5 | |
| 50-54 | 1·58 | 72·9 | 15·0 | 80·1 | 7·8 | 10·5 | 5·93 | 0·32 | 0·13 | 0·18 | Nil | 100 | 7·90 | | | 60 | 4·9 | |



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TABLE 9—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./100 g.: Ca | Mg | Na | K | H | % Saturation | pH | % Carbon | % Nitrogen | mg./100 g. Total $P_2O_5$ | mg./100 g. Read. Sol. $P_2O_5$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 198. | LINKS (CALCAREOUS) ASSOCIATION; Rattray Head, 118385–118389 | | | | | | | | | | | | | | | | | | |
| | 2-6 | 2·98 | 88·3 | 5·1 | 89·1 | 4·3 | 3·6 | 7·90 | 0·24 | 0·08 | 0·22 | Nil | 100 | 7·21 | 1·50 | 0·137 | 101 | 26·4 | High sand content in surface layers. |
| | 10-14 | 1·71 | 93·1 | 4·6 | 95·1 | 2·6 | 0·6 | 11·52 | 0·21 | 0·11 | 0·09 | Nil | 100 | 8·18 | 0·37 | 0·037 | 53 | 6·1 | Fairly high exchangeable Ca. |
| | 20-24 | 2·22 | 70·2 | 18·5 | 79·7 | 9·0 | 9·1 | 7·53 | 0·32 | 0·11 | 0·12 | Nil | 100 | 7·74 | | | 57 | 1·3 | Low total $P_2O_5$ except in surface layer. |
| | 28-32 | 2·92 | 65·0 | 17·4 | 72·4 | 10·0 | 14·7 | 8·20 | 0·46 | 0·16 | 0·14 | Nil | 100 | 7·91 | | | 82 | 5·1 | High readily soluble $P_2O_5$ in surface layer, low in middle and bottom layers. |
| | 41-45 | 2·13 | 61·5 | 18·0 | 70·3 | 9·2 | 18·4 | 7·83 | 0·81 | 0·19 | 0·19 | Nil | 100 | 7·79 | | | 57 | 2·5 | |
| 199. | LINKS (CALCAREOUS) ASSOCIATION; St. Fergus Links, 118390–118394 | | | | | | | | | | | | | | | | | | |
| | 1-5 | 7·81 | 90·6 | 4·7 | 93·4 | 1·9 | 0·8 | 7·95 | 1·34 | 0·17 | 0·18 | 1·72 | 85·0 | 6·24 | 4·21 | 0·322 | 69 | 4·7 | High sand content. |
| | 8-12 | 1·11 | 97·1 | 1·8 | 97·1 | 1·8 | Nil | 17·30 | 0·14 | 0·03 | 0·09 | Nil | 100 | 6·66 | 0·48 | 0·052 | 42 | 4·3 | High exchangeable Ca. |
| | 14-18 | 2·37 | 95·6 | 2·0 | 96·2 | 1·4 | Nil | 10·97 | 0·12 | 0·11 | 0·09 | Nil | 100 | 8·32 | | | 68 | 4·0 | Low exchangeable Mg except in surface layer. |
| | 21-25 | 3·20 | 95·6 | 1·2 | 96·6 | 0·2 | Nil | 14·58 | 0·28 | 0·13 | 0·12 | Nil | 100 | 8·79 | | | 36 | 4·6 | Low total $P_2O_5$. |
| | 32-36 | 2·26 | 97·7 | Nil | 97·7 | Nil | Nil | 12·33 | 0·33 | 0·12 | 0·10 | Nil | 100 | 9·21 | | | 29 | 4·3 | |

# APPENDIX II

## Silica-sesquioxide Ratios of the Clay Fractions

TABLE 10. BROWN FOREST SOILS, FREELY DRAINED

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Insch | Insch Deep phase | 10 | S | 39·66 | 23·43 | 23·45 | 1·75 | 4·48 | 2·87 | 1·56 |
| | | | S | 37·55 | 24·36 | 27·63 | 1·47 | 4·08 | 2·30 | 1·77 |
| | | | S | 36·74 | 26·36 | 29·06 | 1·36 | 3·69 | 2·14 | 1·72 |
| | | | $B_2$ | 31·64 | 24·24 | 33·28 | 1·10 | 3·46 | 1·61 | 2·15 |
| | | | $B_3$ | 39·49 | 27·05 | 37·75 | 1·22 | 3·87 | 1·77 | 1·73 |
| | | | C | 38·79 | 20·27 | 28·78 | 1·57 | 5·07 | 2·28 | 2·22 |
| | | | C(g) | 40·79 | 22·49 | 25·68 | 1·73 | 4·81 | 2·69 | 1·78 |
| Insch | Insch Intermediate | 11 | S | 27·45 | 13·79 | 23·10 | 1·47 | 5·32 | 2·03 | 2·63 |
| | | | $B_2$ | 26·12 | 16·66 | 27·12 | 1·18 | 4·17 | 1·64 | 2·56 |
| | | | $B_3$ | 38·42 | 17·01 | 26·39 | 1·71 | 5·94 | 2·47 | 2·42 |
| | | | C | 32·66 | 10·72 | 22·44 | 1·81 | 8·13 | 2·47 | 3·28 |
| Insch | Insch Intermediate | 12 | S | 41·74 | 15·50 | 17·06 | 2·62 | 7·19 | 4·15 | 1·73 |
| | | | S | 41·90 | 16·00 | 33·72 | 1·66 | 7·00 | 2·18 | 3·51 |
| | | | $B_2$ | 36·10 | 14·20 | 31·78 | 1·50 | 6·78 | 1·98 | 3·50 |
| | | | $B_3$ | 42·10 | 13·50 | 35·69 | 1·61 | 8·30 | 2·00 | 4·16 |
| | | | C(g) | 50·40 | 14·10 | 26·92 | 2·38 | 9·45 | 3·17 | 2·98 |
| Insch | Insch | 14 | S | 41·67 | 18·30 | 28·36 | 1·77 | 6·05 | 2·50 | 2·42 |
| | | | $B_2$ | 38·30 | 19·54 | 31·41 | 1·48 | 5·18 | 2·06 | 2·51 |
| | | | $B_2$ | 38·26 | 15·10 | 41·34 | 1·27 | 6·72 | 1·57 | 4·27 |
| | | | $B_3$ | 50·67 | 13·62 | 33·83 | 2·02 | 9·93 | 2·54 | 3·90 |
| | | | C | 48·20 | 16·65 | 28·69 | 2·08 | 7·73 | 2·85 | 2·70 |
| Leslie | Leslie | | S | 35·30 | 27·30 | 18·94 | 1·65 | 3·44 | 3·16 | 1·09 |
| | | | $B_2$ | 34·20 | 19·70 | 21·88 | 1·67 | 4·49 | 2·65 | 1·69 |
| | | | C | 48,20 | 17·60 | 15·34 | 3·30 | 7·30 | 5·31 | 1·37 |

TABLE 10—Continued

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Tarves | Tarves | 26 | S | 39·60 | 13·10 | 16·93 | 2·64 | 8·00 | 3·94 | 2·02 |
| | | | S | 44·30 | 13·73 | 25·62 | 2·17 | 8·60 | 2·90 | 2·90 |
| | | | $B_2$ | 40·60 | 11·60 | 27·73 | 1·98 | 9·27 | 2·48 | 3·73 |
| | | | $B_3$ | 51·00 | 12·45 | 29·64 | 2·30 | 10·90 | 2·91 | 3·74 |
| | | | C | 38·40 | 10·10 | 25·14 | 2·06 | 10·20 | 2·59 | 3·92 |

TABLE 11. BROWN FOREST SOILS WITH GLEYED B AND C HORIZONS

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Peterhead | Blackhouse | 36 | S | 51·04 | 11·10 | 27·00 | 2·53 | 12·13 | 3·20 | 3·79 |
| | | | $B_2$(g) | 51·40 | 11·05 | 27·95 | 2·49 | 12·39 | 3·12 | 3·97 |
| | | | $B_2$(g) | 52·42 | 11·90 | 25·35 | 2·75 | 12·82 | 3·50 | 3·66 |
| | | | $B_3$(g) | 52·30 | 11·70 | 25·90 | 2·34 | 11·92 | 3·43 | 3·48 |
| | | | $B_3$(g) | 52·16 | 12·95 | 25·00 | 2·66 | 10·72 | 3·54 | 3·02 |
| | | | C(g) | 54·00 | 12·80 | 24·80 | 2·78 | 11·24 | 3·70 | 3·04 |
| Tipperty | Tipperty | 45 | S | 51·84 | 9·40 | 26·90 | 2·67 | 14·63 | 3·27 | 4·47 |
| | | | $B_2$(g) | 49·78 | 14·25 | 23·00 | 2·63 | 9·30 | 3·66 | 2·54 |
| | | | $B_3$(g) | 51·42 | 12·10 | 26·35 | 2·56 | 11·26 | 3·31 | 3·41 |
| | | | $B_3$(g) | 52·86 | 11·50 | 25·75 | 2·71 | 12·22 | 3·48 | 3·51 |
| | | | C(g) | 52·50 | 11·60 | 23·70 | 2·86 | 11·97 | 3·75 | 3·19 |

TABLE 12. IRON PODZOLS, FREELY DRAINED

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Foudland | Foudland (uncultivated) | 81 | $A_2$ | 54·44 | 2·31 | 35·00 | 2·54 | 64·71 | 2·64 | 24·50 |
| | | | $B_2$ | 39·70 | 21·35 | 29·80 | 1·55 | 4·93 | 2·26 | 2·18 |
| | | | $B_2$ | 41·02 | 12·55 | 35·35 | 1·60 | 8·65 | 1·97 | 4·39 |
| | | | $B_3$ | 46·02 | 8·85 | 35·80 | 1·89 | 13·93 | 2·18 | 6·38 |
| | | | C | 44·90 | 9·70 | 37·25 | 1·75 | 12·25 | 2·05 | 5·98 |
| | | | C | 43·18 | 10·85 | 38·20 | 1·62 | 10·56 | 1·91 | 5·51 |
| Foudland | Foudland (cultivated) | 74 | S | 41·94 | 18·40 | 26·95 | 1·84 | 6·07 | 2·64 | 2·30 |
| | | | $B_2$ | 37·68 | 17·15 | 33·30 | 1·44 | 5·86 | 1·92 | 3·06 |
| | | | C | 44·74 | 13·90 | 27·55 | 2·08 | 8·55 | 2·76 | 3·10 |
| Countesswells | Countesswells | 61 | S | 42·56 | 15·85 | 27·95 | 1·90 | 7·15 | 2·58 | 2·77 |
| | | | $B_2$ | 35·94 | 19·10 | 30·00 | 1·44 | 4·98 | 2·03 | 2·45 |
| | | | $B_3$ | 45·34 | 12·60 | 28·80 | 2·08 | 9·54 | 2·66 | 3·58 |
| | | | $B_3$ | 45·96 | 13·70 | 29·65 | 2·03 | 8·90 | 2·63 | 3·38 |
| | | | C | 45·62 | 14·85 | 29·00 | 2·02 | 8·19 | 2·67 | 3·06 |
| Strichen | Strichen | 87 | S | 47·66 | 16·15 | 28·60 | 2·08 | 7·85 | 2·82 | 2·78 |
| | | | $B_2$ | 45·06 | 13·15 | 33·60 | 1·82 | 9·15 | 2·27 | 4·02 |
| | | | $B_3$ | 48·88 | 7·05 | 43·60 | 1·72 | 18·48 | 1·90 | 9·73 |
| | | | C | 48·68 | 5·30 | 42·60 | 1·80 | 24·55 | 1·94 | 12·67 |
| | | | D | 48·92 | 5·15 | 43·00 | 1·79 | 25·44 | 1·93 | 13·19 |

TABLE 13. IRON PODZOLS, IMPERFECTLY DRAINED

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Foudland | Mairlenden (cultivated) | 101 | S | 46·64 | 16·70 | 25·95 | 2·16 | 7·39 | 3·04 | 2·43 |
| | | | $B_2$(g) | 43·78 | 20·40 | 26·60 | 1·87 | 5·69 | 2·79 | 2·04 |
| | | | $B_3$(g) | 50·02 | 11·45 | 29·20 | 2·32 | 11·56 | 2·90 | 3·99 |
| | | | C(g) | 50·10 | 12·20 | 29·55 | 2·28 | 10·97 | 2·88 | 3·82 |
| Foudland | Mairlenden (uncultivated) | 103 | A | 44·50 | 15·60 | 31·90 | 1·80 | 7·55 | 2·36 | 3·19 |
| | | | B | 40·06 | 20·15 | 33·00 | 1·48 | 5·29 | 2·05 | 2·71 |
| | | | C(g) | 42·92 | 12·80 | 38·35 | 1·57 | 8·93 | 1·90 | 4·70 |
| | | | C(g) | 44·06 | 15·15 | 35·80 | 1·64 | 7·71 | 2·09 | 3·69 |
| | | | D | 43·50 | 14·50 | 37·20 | 1·57 | 7·89 | 1·99 | 4·01 |

TABLE 14. NON-CALCAREOUS GLEYS

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Countesswells | Terryvale | 124 | S | 44·08 | 16·20 | 29·00 | 1·90 | 7·26 | 2·57 | 2·82 |
| | | | Bg | 43·22 | 20·85 | 28·20 | 1·76 | 5·49 | 2·60 | 2·11 |
| | | | Bg | 46·96 | 16·15 | 27·20 | 2·12 | 7·73 | 2·93 | 2·64 |
| | | | Cg | 46·48 | 15·60 | 28·00 | 2·07 | 7·89 | 2·81 | 2·81 |
| Foudland | Fisherford | 135 | S | 49·30 | 14·10 | 25·85 | 2·40 | 9·32 | 3·23 | 2·89 |
| | | | $B_2$g | 51·84 | 9·00 | 29·70 | 2·49 | 15·41 | 2·97 | 5·20 |
| | | | $B_3$g | 52·76 | 8·85 | 28·40 | 2·63 | 15·96 | 3·15 | 5·07 |
| | | | Cg | 52·64 | 9·85 | 30·30 | 2·44 | 14·13 | 2·65 | 4·79 |

TABLE 14—Continued

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Insch | Myreton | 142 | S | 36·29 | 17·55 | 30·64 | 1·47 | 5·48 | 2·00 | 2·74 |
| | | | $B_2g$ | 41·82 | 16·89 | 31·46 | 1·68 | 6·56 | 2·30 | 2·86 |
| | | | $B_3g$ | 45·50 | 20·14 | 25·09 | 2·08 | 5·98 | 3·08 | 1·94 |
| | | | Cg | 47·62 | 14·80 | 26·83 | 2·22 | 8·53 | 3·01 | 2·84 |
| Peterhead | Peterhead | 151 | S | 55·06 | 10·25 | 27·10 | 2·78 | 14·31 | 3·44 | 4·16 |
| | | | $B_2g$ | 53·48 | 9·15 | 24·60 | 2·99 | 15·61 | 3·69 | 4·23 |
| | | | $B_2g$ | 52·96 | 10·15 | 27·30 | 2·65 | 13·77 | 3·29 | 4·19 |
| | | | $B_3g$ | 53·52 | 10·25 | 26·55 | 2·74 | 13·92 | 3·41 | 4·08 |
| | | | $B_3g$ | 55·06 | 11·60 | 24·85 | 2·89 | 12·55 | 3·75 | 3·34 |
| | | | Cg | 51·68 | 12·20 | 24·30 | 2·74 | 11·32 | 3·61 | 3·13 |
| Strichen | Anniegathel | 157 | S | 49·98 | 8·45 | 36·20 | 2·04 | 15·70 | 2·34 | 6·70 |
| | | | $A_2g$ | 50·40 | 8·90 | 37·20 | 1·99 | 14·98 | 2·30 | 6·52 |
| | | | $B_2g$ | 49·56 | 12·10 | 35·90 | 1·93 | 10·86 | 2·34 | 4·63 |
| | | | $B_3g$ | 48·02 | 11·15 | 36·30 | 1·88 | 11·41 | 2·24 | 5·09 |
| | | | Cg | 46·18 | 12·75 | 36·85 | 1·74 | 9·60 | 2·12 | 4·53 |
| Tarves | Pitmedden | 168 | S | 45·20 | 10·02 | 21·97 | 2·69 | 11·80 | 3·48 | 3·38 |
| | | | $A_2g$ | 49·50 | 11·10 | 23·01 | 2·80 | 12·00 | 3·65 | 3·28 |
| | | | Bg | 43·10 | 16·30 | 17·17 | 2·66 | 7·04 | 4·27 | 1·65 |
| | | | Cg | 47·70 | 12·80 | 22·35 | 2·66 | 9·94 | 3·63 | 2·74 |
| Tipperty | Birness | 171 | S | 55·66 | 6·10 | 27·25 | 3·04 | 24·37 | 3·47 | 7·03 |
| | | | $A_2g$ | 55·48 | 6·95 | 27·80 | 2·91 | 20·98 | 3·38 | 6·20 |
| | | | $B_2g$ | 55·50 | 7·65 | 26·60 | 2·99 | 19·23 | 3·54 | 5·44 |
| | | | $B_3g$ | 55·28 | 7·25 | 25·70 | 3·10 | 20·44 | 3·65 | 5·60 |
| | | | Cg | 56·38 | 8·40 | 25·05 | 3·14 | 17·70 | 3·81 | 4·64 |

## TABLE 15. PEATY GLEYS

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Strichen | Hythie | 185 | S | 49·06 | 10·10 | 26·60 | 2·52 | 12·95 | 3·13 | 4·14 |
| | | | $A_2g$ | 49·26 | 10·35 | 27·40 | 2·46 | 12·62 | 3·05 | 4·14 |
| | | | $B_2g$ | 45·52 | 15·00 | 26·90 | 2·11 | 8·05 | 2·87 | 2·81 |
| | | | $B_3g$ | 47·14 | 12·45 | 34·25 | 1·89 | 10·05 | 2·33 | 4·31 |
| | | | Cg | 44·44 | 16·25 | 34·70 | 1·67 | 7·25 | 2·17 | 3·34 |
| | | | Cg | 46·90 | 12·95 | 35·40 | 1·82 | 9·63 | 2·25 | 4·28 |

## TABLE 16. PEATY PODZOLS WITH IRON PAN

| Association | Series | Profile No. | Horizon | Percentages | | | Ratios | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2/R_2O_3$ | $SiO_2/Fe_2O_3$ | $SiO_2/Al_2O_3$ | $Al_2O_3/Fe_2O_3$ |
| Foudland | Suie | 111 | $A_2$ | 48·94 | 3·67 | 34·85 | 2·23 | 35·39 | 2·38 | 14·86 |
| | | | $B_2$ | 35·50 | 22·10 | 29·25 | 1·51 | 4·64 | 2·23 | 2·08 |
| | | | $B_2$ | 40·44 | 17·15 | 31·10 | 1·63 | 6·29 | 2·21 | 2·85 |
| | | | $B_3$ | 44·94 | 11·70 | 31·80 | 1·94 | 10·25 | 2·40 | 4·27 |
| | | | C | 46·04 | 12·15 | 32·45 | 1·94 | 10·08 | 2·41 | 4·18 |

# APPENDIX III

TABLE 17. PERCENTAGE OF MINERALS IN THE CLAY FRACTIONS ($<1.4\mu$)

| Association | Series | Profile No. | Horizon | Illite | Kaolin | Vermiculite | Montmorillonite | Calcite | Remainder[1] |
|---|---|---|---|---|---|---|---|---|---|
| Peterhead | Blackhouse | 36 | S | 60 | 20 | 15 | — | — | 5 |
| | | | $B_2$(g) | 60 | 15 | 5 | 5 | — | 15 |
| | | | $B_3$(g) | 60 | 10 | + | 15 | — | 15 |
| | | | C(g) | 60 | 10 | — | 15 | — | 15 |
| Tipperty | Birness | 172 | $B_3$g | 70 | 10 | — | 15 | — | 5 |
| | | | Cg | 70 | 10 | — | 15 | — | 5 |
| Hatton | Middlehill | 33 | S | 40 | 10 | 40 | — | — | 10 |
| | | | C(g) | 45 | 10 | 10 | 25 | — | 10 |
| | | | C(g) | 50 | 10 | 10 | 25 | — | 15 |
| Skelmuir | Savock | | S | 10 | 85 | 5 | — | — | 0 |
| | | | $A_2$g | 30 | 60 | 10 | — | — | 0 |
| | | | $B_2$g | 30 | 60 | 10 | — | — | 0 |
| | | | Cg | 35 | 65 | — | — | — | 0 |
| Strichen | Strichen | 87 | $B_2$ | 30 | 40 | — | — | 5 | 25 |
| | | | C | 25 | 60 | — | — | + | 15 |
| | | | D | 20 | 70 | — | — | — | 10 |

[1] Remainder may include amorphous material and small amounts of quartz, felspar, haematite, etc.

# APPENDIX IV

## Analysis of Peat Profiles

TABLE 18. ST. FERGUS MOSS

| Depth in cms. | Botanical* composition | % Ash | Bulk density | pH | % Total O.D. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | CaO | $Na_2O$ | $K_2O$ | MgO | $P_2O_5$ | C | N |
| 0–13 | AP | 6·25 | 0·42 | 3·85 | 0·311 | 0·071 | 0·045 | 0·279 | 0·140 | 46·50 | 1·48 |
| 13–25 | Ev, Sph, C | 7·95 | 0·58 | 3·70 | 0·241 | 0·055 | 0·029 | 0·272 | 0·074 | 46·73 | 1·50 |
| 25–50 | Ev, Sph, C | 2·10 | 0·42 | 3·92 | 0·266 | 0·070 | 0·029 | 0·293 | 0·053 | 52·28 | 1·47 |
| 50–100 | Ev, Sph, C | 2·20 | 0·35 | 4·27 | 0·294 | 0·070 | 0·034 | 0·367 | 0·037 | 51·79 | 1·43 |
| 100–150 | Sph, (Ev, C) | 2·05 | 0·22 | 4·49 | 0·333 | 0·108 | 0·035 | 0·413 | 0·020 | 50·82 | 1·07 |
| 150–200 | Sph | 2·45 | 0·22 | 4·57 | 0·308 | 0·094 | 0·034 | 0·432 | 0·021 | 50·31 | 1·11 |
| 200–250 | Sph, Ev, C | 2·20 | 0·44 | 4·54 | 0·319 | 0·080 | 0·029 | 0·359 | 0·025 | 52·96 | 1·48 |
| 250–300 | Sph, Ev, C, AP | 2·00 | 0·43 | 4·57 | 0·351 | 0·086 | 0·013 | 0·436 | 0·024 | 52·06 | 0·97 |
| 300–350 | Sph, Ev, C, AP | 2·00 | 0·48 | 4·59 | 0·349 | 0·105 | 0·026 | 0·386 | 0·028 | 50·33 | 0·87 |
| 350–400 | Sph, Ev, C, AP | 2·10 | 0·47 | 4·56 | 0·370 | 0·113 | 0·022 | 0·395 | 0·028 | 51·26 | 0·90 |
| 400–450 | AP (Ev, Sph) | 2·20 | 0·50 | 4·56 | 0·355 | 0·123 | 0·026 | 0·394 | 0·041 | 54·70 | 0·93 |
| 450–500 | AP (Ev, Sph, W) | 2·10 | 0·50 | 4·65 | 0·399 | 0·102 | 0·023 | 0·428 | 0·049 | 47·09 | 0·92 |
| 500–530 | AP (Ev, Sph) | 2·40 | 0·43 | 4·21 | 0·434 | 0·069 | 0·025 | 0·196 | 0·052 | 55·86 | 1·65 |
| 530–600 | Cx, W | 3·15 | 0·45 | 4·59 | 0·600 | 0·120 | 0·019 | 0·368 | 0·074 | 51·99 | 1·22 |
| 600–650 | Cx, W | 4·65 | 0·46 | 4·66 | 0·786 | 0·121 | 0·029 | 0·313 | 0·092 | 51·89 | 1·26 |
| 650–690 | Cx, M | 6·80 | 0·60 | 4·48 | 0·490 | 0·094 | 0·029 | 0·325 | 0·095 | 51·19 | 1·43 |

* AP—Amorphous material, Ev—*Eriophorum vaginatum*, Sph—*Sphagnum* spp. C—*Calluna vulgaris*, Cx—*Carex* spp., W—Wood (mostly *Betula*), M—*Menyanthes trifoliata* (seeds), PH—*Phragmites communis*, Eq—*Equisetum* sp.

TABLE 19. SKENE MOSS

| Depth in cms. | Botanical* composition | % Ash | Bulk density | pH | % Total O.D. CaO | $Na_2O$ | $K_2O$ | MgO | $P_2O_5$ | C | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–8 | AP (Ev, Sph, C) | 8·85 | 0·54 | 3·12 | 0·158 | 0·033 | 0·045 | 0·153 | 0·083 | 49·54 | 1·59 |
| 8–16 | AP (Ev, Sph, C) | 7·75 | 0·67 | 3·42 | 0·143 | 0·037 | 0·033 | 0·153 | 0·081 | 49·85 | 1·46 |
| 16–40 | Sph, Ev | 2·55 | 0·52 | 3·30 | 0·197 | 0·034 | 0·020 | 0·180 | 0·040 | 52·31 | 1·38 |
| 40–100 | Sph, Ev, C | 1·30 | 0·34 | 3·47 | 0·189 | 0·035 | 0·016 | 0·152 | 0·034 | 51·64 | 1·05 |
| 100–200 | Sph, Ev, C | 1·60 | 0·28 | 3·58 | 0·171 | 0·042 | 0·019 | 0·284 | 0·023 | 50·79 | 0·84 |
| 200–300 | Sph, Ev, C | 1·50 | 0·22 | 4·61 | 0·257 | 0·060 | 0·019 | 0·385 | 0·020 | 50·70 | 0·66 |
| 300–350 | Sph, Ev, C | 1·50 | 0·34 | 4·28 | 0·342 | 0·053 | 0·020 | 0·205 | 0·033 | 52·96 | 0·88 |
| 350–367 | AP | 1·80 | 0·35 | 4·64 | 0·519 | 0·052 | 0·020 | 0·178 | 0·034 | 53·32 | 1·03 |
| 367–395 | Ev, W | 2·20 | 0·38 | 4·00 | 0·679 | 0·051 | 0·027 | 0·176 | 0·028 | 53·98 | 1·17 |
| 395–450 | W, Eq | 3·00 | 0·45 | 3·92 | 0·616 | 0·048 | 0·029 | 0·199 | 0·028 | 52·42 | 1·37 |
| 450–500 | Cx, W | 3·00 | 0·42 | 3·95 | 0·987 | 0·050 | 0·022 | 0·160 | 0·028 | 51·63 | 1·21 |
| 500–570+ | Cx, Eq, M, (PH) | 2·40 | 0·51 | 4·21 | 0·717 | 0·040 | 0·029 | 0·120 | 0·039 | 51·51 | 1·32 |

TABLE 20. CRUDEN MOSS

| Depth in cms. | Botanical* composition | % Ash | Bulk density | pH | % Total O.D. CaO | $Na_2O$ | $K_2O$ | MgO | $P_2O_5$ | C | N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0–14 | AP | 6·30 | 0·54 | 3·15 | 0·224 | 0·073 | 0·047 | 0·228 | 0·136 | 45·71 | 1·71 |
| 14–50 | Ev, Sph | 3·00 | 0·54 | 3·30 | 0·167 | 0·085 | 0·045 | 0·251 | 0·065 | 49·05 | 1·37 |
| 50–150 | Ev, Sph | 2·00 | 0·58 | 3·53 | 0·140 | 0·097 | 0·022 | 0·213 | 0·035 | 51·58 | 1·38 |
| 150–250 | Ev, Sph, AP | 1·60 | 0·45 | 3·73 | 0·160 | 0·094 | 0·025 | 0·365 | 0·034 | 46·07 | 1·00 |
| 250–350 | Ev, Sph, AP | 1·75 | 0·58 | 3·80 | 0·171 | 0·107 | 0·031 | 0·293 | 0·042 | 54·48 | 1·34 |
| 350–450 | AP, W | 12·50 | 0·63 | 3·71 | 0·241 | 0·052 | 0·032 | 0·262 | 0·049 | 51·12 | 1·31 |

* AP—Amorphous material, Ev—*Eriophorum vaginatum*, Sph—*Sphagnum* spp., C—*Calluna vulgaris*, Cx—*Carex* spp., W—Wood (mostly *Betula*), M—*Menyanthes trifoliata* (seeds), PH—*Phragmites communis*, Eq—*Equisetum* sp.

# APPENDIX V

## Plant Lists

The following are selected species lists of 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—freely drained
Brown Forest Soils—imperfectly drained
Iron Podzols—freely drained
Iron Podzols—imperfectly drained
Peaty Podzols—freely drained below iron pan
Non-calcareous Gleys—moderate to low base status
Non-calcareous Gleys—low base status
Peaty Gleys
Soils derived from Ultrabasic Rocks
- (*a*) Freely drained
- (*b*) Imperfectly drained
- (*c*) Poorly drained

Basin Peat
Hill Peat

Maritime vegetation is listed also under the following categories:

Dunes
Dune Slacks, Links and Cliffs

The nomenclature for pteridophytes and spermaphytes is that of Clapham, Tutin and Warburg (1952), for mosses that of Richards and Wallace (1950), for liverworts that of Jones (1958) and for lichens that of Watson (1953).

In the tables which follow the subjective frequency symbols used are:

| | | |
|---|---|---|
| d—dominant | cod—co-dominant | va—very abundant |
| a—abundant | f—frequent | o—occasional |
| r—rare | l—local or locally | |

TABLE 21. BROWN FOREST SOILS—FREELY DRAINED

Woodland

| Species | Mixed Broad-leaved Woodland —higher base status | Mixed Broad-leaved Woodland —policies wood-land | Oakwood | Birchwood | Scots Pine Plantation—60 years old | Scots Pine Plantation—17 years old | Sitka Spruce Plantation—20 years old |
|---|---|---|---|---|---|---|---|
| *Abies* sp. | | lf | | | | | |
| *Acer pseudoplatanus* | lf | f-la | | | | | |
| *Acer* sp. | | o | | | | | |
| *Betula pubescens* | lf | | | | | | |
| *B. verrucosa* | | o | | | | | |
| *B. pubescens/verrucosa* | | | f-la | d | | | |
| *Fagus sylvatica* | | la | | | | | |
| *Fraxinus excelsior* | | la | | | | | |
| *Picea sitchensis* | | | | | | | d |
| *Pinus sylvestris* | | | | | d | d | |
| *Prunus avium* | la-a | | | | | | |

TABLE 21—continued

| Species | Mixed Broad-leaved Woodland —higher base status | Mixed Broad-leaved Woodland —policies wood-land | Oakwood | Birchwood | Scots Pine Plantation—60 years old | Scots Pine Plantation—17 years old | Sitka Spruce Plantation—20 years old |
|---|---|---|---|---|---|---|---|
| *Prunus padus* | o-lf | | | | | | |
| *Quercus robur* | | o | d | | | | |
| *Q. robur/petraea* | | | | lf | | | |
| *Sorbus aucuparia* | o | | | | o | | |
| *Ulmus glabra* | | f | | | | | |
| — | | | | | | | |
| *Corylus avellana* | o-la | | | | | | |
| *Prunus spinosa* | l | | | | | | |
| *Sambucus* sp. | | | | | o | | |
| — | | | | | | | |
| *Acer pseudoplatanus* seedlings | | a | | | | | |
| *Acer* sp. seedlings | | lf | | | | | |
| *Agrostis canina* | | | | lf-la | lf | o | |
| *A. tenuis* | | la-ld | | lf | a-d | la | |
| *Ajuga reptans* | l | | l | | | | |
| *Anemone nemorosa* | | | f-la | | | | |
| *Anthoxanthum odoratum* | | | f | o | o-lf | | |
| *Arrhenatherum elatius* | lf | | | | | | |
| *Athyrium filix-femina* | l | | | | l | | |
| *Blechnum spicant* | l | | o | | | | |
| *Calluna vulgaris* | | | | o | o | | |
| *Campanula rotundifolia* | | l | | | o | | |
| *Cerastium vulgatum* | | o-lf | | | | | |
| *Chamaenerion angustifolium* | | la-ld | | | | l | |
| *Circaea lutetiana* | l | | | | | | |
| *Cirsium palustre* | o | | | l | | | |
| *C. vulgare* | | o | | | | | |
| *Corylus avellana* seedlings | | | l | | | | |
| *Deschampsia flexuosa* | | | a-d | a-ld | lf | lf | |
| *Digitalis purpurea* | o-lf | | | | o | | |
| *Dryopteris austriaca* | o | | | | o-f | o | |
| *D. borreri* | o-lf | | | | | | |
| *D. filix-mas* | f-la | | | | | o | |
| *Epilobium montanum* | | f-la | | | | o | |
| *E. obscurum* | | lf | | | | | |
| *Erica cinerea* | | | | o | | | |
| *Festuca rubra* | | | | l | | | |
| *Galium aparine* | l | | | | | | |
| *G. saxatile* | | | f | lf | a | f-la | o |
| *Geranium robertianum* | l | | | | | | |
| *Geum urbanum* | l | | | | | | |
| *Glechoma hederacea* | l | | | | | | |
| *Holcus lanatus* | | lf | | o-f | f-a | | |
| *H. mollis* | a-ld | la | f-ld | | ld | ld | o |
| *Hypericum pulchrum* | | o | | | o | | |
| *Ilex aquifolium* | | | o | | | | |
| *Lathyrus montanus* | | | | lf | | | |
| *Lonicera periclymenum* | | | f-la | | | | |
| *Luzula campestris* | | | | | lf | | |
| *L. multiflora* | | | | | lf | | |
| *L. pilosa* | o | | f | f | | | |
| *L. sylvatica* | o-lf | | l | | | | |
| *Lysimachia nemorum* | l | | | | | | |
| *Melandrium rubrum* | f | | | | | | |
| *Mercurialis perennis* | lf | | | | | | |
| *Myosotis arvensis* | o | | | | | | |
| *Oxalis acetosella* | lf-la | | f-a | f | l-lf | | |

TABLE 21—continued

| Species | Mixed Broad-leaved Woodland —higher base status | Mixed Broad-leaved Woodland —policies wood-land | Oakwood | Birchwood | Scots Pine Plantation—60 years old | Scots Pine Plantation—17 years old | Sitka Spruce Plantation—20 years old |
|---|---|---|---|---|---|---|---|
| *Poa annua* | | lf-la | | | | | |
| *P. trivialis* | l-lf | la | | | | | |
| *Polygala serpyllifolia* | | | | | o | | |
| *Polypodium vulgare* | l | | | | | | |
| *Potentilla erecta* | | | | lf | lf | | |
| *Primula vulgaris* | l | | l | | | | |
| *Prunella vulgaris* | | | | | | o | l |
| *Pteridium aquilinum* | a-d | | la | ld | | | |
| *Rhododendron ponticum* | | | lf | | | | |
| *Rubus idaeus* | | | | lf | | lf | |
| *Rumex acetosa* | | | | | o | | |
| *R. acetosella* | | | | | lf | | |
| *Sarothamnus scoparius* | | o | | | | o | |
| *Scrophularia nodosa* | l | | | | | | |
| *Senecio jacobaea* | | | | | o | o | |
| *S. sylvaticus* | | | | | | | o-f |
| *Sorbus aucuparia* seedlings | | | o | o | | | |
| *Stachys sylvatica* | lf | | | | | | |
| *Stellaria media* | | | | | | l | l |
| *Succisa pratensis* | | | o | | | | |
| *Trientalis europaea* | | | | la | | | |
| *Trifolium repens* | | | | | o | | |
| *Ulex europaeus* | | | | | o | | |
| *Urtica dioica* | l | l | | l | | l | |
| *Vaccinium myrtillus* | | | f-d | a-ld | | | |
| *V. vitis-idaea* | | | | la | | | |
| *Veronica chamaedrys* | o | o | | o | o | | |
| *V. officinalis* | | o | o | | o | o | |
| *V. serpyllifolia* | | o-lf | | | | | |
| *Viola riviniana* | o-f | | lf | f | o | lf | l |
| *Zerna ramosa* | l | | | | | | |
| — | | | | | | | |
| *Atrichum undulatum* | l | l | | | l | | |
| *Brachythecium rutabulum* | l | lf | | | | l | |
| *Ceratodon purpureus* | | lf | | | | | |
| *Climacium dendroides* | | | l | | | | |
| *Dicranum majus* | | | la | | | | |
| *D. scoparium* | | | l | | | l | |
| *Dicranum* sp. | lf | | | | | | |
| *Ditrichum heteromallum* | | | | | lf | | |
| *Eurhynchium praelongum* | lf-la | lf | | | | la | |
| *E. striatum* | lf | | | | | | |
| *Hylocomium splendens* | | | a | a | | l | |
| *Hypnum cupressiforme* | lf | lf | l | l | | la | |
| *H. cupressiforme* var. *ericetorum* | | | l | | | | |
| *Isothecium myosuroides* | la | | l | | | | |
| *I. myurum* | lf | | | | | | |
| *Lophocolea bidentata* | lf | | | | | la | |
| *Mnium hornum* | l-lf | l | | | | | |
| *M. longirostrum* | | | | | | la | |
| *M. undulatum* | | | | | | l | |
| *Plagiothecium denticulatum* | l | | | | | | |
| *P. undulatum* | | | l | | | l | |
| *Pleurozium schreberi* | | | la | | | | |
| *Polytrichum* sp. | l | | | | | | |
| *Pseudoscleropodium purum* | | | l | l | lf | lf-la | |
| *Rhytidiadelphus loreus* | | | la | | | | |

TABLE 21—continued

| Species | Mixed Broad-leaved Woodland —higher base status | Mixed Broad-leaved Woodland —policies woodland | Oakwood | Birchwood | Scots Pine Plantation—60 years old | Scots Pine Plantation—17 years old | Sitka Spruce Plantation—20 years old |
|---|---|---|---|---|---|---|---|
| *Rhytidiadelphus squarrosus* | lf | | | | a | l | |
| *R. triquetrus* | | | la | la | l | | |
| *Thuidium tamariscinum* | lf-la | | a | | | l | |
| — | | | | | | | |
| *Peltigera canina* | l | | | | | l | |

Grassland and Heath

| Species | Permanent Pasture | Permanent Pasture infested with Gorse | Bracken-dominated Pasture | Very old Pasture | Old Pasture | Heath |
|---|---|---|---|---|---|---|
| *Sarothamnus scoparius* | | | o | | | |
| *Ulex europaeus* | la | a-d | | l | | |
| — | | | | | | |
| *Achillea millefolium* | | f-a | | f | | |
| *Agrostis canina* | lf | | lf | | | |
| *A. tenuis* | cod | a-cod | a-ld | a | cod-d | o |
| *Anemone nemorosa* | lf | | | f | | lf |
| *Antennaria dioica* | o | | | | | o-r |
| *Anthoxanthum odoratum* | f-a | f | f-a | f | lf-la | o |
| *Aphanes arvensis* | | l | | | l | |
| *Arctostaphylos uva-ursi* | | | | | | l |
| *Bellis perennis* | | o | | | | |
| *Blechnum spicant* | | | l | | | l |
| *Calluna vulgaris* | lf-la | | | | | d |
| *Campanula rotundifolia* | o | f | o-lf | f | | |
| *Carex binervis* | | | | | | lf |
| *C. pilulifera* | o-lf | | | | | |
| *Cerastium vulgatum* | | o | | o | f | |
| *Cirsium arvense* | | o | | | o | |
| *C. palustre* | | | o | | | |
| *Cynosurus cristatus* | | | | | l | |
| *Deschampsia caespitosa* | | | | | o | |
| *D. flexuosa* | ld | | | a | | f |
| *Digitalis purpurea* | | | o | | | |
| *Empetrum nigrum* | | | | | | o |
| *Erica cinerea* | l | | | | | f |
| *Festuca ovina* | cod | | f-la | a | | o |
| *F. rubra* | | a-cod | | | la-ld | |
| *Galium saxatile* | a | lf | o-lf | a | l | |
| *G. verum* | | a | | | l | |
| *Genista anglica* | l | | | | | l |
| *Hieracium pilosella* | | | | o | | |
| *Holcus lanatus* | | o-lf | | | a-cod | |
| *H. mollis* | | | la | | la | |
| *Hypericum pulchrum* | | | o | | | |
| *Juncus squarrosus* | l | | | | | |

TABLE 21—continued

| Species | Permanent Pasture | Permanent Pasture infested with Gorse | Bracken-dominated Pasture | Very old Pasture | Old Pasture | Heath |
|---|---|---|---|---|---|---|
| *Koeleria gracilis* | | l | | | | |
| *Larix decidua* | | | | | | o |
| *Lathyrus montanus* | o | | | f | | o |
| *Lolium perenne* | | | | | lf | |
| *Lotus corniculatus* | o | f | | f-a | | |
| *Luzula campestris* | f | l | | o | | |
| *L. multiflora* | | | o | | | |
| *Lycopodium clavatum* | | | | | | lf |
| *Oxalis acetosella* | | | o | | | |
| *Pinus sylvestris* | | | | | | o |
| *Plantago lanceolata* | | f | | lf | | |
| *Poa pratensis* | l | o-f | f | f-la | f-la | |
| *P. trivialis* | | | | | lf | |
| *Polygala serpyllifolia* | o | o | o | o | | |
| *Potentilla erecta* | f | o-f | lf | o-f | | o |
| *Primula vulgaris* | | | l | | | |
| *Pteridium aquilinum* | | | d | | | |
| *Ranunculus repens* | | | l | | l | |
| *Rubus idaeus* | | | l | | | |
| *Rumex acetosa* | | | o | | f | |
| *R. acetosella* | | l | | | | |
| *Senecio jacobaea* | | o | | | | |
| *Sorbus aucuparia* seedlings | | | | | | o-r |
| *Stellaria graminea* | | | | | lf-f | |
| *Thymus drucei* | | | | o | | |
| *Trientalis europaea* | l | | o | | | |
| *Trifolium repens* | | f-a | | o | a | |
| *Vaccinium myrtillus* | lf | | | o | | o-f |
| *V. vitis-idaea* | | | | | | f |
| *Veronica chamaedrys* | o | f | f | lf | o | |
| *V. officinalis* | | l | o | o | | |
| *V. serpyllifolia* | | | o | | | |
| *Viola lutea* | | | | f-la | | |
| *V. riviniana* | f | o-f | f-a | f | | |
| — | | | | | | |
| *Brachythecium albicans* | | la | | | | |
| *Ceratodon purpureus* | | la | | | | |
| *Dicranum scoparium* | | | | | | l |
| *Hylocomium splendens* | a | | | a | | a |
| *Hypnum cupressiforme* | | l | | | | a |
| *Pleurozium schreberi* | la | | | | | a |
| *Pseudoscleropodium purum* | | la | la | la | l | |
| *Rhytidiadelphus squarrosus* | la | la | | a | lf | |
| *R. triquetrus* | l | | | l | | |
| — | | | | | | |
| *Cladonia impexa* | | | | | | f-la |
| *C. sylvatica* | l | | | | | |
| *Hypogymnia physodes* | | | | | | f |

## TABLE 22. BROWN FOREST SOILS—IMPERFECTLY DRAINED

Woodland

| Species | Mixed Broad-leaved Woodland —higher base status | Mixed Broad-leaved Woodland —shelterbelt | Beechwood—moderate canopy | Beechwood—heavy canopy | Birchwood | Scots Pine Plantation | Norway Spruce Plantation—ground cover incomplete |
|---|---|---|---|---|---|---|---|
| *Acer pseudoplatanus* | f-la | f-la | | o | l | | |
| *Betula verrucosa/pubescens* | | | | | d | | |
| *Fagus sylvatica* | o-la | o | d | d | l | | |
| *Fraxinus excelsior* | f-a | f | | | | | |
| *Larix decidua* | | | | | | o | |
| *Picea abies* | | | | | | f-ld | d |
| *Pinus sylvestris* | | | | | | d | |
| *Salix caprea* | | | | | f | | |
| *Sorbus aucuparia* | | o | | | o | | |
| *Tilia vulgaris* | | | o | l | | | |
| *Ulmus glabra* | f-la | a | | | | | |
| — | | | | | | | |
| *Acer pseudoplatanus* seedlings | o | lf | lf | f-a | | l | |
| *Agrostis canina* | | | | | f | | ld |
| *A. stolonifera* | | | | | | l | |
| *A. tenuis* | | | a-ld | l | d | o-lf | |
| *Anthoxanthum odoratum* | | | la | | o-f | | |
| *Arrhenatherum elatius* | | | | | l | | |
| *Betula* seedlings | | | | | | | lf |
| *Cerastium vulgatum* | | | | | | o | lf |
| *Chamaenerion angustifolium* | | | | | | o | o-lf |
| *Conopodium majus* | | | o | | | | |
| *Dactylis glomerata* | | a-d | | | | | |
| *Deschampsia caespitosa* | l | l | | | | o | |
| *D. flexuosa* | | | | | lf | | ld |
| *Dryopteris austriaca* | | | | | o | a | lf |
| *D. filix-mas* | o-lf | o | | | o | | |
| *Epilobium montanum* | lf | | | | | | |
| *Fagus* seedlings | | | | l | | | |
| *Festuca rubra* | | | l | | | | |
| *Fraxinus* seedlings | o | | | | | | |
| *Galium aparine* | | lf | | | | | |
| *G. saxatile* | | | | | o-lf | | la |
| *Geum urbanum* | la-ld | o | | | | | |
| *Heracleum sphondylium* | | f | | | | | |
| *Holcus lanatus* | | | lf | | f-a | o-la | |
| *H. mollis* | | | a-d | l | ld | | l |
| *Lotus uliginosus* | | | | | l | | |
| *Luzula multiflora* | | | o | | | | |
| *Myosotis arvensis* | | l | | | | | |
| *Oxalis acetosella* | | | | | a | | |
| *Poa annua* | | | | l | | lf | |
| *P. pratensis* | | | lf | | | | |
| *P. trivialis* | lf | lf-f | | l | | la | |
| *Prunella vulgaris* | o | | | | | o | |
| *Pteridium aquilinum* | | | | | ld | | |
| *Ranunculus repens* | l | lf | | | | lf | |
| *Rubus idaeus* | | | | | | o | |
| *Rumex acetosa* | | | | | | o | |
| *Sambucus racemosa* | | | | | | f-la | |
| *Sambucus* seedlings | | | | | | | l |
| *Sarothamnus scoparius* seedlings | | | | | f | | |
| *Senecio jacobaea* | o | | | | | o-lf | |
| *Stellaria media* | | | | | | lf | la |
| *Ulmus* seedlings | o | | | | | | |

TABLE 22—continued

| Species | Mixed Broad-leaved Woodland —higher base status | Mixed Broad-leaved Woodland —Shelter belt | Beechwood—moderate canopy | Beechwood—heavy canopy | Birchwood | Scots Pine Plantation | Norway Spruce Plantation—ground cover incomplete |
|---|---|---|---|---|---|---|---|
| *Urtica dioica* | | la-ld | | | | lf-la | |
| *Veronica chamaedrys* | | | o-lf | | | | |
| *V. officinalis* | | | lf | | | | |
| *V. serpyllifolia* | o | | | | | | |
| *Viola riviniana* | f-la | | a | o | | | |
| *V. tricolor* | | | | | | o | |
| — | | | | | | | |
| *Atrichum undulatum* | | | | l | | l | l |
| *Brachythecium rutabulum* | | l | | l | | | |
| *Cirriphyllum piliferum* | | | l | | | | |
| *Dicranella heteromalla* | | | | | | l | lf |
| *Dicranum scoparium* | | | l | | | | l |
| *Eurhynchium praelongum* | la | lf-la | | | | lf | lf |
| *E. striatum* | lf-la | | | | | | |
| *Fissidens bryoides* | l | | | | | | |
| *Hylocomium splendens* | | | | | | | l |
| *Hypnum cupressiforme* | l | | | l | | | l |
| *Isothecium myosuroides* | | | l | | | | |
| *I. myurum* | | | l | | | | |
| *Lophocolea bidentata* | | l | | | lf | l | la |
| *L. cuspidata* | | l | | l | | | lf |
| *Lophocolea* sp. | | | l | | | | |
| *Mnium hornum* | lf | | l | lf | | | |
| *M. undulatum* | | lf | | | | | |
| *Plagiothecium undulatum* | | | l | lf | | | la |
| *Pleurozium schreberi* | | | | | | | l |
| *Polytrichum commune* | | | | | lf | | |
| *P. gracile* | | | l | | | | |
| *Pseudoscleropodium purum* | | | | | lf | | |
| *Ptilidium ciliare* | | | | | | | l |
| *Rhytidiadelphus squarrosus* | | | | | lf-la | | l |
| *R. triquetrus* | | | f-a | l | | | |
| *Thuidium tamariscinum* | | | lf | l | | | |

Grassland

| Species | Very Old Pasture | Old Pasture | Bracken-dominated Pasture |
|---|---|---|---|
| *Agrostis canina* | | | a |
| *A. tenuis* | d | d | a |
| *Anthoxanthum odoratum* | a | o-f | o-f |
| *Calluna vulgaris* | | | l |
| *Carex ovalis* | o | | |
| *Carex* sp. | | | l |
| *Cerastium vulgatum* | o | | |
| *Chamaenerion angustifolium* | | | o |
| *Cirsium arvense* | lf | | |
| *C. palustre* | lf | | o |
| *C. vulgare* | lf | | |

TABLE 22—continued

| Species | Very Old Pasture | Old Pasture | Bracken-dominated Pasture |
|---|---|---|---|
| *Cynosurus cristatus* | f-a | | |
| *Deschampsia caespitosa* | lf-la | | |
| *D. flexuosa* | | | lf |
| *Festuca ovina* | | | lf |
| *F. rubra* | f | | |
| *Galium saxatile* | | | a |
| *Gnaphalium sylvaticum* | | lf | |
| *Holcus lanatus* | f-a | f | f-a |
| *H. mollis* | | lf | |
| *Hypericum pulchrum* | | | o |
| *Hypochaeris radicata* | | o | |
| *Juncus effusus* var. *compactus* | f-la | | |
| *Leontodon autumnalis* | lf | | |
| *Lolium perenne* | | o | |
| *Lotus corniculatus* | l | | |
| *Luzula* sp. | | | o |
| *Phleum pratense* | | o-f | |
| *Polygala serpyllifolia* | | | o |
| *Polygonum persicaria* | | o | |
| *Potentilla erecta* | | | a |
| *Pteridium aquilinum* | | | d |
| *Ranunculus acris* | f | | |
| *Rubus idaeus* | | | o |
| *Rumex acetosa* | f | | lf |
| *R. acetosella* | | a | lf |
| *Succisa pratensis* | | | o |
| *Trientalis europaea* | | | o |
| *Trifolium hybridum* | | o | |
| *T. pratense* | | o-f | |
| *T. repens* | a | o-lf | |
| *Ulex europaeus* | | lf | o |
| *Vaccinium myrtillus* | | | l |
| *Veronica serpyllifolia* | | o-f | |
| *Viola riviniana* | | | o |
| *V. tricolor* | | f-a | |
| — | | | |
| *Atrichum undulatum* | | l | |
| *Bryum* sp. | | | l |
| *Campylopus piriformis* | | | l |
| *Ceratodon purpureus* | | lf | l |
| *Dicranella heteromalla* | | | la |
| *Eurhynchium praelongum* | | f-a | |
| *Pseudoscleropodium purum* | lf | | |
| *Rhytidiadelphus squarrosus* | la-a | | |
| — | | | |
| *Cladonia pyxidata* | | | l |

## TABLE 23. IRON PODZOLS—FREELY DRAINED

Broadleaved Woodland

| Species | Oakwood—on lower slope | Oakwood—on middle slope | Oakwood—on upper slope | Beechwood—moderate canopy | Beechwood—heavy canopy | Birchwood | Birchwood—after felling of coniferous plantation |
|---|---|---|---|---|---|---|---|
| *Betula verrucosa/pubescens* | | | | | | d | a-d |
| *B. verrucosa* | o-f | lf | | | | | |
| *Fagus sylvatica* | | | | d | d | | o-lf |
| *Larix decidua* | | | | | | | o |
| *Picea abies* | | | | | | | o |
| *Pinus sylvestris* | | o | f | | lf | | |
| *Quercus robur* | | | | o | | | |
| *Q. robur/petraea* | d | d | d-ld | | lf | | |
| *Sorbus aucuparia* | | | | | | | lf-f |
| — | | | | | | | |
| *Acer pseudoplatanus* seedlings | | | | | | | r |
| *Agrostis canina* | o | | | | | | |
| *A. tenuis* | | | | | | lf | |
| *Anemone nemorosa* | a | | | | | | |
| *Anthoxanthum odoratum* | l | | | | | | |
| *Calluna vulgaris* | | f | d | | | a | a-d |
| *Carex binervis* | | | | | | | o |
| *Carex* sp. | o | | | | | | |
| *Cerastium vulgatum* | | | | | o | | |
| *Deschampsia flexuosa* | f-la | o | | d | o | a-d | f-la |
| *Dryopteris austriaca* | | | | o-lf | | o | lf |
| *D. filix-mas* | | | | | | | o |
| *Erica cinerea* | o-lf | a-ld | f | | | f | o |
| *Galium saxatile* | f | | o | | | lf | o |
| *Holcus mollis* | lf | | | ld | | | |
| *Luzula pilosa* | o | | | lf | | o | lf |
| *L sylvatica* | | | | | l | l-lf | |
| *Oxalis acetosella* | lf | | | l | | lf | lf |
| *Poa annua* | o | | | | | | |
| *Pteridium aquilinum* | a | | | | | | |
| *Rubus fruticosus* | | | | | | | o-lf |
| *Rumex acetosella* | | | | l | o | | |
| *Teucrium scorodonia* | a | l | l | | | | |
| *Trientalis europaea* | | | | lf | | lf | |
| *Vaccinium myrtillus* | la | a-ld | f-ld | | | f | la-ld |
| *V. vitis-idaea* | l | l | lf | | | | |
| *Veronica chamaedrys* | o | | | | | | |
| *V. officinalis* | o | | | | | o | |
| — | | | | | | | |
| *Barbilophozia hatcheri* | | | l | | | | |
| *Campylopus flexuosus* | | la | la | | l | | |
| *Ceratodon purpureus* | | | l | | | | l |
| *Dicranella heteromalla* | | | | lf | | | |
| *Dicranum fuscescens* | | l | | | | | |
| *D. majus* | la | | | | | | |
| *D. scoparium* | la | la | f | o | | lf | lf |
| *Diplophyllum albicans* | | | | | l | | |
| *Hylocomium splendens* | | l | f | | | a | lf-la |
| *Hypnum cupressiforme* | la | a | a | la | la | lf-la | |
| *H. cupressiforme* var. *ericetorum* | | | | | | | la |
| *Isopterygium elegans* | | | | lf | | | |
| *Isothecium myosuroides* | l | l | l | | l | | |
| *Lophocolea bidentata* | | | | | | l | lf |
| *L. cuspidata* | | | | lf | | | |

TABLE 23—continued

| Species | Oakwood—on lower slope | Oakwood—on middle slope | Oakwood—on upper slope | Beechwood—moderate canopy | Beechwood—heavy canopy | Birchwood | Birchwood—after felling of coniferous plantation |
|---|---|---|---|---|---|---|---|
| *Lophocolea heterophylla* | | | | lf | | | |
| *Mnium hornum* | | | | f | a | | |
| *Plagiochila asplenioides* | | | | | la | | |
| *Plagiothecium denticulatum* | | | | | l | | |
| *P. undulatum* | | | | lf | l | l | lf |
| *Pleurozium schreberi* | l | | l | | | lf | la-a |
| *Pohlia nutans* | | | l | | l | | |
| *Polytrichum gracile* | | | | l | | | |
| *Pseudoscleropodium purum* | | | | | | l | lf |
| *Ptilium crista-castrensis* | | | | | | | l |
| *Rhacomitrium heterostichum* | | | l | | | | |
| *R. lanuginosum* | | | l | | | | |
| *Rhytidiadelphus loreus* | lf | | f | | | | |
| *R. triquetrus* | l | | | | | lf | |
| *Sphagnum plumulosum* | | | | | | | l |
| *Thuidium tamariscinum* | l | | | | o | | |
| *Trichostomum* sp. | | | | | lf | | |
| — | | | | | | | |
| *Cladonia digitata* | | la | | | | | |
| *C. fimbriata* | | la | | | | | |
| *C. pyxidata* | | | la | | | | |
| *C. squamosa* | | | la | | | | |
| *Hypogymnia physodes* | | la | la | | | | la |
| *Sphaerophorus globosus* | | | la | | | | |

Coniferous Plantation

| Species | Scots Pine Plantation—50 years old | Scots Pine Plantation—28 years old | European Larch Plantation—25 years old | Norway Spruce Plantation—25 years old |
|---|---|---|---|---|
| *Betula verrucosa/pubescens* | f | | | |
| *Larix decidua* | | | d | |
| *Picea abies* | | | | d |
| *Pinus sylvestris* | d | d | | |
| *Sorbus aucuparia* | f | o | f | f |
| — | | | | |
| *Agrostis canina* | | lf | la | |
| *Calluna vulgaris* | f-ld | o | o | |
| *Deschampsia flexuosa* | a-ld | a | d | l |
| *Digitalis purpurea* | | | lf | |
| *Dryopteris austriaca* | | f | f-la | l |
| *D. borreri* | | | o | |
| *Erica cinerea* | | | o | |
| *Festuca ovina* | lf | | | |
| *Galium saxatile* | lf | o-f | f | |
| *Holcus* sp. | | o | | |
| *Luzula multiflora* | | o | o | |
| *L. pilosa* | lf | o-f | lf-f | |
| *Oxalis ocetosella* | | a | a | o |

TABLE 23—continued

| Species | Scots Pine Plantation—50 years old | Scots Pine Plantation—28 years old | European Larch Plantation—25 years old | Norway Spruce Plantation—25 years old |
|---|---|---|---|---|
| *Pteridium aquilinum* | | la | la | |
| *Rubus fruticosus* | | o-lf | o | |
| *R. idaeus* | | o | o | |
| *Sarothamnus scoparius* | o | | | |
| *Sorbus aucuparia* seedlings | f | | | |
| *Trientalis europaea* | | o-f | o | |
| *Vaccinium myrtillus* | a-ld | lf-la | o | |
| — | | | | |
| *Dicranella heteromalla* | | | l | |
| *Dicranum scoparium* | | l | l | lf |
| *Hylocomium splendens* | a | | | |
| *Hypnum cupressiforme* | l | lf | l | lf |
| *Lepidozia reptans* | | l | | |
| *Lophocolea bidentata* | | la | a | lf-la |
| *L. cuspidata* | | l | | lf |
| *Mnium hornum* | | l | | |
| *Plagiothecium undulatum* | | lf | lf-la | lf |
| *Pleurozium schreberi* | lf | | | l |
| *Pseudoscleropodium purum* | la | lf | lf | |
| *Rhytidiadelphus squarrosus* | | lf | lf | |

Heath

| Species | Lowland Heath—near Aberdeen | Lowland Heath—near Aboyne | Upland Heath—on acid igneous soil | Upland Heath—on basic igneous soil | Upland Heath—near peaty podzol zone | Upland Heath—adjacent to previous—recently burned |
|---|---|---|---|---|---|---|
| *Agrostis canina* | | | | o | | |
| *Anthoxanthum odoratum* | | | | o-lf | | |
| *Arctostaphylos uva-ursi* | | la | | f-la | | |
| *Calluna vulgaris* | d | d | d | d | d | d |
| *Carex binervis* | l | | o | | o | |
| *C. panicea* | | | | | | o |
| *Carex* sp. | | o | | | | |
| *Deschampsia flexuosa* | o | | f | f | | |
| *Empetrum nigrum* | | | o | | o | o |
| *Erica cinerea* | f-a | f | f-la | o-f | o-f | o-f |
| *E. tetralix* | | | o | | | |
| *Genista anglica* | | f | | | | |
| *Juncus squarrosus* | | | o | | | |
| *Listera cordata* | | | | o | | |
| *Luzula multiflora* | | | | o | | |
| *Pinus sylvestris* | | la | o | | o | |
| *Poa annua* | | | | l | | |
| *Rumex acetosella* | | l | | | | |
| *Sagina procumbens* | | l | | | | |
| *Sarothamnus scoparius* | o | | | | | |
| *Trichophorum caespitosum* | | | | | o-lf | o |
| *Ulex europaeus* | o | | | | | |

TABLE 23—continued

| Species | Lowland Heath—near Aberdeen | Lowland Heath—near Aboyne | Upland Heath—on acid igneous soil | Upland Heath—on basic igneous soil | Upland Heath—near peaty podzol zone | Upland Heath—adjacent to previous—recently burned |
|---|---|---|---|---|---|---|
| *Vaccinium myrtillus* | l | | l-lf | | o | |
| *V. vitis-idaea* | | | f-la | f-la | lf | |
| — | | | | | | |
| *Barbilophozia floerkei* | | | | | l | |
| *Calypogeia trichomanis* | l | | | | | |
| *Campylopus flexuosus* | f | | | | | o |
| *Ceratodon purpureus* | | l | | l | | |
| *Dicranum fuscescens* | | | l | o | | |
| *D. scoparium* | o | | la | l | | o |
| *Hylocomium splendens* | | | la | la | | |
| *Hypnum cupressiforme* | | l-la | a | | | |
| *H. cupressiforme* var. *ericetorum* | lf | | | a | a | |
| *Lophocolea bidentata* | l | | | | | |
| *Lophozia ventricosa* | l | | | | | |
| *Marsupella emarginata* | | | | l | | |
| *Plagiothecium undulatum* | | | a | | | |
| *Pleurozium schreberi* | | | la | a | la | |
| *Pohlia nutans* | a | | | | | |
| *Polytrichum commune* | | | l | lf | l | l |
| *P. piliferum* | | | | l | | |
| *Rhytidiadelphus loreus* | | | | l | | |
| *Sphagnum plumulosum* | | | l | | | |
| — | | | | | | |
| *Cladonia coccifera* | f | | | | | |
| *C. cenotea* | lf | | | | | |
| *C. deformis* | lf | | | | | |
| *C. digitata* | lf | | | | | |
| *C. floerkeana* | | | | | | la |
| *C. gracilis* | | | | | | la |
| *C. impexa* | f | va | f | la | a | lf |
| *C. pyxidata* | | | | | | la |
| *C. squamosa* | f | | o | | | |
| *Cladonia* spp. | | | | | f | la |
| *Hypogymnia physodes* | f-la | f | f | f | | |

Grassland

| Species | Heathy Pasture | *Nardus* Pasture | Gorse Scrub | Bracken-dominated Pasture |
|---|---|---|---|---|
| *Ulex europaeus* | | | d | |
| — | | | | |
| *Agrostis canina* | l | f | a | o |
| *A. tenuis* | a-ld | f-la | a | o-lf |
| *Anthoxanthum odoratum* | | | o-la | o-lf |

TABLE 23—continued

| Species | Heathy Pasture | *Narbus* Pasture | Gorse Scrub | Bracken-dominated Pasture |
|---|---|---|---|---|
| *Calluna vulgaris* | f-ld | | | |
| *Carex binervis* | | | o | |
| *C. pilulifera* | f-a | | | |
| *Deschampsia caespitosa* | o | | lf | |
| *D. flexuosa* | a-d | f-la | | la |
| *Erica cinerea* | lf | f | o-f | |
| *Festuca ovina* | la | f-la | | |
| *Galium saxatile* | a | lf | o | o |
| *Hieracium* sp. | | | o | |
| *Holcus lanatus* | | | f-la | |
| *Hypochaeris radicata* | | | lf | |
| *Juncus squarrosus* | l | | | |
| *Luzula campestris* | | f | | |
| *L. multiflora* | o-f | | | |
| *L. pilosa* | o | | | o |
| *Nardus stricta* | | a-d | | |
| *Polygala serpyllifolia* | o-f | | | |
| *Potentilla erecta* | f | o | f | o |
| *Pteridium aquilinum* | | | | d |
| *Rubus idaeus* | | | | l |
| *Rumex acetosa* | | | o-lf | |
| *R. acetosella* | f | f-a | | |
| *Sarothamnus scoparius* seedlings | | o-lf | | |
| *Trientalis europaea* | | | | lf |
| *Vaccinium myrtillus* | la | | | lf |
| *Veronica officinalis* | o-f | | | |
| — | | | | |
| *Ceratodon purpureus* | | | lf | |
| *Dicranum scoparium* | la | f-la | | |
| *Hylocomium splendens* | la | lf | | |
| *Hypnum cupressiforme* var. *ericetorum* | la | | | l |
| *Pleurozium schreberi* | la | a | | |
| *Polytrichum juniperinum* | l | | | |
| *P. urnigerum* | l | | | |
| *Pseudoscleropodium purum* | l | lf | | |
| *Rhytidiadelphus squarrosus* | l | lf | | l |
| *R. triquetrus* | l | l | | |

## TABLE 24. IRON PODZOLS—IMPERFECTLY DRAINED

| Species | Beechwood | Birchwood | Scots Pine Plantation—50 years old | Scots Pine Plantation—30 years old | Scots Pine Plantation—14 years old | Heath—periodically burned | Heath—cattle grazed |
|---|---|---|---|---|---|---|---|
| *Betula pubescens* | | | o | o | | | |
| *B. pubescens/verrucosa* | | d | | | | | o |
| *Fagus sylvatica* | d | | | | | | |
| *Pinus sylvestris* | | | d | d | d | | |
| *Sorbus aucuparia* | | o | | o | | | o |
| — | | | | | | | |
| *Agrostis canina* | lf | f-la | a-ld | | f | l | lf |
| *A. tenuis* | la | lf | | | | | o |
| *Anthoxanthum odoratum* | o | | | | | | |
| *Betula pubescens* seedlings | o | | o-f | | | | |
| *Calluna vulgaris* | l | f-d | o | o | la-ld | d | d |
| *Carex binervis* | o | o | | | | | lf |
| *Carex* sp. | | | | | | o | |
| *Chamaenerion angustifolium* | | | l | l | | | |
| *Chenopodium* sp. | | | | | | | l |
| *Deschampsia caespitosa* | | o | | | | | |
| *D. flexuosa* | a-d | f-la | a-ld | d | a | l | lf |
| *Digitalis purpurea* | o-lf | | | | | | |
| *Dryopteris austriaca* | lf | | | f-la | | | |
| *Erica cinerea* | | | | | | o | |
| *E. tetralix* | | o | | | o | o-lf | o |
| *Fagus sylvatica* seedlings | lf | o | | | | | |
| *Galium saxatile* | | f-la | f | f-la | | | |
| *Holcus lanatus* | lf | lf | lf | | | l | |
| *H. mollis* | ld | | | | | | |
| *Juncus effusus* | | | o | | | | |
| *J. squarrosus* | | | | | | l | lf |
| *Luzula multiflora* | o | | | | | | |
| *L. pilosa* | lf-f | o-f | lf | f | | | |
| *Luzula* sp. | | | | | | | o |
| *Oxalis acetosella* | lf | | | f-a | | | |
| *Poa pratensis* | | | | | | | l |
| *Potentilla erecta* | | o-f | f | | o-f | | o |
| *Rubus idaeus* | | l | la | | | | |
| *R. fruticosus* | | | lf | o | | | l |
| *Rumex acetosella* | | | | | | | o |
| *Salix atrocinerea* | | o | | | | | o |
| *Sarothamnus scoparius* | | o | | | | | |
| *Sorbus aucuparia* seedlings | | | lf | | | | |
| *Spergula arvensis* | | | | | | | l |
| *Trichophorum caespitosum* | | | | | | a | |
| *Trientalis europaea* | | f-a | f | f-a | | | l |
| *Ulex europaeus* | | | | | | | o |
| *Vaccinium myrtillus* | | l | la | o | f-la | | f |
| — | | | | | | | |
| *Aulacomnium palustre* | | | | | | | l |
| *Campylopus piriformis* | | | l | | | | |
| *Ceratodon purpureus* | | | | | | | lf |
| *Dicranella heteromalla* | | | l | | | | |
| *Dicranum scoparium* | la | l | l | o-f | f | | o |
| *Gymnocolea inflata* | | | | | | la | |
| *Hylocomium splendens* | | a | l | | f | | |
| *Hypnum cupressiforme* | la | | l | | | lf | |
| *H. cupressiforme* var. *ericetorum* | | | | la | f-la | | f |
| *Lepidozia reptans* | l | | | | | | |
| *Lophocolea bidentata* | | | | lf | lf-la | | |

TABLE 24—continued

| Species | Beechwood | Birchwood | Scots Pine Plantation—50 years old | Scots Pine Plantation—30 years old | Scots Pine Plantation—14 years old | Heath—periodically burned | Heath—cattle grazed |
|---|---|---|---|---|---|---|---|
| *Plagiothecium undulatum* | lf | l | l | f-la | lf | | l |
| *Pleurozium schreberi* | | la | l | f-la | f-la | | lf |
| *Pohlia nutans* | | | | | | f-la | a |
| *Polytrichum commune* | | a-ld | la | | lf | lf | la |
| *P. formosum* | la | | | | | | |
| *P. gracile* | | | | l | | | |
| *Pseudoscleropodium purum* | | la | la | f-la | f | | lf |
| — | | | | | | | |
| *Cladonia squamosa* | | | | | | | l |
| *Cladonia* spp. | | | | | | f | |

TABLE 25. PEATY PODZOLS—FREELY DRAINED BELOW IRON PAN

| Species | Open Pinewood | Heath | Heath | Heath—heavily grazed |
|---|---|---|---|---|
| *Pinus sylvestris* | f-ld | | | |
| — | | | | |
| *Agrostis canina* | l | | | lf-la |
| *A. tenuis* | | | | f |
| *Blechnum spicant* | o | | | |
| *Calluna vulgaris* | d | d | d | d |
| *Carex binervis* | o | l | | |
| *C. echinata* | | | o | |
| *C. nigra* | | l | lf | |
| *Carex* sp. | | | | l |
| *Cerastium vulgatum* | | | | o |
| *Deschampsia flexuosa* | | o | o-f | f |
| *Empetrum nigrum* | | o-lf | | |
| *Erica cinerea* | f-a | a | | |
| *E. tetralix* | lf | | f | |
| *Festuca ovina* | | | | f |
| *Holcus lanatus* | | | | o |
| *Juncus squarrosus* | | lf | o | f |
| *Listera cordata* | o-f | | | |
| *Nardus stricta* | | | | lf |
| *Narthecium ossifragum* | l | | | |
| *Poa annua* | | | | l |
| *Potentilla erecta* | o-f | o-lf | o | |
| *Sorbus aucuparia* | o | | | |
| *Trichophorum caespitosum* | l | | f | o |
| — | | | | |
| *Calypogeia trichomanis* | f | | | |
| *Campylopus flexuosus* | | l | | |
| *Dicranum scoparium* | la | l | o | lf |
| *Diplophyllum albicans* | f | | | |
| *Hylocomium splendens* | l | | | |

TABLE 25—continued

| Species | Open Pinewood | Heath | Heath | Heath—heavily grazed |
|---|---|---|---|---|
| *Hypnum cupressiforme* | | | | f |
| *H. cupressiforme* var. *ericetorum* | la | la | la | |
| *Leucobryum glaucum* | | l | | o |
| *Lophocolea bidentata* | f | | | |
| *Plagiothecium undulatum* | la | l | | |
| *Pleurozium schreberi* | la | | lf | lf |
| *Pohlia nutans* | | | la | lf |
| *Ptilium crista-castrensis* | l | | | |
| *Rhacomitrium lanuginosum* | | lf | | |
| *Sphagnum plumulosum* | la | l | | |
| *S. recurvum* | la | | | |
| — | | | | |
| *Cetraria aculeata* | | la | | |
| *Cladonia coccifera* | | lf | | |
| *C. gracilis* | | l | | |
| *C. impexa* | la | lf | l | |
| *C. sylvatica* | | la | | |
| *C. uncialis* | | la | | |
| *Hypogymnia physodes* | | l | | |

## TABLE 26. NON-CALCAREOUS GLEYS—MODERATE TO LOW BASE STATUS

| Species | Broad-leaved Woodland—in policies | Broad-leaved Woodland—shelterbelt | Alderwood | Birchwood | Marshy Pasture | Very Old Pasture | Old Pasture |
|---|---|---|---|---|---|---|---|
| *Acer pseudoplatanus* | lf | f-la | | | | | |
| *Aesculus hippocastanum* | l | | | | | | |
| *Alnus glutinosa* | | | d | | | | |
| *Betula pubescens* | | | l | | | | |
| *B. pubescens/verrucosa* | | | | a-d | | | |
| *Fagus sylvatica* | f-la | | | | | | |
| *Fraxinus excelsior* | f-la | la | lf | o-lf | | | |
| *Prunus padus* | | | o | | | | |
| *Quercus robur* | | | | o-lf | | | |
| *Sorbus aucuparia* | | | o | lf-f | | | |
| *Ulmus glabra* | f | d | | | | | |
| — | | | | | | | |
| *Crataegus monogyna* | | lf | | | | | |
| *Rhododendron ponticum* | la | la | | | | | |
| — | | | | | | | |
| *Acer pseudoplatanus* seedlings | f-la | | | | | | |
| *Achillea millefolium* | | | | | | | f-la |
| *A. ptarmica* | | | | | f | o | o-f |
| *Agrostis canina* | | | la | la | lf | | |
| *A. tenuis* | f-a | la | f-la | lf | | a | d |

TABLE 26—continued

| Species | Broadleaved Woodland—in policies | Broadleaved Woodland—shelterbelt | Alderwood | Birchwood | Marshy Pasture | Very Old Pasture | Old Pasture |
|---|---|---|---|---|---|---|---|
| *Angelica sylvestris* | | | l | | | | |
| *Anthoxanthum odoratum* | | | | lf | f | a | f |
| *Athyrium filix-femina* | o | | o-lf | | | | |
| *Bellis perennis* | o | | | | | | |
| *Betula pubescens* seedlings | o | | | | | | |
| *Calluna vulgaris* | | | | | lf | | |
| *Cardamine* sp. | | o | | l | | | |
| *Carex flacca* | | | | | l | | |
| *C. ovalis* | | | | | | o | o |
| *C. panicea* | | | | | lf | | |
| *C. pulicaris* | | | | | o | | |
| *Cerastium vulgatum* | o-f | | | | | | f |
| *Chamaenerion angustifolium* | lf | lf | | | | | |
| *Circaea lutetiana* | lf | | | | | | |
| *Cirsium palustre* | o | f-la | lf | | o-f | a | |
| *Cynosurus cristatus* | | | | | | | f |
| *Dactylis glomerata* | f | f-la | | | | | |
| *Deschampsia caespitosa* | o | a-d | o | a-d | f | f-a | |
| *Digitalis purpurea* | | | o | | | | |
| *Dryopteris austriaca* | | | a | o-lf | | | |
| *D. filix-mas* | o | o | o | o | | | |
| *Epilobium montanum* | lf | o | | | | | |
| *E. obscurum* | | o | | | | | |
| *Equisetum sylvaticum* | | | | f-la | | | |
| *Erica tetralix* | | | | | l-lf | | |
| *Euphrasia* sp. | | | | | l | | |
| *Festuca rubra* | | a | | | a | | |
| *Fragaria vesca* | a | l | | | | | |
| *Fraxinus excelsior* seedlings | | | o | | | | |
| *Galium aparine* | | l | | | | | |
| *G. saxatile* | | | f-la | | | | o |
| *Geum urbanum* | lf | f | | | | | |
| *Holcus lanatus* | f-la | | | la-ld | a | a | a |
| *H. mollis* | lf | lf-la | d | ld | | | |
| *Juncus acutiflorus* | | | | lf | d | | |
| *J. conglomeratus* | | | | o | | o-f | |
| *J. effusus* | f-la | | f-ld | lf | | a-ld | lf |
| *J. squarrosus* | o | | | | | | |
| *Lathyrus montanus* | | | | | o-lf | | |
| *L. pratensis* | | | | | f | | o-lf |
| *Leontodon autumnalis* | | | | | o | o | f-la |
| *Lotus corniculatus* | | | | | o | | la |
| *L. uliginosus* | | | | | | f | |
| *Luzula campestris* | | | | | | o | |
| *L. multiflora* | o | | | | | | |
| *Myosotis arvensis* | | o-lf | | | | | |
| *Nardus stricta* | | | | | lf | | |
| *Orchis* sp. | | | | | o | | |
| *Oxalis acetosella* | | | f-a | l | | | |
| *Plantago lanceolata* | | | | | f | | f-a |
| *Poa annua* | l | | | | | | |
| *P. pratensis* | lf-la | | | | | | lf |
| *P. trivialis* | | f | la | | | | |
| *Potentilla erecta* | | | o | o | o | | |
| *Prunella vulgaris* | f | lf | | | o-lf | | o-f |
| *Ranunculus acris* | | | | | f-a | f-a | |
| *R. flammula* | | | | | l | | |
| *R. repens* | f-la | lf | | lf | | f | l |

TABLE 26—continued

| Species | Broadleaved Woodland—in policies | Broadleaved Woodland—shelterbelt | Alderwood | Birchwood | Marshy Pasture | Very Old Pasture | Old Pasture |
|---|---|---|---|---|---|---|---|
| *Rhinanthus* sp. | | | | | lf | | |
| *Rubus idaeus* | l | a | l | la | | | |
| *Rumex acetosa* | lf | | a | la | o | f | |
| *Sagina procumbens* | f-la | | | | | | |
| *Senecio jacobaea* | f-a | o | | | | | o-f |
| *Stachys sylvatica* | | | l | | | | |
| *Stellaria alsine* | | | | l | | | |
| *Succisa pratensis* | | | o | o | lf | | |
| *Trifolium pratense* | | | | | | | o |
| *T. repens* | | | | | la | f | a |
| *Ulex europaeus* | | | | | lf | | |
| *Urtica dioica* | l | a | | | | | |
| *Veronica chamaedrys* | f | o | o | | | | |
| *V. officinalis* | l | | | | | | |
| *V. serpyllifolia* | | o | | | | | |
| *Viola palustris* | | | o-la | | | | |
| *V. riviniana* | o | lf | o | | | | |
| — | | | | | | | |
| *Acrocladium cuspidatum* | | | | | lf | | |
| *Atrichum undulatum* | l | l | | | | | |
| *Brachythecium rutabulum* | lf | | | | | | |
| *Ceratodon purpureus* | lf | | | | | | |
| *Cirriphyllum piliferum* | | | l | l | | | |
| *Dicranum bonjeani* | | | | | l | | |
| *Eurhynchium praelongum* | lf | la | f-la | lf | | | |
| *E. striatum* | lf | | l | | | | |
| *Hylocomium splendens* | | | | | la | la | |
| *Hypnum cupressiforme* | l | l | | | | | |
| *Isothecium myurum* | | l | | | | | |
| *Lophocolea bidentata* | | lf | | lf | | | lf |
| *Mnium hornum* | la | | | | | | |
| *M. punctatum* | | | | | l | | |
| *M. undulatum* | lf | lf | | | | | |
| *Polytrichum commune* | | | | la | l | | |
| *Pseudoscleropodium purum* | | | l | lf | lf-la | | |
| *Rhytidiadelphus squarrosus* | | | la | lf-la | lf | la | la-a |
| *R. triquetrus* | | | l | | l | | |
| *Sphagnum palustre* | | | | l | l | | |
| *S. squarrosum* | | | | | lf | | |
| *Thuidium tamariscinum* | la | la-a | a | lf | | | |
| — | | | | | | | |
| *Cladonia pyxidata* | l | | | | | | |

## TABLE 27. NON-CALCAREOUS GLEYS—LOW BASE STATUS

| Species | Birchwood | Scots Pine Plantation—50 years old | Scots Pine Plantation—30 years old | Norway Spruce Plantation—very young | Wet Grassy Heath |
|---|---|---|---|---|---|
| *Betula pubescens* | d | | | | |
| *B. verrucosa* | o-f | | | | |
| *B. pubescens/verrucosa* | | f | | a | |
| *Fagus sylvatica* | | lf | | | |
| *Picea abies* | | o | | a | |
| *Pinus sylvestris* | | d | d | | |
| *Sorbus aucuparia* | o | | | o | |
| — | | | | | |
| *Agrostis canina* | lf | lf | lf | a | f-la |
| *Blechnum spicant* | | | | o-lf | |
| *Calluna vulgaris* | la | f-ld | la | a-d | a |
| *Carex binervis* | | lf | o-lf | | l |
| *C. echinata* | | lf | | | |
| *C. nigra* | | l | | l | |
| *C. pilulifera* | | | | | lf |
| *Carex* sp. | | | | | o |
| *Chamaenerion angustifolium* | | o | | o | |
| *Deschampsia caespitosa* | | | | l | |
| *D. flexuosa* | l-f | lf-f | a-d | la | a |
| *Dryopteris austriaca* | | | f | | |
| *Empetrum nigrum* | | o | | | o |
| *Erica tetralix* | l | f | o | o | a |
| *Galium saxatile* | | | | lf | o |
| *Holcus lanatus* | | | l | | |
| *H. mollis* | la | | | la | |
| *Hypericum pulchrum* | | | o | | |
| *Juncus effusus* | | l | | o-lf | |
| *J. squarrosus* | | l | | | lf |
| *Lonicera periclymenum* | lf | | | | |
| *Luzula campestris* | | | | | l |
| *L. pilosa* | l | o | | o-lf | |
| *L. multiflora* | | l | | | |
| *L. sylvatica* | | o | | | |
| *Nardus stricta* | | | | | a |
| *Oxalis acetosella* | | | | l | |
| *Potentilla erecta* | | | | f | f-a |
| *Trientalis europaea* | o | | | | |
| *Vaccinium myrtillus* | o | a-d | l | l | f |
| *V. vitis-idaea* | | la | | | |
| — | | | | | |
| *Atrichum undulatum* | | l | | | |
| *Dicranella heteromalla* | | l | | | |
| *Dicranum scoparium* | | lf | lf | | f |
| *Hylocomium splendens* | la | la | lf | la | lf |
| *Hypnum cupressiforme* | l | | | l-la | lf |
| *Plagiothecium undulatum* | | la | la | | |
| *Pleurozium schreberi* | la | la-a | a | la | la-a |
| *Pohlia nutans* | | l | l | | |
| *Polytrichum aloides* | | l | | | |
| *P. commune* | d | la | la | la | la |
| *Pseudoscleropodium purum* | l | | | l | |
| *Ptilidium ciliare* | | | | | l |
| *Rhytidiadelphus loreus* | | l | | | |
| *R. squarrosus* | l | | | | |
| *R. triquetrus* | la | l | | | |
| *Sphagnum girgensohnii* | | | | l-la | |

TABLE 27—continued

| Species | Birchwood | Scots Pine Planation—50 years old | Scots Pine Plantation—30 years old | Norway Spruce Plantation—very young | Wet Grassy Heath |
|---|---|---|---|---|---|
| *Sphagnum plumulosum* | la | l | | | |
| — | | | | | |
| *Cladonia cenotea* | | | | | l |
| *C. coccifera* | | | | | lf-la |
| *C. cornuta* | | | | | l |
| *C. deformis* | | | | | l |
| *C. floerkeana* | | | | | l |
| *C. gracilis* | | | | | l |
| *C. impexa* | | | | | lf |
| *C. macilenta* | | | | | lf |
| *C. pyxidata* | | | | | lf |
| *Hypogymnia physodes* | lf | | | | |

## TABLE 28. PEATY GLEYS

| Species | Alderwood | Marsh | Marsh | Open Pinewood | Wet Heath—very poorly drained | Wet Heath—poorly drained |
|---|---|---|---|---|---|---|
| *Alnus glutinosa* | d | | | | | |
| *Betula pubescens* | lf-ld | | | | | |
| *Pinus sylvestris* | | | | lf | | |
| — | | | | | | |
| *Achillea ptarmica* | | lf | | | | |
| *Agrostis canina* | lf | | a | | f-la | |
| *A. canina* var. *canina* | | | | la | | |
| *A. stolonifera* | l | | | | | |
| *A. tenuis* | l | | | lf | | |
| *Angelica sylvestris* | | o | o | | | |
| *Anthoxanthum odoratum* | o | | | | | |
| *Betula pubescens* seedlings | lf | | | | | |
| *Calluna vulgaris* | | | | f | a-ld | d |
| *Caltha palustris* | | la | | | | |
| *Cardamine pratensis* | | f | | | | |
| *Cardamine* sp. | | | f | | | |
| *Carex binervis* | | | | | | f |
| *C. nigra* | | | | | la | l |
| *Carex* spp. | | | | la | lf | |
| *Chamaenerion angustifolium* | f | | | | | |
| *Cirsium palustre* | | o | o-f | | | |
| *Crepis paludosa* | | la | | | | |
| *Deschampsia flexuosa* | | | | lf | f-a | |
| *Dryopteris austriaca* | a | | | | | |
| *Empetrum nigrum* | | | | | lf | |
| *Epilobium obscurum* | | | a | | | |
| *E. palustre* | | | lf | | | |
| *Erica tetralix* | | | | f-ld | f-a | f-a |
| *Eriophorum angustifolium* | | | | lf | f-a | |

TABLE 28—continued

| Species | Alderwood | Marsh | Marsh | Open Pinewood | Wet Heath—very poorly drained | Wet Heath—poorly drained |
|---|---|---|---|---|---|---|
| *Eriophorum vaginatum* | l | | | | f-a | |
| *Filipendula ulmaria* | | | l | | | |
| *Galium palustre* | lf | | a | l | | |
| *G. uliginosum* | | a | | | | |
| *Holcus lanatus* | | la | o | | | |
| *H. mollis* | | la | lf | | | |
| *Hydrocotyle vulgaris* | | | | l | | |
| *Juncus acutiflorus* | lf | d | | | | |
| *J. articulatus* | lf | | | | | |
| *J. bufonius* | o | | | | | |
| *J. bulbosus* | la | | | | | |
| *J. effusus* | f-la | | d | f-ld | | |
| *J. squarrosus* | | | | | l | la |
| *Luzula multiflora* | | | | | o | |
| *Nardus stricta* | | | | | | o-f |
| *Narthecium ossifragum* | | | | | la | |
| *Orchis* spp. | | | | | o-f | l |
| *Poa trivialis* | | f-a | | | | |
| *Potentilla erecta* | | | | o | lf | |
| *Ranunculus flammula* | | | | l | | |
| *R. repens* | l-la | lf | | | | |
| *Rumex acetosa* | | a | a | | l | |
| *R. obtusifolius* | | | o | | | |
| *Stellaria graminea* | | l | | | | |
| *Trichophorum caespitosum* | | | | | f | la |
| *Trientalis europaea* | | | | | lf | |
| *Urtica dioica* | | f | | | | |
| *Vaccinium myrtillus* | | | | | | l |
| *Veronica scutellata* | | | | l | | |
| *Viola palustris* | | | la | l | | |
| — | | | | | | |
| *Acrocladium cuspidatum* | | | lf | l | | |
| *Aulacomnium palustre* | | | | la | lf | |
| *Brachythecium rivulare* | | | la-a | | | |
| *B. rutabulum* | | f | | | | |
| *Calypogeia* sp. | | | | | | l |
| *Campylopus flexuosus* | | | | | | l |
| *C. piriformis* | l | | | | | |
| *Cephalozia bicuspidata* | | | | | | l |
| *Dicranella heteromalla* | la | | | | | |
| *Dicranum scoparium* | l | | | | l | l |
| *Diplophyllum albicans* | | | | | | f |
| *Eurhynchium praelongum* | l | | lf | | | |
| *Hypnum cupressiforme* var. *ericetorum* | | | | | | la |
| *Lophocolea bidentata* | | | lf-la | | | |
| *L. cuspidata* | lf-la | | | | | |
| *Lophozia* sp. | | | | | | l |
| *Mnium hornum* | lf | | | | | |
| *Pellia epiphylla* | lf | | | | | |
| *Plagiothecium undulatum* | | | | | | l |
| *Pleurozium schreberi* | | | | | | l |
| *Polytrichum commune* | lf | | | | la | |
| *Polytrichum* sp. | | | | | | l |
| *Rhytidiadelphus squarrosus* | | | lf | | | |
| *Sphagnum compactum* | | | | | | a |
| *S. palustre* | la | | | | l | |
| *S. papillosum* | | | | la | | |

TABLE 28—continued

| Species | Alderwood | Marsh | Marsh | Open Pinewood | Wet Heath—very poorly drained | Wet Heath—poorly drained |
|---|---|---|---|---|---|---|
| *Sphagnum plumulosum* | | | | | | l |
| *S. squarrosum* | la-a | | | | | |
| *S. subsecundum* | | | | la | | |
| *S. subsecundum* var. *inundatum* | | | | la | | |
| *Sphagnum* sp. | | | | | f-a | |
| *Thuidium tamariscinum* | l | | | | | |
| — | | | | | | |
| *Cladonia digitata* | | | | | | la |
| *C. fimbriata* | | | | | | la |
| *C. floerkeana* | | | | | | la |
| *C. impexa* | | | | | l | la |
| *C. pyxidata* | | | | | l | |
| *C. squamosa* | | | | | | la |
| *Cladonia* sp. | | | | | l | |

## TABLE 29. SOILS DERIVED FROM ULTRABASIC ROCKS—FREELY DRAINED

| Species | Scots Pine Shelter-belt | Permanent Pasture | Gorse Scrub | Heathy Gorse Scrub—periodically burned | Grassy Heath—with gorse | Heath—with juniper |
|---|---|---|---|---|---|---|
| *Pinus sylvestris* | d | | | | | |
| — | | | | | | |
| *Juniperus communis* | | | | | | f-la |
| *Sarothamnus scoparius* | | lf | | | | |
| *Ulex europaeus* | | la-ld | d | d | a | |
| — | | | | | | |
| *Agrostis canina* | | lf | lf | o-f | la | |
| *A. tenuis* | a | a | f-la | lf | f-la | |
| *Anthoxanthum odoratum* | | f | | | lf | |
| *Blechnum spicant* | | | | | | o |
| *Calluna vulgaris* | | l-la | | | f-a | d |
| *Campanula rotundifolia* | | | | o | l | f |
| *Carex panicea* | | | | | lf | |
| *C. pulicaris* | | | | | o | |
| *Cerastium vulgatum* | o-lf | | o | | | |
| *Deschampsia caespitosa* | f-a | o-lf | a | | | f |
| *D. flexuosa* | | o | | | | |
| *Empetrum nigrum* | | l | | | | f |
| *Erica cinerea* | | l-lf | | f-a | a-d | |
| *Festuca ovina* | | a | | | f-la | lf |
| *F. rubra* | a | a-d | a | | lf | f-a |
| *Galium saxatile* | | o | | o | l | |
| *G. verum* | | lf | lf | | lf-f | o |
| *Genista anglica* | | o | | | | |

TABLE 29—continued

| Species | Scots Pine Shelter-belt | Permanent Pasture | Gorse Scrub | Heathy Gorse Scrub—periodically burned | Grassy Heath—with gorse | Heath—with juniper |
|---|---|---|---|---|---|---|
| *Helictotrichon pratense* | | f-la | | | | |
| *Holcus lanatus* | lf | | lf | | | |
| *Hypericum pulchrum* | | o | | o | f | |
| *Koeleria gracilis* | | | o-f | | | |
| *Lathyrus montanus* | o | l | | | o-f | |
| *Luzula pilosa* | | o | | | | |
| *Molinia caerulea* | | l | | lf | a | |
| *Nardus stricta* | | | | | | l |
| *Plantago lanceolata* | | | | | lf | |
| *P. maritima* | | | | | o | |
| *Poa pratensis* | a-d | f | lf | | | |
| *Polygala serpyllifolia* | | o | | | o-f | |
| *Potentilla erecta* | | o-f | | o-lf | o-f | |
| *Rubus idaeus* | | | la | | | |
| *Rumex acetosa* | o | f | o | | | |
| *Rumex* sp. | o | | | | | |
| *Senecio jacobaea* | | | o | | | |
| *Sieglingia decumbens* | | | | | la | |
| *Stellaria media* | lf | | | | | |
| *Succisa pratensis* | | | | l | f-a | |
| *Trientalis europaea* | | | | lf | lf | |
| *Vaccinium myrtillus* | | | | | | f |
| *V. vitis-idaea* | | | | | | lf |
| *Veronica chamaedrys* | | o | | | | |
| *Vicia cracca* | | lf | o | | | |
| *Viola riviniana* | f | f | o-f | o | f | |
| *V. tricolor* | | | o-lf | | | |
| — | | | | | | |
| *Brachythecium rutabulum* | | | la | l | | |
| *Dicranella heteromalla* | | | | l | | |
| *Dicranum scoparium* | | | | | l | |
| *Eurhynchium praelongum* | la | | a | l | | |
| *Hylocomium splendens* | | lf | | l | | a |
| *Hypnum cupressiforme* | | | | | la | l |
| *H. cupressiforme* var. *ericetorum* | | | | lf-la | | |
| *Lophocolea bidentata* | | | | lf | | |
| *Leucobryum glaucum* | | | | | l | o |
| *Pleurozium schreberi* | | l | | | la | a |
| *Pseudoscleropodium purum* | l | | l | | | |
| *Rhytidiadelphus loreus* | | | | | | l |
| *R. squarrosus* | a | l | a | | | |
| *R. triquetrus* | | l | | | | la |
| — | | | | | | |
| *Cladonia fimbriata* | | | | | lf | |
| *C. impexa* | | | | | l | |
| *C. sylvatica* | | | | | l | |
| *C. uncialis* | | | | | l | |

TABLE 29—continued

| Species | Imperfectly Drained: Heath | Imperfectly Drained: Grassy Heath—previous community recently burned | Imperfectly Drained: Juniper Scrub | Poorly Drained: *Molinia* Grassland | Poorly Drained: Wet Heath |
|---|---|---|---|---|---|
| *Pinus sylvestris* | | | o | | |
| — | | | | | |
| *Juniperus communis* | f-la | | a-d | | |
| *Ulex europaeus* | | | o-la | o-la | |
| — | | | | | |
| *Agrostis canina* | f | a | f-la | | f |
| *A. tenuis* | | f | | | |
| *Aira praecox* | | | l | | |
| *Anthoxanthum odoratum* | | | f | | |
| *Calluna vulgaris* | d | f-la | f-a | lf | d |
| *Campanula rotundifolia* | o | o | lf | | |
| *Carex binervis* | o | | | | |
| *C. echinata* | | | | o | |
| *C. panicea* | | f-la | lf | f-a | |
| *C. pilulifera* | | | lf | | |
| *Carex* sp. | | o | | | |
| *Cerastium vulgatum* | | | o-f | o | |
| *Cirsium arvense* | | | l | | |
| *Deschampsia caespitosa* | lf-f | f-la | lf-la | f | f-la |
| *D. flexuosa* | | | f | | |
| *Empetrum nigrum* | lf | lf | o | | o |
| *Erica cinerea* | | | o | | |
| *E. tetralix* | | | l | | |
| *Eriophorum angustifolium* | | | | | f-a |
| *Festuca ovina* | f-la | a-d | f-a | f-la | lf |
| *F. rubra* | f | f | f-a | a | f |
| *Galium saxatile* | | | lf | | |
| *G. verum* | | | f | lf | |
| *Helictotrichon pratense* | o-lf | | o | o | |
| *Juncus bulbosus* | | | | lf | |
| *J. squarrosus* | o | | | l | la |
| *Lotus corniculatus* | | | l | | |
| *Luzula pilosa* | o | | | | |
| *Luzula* sp. | | o | | | |
| *Molinia caerulea* | | | lf | d | l |
| *Nardus stricta* | o | | | | |
| *Polygala serpyllifolia* | | o | f | | |
| *Potentilla erecta* | o | o-f | lf | o-f | o |
| *Ranunculus acris* | | | | o | |
| *Rumex acetosella* | | | o-lf | | |
| *Sagina procumbens* | | | o | | |
| *Trientalis europaea* | | | l | | |
| *Vaccinium myrtillus* | o-lf | lf | | | |
| *Veronica chamaedrys* | | | o | | |
| *Vicia* sp. | | | | | o |
| *Viola riviniana* | | o | f | | |
| — | | | | | |
| *Bryum pseudotriquetrum* | | | | l | |
| *Ceratodon purpureus* | | la | la | | |
| *Dicranum scoparium* | | l | | | |
| *Hylocomium splendens* | a | la | la | l | a |
| *Hypnum cupressiforme* | la | lf | | | |
| *H. cupressiforme* var. *ericetorum* | | | | | lf |
| *Pleurozium schreberi* | la | la | la | | l |
| *Rhytidiadelphus loreus* | l | | | | |
| *R. triquetrus* | la | l | lf | | |

TABLE 30. BASIN PEAT

| Species | Alderwood | Birchwood—peat formerly cut-over and drained | Sedge-Cotton-grass Community | Sedge-Rush Community—remains of cut-over moss | *Calluna–Myrica–Molinia–Erica tetralix* Community | Raised Moss Community | Raised Moss Community |
|---|---|---|---|---|---|---|---|
| *Alnus glutinosa* | ld | | | | | | |
| *Betula pubescens* | o | d | | | } f | | |
| *B. verrucosa* | | o-lf | | | | | |
| *Fraxinus excelsior* | f-la | | | | | | |
| *Sorbus aucuparia* | | f | | | | | |
| — | | | | | | | |
| *Agrostis canina* | | | lf | | | | |
| *A. canina* var. *canina* | | | | | la | | |
| *A. tenuis* | | | | | | l | |
| *Anthoxanthum odoratum* | | | | f | | | |
| *Betula* seedlings | | o | | | | | |
| *Calluna vulgaris* | | la | | la | a-ld | d | cod |
| *Cardamine pratensis* | | | | o-f | | | |
| *Carex curta* | | | a | | | | |
| *C. diandra* | | | | la | | | |
| *C. nigra* | | | | a-ld | | | |
| *C. rostrata* | | | a | lf | l | | |
| *Carex* spp. | | | | | f | | |
| *Cerastium vulgatum* | | | | o | | | |
| *Cirsium palustre* | f | | | o | | | |
| *Deschampsia caespitosa* | a-d | | | | | | |
| *D. flexuosa* | | lf-f | | | | l | |
| *Drosera anglica* | | | | | | o | |
| *D. rotundifolia* | | | | | | o | l |
| *Dryopteris austriaca* | a | a | | | | | |
| *Eleocharis pauciflora* | | | | la | | | |
| *Empetrum nigrum* | | | | o | | | f |
| *Epilobium palustre* | | | | o | | | |
| *Equisetum arvense* | | | | l | | | |
| *E. fluviatile* | | | | l | l | | |
| *Erica tetralix* | | | | f-la | a | f-a | f |
| *Eriophorum angustifolium* | | | a | lf | lf-la | a | f |
| *E. vaginatum* | | | | | | f-la | cod |
| *Festuca* sp. | | | | | l-la | | |
| *Galium aparine* | o | | | | | | |
| *G. palustre* | o | | | | | | |
| *G. saxatile* | | la-a | | | | | |
| *Holcus lanatus* | a | | | a | | | |
| *Juncus articulatus* | | | | la-ld | | | |
| *J. effusus* | l | | lf | | l | | |
| *Luzula campestris* | | | | lf | | | |
| *L. pilosa* | | lf | | | | | |
| *Lychnis flos-cuculi* | | | | o | | | |
| *Menyanthes trifoliata* | | | | la | | | |
| *Molinia caerulea* | | | | | a | | |
| *Myrica gale* | | | | | a | | |
| *Nardus stricta* | | | | | l | | |
| *Narthecium ossifragum* | | | | | | la | la |
| *Orchis* sp. | | | | o | | | |
| *Parnassia palustris* | | | | a | | | |
| *Pinguicula vulgaris* | | | | o | | | |
| *Poa annua* | | | | | | l | |
| *Potentilla palustris* | | | lf | lf-la | l | | |
| *Ranunculus acris* | | | | o | | | |
| *R. repens* | lf | | | | | | |
| *Rhinanthus stenophyllus* | | | | la | | | |
| *Rubus idaeus* | lf | | | | | | |
| *R. fruticosus* | l | | | | | | |

TABLE 30—continued

| Species | Alderwood | Birchwood—peat formerly cut-over and drained | Sedge–Cotton-grass Community | Sedge–Rush Community—remains of cut-over moss | *Calluna–Myrica–Molinia–Erica tetralix* Community | Raised Moss Community | Raised Moss Community |
|---|---|---|---|---|---|---|---|
| *Rumex acetosa* | a | | | | | | |
| *R. acetosella* | | lf | | | | | |
| *Succisa pratensis* | | | | f | | | |
| *Trichophorum caespitosum* | | | | | | o-lf | |
| *Trifolium pratense* | | | | l | | | |
| *T. repens* | | | | f-a | | | |
| *Viola palustris* | | | | | l | | |
| — | | | | | | | |
| *Acrocladium cuspidatum* | | | | lf | | | |
| *A. giganteum* | | | | l | | | |
| *A. stramineum* | | | | | l | | |
| *Aulacomnium palustre* | | | | lf-la | la | l | lf |
| *Brachythecium rutabulum* | la | | | | | | |
| *Bryum* sp. | | | | l | | | |
| *Calypogeia trichomanis* | | | | | | | lf |
| *Campylium stellatum* | | | | la | | | |
| *Campylopus flexuosus* | | | | | | lf | l |
| *Cephalozia bicuspidata* | | | | | | l | |
| *Cephalozia* sp. | | | | | | | l |
| *Ceratodon purpureus* | | | | | | lf | |
| *Dicranella heteromalla* | | lf | | | | | |
| *Dicranum scoparium* | | f | | | | l | l |
| *Drepanocladus vernicosus* | | | | la | | | |
| *D. fluitans* | | | | | | l | |
| *Drepanocladus* sp. | | | | | l | | |
| *Eurhynchium praelongum* | lf | | | | | | |
| *Gymnocolea inflata* | | | | | | l | lf |
| *Hylocomium splendens* | | l | | | la | | |
| *Hypnum cupressiforme* | | l | | | la | | |
| *H. cupressiforme* var. *ericetorum* | | | | | | lf | f |
| *Lophocolea bidentata* | la | l | | l | | | |
| *Lophozia ventricosa* | | | | | | l | |
| *Mnium hornum* | | l | | | l | | |
| *M. undulatum* | | | | l | | | |
| *Odontoschisma sphagni* | | | | | | | lf-f |
| *Pellia epiphylla* | l | | | | | | |
| *P. fabbroniana* | | | | l | | | |
| *Philonotis fontana* | | | | lf | | | |
| *Plagiothecium undulatum* | | l | | | | | |
| *Pleurozium schreberi* | | | | | | | f |
| *Pohlia nutans* | | | | | | lf | lf |
| *Polytrichum commune* | | lf | lf | | | | |
| *P. formosum* | | lf | | | | | |
| *Sphagnum cuspidatum* | | | a | | la | lf-la | lf |
| *S. palustre* | | | | lf | | | |
| *S. papillosum* | | | | | la | | l |
| *S. plumulosum* | | | | | la | lf | la |
| *S. rubellum* | | | | | | | la |
| *S. subsecundum* var. *auriculatum* | | | | | la | | |
| *S. tenellum* | | | | | | | l |
| *S. teres* | | | | la-a | | | |
| *Thuidium tamariscinum* | lf | | | | | | |
| — | | | | | | | |
| *Cladonia coccifera* | | | | | | | l |
| *C. impexa* | | | | | | l | lf |
| *C. pyxidata* | | | | | | l | |

## TABLE 31. HILL PEAT

| Species | Cotton-grass–Heather Community | Cotton-grass–Heather Community—on saddle | Heather-dominated Community—on 'hagged' peat | Heather–Cloudberry Community |
|---|---|---|---|---|
| *Calluna vulgaris* | cod | a-cod | d | a-d |
| *Deschampsia flexuosa* | f-la | | | |
| *Drosera rotundifolia* | | o | | |
| *Dryopteris spinulosa* | lf-f | | | |
| *Empetrum nigrum* | f | a | f-a | f-la |
| *Erica tetralix* | f | | o-f | |
| *Eriophorum angustifolium* | la | la-ld | la | |
| *E. vaginatum* | cod | a-cod | a | o |
| *Juncus bulbosus* | | | l | |
| *J. squarrosus* | | | lf | |
| *Listera cordata* | | | l | |
| *Narthecium ossifragum* | l | | | |
| *Rubus chamaemorus* | | l | | va |
| *Vaccinium myrtillus* | | | lf | a |
| *V. vitis-idaea* | | | | f |
| — | | | | |
| *Calypogeia trichomanis* | f | | l | |
| *Cephalozia* sp. | f | | | |
| *Dicranum scoparium* | o | o | la | o-f |
| *Hylocomium splendens* | | f | l | |
| *Hypnum cupressiforme* | | | lf | f-la |
| *H. cupressiforme* var. *ericetorum* | f | f | | |
| *Leucobryum glaucum* | | | | l |
| *Mylia anomala* | lf | la | | |
| *Odontoschisma sphagni* | f | | | |
| *Plagiothecium undulatum* | o | | | |
| *Pleurozium schreberi* | f-la | f | | |
| *Pohlia nutans* | | | | f |
| *Polytrichum commune* | l | | | |
| *Rhytidiadelphus loreus* | | | l | |
| *Sphagnum cuspidatum* | lf | la | la | |
| *S. girgensohnii* | | lf | | |
| *S. palustre* | l | | | |
| *S. plumulosum* | la | a | la | la |
| *S. papillosum* | | lf | l | |
| — | | | | |
| *Cladonia fimbriata* | | l | | |
| *C. impexa* | l | a | la | |
| *C. pyxidata* | l | | | |
| *Cladonia* spp. | l | | | f |
| *Hypogymnia physodes* | | | f | |
| *Sphaerophorus melanocarpus* | | l | | |

TABLE 32. DUNES

| Species | Embryonic Dunes | Yellow Dunes—early stage | Yellow Dunes—later stage | Grey Dunes |
|---|---|---|---|---|
| *Achillea millefolium* | | | | lf |
| *Agropyron junceiforme* | | | la | |
| *Agrostis tenuis* | | | | a |
| *Ammophila arenaria* | | d | d | a |
| *A. arenaria* seedlings | a | | | |
| *Angelica sylvestris* | | | o | |
| *Cakile maritima* | | o | | |
| *Calluna vulgaris* | | | | lf |
| *Campanula rotundifolia* | | | | f |
| *Carex arenaria* | | | | la |
| *Cerastium vulgatum* | | | | o |
| *Cirsium arvense* | | la | | |
| *Dactylis glomerata* | | | o | |
| *Elymus arenarius* | | | f-la | |
| *Festuca ovina* | | | | lf-la |
| *F. rubra* | | | la | lf |
| *F. rubra* var. *arenaria* | | la | | |
| *Galium verum* | | | | lf |
| *Hieracium pilosella* | | | | l |
| *Hypochaeris radicata* | | | lf | |
| *Koeleria gracilis* | | | | f-a |
| *Lathyrus pratensis* | | | l | |
| *Lotus corniculatus* | | | o | l |
| *Luzula campestris* | | | | l |
| *Ranunculus* sp. | | | o | |
| *Rumex crispus* | | o | | |
| *Senecio jacobaea* | | lf | o | o |
| *Sonchus arvensis* | | lf | | |
| *Taraxacum officinale* | | | o | |
| *Thalictrum minus* | | | o-la | |
| *Thymus drucei* | | | | f-la |
| *Trifolium repens* | | | | la |
| *Veronica officinalis* | | | | o |
| *Vicia cracca* | | | l | |
| *Viola canina* | | | | lf |
| *V. riviniana* | | | | lf |
| — | | | | |
| *Brachythecium albicans* | | | l | lf |
| *Bryum* sp. | | | la-a | |
| *Ceratodon purpureus* | | | f | |
| *Climacium dendroides* | | | | lf |
| *Hylocomium splendens* | | | | la |
| *Pleurozium schreberi* | | | | la |
| *Rhytidiadelphus squarrosus* | | | | la |
| *R. triquetrus* | | | | lf |
| *Tortula ruraliformis* | | | l | lf |
| — | | | | |
| *Cladonia sylvatica* | | | | la |
| *Peltigera canina* | | | | lf |

## TABLE 33. DUNE SLACKS, LINKS AND CLIFFS

| Species | Dune Slack Community | Pasture on Links | Heath on Old Fixed Dune | Pasture on Sea Cliff |
|---|---|---|---|---|
| *Achillea millefolium* | | o | | |
| *Agrostis canina* | | la | | |
| *A. stolonifera* | d | | | |
| *A. tenuis* | | a | lf-la | f-a |
| *Aira praecox* | | | lf | |
| *Ammophila arenaria* | l | lf | l | |
| *Anthoxanthum odoratum* | | f | | o-f |
| *Anthyllis vulneraria* | | | | lf |
| *Armeria maritima* | | | | lf |
| *Bellis perennis* | l | | | f |
| *Calluna vulgaris* | | o | d | |
| *Campanula rotundifolia* | | lf | o | f |
| *Cardamine pratensis* | lf | | | |
| *Carex arenaria* | lf-f | la | a | |
| *C. flacca* | o-lf | | | |
| *Carex* sp. | | | | lf |
| *Cerastium vulgatum* | | o | | f |
| *Cirsium arvense* | | | | f |
| *Cynosurus cristatus* | o | | | f |
| *Dactylis glomerata* | | | | o-a |
| *Deschampsia caespitosa* | l | | | |
| *Eleocharis palustris* | lf-ld | | | |
| *Empetrum nigrum* | | | f-a | |
| *Equisetum arvense* | | | | lf |
| *Erica cinerea* | | | o-f | |
| *E. tetralix* | | l | | |
| *Euphrasia brevipila* | l | | | lf |
| *Festuca ovina* | | d | o | |
| *F. rubra* | la | | a-ld | |
| *Galium palustre* | lf | | | |
| *G. saxatile* | | a | | |
| *G. verum* | l | | | la |
| *Gentianella campestris* | o | | | |
| *Heracleum sphondylium* | | | | o-f |
| *Holcus lanatus* | f | l | | a |
| *Hydrocotyle vulgaris* | a | | | |
| *Hypochaeris radicata* | | | | f |
| *Juncus articulatus* | l | | | l |
| *J. gerardi* | lf | | | |
| *J. squarrosus* | | lf | lf | |
| *Koeleria gracilis* | | lf | | lf |
| *Lathyrus pratensis* | f-a | | | |
| *Leontodon autumnalis* | o | | | lf |
| *Linum catharticum* | o-lf | | | lf |
| *Lolium perenne* | | | | lf |
| *Lotus corniculatus* | lf-f | | | f |
| *Luzula campestris* | | f-la | | l |
| *Lychnis flos-cuculi* | l | | | |
| *Mentha* sp. | l-la | | | |
| *Myosotis palustris* | l | | | |
| *Nardus stricta* | | f | | |
| *Parnassia palustris* | f-la | | | l |
| *Pedicularis palustris* | l | | | |
| *Plantago lanceolata* | l | | | f |
| *P. maritima* | | | | f |
| *Poa pratensis* | lf | lf | | |
| *P. trivialis* | lf | | | |
| *Potentilla anserina* | la-a | | | |
| *P. erecta* | | o | | |

TABLE 33—continued

| Species | Dune Slack Community | Pasture on Links | Heath on Old Fixed Dune | Pasture on Sea Cliff |
|---|---|---|---|---|
| *Primula vulgaris* | | | | l |
| *Prunella vulgaris* | f | | | o |
| *Ranunculus acris* | o-f | | | |
| *R. flammula* | lf | | | |
| *Rumex acetosa* | | o | | lf |
| *R. crispus* | o | | | |
| *Sagina nodosa* | lf | | | |
| *Sieglingia decumbens* | | l | | |
| *Taraxacum* sp. | o | | | |
| *Trifolium pratense* | l | | | f-la |
| *T. repens* | lf | | | lf-la |
| *Veronica officinalis* | | o | o | |
| *Vicia cracca* | lf | | | |
| *Viola riviniana* | | f | | |
| *Viola* sp. | | | | lf |
| — | | | | |
| *Acrocladium cuspidatum* | a | | | l |
| *Barbula fallax* | | | | l |
| *Brachythecium rutabulum* | | | | l |
| *B. mildeanum* | l | | | |
| *Campylium stellatum* | | | | l |
| *Ctenidium molluscum* | | | | l |
| *Dicranum scoparium* | | lf | a | |
| *Hylocomium splendens* | | lf | lf | |
| *Hypnum cupressiforme* | | | lf | |
| *Leiocolea turbinata* | | | | l |
| *Mnium undulatum* | | l | | |
| *Pleurozium schreberi* | | a | la | |
| *Polytrichum juniperinum* | | | l | |
| *Pseudoscleropodium purum* | | | | l |
| *Ptilidium ciliare* | | | l | |
| *Rhytidiadelphus triquetrus* | lf | lf | l | |
| *Riccardia* sp. | | | | l |
| — | | | | |
| *Cetraria aculeata* | | | f-la | |
| *Cladonia coccifera* | | | l | |
| *C. floerkeana* | | | l | |
| *C. gracilis* | | | f-la | |
| *C. impexa* | | | la | |
| *C. pyxidata* | | | f | |
| *C. sylvatica* | | lf | la | |
| *C. uncialis* | | | o | |
| *Cladonia* sp. | | | f | |
| *Hypogymnia physodes* | | | lf-la | |
| *Parmelia* sp. | | | f | |
| *Peltigera canina* | | l | | |
| *Peltigera* sp. | | | l | |

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