The Soils of Orkney

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1. The Soils

GEOLOGY and SCENERY

The Orkney archipelago comprises some 90 islands and skerries extending 80 kilometres from north to south and 62 kilometres from east to west, with a land area of approximately 975 square kilometres.

The Orkney Islands consist almost entirely of relatively gently inclined sedimentary rocks and subordinate lavas and tuffs of Middle and Upper Old Red Sandstone age. A crystalline basement complex composed of Moinian metamorphic rocks intruded by Caledonian granites crops out as a series of inliers within a north-west-trending belt extending from the island of Graemsay to Yesnaby, the largest outcrop forming the hilly ground immediately north and west of Stromness. A high proportion of the complex is made up of coarse, pink or greyish, poorly foliated granite which grades locally into granite-gneiss.

The general succession is:

Upper Old Red Sandstone	Hoy Sandstones
	Hoy Volcanics
	Eday Beds
	Rousay Flags
Middle Old Red Sandstone	Upper Stromness Flags
	Lower Stromness Flags
Moinian	Basement Complex

The Stromness Flags and the Rousay Flags consist largely of flagstones and are made up of rhythmic sequences of thinly bedded and, in part, laminated, grey and black, carbonate-rich siltstones and silty mudstones alternating with generally thin beds of fine-grained sandstones or sandy siltstones. The Eday Beds comprise three sequences of yellow and red sandstones with pebbly lenses, the Lower, Middle and Upper Eday Sandstones separated respectively by the Eday Flags, a rhythmic sequence of buff, yellow or red sandstones and partially laminated siltstones, and the Eday Marls, a sequence of interbedded red sandy and micaceous marls, red and green marly sandstones and occasional yellow sandstones.

The Upper Old Red Sandstone rocks are confined to the Island of Hoy and consist of red, pink and yellow sandstones with subordinate bands of marl. The sandstones are underlain by a variable thickness of basalt lava and tuff which rests on an eroded surface of faulted and gently folded Middle Old Red Sandstone rocks.

With the exception of western Hoy, Rousay and western Westray, the Orkney Islands have a gently undulating landscape of subdued relief. The dominant characteristic of the topography is its drowned appearance. The hills of north Hoy excepted, most hill slopes are convex, the lower, normally concave, slopes being submerged with the many bays and sounds representing drowned valleys: submersion was such that river systems were severely truncated and only small streams remain.

For descriptive purposes the island group can be divided into four regions:

1. East Mainland, the south isles, the Longhope district of the parish of Walls, Hoy and the north isles with the exception of Rousay and western Westray.
2. West Mainland
3. Western Hoy
4. Rousay and western Westray

East Mainland has a gently rolling landscape of low and open relief with geological influences on topography modified by drift cover. A number of ridges and escarpments trending either south-west to north-east or south to north reflect the influence of geology and, particularly, the presences of thick resistant beds of sandstone upon topography. Areas of hummocky moraine occur in the south-western part of the parish of Holm and in the Toab area of the parish of St. Andrews and Deerness.

West Mainland has an amphitheatre-like appearance, a low-lying interior with a mean height of about 15 metres, that area being occupied by the Loch of Harray and the Loch of Stenness, and a surrounding girdle of rounded hills. The hills reach their greatest heights, 193 metres (Mid Hill) and 221 metres (Mid Tooin), in the Evie hills ranging the eastern border of west Mainland, and in the Orphir hills to the south-east with Ward Hill (268 metres) the highest in Mainland Orkney. The hills of the western edge are somewhat lower, with Vestra Fiold (127 metres), Hill of Miffia (158 metres) and Hill of Lynedardy (136 metres) the major prominences. The eastern hills, broken by the Finstown gap and the Settascarth gap, display striking east-facing escarpment slopes.

Areas of hummocky moraine occur on the central lowland feature. The most extensive area extends westwards from the head of the Finstown gap for some 3 kilometres along the Stromness road and for approximately 2 kilometres north-westwards between the Loch of Harray and the Dounby road; other large areas of moraine are found along the Dounby road in the vicinity of the Loch of Bosquoy and The Shunan.

Western Hoy consists of a range of rounded and relatively steep-sided hills extending from The Berry (199 metres) in the south to Cuilags (433 metres) in the north. Much of the central part is over 300 metres in height and rises to 479 metres on Ward Hill, the highest point in Orkney. Ward Hill is an isolated, steep-sided eminence bounded by the glacial valleys of the South Burn and the Ford of Hoy. The plateau summit of Ward Hill displays strongly developed patterned-ground features such as stripes and terraces. Similar features, varying in their degree of development, are found on Cuilags, Knap of Trowieglen and plateau summits of heights above approximately 280 metres.

Rousay and western Westray display a strikingly rugged topography, yet markedly dissimilar from that of western Hoy as a consequence of differing geology. The bedrock of Rousay and Westray is composed of gently dipping sediments, flagstones and sandstones of varying resistance to weathering. Differential weathering and erosion have resulted in stepped hillsides, often with craggy risers (hamars). This type of landform is found in its most extreme development along the south-east-facing hillside between Frotoft and Mansemass Hill in Rousay and on the south-facing slopes of Fitty Hill in Westray.

CLIMATE

The climate of the Orkney Islands is governed basically by three factors, namely the intimate relationship with the sea, an open, gently undulating topography and a high latitude. Orkney lies at a mean latitude of 59 north but the more extreme climatic aspects of such a latitude are ameliorated by the moderating influences of the sea and the climate is not nearly so severe as in some regions of similar latitude.

The relatively low evaporation associated with low summer temperatures and high relative humidities makes the mean annual rainfall of about 950 millimetres relatively excessive. Add to this the high incidence of strong winds and lack of natural shelter and the climate assumes a bleak and inhospitable aspect, but the area suffers no great extremes of heat or cold. The very severe cold winters of more southerly eastern regions generally do not occur. The area has a good sunshine record and during the summer months experiences prolonged daylight which compensates for the dismal days of winter. Overall, the climate is cool but equable.

The average annual rainfall varies from approximately 800 millimetres along the southern and eastern seaboards to over 1000 millimetres on the hills of Rousay, west Mainland and Hoy and to over 1200 millimetres on the highest hills exposed to the south-west, with much of the archipelago, and the greater percentage of arable ground, having an average annual rainfall of between 900 and 1000 millimetres.

Rainfall is distributed more or less evenly throughout the year with May, on balance, the driest month and October the wettest. A feature of the annual rainfall is the high number of days with recorded rainfall.

The annual range of average mean monthly temperature is around 8.9 C, increasing from 3.4 C in February to 12.3 C in August. Although winter temperatures are not very low, there is only a slow build-up of temperature and winter and spring tend to be rather prolonged.

SOIL PARENT MATERIALS

Superficial deposits cover approximately 95 percent of the area with till (75 percent) and peat (15 percent) being the most extensive. Windblown sand is locally extensive, while fluvioglacial deposits and alluvium are of minor extent.

Four types of till have been recognized:

1. Till of moderately fine texture is generally widespread throughout the island group. It occurs most extensively in east Mainland and South Ronaldsay, in Shapinsay, Stronsay and Westray. The till occurs in Stenness, Orphir and locally on Rousay, Wyre, Egilsay and Eday. It is a firm, compact deposit of sandy clay loam or clay loam texture and contains strongly weathered stones. A thickness of some 100 to 125 centimetres is usual, but deeper sections of till occur where valleys and bays have been infilled. Shell fragments are often encountered at depth in till-cliff sections and the occasional soil profile is found to be calcareous in the lowest horizon.

2. Till of a loamy sand or sandy loam texture occurs on Hoy and on Eday and very locally on west Mainland.

3. Till of a sandy loam or loam texture is common throughout west Mainland aand of local occurrence on east Mainland. The till occurs quite extensively throughout the north isles.

4. Till, of a morainic nature and landform, with a sandy loam or loam texture, occurs locally on Mainland.

A widespread feature of the last two types of till is the presence of a hard indurated horizon in the upper part of the deposit.

Blanket peat is extensive on Hoy, on the Evie and Rendell hills, on the Orphir hills, and on Rousay and Eday. Basin and valley peat occurs locally throughout the area, in some instances being underlain by marl. Windblown shelly sand deposits occur round many of the more open, shallow bays of the area. Approximately one third of Sanday and of North Ronaldsay is covered by shelly sand and there are extensive deposits on Westray. Noncalcareous windblown sand (Links) is much less extensive, the largest area occurring around the Loch of Doomy on Eday. Fluvioglacial deposits occur principally as ridges and terraces in the valley of the South Burn and as mounds at the Ford of Hoy on Hoy; in west Mainland small, isolated mounds extend westwards from Stromness along the Innertown-Outertown road.

SOILS

Twenty-eight soil series and fourteen soil complexes have been identified and they represent the following ten soil associations:

Association	Parent Material
Stromness	Drift derived from sandstones and breccias of the Middle Old Red Sandstone and rocks of the granite-schist complex of the Moinian
Lynedardy	Drift derived from flagstones and sandstones of the Middle Old Red Sandstone with rocks of the granite-schist complex of the Moinian
Thurso	Drift derived from strata of the Stromness Flags and the Rousay Flags of the Middle Old Red Sandstone
Canisbay	Drift derived from strata of the Stromness Flags, the Rousay Flags and the Eday Beds of the Middle Old Red Sandstone
Flaughton	Drift derived from sandstones of the Eday Beds of the Middle Old Red Sandstone
Darleith	Drift derived from basic lavas and intrusions
Dunnet	Drift derived from strata of the Upper Old Red Sandstone
Rackwick	Fluvioglacial sands and gravels derived from sandstones of the Upper Old Red Sandstone
Boyndie	Fluvioglacial sands
Fraserburgh	Shelly sand

In addition, deep peat, thin peat, their cut-over and eroded phases, links, alluvium, peat-alluvium complex, hill dunes, colluvial fans, saltings and mixed bottom lands have been recognized.

The soil series identified represent nine major soil groups or subgroups of which the most widespread are noncalcareous gleys, podzols, peaty podzols and peaty gleys. Brown calcareous soils, calcareous gleys and saline gleys are locally extensive, while peaty brown soils are of very limited local extent.

The Orkney landscape is dominated by four principal soil associations, the Thurso, Canisbay, Dunnet and Fraserburgh Associations - and peat. The Thurso Association is the dominant soil association of west Mainland, Rousay and western and northern Westray. The principal soil of the association is Bilbster Series, a freely or imperfectly drained soil which has been derived from a peaty podzol by cultivation. The soils are developed on a brown or yellowish brown, commonly stony, sandy loam or loam till with usually a strongly indurated subsoil immediately below a shallow brown or dark greyish brown plough layer of loam, sandy loam or silty loam texture. Between the two horizons there is commonly a thin zone of iron accumulation - a thin iron pan. The pan restricts both root and water penetration. A root mat commonly occurs on the upper surface and there can be a thin horizon of mottled material immediately above the pan. Where the total thickness of the topsoil commonly exceeds 75 centimetres a deep-topsoil phase of the Bilbster Series has been recognized.

Total soil depths (i.e. to bedrock) commonly exceed 100 centimetres, but where bedrock is within 50 centimetres of the surface a shallow phase of the Bilbster Series is noted.

Analyses usually indicate medium values of exchangeable bases but with high exchangeable sodium in the surface horizon and commonly low exchangeable calcium at depth, while pH values vary from moderately acid to slightly acid. The amount of total phosphate is usually low below the surface horizon; a Bilbster Series deep-topped phase shows a very high amount of total phosphate in the topsoil horizons.

The Thurso Series is a noncalcareous gley developed on a yellowish brown or greyish brown loam or sandy clay loam till. Profile morphology is typically that of surface-water gleys; grey colours predominate, with associated coarse ochreous and pale brown mottling, while structure in the subsoil is usually coarse prismatic, the ped faces have grey sandy coatings. Soil depth rarely exceeds 120 centimetres and is often much shallower. There can be little doubt that many of the Thurso Series soils are the product of reclamation and improvement of peaty gleys.

Values for exchangeable bases are usualy medium, with high exchangeable sodium in the surface horizon, but high amounts of exchangeable calcium are occasionally recorded in the parent material. Similarly, pH values are slightly acid in the topsoil increasing to nearly pH 7 with depth. A pH value of 7.9 was noted in the basal sample of one Thurso Series soil. Total phosphate values are generally low in the sub-surface horizons.

Olrig Series, a peaty gley, developed on a loam or sandy clay loam till occurs under a heather-dominated moorland vegetation. The profile is characterized by a peaty surface horizon, up to 50 centimetres thick, underlain by a dark brown, organic-stained horizon and a greyish brown, gleyed horizon with some organic staining and a few drab mottles.

Values for pH vary from pH 4.0 in the organic horizons to pH 5.3 in the parent material. Values of exchangeable cations, with the exception of exchangeable calcium, are usually medium in the mineral soil: values of exchangeable calcium are low.

Camster Series, a peaty podzol, is developed on a brownish yellow, stony loam or sandy loam till on moderate slopes under a heather-dominated moorland vegetation. The profile displays the characteristic features of a peaty podzol with a thin iron pan, a gleyed horizon above the pan and a brightly coloured horizon immediately below the pan. The brightly coloured horizon may be absent, the thin iron pan then being directly underlain by a hard indurated horizon. The pH values in the organic surface horizons are about pH 4, while the pH of the parent material varies from pH 5.5 to pH 6.3. Exchangeable bases show low or medium values in the mineral soil.

Mousland Series, a saline gley, is found along the western seaboard of the archipelago. The soil is developed on strongly weathered and gleyed till or rock and displays commonly a striking coarse prismatic or columnar structure in the subsurface horizons. Structure in the C horizon is usually massive, but sometimes the horizon retains the banded structure of the original rock. The prismatic structure is emphasised by intense organic staining along the ped faces. Those soils immediately adjacent to the cliff edge have worked upper horizons, generally of a banded appearance with the admixture of wind-borne or water-borne small rock fragments. Not surprisingly the soils have a high sodium content throughout and a high exchangeable magnesium value in the upper horizons. The soils support a maritime heath or pasture vegetation.

Two series of little extent are the Ness Series, a noncalcareous gley developed in a loam till over weathered rock, and Hunster Series, a very poorly drained noncalcareous or humic groundwater gley of flushed sites. A very small area of alpine podzol, Knitchen Series, occurs on the plateau summit of Knitchen Hill on Rousay.

A number of soil complex map units have been recognized in the Thurso Association.

The Sordale Complex occurs on moundy topography associated with areas of moraine. It is a complex of Bilbster Series and Thurso or Olrig Series with some peat. The predominant soil is the Bilbster Series, which occurs on the mounds; the intervening hollows and channels contain the poorly drained Thurso or Olrig Series and in some instances peat. The complex is most extensively developed in the Toab district, in the parish of Holm around the farm of Hestwall and in the parish of Stenness around the farm of Moa.

The Ulbster Complex is a complex of mineral soils on a low, moundy, ridged or stepped, rock-controlled topography. The principal component soils are Bilbster Series and Thurso Series, with shallowness the dominating soil influence. It occurs on Egilsay, on the Aiker Ness peninsula in Evie, along the southern coastal fringe of Rousay, and in the Stany Hill area of the parish of Harray. (A Canisbay variant with Tresdale Series replacing the Thurso Series is mapped extensively on Shapinsay.)

The Frotoft Complex, occurring principally in Rousay and in western Westray, is developed on stepped, rocky and often steep hillsides. It is characterized by the shallowness of its constituent soils, Camster, Bilbster, Thurso and Olrig Series, with rock outcrops a major component.

The Eskihold Complex, developed extensively to the north-west of Stromness and at Vestra Field in Sandwick, is dominated by soils of the Olrig and Camster Series and by their shallow phases. It occurs on a low moundy or gently ridged nock-controlled landscape. Rock outcrops are rare. The complex bears strong affinities to the Ulbster Complex.

The Huntis Complex, one of cut-over and eroded peat with Olrig Series and some Camster Series, is developed most extensively in Birsay and Harray. It occurs on smooth or gently ridged landscapes and results directly from the influence of man and his extraction of peat.

The soils of the Canisbay Association are developed on a reddish brown or, occasionally, red till with usually a sandy clay loam or clay loam texture. The till is commonly strongly weathered and a local predominance of weathered sandstone in the till results in a sandy loam texture.

Tresdale Series, a noncalcareous gley, is the dominant series of the association. There is little doubt that in most instances the soil profile is the result of the cultivation and continued husbandry of peaty gleys, for profiles with evidence of their former peaty surface nature, a dark grey or very dark greyish brown plough layer with moderate or high organic matter or a horizon of organic matter enrichment immediately below the plough layer are common. The relationship between soils still bearing witness to their former peaty nature and soils where any evidence of their former status has been totally destroyed is very complicated and indefinite - often merely the product of the vagaries of plough depth within an individual field.

Typically, the Tresdale Series exhibits a dark greyish brown plough layer with a loam, silty loam or sandy loam texture and a thickness of 25 centimetres. Beneath the plough layer, a narrow, often lenticular, brown horizon enriched with organic matter is sometimes encountered. A reddish brown, strongly mottled and gleyed subsoil with a sandy clay loam or clay loam texture and most usually a strongly developed prismatic structure underlies the surface horizons. The subsoil is usually up to 30 centimetres in thickness. The parent material is reddish brown or red and has a sandy clay loam or clay loam texture and usually a massive structure. The soil is commonly strongly weathered throughout, the rock components of the till being readily broken down. Total soil depth rarely exceeds 120 centimetres, but where it does so, the material below this depth is often calcareous. The soils exhibit the typical characteristics of a surface-water gley in that the subsoil shows stronger gleying and mottling features than does the parent material.

Analyses usually indicate exchangeable bases to be at medium levels, although high amounts of exchangeable calcium are occasionally recorded in some basal horizons and, as with most of the soils of Orkney, high levels of exchangeable sodium are common throughout. The pH values increase generally from the slightly acid pH 6 to pH 6.5 in the surface horizon to pH values in excess of pH 7 in the parent material. Total phosphate is generally low below the plough layer.

The Ocklester Series is a freely or imperfectly drained soil, a podzol, which has been derived from a peaty podzol by cultivation. The noteworthy feature of the profile is an indurated reddish brown sandy loam, loam or very rarely sandy clay loam subsoil, usually immediately beneath a dark greyish brown sandy loam or loam plough layer; in some instances a thin zone of mottled and gleyed material occurs between the two horizons. The chemistry of the soil is markedly affected by management and closely resembles that of the Tresdale Series.

In an intensively cultivated landscape, Canisbay Series, a peaty gley, Warth Series, a peaty podzol, Gaira Series, a very poorly drained noncalcareous or humic gley and Dalespot Series, a very poorly drained peaty gley often associated with thin peat, are of minor extent and subject to the processes of reclamation.

Gessan Series is a saline gley. The soil is profoundly influenced by salt-spray and sea-gusting and is found along the eastern seaboard of the area. A feature is the very coarse prismatic or columnar structure of the subsoil, the structure units being vividly expressed by translocated organic matter along the ped faces. The surface horizon is usually thin, rarely exceeding 20 centimetres, and is usually of a peaty nature.

The soils are moderately acid with high levels of exchangeable bases in the surface horizon and very high exchangeable sodium throughout. The soils support a maritime heath vegetation.

Soils of the Dunnet Association are confined to the island of Hoy and two soil series have been mapped: Dunnet Series, a peaty podzol, and Trowieglen Series, an alpine podzol.

The Trowieglen Series exhibits a very dark grey, organic loamy sand surface horizon of less than 10 centimetres thickness underlain by a brown to dark brown horizon with low organic matter content, sand texture, weak structure and friable consistence. Below, the soil is a strong brown or brownish yellow colour, usually with a slight degree of mottling and a loamy sand texture. Locally the parent material is red or light reddish brown in colour. Total soil depth exceeds 120 centimetres. Values of pH vary from about pH 5 in the surface horizon to about pH 5.5 in the parent material.

Soils of the Fraserburgh Association are developed on windblown shelly sand deposits which occur locally around some of the bays and more extensively on Sanday, North Ronaldsay and Westray. They are characterized by extreme sandiness, loose consistence and high pH. Fraserburgh Series, a brown calcareous soil, occurs on freely drained, low, stable dunes. Below a dark grey or dark brown surface horizon of sand and organic matter there is a pale brown subsoil and a slightly paler-coloured parent material. Whitelinks Series is a calcareous groundwater gley in which the main features are a coarsely mottled subsoil overlying grey, wet sand.

Soils of the Stromness Association are limited to the hilly ground fringing Stromness with an outlier on the north side of Graemsay and small isolated pockets to the north-west of Stromness. One soil series, Stromness Series, a peaty podzol, has been mapped and is of minor extent. The parent material of

the Lynedardy Association is similar to that of the Thurso Association in its colour and texture, but in addition to middle Old Red Sandstone rocks contains rocks of the granite-schist basement complex. Four soil series, Millfield Series, a peaty podzol, Midgarth Series, a noncalcareous gley, Fletts Series, a saline gley and Lynedardy Series, a peaty gley, occur in a narrow belt trending north-westwards from Stromness.

Soils of the Flaughton Association occur on coarse-textured drift derived from sandstones of the Eday Beds. One soil series, Flaughton Series, a peaty podzol, has been distinguished. It is a soil of limited extent. A soil of very limited extent is Tomtain Series, a peaty brown soil of the Darleith Association; it is confined to the island of Hoy where it is developed on basic lavas and on two isolated volcanic necks.

Fluvioglacial sands and sands and gravels are of very minor extent in Orkney, but two associations have been identified, the Boyndie Association and the Rackwick Association. Boyndie Series, a humus-iron podzol, and Rackwick Series, a peaty podzol, are developed.

Three series were recognized on the Links deposits: Dornoch Series, a freely drained soil, Eigie Series, an imperfectly drained soil, and Morvich Series, a poorly drained soil.

The extensive deposits of peat occur as either shallow (50-100 centimetres in depth) or deep (more than 100 centimetres), together with eroded and cut-over phases. Much of the peat is of the blanket bog type, but a number of well-defined basins of peat are present. A shallow peat deposit on the exposed St. John's Head on Hoy contains an appreciable amount of windblown mineral matter.

Areas of windblown quartzose sand on the summit of Ward Hill in Hoy occur as hill dunes.

LAND USE

Agriculture of the upland stock-rearing type is the principal land user, with beef cattle, sold traditionally as stores, and sheep being the chief sources of income. The dominance of the store industry has been sustained and strengthened by improvements in grassland quality with the introduction of new grass varieties better able to withstand the rigours of climate, by superior grass conservation with advances in silage- and hay-making techniques and by the introduction of the so-called exotic animal breeds.

In 1983 the total area of grassland approached some 43,000 hectares or 44 percent of the land area with sown grasses accounting for about two fifths of this sum. The past decade has seen a marked increase in the area of fodder barley; in 1973 approximately 1300 hectares were planted out to fodder barley, but by 1983 the area had increased to some 2750 hectares. Continuing increases in the areas of barley and grassland have led inevitably to a decline in the area of the historical winter-feed supplements of swedes, turnips and oats, although oats have to some extent maintained their status in some of the northern isles and particularly in those areas dominated by windblown shelly sand. The area under oats has declined from approximately 10,000 hectares in 1939 to some 1100 hectares in 1983, a dramatic illustration of the change to a grassland-dominated economy and further evidence of the advances made in grass conservation.

Seed and ware potatoes are produced on a small scale.

Much of the hill ground is utilized as rough grazing with minor sporting interests.

Some of the shelly sand deposits are extracted for use as agricultural lime and peat is cut locally for domestic heating purposes.

FURTHER READING

Dry, F.T. and Robertson, J.S. (1982). Soil and Land Capability for Agriculture: Orkney and Shetland. Aberdeen: The Macaulay Institute for Soil Research.

Maps

1:50 000 Soil Maps. Soil Survey of Scotland

1. Orkney - Mainland
2. Orkney - Hoy
3. Orkney - Northern Isles.

2. Soil Fertility

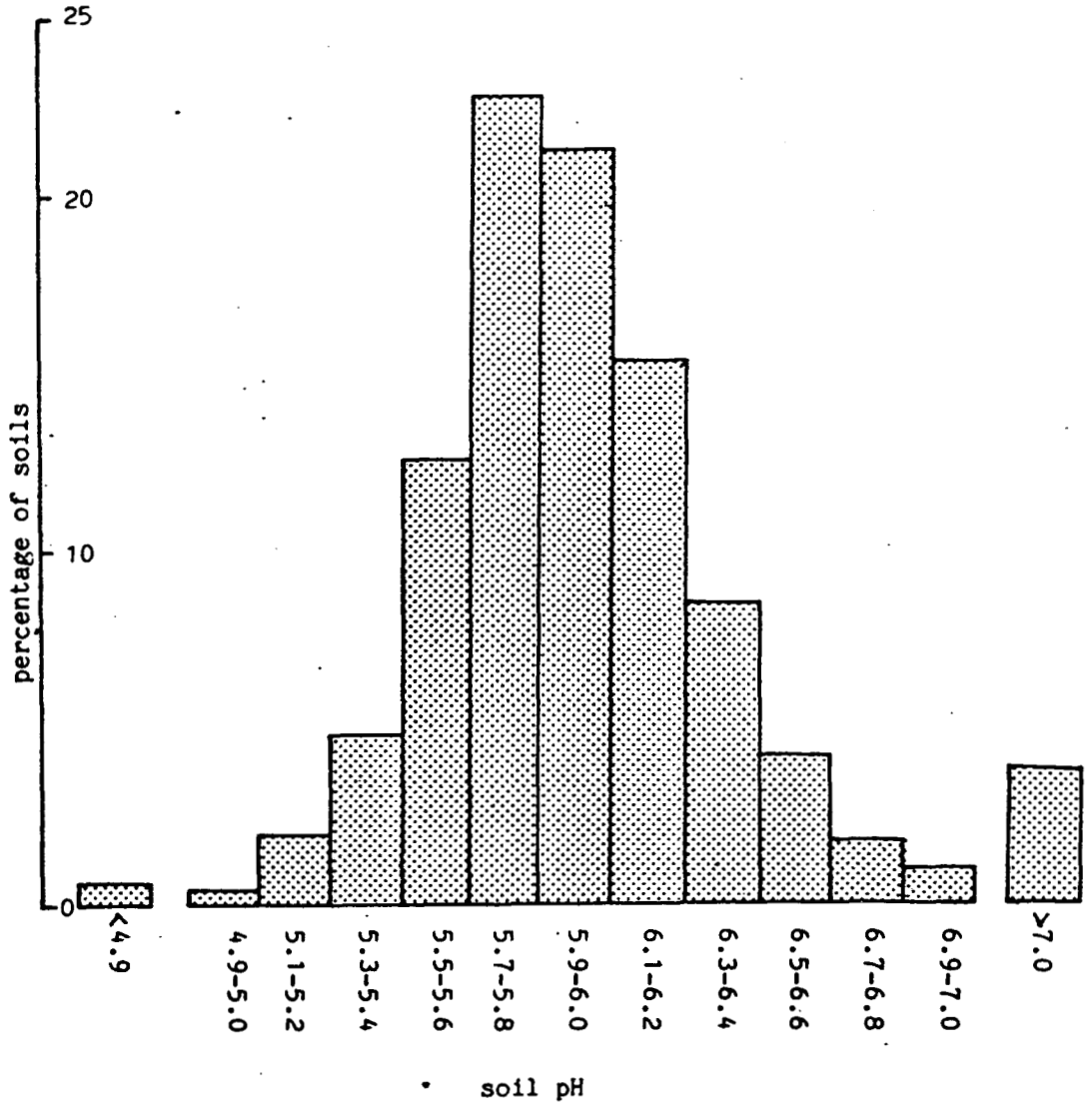
Orkney is renowned for its potential for the production of grass, this potential being dependent not only upon the mild, damp climate, but also upon the inherent fertility of the soils. The lime and macronutrient fertility of the soils of Orkney have been assessed using soil analyses carried out on over 2,500 fields. These fields were sampled between 1982-84 by staff of the North of Scotland College of Agriculture and analysed at the Macaulay Institute. As these analyses are on samples submitted by College staff as a result of requests by individual farmers rather than resulting from a systematic sampling there could be some bias in the results towards the more intensively farmed areas. Micronutrient levels are based only on the analyses of about 300 fields.

The assessment of the availability of soil nutrients is based on the methods of extraction and interpretation reported in "Advisory Soil Analysis and Interpretation", The Macaulay Institute for Soil Research/Council of Scottish Agricultural Colleges Bulletin No. 1, 1985.

SOIL ACIDITY AND LIMING

Soil pH is a measure of acidity or alkalinity. The distribution of pH in mineral soils from Orkney is shown in Figure 1.

Figure 1. Distribution of pH in mineral soils



The desirable pH for grassland growing on mineral soils is 5.7 to 6.0. At pH values less than 5.5 the persistence and vigour of clover and ryegrasses are reduced. As the soil pH is increased above 6.0, manganese and cobalt in herbage decrease. A slightly higher pH range 5.9 to 6.2, is recommended for barley. Sixty per cent of the soils tested from Orkney were in the pH range 5.7 to 6.2. Twenty per cent had pH values above 6.2. These were either shelly sands or soils which had been given over generous amounts of lime or shell sand. The remaining 20 per cent of soils had pH values below 5.7 and would require more than maintenance applications of lime to bring their soil pH to a satisfactory level. The average rate of the loss of lime from soil is likely to be between 0.3 and 0.4 tonne calcium oxide (CaO) per hectare per year. i.e. approximately 4 to 6 hundredweights calcium carbonate ($CaCO_3$) per acre. The higher losses are likely to occur where annual rainfall is greater than 1000 mm, where soil pH is high, or where large infrequent dressings of lime have been applied. Two years after the application, fine shell sand is likely to be as effective in raising soil pH as an equivalent amount of ground mineral limestone.

Much lower pH values can be tolerated without adverse effects on peats than on mineral soils. Most plant species, including clover, grow successfully with pH values of 5.0 or less. Organic top soils (those with a high organic matter content but not sufficiently organic to be termed peaty) need to be limed only to pH 5.5. Sixty per cent of organic soils in Orkney have pH values of 5.5 and above, and a further 20 per cent of 5.0 to 5.4. The remaining 20 per cent are below 5.0. The pH of virtually all of the peat soils are below 5.0.

MAGNESIUM

Despite the use of shell sand containing little magnesium Orkney soils are well supplied with magnesium (Table 1). About 80 per cent of the mineral soils are classified as moderate, and the other 20 per cent as high. Magnesium deficiency in agricultural crops is unlikely although the magnesium content of the herbage from moderate status soils may not be adequate in relation to animal health. Where lime dressings are required and soil magnesium is moderate, magnesian limestone would raise the magnesium content of herbage.

Virtually all the organic soils and peats contained moderate or high levels of magnesium.

Table 1. Macronutrient status of mineral soils

Soil nutrient status	Magnesium	Phosphorus	Potassium
	no. of samples as per cent of total		
Very low	0	4	2
Low	0	41	41
Moderate	81	48	56
High	19	7	1

NITROGEN

Nitrogen is the nutrient which, in the absence of fertilisers, most often limits the yield of crops. At present there are no methods of analysing soils which reliably predict their ability to supply nitrogen. The main reserve of nitrogen in the soil is in the form of organic matter accumulated from fresh and old plant and animal remains. Orkney soils are well supplied with organic matter as a result of the mild, damp climate and an agriculture based on grassland. Over 80 per cent of the analysed soils contained between 6 and 15 per cent organic matter. When organic matter is broken down.by soil bacteria and fungi some nitrogen is released although the amounts released are usually too small for the optimum growth of crops.

The soil nitrogen status depends on the number of years of grass in the rotation, and on the previous crop grown. Soils receiving large annual dressings of farmyard manure or slurry will usually have a high nitrogen status. If, however slurry is applied in autumn or winter, a considerable proportion of the nitrogen will be washed out of the soil. A high nitrogen status can be expected in soils during the first two years after ploughing out either grass more than 4 years old, which received more than 125 kg/ha nitrogen per year or a strong clover sward. A high nitrogen status can also be expected after a 2 year old ley grazed intensively and given over 250 kg/ha nitrogen per year, a strong clover sward or after a grazed forage crop.

PHOSPHORUS

A shortage of phosphorus restricts root development and the early growth of both grass and cereals, and delays ripening. The growth of clover in grassland is increased by phosphate as is the feeding value of grass, hay and fodder crops. The most responsive crop to phosphorus additions is swedes while phosphorus applied to seed potatoes gives quicker, early growth resulting in an increase in the number of seed sized tubers and their quality.

Forty-five per cent of the analysed mineral soils of Orkney were poorly supplied with phosphorus (Table 1). Where soil phosphorus is low, fertiliser phosphorus at a rate according to responsiveness, should be adjusted to give more than a maintenance application to each crop. Placement near to the seed will increase efficiency. In this way the problems of low soil phosphorus can be reduced and available soil phosphorus increases gradually with time. Soil phosphorus is immobile and losses of added phosphorus by leaching do not occur from mineral soils but crops only use the phosphorus immediately surrounding the roots. Up to 20 per cent of crop requirement comes from the applied phosphorus fertiliser; the actual amount depending on crop, soil and fertiliser type, and the appropriate use of placement and cultivations. The bulk of the phosphorus supply comes from the soil reserves so it is important that the soil is well supplied.

Where soil phosphorus is low cereals usually give an economic response to fertiliser phosphorus. This is most efficient when combine-drilled with the seed. If this technique is not used an extra 30 kg/ha (24 units/acre) of phosphate should be broadcast, preferably immediately prior to seed drilling. This ensures some fertiliser phosphorus is mixed with the soil and ends in the volume where roots grow. Where phosphorus is applied to ploughed land, cultivations which tend to move the soil and fertiliser into bands should be avoided as cereal growth and ripening may be uneven, resulting in yield loss. The most efficient method of phosphorus application for potatoes is placement in bands, 50 mm (2 inches) to the side and slightly below the level of the tuber. For swedes and turnips fertiliser should be broadcast after cultivation but just before ridging, thus ensuring it is concentrated in the centre of the ridge near the developing roots.

For grass sown in soils low in phosphorus, an application of 150-200 kg P_2O_5/ha (120-160 units/acre), worked into the seedbed, is justified as this ensures phosphorus is available for the establishment of a good root system. No phosphorus fertiliser has been found consistently superior to water soluble phosphate for grass during establishment. Water-insoluble rock phosphate is suitable for maintaining the phosphorus status of established grassland where the pH value is 6 or below and has not recently been limed. Even where a shortage of phosphorus in the soil does not reduce herbage growth its phosphorus content may be decreased with adverse consequences for animal health.

Seventy-five per cent of the organic soils and virtually all of the peats analysed were poorly supplied with phosphorus.

POTASSIUM

Potassium deficiency in grassland soils can adversely affect yield reponse to nitrogen fertiliser and cause desirable species to be replaced by weed grasses. Severe potassium deficiency in arable crops causes marked stunting of growth and in extreme cases premature death. Potatoes readily show shortages of potassium. High levels of soil potassium can result in luxury uptake by herbage and result in imbalances with other elements necessary for animal health. Moderate soil potassium levels are desirable and nearly 60 per cent of the soils analysed were in this category (Table 1). The other 40 per cent of soils were classed as low or very low perhaps reflecting the large amounts of potassium removed from the soil by conserved grass, potatoes and swedes. For example, 180 kg K_2O/ha may be removed in two cuts of silage. On grassland potassium fertilisers are best applied in increments throughout the growing season. The risk of hypomagnesaemia (grass tetany) is reduced by potassium applications made in mid season. This includes cattle slurries which are relatively rich in potassium.

About 60 per cent of the organic soils and 25 per cent of peats were low in potassium.

MICRONUTRIENTS

Data are available for the micronutrients copper, molybdenum, cobalt and manganese although based on a much smaller number of samples. Liming reduces the availability of manganese and cobalt from the soil, but has no effect on copper uptake and liming increases the uptake of molybdenum. Molybdenum limits copper absorption by ruminants, and so may induce the symptoms of copper deficiency.

COPPER

Copper deficiency may occur in cereals grown on soils which are very low or low in readily extractable soil copper (Table 2).

Table 2. Copper status of some soil series

Soil Assoc.	Soil Series	Very low	Low	Moderate	High	No. of fields analysed
		no. of fields as per cent of total				
Thurso	Bilbster	0	12	87	1	122
	Thurso	0	11	89	0	28
	Olrig	0	0	100	0	12
Canisbay	Tresdale	4	17	77	2	133
	Warth	39	39	22	0	28
	Ocklester	0	42	58	0	12
Fraserburgh	Fraserburgh	54	8	38	0	13

Most fields of the Bilbster, Thurso, Olrig and Tresdale soils appear adequately supplied with copper for cereals. Although based on few samples, over 60 per cent of fields on Warth and Fraserburgh soils cereals seem likely to be copper deficient. Organic soils and peats are also likely to be low in copper. Copper deficiency in cereals can be eliminated by working into the soil by normal cultivations 5 kg/ha of copper, in the form of a copper salt. As copper is not readily leached from the plough layer treatment should last for at least 10 years. Applying copper to the soil is ineffective in increasing the copper content of herbage and controlling copper deficiency in livestock. Soil copper is concentrated in plant root systems with relatively little transferred to the aerial parts. Summer herbage, grown on soils of moderate copper status, is unlikely to contain more than 8 mg/kg copper in the dry matter, and so may not meet the copper requirement of cattle. Copper deficiency in livestock may be induced by the overgrazing of autumn pasture and a consequent increase in soil iron ingestation, or by the intake of herbage with an above normal concentration of molybdenum.

MOLYBDENUM

Liming acid soils increases the availability of soil molybdenum. An assessment is given in Table 3 of the readily extractable soil molybdenum from some soil series.

Table 3. Molybdenum status of some soil series

Soil Assoc.	Soil Series	Low	Moderate	High	No. of fields analysed
		no. of fields as per cent of total			
Thurso	Bilbster	54	34	12	56
	Thurso	80	20	0	20
Canisbay	Tresdale	77	23	0	101
	Warth	36	55	9	22
	Ocklester	40	60	0	5
Fraserburgh	Fraserburgh	100	0	0	4

Low molybdenum levels are desirable and are found in most Thurso, Tresdale and Fraserburgh soils. Between 30 and 60 per cent of the relatively few Bilbster, Warth and Ocklester soils analysed contained moderate molybdenum contents and so were likely to give autumn herbage containing 1.5 to 3.5 mg/kg of molybdenum in the dry matter. This concentration of molybdenum can induce copper deficiency in livestock. About 10 per cent of Bilbster and Warth soils were of high molybdenum status and here autumn herbage is likely to contain 3 and 8 mg/kg of molybdenum with molybdenum-induced copper deficiency probable.

Molybdenum should not be applied to the soil as it is readily absorbed by herbage, particularly clover, and even small increases in herbage molybdenum can adversely affect copper metabolism in ruminants.

COBALT

Virtually all Bilbster, Warth and Ocklester soils and about 80 per cent of the Thurso and Tresdale soils had either very low or low contents of readily extractable cobalt (Table 4). Summer herbage is likely to contain less than 0.07 mg/kg of cobalt in dry matter where soil cobalt is very low or low.

Table 4. Cobalt status of some soil series

oil Assoc.	Soil Series	Very low	Low	Moderate	High	No. of fields analysed
		no. of fields as per cent of total				
Thurso	Bilbster	34	60	3	3	113
	Thurso	34	48	17	0	29
	Olrig	9	45	45	0	11
Canisbay	Tresdale	34	47	19	0	118
	Warth	45	52	3	0	29
	Ocklester	44	56	0	0	9

In order to reduce the risk of "pine" in livestock ideally cobalt concentrations in uncontaminated herbage should not be allowed to fall below 0.08 mg/kg dry matter. This cobalt concentration can only be sustained on soils with moderate or high cobalt contents which seem rare in Orkney. The exceptions seem to be about 20 per cent of the naturally poorly-draining Thurso and Tresdale soils and 45 per cent of the peaty gley Olrig Series. Liming reduces the availability of soil cobalt and all shelly sands are likely to be low. Cobalt sulphate applications to dormant grassland or ploughed land is usually effective in raising the cobalt concentration in herbage to a satisfactory level. One application of 2 kg/ha of cobalt sulphate should be sufficient for 3 or 4 years on acid mineral soils and for at least 5 years on organic and peaty soils. Animals given access to treated pasture for 50 per cent of grazing time should perform satisfactorily. Thus, one quarter of the grazing has to be treated every second year in order to maintain at least half the pasture adequately supplied with cobalt. The shell sands are likely to require 4 to 6 kg/ha to give the same benefits. Cobalt sulphate should not be applied in the same year as lime.

MANGANESE

Manganese deficiency in oats (Grey Speck) is common on shelly sands and other soils with pHs greater than 6.3. The symptoms of manganese deficiency can also be seen in barley, particularly in patches of high pH within fields. Manganese deficiency is aggravated in dry, poorly consolidated seedbeds. In apparently deficient fields normal manganese uptake, shown as greener growth, can occur in wheel tracks. In spring sown cereals the appearance of manganese deficiency can be delayed by sowing into a firm seedbed and combine drilling a NPK fertiliser containing the acidifying ammonium nitrate. As manganese deficiency is due to reduced soil availability at high pH, soil applications are not worthwhile.

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