

SOILS IN EASTER ROSS

1. The Black Isle
(part of Sheets 83, 84, 93 and 94)

2. Cromarty and Invergordon
(Sheet 94)

TECHNICAL REPORT NO. 1

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Preface

The two reports covering soils in Easter Ross are edited versions of general accounts, written by J.C.C. Romans, which appeared in the Macaulay Institute for Soil Research Annual Reports Nos. 38 and 40. The first deals with the area covered by the Black Isle soil map (Parts of Sheets 83, 84, 93 and 94) and the second the area covered by the Cromarty and Invergordon soil map (Sheet 94).

A bulletin describing the soils of the Black Isle will be published later this year.

The Macaulay Institute for Soil Research,
Aberdeen.

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1. THE BLACK ISLE

(part of Sheets 83, 84, 93 and 94)

The Black Isle is a narrow peninsula in Easter Ross about 20 miles long lying between the Cromarty Firth and the Moray Firth. Its western boundary is taken to be the road between the Inverness district boundary and Conon Bridge. It has an area of about 280 square kilometres with a width of 7 or 8 miles in the broadest part, narrowing to 4 miles near Rosemarkie, and to less than 2 miles near Cromarty.

When viewed from the hills on the north side of the Cromarty Firth the Black Isle stands out long, low and smooth in outline, with a broad central spine rising to over 240 metres at the summit of Mount Eagle. At the west end the ground falls away from this axial ridge towards the Cromarty Firth in a succession of gently sloping steps. Between St. Martins and Balblair a broad valley separates the central ridge from a lower coastal rise, 100 to 120 metres high. East of Udale the central ridge narrows and falls to about 120 metres near Cromarty. The coastal edge of the north-facing slope between Jemimaville and Cromarty is dissected by many gullies which are deeply incised into the low cliff-line.

The south-facing aspect is quite different, with steep rocky cliffs, often 60 to 90 metres high, from Cromarty to Rosemarkie, and a tree-clad outline of hills and ridges from Rosemarkie westwards. Even the wide inlet of Munlochy Bay is a remarkably inconspicuous feature when viewed from the Inverness side of the Moray Firth.

The climate of the Black Isle is relatively mild and the agricultural cropping pattern of the lower ground is more

comparable with the coastal parts of eastern Strathmore than with Aberdeenshire. Rainfall at coastal stations averages about 650 millimetres per annum, while 800-850 millimetres may be expected on the central ridge. There are two relatively dry periods in the year, the first from April to June, and the second in September.

Beneath a discontinuous mantle of superficial deposits the solid rocks consist mainly of sandstone and conglomerates of Middle Old Red Sandstone age, with two small blocks of Moine gneiss faulted in on the south-facing coast between Cromarty and Rosemarkie. The Middle Old Red Sandstone strata also include subordinate calcareous shales, and fish beds containing limestone nodules; in addition, some of the sandstones are slightly calcareous, and have contributed appreciable amounts of calcium carbonate to the derived glacial tills which overlie them.

During the last major glaciation the Black Isle was covered by an ice-sheet which left behind erratics of Inchbae gneiss and a slight overstep of sandstone-derived till on the Moine gneiss outcrops, as indicators of its direction of passage from slightly south of west to slightly north of east.

When the main ice-sheet melted it left behind on the lower ground a stiff, reddish brown, basal till overlain by coarser-textured, stony moraine. At the west end of the peninsula the thickness of the overlying material may locally be 1.2 metres or more, but it thins out to 60 centimetres in the central part and becomes negligible east of Grey Cairn Wood. Both the moraine and the basal till are derived from the local Middle Old Red Sandstone strata with very little admixture of external material other than erratic stones: they are the most important soil parent materials in the Black Isle, covering about 75 per cent of the total area. The higher ground on Mount Eagle

and the south-facing coastal ridges between Kessock and Cromarty is generally covered by thin semi-residual drift derived from sandstone, conglomerate or gneiss. These thin drifts account for about 11 per cent of the area. Fluvioglacial sands and gravels occupy less than 2 per cent and are concentrated at the western end, between Muir of Ord and the Beaully Firth, with intermittent patches of gravelly moraine fringing the coast as far east as Kessock.

A very narrow and not quite continuous strip of low raised beach fringes the coast. The high raised beach is slightly more extensive but is very intermittently developed. These beach deposits occupy only 3 per cent of the area. The remaining part of the mantle of superficial deposits consists of alluvium, solifluction deposits and peat.

Over 85 per cent of the soils of the Black Isle are podzols, the remainder comprising gleys, immature soils and peat.

Seven soil associations have been distinguished, and these have been subdivided into twenty named soil series and one soil complex.

Association	Parent Material
Millbuie	Morainic till derived from arenaceous strata of Middle Old Red Sandstone age.
Cromarty	Compact till derived from Middle Old Red Sandstone strata.
Mount Eagle	Shallow drift derived from Middle Old Red Sandstone rock.
Ethie	Shallow drift derived from Middle Old Red Sandstone rock and Moine gneiss.
Kessock	Shallow drift derived from Middle Old Red Sandstone conglomerates.
Corby	Fluvioglacial and morainic gravels.
Boyndie	Fluvioglacial sands.

In addition, the following miscellaneous soils have been

mapped:

Low Raised Beach
 High Raised Beach
 Undifferentiated Solifluction Deposits
 Alluvium
 Saltings
 Basin Peat
 Skeletal Soils
 Mixed Bottom Land

The Millbuie Association is the most extensive association in the Black Isle. It occupies 186 square kilometres, extending eastwards from the Muir of Ord gravel flats to Udale Bay on the north side, and to Rosemarkie on the south side. The altitudinal range extends from the landward edges of the raised beaches to about 120 metres around the Kessock ridges, and 180 metres on the south-west and north-east sides of Mount Eagle. The greater part of the cultivated land lies below 150 metres, with the higher-lying moorland now for the most part under planted woodland.

The parent material upon which the soils have developed is a stony, coarse-textured moraine with a clay content between 2 and 12 per cent which may vary irregularly throughout the solum. The colour ranges from brown or yellowish brown to reddish brown reflecting the variations in colour of the underlying Middle Old Red Sandstone strata.

Three soil series of the Millbuie Association and one complex have been distinguished on the soil map. Podzols with free drainage have been included within the Allangrange Series, podzols with imperfect drainage within the Millbuie Series, and noncalcareous gleys within the Roskill Series. The complex is a patch of knob and kettle terrain, and includes soils of all three

series together with wet sandy alluvium and peat.

The Allangrange Series covers about 62 square kilometres, and is best developed on the rising ground at the west end of the peninsula between Muir of Ord and Monadh Moor, where the moraine is generally deepest. The semi-natural soil has a surface layer 5-10 centimetres thick of litter and fibrous dark brown to black raw humus, overlying a leached E horizon composed of dark grey humose loamy sand of similar thickness. The underlying friable yellow-brown stony sandy loam B horizon is usually 5-25 centimetres thick and may sometimes show very slight evidence of mottling and impence of drainage at the base, just above the strongly indurated stony Bx horizon. This indurated layer may vary from a few to over 45 centimetres thick; the induration is toughest in the upper part and fades out gradually with depth. The C horizon consists of stony coarse sandy loam, which may be underlain by the compact reddish brown till which forms the parent material of the Cromarty Association further east. A large percentage of the soils of this series are cultivated and have the indurated horizon within 25-40 centimetres of the surface. Where the indurated layer lies at 60 centimetres or more, deep surface horizons, sometimes 45 centimetres or more in thickness, are found, probably indicating selective improvement of infield land.

The Millbuie Series covers 111 square kilometres and is the most extensive in the Black Isle; it is widely distributed over the lower ground west of a line from Rosemarkie to Udale Bay. The series is large enough to reflect the whole range of parent material variation within this association, though the general development of some degree of drainage impence is in itself an indication that shallower moraine underlain by compact till at less than 90 centimetres is most often encountered. The soils

of the Millbuie Series include imperfectly drained podzols with either strongly or weakly developed indurated layers. The semi-natural podzol profile generally has a surface layer of about 10 centimetres of litter and very dark brown fibrous humus, with a trace of well-decomposed, black, greasy humus seldom more than 2 centimetres thick at the base. This is underlain by an E horizon about 3 centimetres thick of dark grey, humose sandy loam with prominent bleached sand grains. The indurated B horizon is frequently encountered within 30 centimetres of the mineral ground surface, and not often below 40 centimetres. On the high central moor the moderately friable yellow-brown sandy loam B horizon with ochreous mottling, which is normally found between the E and the indurated layer, is often replaced by a patchy-coloured humose horizon in which shades of grey, grey-brown and black predominate. This mixed horizon is interpreted as probably representing a long-term churning up of the E and B horizons by the natural windblow of mature trees before extensive settlement and deforestation of the Black Isle took place. Compact reddish brown till generally forms the C horizon of the profile, but in soils transitional to the Cromarty Association (as in the Grey Cairn Wood area) it may be present at the level of the indurated horizon.

The Roskill Series includes only about 3 per cent of the soils of the Millbuie Association. It is best developed in the western half of the Black Isle between the B9162 road and Mount Eagle, particularly on the broad central part of the Millbuie ridge where lateral drainage is difficult. The soils are noncalcareous gleys.

The Cromarty Association is approximately 25 square kilometres in extent and the second largest in the district. The greater part is located within the parish of Cromarty, though

nearly 5 square kilometres have been mapped in Resolis, Avoch and Rosemarkie, on both sides of the central ridge, and there are small additional patches still further west in Knockbain and Killearnan. The altitudinal range of the association is from below 23 metres near Cromarty to nearly 180 metres in Grey Cairn Wood. A high proportion of the soils have been cultivated, and they include what have long been reputed to be the best arable lands of the Black Isle. The parent material is a compact reddish brown till containing 14 to 21 per cent of clay with a surface veneer of coarser-textured material most of which becomes incorporated with the plough layer of the arable soil. The clay content of this surface horizon usually exceeds 12 per cent.

The dominant Cromarty Series, podzols with imperfect drainage, covers about 24 square kilometres. The combined extent of the Brucefield and Navity Series is 1.5 square kilometres. The Brucefield Series includes podzols with free drainage while the soils of the Navity Series are noncalcareous gleys. A profile of the Cromarty Series from Cromarty Mains at about 70 metres had a dark brown sandy loam cultivated surface horizon, with subangular blocky structure and friable consistency, about 30 centimetres thick. This rather deep plough layer had incorporated the upper horizons of the semi-natural soil, and overlay a brown to reddish brown compact, weakly indurated, sandy loam B horizon, which merged gradually into compact reddish brown sandy clay loam till forming the C horizon. The cultivated surface horizon of this profile had a pH value over 6 and a total phosphate content over 180 mg per g. Comparable C horizon values for soils of this series range from pH 5 to 5.5 and from 70 to 100 mg per g. This illustrates the overwhelming importance of the management factor in the improvement of these soils. Soils of the Cromarty Association

are decalcified to a depth considerably below that to which the profile pits are normally dug (90-120 centimetres), but the value of 6 per cent free carbonate obtained from a sample taken about 5.5 metres below the surface from the side of a deep gully, a mile from Cromarty Mains, may give some indication both of the free carbonate originally present in this soil parent material and of the amount of leaching that has taken place.

The Mount Eagle, Ethie and Kessock Associations cover nearly 31 square kilometres on the highest parts of the central sandstone ridge around Mount Eagle, on the coast ridges of gneiss between Cromarty and Rosemarkie, and on the conglomerate ridges between Munloch and Kessock. The soil parent materials are all thin semi-residual drifts, and the soils are predominantly podzols with free or imperfect drainage. A very large proportion of the soils of all three associations are now under planted woodland.

The Mount Eagle Series of the Mount Eagle Association, with an extent of nearly 11 square kilometres, is the largest series within this group of hill soils. The soils are podzols, freely drained, with or without a thin iron pan. Where the iron pan is present there is some gleying in the overlying E horizon but below the pan the morphology is that of a freely drained soil. A profile of this series from a site at Wester Brae, at about 170 metres, 2 miles from the summit of Mount Eagle has a surface layer 8 centimetres thick of pine litter and very dark brown surface humus overlying a grey to dark grey sandy loam E horizon of similar thickness. Below, an olive-grey sandy loam E(g) horizon 13 centimetres thick with darker patches of colloidal humus accumulation near the base overlies a hard thin iron pan with a root mat on its upper surface. Below the thin iron pan there is a pale brown to yellowish brown, stony, indurated, sandy

loam B horizon about 23 centimetres thick, which merges gradually into softer reddish brown sandy loam. Shattered sandstone rock is encountered at 40 to 50 centimetres below mineral ground surface.

Though the Corby and Boyndie Associations are not extensive, the greater part of their soils, which are developed on morainic and fluvioglacial gravel and sand, are freely drained podzols, and lie below 60 metres around the west and south-west margins of the Black Isle. The soils were formerly extensively cultivated wherever the ground was sufficiently level. A profile sited on the gravel flat about half a mile south-east of Muir of Ord has been cultivated, but still retains the dark-coloured cemented B horizon of the humus podzol. The surface layer consists of about 25 centimetres of dark reddish brown stony sandy loam overlying a cemented stony loamy coarse sand B horizon about 40 centimetres thick, which is dark brown to very dark grey-brown in the upper part, and dark brown to yellowish brown below. Below the B horizon there was a merging change into brown coarse sandy gravel.

Within the group of miscellaneous soils, undifferentiated solifluction soils and alluvium account for about 18 square kilometres of predominantly gleyed soils with rather variable parent material. The raised beaches include over 8 square kilometres of generally free draining sandy and gravelly soils. On the high beach the soils have generally been humus podzols before cultivation, while on the low beach the profile is generally immature. Mixed bottom land, peat, and skeletal soils cover 8 square kilometres.

2. CROMARTY AND INVERGORDON

(Sheet 94)

Of the 430 square kilometres covered by Sheet 94 (Cromarty and Invergordon) about 85 per cent lie within Easter Ross. The area is bounded to the east by the open water of the Moray Firth and heavily indented on its upper and lower margins by the Dornoch and Cromarty Firths. The western margin is a north-south line running half a mile to the east of the A836 at Aultnamain. There is a small strip in the north along the Sutherland coast from Spinningdale to Dornoch, and a more substantial area, including Culbin and the Findhorn estuary, in the south-west corner in Moray and Nairn.

The land is almost equally distributed above and below the 100-metre contour. The main part of the productive arable land lies east of a line curving down from Tain to Newmore House (about 2.5 miles north-west of Invergordon), with subsidiary portions in the Cromarty peninsula of the Black Isle and in Moray and Nairn. The uplands in the north-west consist of four substantial sandstone or conglomerate hills (Struie Hill, Edderton Hill, Cnoc an t-Sabhail and Kinrive Hill) of between 320 and 380 metres in height, all with wide, low-angle summit plateaux, and the smaller ridge-like Scotsburn Hill (252 metres). There is an additional isolated gneissic mass, the Hill of Nigg, rising out of the Nigg-Balintore lowlands to dominate the narrow entry to the Cromarty Firth.

Most of the district is underlain by red or yellowish brown sandstones of Middle and Upper Old Red Sandstone age. Conglomerate beds form part of Struie Hill and the north-east end of Nigg Hill; some of the sandstones are slightly calcareous

and there are occasional grey shaly bands. Moine gneiss underlies the greater part of the Hill of Nigg, forming the steep cliffs of the North Sutor of Cromarty; there are further outcrops on the Sutors of Cromarty and along the south-east-facing cliff-line of the Black Isle. Small areas of quartzose Moine schist are present below superficial deposits in the extreme north-west and south-east corners of the area.

Superficial glacial and periglacial deposits cover most of the ground. There are two distinctive regional tills, both derived principally from the sandstone, one brown in colour and the other red or reddish brown. The former covers the hilly zone of the north-west, while the red till is more generally distributed over lowland Easter Ross including the Black Isle. The Sabhail Association is developed on the brown till and the Cromarty and Kindeace Associations over the red till. Along the coastal lowlands skirting the hill edge from Alness to Loch Eye, and more locally elsewhere, there are extensive deposits of moraine and fluvioglacial material derived from schist and sandstone overlying the till, and the Ardvanie, Corby and Boyndie Associations have been distinguished. On the Black Isle the Millbuie Association forms a sandstone-derived analogue of the more generally occurring Ardvanie Association. Below the 30-metre contour, both on the north shore of the Cromarty Firth and on the south shore of the Dornoch Firth, the moraines are frequently planed level to form the high beach terrace, while between Invergordon and Nigg Bay there are quite extensive silty and sandy lagoonal/estuarine low beach deposits. The low beach platform is more widely developed on Morrich More near Tain and at Culbin on the Moray coast, but is covered by links, micro-dunes, shingle and larger sand dunes. A less extensive but more spectacular deposit of windblown sand extends in a broad

tongue right up the south-facing side of Nigg Hill to over 150 metres.

Climatically, lowland Easter Ross, including the coastal part of the Black Isle, is mainly in the category of warm, dry lowland, moderately exposed, with fairly mild winters. The zonal soils on the more free-draining sites are podzols, a humus podzol with dark-coloured cemented B horizon of 'Moray pan' type being prevalent on sandy moraines and beach deposits at an altitude of 30 metres. Rainfall rises to 760 millimetres at the hill edge, and ranges from 760 to 1140 millimetres over the north-western upland area where the increasing severity of climate is reflected in the development of peaty podzols and blanket peat.

Twelve soil associations have been distinguished and these have been subdivided into thirty-one named soil series and three soil complexes. One series of the Sabhail Association has been subdivided into two slope phases.

Association	Parent Material
Sabhail	Compact till derived from grey-brown and pale yellow flaggy sandstone of Middle Old Red Sandstone age.
Cromarty	Compact till derived from red sandstone of Middle Old Red Sandstone age.
Kindeace	Shallow coarse-textured drift overlying compact till of Cromarty type.
Millbuie	Coarse-textured moraine derived from sandstone of Middle Old Red Sandstone age.
Ardvanie	Coarse-textured stony moraine derived from schists and sandstone.
Corby	Coarse sandy gravel moraine, and fluvioglacial outwash deposits.
Boyndie	Fluvioglacial outwash sands.
Ethie	Shallow drift derived from sandstone and Moine gneiss.
Cadboll	Thin semi-residual drift derived from soft red sandstone of Middle Old Red Sandstone age.
Mount Eagle	Shallow stony drift derived from yellow and brown sandstone of Middle Old Red Sandstone age.
Kessock	Shallow drift derived from conglomerates of Middle Old Red Sandstone age.
Strichen (now Arkaig)	Till derived from acid schists.

Soils developed on the raised beaches have not been given association and series names but have been subdivided on the basis of drainage, which in some parts is natural and in others artificial, into nineteen units of approximately series status. These include the soils developed on high beach deposits not included within either the Corby or Boyndie Associations and noncalcareous gleys on the sandy and silty low beach sediments. The soils on the semi-stabilized links, where ground-water levels can be very variable, have weakly differentiated profile morphology. In addition, peat, alluvium, peat-alluvium complex, undifferentiated solifluction deposits, windblown sand, saltings and mixed bottom land have been delineated.

Four of the principal associations, Sabhail, Kindeace, Cromarty and Millbuie, cover areas of 40 to 50 square kilometres. Three natural groupings of associations or sub-units of series status form collective units of the same order of size. These are the Ardvanie, Corby and Boyndie Associations, the differentiated low raised beach soils, and the links together with separated blown sand and shingle deposits. All other associations or delineated units are less than 13 square kilometres in extent. The Strichen (recently renamed Arkaig) and Kessock Associations, though present on the map, are of negligible proportions and are not discussed further in this account.

The Sabhail Association is the largest in the generally hilly north-western part of the area. It dominates the side slopes and shares the flatter hill tops and the upper slopes of the Aultnamain-Edderton shelf with blanket peat. It shares the lower part of the Aultnamain-Edderton shelf with series of the Cromarty and Ardvanie Associations. Three series, Sabhail, Edderton and Bogrow, have been distinguished. The Sabhail Series is the most extensive and has been subdivided into two slope phases. Peaty podzols, with gleying above a thin iron pan, are usually developed on shallow slopes up to about 5 degrees, while peaty podzols with or without thin iron pan develop on steeper slopes over about 7 degrees. The former are usually found on the upper slopes and flatter tops of Edderton Hill, Cnoc an t-Sabhail and Scotsburn Hill and on the Edderton shelf, and the peaty podzols, whose morphology often includes a relatively early stage of active development from humus-iron podzol to peaty podzol, are most often encountered on the steeper side slopes of these hills where slopes of up to 15 degrees are common and slopes over 20 degrees can be found locally. The

peaty podzol with gleying above an iron pan usually has 10 to 30 centimetres of organic surface horizon with a sticky black A horizon 2-3 centimetres thick at the base, overlying a very dark grey humose E horizon 13 to 25 centimetres thick. Below the E horizon there is a strong thin iron pan which usually rests directly upon the indurated Bx horizon below. The peaty podzol has either recognizable L, F and H layers (as seen on the slopes of Edderton Hill) or an O horizon up to about 30 centimetres overlying a dark AE horizon (varying in colour from black to dark grey-brown) with bleached sand grains.

The lower part of the E horizon is gleyed and a root mat may have developed over a thin iron pan or somewhat cemented thin humus-iron Bhs horizon. Below is a moderately friable ochreous Bs horizon, 15 to 25 centimetres thick, which in turn overlies a massive, strongly indurated Bx horizon. The clay content of the till rarely exceeds 15 per cent and the texture is usually within the sandy loam class.

The other two series of this association occupy less than two square kilometres each. The Edderton Series includes podzols with a gleyed B horizon and a compact indurated Bx horizon, while the Bogrow Series includes poorly and very poorly drained peaty gleys, generally found around the lowest footslopes of Edderton Hill.

The Cromarty Association is well developed above the high beach level throughout lowland Easter Ross in a composite pattern with the Kindeace, Corby and Boyndie Associations. The soil parent material is a compact reddish brown till with clay content up to 25 per cent. A very high percentage of the soils is cultivated, and semi-natural soils are only found locally on the higher parts of Nigg Hill and on several small areas of land lying just above 30 metres at the base of the Tarbat Ness

peninsula. The semi-natural freely and imperfectly drained soils are podzols, but the thickness of the A and B horizons may be such that after cultivation the presence of an indurated Bx horizon is often the only indication that the soil was not originally a brown forest soil.

Three series have been distinguished, the freely drained Brucefield Series, the imperfectly drained Cromarty Series and the poorly drained Navity Series. The Cromarty Series is the most extensive. A cultivated profile of this series from Cromarty Mains at about 70 metres, had a dark brown sandy loam surface horizon about 30 centimetres thick overlying a brown to reddish brown, compact, somewhat indurated, sandy loam B horizon which merged gradually down into compact, reddish brown, sandy clay loam till. A semi-natural soil of the same series from Pitkerrie Moor near the Dornoch Firth, at about 25 metres, had a black to very dark grey-brown loamy sand AE horizon, with bleached sand grains, about 18 centimetres thick, overlying a reddish brown sandy loam B(g) horizon about 7 centimetres thick. Below the B(g) horizon there was a sharp change into a brown to reddish brown, indurated Bx horizon which merged gradually down into reddish brown sandy loam or sandy clay loam till. The Brucefield Series is about 5 square kilometres in extent and is developed on free-draining or shedding sites along the south-east-facing coastline of Easter Ross. The cultivated soil is similar to that of the Cromarty Series but with a friable, more ochreous-coloured B horizon between the plough layer and the indurated Bx horizon. The soils of the Navity Series are noncalcareous gleys limited to small hollows and wet spots.

The greater part of the Kindeace Association is concentrated within the western periphery of lowland Easter Ross excluding the Black Isle. Behind Invergordon it forms an intermixed pattern

with the Ardvane and Corby Associations and further east and north with the Cromarty Association. The Rarichie, Kindeace, Torlean and Balangowan Series have been distinguished. The dominant Kindeace Series includes podzols with imperfect drainage; freely drained podzols have been grouped within the Rarichie Series. The Torlean and Balangowan Series, of much more limited extent, are respectively noncalcareous and peaty gleys. The soils of the Kindeace Series are developed on gently to moderately sloping ground, mostly lying below 150 metres. In both semi-natural and cultivated profiles the indurated Bx horizon is most often encountered between 25 and 50 centimetres below the surface, with extreme limits between 15 and 66 centimetres. In the semi-natural profile 7 to 10 centimetres of black surface humus usually overlies thin humus-stained A and dark grey to very dark grey-brown E horizons with a combined thickness of from 5 to 20 centimetres. The Bg horizon is also very variable in thickness and colour, though some rusty mottling (often associated with small fragments of weathered sandstone) is invariably present. A substantial proportion of the soils of this series (and of Rarichie Series) is now cultivated, the remainder being under moorland or plantation. The texture of the surface horizon of the cultivated soil is usually sandy loam, with loamy sand or sandy loam in the B horizons, and sandy loam (or occasionally loam) in the compact C horizon.

The Millbuie Association is extensive only in the Black Isle, where the parent material is a coarse-textured moraine derived from sandstone, sometimes underlain by reddish brown till of Cromarty type. Three series are present, but only the imperfectly drained podzols of the Millbuie Series are at all extensive within the confines of this area. The series of the Millbuie Association, together with that part of the Cromarty

Association falling within the Black Isle are described in Part 1.

The Ardvane and Corby Associations and the less extensive Boyndie Association are in close complex along the coastal ridge and moraine area between Invergordon and Nigg Bay, while farther east the Corby Association forms part of the north-facing high beach platform and caps some of the till-covered ridges about Fearn; most of the soils are podzols, freely or imperfectly drained. The greater part of the soils of the Corby and Boyndie Associations and a substantial proportion of the soils of the Ardvane Association have been cultivated.

The silty and sandy soils of the low beach between Invergordon and Nigg Bay share a common soil ground-water problem with the extensive blown sand and shingle bar terrain of the links on Morrich More and at Culbin. But whereas extensive artificial drainage has produced arable land on the Nigg lowlands, land use on the links is restricted to limited grazing or afforestation.

The Ethie, Cadboll and Mount Eagle Associations form a minor group of soils in which thin drift overlies solid rock. The soils of the Ethie and Mount Eagle Associations are mostly humus-iron podzols or peaty podzols developed on upland or hill and have a limited agricultural potential. The soils of the Cadboll Association, by contrast, are developed on a few small outcrops of soft red sandstone in lowland Easter Ross and have for the most part been developed into arable soils of high quality.

A significant area of blanket peat occurs in the hilly north-western region of the map. Basin peats are a localized minor feature of inter-ridge and kettlehole hollows from Alness to Balnagowan and again in small hollows and kettleholes around Cadboll. Most of the basin peats are acid, but are sometimes

underlain by calcareous marl, as at White Hills by Alness and at North Cadboll.

Scattered patches of deep cultivated surface soil are a distinctive feature of the arable lands of lowland Easter Ross, comparable with, though less extensive than, similar occurrences in the Inch area of Aberdeenshire. These are generally found on ridge tops or rising ground standing above the formerly marshy low beach levels. Surface soils up to 90 centimetres thick have been encountered, and below these traces of A and E horizons of the buried podzol can sometimes be located, though usually they were incorporated with the original cultivated surface horizon. The occurrence of these improved arable lands around the site of Fearn Abbey (founded in the year 1221) is indicative of their anthropogenic origin. Their extent, though not precisely known, is probably of the order of 13 square kilometres. It is therefore no accident that many of the larger contemporary mixed arable farms are found within the parishes of Nigg and Fearn, although, following extensive land drainage works, these now incorporate the low-lying silty and sandy ground between Fearn and Bay of Nigg as well as the improved ridges.