An Foras Talúntais

Soil associations of Ireland and their land use potential

Explanatory Bulletin to Soil Map of Ireland 1980

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Miscellaneous

General Soil Map of Ireland, 1969
Survey of some Midland sub-peat mineral soils (with Bord na Móna), 1971 — *M. L. Carey*
The Potential of Irish Land for Livestock Production, 1972 — *J. Lee and S. Diamond*
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Soil Associations of Ireland and Their Land Use Potential

Explanatory Bulletin to Soil Map of Ireland
1980

by

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Foreword

The role of agriculture as a major growth area in this country's economy is now widely accepted. Particularly since membership of the European Economic Community agriculture is recognized as a generator of finance to stimulate other activities, as a supplier of food and raw materials for home and export markets, a supplier of valuable labour, a market for industrial goods and a source of agri-oriented industrialization. For the foreseeable future agriculture will continue to fulfill these roles and to be vitally important in maintaining economic stability, particularly at times of negative growth in other sectors.

For agricultural development, investment in land as a basic resource is of primary concern. If this investment is to be properly based, however, an adequate knowledge of land resources is a prerequisite.

Within An Foras Taluntais, the approach to agricultural research and development has centred on the fact that every tract of land has a specific optimum use either in economic or social terms. For this reason land use planning is essential.

Because of the interactions of various physical, social, economic, environmental and institutional forces, land-use planning is a complicated process. It consists of the allocation of land between competing demands and has as its objective the proper allocation of land to various uses as well as its protection and conservation for the future. It must involve, therefore, the making of inventories of the land itself based on its inherent permanent characteristics.

Through the National Soil Survey programme, established within An Foras Taluntais in 1959, we already have soil and land capability maps and reports for a number of counties and regions. These, as well as the first edition of the General Soil Map of Ireland published in 1969, provided a framework for the establishment of the agricultural potential of different regions and for studies such as the Grazing Potential of Irish Land, and the Distribution of Marginal Land in relation to the EEC Disadvantaged Areas Directive.

This Second Edition of the General Soil Map is a major step forward. It includes much new information both in terms of different soil types and more precise distribution patterns. For the first time, it is accompanied by a Bulletin which describes the major soils of the country and outlines their basic limitations as well as their potential for different uses. It will undoubtedly provide a more reliable picture of land use potential in Ireland.

It is a pleasure to be able to congratulate the authors and to be associated with the highly merited acknowledgements given to those within An Foras Taluntais and to those outside who cooperated in this work.

P. Ryan,
Director

Acknowledgements

The map is based mainly on the work of the field staff of the National Soil Survey. Research Staff: M. Bulfin, Dr. M. Conry, S. Diamond, T.F. Finch, Dr. M.J. Gardiner, R.F. Hammond, J. Kiely, M. Walsh and Dr. E. Culleton who also edited the bulletin. Technical Staff: E. Brennan, P.J. Burke, A. Comey, P. Feeney, T. Martin, J. Hartigan, T. O'Shea and T. Radford.

For Northern Ireland, the soils information is the same as that used in the first edition which was supplied by Dr. J.S. V. McAllister and Professor S. McConaghy. Only the soil numbers have been changed to fit into the new legend.

The map was prepared for printing by the Cartographic Section of the National Soil Survey at Johnstown Castle and was printed at the Ordnance Survey, Phoenix Park, Dublin.

The soil profile descriptions and analyses are taken from the published reports of the National Soil Survey except where otherwise acknowledged.

The analyses were provided by the Analytical Section of the National Soil Survey, apart from the trace element analyses provided by the Plant Nutrition and Biochemistry Department and the peat analyses carried out at Lullymore Experimental Station.

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Introduction

This publication has been prepared to accompany the Second Edition of the General Soil Map of Ireland (scale 1:575,000). The first edition was published in 1969, also on a scale of 1:575,000. It was based almost entirely on the findings of the National Soil Survey of An Foras Taluntais which had been in operation over the previous ten years. At that time, only four counties and two regions had been surveyed at detailed reconnaissance scale, while surveys at reconnaissance level had been in operation in another ten counties. The remaining twelve counties had been covered only by preliminary reconnaissance surveys specially conducted for the production of that first soil map. For these reasons, the first edition lacked detail and precision for many areas.

In the intervening years much new information has come to hand, again, almost entirely through the work of the National Soil Survey. At present, seven county soil maps at detailed reconnaissance scale, and three regional maps have been published; one other county map (Co. Meath) is at an advanced stage of preparation and field work is well advanced in six other counties. Of the remaining counties, reconnaissance surveys have been conducted in eight. A considerable amount of new information on the soil distribution pattern in the country is therefore available.

The bulletin is intended to deal mainly with the soils of the Republic of Ireland although the map and legend cover Northern Ireland also. The soil categories* and boundaries for Northern Ireland have not been altered from the First Edition.

A separate chapter is devoted to land use interpretation which is derived from the basic soils information shown on the map. This includes assessments of the nature, extent and distribution of: i) marginal land; ii) land suitable for tillage, and iii) land suitable for grassland. In the case of grassland a more detailed account of the grazing capacity of the different soils will follow this publication.

It has been calculated that marginal land occupies 3.4 million hectares in the country (50%). This land consists of 1) Mountain and Hill land (10%). 2) Hill Land (2%), Wet Mineral Lowland (21%) and Peat (17%). It is distributed on a provincial basis approximately as follows: Munster 1.2m ha, Connacht 1.1m ha, Ulster 0.6m ha, and Leinster 0.5m ha**.

On a county basis Leitrim with 97% has the highest percentage of marginal land while Waterford has the lowest with 8%. In terms of extent (m.ha), however, the order of magnitude is Mayo (0.39), Donegal (0.38), Kerry (0.38), Gal way (0.31) and Cork (0.27).

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* Apart from those made essential by changed soil categories in border counties of the Republic, especially Donegal.

**Unless otherwise stated all figures refer to the Republic of Ireland only and are rounded off.

Land use interpretation from this second edition reveals the following information: Good agricultural land occupies some 50% (3.4m ha) of the land area whilst marginal land occupies some 49% (3.4m ha).

The good agricultural land can be subdivided into tillage suitability classes as follows: highly suitable 15%, suitable 15%, moderately suitable 7%, and only marginally suitably 14%. In terms of distribution in the provinces, it is found that of the total suitable tillage land in the country 41 % occurs in Leinster, 36% in Munster, 18% in Connacht and 6% in Ulster. Comparison between the present tillage crop acreage and the extent of land suitable for tillage shows that suitable land resources are not a constraint to the expansion of the present tillage acreage. For example, on a national basis, only 13% of the land suitable for tillage is used for that purpose annually whilst on a provincial basis, although Leinster has the greatest extent of tillage crops at 252,785 hectares, this constitutes only about 18% of suitable tillage land in the province. Comparative figures for Munster are 12%, for Connacht 6% and for Ulster 13%.

In terms of suitability for tillage, it has been estimated that some 1.0m ha are highly suitable, 1.0m ha are suitable and 0.5m ha are moderately suitable, giving a total of 2.5m ha or 36% of the country. A further 0.9m ha is classified as marginally suitable for tillage.

The counties with the greatest amounts of land suitable for tillage are Cork with 470,307 ha, Tipperary 267,097 ha, Galway 271,586 ha and Meath 204,195 ha.

Various other land use interpretations are outlined in detail in this bulletin. These include the use-range of soils on a national, provincial and development region basis. The latter study shows, for example, that on the basis of percentage of good land, the Southeast (78%), East (70%) and Midland (58%) regions are highest whilst the Donegal (20%), Northwest (26%) and West (37%) regions are lowest.

In addition to the examples presented here, this publication provides a scientific basis for many other land use interpretive studies. In this way the basic soil survey information can be used for optimum land use planning and for agricultural development in particular.

Soil Formation in Ireland

THE SOIL FORMING PROCESSES

Three principal soil forming processes take place in Ireland; leaching, gleisation and calcification.

Through the leaching process, soluble constituents are carried down through the soil profile. The soil becomes progressively more acid, until eventually relatively insoluble constituents such as iron, aluminium and humus are eluviated. Organic matter may accumulate on the surface and an iron pan may be formed at a lower level in the soil. At this stage the leaching process may be referred to as podzolisation. Most free-draining soils in Ireland are influenced to varying degrees by this process and therefore require a continuous renewal of nutrients and lime over and above the amounts removed through crop and animal production alone.

In many soils movement of clay particles down the profile often precedes or accompanies the movement of soluble constituents. This process usually takes place where soils contain very fine clays, are low in carbonates and free oxides and are subject to alternate wetting and drying. As a result of this process an eluvial A2 horizon is often formed beneath the surface A1 horizon whilst an illuvial B horizon, in which there is a significant accumulation of clay, forms beneath the A2 horizon. Carbonates are thought to be largely responsible for the flocculation and accumulation of clay particles in the B horizon.

Gleisation is the soil-forming process resulting from water-logging. This may be due to the presence of a high watertable or to the impermeable nature of the soil itself. The movement of water through the soil profile is greatly restricted and leaching is very limited. Due to anaerobic conditions, many soil constituents are converted by chemical processes into reduced forms, and as a result the soil usually takes on a grey or blue colour with ochreous mottling, the result of reoxidation processes.

Calcification is a process resulting in the redistribution of calcium carbonate in the soil profile without complete removal of it. The regions so affected are those of restricted rainfall and include those parts of the temperate zone where rainfall is approximately 750 mm or less. Since the rainfall is low, the percolation of water through the profile is not sufficient to remove wholly the calcium carbonate that existed in the parent material or that was produced by reaction between carbonic acid and the calcium hydrolysed from silicate minerals.

The usual result is the accumulation of carbonates at some point in the profile below the surface. A secondary result of calcification is that calcium tends to keep the fine clay in a granular condition, consequently there is relatively little downward clay movement.

The calcification process applies generally to climatic conditions drier than those in Ireland. However, the calcification process not only connotes the accumulation of lime in the soil but also the absorption of calcium by colloids. Grasses and other plants requiring high amounts of bases bring these to the surface and, through decay, replenish losses of leaching. It is believed that Brown Earth soils (Brown Forest soils) owe their lack of eluviation to this kind of calcification and are limited to areas which had (or have) a forest vegetation with a high content of bases in its leaves. Rendzina soils are also calcified but in spite of calcareous parent material do not always contain free carbonates.

Even though the climatic conditions are not dry enough for the calcification process to take place to any great extent this process plays a role in the formation of those soils which we have classified as Rendzinas and as Brown Earths of high base status.

FACTORS OF SOIL FORMATION

The character of every soil can be attributed largely to the interaction of five major factors of soil formation. These genetic factors are parent material, climate, living organisms, topography and time. These factors control the rate of weathering of rocks, the constitution and composition of the resultant soils, as well as the subsequent gains, losses and alterations within the profile. The relative degree of influence of these factors is responsible for many of the differences to be found in our soils. A sixth factor influencing many non-virgin soils is the human factor or man's interference with the natural development tendencies in soils whilst modifying them for his own particular purposes.

Parent Material

Parent material may be either solid rock which has weathered or some superficial deposit such as glacial drift or alluvium that has been derived from weathered rocks and transposed. Rocks vary tremendously in composition and such variation is reflected in the derived soils. For example, quartzite is highly resistant to weathering and its composition is such that during the slow weathering process little clay is formed and release of mineral nutrients is poor. Besides being inherently poor, soils on such materials degrade easily as the leaching process outpaces the rate of weathering. Fortunately, most rocks are mixtures of many minerals, few of which are able to withstand weathering as well as quartz. Glacial drift, the most common parent material of Irish soils, varies considerably in constitution and in geological composition, giving rise to many different soils.

Solid Geology

Although Precambrian rocks dating back to more than 2,000 million years ago have been identified in coastal sections at Rosslare and Kilmore Quay in Wexford, the most extensive older rock formations in the country are represented by those of the Lower Palaeozoic and the youngest (60 million years ago) by those of the Tertiary Period.

The Palaeozoic Era

These consist of Cambrian, Ordovician and Silurian rocks (mainly shales). They are usually metamorphosed and trend in a south-westerly direction.

The Cambrian rocks occur in south-east Wexford and east Wicklow while the Ordovician are widespread throughout Wexford and Wicklow and also occur in Cavan,

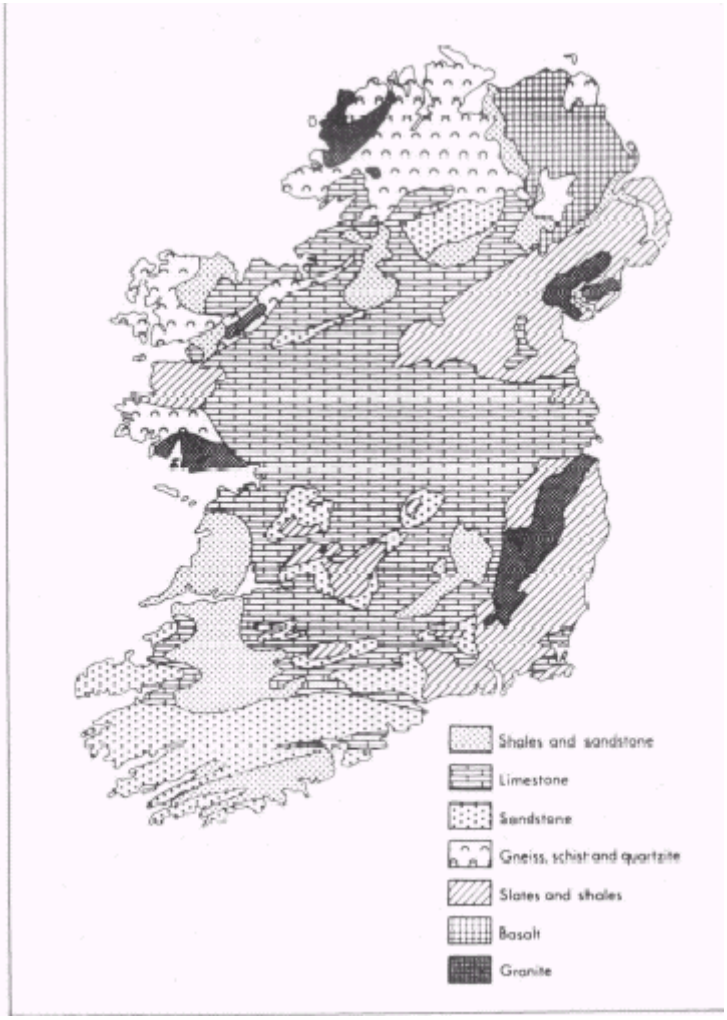


Fig. 1: *Principal rock types in Ireland*
(*from "A Systematic Geography of Ireland" by D. Gillmor, Gill and Macmillan, 1971)*.

Monaghan, Armagh and in south-west Mayo. The Silurian rocks are widely represented in Louth, Cavan, Monaghan and Down. They also form the core of a number of the hills and mountains of the south, notably the Commeraghs, Galtees, Slievenamon, Keeper Hills, the Aughtys and the Slieve Blooms. The more highly metamorphosed rocks of this period, e.g. schist and gneiss and to a lesser extent quartzite, occur extensively in the Donegal-Derry-Tyrone region and also in west Mayo and west Galway.

Caledonian Intrusions

Rock folding on an enormous scale, in a north-east to south-west direction, took place at this time (400 million years ago). The clays and sands which had been previously deposited to form shales and grits were strongly metamorphosed into schists and gneisses and quartzite. Massive igneous intrusions took place, the most widespread of which were the granites dating back to about 380 million years ago. There are five major granite intrusions in the country, namely, the Leinster, Galway, Foxford, Donegal and Newry. Except in Galway, they are all elongated along the south-westerly Caledonide strike.

Devonian Period

At the end of the Caledonian period, great sedimentation again took place, especially in what is now south and south-west Ireland. The climate was dry and warm so that iron in the depositing spreads of sand and gravel became oxidized and reddened. The sandstone which formed and which was subsequently folded and uplifted during the Armorican orogeny became known as *Old Red Sandstone*. This folding took place in an east-west direction and has given, to southern Munster in particular, its typical east-west trending hill and valley topography.

The Old Red Sandstone occupies much of the area south of a line from Dingle Bay to Dungarvan and also the main component rock type of the Knockmealdowns, the Galtees, the Slievenamon Range, Slieve Bernagh, Slieve Aughty and the Slieve Blooms. It also stretches from Pomeroy in Tyrone to Irvinstown in Fermanagh.

The Carboniferous Period

More than 40% of the surface area of Ireland is underlain by Carboniferous sediments. The entire Central Plain is an extensive sheet of Carboniferous strata pierced by only a few scattered inliers. Most of this is calcite-rich limestone which stretches from Fermoy in the south to Dungannon in the north and from the Galway/Clare coast in the west to the Dublin/Meath/Louth coast in the east.

At the later stages of the Carboniferous Period, the sediments became more laden with organic debris and with silt and clay particles. This resulted in the formation of the Upper Carboniferous shales, Coal Measures and Millstone grits. These occur most widely on the Castlecomer Plateau, the Slievardagh hills and in north Kerry, west Limerick, west Clare and in Leitrim and Fermanagh. Because they are rich in clay and silt, they usually weather to form poorly-drained, difficult soils.

The Armorican Folding

During this period folding again took place. The Devonian Old Red Sandstone and the Carboniferous limestones and shales were compressed into a series of east-west folds and this has given to south Munster, in particular, its typical east-west trending hill and valley topography. Due to subsequent erosion, the Old Red Sandstone is now

Plate 1: *In Ireland most of the solid geological formations are overlain by glacial drift from which the soils are formed.*

at the surface of the anticlinal uplands whilst the synclinal valley floors consist of Carboniferous limestone and shale.

The Mesozoic Era

This period stretches from 225 to 70 million years ago. After the Armorican upheaval, great masses of eroded debris were trapped in basins to form the New Red Sandstone. Relative to the Old Red Sandstone however, its extent is very limited. It is found only in small enclaves close to Kingscourt, in Belfast Lough and between Armagh and Dungannon, close to Cookstown and in the vicinity of Larne.

In Ireland, Jurassic deposits of calcareous marine clays only occur in the north-east (mainly around Lough Neagh) where they were protected from erosion by the later volcanic rocks.

About 135 million years ago, there was renewed deposition in the form of a white calcareous ooze with traces of silica. This has been transformed into chalk containing nodules of siliceous flint. It was problably fairly extensive at first but, due to erosion eventually remained mainly in areas of the north-east.

Some 60 million years ago fissures began to open in previous strata due to earth movements. These fissures were most numerous close to the North Channel and here molten lava emerged to engulf the surrounding countryside with great sheets of basalt which covers almost the entire north-eastern part of the country.

Glacial Geology

Ireland was affected by three successive glaciations, often named the Elster, the Saale and the Weichsel. In recent times, the terms Munsterian and Midlandian have replaced the latter two respectively in Ireland.

Plate 2: *Glacial deposits can be several metres thick as in this section showing limestone till in Co. Limerick.*

Glacial deposits are widespread throughout the country but those of the Elster glaciation occur in a few places only and have had little if any effect on the subsequent soil pattern.

Between the Elster and the Munsterian glaciations the climate became warmer and sea level rose to about 30m above its present level. Evergreen trees such as fir, spruce, pine and yew were dominant.

Munsterian Glaciation

As the cold conditions of the Munsterian glaciation set in a powerful ice cap developed in the Scottish Highlands. This eventually sent a massive ice sheet along the bed of the Irish Sea and deposited shelly calcareous till along the east coast from Down to Wexford and even as far west as Ballycroneen in Cork. This till has a high calcium carbonate content together with marine shell fragments and erratics from geological formations in Scotland (e.g. Ailsa Craig microgranite). The Scottish ice also penetrated northwest to Malin Beg in Donegal and as far as the Lough Neagh basin.

At a later stage during this glaciation, ice appears to have increased in volume again. This ice had its axis running from the Lough Neagh basin to Connemara from whence granite was carried as far as the south coast. This ice build-up was very powerful and made contact with the Irish Sea component along the east and south east coasts.

At this time also, important independent ice caps with valley glaciers are thought to have existed. These were concentrated in the mountains of Wicklow, Down, west Cork, Kerry, Donegal, Derry and Tyrone. Ice accumulated to such great thicknesses at this time that it seems to have amalgamated from different centres, especially in the Central Plain and in the mountains of the west.

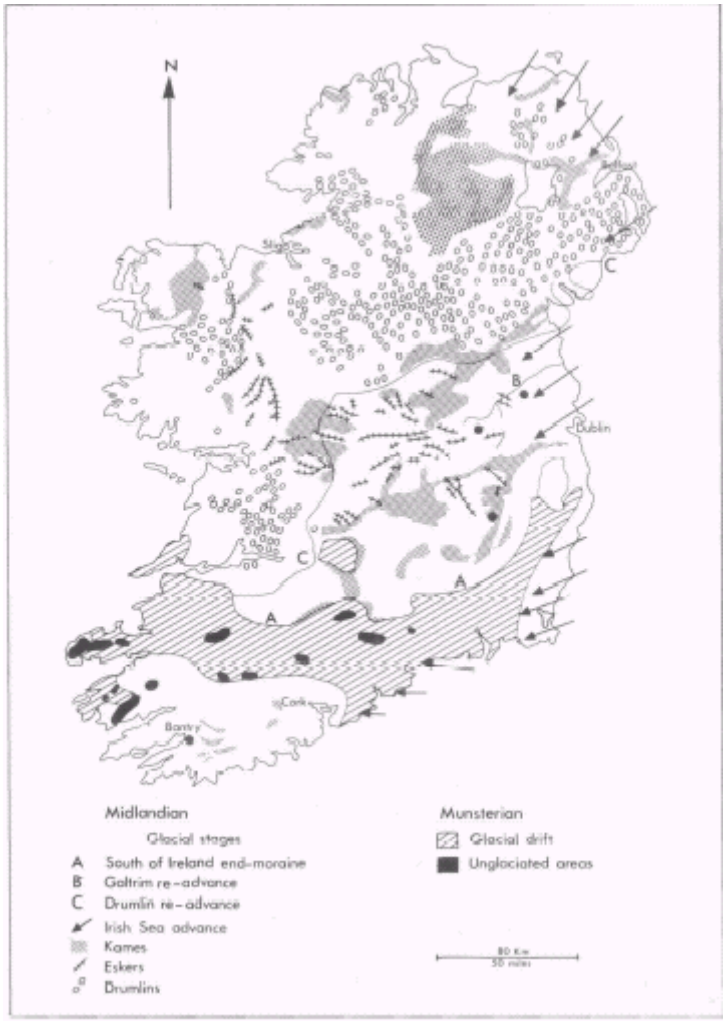


Fig. 2: *Glacial geology of Ireland*.

Midlandian Glaciation

The ice masses were less extensive during this, the most recent glaciation. Nevertheless, a number of centres of accumulation existed. The Irish Sea ice seems to have only affected a narrow belt along the east coast.

The main ice mass did not cover the most southern parts of the country at all. Its limit is marked by a conspicuous end moraine which stretches from Curracloe in Wexford around the northern tip of the Wicklow mountains through Myshall in Carlow, east of the Castlecomer Plateau through Tipperary and Limerick to Loop Head in Clare.

This general ice mass was not powerful enough to make contact with the ice mass of the Cork-Kerry mountains which is thought to have affected the area as far north and east as a line running from Dingle Bay south of the Boggeragh and Nagle mountains to Cork Harbour.

In the materials deposited by the Munsterian glaciation there is evidence of a greater degree of weathering and cryoturbation than in those of the Midlandian glaciation. In addition, there is an absence of the well marked topographic features such as kames, eskers, moraines and drumlins which are widespread throughout the area affected by the Midlandian glaciation.

Climate

Climate is directly or indirectly responsible for variation in plant or animal life as well as for major soil differences. On a global basis the effects of rainfall, temperature, and evapotranspiration can be seen in a broad zonation of soils for major regions, and they have a major influence on the soil forming processes.

Ireland has a cool-temperate west maritime climate with mild, moist winters and cool cloudy summers. For the greater part of the year warm maritime air associated with the Gulf Stream helps to moderate the climate. The prevailing winds are westerly to southwesterly. Average relative humidity is high. Annual average precipitation, which exceeds evapotranspiration by over 500 mm, is highest on the west coast and in inland areas of high relief.

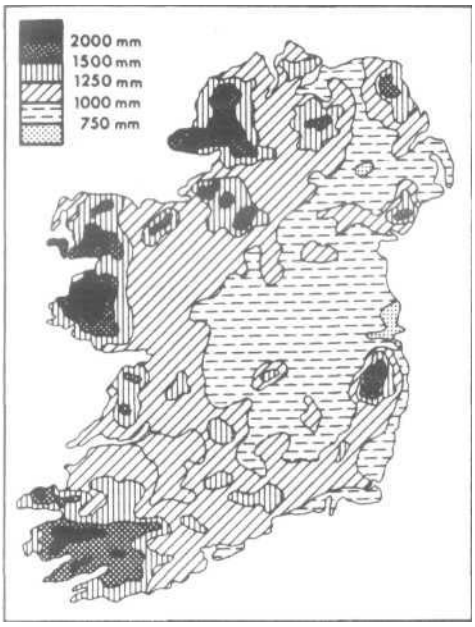
Temperature

Average temperatures range from 9.0°C in the north-east to 10.5°C in the south-west. The pattern of the isotherms reflects the ameliorating effect of the Gulf Stream so that it has a warming effect in winter and a cooling effect in summer. Winter temperatures are higher in Ireland than in most other parts of the world at the same latitude. Soil temperatures are favourable for grass growth for about 11 weeks longer per year in the coastal districts of the south and south-west compared to the midlands.

Rainfall

Rainfall is highest in the western mountains where it can exceed 3,000mm and lowest along the east coast where it is generally less than 1,000mm (Fig. 3).

Although the driest month is April and the wettest is December, rainfall is rather evenly distributed throughout the year, the driest month having more than 40mm. The number of days on which rain falls is high, ranging from less than 200 in the south east to 270 in the west (Fig. 4).



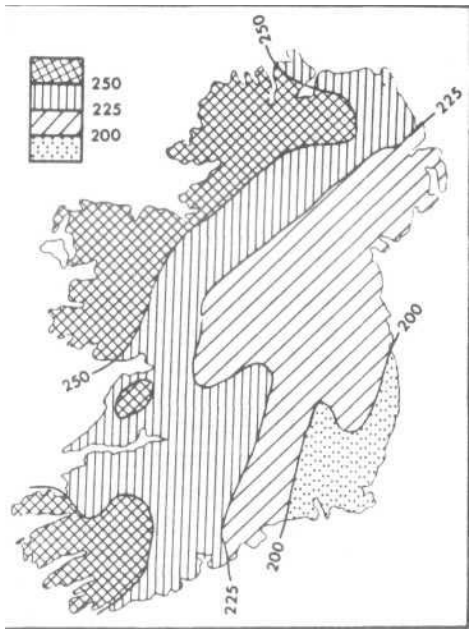


Fig. 3: *Mean annual rainfall* Fig. 4: *Average number of raindays per year.*

(from "A Systematic Geography of Ireland" by D. Gillmor, Gill and Macmillan, 1971).

Sunshine

The frequency of cloud cover and rainfall limit the amount of sunshine received. The average duration of bright sunshine per day varies from more than 4 hours along the south and east coasts, to less than 3.5 hours in much of the north-west. May and June are the sunniest months.

Frost

Frost occurs on an average of less than 25 days per year in coastal districts of the west and on more than 50 days in the interior of the country.

The Biotic Factor

Living organisms in the soil include plants, animals, insects, fungi, bacteria and other biological forms. These play an important role in soil development such as determining the kind and amount of organic matter that is incorporated in the soil under natural conditions. They also govern the manner in which organic matter is added, whether as leaves and twigs on the surface or as fibrous roots within the profile. The rate of decomposition of organic matter is strongly influenced by the type and activity of living organisms present. Plants can reverse the leaching process in part. The roots may take up calcium, potassium, phosphorus and other elements from the lower horizons and these

elements are returned to the surface with the decay of leaves, roots and other plant remains.

Organisms such as earthworms and insects and also micro-organisms such as fungi and bacteria perform many important functions in the soil and strongly affect soil character and behaviour.

The nature of the vegetative cover itself is known to have a decided influence on soil development. Other factors being equal a forest cover promotes a different soil forming process to either grass or cultivated cropping. Trees also differ in their influence on soil development, the main difference in this respect being between the conifers and the deciduous trees. In general, coniferous species are more conducive to soil degradation and the formation of podzolised soils, particularly on acid parent materials. Certain forms of ground cover, such as heath vegetation, are even more conducive to podzol formation.

Because forests occupy only some 4.5% of our present land surface, it is difficult to imagine the Irish landscape in its original natural state, covered by extensive forests except for areas over 600 metres in height and where ground conditions were so wet that fen peats were developing.

Through pollen count studies it has been possible to reconstruct the history of development of the Irish flora.

With the ending of the last glaciation and the development of the current (Littletonian) warm stage, woodland began to develop throughout the country in a number of stages. These have been traced by Mitchell from 10,000 years ago, when there was a general absence of woodland, to 5,500 years ago when almost the entire country was covered by woods and man was beginning to exploit them (Mitchell 1976).

At first, Juniper began to flower freely. Willow was also important at this time but both of these were soon shaded out by Birch woods. Hazel began to be important about 9,250 years ago. Pine pollen appears at the same time and both climbed rapidly to high values as the birch trees were overshadowed and disappeared beneath the higher canopy. Pine flourished on the drier soils except where they were on limestone, whereas hazel would have done better on the limestone and on wetter soils.

Oak, elm and alder had reached the country about 9,000 years ago but at first they were unable to displace the pine and hazel so that there was a hazel-pine dominated woodland which covered almost the whole country from about 9,250 until 8,000 years ago.

By 8,000 the oak and the elm were beginning to overshadow the hazel on the heavier soils, and the amount of hazel pollen falls. This hazel-pine-oak-elm period lasted from 8,000 to 7,000 years ago. The alder, ash and yew were also present at this time but were probably much less extensive than the others. (It was during this period also, that man became firmly established in Ireland, especially in the north-east). Pollen diagrams indicate that from 7,000 to 5,500 years ago alder became much more widespread and pine fell back to a much lower level. Climate seems to have become wetter. It is thought that dense, tall deciduous woodland dominated by alder, oak and elm occupied the better lowland soils at this time, with birch and pine still probably holding their own on the uplands. The climax-phase of woodland stability, dominated by hazel-oak and alder became established and persisted for about 1,500 years until the first Neolithic farmers began clearances for farming operations.

Thus, at that time, Ireland was covered by primeval woods and these played a significant role in soil development. However, it is important to realise that the composition of the woodlands varied from place to place depending on the geological formations beneath and on the glacial deposits overlying them.

Apart from woodlands, the other major component of the Irish landscape dating from 10,000 years ago, was the growth of marginal fens and marshes leading eventually, to the building up of the raised bogs. Plants capable of spending their entire life largely submerged (Bladerworth and Hornworth) established themselves in shallow waters and their debris, together with silt and clay, diminished the depth. Bullrushes, reeds and sedges gradually became consolidated into fen peat. As the fen built up and the influence of nutrients from the underlying soil became less, plants such as sphagnum mosses and eventually, heather developed and accumulated to form raised bogs. It is thought that raised bogs had started to form not less than 7,000 years ago.

On the uplands, soils which had carried woodland up to 600 m had begun to degrade with the deterioration in climate from 7,000 years onwards and by 4,000 years ago began to be buried beneath thick layers of climatic peat. At first, this contained a lot of rush but as the nutrient supply became less, it was dominated by mosses and, eventually by both heather and mosses.

Topography

Since topography governs the position of a soil on the landscape it is important in many respects, especially in its effect on water runoff and drainage. The amount of water that moves through a soil is less on steep than on gentle slopes, and low-lying and flat areas generally receive more water. This accounts to some extent for the preponderance of poorly drained soils in low-lying areas. Soils of poor drainage, however, may be found on good slopes where the lower soil horizons or parent material are of poor permeability, leading to retardation of water movement.

Elevation, with its attendant climatic and vegetational changes, has a strong influence in conditioning the soil development pattern. Other features such as erosion and those related to aspect are also associated with topography. Apart from its influence in soil formation, topography can be an important deciding factor in the use of soils.

In Ireland there is a close relationship between lithology and relief. The Carboniferous limestone of the Midlands forms a gently undulating “Central Plain” which is almost always below the 120 m contour. Pre-Carboniferous and Tertiary igneous rocks form a peripheral discontinuous upland rim. As pointed out by Davies and Stephens (1978), “not one of the 45 peaks exceeding 750 metres in height stands more than 56 kilometres distant from sea-water”.

The quartzites and the Old Red sandstone, because of their hardness, contribute significantly to Ireland’s geomorphology. Quartzites are widely scattered amongst the ancient schists of Galway, Mayo and Donegal and in parts of Wicklow (Bray Group). Quartzite outcrops are not extensive, but they form some 12% of the peaks over 600 metres in height e.g. Mount Errigal, Croagh Patrick and the Great Sugar Loaf mountain.

Old Red sandstone supports a topography of hills and mountains mainly in the south. Although it underlies only 10% of Ireland’s surface, it forms almost 50% of the 190 peaks that rise above 600 metres.

The granites in some places give rise to mountains and in others they underlie extensive lowlands. Granite forms the bold massif of the Mourne mountains, the Leinster mountain chain and the Derryveagh mountains of Donegal, but in Galway, it underlies the subdued topography of the Connemara lowland.

Although Ireland has great topographical diversity, related to its solid and glacial geological history, we have divided it into five major physiographic divisions which are significant with regard to soil type and land use. These divisions are: (1) Mountain and Hill; (2) Hill; (3) Rolling Lowland; (4) Drumlin; (5) Flat to Undulating Lowland (Fig. 7). They are described in some detail in Chapter 5.

Time

Considerable time is needed for the accumulation of soil parent material and for the development of horizons in the soil profile. The degree of maturity of a soil depends to a large extent on age, as well as on the parent material and other factors. Soils developed on young deposits, such as alluvium, show less distinct horizons, in general, than soils developed on older materials over a longer period.

Being formed mostly from glacial deposits, Irish soils are relatively young. North of the end moraine, which marks the limits of the last ice sheet and which runs across the country from Loop Head in Clare to Curracloe in Wexford, soils date from the end of the Midlandian glaciation, about 15,000 years ago. South of this limit, they date from the termination of the previous Munsterian glaciation, which is considered to have occurred about 100,000 years ago. Soils formed from this older drift are more weathered and compacted and the landscape in which they occur tends to have smoother slopes.

Man's Influence

Man, by his activity in changing the natural environment, has profoundly influenced soil development. In Ireland, the natural forest cover has been removed, cultivation has taken place and lime and fertilisers have been applied. The leaching process has been arrested and in some places large quantities of sand and marl have been incorporated with surface soils to increase their fertility status.

None of the factors of soil formation is universally uniform. There are many kinds of rocks, many types of climate, many combinations of living organisms, great variation in topography and in age of different land surfaces. As a result, there are innumerable combinations of the factors of soil formation giving many different soils.

Although it is true that great variability exists, the distribution of soils is not so haphazard as might be expected. Each soil reflects the environment in which it has formed, occupies a definite geographic area and occurs in certain patterns with other soils. By recognising the main factors of soil formation and by distinguishing the reflected characteristics in the soils themselves, we can segregate geographic soil units. Thus similarities and differences among soils can be recognised and the various soils can be classified and their distribution mapped.

Soil Survey Method

Soil survey and classification require detailed descriptions of the various layers of soil which are exposed in any vertical section. The criteria used for differentiating between such layers and the reasons for their occurrence, together with details of the soil survey method, are summarised here.

THE SOIL PROFILE

The soil profile refers to a vertical section of the soil down to and including the geological parent material. The nature of the profile is important in many aspects of plant growth including root development, moisture storage and nutrient supply. The profile is, therefore, the basic unit of study in assessing the true character of a soil. It usually displays a succession of layers that may differ in properties such as colour, texture, structure, consistence, porosity, chemical constitution, organic matter content and biological composition. These layers, known as soil horizons, occur approximately parallel to the land surface.

Soil Horizons

Most soil profiles include three main horizons that are usually identified by the letters A, B, C (Fig. 5). The combined A and B horizons constitute the so-called solum or ‘true soil’ whilst C refers to the parent material beneath. Certain soils lack a B horizon and are said to have AC profiles. In some soils also, organic layers (O horizons) overlie the mineral horizons. Underlying rock is indicated by the symbol R.

Some soils may have a relatively uniform profile with A and C horizons whilst others are so complex that they possess not only A, B and C horizons but also several sub-horizons. Where horizons need to be sub-divided on the basis of significant differences, the sub-horizons are identified by the horizon designation plus a suffix number thus: A1, A2, A3, B1, B2, etc. The various horizons in a soil and their character reflect the processes of soil formation that have been operative and they present a picture of the true nature and salient characteristics of a soil which are important in its use and management.

The A Horizon

This horizon is the uppermost layer in mineral soils and corresponds closely with the so-called ‘surface soil’. It is that part of the soil in which living matter, e.g., plant roots,

Plate 3: *Soil profiles, showing a succession of different layers or horizons are examined, described and sampled for analysis.*

bacteria, fungi, earthworms, and small animals, is most abundant, and in which organic matter is usually most plentiful. Being closest to the surface, this horizon is the first to be reached by rainfall and is, therefore, more leached than underlying horizons. The A horizons in most Irish soils have been depleted of soluble chemical substances and in certain cases, also, of some of their very fine clay particles. Where the soils have been strongly leached they may be depleted of iron and aluminium oxides and of other constituents besides. Two sub-divisions of the A horizon are commonly made, namely, A1 and A2. Either the A1 or both may be represented in a profile. The A1 is a surface mineral horizon that usually contains a higher proportion of organic matter incorporated with the mineral mater than any of the underlying horizons. In cultivated soils this horizon corresponds to the plough layer and may be designated Ap. The A2 is a comparatively light-coloured horizon and frequently has a bleached appearance. The A2 always refers to the horizon which has undergone the greatest degree of leaching. This is reflected in the lighter colour, mostly the result of a partial removal of colouring constitutents, principally iron. The A3 signifies a transition zone between the A and B horizons.

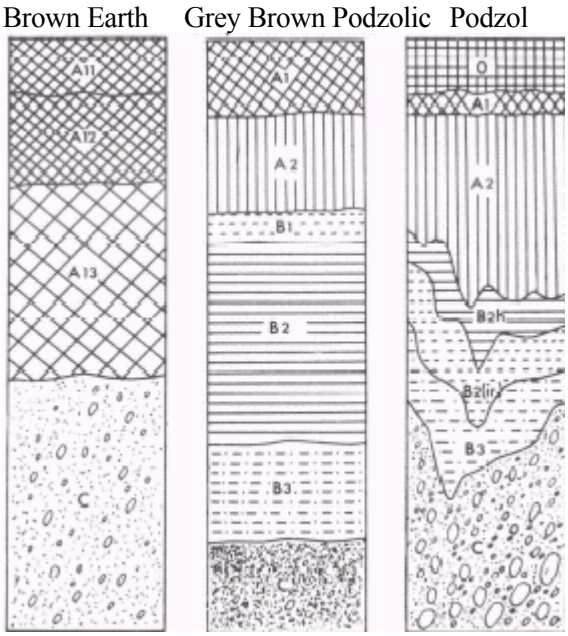


Fig. 5: *Diagrammatic representation of hypothetical soil profiles showing horizon sequence.*

The B Horizon

This horizon lies immediately beneath the A and corresponds closely to the so-called ‘sub-soil’. Lying between the A and C horizons, it possesses some of the properties of both. Living organisms are fewer than in the A but more abundant than in the C horizons. Compared with the A horizon, the B horizon is one of accumulation and usually has a relatively high content of iron and aluminium oxides, humus or clay that, in part at least, have been leached from the overlying horizons. Usually a more pronounced blocky or prismatic structure is found where this horizon is clay-enriched. Stronger colours are apparent in the B horizon, especially when the accumulation products are iron oxides or humus, or both.

Depending on the degree and pattern of accumulation of constituents within the B horizon, several divisions of the horizon, e.g., B1, B22, B3, may be warranted, B2 representing the zone of most intense accumulation. Besides, symbols such as B2t, B2ir and B2h are used to denote significant accumulations of clay, iron and humus respectively. B1 and B3 denote transitional horizons from A to B and from B to C

horizons, respectively. If the B horizon is without any appreciable accumulation of leached products but has distinctive colour or structure characteristics it is usually referred to as a (B) horizon.

The C Horizon

This horizon refers to the geological material beneath the A and B horizons (solum). It consists of the upper part of the loose and partly decayed rock or other geological material, such as glacial drift, similar to that from which the soil has developed. It may have accumulated locally by the breakdown of the native rock or it may have been transported by ice, water or wind. The C horizon is less weathered, has less organic matter and is usually lighter in colour than overlying horizons.

The O Horizon

This horizon refers to a surface layer of raw or partly decomposed organic soils. Where little or no decomposition has taken place the symbol O1 is used; O2 denotes more advanced decomposition. The organic matter content of O horizons is commonly several times greater than that of the underlying mineral horizons or of surface A horizons.

During the survey of any area, profiles typical of each soil are selected for special study. Fresh pits are opened for this purpose. The depth of pit varies according to soil depth. Each profile is thoroughly examined and described and a record made of its salient characteristics.

A soil profile is described by first noting certain features of the soil's environment, followed by details of its general characteristics. The characteristics which apply to the site include relief, slope, aspect, altitude and vegetation. Drainage conditions and the pattern of horizon development within the profile are considered next and, finally, properties of the individual soil horizons such as texture, structure, consistence, colour, mottling, amount of organic matter, stoniness, presence of hard-pans and root development are described.

A bulk sample from each soil horizon is analysed physically and chemically at the Soil Laboratory. The analytical data supplement many of the field observations and provide a more complete picture of the true soil character.

The profile descriptions and analyses included in this bulletin are representative of the modal concept of the principal soil in each association.

DEFINITION OF TERMS USED IN PROFILE DESCRIPTIONS

Texture

Soil texture refers to the relative proportions of the various size particles in the mineral fraction of a soil. More especially, it refers to the relative proportions of clay, silt and sand in the mineral fraction less than 2 millimetres in diameter. Texture, which is one of the more important of the soils's physical characteristics, influences such factors as moisture retention, drainage and tilling properties of soils, their resistance to damage by stock and heavy machinery and earliness of crop growth.

Classes of texture are based on different combinations of sand, silt and clay; the proportions of these are determined by mechanical analyses in the laboratory. The basic textural classes in order of increasing proportions of the finer separates are sand, loamy sand, sandy loam, silt-loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. Definitions of the basic classes in terms of clay (less than 0.002 mm), silt (0.002 to 0.05 mm) and sand (0.05 to 2.00 mm diameter size) are presented in graphic form (Fig. 6).

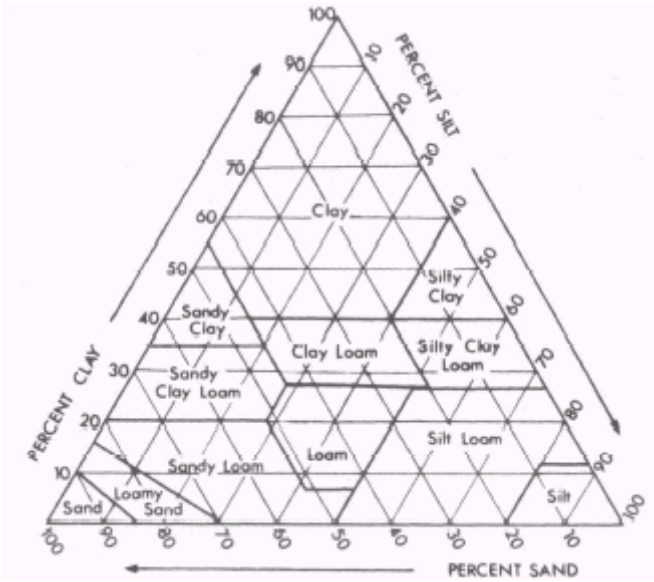


Fig. 6: *Chart showing the percentages of clay (less than 0.002 mm) silt (0.002 to 0.05 mm) and sand (0.05 to 2.0 mm) in the basic soil texture classes (After Soil Survey Manual, U.S.D.A. Handbook No. 18, Washington, D.C., 1951).*

Structure

Soil structure refers to the aggregation of primary soil particles into compound particles, which are separated from adjoining aggregates by surfaces of weakness. An individual natural soil aggregate is called a ped.

The productivity of a soil and its response to management depend on its structure to a large extent. Soil structure influences pore space, aeration, drainage conditions, root

development and ease of working. Soils with aggregates of spheroidal shape have a greater pore space between peds, are more permeable and are more desirable generally than soils that are massive or coarsely blocky.

Field descriptions of soil structure indicate the shape and arrangement, the size and the distinctness and durability of the aggregates. Shape and arrangement of peds are designated as type of soil structure; size of peds, as class; and degree of distinctness, as grade.

Porosity

Porosity of a soil is conditioned by the shape, size and abundance of the various crevices, passages and other soil cavities which are included under the general name of soil pores. In this bulletin, porosity refers mainly to the voids between the soil structural units, which is strictly the structural porosity. Soil porosity is influenced largely by type of structure; it is also influenced by rooting and by the activity of earthworms and other soil macro-organisms.

Porosity determines, to a large extent, the permeability rate in the soil and the air to water ratio prevailing and is thus of considerable importance with regard to soil aeration and drainage regime.

Consistence

Soil consistence is an expression of the degree and kind of cohesion and adhesion or the resistance to deformation and rupture that obtains in a soil. Interrelated with texture and structure, and strongly influenced by the moisture condition of the soil, this characteristic is most important in developing a good tilth under cultivation practices. On account of the strong influence of moisture regime, the estimation of soil consistence is usually considered at three levels of soil moisture — wet, moist and dry.

Soil Colour

Colour is the most obvious and easily determined of soil characteristics. Although it has little direct influence on the functioning of the soil, one may infer a great deal about a soil from its colour, if it is considered with the other observable features. The content of organic matter in soil, for example, is a characteristic that is commonly indicated only approximately by soil colour. Generally in temperate climates dark-coloured soils are relatively higher in organic matter than light-coloured soils. In well-drained soils, the colours usually range from very pale brown, through the intermediate browns, to very dark brown or black, as organic matter increases.

DEFINITION OF TERMS USED IN PROFILE ANALYSES

Mechanical Analysis (particle size analysis)

In mechanical analysis, the percentages of coarse sand, fine sand, silt and clay in the mineral fraction of the soil are determined. From these the soil can be placed in a certain textural class.

Cation Exchange Capacity

The cation exchange capacity of the soil, in its simplest terms, is an index of the capacity of a particular soil to adsorb and release cations such as hydrogen, calcium, magnesium, sodium and potassium; it is an indication of the ability of the soil to supply important nutrients to the growing plant. It is governed chiefly by the organic matter and clay contents of the soil. Soils with high organic matter content usually have a high cation exchange capacity (25-40 m.eq./100 g. of soil). The cation exchange capacity of a soil low in, or devoid of, organic matter is generally less than 12 m.eq./100 g., and is conditioned chiefly by the clay fraction.

Light sandy soils containing little organic matter, or clay, usually have a very low cation exchange capacity and, consequently, have a low potential for retaining applied plant nutrients; hence the necessity for the application of relatively frequent fertiliser dressings on these soils. Heavier textured soils, on the other hand, usually have a high cation exchange capacity and are capable of adsorbing and retaining larger quantities of applied nutrients, especially calcium and potassium, which are slowly released to meet the needs of growing plants. On such soils, therefore, fertiliser and lime applications can be larger and less frequent.

pH

pH is a measure of soil acidity or alkalinity. A soil having a pH value of 7.6-8.3 is moderately alkaline; pH 7.1-7.5, slightly alkaline; pH 7.0. neutral; pH 6.6-6.9, nearly neutral; pH 6.0-6.5, slightly acid; pH 5.3-5.9, moderately acid; pH 4.6-5.2, strongly acid; and pH below 4.5, very acid.

Total Neutralizing Value (T.N.V.)

This is an index of the level of carbonates present in a soil. These carbonates modify the solubility of other nutrients. Soils showing positive T.N.V. values in the surface horizons contain adequate or excess neutralizing materials and are not in need of liming.

Carbon and Nitrogen

The level of organic carbon indicates the amount of organic matter in the soil (C× 1.72 = organic matter). The content and nature of organic matter are of fundamental importance. The high cation exchange capacity of organic matter enables it to act as an ideal reservoir of plant nutrients, which are gradually released to meet the requirements of the growing plant. At the same time acid humus supplements the supply by influencing the extraction of nutrients from the mineral fraction of soils. Organic matter creates favourable physical conditions for crop growth: promotes granulation of structure by reducing plasticity; influences cohesion and increases the water-holding capacity of the soil. Organic matter in the surface also influences the temperature of soils, thus conditioning seasonal growth.

Depending on organic carbon content, soils are classified as follows: over 30%, peats; 20 to 30%, peaty; 10 to 20%, slightly peaty; and those with 6 to 10% organic carbon are

usually referred to as 'organic'. In the case of the terms 'peaty', 'slightly peaty' and 'organic', the mineral textural class is included in the definition of the soil, e.g. peaty sandy loam; slightly peaty clay loam; organic loam. The surface horizon of mineral soils in Ireland normally contains 3-6% organic carbon.

Nitrogen, which is normally present in soils in relatively small amounts, is extremely important as a plant nutrient. It is easily lost from the soil by leaching, and supplies need to be constantly replenished. The ratio of carbon to nitrogen indicates generally the degree of decomposition of organic matter; a ratio between 8 and 15 is considered satisfactory, and indicates conditions favourable to microbial activity. Ratios higher than 15 are associated with a slower decomposition rate and with the accumulation of raw organic matter or, in more extreme cases, with peat development, and are indicative of unfavourable conditions for microbial activity.

Free Iron

A localised accumulation of free iron in a soil profile (B_{ir} horizon) as is evidenced in brown podzolic and podzol soils, indicates that leaching and podzolising processes have been operative to a considerable degree. On the other hand, a uniform distribution of free iron throughout a profile, as is the case in the Brown Earths, indicates that there has been little tendency towards podzolisation.

Trace Elements*

Trace or minor elements are found in varying amount in most soils. The ability of soils to supply these elements to the plant as required is also variable. Some soils may contain abnormally high or low levels of certain of these elements. Several trace elements are known to be important in the nutrition of plants and animals, and the soil is the main source of supply. Deficiency or toxicity levels in the soil greatly influence production, especially of crops or animals which have specific trace element requirements.

Whilst the inherent contents of trace elements in a soil profile depend largely on the nature and, in particular, on the mineral composition of the parent materials, the distribution within the profile is conditioned by soil forming processes such as weathering, leaching and organic matter accumulation. These processes affect different trace elements to varying degrees. Trace elements such as nickel and cobalt are most often associated with primary minerals that weather readily while zirconium is derived mainly from zircon, which is very resistant to weathering.

The trace element status of a number of the soils of the country is included. In endeavouring to foretell the trace element content of a soil, accurate knowledge of the composition of the parent material and of the soil profile character can provide valuable guidance. Where the parent material is composed of glacial drift of mixed geological origin, the inference is less clear-cut but not necessarily fruitless. From the point of view of general agriculture, the availability to the plant of a particular trace element is more important than the total content in the soil. Nevertheless, total soil values can provide considerable guidance in predicting likely toxicities or deficiencies. Spectrographic methods described later in this chapter were used in determining these values; total contents for a number of trace elements are also given.

*These notes on trace elements by G.A. Fleming and P.J. Parle are taken from county soil survey reports.

The term ‘trace element’ is usually taken to include any element whose content in soils lies below 1% (10,000 parts per million) and whose content in agricultural crops is usually not greater than 100 parts per million. This excludes such elements as phosphorus, which rarely exceeds 0.5% in soil but is normally far in excess of 100 parts per million in crops.

The range of trace elements encountered in soils may be quite large (Table 1) and a hundred fold variation in content is by no means exceptional. In this respect trace elements differ appreciably from elements such as calcium, phosphorus and potassium — often referred to as major elements — where variations in excess of tenfold are quite uncommon.

Extractable trace element data provide a guide to the availability of some nutritionally important trace elements to plants, and indirectly to grazing stock. The soil values below which deficiencies might be expected to occur are as follows: for copper and zinc 1.0 ppm, molybdenum 0.01 ppm, manganese 40 ppm, and cobalt 5.0 ppm. It must be stressed, however, that these figures can only be regarded as broad guidelines. For example, the uptake of cobalt by herbage is to a large extent influenced by the manganese oxides in the soil. More precise information for different soils can only be achieved after calibration experiments linking extractable levels with plant uptake. Nevertheless, the figures can be used to assess the values given for the various soils of the country and to draw attention to likely anomalous areas and to indicate where corrective measures are advisable.

TABLE 1: Normal ranges of some trace elements in soils; total contents in parts per million (ppm)

Element	Range (ppm)	Element	Range (ppm)
Tin	1-10	Lead	2-200
Gallium	5-70	Molybdenum	0.2-5
Vanadium	20-500	Copper	2-100
Silver	0.1-1	Cadmium	1-1
Zinc	10-300	Nickel	5-500
Cobalt	1-40	Chromium	5-1000
Titanium	1000-10000	Manganese	200-3000
Selenium	0.1-2		

Summary of Analytical Methods

Analytical methods used in the various laboratory tests were as follows:

Particle size analysis: Determined by the International Pipette Method as described by Kilmer and Alexander (1949), using sodium hexametaphosphate as dispersing agent.

Cation exchange capacity: Determined by the method of Mehlich (1948). Soil was leached with buffered $BaCI_2$ to displace exchangeable cations, Ba displaced by $CaCl_2$ and K_2CrO_4 was used in the colorimetric estimation.

Total exchangeable bases: Extracted by method of Mehlich (1948). Ca, Mg and K estimated by atomic absorption spectroscopy.

pH: Determined on a 1:2 soil/water suspension using a glass electrode.

Total neutralizing value: Determined on a HCl extract using phenolphtalein as indicator and titrating against NaOH. $CaCO_3$ was used as a 100 per cent standard.

Organic carbon: Estimated by the Walkley-Black dichromate oxidation method as described by Jackson (1958), modified for colorimetric estimation. Values were read on a Spekker Absorptiometer using Orange Filter No. 607. A recovery factor of 1.1 was used.

Total nitrogen: Estimated by a modification of the method of Piper (1950) by digesting soil with cone H_2SO_4 using selenium as a catalyst, distilling into boric acid and titrating with HCl.

Free iron: Extracted with bufferred sodium hydrosulphite (Mehra and Jackson, 1960). Fe determined colorimetrically using o-phenanthroline.

Trace element analyses: Total analyses are semi-quantitative in nature and were carried out spectrographically by the methods described by Nicol and Henderson-Hamilton (1964) and Mitchell (1948). These methods, which are rapid, have been used extensively in soil analysis and are of value in revealing major trace element differences between soils. Several different methods are used to determine the extractable trace element levels, Alston and McConaghy (1965). Ellis *et al* (1949), Grigg (1953), Heintze and Mann (1949), Kidson *et al* (1936), Lane (1966) and Mitchell *et al* (1956).

4

Soil Classification

It is usually difficult, or sometimes even impossible, to understand complex things unless like members are classified together. Since there is a great number of different kinds of soil, varying from one another in different degrees of contrast, it is necessary to group them into progressively higher categories so that the maximum application of our knowledge may be made.

The soil classification system used in Ireland is a modification of the system established by the United States Department of Agriculture in 1938. An indication of the categories used in this system with particular reference to the mapping units used on the General Soil Map is given in Table 2.

GREAT SOIL GROUPS

Great Groups are soils having the same kind, arrangement and degree of expression of horizons in the soil profile. They also have close similarity in soil moisture and temperature regimes and in base status. Only Great Soil Groups are shown on the General Soil Map accompanying this bulletin, because of scale limitations.

The ten main Great Soil Groups occurring in Ireland are indicated in Table 2. These are the Podzols, Brown Podzolics, Brown Earths, Grey Brown Podzolics and Blanket Peats (zonal soils), the Gleys and Basin Peats (hydromorphic soils) the Rendzinas, (calcimorphic soils), Regosols and Lithosols.

TABLE 2: Soil classification scheme (USDA, 1938) with particular reference to Irish soils

Great Soil Group	Series
1. Podzols	Blackstairs
2. Brown Podzolics	Mountcollins
3. Brown Earths	Clonroche
4. Grey Brown Podzolics	Fontstown
5. Blanket Peats	Glenamoy
6. Gleys	Kilrush
7. Basin Peats	Allen
8. Rendzinas	Kinvarra
9. Regosols	Liffey
10. Lithosols	Slievereagh

Regosols and Lithosols (azonal soils) are formed mostly from the alluvial deposits of rivers and from shallow stony deposits respectively.

Peaty Podzols and Peaty Gleys also appear in the legend and these terms are included in the following definitions.

Podzols

Through the podzolisation process, soils are first subject to leaching. They are depleted of nutrients, become acid and develop eluvial A2 horizons (subsurface layers of removal) and illuvial B horizons (layers of accumulation). Specifically, the term podzolisation refers to the removal of iron and aluminium in solution from the surface horizons. This occurs as soon as conditions become sufficiently acid.

The podzol profile usually has a distinct sequence of horizons (Fig. 5). At the surface there is an O horizon underlain by a thin A1 horizon and a thicker A2 horizon. Underneath is a B horizon in which iron and aluminium from the A horizons have accumulated to a significant extent. Sometimes these accumulations in the B horizon are concentrated into a thin cemented layer referred to as an iron pan. This pan can restrict the penetration of roots and water. The profile is underlain by the parent material or C horizon.

Podzols are generally poor soils with high lime and fertiliser requirements. They are usually formed in hill and mountain areas where mechanical means of reclamation and cultivation are not feasible. For these reasons they are often devoted to forestry.

Peaty podzols are referred to in places in the legend. Here the organic horizon on the surface (O horizon) is relatively thick (20-40cm) and contains from 10 to 30% organic carbon.

Brown Podzolics

The Brown Podzolic soils are somewhat similar to the podzols and have been formed under the influence of the podzolisation process. They are less depleted than the podzols and the profile usually consists of a surface A1 horizon in which organic matter is intimately mixed with mineral matter. This overlies a reddish-brown B horizon, in which iron and aluminium and sometimes humus have accumulated. An A2 horizon, if present, is usually only weakly expressed and there is no iron pan.

Because of their desirable physical characteristics, Brown Podzolics are often devoted extensively to cultivated cropping and pasture production. Their inherent low nutrient status is easily overcome by addition of lime and fertiliser.

Brown Earths

These are relatively mature, well-drained, mineral soils possessing a rather uniform profile, with little differentiation into horizons. It follows, therefore, that these soils have not been too extensively leached or degraded, with the result that there are no obvious signs in the profile of removal and deposition of material such as iron oxides, humus or clay. However, in many cases, a certain degree of leaching has taken place resulting in the translocation of soluble constituents, notably calcium and magnesium.

Most Brown Earths occur on lime-deficient parent materials, and are, therefore, acid in nature; these are called Acid Brown Earths or Brown Earths of low to medium base status; some occur on more lime-rich parent materials, are neutral or alkaline in reaction, and are distinguished as Brown Earths of medium to high base status. These soils, in general, possess medium textures (sandy loam, loam, sandy clay loam) and this, together with their friability, desirable structure and drainage characteristics, accounts for the fact that they are amongst the most extensively cultivated soils. Although often of relatively low nutrient status, they respond well to manurial amendments.

Grey Brown Podzolics

The Grey Brown Podzolic soils are usually formed from a calcareous parent material, which counteracts the effects of leaching. Because of this, the podzolisation process is restricted and the principal materials translocated from the A horizon to the B horizon are the clay particles themselves. The B horizon, therefore, becomes heavier in texture than the A horizon and a weakly developed A2 horizon, from which clay has been eluviated, forms between the A1 and B horizons. The C horizon is usually calcareous.

The lighter textured Grey Brown Podzolics are good all-purpose soils, while the heavier textured members are highly suited to pasture production, responding well to manurial and management practices.

Gleys

Gleys are soils in which the effects of drainage impedance dominate and which have developed under the influence of permanent or intermittent waterlogging. The impedance may be due to a high water-table, to a 'perched' watertable caused by the impervious nature of the soil itself, or to seepage or runoff from slopes. Where gley conditions are the result of a high watertable or of seepage or spings, the soil is referred to as a groundwater gley. Where gleisation is due to a 'perched' watertable, the soil is referred to as a surface water gley. Most gleys have poor physical conditions which make them unsuitable for cultivation or for intensive grassland farming. Their productive capacity is also affected by restricted growth in spring and autumn.

Peaty Gleys are referred to in places in the legend. These soils have a relatively thick organic horizon (20-40cm) which contains 10 to 30% organic carbon. The presence of this horizon is usually an indication of wetter conditions than for the Gley soil.

Rendzinas

Rendzinas are shallow soils, usually not more than 50 cm deep, derived from parent material containing over 40% carbonates. The surface horizon is very dark in colour, with a strong structure and with a neutral or alkaline reaction. A calcareous B horizon may be present but very often the shallow A horizon directly overlies the calcareous parent material.

The use range of Rendzinas is often limited by their shallow depth. They are suited mostly to extensive grazing but where sufficiently deep they can also be excellent tillage soils.

Regosols

Regosol profiles show no distinct horizon development. They usually have a light-coloured A1 horizon directly overlying the C horizon. The texture of these soils can vary between sands and clays, depending on the material from which they are derived. They may be acid or alkaline for the same reason.

Regosols can have a wide use range but they are often subject to flooding hazards. For this reason, they are mostly used for grazing.

Lithosols

Lithosols are skeletal stony soils, usually overlying solid or shattered bedrock. They are often associated with podzols at higher elevations. Generally such soil areas have bare rock outcropping at frequent intervals and many also have steep slopes. Their use-range is usually limited to rough grazing.

Peats

Peats are characterised by a high content of organic matter, over 30%, and by being at least 30 cm in depth. Two basically different types, blanket and basin peat, occur in the country.

Blanket peat, also referred to as climatic peat, accumulated under conditions of high rainfall and humidity. Such conditions prevail over much of the west of the country and in the upper parts of mountain ranges due to high altitudes and associated adverse climatic conditions. The climatic peat profile varies from one to two metres in depth and it is usually characterised by a basal layer of fine matter overlain by a peat layer more highly humified than that occurring in the basin peats. The degree of humification decreases towards the surface. The dominant plant remains include bog cotton *(Eriophorum spp)*, purple moor grass *(Molinia caerulea)*, black bog rush *(Schoenus nigricans)* and bog asphodel *(Narthecium ossifragum)*. In some instances, variations may occur in composition and nutrient status due to topographic and soil factors, particularly in the basal layer, where the humified peat with pine *in situ* may be replaced in localised depressions by a peat composed mainly of reed remains.

Because of poor drainage, adverse physical conditions and their occurrence in areas of poor climate, the range of uses of blanket peat in agriculture is very limited.

Basin peats have formed in lake basins, hollows and river valleys, or where the sub-soil is sufficiently impermeable to give a high watertable. Two types, fen peats and raised bog peats, are recognised. Fen peat was formed under the influence of base-rich groundwater and is composed mainly of the remains of reeds, sedges and other semi-aquatic or woody plants. Variations in the concentration of component plant remains depend on the topographic situation and nutrient content of the water supply.

Raised bog peat may be built up on top of fen peat under suitable climatic conditions. As the depth of fen peat increases its living vegetation is less influenced by groundwater and more dependent on atmospheric precipitation as a source of moisture. This change in moisture supply results in the growth and development of a raised bog, with its characteristic convex surface and acid plant remains. The profile usually consists of a basal layer of fen or woody fen, overlain by a layer of acid peat

characterized mainly by its high content of *sphagnum* mosses, variable quantities of bog cotton *(Eriophorum spp)*, heather *(Calluna vulgaris)* and heath remains *(Erica spp)*. In their natural state, raised bog peats vary from about three to ten metres in depth and are typically acid in reaction.

When drained and reclaimed, basin peats can have a wide use range in agriculture. Recent experiments indicate their potential to produce a range of cultivated crops and pasture.

Soil Series and Soil Phases

Below the Great Soil Group category soils may be classified into series and subsequently into phases. The series is defined as a 'collection of soil individuals essentially uniform in differentiating characteristics and in arrangement of horizons'. It is usually named after the area in which it is most widely distributed or in which it is best expressed, for example, the Clonroche Series was first described in Co. Wexford. The series can be separated into phases on the basis of certain features such as depth or stoniness which may interfere with agricultural practice. Examples of soil series are shown in Table 2. Soil series and phases are shown on detailed soil maps but they cannot be shown on the General Soil Map because of its limited scale.

Soil Mapping

A soil map is a representation on paper of the distribution of the mappable soil units of a given landscape. These units have been described under soil classification but the kind of unit shown depends primarily on the scale of map as well as on the complexity of the soil distribution pattern. Detailed maps show soil phases or series but more generalised maps may only be able to show associations of soils due to limitations of scale.

Soil Associations

The soil association is not a soil classification category but is a cartographic (or mapping) unit. It consists of two or more soils, usually formed from the same type of parent material, which are associated on the landscape in a particular pattern. For example, one may have an association of two soils — one a well-drained Browth Earth which occurs on the more favourable topographic positions and a poorly-drained Gley soil occurring in the depressional positions.

5

The Soil Map Legend

PHYSIOGRAPHIC DIVISIONS

The map legend is based on five major physiographic divisions: 1) Mountain and Hill; 2) Hill; 3) Rolling Lowland; 4) Drumlin; 5) Flat to Undulating Lowland.

1. Mountain and Hill

Mountain and hill soils occur mostly above 500 metres and very steep (16-23°) and steep (12-16°) slopes are common. They cover about 1.1 million ha. They are distributed mainly throughout the western seaboard counties as well as in Wicklow, Waterford and Tipperary. They consist mainly of Peaty Podzols, Peaty Gleys, Blanket Peat and Lithosols. Outcropping rock is common while other major limitations to agricultural use are high altitude and steep slopes.

2. Hill

Hill soils occur mainly between 150 and 365 metres and occupy about 400,000 ha. Slopes up to 24° can be found but in many places slope is less than 12° and does not constitute a serious hazard to machinery use. They are mainly acidic, being formed from shale, sandstone or granite. The largest of these areas is the Old Red Sandstone Upland of Munster which ranges in altitude from 100 to 300 metres O.D. and which, for the most part, has gentle slopes. The principal soils in this area are Brown Podzolics but other soils included in this division are the Rendzinas and outcropping rock of the Burren and the Gley soils of the Collon area of county Louth.

3. Rolling Lowland

The rolling lowland soils occur mainly at elevations below 150 metres and (excluding low level blanket peat) occupy about 1.75 million ha (25%). They have slopes ranging mostly between 2 and 6°. Here, all types of farm machinery can be used successfully, except in very exceptional positions where difficulties may be encountered with heavy machines. Many of the soils in this category are formed from shales, sandstone, granite or mica schist and consist mainly of Acid Brown Earths and Brown Podzolics. However, the extensive areas of Gley soils formed over both Carboniferous shale (West Limerick, Clare, Castlecomer) and Old Red Sandstone (parts of Clare, Tipperary, Limerick, south Galway and west Mayo) are also included.

Plate 4: *Mountain and hill soils (background) have steep slopes, high altitude and outcropping rock whilst rolling lowland soils (foreground) have slopes ranging between 2° and 6° where all types of farm machinery can be used successfully.*

4. Drumlins

Drumlins consist of a thick cover of boulder clay deposited in the form of small hills. They are oval in plan and can be up to 800 metres in length and 90 metres in height. As they were formed beneath moving ice, they tend to parallel the direction of ice flow. Generally, they stand out as islands surrounded by marshy flats or lakes.

The north-west drumlin belt, stretching from Strangford Lough westwards via Armagh, Monaghan, north Louth and north Meath, Cavan, Leitrim, Fermanagh and south Donegal is one of the most extensive drumlin fields in the world. The number of drumlins within some parts of this belt exceeds twenty per square mile. Drumlins also occur at the head of Bantry Bay and somewhat more extensively in Clare, parts of Longford, Westmeath, Sligo, Mayo and Roscommon. They occupy about 750,000 ha.

Although soils on drumlins in Ireland are often poorly drained, this is largely a function of the parent material composition rather than an inherent feature of drumlin soils. For example, the drumlin soils of Leitrim are almost entirely poorly drained, even on the most favourable slopes, due to their very heavy impermeable boulder clay of

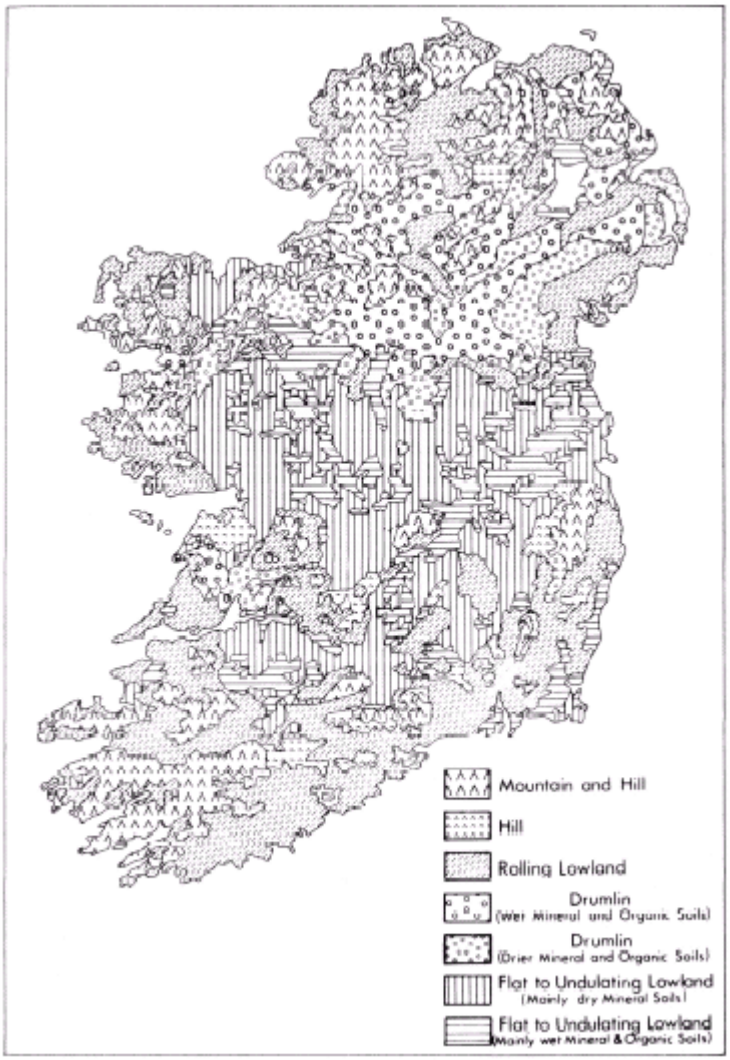


Fig. 7: *Main physiographic divisions significant for soil formation in Ireland.*

Upper Carboniferous shale composition. On the other hand, drumlin soils in parts of Monaghan, where the boulder clay is formed from Palaeazoic shales, are free draining.

Drumlinoid topography is a disadvantageous feature in agricultural land use. Slopes are often too steep for the easy use of agricultural machinery either in grassland or in tillage. Measurements show that over 25% of drumlin fields are too steep (slopes $\rangle$ 9°) for such operations. This problem is compounded when the soils are heavy and wet. In addition, interdrumlin areas are usually flat and poorly drained and it is often difficult to install artificial drainage because of lack of outfall.

5. Flat to Undulating Lowland

Flat to undulating lowland has slopes generally less than 3° and elevations mostly below 100 metres. Therefore all types of agricultural machinery can be used without difficulty insofar as slope is concerned. They cover about 2.47 million ha, stretching from the Golden Vale across the Central Plain to the east coast (north of the Wicklow Mountains) as well as occupying large areas of east Galway and Roscommon.

Composition of the Soil Associations

There are 44 Soil Associations included in the legend. Each association is made up of two or more Great Soil Groups which are associated in a particular pattern on the landscape.

The legend shows the principal and the associated soils in each association. The principal soil usually comprises about 75% of the association but this may be as low as 50%. The percentage composition of each association is given and these are based on estimates from more detailed county or regional soil maps. Where an associated soil comprises less than 5% of the association it is not shown on the legend but is mentioned in the text.

The land use potential of an area is determined mainly by the nature of the principal soil but it is also influenced by the nature, extent and distribution pattern of the associated soil(s).

The Legend

The format of the map legend for this Second Edition is similar to that of the First Edition (1969). The 44 soils associations are grouped according to principal physiographic division. Only 31 associations were shown on the First Edition. The principal soil and the associated soils are given in each association, together with an estimate of their extent. The 28 mineral soil associations from the First Edition are retained (but new soil numbers have been used) while thirteen new mineral soil associations have been added.

A Peatland Map of Ireland was published at a scale of 1:575,000 by the National Soil Survey in 1978 and showed 14 different peat types. For this map these have been simplified down to 3 and have been integrated into the legend within the appropriate physiographic division.

Legend for General Soil Map of Ireland

Broad Physiographic Division	Social Association No.	Principal Soil	Associated Soils	Parent Material
Mountain and Hill	1	Peaty Podzols (75%)	Lithosols (15%), Blanket Peats (10%)	Mostly granite — sandstone
	2	Peaty Gleys* (70%)	Blanket Peats (20%) and Peaty Podzols (10%)	Mostly mica schist, gneiss, quartzite and sandstone
	3	Blanket Peats (75%)	Shallow Brown Earths (25%)	Mostly basalt
	4	Lithosols and Outcropping Rock (70%)	Blanket Peats (25%) Peaty Podzols (5%)	Mostly sandstone, granite, quartzite or mica schist
	5	Blanket Peats (High Level)	—	—
	6	Brown Podzolics (80%)	Gleys (15%) and Podzols (5%)	Mostly sandstone
	7	Rendzinas(15%)with Outcropping Rock (75%)	Lithosols (5%) and Shallow Brown Earths (5%)	Limestone
	8	Brown Podzolics (60%)	Gleys (20%), Podzols (10%) and Blanket Peats (10%)	Mainly granite
Hill	9	Brown Podzolics (80%)	Gleys (15%) and Podzols (5%)	Ordovician-Silurian, Cambrian shales and mica schist
	10	Grey Brown Podzolics (75%)	Gleys (15%), Brown Earths (10%)	Mostly limestone and shale
	11	Gleys (90%)*	Brown Earths (10%)	Mostly Silurian shale

*Dominantly influenced by surface-water impedance.

Soil Association

Broad Physiographic Divisions	No.	Principal Soil	Associated Soils	Parent Material
	12	Acid Brown Earths (70%) (Coarse texture)	Gleys (25%) and Podzols (5%)	Mostly granite or rhyolite glacial till
	13	Acid Brown Earths (70%)	Grey Brown Podzolics (15%) and Gleys (15%)	Mixed sandstone, limestone glacial till
	14	Acid Brown Earths (75%)	Gleys (15%), Brown Podzolics (10%)	Ordovician-Silurian-Cambrian shale glacial till
	15	Brown Podzolics (60%)	Acid Brown Earths (20%) and Gleys (20%)	Sandstone, Lower Avonian shale glacial till
	16	Acid Brown Earths (90%)	Gleys (5%) Regosols (3%), Podzols (2%)	Morainic sands and gravels and blown sands
	17	Acid Brown Earths (90%)	Gleys (5%) and Peaty Gleys (5%)	Basalt glacial till
Rolling Lowland	18	Podzols (70%)	Gleys (20%), Peats (10%)	Sandstone, granite, mica schist glacial till
	19	Acid Brown Earths (70%)	Gleys (15%), Peaty Gleys (15%)	Upper Carboniferous shale and sandstone glacial till
	20	Brown Podzolics (60%)	Acid Brown Earths (20%), Gleys (20%)	Mica schist glacial till
	21	Gleys(75%)	Peaty Gleys (25%)	Sandstone glacial till
	22	Gleys (75%)*	Acid Brown Earths (15%), Peats (10%)	Upper Carboniferous shale glacial till
	23	Lithosols(80%)	Rock Outcrop and Peats (20%)	Granite and sandstone and shallow glacial till (quartzite in places)
	24	Blanket Peats (Low Level)	—	—

*Dominantly influenced by surface-water impedance.

Broad Physiographic Divisions	Soil Association No.	Principal Soil	Associated Soils	Parent Material
Drumlin (wet Mineral and Organic soils)	25	Gleys(50%)*	Acid Brown Earths (40%) Inter-drumlin Peats and Peaty Gleys (10%)	Mostly Ordovician-Silurian shale-sandstone glacial till
	26	Gleys (60%)*	Acid Brown Earths (40%)	Basalt glacial till
	27	Gleys (85%)*	Interdrumlin Peats and Peaty Gleys (15%)	Mostly upper Carboniferous Limestone and shale-sandstone glacial till
Drumlin (drier Mineral soils and Organic soils)	28	Grey Brown Podzolics (60%)	Gleys (20%), Interdrumlin Peats and Peaty Gleys (20%)	Mostly limestone glacial till
	29	Acid Brown Earths (75%)	Interdrumlin Peats and Peaty Gleys (25%)	Mostly Ordovician-Silurian shale, glacial till
	30	Grey Brown Podzolics (70%)	Brown Earths (20%), Gleys (5%) and Basin Peats (5%)	Limestone morainic gravels and sands
Flat to undulating Lowland (dry)	31	Minimal Grey Brown Podzolics (80%)	Gleys (10%), Brown Earths (5%) and Basin Peats (5%)	Limestone glacial till
	32	Degraded Grey Brown Podzolics (50%)	Peat (15%), Brown Earths (15%) Gleys (10%), Podzols (10%)	Mostly limestone glacial till
	33	Shallow Brown Earths Rendzinas (60%)	Grey Brown Podzolics (25%), Gleys (10%) and Peats (5%)	Limestone till, shallow in places
	34	Minimal Grey Brown Podzolics (70%)	Gleys (20%) and Brown Earths (10%)	Limestone glacial till

*Dominantly influenced by surface-water impedance.

Broad Physiographic Divisions	Soil Association No.	Principal Soil	Associated Soils	Parent Material
	35	Grey Brown Podzojics (80%)	Brown Earths (10%), Gleys (10%)	Stony limestone glacial till
	36	Grey Brown Podzolics (80%)	Gleys (20%)	Limestone gravelly till
Flats to Undulating Lowland (dry)	37	Grey Brown Podzolics (75%)	Gleys (20%), Brown Earths (5%)	Limestone and shale glacial till
	38	Grey Brown Podzolics (75%)	Gleys (25%)	Till of Irish Sea origin with limestone and shale
Flat to Undulating Lowland (wet)	39	Gleys* *(90%)	Grey Brown Podzolics (10%)	Limestone glacial till
	40	Gleys* (80%)	Grey Brown Podzolics (20%)	Till of Irish Sea origin with limestone and shale
Flat to Undulating Lowland (mostly wet mineral soils)	41	Gleys* (75%)	Acid Brown Earths (15%) and Peaty Gleys (10%)	Basalt glacial till
	42	Gleys* (90%)	Grey Brown Podzolics (10%)	Glacial muds of Irish Sea origin Alluvium
	43	Gleys (60%)	Brown Earths (20%), Peaty Gleys (20%)	
	44	Basin Peats	—	—

**Dominantly influenced by ground water, seepage or springs.

6

Soil Associations of Mountain and Hill

ASSOCIATION 1:

PEATY PODZOLS 75%, LITHOSOLS 15%, BLANKET PEATS 10%

This association occupies 7.31 % of the country* (1,235,571 ac; 500,029 ha). It is located on the granite and sandstone mountainous areas of Cork, Kerry, Wicklow, Waterford, Tipperary, north Clare, Donegal and the Mourne mountains (although in some areas in west Kerry this soil extends down to sea level). Altitudes are high (250-1,000 m) and the topography varies from flattish to very steep slopes — normally slopes are between 5° and 12°. Outcropping rock is common. Rainfall ranges from 1,500 to 2,500 mm and evapotranspiration is low.

The profile of the principal soil is characterised by a peaty surface horizon less than 30 cm thick. The soil is usually coarse-textured and moderately well to imperfectly drained; frequently the A1 horizon is absent and the leached A2 horizon overlies an ironpan. This is permeable in places but prevents root penetration. An iron-enriched B horizon usually overlies solid or shattered bedrock. Because of topographic changes the depth and thickness of the different horizons are variable. Lithosols occupy 15% of the association. They are shallow in depth, stony, and occur on very steep slopes (see Association 4). The Blanket Peats comprising 10% of the association are 1 to 2m deep mostly wet and poorly drained.

Suitability

The use range of these soils, as well as that of the associated Peats and Lithosols, is very limited. High elevation, inaccessability, a peaty surface, together with the very low lime, and nutrient status and in some cases ironpan development in the profile are the main limiting factors. They are not suitable for tillage or intensive grassland, but are confined mainly to mountain sheep grazing, amenity and some forestry.

Principal Soil — Association 1: Peaty Podzol

Topography:	Hilly topography near summit of mountain.
Slope:	10°
Altitude:	290m O.D.
Vegetation:	Semi-natural heath communities dominated by *Calluna vulgaris (heather), Molinia caerulea* (purple moor-grass), *Nardus stricta* (mat-grass) and *Scirpus caespitosus* (deer grass).
Drainage:	Excessively drained below the peat.
Parent material:	Old Red Sandstone and conglomerate.

*These areas refer to the Republic of Ireland only.

Horizon	*Depth (cm)*	*Description*
02	25-0	Peat; black, massive; moist friable; plentiful roots; clear, smooth boundary.
A2	0-10	Gravelly sandy loam; grey (10YR 5/1); massive structure; firm breaking into friable; plentiful roots; abrupt, wavy boundary.
B2 1ir	10	Ironpan.
B22ir	10-18	Gravelly sandy loam; yellowish-red (5YR 5/8); weak, fine sub-angular blocky structure; friable; few roots; gradual smooth boundary.
B3	18-30	Gravelly sandy loam; reddish-yellow (7.5YR 6/6); weak, fine sub-angular blocky structure; moist, slightly plastic; few roots; abrupt, irregular boundary.
R	30	Old Red Sandstone bedrock.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC Meq/100g	C%	N%	C/N	Free iron %
02	57	3	38	2	4.1	130.0	41.0	0.99	41.4	0.1
A2	47	20	24	9	4.1	24.4	3.2	0.12	26.7	0.1
B22ir	35	25	25	15	4.3	29.3	1.7	0.10	—	3.6
B3	32	28	32	8	4.5	16.8	1.2	0.08	—	1.6

Coarse Sand 2.0-0.2 mm; Fine Sand 0.2-0.05 mm; Silt 0.05-0.002 mm; Clay < 0.002 mm diameter size. C.E.C. = Cation Exchange Capacity; T.E.B. = Total Exchangeable Bases; C/N = Carbon/Nitrogen Ratio: T.N.V. = Total Neutralising Value; nd = not determined.

Trace elements — total contents (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Zn	Ni	Co	Cr	Ti	Mn
02	2	3	8	1	60	3	25	10	2	60	800	65

Trace elements — extractable contents (ppm)

Hor.	*Cu*	*Zn*	*Mo*	*Mn*	*Co*
02	1.25	3.8	0.13	5	1.3

S*n* = Tin
Pb = Lead
Ga = Gallium
Mo = Molybdenum
V = Vanadium
Cu = Copper
Ag = Silver
Zn = Zinc
Ni= Nickel
Co = Cobalt
Cr = Chromium
Ti = Titanium
Mn = Manganese
ppm = parts per million

Plate 5: A podzol profile typical of the principal soil in Association 1 shows a shallow peaty surface horizon underlain by a grey leached A2 horizon, a thin iron-pan and a yellowish-red B horizon of sesquioxide accumulation.

ASSOCIATION 2:

PEATY GLEYS 70%, BLANKET PEATS 20%, PEATY PODZOLS 10%

This association occupies 0.30% of the country (50,602 ac; 20,478 ha). It is composed mainly of Peaty Gleys (70%) and Climatic Peats (20%) and Peaty Podzols (10%). It occurs mainly in the North of Ireland, on the Sliabh Bloom mountains, and in small areas in Laois, Offaly and West Mayo. Parent material is mainly non-calcareous carbonaceous shales with some sandstone influence, both of Namurian age. Topography varies from flattish to steep and elevations range from 150 to 700 m.

The profile of the principal soil, the Peaty Gley, is characterised by a peaty topsoil varying from 10 to 30 cm in depth, overlying a grey mineral B horizon of silty clay to clay texture and of medium to low base status. The B horizon becomes dark grey with depth and has a weak coarse prismatic to massive structure. The parent material (below 70 cm) is of gravelly clay loam texture and is massive, sticky and plastic. (In some places where the parent material is dominated by sandstone, e.g. Northern Ireland, this soil is not so heavy in texture).

Principal Soil — Association 2: Peaty Gley

Topography:	Mountain slope
Slope:	3°
Altitude:	168 m O.D.
Drainage:	Poor
Parent material:	Glacial drift derived from Namurian smile with some limestone conglomerate and sandstone influence.

Horizon	*Depth (cm)*	*Description*
0	12-0	Peaty clay; dark yellowish brown (10 YR 3/4); weak fine crumb fairly friable; colour changes to very dark brown (10 YR 2/2) between 9 and 12 cm; abundant very fine to medium roots; clear wavy boundary to:
B1g	0-28	Clay; light brownish grey (2.5 YR 6/2) with many fine to coarse prominent sharp strong brown (7.5 YR 5/8) mottles; weak coarse prismatic; massive within prisms; slightly sticky, plastic; common fine and medium roots mottles often follow root channels; clear smooth boundary to:
B2g	28-53	Clay; dark grey (N 4/0) with many coarse prominent clear strong brown (7.5 YR 5/6-5/8) mottles; weak coarse prismatic; medium to coarse decaying roots; rare fine living roots; gradual boundary to:
B3g	53-71	Silty clay; black (N 2/0); massive; sticky, plastic; common fine to medium decaying roots with common medium and coarse prominent sharp strong brown (7.5 YR 5/8) mottles along root channels; no living roots; clear smooth boundary to:
C	71-80	Gravelly clay loam; dark grey (10 YR 4/1); massive; sticky, slightly platic; no roots; calcareous below 63 cm.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
O	8	7	28	57	4.3	70.5	3.8	5	20.4	0.80	25.5	3.4
B1g	5	3	33	59	4.4	34.4	5.8	17	0.9	0.07	12.8	2,5
B2g	1	1	28	70	5.4	36.4	19.5	54	1.7	0.11	—	6.0
B3g	5	4	43	48	6.3	41.0	31.2	76	0.5	0.10	—	2.0
C	31	10	24	35	7.6	10.9	12.9	sat.	1.1	—	—	1.5

Suitability

These soils have a very limited use range. Peaty topsoils, high elevation, sharpslopes and poor drainage restrict their potential to extensive grazing or to forestry for which they have a good potential, especially at the lower elevations. Reclamation, including drainage, is hampered by the plastic impervious subsoil and by the frequent occurrence of boulders.

The associated Peat soils also have a very limited use range while the Peaty Podzol, although somewhat better drained than the others, is also very limited in its use range because of high elevation, steep slopes and poor climatic conditions.

ASSOCIATION 3:

BLANKET PEATS 75%, SHALLOW BROWN EARTHS 25%

This association is shown only in Northern Ireland and consists mainly of Blanket Peats (75%) but because shallow Brown Earths occupy about 25% of the association it has been treated separately from the other peat associations named on the legend. Bedrock consists either of limestone or basalt. The soils are found mainly on plateaux between 500 and 700 m elevation with annual rainfall of about 1,200 mm. The Brown Earths occur more on the slopes while the Peats occupy the flatter areas.

Suitability

The land use potential of the entire association is extremely limited. Due to high quite a high acreage of forestry is planted on this soil. The Brown Earths have a moderate potential for grass production but can only be used for extensive grazing because of steep slopes. The profile description and analyses for the principal soil are the same as for Association 5.

ASSOCIATION 4:

LITHOSOLS AND OUTCROPPING ROCK 70%, BLANKET PEATS 25%, PEATY PODZOLS 5%

The association occupies 2.3% of the country (389,163 ac; 157,492 ha). It consists of very shallow and stony soils, which occur on the steep slopes of the mountains. It occurs mainly in Cork, Kerry, Galway, Mayo, Donegal and Wicklow. Parent material consists mostly of granite, Old Red Sandstone, mica schist and quartzite. Outcropping rock and boulders are very common. Peaty Podzols and Blanket Peats occupy some 30% of the association. On the principal soil, a partial skeletal soil cover with a vegetation characteristic of dry, acid conditions has developed. The soil usually consists of a shallow, black turfy layer, which varies in depth from 2.5 to 10.0 cm, is coarse-

? and excessively drained, with a very low base status. Organic matter content is ?.

?
? use potential of the entire association is extremely limited. Due to high ?, steep slopes, outcropping rock, shallowness and inaccessability this soil is ? confined to amenity use.

Principal Soil — Association 4: Lithosol

?	Slope near summit of mountain
?	7°
?	360m O.D.
?	Almost entirely *Calluna vulgaris*
?	Excessively drained
?:	Old Red Sandstone bedrock

?	*Depth (cm)*	*Description*
?	0-5	Organic sandy loam; dark reddish-brown (5 YR 2/2); moderate, medium crumb structure; friable; plentiful rooting; abrupt, irregular boundary to:
?	Below 5	Bedrock.

Analytical data

?	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron%
	47	23	22	8	4.3	15.2	6.1	0.20	30.5	0.9

ASSOCIATION 5:

HIGH LEVEL BLANKET PEATS

? Level Blanket Peat association occupies 5.67% of the country (957,948 ac; ? ha). It is widespread throughout the western part of the country, in particular. It ? west Cork, Kerry, Clare, west Galway, Mayo, Sligo, Leitrim, Donegal and on ? Sliabh Bloom, Commeragh and Wicklow mountains and ? Antrim Plateau in Northern Ireland.
? is mainly rolling and elevations range from 150 to over 1,000 m.

Principal Soil — Association 5: High level Blanket Peat

Topography: Mountainous
Slope: 3-4°
Altitude: 280 m O.D.
Vegetation: *Calluna vulgaris, Polytrichum sp., Eriophorum sp., Vaccinium oxycoccus, Potentilla sp.*

Horizon	*Depth (cm)*	*Description*
Oa11	0-30	Dark reddish brown (5 YR 3/2); peat; sapric; well humified; greasy; humification 7; strong recent and fossil cyperaceous fibres; recent roots to at least 50 cm; plant residues, mostly cyperaceous root and leaf material; *Sphagnum* and *Calluna* leaves and leaflets, *Calluna* flower heads; *Juncus* seeds; clear boundary to:
Oa12	30-60	Similar to above.
Oa2	60-90	Dark reddish brown (5 YR 3/2); peat; strong in cypearaceous remains; sapric; well humified; greasy; humification 7/8; increases towards base of layer; plant residues, mainly fine divided rootlet material with amorphous organic matter charcoal fragments (carbonised *Calluna* leaflets), many remains of *Carabid beetles*: clear, boundary to:
Oa_3	90-110	Black (5 YR 2/1); peat; sapric; very well humified; few fine fibres; greasy; plant residues; finely divided leaf and root material, wood remains of birch, much charcoal debris, *Juncus* seeds common, some fine quartz grains; abrupt, smooth boundary to:
IC	110+	Glacial till, Namurian shale with yellow sandstone.

Analytical data

Hor.	Depth (cm)	Field moisture (%)	Saturated moisture (%)	Ash (%)	D_b (g/cc)	Rubbed fibre (%)	PI index	N (%)	Ex.Ca/Mg. ratio	pH (H_2O)
0a1	0-30	85.1	1171	4.2	0.094	1.0	0	2.52	0.6	4.22
0a1	30-60	90.5	1056	1.9	0.091	2.0	1	2.01	0.5	4.00
0a2	60-90	89.7	1077	3.6	0.094	2.0	1	2.01	0.8	4.10

The line of demarcation between this type and low level blanket peat is based on the fact that black bog rush *(Schoenus nigricans)* is not a major component in the high level type but is in the low level type. This line of demarcation varies in altitude from 150m on the western seaboard to 210 m in the Slieve Blooms, and 330 m in the Wicklow mountains. Rainfall is greater than 1,250 mm per annum with 225 rain days per year.

These soils in their natural state are acid and poorly drained.

Blanket Peat profiles vary in depth from 1 to 2 m but average depth at this level is 1.2 m. It is characterised by a highly humified lower layer, the degree of humification decreasing towards the surface. The dominant plant remains include bog cotton *(Eriophorum spp)*, purple moor grass *(Molinea caerulea)*, bog asphodel *(Narthecium ossifragum)*, Deer Grass *(Trichophorum caespitosum)*, Crowberry (*Empetrum nigrum*). Variations may occur in botanical composition and nutrient status due to topographic and edaphic factors, particularly in the basal layer which often has pine in *situ* but this is sometimes replaced by reed remains. It is estimated that about 25% of this peat type has been cut-over mainly for fuel.

Suitability

These soils have a very limited use range and are best suited to extensive grazing. Their organic nature, elevation and wetness are the main limitations. Improved grass swards can be stabilised in some areas by drainage, manuring and surface seeding.

7

Soil Associations of Hills

ASSOCIATION 6:

BROWN PODZOLICS 80%, GLEYS 15%, PODZOLS 5%

This association occupies 1.88% of the country (317,733 ac; 128,585 ha.). It is dominated by Brown Podzolic soils formed mainly from glacial till of predominantly Old Red Sandstone composition. It occurs mainly in the Cork-Waterford area on accordant

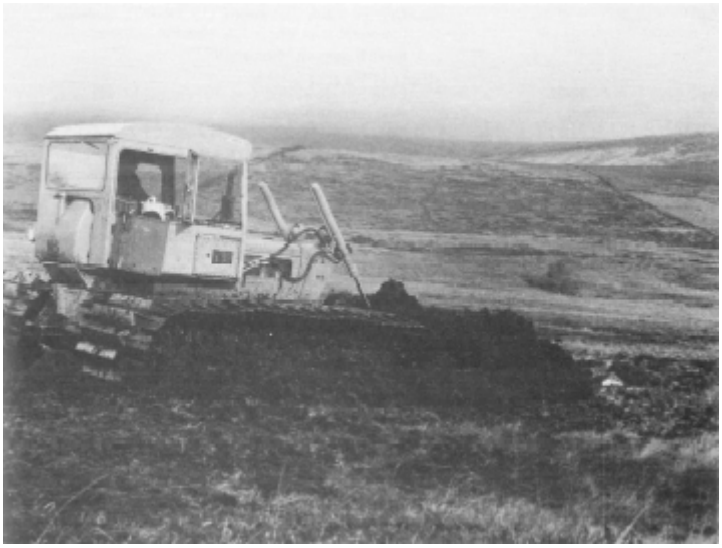


Plate 6: *Reclamation of the soils of Association 6 through deep ploughing, ripping or rotovating has been very successful in recent years, particularly in the Fermoy region.*

summits of the "South of Ireland peneplain" which stretches in an east-west direction across the Armorican foldings at an elevation of 183-244 m. It also occurs in parts of Tipperary, Kilkenny, Kerry, Tyrone and Antrim, and, in some of these, may occur at up to 335 m.

The topography is rolling but most slopes are less than 10°. In fact, in the "Peneplain" area, most slopes are only 2-3°.

The profile of the principal soil is characterised by a dark, organic loam surface horizon overlying a yellowish-red, iron-enriched B horizon of loam texture. This grades into a reddish-brown sandy loam parent material at about 75 cm.

Principal Soil — Association 6: Brown Podzolic

Topography:	Slopes on peneplain
Slope:	5°
Altitude:	274m O.D.
Vegetation:	Old pasture
Drainage:	Well drained
Parent material:	Colluvium derived from Old Red Sandstone and conglomerates, of Devonian Age.

Horizon	*Depth (cm)*	*Description*
Ap1	0-10	Organic loam; dark-brown (10 YR 3/3); moderate, fine crumb structure; friable, plentiful, diffuse rooting; gradual, smooth boundary to:
Ap2	10-22	Loam; otherwise similar to above but with fewer roots; clear, smooth boundary to:
B2ir	22-42	Loam; yellowish-red (5 YR 5/6); very weak, fine sub-angular blocky structure; friable, limited rooting; gradual, smooth boundary to:
B22	42-50	Sandy loam; brown (7.5 YR 5/4); massive structure; firm to slightly indurated; very limited rooting; gradual, smooth boundary to:
B/C	50-80	Sandy loam; reddish-brown (5 YR 5/4); weak, fine crumb structure; friable; very limited rooting.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron %
Ap1	24	26	31	19	5.4	18.4	7.1	0.55	12.9	1.2
Ap2	29	21	32	18	5.3	16.1	3.7	0.27	13.7	1.2
B2 ir	26	20	37	17	5.3	9.0	0.9	0.10	—	1.6
B22	36	24	30	10	5.4	7.1	0.3	0.07	—	1.0
B/C	46	15	26	13	5.5	6.9	0.1	0.05	—	1.2

These soils are free-draining and rooting is well developed. Permeability is improved by the frequent presence of stones throughout the profile. Moisture holding capacity is good. In some places throughout the association, an A2 horizon is present in the soil profile from about 20-35 cm and this is underlain by a thin iron-pan. Occasionally, the iron pan is impermeable, resulting in impeded drainage and mottling of overlying horizons and in restriction of root penetration. But, where the soil has been reclaimed either by deep ploughing, ripping or rotovating, only relics of the iron pan are visible and the profile is free-draining throughout and roots penetrate freely. Reclamation has been done on a wide scale on these soils over the past ten years.

Suitability

The use range of these soils depends largely on slope and altitude but in the area of their principal occurrence (South of Ireland Peneplain), they have a somewhat limited use range. They can be used successfully for tillage crops but their best use is in pasture. When well managed, including adequate lime and fertiliser use, their stock carrying capacity can be raised to 185 livestock units per 100 ha.

Gleys (15%) and Podzols (5%) are found in places through this association. The Gleys tend to occur in the depressional and low lying areas, while the Podzols are found mostly in more elevated positions. Both are limited in their use range.

ASSOCIATION 7:

RENDZINAS 15%, OUTCROPPING ROCK 75%, LITHOSOLS 5%, SHALLOW BROWN EARTHS 5%

This association occupies 0.81% of the country (136,192 ac; 55,116 ha.). It is located mainly in the Burren area of north Clare. It also occurs to a limited extent, in Galway, Sligo, Leitrim, Mayo and Tipperary. Parent material is limestone rock. Topography may vary from flat to steep and elevations from near sea level to 305 m.

The dominant soil (15%), a Rendzina, is less than 25 cm deep. Texture is slightly peaty clay loam; organic matter content ranges from 20 to 40% and pH values are high. In some places where pockets of glacial drift occur, the soils may be up to 40 cm deep. The Brown Earth soil (5%) is similar to the Rendzina but is not as dark in colour. The Lithosol soil (5%) in the association is mainly less than 10 cm deep. It has been estimated that outcropping rock occupies 75% of this association.

The typical profile is characterised by a dark-brown A horizon with moderate crumb structure, overlying limestone rock which outcrops frequently.

The Burren is well known for its karst scenery and unusual flora. It has long been a “place of pilgrimage” for naturalists. Pollen analyses have shown that there was a complete cover of pine, with subsidiary hazel and yew, on the Burren during the Boreal and Atlantic periods. Today, woodland is rare but patches of hazel are fairly widespread. There is evidence of human settlement in the area dating back at least 4,000 years.

The Burren is most colourful in May and June when *Gentiana verna, Dryasoctopetala, Geranium sanguineum, Saxifrega hypnoides, Potentilla fruitcosa and Helianthemum canum* are flowering.

The numerous parallel fissures dissecting the soil-free limestone pavement harbour an abundant and diverse flora consisting mostly of fragmentary patches of limestone grassland (shallow crevices) or a woodland ground flora (deep crevices), or perhaps fen plants in crevices with ground-water influence. There are no special plants whose occurrence is confined to the limestone crevices, all of them occur as components of other vegetation in the vicinity.

Suitability

These soils have an extremely limited use range. Due to shallow depth and frequent rock outcrops, tillage on the conventional basis is not practicable. Their agricultural use is confined mainly to grazing. Overwintering of stock is common. Due to exposure and the other serious limitations listed, forestry is not feasible.

Plate 7: *On the shallow limestone soils of the Burren, Co. Clare, rock outcrop is very common*

Principal Soil — Association 7: Rendzina

Topography:	l; rock outcrops common
Slope:	1°
Drainage:	Well to excessively drained.
Parent material:	Limestone bedrock with some glacial drift.

Horizon	*Depth (cm)*	*Description*
A11	0-8	Slightly peaty clay loam: dark brown (10 YR 3/3); moderate, fine crumb structure; friable, plentiful abundant roots, forming a root mat; clear, smooth boundary.
A12	8-18	Organic clay loam; brown to dark brown (10YR 4/3); moderate, fine crumb structure; friable, plentiful roots; abrupt, smooth boundary.
R	Below 18	Limestone bedrock.

Analytical data

Hor	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron %
A11	12	12	45	31	6.0	59.2	12.8	1.25	10.2	2.3
A12	15	15	41	29	6.5	52.4	10.0	1.05	9.5	2.2

ASSOCIATION 8:

BROWN PODZOLICS 60%, GLEYS 20%, PODZOLS 10%, BLANKET PEATS 10%

This association occupies 0.52% of the country (87,920 ac; 35,581 ha.). It is found mainly in Wicklow, Wexford, Carlow and south Dublin, where it is associated with the lower slopes of the Leinster mountains. The topography is mostly rolling to steep and elevations range from 152 to 304 m. Slopes vary from 8° to 22°, the more dominant ones being 12°-16°. Due to elevation and slope glacial drift cover is limited and the parent material consists mainly of acid igneous (granite) bedrock. In places there is a significant amount of limestone, chert and shale through the association, this applies particularly in the south Dublin area.

Distinctive features associated with these soils are the sharp slopes and high proportion of boulders and outcropping rock in many places. The principal soil is moderately deep, well to excessively drained, of coarse sandy loam texture and of low base status. The profile consists of a very dark greyish-brown, friable surface horizon overlying a fairly thick sub-surface B horizon in which iron oxide enrichment is apparent. In places, an iron-pan is present. The A horizon is relatively thin (18-20 cm) and

has a moderately strong granular structure and a diffuse rooting system. The B horizon can be up to 50 cm thick.

Suitability

These soils have a limited use range. Due to slopes, rockiness and altitude, they are generally unsuitable for tillage except in small pockets and at lower elevations where they merge with the soils of Association 12 and have a use range similar to them. These soils are best suited to sheep and dry stock grazing. Where farm management is poor these soils quickly revert to fern and scrub.

Poorly drained Gleys and Peaty Gleys and more depleted Podzol soils with some Peats occur within the Association, especially at the higher elevations. The peat soil is most obvious in south-west Wicklow, between Rathdangan and Knockananna. The Podzols are usually shallow and of peaty loamy coarse sand texture. They frequently have an iron-pan. Their use range, as well as that of the Gleys and Peats, is limited mainly to grazing.

Principal Soil — Association 8: Brown Podzolic

Topography:	Moderately steep to steep
Slope:	22°
Altitude:	221 m O.D.
Vegetation:	*Pteridium* heath. Well grazed grassy patches alternate with patches dominated by *Pteridium aquilinum.* The grasses *Agrostis tenuis* (bentgrass), *Holcus lanatus* (Yorkshire fog) and *Poa pratensis* (smooth-stalked meadow-grass) are important components of the sward both in the grass and bracken-dominant patches.
Drainage:	Well drained
Parent material:	Granite bedrock

Horizon	*Depth (cm)*	*Description*
A1	0-17	Coarse sandy loam; very dark greyish-brown (10 YR 3/2); moderate, fine and very fine grey structure; very friable; abundant roots; abrupt, smooth boundary to:
B2	17-65	Coarse sandy loam; dark yellowish-brown (10 YR 4/4-3/4) with patches of pale-brown (10 YR 6/3); weak, fine granular structure; very friable; plentiful roots; abrupt, irregular boundary.
C	Below 65	Granite bedrock.

Analytical data

Horizon	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron %
A1	50	20	21	9	4.8	23.2	3.8	0.22	17.3	0.7
B2	48	14	27	11	5.0	19.0	2.0	0.12	16.7	0.8

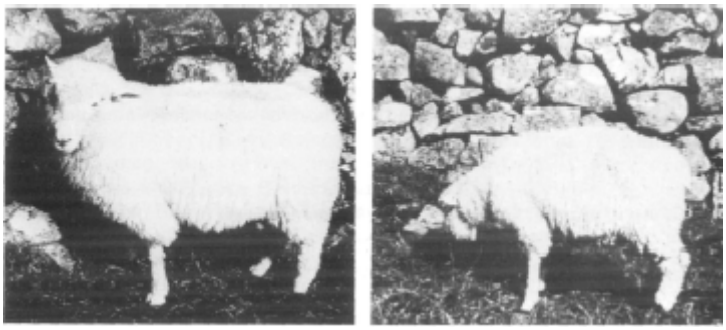


Plate 8: *Two-year old sheep, one healthy, the other suffering from pining due to cobalt deficiency which is common on the granite derived soils of Associations 8 and 12.*

ASSOCIATION 9:

BROWN PODZOLICS 80%, GLEYS 15%, PODZOLS 5%

The soils of this association occupy 1.85% of the country (313,274 ac; 126,780 ha.). They occur mainly in Wicklow, Wexford, Tipperary, and to a lesser extent in Waterford, Carlow, Limerick, Meath, Dublin, Louth, Laois, Clare and part of south Kilkenny. They occupy the more elevated positions (152-366 m) in areas underlain by Palaeozoic shales (Cambrian, Ordovician and Silurian) and mica schist. They may be formed from the bedrock, or from glacial drift of similar composition. Slopes vary from about 4° to 20°.

The principal soil is a somewhat shallow (< 75 cm) well drained Brown Podzolic of mainly loam to clay loam texture and of low base status. The profile, which usually contains about 20% clay and 35% silt. The organic matter level is variable. The moisture surface horizon about 25 cm deep overlying a reddish-brown B horizon from 25-50 cm thick. Below this level the parent material usually consists of brashy light-yellow bedrock. The A horizon contains about 30% clay and 35% silt, while the B horizon contains about 20% clay and 35% silt. The organic matter level is variable. The moisture

holding capacity of these horizons is good but is limited due to shallow depth. Occurring through this association are Gleys and Peaty Gleys (15%) and Podzols (5%).

Suitability

The use range of these soils is somewhat limited mainly by the degree of slope, altitude and the amount of boulders or outcropping rock. Generally, the amount of boulders or outcropping rock is not as widespread as in Association 8. Where the slopes are less than 12°, as they are in many places, they can be used for tillage as well as for grassland. Yields are limited due to altitude and shallow depth but, for grassland, the lack of moisture due to shallow depth is compensated for by higher rainfall. Like the soil of Association 8, inferior grasses (agrostis), bracken and furze appear with the lack of lime, fertilisers and good management.

The associated Gleys, Peaty Gleys and Podzols are limited in their use range mainly to grazing.

Principal Soil — Association 9: Brown Podzolic

Topography:		Rolling hill
Slope:		11°
Altitude:		244 m O.D.
Vegetation:		Heath vegetation — *Calluna, Erica* with *Ulex* and *Pteridium* spp.
Drainage:		Well-drained
Parent material:		Ordovician shale
Horizon	*Depth (cm)*	*Description*
A1	0-25	Loam to clay loam; dark-brown (10 YR 3/3); strong, medium crumb structure, held in sod by abundant roots; friable, gradual, smooth boundary to:
B2ir	25-50	Loam: reddish-brown (5 YR 4/4); moderate, fine, crumb structure; very friable; plentiful, diffuse roots; clear, smooth boundary to:
C	Below 50	Brashy subsoil on rock.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron %
A1	28	5	38	29	5.2	20.0	8.2	0.63	13.0	2.7
B2ir	33	9	39	19	5.6	10.6	3.4	0.22	—	4.2

ASSOCIATION 10:

GREY BROWN PODZOLICS 75%, GLEYS 15%, BROWN EARTHS 10%

This association occupies 0.37% of the country (62,519 ac.; 25,301 ha.). It occurs mainly in west Wicklow and east Kildare, on rolling topography close to the Leinster mountains at elevations ranging from 122 to 274 m. It is also found on the Upper Carboniferous outlier ridge running from east of Johnstown in north Kilkenny to south of Durrow in south Laois, at elevations between 152-304 m. On the top of this ridge the parent material is influenced by Upper Carboniferous sandstone and shale, but in general throughout the association, it consists of glacial till of mixed limestone, shale and sandstone composition. In a few places in Wicklow fluvioglacial gravels are present.

The principal soil is a deep, well-drained loam of medium base status. The profile has a moderately deep, brown to dark brown surface horizon with moderately good structure. It has 10-20% clay, 35-46% silt and 2.5-4.0% organic carbon. The soil is classified as a Grey Brown Podzolic. The B horizon shows a slight clay increase and the profile is usually about 90 cm deep. The main associated soil is a poorly drained Gley of silty clay loam texture.

Principal Soil — Association 10: Grey Brown Podzolic

Topography:	Rolling hill
Slope:	4°
Altitude:	160 m O.D.
Vegetation:	Old pasture with furze
Drainage:	Well-drained
Parent material:	Calcareous, non-tenaceous till, of Midlandian age, composed mainly of limestone with shale and sandstone.

Horizon	*Depth (cm)*	*Description*
A11	0-10	Loam; brown to dark brown (7.5 YR 4/2); moderate medium subangular blocky structure and very fine granular; moist friable; abundant roots; abrupt boundary to:
A12	10-36	Loam; dark yellowish brown (10 YR 3/4); moderate medium subangular blocky structure; moist friable; plentiful roots; charcoal present; clear boundary to:
A2	36-56	Loam; dark yellowish brown (10 YR 4/4); weak fine granular structure; moist friable; plentiful roots; gradual boundary to:
B2t	56-104	Loam; dark yellowish brown (10 YR 4/4); weak medium subangular blocky structure; moist slightly plastic; sparse roots; abrupt boundary to:
C	Below 104	Stony loam; brown (10 YR 5/3); structureless; moist firm; no roots; strongly calcareous.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron %
A11	23	20	38	19	5.3	32.0	4.0	0.36	11.1	1.4
A12	27	20	35	18	5.8	20.4	1.3	0.15	8.7	1.6
A2	26	21	36	17	6.0	12.2	0.5	—	—	1.8
B2t	25	20	35	20	6.2	11.2	0.4	—	—	1.9
										1.1

Suitability

These soils have a somewhat limited use range being suited mainly to grassland, although cereals are also grown. The colder climatic conditions associated with the higher elevation cause some difficulty. Due to their depth and friable structure these soils have a high potential for grass production.

The associated Gley soil is mainly suited to grazing but good management is required if poaching by livestock is to be avoided.

Brown Earths occupy 10% of this association and are found mostly on kames and hillocks. They are somewhat shallow but well drained and have the same potential as the principal soil.

ASSOCIATION 11:

GLEYS 90%, BROWN EARTHS 10%

This association occupies 0.35% of the country (59,004 ac; 23,879 ha.). It occurs mainly in Louth, east-Meath, Roscommon and east Donegal and is formed from heavy textured glacial till of predominantly Silurian shale composition. In Roscommon there is a strong limestone influence in the drift. On the east coast Irish Sea drift has been incorporated into the parent material. Elevations range from 122-244 m and slopes are gentle.

The principal soil consists of a surface-water Gley whose origin is due mainly to the impermeable nature of the parent material. The surface horizon is about 15 cm thick and consists of a greyish-brown clay loam to silty clay loam which contains about 30% clay and 35% silt. This overlies a pale-olive Bg horizon of similar texture which has massive structure and large pronounced mottles. The parent material consists of a light grey, massive, silty clay loam.

Suitability

The predominant soil has a limited use range. It is unsuited to tillage. For grassland, drainage improvements are necessary to avoid poaching by grazing livestock, to facilitate machinery use and to extend the growing season. However, because of their impermeable nature, drainage is difficult on these soils. Brown Earths occupy about 10% of the area, and are mainly found on the steeper slopes and therefore are restricted in use range.

Principal Soil — Association 11: Gley

Topography:		Rolling hill
Slope:		3°
Altitude:		140 m
Drainage:		Poor
Parent material:		Glacial till of predominantly Silurian shale composition with Irish Sea drift influence.
Horizon	*Depth (cm)*	*Description*
A11	0-15	Greyish brown (10 YR 5/2); clay loam; weak, medium crumb structure held together in a sod by grass roots; friable; many, medium, distinct yellowish-red (5 YR 5/6) mottles especially along root channels; plentiful, diffuse roots; boundary gradual to:
A12g	15-41	Olive grey (5 YR 5/2); clay loam; massive structure; firm; many, medium and coarse prominent yellowish-brown (10 YR 5/8) mottles; sparse roots; boundary abrupt to:
A/C/G	41-53	Light olive grey (5 YR 6/2); loam approaching sandy clay loam; massive structure; firm; many, coarse prominent yellowish-brown (10 YR 5/8) mottles; abundant, fine black spots of MnO_2.
C/G	Below 53	Similar to above

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N
A11	8	27	35	30	6.0	18.6	11.3	61	4.8	0.5	9.6
A12	9	27	34	30	6.2	14.9	11.5	77	1.8	0.2	9.0
A/C/G	21	27	31	21	6.8	13.5	12.4	92	—	—	—
C/G	23	28	27	22	7.0	13.8	12.9	94	—	—	—

Soils of Rolling Lowland

ASSOCIATION 12:

ACID BROWN EARTHS 70%, GLEYS 25%, PODZOLS 5%

The soils of this association occupy 1.13% of the country (190,831 ac; 77,228 ha.). They occur mainly in Carlow, Wicklow, Wexford, Waterford, the Carlingford Peninsula, Louth and in the Mourne area of Down and Armagh. They occur on rolling topography with elevations mainly between 76 and 152 m. They are formed mainly from acid igneous rocks (mainly granite) and drift material of similar composition. In some areas in Louth the granite is mixed with local shale. The principal soil, Acid Brown Earth, is well drained, has a coarse sandy loam texture and a low base status. The profile is characterised by a dark greyish-brown surface horizon and by a reddish-yellow sub-surface (B) horizon. The (B) horizon merges with the light yellowish-brown parent material. The A horizon varies in depth from 30 to 45 cm and contains 8 to 13% clay and 6 to 16% organic matter. The solum is usually 85 to 125 cm deep. Moisture-holding capacity is moderately good and roots penetrate freely throughout the profile.

The main associated soil is a poorly drained Gley which occupies a significant proportion (25%) of the association. The poor drainage is due mainly to the presence of a high water table and, where an outlet can be found, these soils can be successfully drained. Podzol soils occupy 5% of the association and are confined mainly to the more elevated positions.

Suitability

The well-drained soils of this association have a moderately wide use-range. They are suited to tillage but are also noted for their general suitability for sheep grazing. Being coarse-textured and friable, with a strong crumb structure, they are very easily tilled and can produce good crops. However, near-surface igneous boulders and occasional bedrock can make cultivation difficult in places. Their natural nutrient status is low but excellent responses to lime and fertiliser are obtained. Soil moisture deficit is a problem in very dry seasons.

Cobalt deficiency can be a problem on these soils and levels of two parts per million (2 ppm) and even lower are not uncommon. As a result, pining in sheep and cattle can occur but the condition can be remedied by cobalt sulphate dressings on the soil or oral administration of cobalt to the animal.

Principal Soil — Association 12: Acid Brown Earth

Topography:	Rolling
Slope:	10-12°
Altitude:	122m O.D.
Vegetation:	*Centaureo-Cynosuretum*, typical Sub-ass. Old pasture. Rather poorly growing, heavily grazed sward with much *agrostis tenuis* (bentgrass), *Festuca rubra* (red fescue) and *Rannunculus repens* (creeping buttercup). There are many poverty indicator-species in the sward, notably *Centaurea nigra* (knapweed), *Hypochaeris radicata* (cat's ear), *Luzula campestris* (field woodrush) and *Lotus corniculatus* (birdsfoot trefoil).
Drainage:	Well-drained
Parent material:	Compact, non-calcareous glacial till, of Munsterian Age, composed of granite with some chert.

Horizon	*Depth (cm)*	*Description*
Ap	0-30	Coarse sandy loam; dark-brown (10 YR 3/3); moderate, fine and medium granular structure; friable; plentiful roots; clear wavy boundary to:
(B)	30-70	Coarse sandy loam; strong-brown (7.5 YR 5/8); weak, fine granular structure; very friable, plentiful roots; worm casts of Ap present; gradual irregular boundary to:
C	Below 70	Bouldery, coarse loamy sand to sandy loam; light yellowish-brown (10 YR 6/4); structureless; dry, hard *in situ;* no roots; non-calcareous.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	Ph	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
Ap	51	21	18	10	6.0	20.3	7.1	35	3.3	0.24	13.8	0.7
(B)	54	21	17	8	5.0	13.9	2.6	19	0.9	nd	—	0.7
C	58	19	17	6	5.2	6.3	3.0	48	0.3	nd	—	0.4

*Relatively high surface pH due to recent liming.

Trace elements — total content (ppm)

Hor.	Sn	Pb	Ga	Mo	V	Cu	Ag	Zn	Ni	Co	Cr	Ti	Mn
Ap	30	35	50	1	25	20	1	65	9	5	25	1750	650
(B)	20	25	50	1	50	20	1	75	25	5	40	2000	200
C	25	40	60	1	25	8	1	100	15	4	10	1000	200

ASSOCIATION 13:

ACID BROWN EARTHS 70%, GREY BROWN PODZOLICS 15%, GLEYS 15%

This association occupies 1.69% of the country (286,389 ac.; 115,900 ha.). It occurs in the gently rolling east-west Armorican synclinal valleys of Cork and Waterford, in particular, and also in south Kilkenny and south Tipperary. It is well represented in the Fermoy region. Topography is gently rolling and elevations are mainly 0 to 75 m O.D. The soils are formed from glacial drift of mixed Old Red Sandstone-Carboniferous limestone composition while the underlying rock is Carboniferous limestone.

The principal soil is a well-drained Acid Brown Earth (low to medium base status) of sandy loam texture throughout the profile depth. The profile is characterised by a dark yellowish brown A horizon about 30 cm deep overlying a weakly developed B horizon to a depth of about 125 cm. Clay content is about 15% while silt content is about 25%. The soil has a good structure and is very friable. Moisture holding capacity is good. The associated Grey Brown Podzolic (15%) soils occur where there is a stronger limestone influence in the parent material. Their base status is somewhat higher and clay movement in the soil profile is evident.

In the low lying areas, Gley soils occur within this association but are limited in extent (approx. 15%). Impedance is usually evident from 30 cm downwards but as textures are still sandy loam to loam, these areas can be readily drained if an outfall is available.

Principal Soil — Association 13: Acid Brown Earth

Topography:	Gently rolling
Slope:	2°
Altitude:	50 m O.D.
Drainage:	Well-drained
Parent material:	Glacial till of mixed Old Red Sandstone — Carboniferous limestone composition.

Horizon	*Depth (cm)*	*Description*
A11	0-15	Dark-reddish brown (5 YR 3/3); sandy loam to loam weak to moderate fine sub-angular blocky structure; friable; abundant diffuse roots; gradual boundary to:
A12	15-33	Reddish-brown (5 YR 4/3); sandy loam to loam; moderate fine sub-angular blocky structure; friable; abundant diffuse roots; clear smooth boundary to:
(B)	33-41	Yellowish-red (5 YR 4/6); sandy loam to loam; weak very fine sub-angular blocky structure; friable; plentiful diffuse roots; boundary gradual to:
C	41-91	Reddish brown (5 YR 5/3); sandy loam to loam; moderate fine to medium sub-angular blocky structure; friable; some roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	40	19	25	16	5.5	13.6	5.9	44	3.6	0.32	11.3	1.4
A12	33	22	29	16	5.3	10.4	6.3	61	1.6	0.14	11.4	1.4
B	32	22	33	13	5.7	5.5	4.7	87	0.8	—	—	1.4
C	35	18	34	13	6.2	3.4	2.0	58	0.2	—	—	

Suitability

These soils have a wide use range and are very suitable for both tillage and grass production. Because of their sandy loam texture, free drainage and good structure, they are easy to cultivate and can produce a wide range of crops, including malting barley and sugar beet. The climatic advantages of their southern location increase both crop and pasture yields. They also have a high reputation for apple production where they have been devoted to orchards, as in south Kilkenny and Waterford.

The suitability of the associated Grey Brown Podzolic soil is similar to the principal soil but that of the Gley soil is limited due to impedance.

ASSOCIATION 14:

ACID BROWN EARTHS 75%, GLEYS 15%, BROWN PODZOLICS 10%

The soils of this association occupy 4.22% of the country (712,885 ac.; 288,501 ha.). They occur mostly in Wexford, Waterford, Wicklow, Kilkenny, Tipperary, Louth, Meath, east Clare, Cavan, Longford, and to some extent in Limerick, south Armagh and Down, and are formed from glacial till of predominantly Palaeozoic shale composition. Topography generally is gently rolling with uniform slopes.

The principal soil consists of a well-drained Acid Brown Earth of loam to clay loam texture. Base status is low to medium. The profile is characterised by a dark brown surface horizon about 30 cm deep, with a moderately strong, medium crumb structure. Sometimes there is a strong brown B horizon (Brown Podzolic component) about 7.5 to 15 cm thick, but more often this is either absent or weakly expressed. The parent material consists of a yellowish-brown to pale-brown loam with moderate medium sub-angular blocky structure. The entire profile is friable to very friable and moisture holding capacity is good except on limited shallow sites. The A horizon contains about 24 to 26% clay and about 40% silt while the B horizon contains about 20% clay and 40% silt. In the parent material the clay and silt contents are somewhat less. The profile usually contains appreciable quantities of small stones which aid internal drainage.

Brown Earths formed chiefly from shale gravels and sands are found sporadically throughout this association. They are most obvious in Wicklow where they extend in a narrow strip one to two miles wide from Delgany to Rathnew and occupy 6,000 ha. In Louth they occur around Kilsaran and Castlebellingham, north west of Ardee and in the area north west of Dundalk, near Kilcurry and occupy in all around 6,000 ha. This soil is well to excessively drained with a sandy loam to loam surface texture. Its use range is similar to the main association, but drought and sharp steep slopes reduce its production capabilities.

Principal Soil — Association 14: Acid Brown Earths

Topography:	Rolling
Slope:	Flat
Altitude:	100 m O.D.
Drainage:	Well-drained
Parent material:	Ordovician shale glacial till

Horizon All	*Depth (cm)*	*Description*
A11	0-15	Dark brown (7.5 YR 4/2) loam; moderate medium crumb structure; friable; plentiful diffuse roots; gradual smooth boundary.
A12	15-32	Dark brown (7.5 YR 4/2) loam; moderate to strong fine to medium crumb structure; friable; plentiful diffuse roots; clear smooth boundary.
(B)	32-40	Reddish-brown (5 YR 4/4) loam; moderate medium sub-angular blocky structure; very friable; few roots; clear smooth boundary.
C11	40-70	Brown (10 YR 5/3) loam; moderate medium sub-angular blocky structure; friable; few roots; gradual smooth boundary.
C12	70-90	Brown (10 YR 5/3) loam; moderate medium sub-angular blocky structure; friable; no roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	PH	CEC meq/100g	TEB Meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	22	8	43	27	6.0	25.2	15.7	62	3.4	0.28	12.1	nd
A12	25	8	39	28	5.7	24.0	13.9	58	2.2	0.13	16.9	nd
(B)	29	9	38	24	5.6	15.0	3.6	24	1.2	0.13	—	nd
C11	36	13	36	15	6.0	8.0	3.6	45	0.4	nd	—	nd
C12	27	11	45	17	6.0	8.0	3.3	41	0.4	nd	—	nd

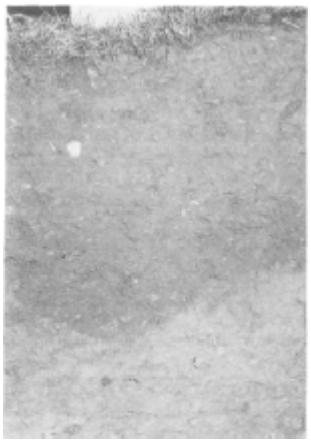


Plate 9: *This uniform profile is typical of the Acid Brown Earth soils of Association 14.*

Plate 10: *The soils of Association 14 are widespread in Wexford, Waterford and Louth in particular and are suited to a wide range of farm, fruit and vegetable crops.*

The principal associated soil is a ground water Gley (15%) with clay loam texture and low to medium base status. It occurs in the depressions and the poor drainage is due to the presence of a high water table.

Suitability

Generally, these soils have a wide use range. They are excellent for tillage, being suited to a wide range of farm, fruit and vegetable crops — including good quality malting barley and soft fruit. Grassland is also very successful especially in the form of highly productive short-term leys. This applies in particular in its more southern and eastern areas of occurrence but because of somewhat more restrictive climatic conditions, the use range is not as wide in areas such as Meath, Cavan, Longford and east Clare.

Occurring within this association is a well drained Brown Podzolic (10%). It is more leached than the Brown Earth with a well expressed B ir horizon. The use range is similar to that of the principal soil.

If a suitable drainage outfall is available the associated Gley soil can be reclaimed to have a moderately wide use range, being suited to pasture or tillage.

ASSOCIATION 15:

BROWN PODZOLICS 60%, ACID BROWN EARTHS 20%, GLEYS 20%

The soils of this association occupy 6.31% of the country (1,065,864 ac; 431,349 ha.). They are formed from glacial drift of mixed Old Red sandstone, shale and slate composition. They are most widespread in Cork, Kerry and Waterford, with smaller areas in Tipperary, Kilkenny and Limerick. Soils occurring in the Cliffony-Tullahan areas of north Sligo, Leitrim and south Donegal and formed from Carboniferous sandstone on fluvioglacial kames, have also been included in this asociation, but because of their hummocky topography and because of climatic factors, they have a much more limited use range.

Elevations range mainly from 30 to 150 m. The gently rolling to rolling physiographic features of the landscape are an expression of the geological structure. The sandstone bedrock had been compressed into a series of elongated ridges with their long axes running east-west, forming a succession of anticlines and synclines. (The soils of Association 13 occur mainly in the synclinal valleys underlain by Carboniferous limestone). Locally, the topography is somewhat broken with small Old Red sandstone hillocks out-cropping frequently through the gently rolling glacial till landscape.

The principal soil in the association is a well drained Brown Podzolic of sandy loam to loam texture and of low to medium base status. The profile is characterised by a dark-brown surface horizon which can be up to 40 cm deep overlying a yellowish-red B horizon to a depth of about 60 cm. Below this level, the parent material consists of a greyish-brown gravelly loam which tends to be firm *in situ* and friable *ex situ*.

In some places, the B horizon is not sufficiently well expressed to allow the soil to be classified as a Brown Podzolic. The proportion in the association is estimated to be 60% Brown Podzolics and 20% Acid Brown Earths.

The surface horizon contains 14 to 18% clay and about 35% silt. The Band C horizons can have up to 40% silt while the percentage clay drops to about 12% in the B horizon and to 6 to 10% in the parent material. Gley soils occupy some 20% of the association and occur mostly in depressions. They are usually loam to sandy loam in texture and can be successfully drained if an outfall can be obtained.

Principal Soil — Association 15: Brown Podzolic

Topography:	Rolling
Slope:	8˚
Altitude:	76 m O.D.
Drainage:	Well drained
Parent material:	Glacial drift composed of a mixture of sandstone, shaly sandstone and shale.

Horizon	*Depth (cm)*	*Description*
A11	0-14	Gravelly loam; brown (10 YR 4/3); moderate fine granular; friable; abundant roots; arbitrary boundary to:
A12	14-29	Similar to A11
A13	29-64	Similar to A11 but contains more gravel; plentiful roots; clear wavy boundary.
B2	64-86	Loam; yellowish red (5 YR 5/6); weak fine granular; very friable; sparse roots; gradual tonguing boundary to:
C	Below 86	Gravelly loam; light olive brown (2.5 YR 5/4) moist slightly firm in situ; no roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free Iron %
A11	28	23	35	14	5.5	19.0	3.3	0.32	10.3	1.7
A12	27	24	34	15	5.5	11.6	2.9	0.20	14.5	2.0
A13	27	21	37	15	5.4	12.0	2.2	0.16	—	2.1
B2	22	22	46	10	6.0	15.6	1.0	0.07	—	3.5
C	22	24	41	13	6.3	5.4	0.3	0.04	—	1.4

Suitability

The Brown Podzolic and Acid Brown Earth soils have similar land use ranges. They have desirable structure, texture, drainage and depth features. As a result, they have a wide range of potential uses and are well suited to arable cropping and grassland. Furthermore, their occurrence mainly in the extreme south, affords a climatic advantage for crops and pasture. Although much of the area in which they occur is at elevations around 120 m they are still placed in the wide use range category since it is considered that this is offset by such a favourable climate. Large rock outcrops occur in some places imparting a somewhat broken aspect to the landscape. Generally, however, these do not interfere with farming operations.

Where this soil occurs in the north-west* it is not suitable for tillage because of hummocky topography and unsuitable climate.

The associated Gley soils can be reclaimed but are mainly suitable for grass production.

ASSOCIATION 16:

ACID BROWN EARTHS 90%, GLEYS 5%, REGOSOLS 3%, PODZOLS 2%

The soils of this association occupy 0.42% of the country (70,842 ac; 28,669 ha.). They occur mainly in Wexford. Sandy texture is their outstanding feature. They are derived mainly from coarse textured end moraine deposits of the Midlandian glaciation. The area has all the distinctive features of a young morainic landscape, displaying a definite "kame and kettle" pattern. Elevation ranges up to 110 m and the topography is moderately to steeply rolling.

In Limerick and Clare, small enclaves of soils formed over sandstone-shale fluvioglacial material have been included in this association. The wind-blown sands on the coasts of Donegal, Sligo and Mayo, are also included.

The predominant soil is an excessively drained Acid Brown Earth of coarse sand texture and of low base status. The profile is characterised by very dark greyish-brown upper horizons overlying a yellowish-red horizon in which leached constituents have accumulated. However, this horizon seldom qualifies as a podzolic B horizon. The entire profile is very friable.

The surface horizon has only about 2% clay and 4 to 5% silt. Coarse sand content is 70 to 75%. Organic matter content is also low at about 3%. In the B horizon, clay plus silt content is usually less than 5%, with organic matter of about 1%. The parent material has almost 99% sand.

The main associated (5%) soil is a poorly drained Gley situated in depressions. It has loamy coarse sand texture and an organic surface layer. Because of its very sandy texture, it can be easily drained if the water table can be lowered through the location of a suitable outfall.

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*Connacht 0.4%, Donegal 0.9%.

The other soils in the association are Regosols (3%) and Podzols (2%). The Podzols have a well defined B horizon and a strongly developed leached A2 horizon over a somewhat cemented humus-enriched B horizon. These soils tend to occur where the sand is coarser in texture but they are of limited extent. They can be reclaimed by deep ploughing, through which the humus B horizon can be broken up and mixed with the upper layers.

Suitability

These soils have a somewhat limited use range. Because of their coarse texture, the moisture holding capacity is very low. Pastures, if neglected, become bracken *(Pteridium)* and sorrel *(Rumexacetosa)* dominated. The soil is suited to a narrow range of tillage crops and short term leys. High yields of good quality early and main crop potatoes and carrots can be obtained but yields from cereal crops are generally disappointing. Pastures are noted for early growth but due to lack of moisture they fail to maintain growth in drier periods, thus curtailing stock carrying capacity over the entire season. With irrigation this soil has a high potential for many crops.

Plate 11: *Very sandy humus podzol soils displaying distinctive leached A2 and dark coloured humus B horizons occur within Association 16 in the Screen area of Wexford.*

When reclaimed the land use range of the associated Gley, Regosol and Podzol soils is similar to that of the principal soil, but because of the coarser texture of the Regosols and Podzols they tend to revert more quickly to their original strongly acid state.

Principal Soil — Association 16: Acid Brown Earth
(Profile representative of less coarse textured soils in this association)

Topography:	Rolling kames
Slope:	2°
Altitude:	46 m O.D.
Vegetation:	Cultivated
Drainage:	Well to excessively drained
Parent material:	Coarse textured, end-morainic materials of the Midlandian glaciation.

Horizon	*Depth (cm)*	*Description*
A11	0-22	Loamy coarse sand; dark-brown (10 YR 3/3); weak; medium crumb structure; very friable; sand grains bleached; plentiful, diffuse roots; gradual, smooth boundary to:
A12	22-47	Coarse sandy loam; dark yellowish-brown (10 YR 3/4); moderate, medium crumb structure; very friable; sand grains bleached; plentiful, diffuse roots; abrupt, smooth boundary to:
B	47-57	Coarse sand; reddish-brown (5 YR 4/4); single grain structure; very friable; some roots; evidence of good earthworm activity; clear, smooth boundary to:
C	57-70	Coarse sand; brown (7.5 YR 4/4) to strong brown (7.5 YR 5.6); single grain structure; loose; few roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay%	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A1p	61	19	13	7	6.0	7.0	2.4	34	2.0	0.20	10.0	0.8
A12	54	15	21	10	5.3	6.8	3.6	53	1.0	0.10	10.0	1.2
B	72	16	7	5	5.8	3.2	2.0	63	0.1	0.04	—	1.0
C	79	12	5	4	5.8	1.6	1.2	75	0.2	0.02	—	1.1

ASSOCIATION 17:

ACID BROWN EARTHS 90%, GLEYS 5%, PEATY GLEYS 5%

The soils of this association occupy 0.02% of the Republic (3,876 ac; 1,569 ha.). They are formed from glacial till of predominantly basaltic composition. They occur mainly in Northern Ireland on the less elevated parts of the Antrim Plateau, in small areas near Slane in Co. Meath and in Co. Limerick. They are found on undulating to rolling relief, mainly at elevations varying from 61 to 152 m.

The principal soil consists of a well-drained Brown Earth of medium base status. The profile is characterised by a dark reddish-brown surface horizon which can be up to 40 cm deep. This is underlain by a reddish-brown (B) horizon to a depth of about 75 cm overlying a yellowish-brown parent material. Texture, which is relatively uniform with depth, consists of a clay loam to loam, although mechanical analyses often indicate lower contents of clay and silt. But this is probably due to the difficulty of properly dispersing these soils in the analytical procedure. This is confirmed by observations of field textures. Another feature of these soils is their high cation exchange capacity and their high content of montmorillonite. Exchangeable magnesium values are high. Structure tends to be strongly developed both in the surface A and in the B horizon.

The main associated soils are Gleys and Peaty Gleys occurring in the depressions.

Principal Soil ─ Association 17: Brown Earth

Topography: Rolling
Slope: 4°
Drainage: Well drained
Parent material: Morainic glacial till of basaltic composition

Horizon	*Depth (cm)*	*Description*
A	0-30	Medium loam, friable; dark chocolate-brown with excellent crumb structure and plentiful supply of fine roots; changes fairly sharply to:
B	30-60	Bright orange-brown or yellow-brown loamy layer; rather cemented but crumbles under pressure to a friable gravelly loam; some a mygdaloidal basalt fragments in different stages of composition.
C	60+	More moist, gravelly loam; slightly mottled but predominantly rusty brown.

Analytical data

	Coarse	Fine					Exchangeable cations						CEC
Horiz.	sand%	sand%	Silt%	Clay%	C%	pH	Ca	Mg	K	Na	H	Sum.	meq/100g
A	9	26	32	33	5.5	5.8	22.6	4.1	0.60	0.62	19.7	47.7	45.3
B	14	39	23	25	1.6	6.3	16.7	2.6	0.23	0.34	10.3	30.2	29.8
C	12	45	30	13	0.5	6.4	23.6	11.4	0.37	0.96	10.9	47.3	41.2

Suitability
Where these soils occur in the Republic of Ireland (Limerick and Meath) they have a limited use range due to shallow depth and rock outcrop. In Northern Ireland, however, they have a wide use-range and because of their loam textures, good structure and moisture holding capacity, they are highly productive grassland and tillage soils. Because of their high iron content, however, they have a relatively high capacity for phosphate fixation but this can be taken into account in fertiliser practice.
The associated gley and peaty gley soils are mainly suited to grass production but they can be improved through drainage.

ASSOCIATION 18:

PODZOLS 70%, GLEYS 20%, PEATS 10%

This association occupies 0.74% of the country (124,577 ac.; 50,416 ha.). It occurs mainly in the Kiltimagh-Kilkelly-Charlestown areas of east Mayo and close to the northern shores of Clew Bay, parts of Sligo, also in north Leitrim and, to some extent, in parts of Tipperary. The parent material consists mainly of glacial drift of acid igneous, sandstone or mica schist composition. Some of them have a Carboniferous limestone/sandstone influence in the parent material. The topography consists of rugged, rolling lowland with many short slopes, 0 to 7°, and much rock outcrop. Altitudes are about 91 m but in Tipperary may be up to 152 m.

The principal soil, a Podzol, ranging in depth from 70 to 100 cm, is derived from glacial drift composed mainly of sandstone. The surface texture of this soil ranges from sandy loam to organic and peaty sandy loam. Organic matter contents tend to be relatively high.

Structure in the surface is moderate. The leached, almost structureless A2 horizon(5-15 cm thick) overlies an iron enriched B horizon which is frequently streaked with humus and shows an increase in clay content. pH values are low to medium. Reclamation which breaks the iron-pan and mixes the subsoil with the peaty surface improves the strength of the topsoil. Brown Podzolic soils also occur to a significant extent (< 10%) especially in the Sligo and east Mayo area. Some Gleys, Basin and Blanket Peats are also associated with this soil.

Suitability
These soils have a limited use range. Natural lime and nutrient levels are very low and generally, the supplementation of these is difficult due to the nature of the landscape.

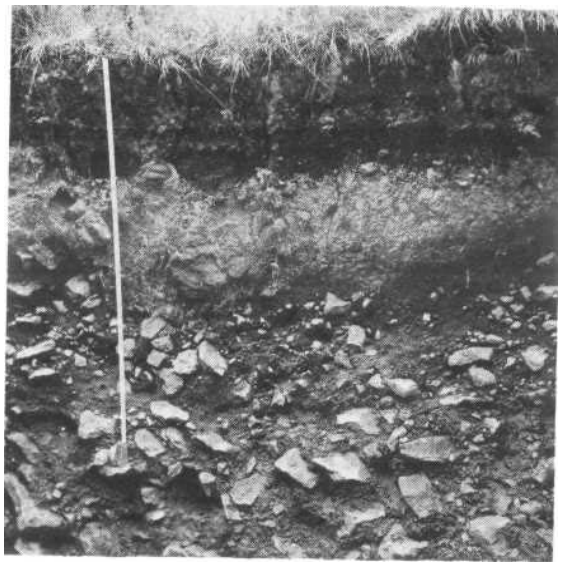

Plate 12: *Podzol profiles of the rugged rolling lowland of east Mayo and parts of Sligo and Leitrim (Association 18) are developed from glacial drift of mainly acid igneous, sandstone and mica schist composition. They display an organic or peaty surface A horizon overlying a leached light grey A2 horizon and a brown to dark brown B horizon of sesquioxide accumulation.*

Principal Soil — Association 18: Podzol

Topography:	Gently rolling kame and kettle topography
Slope:	3°
Altitude:	61 m O.D.
Drainage:	Well drained
Parent material:	Old Red Sandstone drift, of Midlandian age.

Horizon	*Depth (cm)*	*Description*
A11	0-10	Organic gravelly loam; dark greyish-brown (10 YR 4/2); moderate, medium to fine crumb structure; moist friable to moist firm; root mat; gradual, smooth boundary:
A12	10-20	Sandy loam to loam, with some gravel; brown to dark brown (10 YR 4/3); weak, fine crumb structure with weak, fine sub-angular blocky structure also; friable; plentiful roots; clear, irregular boundary;
A2	20-25	Loam; light grey (10 YR 7/2); massive to single grain structure; friable, almost loose; few roots; abrupt, wavy boundary:
B2ir	25-41	Clay loam, with gravel; brown to dark brown (7.5 YR 4/2) with mottles of strong brown (7.5 YR 5/6); massive structure; firm; no roots; gradual, wavy boundary:
B2irh	41-70	Clay loam; brown to dark brown (7.5 YR 4/4); medium sub-angular blocky to weak, fine crumb structure; friable; no roots; gradual, smooth boundary:
C	70-89	Gravelly loam, with large stones; yellowish-brown (10 YR 5/6); weak, medium sub-angular blocky structure; moist plastic; no roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N	Free iron %
A11	23	26	35	16	5.5	20.4	4.1	0.41	10.0	1.0
A12	27	24	34	15	5.5	20.0	1.7	0.25	6.8	0.9
A2	25	25	40	10	5.7	8.0	0.5	nd	—	0.6
B2ir	13	16	42	29	5.8	17.2	0.6	nd	—	3.4
B2irh	13	13	45	29	5.8	17.8	1.0	nd	—	4.5
C	20	22	42	16	5.8	11.6	0.6	nd	—	1.9

Trace elements — total contents (ppm)

Hor.	Sn	Pb	Ga	Mo	V	Cu	Zn	Ni	Co	Cr	Ti	Mn
A	2	20	5	1	30	6	25	6	4	30	650	140

Trace elements — extractable contents (ppm)

Hor	Cu	Zn	Mo	Mn	Co
A	4.0	3.9	0.43	90	3.4

The thin cemented iron pan restricts root penetration and water movement. Consequently, these soils are generally not suited to tillage. They are moderately suitable for grassland, but, because of the weak structure and high organic matter content of the surface horizon, they require careful management, even in pasture.

The principal associated soil is a poorly drained Gley. This is mainly suited to grazing but can be improved through drainage. The associated Brown Podzolic soils are similar in their suitability to the principal soil.

ASSOCIATION 19:

ACID BROWN EARTHS 70%, GLEYS 15%, PEATY GLEYS 15%

This association occupies 0.77% of the country (130,857 ac.; 52,957 ha.). It occurs mainly in Clare but also to some extent in Limerick and on the Slieveardagh Plateau in Tipperary and Kilkenny, and in Kerry and north Dublin. It is associated with the Upper

Carboniferous shales and sandstones on rolling topography. In north Dublin the soil is formed from Upper Carboniferous shale with an Irish Sea drift influence. Slopes range from 2 to 10° and altitudes are generally less than 180 m but they may reach 400 m,as on the Slieveardagh Plateau, and on the lower slopes of the Mullaghareirk range on the Limerick/Cork border.

The principal soil is a well-drained Acid Brown Earth of clay loam to silty clay loam texture and of low to medium base status.

Principal Soil — Association 19: Acid Brown Earth

Topography:	Rolling landscape
Slope:	2°
Altitude:	40 m O.D.
Vegetation:	*Centaureo-Cynosuretum,* typical Sub-ass. Old, poor quality meadow. Weedy sward dominated by *Agrostis tenuis* (bentgrass) and *Anthoxanthum-odoratum* (sweet vernal grass). *Centaurea nigra* (knapweed) and *Dactylorchis spp.* (Orchids) are very common.
Drainage:	Well drained
Parent Material:	Upper Carboniferous shale and sandstone drift of Midlandian age.

Horizon	*Depth (cm)*	*Description*
A11	0-8	Organic clay loam to silty clay loam; dark greyish-brown (10 YR 4/2); moderate, fine crumb structure; moist friable and slightly plastic; root mat; clear, smooth boundary:
A12	8-20	Clay loam; brown to dark brown (10 YR 4/3); weak, fine crumb structure; moist, slightly plastic and slightly friable; plentiful roots; gradual, smooth boundary.
(B)	20-30	Shaly clay loam; dark yellowish-brown (10 YR 4/4); weak, fine sub-angular blocky structure; moist slightly plastic; many roots; clear, smooth boundary:
C	30-51	Glacial till.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay	% pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	10	10	46	34	5.1	36.8	9.9	27	8.6	0.69	12.5	2.6
A12	13	11	44	32	5.2	27.4	8.7	32	5.9	0.42	14.0	2.5
(B)	14	11	42	33	5.6	24.5	8.4	34	3.5	0.30	—	2.6
C	49	4	44	3	5.9	18.0	6.9	38	2.2	0.15	—	2.2

Trace elements — total contents (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Zn	Ni	Co	Cr	Ti	Mn	Se
A	2	10	10	1	60	18	40	8	6	45	1,200	650	0.7

Trace elements — extractable contents (ppm)

Horizon	Cu	Zn	Mo	Mn	Co	B
A	4.4	5.2	0.72	290	6	1.5

The profile is characteristed by a rather heavy texture. There is a dark greyish-brown surface horizon about 20 cm deep containing 30 to 35% clay and about 45% silt. Organic matter content is relatively high at about 10 to 15%. The dark yellowish-brown B horizon which extends to about 30 cm depth contains similar amounts of clay and silt. Nevertheless, there is no indication of impeded drainage. Due to an influence of a drift of Irish Sea origin some Grey Brown Podzolics occur through the Brown Earths in north Dublin.

The associated Gley (15%) and Peaty Gley soils (15%) are poorly drained and heavy textured. They occur in the more depressional parts of the landscape as well as where seepage and springs are present. Their main use is in summer grazing. They can be improved through drainage, but because of their heavy texture, this is not as successful as on the more coarse textured soils of some other associations.

Suitability

These soils have a somewhat limited use range. Because of their rather heavy texture, tillage operations or intensive grazing are difficult especially at the higher elevations. Here, also, the climatic factor is responsible for a restricted growing season, despite the free draining nature of the soil itself. Nevertheless, they can be used for cereal growing as well as being good but somewhat "late" soils for grassland.

The associated Gley and Peaty Gley soils are suitable mainly for grassland.

ASSOCIATION 20:

BROWN PODZOLICS 60%, ACID BROWN EARTHS 20%, GLEYS 20%

The soils of this association occupy 1.41% of the country (237,583 ac.; 96,149ha.). They are derived from drift material of predominantly mica schist composition. They occur mainly in Wexford, Wicklow, Carlow and Donegal, west Derry and Tyrone. Topography is rolling and elevations are mostly below 152 m.

Plate 13: *Somewhat shallow Acid Brown Earth soils formed from glacial till of mica schist composition (Association 20) occur extensively in East Donegal as well as in Derry, Tyrone, Carlow, Wexford and Wicklow.*

The principal soil is a well drained Brown Podzolic of clay loam to loam texture and of low base status. In some places the B horizon is weakly expressed and here the soil is classed as an Acid Brown Earth. The profile is characterised by a reddish-brown surface horizon overlying a yellowish-red B horizon at a depth of 30 cm. This merges with the pale brown brashy parent material at around 40 cm. Clay content decreases from 30% in the surface to about 20% in the B horizon and 14% in the parent material. Similarly, the silt content decreases from about 40% to 30%.

Suitability

These soils and the Acid Brown Earth in the association have a moderately wide use range. They are well suited to tillage and pasture but they sometimes occur in less favoured climatic areas and, therefore, are not as well suited to crops such as sugar beet. Productive pastures can be established on them and they can be grazed over a long period of the year. The associated (20%) Gley soils have a limited use range due to poor drainage. Although occurring in the lower landscape positions, they can be improved through drainage.

Principal Soil — Association 20: Brown Podzolic

Topography:	Rolling
Slope:	6°
Altitude:	152 m O.D.
Vegetation:	Old pasture, mostly *Agrostis spp.*
Drainage:	Well drained
Parent material:	Glacial till of predominantly mica schist composition.

Horizon	*Depth (cm)*	*Description*
A11	0-15	Clay loam to loam; reddish-brown (5 YR 4/3-4/4); moderate, medium crumb structure; friable; plentiful, diffuse roots; gradual boundary to:
A12	15-27	Clay loam to loam; reddish-brown (5 YR 4/3-4/4); moderate to strong, medium crumb structure; friable; plentiful, diffuse roots; abrupt, smooth boundary to:
B	27-37	Loam; yellowish-red (5 YR 5/6); moderate, fine crumb structure; friable; some roots; clear, wavy boundary to:
B/C	Below 37	Sandy loam; pale-brown (10 YR 6/3); moderate; fine granular structure; very friable; few roots; many, medium-sized schist fragments present.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A12	21	7	42	30	5.9	14.2	2.9	20	4.9	0.35	14.0	Nd
A12	27	7	39	27	6.0	12.8	3.0	23	3.6	0.28	12.9	Nd
B	36	8	37	19	6.1	6.7	1.3	19	1.6	—	nd	
B/C	46	9	31	14	6.3	4.5	1.9	42	0.7	0.06	—	Nd

ASSOCIATION 21:

GLEYS 75%, PEATY GLEYS 25%

The soils of this association occupy 2.95% of the country (499,030 ac; 201,955 ha.). They occur mainly in Clare, south Galway, west Mayo, Tipperary, Limerick, and to a lesser extent in Cork, Offaly, Laois, Kilkenny, Sligo, Roscommon, Tyrone and Fermanagh. They are formed from glacial till of mixed sandstone-shale composition with a small

Principal Soil — Association 21: Gley

Topography:	Rolling
Slope:	4°
Altitude:	146 m O.D.
Vegetation:	Old grassland *(Junco Molinietum, Sub-ass, of Agrostis canina)*
Drainage:	Poorly drained
Parent material:	Glacial drift mainly of mixed sandstone-shale composition, with a little limestone; of Munsterian Age.

Horizon	*Depth (cm)*	*Description*
A1	0-22	Loam; greyish-brown (10 YR 5/2); weak, medium crumb structure; slightly friable; plentiful roots; clear, smooth boundary to:
(A)2g	22-35	Loam; light-grey (10 YR 7/1); weak, very fine prismatic structure; wet, sticky; few roots; clear, smooth boundary to:
B2irg	35-56	Gravelly loam; greyish-brown (10 YR 5/2); few, fine, distinct, yellowish-brown (10 YR 5/8) mottles; weak, fine sub-angular blocky structure; wet, sticky; few roots; diffuse, smooth boundary to:
B3g	56-81	Loam; light-grey (10 YR 7/1); common, medium, distinct, reddish-brown (5 YR 5/4) mottles; massive structure; wet, sticky; few roots; clear, irregular boundary to:
C1g	81-90	Loam: greyish-brown (10 YR 5/2) and black (10 YR 2/1); common, medium, distinct, strong-brown (10 YR 5/6) mottles; massive structure; wet, sticky; few roots; clear, irregular boundary to:
C2g	90-127	Sandy clay loam; otherwise similar to C1g.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A1	26	19	33	22	5.7	12.2	9.2	75	3.1	0.26	11.9	1.6
(A2)g	25	16	33	26	6.0	6.6	5.5	83	0.3	0.08	3.8	1.6
B2irg	25	22	32	21	6.0	4.7	3.5	75	0.3	0.07	—	2.6
B3g	26	16	34	24	6.2	5.6	5.5	98	0.3	0.07	—	2.5
C1g	36	12	29	23	5.5	6.1	5.2	85	0.3	0.07	—	2.2
C2g	31	20	26	23	5.7	5.7	5.0	88	0.1	0.05	—	1.2

admixture of limestone in places. The relief is variable, ranging from rolling to level with altitudes mostly between 76 m and 152 m but reaching 304 m in small enclaves in places, as, for example, in the Slieve Phelim and Silvermine areas of north Tipperary.

The predominant soil is poorly drained, of loam to sandy loam texture, and medium base status and is classified as a Podzolised Gley. The profile usually displays a greyish-brown surface horizon. The lower horizons have drab grey colours and are distinctly mottled. Structure is weak and the soil is sticky when wet in all horizons except the surface. Clay content in surface horizons ranges from about 22 to 27% with silt contents of 30 to 35%. B and C horizons are slightly coarser. Soil depth varies from 0.9 to 1.8 m. The associated peaty Gley soil (25%) is similar, except that drainage conditions are worse and a peaty surface horizon of about 15 cm has developed.

Suitability

These soils have a limited use range. They are poorly drained, even on favourable slopes. This drainage problem seems to consist mainly of seepage associated with stratification of the underlying bedrock. Cultivation is very difficult unless the soils are at an ideal moisture balance; they are best suited to grassland. Drainage, especially the tapping of springs and control of seepage, liming, manuring and good management, including avoidance of overstocking in wet periods, are essential.

ASSOCIATION 22:

GLEYS 75%, ACID BROWN EARTHS 15%, PEATS 10%

This association occupies 4.86% of the country (820,563 ac.; 332,077 ha.). It occurs widely on the Clare, Castlecomer and Abbeyfeale plateaux, and also in parts of north Kerry and north Cork. In the former location, altitudes are mainly between 183 and 304 m but the altitude of the association generally ranges from about 61 to 213 m. It is formed from till of Upper Carboniferous shale and sandstone composition. Topography varies from flat to rolling.

The principal soil usually consists of a very dark brown surface horizon of weak structure and poor consistence about 20 to 25 cm deep. In some places, particularly in south west Limerick, the topsoil may have a surface accumulation of peaty material which varies from 0 to 23 cm in depth. This overlies a grey and mottled, plastic subsurface horizon which has a coarse prismatic structure and which merges with the dense parent material at 90 to 100 cm. There may be podzolisation in places. An outstanding feature of these soils is their heavy texture. Clay plus silt contents can be up to 65% in the surface horizon and up to 80% in the subsoil. In some better-drained positions on good slopes Acid Brown Earths occupy about 15%. Peats and Peaty Gleys are found sporadically through this association, amounting to about 10% of the area.

Plate 14: *Rush-infested pastures typical of the poorly drained gley soils of Clare, West Limerick and the Castlecomer Plateau are formed mainly from till of Upper Carboniferous shale and sandstone composition.*

Suitability

These soils have a limited use range. Owing to their adverse physical properties they are generally unsuitable for tillage. With drainage and lime and fertiliser use, they have a potential for grass production, but management must be of a high order if worthwhile returns are to be obtained. Poaching and rush *(Juncus)* infestation are serious problems, so the grazing season must be confined largely to the drier summer period.

In some better drained positions associated Acid Brown Earths occur. Due to a rather heavy texture and strong slopes they have a somewhat limited use-range.

The Peats and Peaty Gleys are also very limited in their use range.

Principal Soil — Association 22: Gley

Topography:	Rolling
Slope:	5°
Altitude:	50mO.D.
Vegetation:	Old Pasture *(Centaureo-Cynosuretum, Sub-ass, of Juncus effusus,* Var. of *Lolium perenne)*
Drainage:	Poorly drained
Parent Material:	Glacial drift of Upper Carboniferous shale sand stone origin and mainly Midlandian age.

Horizon	*Depth (cm)*	*Description*
A 11	0-14	Clay loam; greyish-brown (10 YR 5/2); weak, fine crumb structure; slightly friable but sticky when wet; abundant, diffuse roots; gradual, smooth boundary to:
A12g	14-37	Clay loam; grey (10 YR 6/2) with many, fine, distinct, brownish-yellow (10 YR 6/6) mottles; weak, fine crumb structure; slightly friable but sticky when wet; plentiful, diffuse roots; clear, smooth boundary to:
(B)g	37-58	Clay loam; light-grey (10 YR 6/1) with many, fine, prominent, reddish yellow (7.5 YR 6/6) mottles; massive, breaking to weak, medium sub angular blocky structure; wet, sticky; few roots; clear, wavy boundary to:
B/Cg	58-66	Clay loam to loam; light-grey (10 YR 6/1) with common, medium, prominent, strong-brown (7.5 YR 5/8) mottles; massive, breaking to weak, fine blocky structure; wet, sticky; no roots; clear, irregular boundary to:
Cg	66-91	Shaly clay loam; grey (10 YR 5/1) with very few mottles

Analytical data

Horizon	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat.	C%	N%	C/N ratio	Free iron %
A11	10	17	43	30	6.3	17.9	12.4	69	3.5	0.36	9.7	1.7
A12g	1!	11	41	37	6.2	12.5	10.5	84	1.4	0.18	7.8	1.7
(B)g	11	9	45	35	5.9	9.8	6.8	69	0.4	0.08	5.0	1.8
B/Cg	15	10	45	30	5.5	9.8	5.7	58	0.4	0.07	5.7	1.5
Cg	20	11	41	28	5.7	10.3	9.0	87	0.3	0.07	4.3	1.8

Trace elements — total contents (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Zn	Ni	Co	Cr	Ti	Mn
A11	2	12	20	4	135	15	30	6	2	30	1,500	60
A12g	2	4	10	25	45	10	25	4	1	25	900	35
(B)g	2	20	18	40	200	45	50	10	2	60	1,000	150

Trace elements — extractable contents (ppm)

Horizon	Cu	Zn	Mo	Mn	Co
A	8.8	5.0	2.44	35	.0

ASSOCIATION 23:

LITHOSOLS 80%, ROCK OUTCROP AND PEATS 20%

This association occupies 1.20% of the country (221,376 ac; 89,590 ha.). It occurs mainly in the Iar Connacht or Connemara lowland, west Donegal and Cork, but small areas in west Kerry, west Mayo and Sligo are also included. The parent material consists mainly of granite rock with very shallow pockets of glacial drift in some places. The topography is mainly broken lowland which is mostly below 120 m, but some small areas occur over 120 m in west Donegal. The outstanding feature is the predominance of boulders and outcropping rock.

The soils are predominantly very shallow (< 10 cm) Lithosols. In small pockets there are shallow accumulations (1.2 m) of peaty or organic soils with a few Brown Podzolics also and these provide almost the only opportunities in the area for crop production, especially potatoes and oats.

Principal Soil — Association 23: Lithosol

Topography:	Gently rolling
Slope:	6°
Altitude:	91 m O.D.
Drainage:	Imperfectly drained
Vegetation:	Dry *calluna* heath. In the pockets of soil between the granite boulders *calluna vulgaris* (heather), *Vaccinium myrtillus* (bilberry) and *Deschampsia caespitosa* (tufted hair-grass) grow vigorously in company with many other acidophile heath species
Parent material:	Granite bedrock
Depth (cm)	*Description*
0-20	Peat and stones, black (10 YR 2/1); partial cover only — up to 80% outcrops; abrupt, wavy boundary to:
Below 20	Granite bedrock and rock fragments

Analytical data

Depth (cm)	pH	C.E.C. meq/100 g	C%	N%	C/N
0.20	4.3	88.8	23.8	0.87	27

Suitability
This association is very limited in its use range. Due to shallow depth, very frequent outcropping rock and hummocky microtopography its use is confined mainly to extensive grazing or very small plot cultivation, mainly by hand implements. The small inclusions of Peat soils are the most suitable for the latter purpose.

ASSOCIATION 24:

LOW LEVEL (ATLANTIC TYPE) BLANKET PEATS

This association occupies 5.14% of the country (868,930 ac.; 351,651 ha.). It occurs widely along the western seaboard, especially in Galway and west Mayo,* Connemara, Cork, Donegal and to a lesser extent in Kerry. It occurs mainly below the 150 m contour on topography that varies from flat lowland to rolling hill. Rainfall is greater than 1,250 mm and black bog rush *(Schoenus nigricans)* is a major component in its vegetation. *Molinia caerulea* (purple moor grass), *Campylopus atrovirens and Pleurozia purpurea* are other important components.

The profile is similar to that of the high level type but because it occurs on flatter topography it has a greater average depth, usually about 3 m. In some places it can reach depths of 5 to 6 m.

At present, these Peats show relatively little man modification. However, with increasing forestry planting this situation is changing. In the Connemara area of west Galway large granite boulders are widespread through this association. Organic soils of this type are extremely wet and acid and have very low permeabilities. Peat depths vary according to the underlying topography from less than 1 m to greater than 6 m.

Suitability
The very limited suitability of this soil is similar to the high level type except that slopes are not as steep and altitudes not as high. As in the high level blanket bog it has been estimated that 25% of this type is cut-over mainly for fuel.

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*The two areas (7,160 ha.) delineated within the main association in west Mayo are the industrial peat areas at 1) Bellacorick (E.S.B. Power Station) 2) Geesala (Minéar Teóranta).

Principal Soil — Association 24: Low level Blanket Peat (Atlantic type)

Topography:	Rolling
Altitude:	20 m O.D.
Drainage:	Poor
Permeability:	Very slow
Vegetation:	Natural blanket bog vegetation
Parent material:	Ombrotrophic peat

Horizon	*Depth (cm)*	*Description*
Oa1	0-40	Reddish brown (2.5 YR 2/2); sapric; finely fibrous, somewhat dried out; liberates only turbid water on squeezing; matrix moderately to well humified greasy; plant residues, rootlet material and fine amorphous debris with charcoal fragments and *Cenococcum geophilum* fruiting bodies; clear smooth boundary to:
Oa2	40-52	Dark reddish brown (5YR 2/2); sapric; well humified; greasy; greater than one third of the peat material passes through the fingers on squeezing; plant residues, leaf and rootlet debris and amorphous material; abrupt irregular boundary to:
Oa3	52-120+	Dark reddish brown (5 YR 3/2 to 2/2) on exposure; hemic to sapric; well humified greasy; half peat material passes through fingers; some *Carex* residues; plant residues, *Calluna* rootlet material, occasional charcoal and *Sphagnum* leaf.

Analytical data

Hor.	Depth (cm)	Field moisture (%)	Ash (%)	Db (g/cc)	P.I. index	Rubbed fibre (%)	N (%)	Ex. Ca./Mg. ratio	pH (H_2O)
Oe1	0-40	87.1	3.3	0.100	1	10	1.94	1.58	3.8
Oe2	40-50	84.8	1.8	0.099	6	8	1.93	0.55	3.8
Oe3	50-120+	91.3	2.1	0.093	7	8	1.22	1.39	4.1

Soil Associations of Drumlins

Associations 25, 26 and 27 are dominated by poorly-drained soils while Associations 28 and 29 are dominated by more freely drained soils.

ASSOCIATION 25:

GLEYS 50%, ACID BROWN EARTHS 40%, INTERDRUMLIN PEATS AND PEATY GLEYS 10%

This association occupies 2.57% of the country (435,163 ac.; 176,108 ha.). It occurs mainly in Cavan, Monaghan, west Mayo, Longford, Clare, Donegal and Leitrim. Parent material is composed mainly of till of Ordovician or Silurian shale and sandstone composition.

The predominant soil (50%) is an imperfectly to poorly drained surface water Gley of loam to clay loam texture and of medium base status.

In the surface structure is a weak crumb, becoming massive at about 30 cm. Below this soil consistence is plastic and root penetration poor. The drainage impedance is attributed mainly to the heavy texture. Surface horizons have over 30% clay and 35% silt, while the parent material has about 27% clay and 33% silt. The retentive nature of the sub-soil predisposes it to periodic water saturation. Moreover, the slow surface runoff, typical of gentle slopes, accentuates this condition and a seasonal "perched" water-table results.

The main associated soil (40%) consists of a moderately well-drained Acid Brown Earth* of loam to clay loam texture and low base status. It is usually freely-drained to about 60 cm (including A1, B2 and B3 horizons) below which some drainage impedance is evidenced by mottling. The combined depth of the A and B horizons is usually about 50 cm and root development is satisfactory to this depth. The B horizon is dark brown in colour, indicating some translocation of iron and aluminium.

The soil is friable and structure is usually fairly well developed. However, the lower horizons tend to be plastic when wet with less well-developed structure.

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*In places the B horizon is sufficiently developed to classify this soil as a Brown Podzolic.

Principal Soil — Association 25: Gley

Topography:	Drumlin slope
Slope:	3 to 9°
Altitude:	50 m O.D.
Drainage:	Imperfect to poor
Parent material:	Till of predominantly Silurian sandstone-shale composition

Horizon	*Depth (cm)*	*Description*
A11	0-13	Dark greyish-brown (10 YR 4/2); clay loam; weak, fine and medium crumb and granular structure; friable; rust coloured mottles along root channels; plentiful, diffuse roots; pH 7.0; clear, smooth boundary to:
A12	13-22	Brown (10 YR 5/3); loam to clay loam; weak, fine and medium crumb and granular structure; friable; rust coloured mottles along root channels; plentiful, diffuse roots; pH 6.7; abrupt, wavy boundary to:
A2g	22-30	Pale-yellow (5 YR 7/3) to pale olive (5 YR 6/3); gritty loam; weak, fine and medium, sub-angular blocky structure; friable; sparse roots; pH 6.1; clear, smooth boundary to:
(B)g	30-53	Pale-yellow (5 YR 8/3); gritty loam; almost massive to very weak, medium sub-angular blocky structure; slightly plastic in wet state; ped faces a reduced grey colour; common, medium, distinct, reddish-yellow (7.5 YR 6/6) mottles; stones common (5-15 cm dia.); sparse roots; pH 5.9; gradual, smooth boundary to:
C1g	53-71	Light olive grey (5 YR 6/2); stony, gritty loam; massive structure; plastic in wet state; ped faces grey; many, medium, distinct, strong-brown (7.5 YR 5/6) mottles; few, fine, dead roots; pH 6.2; gradual, smooth boundary to:
C2g	Below 71	White (5 YR 8/1); stony, gritty clay loam; massive structure; plastic in wet state; many, medium, distinct, strong-brown)7.5 YR 5/6) mottles; roots absent.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	15	17	37	41	7.0	29.4	17.0	58	4.6	0.42	11.0	1.7
A12	16	18	39	27	6.7	19.8	10.1	51	2.4	0.30	8.0	1.5
A2g	14	21	44	21	6.1	9.0	3.8	42	0.6	0.06	10.0	0.7
(B)g	19	22	35	24	5.9	10.2	6.3	62	0.3	0.04	—	1.8
C1g	24	17	35	24	6.2	15.4	11.0	71	0.4	0.05	—	1.4
C2g	14	21	36	29	6.5	16.5	11.9	72	0.3	0.05	—	1.9

Suitability

The use-range of the principal soil is limited. It is more suitable to pasture than to arable cropping. Poaching may be a serious limitation to pasture utilisation in wetter periods, whilst growth is also somewhat restricted in spring and autumn.

The associated soil can be utilised for arable crops and pasture. From the physical standpoint, it is moderately suited to tillage. However, frequency and degree of drumlin slopes is a limitation to machinery use.

In the interdrumlin flats Peat and Peaty Gleys occur to the extent of about 10% but in Monaghan interdrumlin soils occupy only about 5%. These have serious drainage problems and cannot be greatly improved unless an outfall is made available through arterial drainage schemes which would significantly lower the water-table levels of local streams and rivers. Their main use is for summer grazing.

ASSOCIATION 26:

GLEYS 60%, ACID BROWN EARTH 40%

This association is confined mainly to Northern Ireland. It includes most of the drumlin soils derived from relatively unsorted basaltic till. They are found mainly in Antrim where they stretch from the eastern shores of Lough Neagh to Larne on the coast, and as far north as Ballymoney. They also occur in Derry, between Magherafelt and Coleraine.

Texture is clay to clay loam in the surface and subsurface horizons and loam in the parent material. Cation exchange capacity and exchangeable magnesium contents in particular are high.

Principal Soil — Association 26; Gley*

Topography:	Drumlin
Slope:	3°
Drainage:	Poor
Parent material:	Glacial till of basalt composition.

Horizon	*Depth (cm)*	*Description*
A11	0-25	Greyish-brown, clay loam to clay with brown and rust coloured mottles, cloddy structure, gradual boundary;
A12	25-40	Brownish-grey, clay to clay loam with rust coloured mottles, compact, sharp boundary;
Cg1	40-50	Grey and yellowish-brown clay to clay loam with ochre mottles, gradual boundary;
Cg2	Below 50	Grey clay loam to clay with intensive yellowish-brown mottles.

*Reference: McConaghy, S and McAleese, D.M. 1957, The basaltic soils of Northern Ireland. J1. Soil Sci. *8*: 127.

Analytical data

	Coarse	Fine					Exchangeable cations (meg/100g)					CEC
Horizon	sand %	sand %	Silt %	Clay %	C%	pH	Ca	Mg	K	Na	H	meq/100g
A11	9	18	23	49	4.8	6.1	27.0	5.0	0.28	0.57	8.6	41.5
A12	11	19	20	49	2.6	6.4	32.1	3.5	0.45	0.64	5.2	42.1
Cg1	5	23	29	43	0.3	6.9	30.7	5.6	0.17	0.86	2.8	43.6
Cg2	6	26	35	33	0.2	7.0	36.3	16.5	0.14	0.84	3.1	57.1

Suitability

Many of these soils show distinct gleying and mottling in the profile but, the relatively high percentage of more freely drained soils in the association improves their overall use-range. They are therefore suitable mainly for grassland but can also be successful tillage soils. In the latter use, however, the drumlin topography imposes certain limitations on the use of machinery.

ASSOCIATION 27:

GLEYS 85%, INTERDRUMLIN PEATS AND PEATY GLEYS 15%

This association occupies 3.77% of the country (637,388 ac; 257,947 ha.). It occurs extensively in the north-west drumlin belt in Cavan, Monaghan, north Roscommon, Sligo, south Donegal, Longford, north Meath and Mayo, but is most widespread in Leitrim. It also occurs in Clare. The parent material consists of a very sticky glacial till derived mainly from Upper Carboniferous limestone, Ordovician and Silurian shale, Coal Measure shale and Millstone Grit.

The predominant soil is extremely heavy in texture and is a poorly drained surface water Gley. The profile usually consists of a weakly structured A horizon, 5 to 15 cm thick, overlying a massive, sticky and plastic B horizon which varies in thickness from 30 to 40 cm. The A horizon can have over 30% clay and 40% silt, with 6 to 18% organic matter. The clay content of the B horizon can be as high as 47% with over 40% silt. Base status is medium. Some Acid Brown Earths are associated with the principal soil on slopes less than 5°.

Suitability

These soils have a limited use range. Poor drainage, adverse soil physical conditions and frequent steep slopes inhibit the use of machinery. They are unsuitable for tillage and only moderately suitable for grassland. Weak soil structure and high rainfall restrict the grazing season and make it very difficult to utilise the herbage produced. Because of their low permeability, these soils are very difficult to drain and, for any degree of success, require special techniques such as gravel-filled moles. Forestry has proved highly productive on these soils, showing growth rates well above the national average.

Because of poor drainage and position on the landscape the interdrumlin Peats and Peaty Gleys have a very limited use range and are mainly suitable for summer grazing.

Principal Soil — Association 27: Gley

Topography:	Drumlin
Slope:	5°
Altitude:	104 m O.D.
Drainage:	Poor
Parent material:	Glacial till dominantly of calcareous shale with some sandstone and siliceous limestone influence, some fossilised shell fragments present

Horizon	*Depth'(cm)*	*Description*
A1	0-5	Clay loam; dark greyish-brown (10 YR 4/2) with iron staining on root channels; weak medium subangular blocky structure; friable; abundant very fine and fine roots; clear smooth boundary to:
A2g	5-21	Clay loam; greyish brown (2.5 YR 5/2) with many medium prominent yellowish red (5 YR 4/8) mottles; very weak medium sub-angular blocky structure; friable; frequent roots; abrupt smooth boundary to:
B2tg	21-52	Clay; grey (5 Y 6/1) with fine and medium prominent yellowish brown (10 YR 5/4) mottles; massive tending to very weak coarse prismatic structure; grey coating on ped faces; slightly sticky, plastic; common roots often penetrating along structural cracks; gradual smooth boundary to:
Cg	52-129	Silty clay loam; grey (N 6/0) with many medium prominent olive brown (2.5 Y 4/4) mottles; massive tending to form coarse prisms; sticky, plastic; large alder roots appearing in lower part of horizon.

Analytical data

	Coarse	Fine				CEC				Free
Hor.	sand %	Sand	Silt %	Clay %	pH	meq/100g	C%	N%	C/N	iron %
A1	8	13	43	36	7.1	23.6	3.0	0.27	11.1	1.4
A2g	9	14	45	32	6.0	23.6	2.6	0.30	8.7	0.8
B2tg	9	7	38	46	5.8	18.2	0.9	nd	—	2.1
Cg	15	4	44	37	6.7	13.8	0.3	nd	—	4.0

ASSOCIATION 28:

GREY BROWN PODZOLICS 60%, GLEYS 20%, INTERDRUMLIN PEATS AND PEATY GLEYS 20%

The soils of this association occupy 3.43% of the country (580,383 ac; 234,878 ha.) They are widely distributed in the country and occur in Sligo, Clare, Mayo, Longford,

Principal Soil — Association 28: Grey Brown Podzolic

Topography:	Gently rolling, subdued drumlin
Slope:	2°
Altitude:	1 m O.D.
Vegetation:	*Centaureo-Cynosuretum*, Sub-ass, of *Galium verum*. Poor, old meadow with a short, stemmy sward composed mainly of *Festuca rubra* (red fescue), *Agrostis tenuis* (bentgrass) and *Anthoxanthum odoratum* (sweet vernal grass). Abundant herbs are *Plantago lanceolata* (plantain); *Ranunculus-bulbosus* (bulbous buttercup) and *Dactylorchis majalis*, spp. *accidentalis*, this latter being confined to the south western counties.
Drainage:	Moderately well drained
Parent material:	Drift of Midlandian age composed of limestone with a small proportion of granite.

Horizon	*Depth(cm)*	*Description*
A11	0-10	Loam; brown to dark brown (10 YR 4/3); moderate, fine crumb structure; friable; root mat; clear
A12	10-38	Loam; dark yellowish-brown (10 YR 4/4); weak, fine crumb structure; friable; abundant roots; clear, irregular boundary;
B1	38-51	Loam; yellowish-brown (10 YR 5/4) to light yellowish-brown (10 YR 6/4); weak, medium angular blocky structure; slightly firm, slightly friable; plentiful roots; clear, smooth boundary;
B2t	51-64	Clay loam; yellowish-brown (10 YR 5/4); weak, medium sub-angular blocky structure; slightly friable; many roots; clear, smooth boundary:
C	64-76	Stony, gravelly loam; light grey (10 YR 7/1); massive structure; friable; no roots; calcareous.

Analytical data

Horizon	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH	CEC meq/100g	C %	N %	C/N	Free iron %	TNV %
A11	15	29	36	20	6.3	19.6	3.6	0.35	10.3	1.6	0.0
A12	15	28	35	22	6.3	14.2	1.2	0.18	6.7	1.5	0.0
B1	7	26	42	25	6.7	12.8	0.7	0.10	—	1.8	0.0
B2t	8	23	41	28	6.8	15.0	0.5	0.10	—	2.3	0.0
C	19	25	31	25	7.8	11.2	0.3	0.04	—	0.3	84.3

Trace elements — extractable contents (ppm)					
Modal profile					
Hor.	Cu	Zn	Mo	Mn	Co
A	1.9	2.6	0.14	235	5.6

Monaghan, Roscommon, Cavan, south Donegal and in the northern parts of Meath, Westmeath and Louth on the southern limit of the north-west drumlin belt. The parent material of these soils consists of glacial till of mainly limestone composition. In some places a small proportion of sandstone is present. The predominant soil consists of a moderately well-drained Grey Brown Podzolic of loam texture and of medium base status. This soil gives way in places to Gleys on flat drumlin summits and to Peaty Gleys and Peats on interdrumlin flats.

The profile of the principal soil can be up to 70 cm deep. It usually exhibits mottling in the parent material. The dark-brown surface horizon contains from 20 to 24% clay and 30 to 40% silt. At about 40 cm this gives way to a clay loam textural B horizon whose clay and silt contents are about 27% and 40% respectively.

Suitability

This soil has a somewhat limited use range, it can be used for tillage, but is best suited to grassland. However, the drumlin slopes impose limitations to machinery use. Poaching damage can occur due to weak soil structure and there is a constant need to avoid topsoil compaction in grazing management.

The main associated soils (40% Gleys, Peaty Gleys and Peats) have a limited use range because of poor drainage. They are suited mainly to pasture production. They reduce the use range of the whole association, especially in those places where they form an intricate distribution pattern with the better-drained Grey Brown Podzolics.

ASSOCIATION 29:

ACID BROWN EARTHS 75%, INTERDRUMLIN PEATS AND PEATY GLEYS 25%

This association occupies 1.16% of the country (196,743 ac.; 79,621 ha.). It occurs mainly in Monaghan, Cavan, Longford, Meath, Clare and Louth. In Meath and Louth, however, the drumlins are subdued since they mark the southern limit of the north-west drumlin swarm. The association is formed on drumlinoid topography of predominantly shale glacial till composition. In some places a small proportion of sandstone is also present. Natural drainage is mainly good but is somewhat impeded on the more gentle lower slopes. The predominant soil is a well-drained Acid Brown Earth of gravelly loam

texture and low base status. In some places the soil is shallow but is mostly over 45 cm in depth. In some areas this soil is more leached, giving a Brown Podzolic.

The profile is characterised by a very dark greyish-brown loam to clay loam surface horizon, varying in depth from 25 to 45 cm, overlying a strong-brown (B)2 horizon of loam to sandy loam texture. Structure is moderate and consistence is moist friable but slightly sticky. The parent material at about 90 cm depth consists of a sandy loam with many thin, flat stones.

Principal Soil — Association 29: Acid Brown Earth

Topography:	Drumlin
Slope:	6°
Altitude:	92 m O.D.
Parent material:	Glacial till composed of sandstone and shale

Horizon	*Depth (cm)*	*Description*
A1	0-28	Loam to clay loam; very dark greyish brown (10 YR 3/2): fine, weak crumb; moist friable and slightly sticky; abundant roots; clear, wavy boundary.
(B)1	28-45	Loam to clay loam; brown (7.5 YR 5/4); fine, moderate subangular blocky structure breaking to crumb; moist friable to slightly sticky; common rooting; gradual wavy boundary.
(B)2	45-95	Loam to sandy loam; strong brown (7.5 YR 5/8); fine, weak subangular blocky structure breaking into crumb; moist friable slightly sticky; few roots present; gradual, wavy boundary.
C	Below 95	Channery sandy loam.

Analytical data

Horizon	Coarse sand %	Fine sand %	Silt %	Clay %	pH	C%	N%	C/N	Free iron %
A1	25	16	30	29	4.4	8.5	0.64	13.3	1.4
(B)1	19	17	35	29	4.9	2.5	0.15	16.7	—
(B)2	38	14	30	18	5.5	1.5	—	—	1.6
C	46	30	17	7	5.4	0.5	—	—	0.9

*The B horizon of the profile may qualify as a podzolic B horizon but most soils in the area are acid Brown Earths rather than Brown Podzolics.

Suitability

These soils are somewhat limited in their use range mainly because of slope problems. However, because of their good drainage and desirable physical structure, the soils are suitable for tillage and for grassland and are used for these purposes except where drumlin slopes inhibit the easy use of machinery. These soils occur generally in areas that are less favourable climatically for cereal growing, particularly wheat, malting barley and sugar beet. Overall they are best suited to grassland enterprises.

Poorly drained Gleys and Peaty Gleys occur as associated soils (25%) and are located mainly at the foot of drumlin slopes and in interdrumlin flats. These soils are best suited to summer grazing and poaching and flooding are a common problem.

Soils of Flat to Undulating Lowland

ASSOCIATION 30:

GREY BROWN PODZOLICS 70%, BROWN EARTHS 20%, GLEYS 5%, PEATS 5%

The soils of this association occupy 2.64% of the country (445,567ac.; 180,319ha.). They are widespread throughout the Midlands, especially in Offaly, Kildare, Carlow, south Roscommon, east Galway, south Westmeath and north Tipperary. They are formed from fluvioglacial coarse-textured gravels and sands of predominantly Carboniferous limestone composition, deposited widely during the last glaciation in the form of kames, eskers and outwash materials. In south Roscommon some sandstone is present in the limestone drift. (In north-east Wicklow, a small extent of this soil is shown even though there is a mixture of granite in the parent material.) Elevation is mainly around 120 m O.D. but may be less in the vicinity of river valleys and depressions. In west Wicklow near Blessington and in east Kildare near Ballymore-Eustace these soils occur at elevations up to 300 m but because of their limited occurrence, they have not been separated from Association 30, even though they have a more limited land-use potential due to their higher elevation.

The topography of this association varies from flattish to gently undulating, but some areas are hummocky with sharp slope changes ranging from 0° to 12° and occasionally up to 20°, e.g., on the steep sides of eskers. These sharp changes in landscape features are mainly responsible for the variability of soils and the intricate pattern of soil distribution within this association.

Four major soils occur within the association: (i) a moderately deep component, (ii) a shallow component, (iii) an imperfectly drained component and (iv) a poorly drained component. On the flattish to undulating topography and on the lower slopes of the hummocky hills and eskers, the moderately deep components occur. These are well-drained, friable, gravelly sandy loams of high base status and have been classified as Grey Brown Podzolics. They account for about 70% of the association.

The profile is characterised by a dark greyish-brown to dark brown surface horizon which varies in depth from 25 to around 40 cm and overlies a brown to yellowish-brown leached A2 horizon. This overlies an undulating, dark greyish-brown B horizon of distinct clay accumulation and this, in turn, overlies the very coarse-textured (gravelly coarse sand or gravel) parent material at a depth of from 0.5 to 0.8 m. The surface horizon

Principal Soil — Association 30: Moderately Deep Component

Topography:	Undulating
Slope:	2-3°
Altitude:	60 m O.D.
Vegetation:	*Centaureo-Cynosuretum*, typical Sub-ass. Reseeded pasture. Moderately growing sward composed mainly of *Poa trivialis* (rough-stalked meadow-grass) and *Trifolium repens* (white clover). *Lolium perenne* (perennial rye-grass) contributes about 10% of the total cover.
Drainage:	Well drained
Parent material:	Calcareous, fluvio-glacial gravels, of Midlandian age, composed mainly of limestone with a very small proportion of sandstone and granite

Horizon	*Depth (cm)*	*Description*
A11	0-9	Gravelly sandy loam; very dark greyish-brown (10 YR 3/2); moderate, fine and very fine granular structure; very friable; bleached quartz grains; non-calcareous; abundant roots; clear, smooth boundary to:
A12	9-36	Gravelly sandy loam; dark-brown (10 YR 3/3); moderate, fine and medium granular structure; friable; bleached quartz grains; non-calcareous; plentiful roots; clear, smooth boundary to:
A2	36-57/70	Coarse sandy loam (few gravels); brown to dark yellowish-brown (10 YR 4/3-4/4); weak, very fine granular structure; very friable; many worm channels lined with material from A12; plentiful roots; non-calcareous; abrupt, wavy boundary to:
B2t	57/67/87	Gritty sandy clay loam; dark greyish-brown to brown (10 YR 4/2-4/3); moderate, medium sub-angular blocky structure; wet, slightly plastic; plentiful roots; non-calcareous; clear, smooth boundary to:
B3	67-70/97	Gritty sandy loam; brown to dark-brown (10 YR 4/3); weak, fine granular structure; very friable; sparse roots; weakly calcareous; abrupt, tonguing boundary to:
C	Below 70	Gravelly coarse sand; grey (5 Y 5/1); structureless; loose; no roots; strongly calcareous with bands of secondary calcium carbonate present.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	C.E.C. meq/100g	T.E.B. meq/100g	Base sat. %	C%	N%	C/N	Free iron %	T.N.V. %
A11	34	23	28	15	6.9	24.9	21 4	86	4.8	0.47	10.2	2.2	0.0
A12	34	24	27	15	7.5	16.0	15.7	98	1.5	0.20	7.5	1.5	0.0
A2	46	20	24	10	7.4	7.3	—	Sat.	0.4	nd	—	1.1	0.0
B2t	38	15	23	24	7.5	13.8	13.5	98	0.6	nd	—	1.8	0.0
B3	42	31	13	15	7.4	8.0	—	Sat.	0.1	nd	—	0.9	0.4
C	nd	nd	nd	nd	8.5	1.9	—	Sat.	0.0	nd	—	0.4	51.4

Trace elements — total content (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Ag	Zn	Ni	Co	Cr	Ti	Mn
A11	7	25	17	2	65	65	1	150	40	9	45	1300	2000
A12	8	25	20	2	75	35	1	175	75	15	50	2000	3000
A2	5	20	10	2	75	25	1	75	100	20	100	3000	1500
B2t	—	—	—	—	—	—	—	—	—	—	—	—	—
B3	5	25	20	2	150	25	1	150	125	15	75	2500	2000
C	3	15	8	2	75	25	1	—	100	25	50	2000	1000

contains 12 to 15% clay and 6 to 12% organic matter; the B2t horizon has 20 to 30% clay. Diagnostic features of this soil are the high content of gravels throughout the profile, the distinct tonguing A2 horizon, the well-developed textural Bt and the high pH and base status throughout the profile. Moisture holding capacity is moderate but in prolonged dry period a moisture deficit develops.

On the crests of hummocks and high parts of eskers and kames the soil becomes very shallow, excessively drained, of gravelly or stony coarse sandy loam texture and of high base status. This shallow component which is classified as a Brown Earth can occupy up to 20% of the association in many places.

On the lower portions of the topography where the water-table is permanently high, the soils are imperfectly or poorly drained, of sandy loam texture and of high base status. They have been classified as Gleys and occupy about 5% of the association. Basin Peats (5%) are interspersed throughout this association. When reclaimed, these soils offer good potential for both tillage (particularly vegetable growing) and grass production.

Suitability

With the exception of the poorly drained component, which is mainly suited to summer grazing, this association has a moderately wide use range. The soils are suited to the production of a wide range of farm, fruit and vegetable crops. They are very easily tilled and are widely devoted to the production of cereals, including malting barley and sugar beet. The shallow component is subject to drought and the deeper component to moisture deficit so that uneven ripening can result. Short-term grass leys do well on these soils when fertilised and well managed and the sward can be intensively used at almost any time of the year.

ASSOCIATION 31:

MINIMAL GREY BROWN PODZOLICS 80%, GLEYS 10%, BROWN EARTHS 5%, BASIN PEATS 5%

This association occupies 4.47% of the country (755,155 ac.; 305,591 ha.). It occurs mainly in Tipperary, Offaly, Westmeath, Roscommon, Meath, Louth, Laois, Limerick, Longford and Kilkenny. The soils are formed from glacial till of predominantly

Carboniferous limestone compostion. They are also found in the south Wexford area where the parent material is influenced by calcareous Irish Sea drift. The topography is mainly gently undulating with slopes ranging from 2 to 5° and elevations generally up to 100 m.

The principal soil is a well-drained minimal Grey Brown Podzolic of loam texture. Generally the soil occurring in Roscommon has a surface clay loam texture. The profile is characterised by a brown to dark brown surface horizon about 20 cm in depth. This is underlain by a loam to clay loam textural B horizon to about 40 cm. The clay and silt contents of the surface horizon are about 20% and 35% respectively and these increase to about 25% and 30% respectively in the Bt horizon. The parent material consists of a somewhat stony gravelly till of loam texture. Base status is high. The profile is friable

Principal Soil — Association 31: Grey Brown Podzolic

Slope:	4°
Altitude:	50 m O.D.
Vegetation:	Old pasture (*Lolio-Cynosuretum*, typical Sub-ass or *Cent.-Cynosuretum*, Sub-ass. of *Galium verum)*.
Drainage:	Well drained.
Parent Material:	Glacial drift predominantly of limestone composition with slight sandstone admixture, of Midlandian Age.

Horizon	*Depth (cm)*	*Description*
A1	0-10	Loam: very dark greyish-brown (10 YR 3/2); weak to moderate, fine crumb structure; friable, abundant rooting; gradual, smooth boundary to:
A2	10-20	Gravelly loam; dark-brown (10 YR 3/3); moderate, fine crumb structure; friable; plentiful rooting; clear smooth boundary to:
B2t	20-40	Gravelly loam to clay loam dark yellowish-brown (10 YR 4/4); moderate, fine sub-angular blocky structure; dry, hard; few roots; clear, smooth boundary to:
C	40-60	Gravelly sandy loam; very pale-brown (10 YR 7/4) massive structure; dry, hard; no roots.

Analytical data

Horizon	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	C%	N%	C/N ratio	Free iron %	T.N.V.%
A1	23	19	36	22	6.9	18.4	4.0	0.43	9.3	1.5	0.0
A2	23	20	43	14	7.4	15.3	2.1	0.29	7.2	1.5	0.0
B2t	20	23	32	25	8.3	7.1	0.5	0.10	5.0	o.8	29.4
C	25	26	29	20	8.5	5.8	0.3	0.04	7.5	0.4	43.7

throughout and moisture holding capacity is good, although in certain shallow places a moisture deficit can occur in dry seasons. The main associated soil (10%) is a poorly drained Gley which would be classified with the principal soil in Association 39. In addition, a Brown Earth, similar to the Brown Earth soil of Association 30, occurs sporadically (5%) throughout this association where some fluvioglacial gravels are present, e.g., on the crests of kames. Basin Peats are also found (5%) throughout this association.

Suitability

This soil has a wide use-range and is suitable for both tillage and pasture. It can be successfully used for crops such as barley, wheat, oats, potatoes, swedes and mangels. However, where it occurs in north midland counties it has a climatic disadvantage which can result in reduced yields of sugar beet and in the late ripening of wheat.

The associated Gleys and Basin Peats are limited in their use due to poor drainage. Where an outfall can be obtained they can be reclaimed.

ASSOCIATION 32:

DEGRADED GREY BROWN PODZOLICS 50%, BROWN EARTHS 15%, PEATS 15%, GLEYS 10%, PODZOLS 10%

The soils of this association occupy 3.08% of the country (520,335 ac.; 210,577 ha.). They occur mainly in Galway, Sligo and east Mayo. They are formed mainly from compact calcareous, gravelly loam till of predominantly Carboniferous limestone composition. The till has an appreciable igneous and metamorphic rock influence over most of the area, particularly in Mayo and Sligo. The till varies from 2 to 5 m in thickness and overlies the Carboniferous limestone from which it is derived. Carbonates constitute a significant proportion of the fraction less than 2 mm and the clay content is about 10%. The coarse material consists of stones and boulders.

In some places, in particular Galway, the parent material tends to be gravelly and is locally referred to as “white sand”.

The relief often consists of alternating hollows and rounded hillocks but in some places the topography is more broken and hummocky, with slopes frequently ranging from 7° to 10° and occasionally from 10° to 18° in the Galway area.

The principal soil in the association has been classified as a degraded Grey Brown Podzolic. The surface textures vary from sandy loams to loams. The profile is characterised by the presence of a clay layer (partly depositional) which is only slowly permeable, giving rise to reducing conditions. As a result, iron and manganese leached down the profile are precipitated in the form of nodules or an iron pan between the leached layer and the “textural” B horizon. The soil is non-calcareous except at the boundary with the underlying drift material and it is moderately acid in the A1 horizon. The surface horizon contains about 20% clay and 40% silt while the Bt horizon contains almost 40% clay and 50% silt.

Principal Soil — Association 32: Degraded Grey Brown Podzolic

Topography:	Gently undulating
Slope:	3°
Altitude:	50 m O.D.
Drainage:	Well drained
Parent material:	Calcareous, compact gravelly loam till of Carboniferous limestone composition

Horizon	*Depth (cm)*	*Description*
A11	0-13	Loam to sandy loam; dark-grey (10 YR 4/1); weak, medium granular structure; friable; many, diffuse roots; root channels iron stained; non-calcareous; gradual, smooth boundary:
A12	13-38	Loam; dark greyish-brown (10 YR 4/2) becoming dark-grey (10 YR 4/1) with depth; moderate, medium and fine sub-angular blocky structure; friable; few roots; gradual, smooth boundary:
A2	38-46	Silt loam with clay pockets in tongues; light-grey (10 YR 7/1) becoming grey (10 YR 5/1) towards the A12; common, fine, prominent strong brown mottles near lower boundary; very weak, coarse prismatic structure, slightly firm; distinct clay skins on ped surfaces in lower part of horizon; brown staining along worm borings; few roots, mainly vertical but horizontal along iron pan; abrupt, wavy boundary:
B2ir	46	Iron pan, 0.5 cm thick, continuous, wavy
B21t	46-71	Silty clay loam; brown (10 YR 5/3) to yellowish-brown (10 YR 5/4) with pale-brown ped coatings and black and dark-red streaks, weak, moderate, coarse sub-angular blocky structure; slightly firm; clay skins and pinholes distinct; very few roots; non-calcareous; diffuse, smooth boundary:
B22t	71-101	Silty clay loam; brown (7.5 YR 4/4) with pale-brown (10 YR 6/3) to brown (10 YR 5/3) coatings; moderate weak, coarse sub-angular blocky structure; slightly firm, pinholes and clay skins distinct; very few roots; non-calcareous; gradual, smooth boundary
B3t	101-112	Loam; dark-grey (10 YR 4/1), very weak, medium sub-angular blocky structure; slightly sticky when wet; very few, fine roots, slightly calcareous; clear, smooth boundary:
C	Below 112	Coarse, gravelly limestone drift; weathering limestone forms black patches.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay%	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	18	21	41	20	5.7	12.5	9.0	72	4.5	0.39	11.5	1.2
A12	20	20	38	22	6.0	9.0	6.8	75	1.8	0.15	12.0	1.0
A2	5	21	54	20	6.2	4.5	4.1	90	1.0	0.07	14.2	0.9
B21t	2	5	56	37	6.4	8.2	7.7	94	0.5	0.07	—	2.0
B22t	2	9	50	39	6.6	8.8	8.1	92	0.7	0.07	—	1.8
B3t	4	26	48	22	7.5	5.7	—	Sat.	0.8	0.10	—	1.1

As can be seen from its composition, this association is rather complex. The associated soils consist of Brown Earths (15%), Peats (15%), Gleys (10%), and Podzols (10%).

The Peats and Gleys occur in the more depressional positions where there is a high water-table. They can be improved by both arterial and artificial drainage where an adequate outfall can be obtained. The Brown Earths tend to occur in those parts of the association where the parent material is more shallow and stony and more calcareous. In some instances they are sufficiently calcareous and dark in colour to be classified as Rendzinas. The Podzols occur in places where the Grey Brown Podzolic soil has already become degraded, leading to the development of a strongly expressed A2 horizon. This happens especially where the parent material is more gravelly.

Suitability

The principal soil has a somewhat limited use range. It is sufficiently friable and deep to be moderately suitable for cultivation as well as for grassland. However, some poaching may occur early in the year but not to a serious degree. The hummocky topography inhibits machinery use and the intricate pattern which the associated soils (especially the Peats and Gleys) form within the association restricts its use range to mainly grassland, with relatively small areas of cultivation. The shallower Brown Earth soils tend to occur on steep slopes. This restricts their use for tillage and because of excessive permeability, they have a shorter growing season and may also suffer from summer drought. Small holdings and small fields are some of the other problems facing intensification of agriculture on these soils, particularly in the Galway area.

ASSOCIATION 33:

SHALLOW BROWN EARTHS AND RENDZINAS 60%, GREY BROWN PODZOLICS 25%, GLEYS 10%, PEATS 5%

The soils of this association occupy 3.21% of the country (541,965 ac.; 219,330 ha.). They occur mainly in Galway, Clare, south Mayo and Limerick. The predominant soil is a shallow Brown Earth which is well to excessively drained. (Some Grey Brown Podzolics

occur in places through this association and vary in depth from 40 to 100 cm.) They are formed from shallow glacial till of Carboniferous limestone composition and occur on flat to undulating relief at elevations ranging from near sea level to 60 m. Slopes are generally 1 to 2° and rarely exceed 5°.

The predominant soil, which is shallow, has a gravelly loam to silt loam texture and is classified as a Brown Earth of high base status. The profile displays a dark surface horizon containing about 20% clay and 35% silt overlying a pale-brown subsoil. This rests on the limestone bedrock. Overall depth is usually about 30 to 45 cm.

Suitability

These soils have a moderately wide use range. Even though they are generally somewhat shallow there are moderately deep components through the association. Locally, where soil depth permits, cereals and root crops are grown successfully. Moisture deficit sometimes limits production in dry seasons; otherwise these are good grassland soils and carry intensive sheep enterprises. Pastures can be grazed over a long season without poaching. The well drained associated Grey Brown Podzolics (25%) vary in depth from 40 to 100 cm. Surface soil textures are sandy loams to loams, and structure is moderately strong. The soils are suitable for both tillage and grassland farming, except for a few areas of outcropping limestone bedrock and boulder-strewn and scrub areas.

Principal Soil — Association 33: Brown Earth

Topography:		Gently undulating
Slope:		8°
Altitude:		30 m O.D.
Vegetation:		*Centaureo-Cynosuretum,* Sub-ass, of *Galium verum*. Poor, species-rich old meadow. The dominant species are *Anthoxanthum odoratum* (sweet vernal grass). *Trifolium pratense* (red clover), *Festuca rubra* (red fescue) and *Plantago lanceolata* (plantain). Many colourful herbs present, notably *Primula veris* (cowslip) and
Drainage:		Well drained
Parent material:		Drift of limestone origin with some granite, of Midlandian age
Horizon	*Depth (cm)*	*Description*
A1	0-9	Organic, gravelly loam; dark, yellowish-brown (10 YR 3/4); moderate, fine crumb structure; friable; abundant roots; calcareous; gradual, smooth boundary:
(B)	9-20	Gravelly sandy loam; reddish-brown (5 YR 5/4); weak, fine sub-angular blocky structure; moist plastic; plentiful roots; calcareous; clear, irregular boundary:
C	20-44	Gravelly clay loam; white; with streaks of light brownish-grey (10 YR 8/2 and 6/2); massive structure; moist plastic; few roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	PH	C.E.C. meq/100g	T.E.B. meq/100g	Base sat. %	C%	N%	C/N	Free iron %	T.N.V. %
A1	21	26	34	19	7.4	42.2	33.6	80	8.9	0.68	13.1	0.9	13.0
(B)	25	28	35	12	7.8	19.2	17.3	90	3.9	0.25	—	0.5	37.7
C	17	21	34	28	8.3	3.5	6.9	Sat.	—	—	—	0.1	91.5

Trace elements — total contents (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Zn	Ni	Co	Cr	Ti	Mn
A1	2	2	<1	<1	10	7	30	18	5	12	530	850
(B)	2	10	1	<1	20	12	30	18	3	25	700	650
C	2	1	<1	<1	20	<2	<25	5	<1	3	150	90

Trace elements — extractable contents (ppm)

Modal profile					
Horizon	Cu	Zn	Mo	Mn	Co
A	1.8	5.2	0.22	325	4.2

The poorly-drained associated Gley soil has a limited use range, being suitable mainly for summer grazing. The peat soils occupy roughly 5% and are interspersed through the other soils. They are predominantly of Basin type and after drainage, coupled with a proper fertiliser programme and good management, can yield successful crops.

ASSOCIATION 34:

MINIMAL GREY BROWN PODZOLICS 70%, GLEYS 20%, BROWN EARTHS 10%

The soils of this association occupy 6.02% of the country (1,016,393 ac; 411,329 ha.). They occur widely throughout the limestone areas of the country but especially in Tipperary, Limerick, Kilkenny, Laois, Offaly, Kildare, and to a lesser extent in Cork and Kerry. The topography is flattish to gently undulating (slopes 4 to 6°) with elevations mainly below 60 m but almost always below 150 m O.D.

They are derived from calcareous non-tenaceous glacial till of predominantly Carboniferous limestone composition. In places, there is a small admixture of sandstone, shale or volcanic materials.

Plate 15: *The well-drained limestone till-derived soils of Association 34 are suited to grassland and tillage. They are extensive in the Golden Vale where they are used widely for dairying.*

The predominant soil is a well drained Grey Brown Podzolic of loam texture and of high base status. The profile is characterised by a dark-brown loamy surface horizon from 25 to 40 cm thick. This overlies a weakly leached A2 horizon and a clay loam Bt horizon which often has a minimal amount of clay accumulation. These are deep soils, the solum depth (A+B horizons) is at least 75 cm and this is the main difference from the principal soil of Association 31.

The surface horizon contains about 18 to 26% clay and 30 to 45% silt. Structure is moderately well developed, roots are plentiful and penetrate freely to a considerable depth. Moisture-holding capacity is good.

The main associated soil (20%) is a poorly drained Gley which would be classified with the principal soil in Association 39.

Occurring also in this association is a Brown Earth very similar to the Brown Earth soil of Association 30. This soil occupies about 10% of the area, and is found sporadically throughout the association on kames and knolls.

Suitability

These soils have a wide use range. Owing to their depth, free drainage, medium texture and good moisture holding capacity, they are first class grassland soils. Although more noted for grass production, they are also good tillage soils and are suitable for cereals and

root crops. However, they tend to have a tilth problem. Good yields of wheat, feeding barley, oats, potatoes, sugar beet, swedes and mangels can be obtained. They are generally not devoted to malting barley as they are considered slightly "heavy" for this purpose and not likely to produce good quality grain for malting. The associated poorly drained Gley soils can be drained if a suitable outfall is available. They are then suitable mainly for grassland but to some extent for tillage.

Principal Soil — Association 34: Grey Brown Podzolic

Topography:	Gently undulating
Slope:	4°
Altitude:	122 m O.D.
Vegetation:	Old pasture *(Lolia-Cynosuretum*, typical Sub-ass., *Centaureo-Cynosuretum*, typical Sub-ass, or *Cent.-Cyn*., Sub. ass. of *Galium verum)*
Drainage:	Well drained
Parent material:	Glacial drift predominantly of limestone composition but with a small proportion of sandstone, shale and volcanics; of Midlandian age.

Horizon	*Depth (cm)*	*Description*
A11	0-20	Gravelly loam; brown to dark-brown (7.5 YR 4/4); moderate, medium crumb structure; friable; abundant rooting; clear, smooth boundary to:
A12	20-37	Gravelly loam; brown to dark-brown (7.5 YR 4/4); moderate, medium crumb structure; friable; plentiful rooting; gradual, smooth boundary to:
B21	37-57	Gravelly loam; brown to dark-brown (7.5 YR 4/4); weak, medium sub-angular blocky structure; friable; plentiful rooting; clear, smooth boundary to:
B2t	57-100	Gravelly clay loam; brown to dark-brown (10 YR 4/3); weak, coarse sub-angular blocky structure; clay coatings on some ped faces and along vertical cracks; wet sticky; few, fine roots.
C	Below 100	Gravelly loam, white (10 YR 8/2) with streaks of yellowish brown (10 YR 6/4) massive friable, no roots, calcareous.

Analytical data

Horizon	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	23	23	33	21	5.5	15.5	10.0	65	3.1	0.34	9.1	1.8
A12	22	25	35	18	5.7	10.6	7.0	66	1.3	0.15	8.7	1.9
B21	20	22	33	25	6.6	12.9	—	Sat.	0.8	0.13	—	1.8
B2t	18	20	33	29	7.3	10.0	—	Sat.	0.2	0.08	—	2.1

ASSOCIATION 35:

GREY BROWN PODZOLICS 80%, BROWN EARTHS 10%, GLEYS 10%

This association occupies 0.64% of the country (107,677 ac.; 43,576 ha.). It occurs mainly in parts of Kildare, Laois and north Kilkenny on flattish to gently undulating topography at elevations mainly between 60 and 120 m. The parent material consists of calcareous, non-tenaceous, compact, stony till (sometimes known locally as corn gravel) composed almost entirely of limestone. Small pockets of loose gravelly material are commonly observed in profile sections.

These are somewhat shallow, well drained, Grey Brown Podzolic soils of sandy loam to loam texture and high base status. The profile is generally 37 to 45 cm deep and
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Principal Soil — Association 35: Grey Brown Podzolic

Topography:	Undulating
Slope:	1°
Altitude:	84 m O.D.
Vegetation:	Old pasture
Drainage:	Well drained (top excessively drained in places)
Parent material:	Calcareous, stony till, of Midlandian age, composed mainly of limestone

Horizon	*Depth (cm)*	*Description*
A11	0-15	Sandy loam to loam; brown to dark brown (10 YR 4/3-3/3); moderate fine to medium sub-angular blocky structure and weak fine granular structure; moist friable; abundant roots; clear boundary to:
A12	15-27	Sandy loam; brown to dark-brown (10 YR 4/3); moderate fine granular; moist friable to dry firm *in situ;* plentiful roots; clear boundary to A2, B2t or C horizons.
A2	27-33/94	Loamy sand; pale brown (11 YR 6/3) with few yellowish brown clay bands (1 cm wide); structureless, moist friable; sparse roots; highly porous; many worm channels; clear tonguing boundary to B2t; less well developed portions have yellowish brown colour (10 YR 5/8) and sandy loam texture.
B2t	28-46/107	Clay loam; brown to dark yellowish brown (10 YR 4/3-4/4); moderate medium to coarse sub-angular blocky structure; moist firm; wet plastic; sparse roots in deep parts of B2t; peds highly porous; abrupt tonguing boundary to:
C	Below 28	Stony loam; light yellowish brown (10 YR 6/4); structureless; dry hard *in situ;* no roots; strongly calcareous

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	13	39	33	15	7.6	18.6	17.2	93	1.4	0.17	8.2	1.2
A12	14	44	27	15	7.7	14.0	10.9	78	0.5	0.08	6.3	1.2
A2	14	68	12	6	7.5	8.0	2.7	34	0.3	nd	—	0.5
B2t	8	17	46	29	7.8	16.0	15.5	97	0.3	nd	—	2.4
C	9	20	44	27	8.2	8.0	12.8	Sat.	0.3	nd	—	1.2

consists of a brown to dark brown Ap horizon with a moderately strong structure and friable consistence. This horizon is generally 25 cm deep and usually contains 15 to 18% clay and 35% silt. Sometimes, beneath this horizon there is a leached, indurated pale brown A2 horizon overlying a dark yellowish-brown B horizon which shows a strong textural increase. There is then an abrupt transition to the stony parent material. In shallower places the A2 and B horizons are absent and these soils are classified as Brown Earths. The soils generally have a very high base status with free carbonates present throughout the profile.

Brown Earths, occupying 10%, are found throughout this association. They are located mostly on knolls and crests on the landscape and are shallow and well drained. Poorly drained Gley soils occupy a small proportion (10%) of this association where a high water table occurs in low-lying positions.

Suitability

These soils have a moderately wide use range. With their light to medium texture, good structure and friability, they are easily tilled. Where properly manured, especially with potassium, excellent yields of malting barley, wheat, sugar beet, swedes and other crops can be obtained.

They are also highly suited to grass production in the form of short term leys and are used intensively for sheep production in particular. Due to the light texture and shallow depth, a moisture deficit can severely limit production in dry seasons.

The suitability of the Brown Earth is similar to the principal soil whilst that of the Gley soil is mainly in grassland.

ASSOCIATION 36:

GREY BROWN PODZOLICS 80%, GLEYS 20%

The soils of this association occupy 0.70% of the country (118,186 ac.; 47,829 ha.). They occur mainly in Laois, Carlow, and south east Kildare on undulating to rolling topography at elevations ranging from 60 to 120 m O.D. Parent material consists of calcareous, non-tenaceous glacial till of mainly limestone composition but with an admixture (20%) of granite or sandstone.

Plate 16: *The deep, well-drained, sandy loam soils of Association 36 which occur mainly in Laois, Carlow and south Kildare are highly suited to tillage crops including sugar beet.*

The principal soil is a deep, well-drained Grey Brown Podzolic of sandy loam texture and of medium base status. The profile has a deep, friable, dark greyish-brown to brown sandy loam surface horizon with a moderately strong granular structure. It is normally 30 to 45 cm deep and contains 13 to 15% clay and 4 to 7% organic matter. Beneath this horizon, a leached slightly indurated A2 horizon occurs, varying in thickness from 5 to 20 cm. This overlies a thick, dark yellowish-brown textural B horizon with a clay content of 18 to 24%. There is an abrupt transition to the parent material at depths varying from 95 to 135 cm.

The main associated soil (20%) is a ground water Gley which occurs on concave slopes, flattish topography and in local depressions. The texture is mainly organic sandy loam and the base status is high. The poor drainage is due to the presence of a high water-table and in most areas springs and water seepage are contributing factors.

Suitability

These soils have a wide use range, being well suited to the production of a wide range of farm, fruit and vegetable crops, including malting barley. They are deep and, with their medium to light texture and their good structure and friability, are easily tilled. They also have a high potential for grass production which can be utilised over a long grazing season.

For the associated Gley soil, if a suitable outfall can be obtained through arterial drainage, it can be successfully drained and reclaimed and can be used more intensively for grassland and tillage; otherwise it is suitable mainly for grazing.

Principal Soil — Association 36: Grey Brown Podzolic

Topography: Undulating

Slope: 2-3°

Altitude: 91 mO.D.

Vegetation: *Lolio-Cynosuretum*, typical Sub-ass. Old pasture. High quality, vigorously growing sward composed mainly of *Lolium perenne* (perennial rye-grass) and *Trifolium repens* (white clover). The most common and troublesome weed is *Cirsium arvense* (creeping thistle).

Drainage: Well drained

Parent Material: Calcareous, non-tenaceous glacial till, of Midlandian age, composed mainly of limestone with a small percentage of granite and sandstone

Horizon	*Depth (cm)*	*Description*
A11	0-17	Sandy loam; dark greyish-brown to brown (10 YR 4/2-4/3); moderate, fine granular structure; friable; abundant roots:
A12	17-37	Similar to above horizon; abrupt, smooth boundary to:
A2	37-45	Gritty sandy loam; yellowish-brown (10 YR 5/4); weak fine granular structure; firm to very firm in *in situ;* plentiful roots; clear, wavy boundary to:
B2t	45-95	Sandy loam to loam; dark yellowish-brown (10 YR 4/4); moderate, medium sub-angular blocky structure; wet plastic; sparse roots; clay skins abundant; abrupt, smooth boundary to:
C	Below 95	Gravelly sandy loam; yellowish-brown (10 YR 5/4); structureless; friable; no roots; calcareous.

Analytical data

Horizon	Coarse sand%	Fine sand %	Silt %	Clay %	pH	C.E.C. meq/100g	T.E.B. meq/100g	Base sat. %	C%	N%	C/N	Free iron %	T.N.V. %
A11	32	25	29	14	5.6	16.0	5.8	36	2.2	0.23	9.6	0.8	0.0
A12	29	27	30	14	5.9	11.9	3.8	32	1.1	0.14	7.9	1.0	0.0
A2	38	21	28	13	5.9	6.2	3.2	52	0.4	nd	—	0.6	0.0
B2t	35	20	27	18	6.9	8.2	7.0	85	0.3	nd	—	0.8	0.0
C	38	30	27	15	8.6	5.2	—	Sat.	0.3	nd	—	0.3	6.7

Trace elements — total content (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Ag	Zn	Ni	Co	Cr	Ti	Mn
A11	8	25	20	4	75	40	<1	150	50	12	75	5000	1000
A 12	7	20	15	2	75	20	<1	125	50	15	50	5000	1000
A2	10	20	15	2	75	25	<1	150	75	12	50	2500	1000
B2t	8	40	20	2	75	50	<1	100	75	15	50	3000	2000
C	8	25	20	3	100	50	<1	75	75	15	75	4000	1000

ASSOCIATION 37:

GREY BROWN PODZOLICS 75%, GLEYS 20%, BROWN EARTHS 5%

The soils of this association occupy 1.42% of the country (240,754 ac.; 97,432 ha.). They occur mainly in Meath, Westmeath and Longford. The topography varies from till plains to drift ridges and kame and kettle moraines. The soils are, therefore, associated with a wide range of slopes, ranging from 0° to 12°. Elevation is mainly between 60 and 150 m.

The parent material consists of glacial till of limestone, shaly limestone and shale composition. The predominant soil consists of a moderately well-drained Grey Brown Podzolic of loam to clay loam texture and of medium base status. Depth is usually 80 to 110 cm and the profile is characterised by a weakly expressed Bt horizon of clay loam texture, and by slight mottling in the lower part of the B horizon. The soil is sticky and slightly plastic when wet, with weak structure from the surface downwards. In comparison with the principal soil of Association 34 it has somewhat heavier texture, is less well drained, has lower base status and weaker structure.

Principal Soil — Association 37: Grey Brown Podzolic

Topography:		Undulating
Slope:		1°
Altitude:		76 m O.D.
Drainage:		Moderately well drained
Parent material:		Limestone and shale drift
Horizon	*Depth (cm)*	*Description*
A1	0-12	Gravelly loam; light brownish grey (10 YR 6/2); weak, fine sub-angular blocky with crumb structure; moist sticky and slightly plastic; root mat present; clear, smooth boundary:
A12	12-36	Gravelly loam; very dark greyish brown (10 YR 3/2); weak, fine to medium sub-angular blocky structure; moist sticky and slightly plastic; diffuse rooting; clear, smooth boundary:
B2tl	36-63	Gravelly loam to clay loam; yellowish brown (10 YR 5/4 & 5/5); weak, fine to medium sub-angular blocky structure; moist sticky; plentiful diffuse rooting; clear, smooth boundary:
B2t2	63-78	Gravelly sandy clay loam; yellowish brown (10 YR 5/4); weak, medium prismatic structure breaking into weak fine sub-angular blocky; moist sticky; few roots; clear smooth boundary:
B3g	78-101	Gravelly loam; yellowish brown (10 YR 5/4) with few fine distinct mottles, moist sticky; very few roots.

Analytical data

Horizon	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH	C%	Free iron %
Al	17	18	43	22	5.7	4.8	0.9
A12	20	16	40	24	5.9	1.6	0.9
B2tl	18	16	42	27	6.6	0.5	1.2
B2t2	29	18	24	29	7.3	0.4	1.1
B3g	17	18	39	26	7.7	0.2	0.8

The surface horizon contains about 24% clay and 40% silt while the Bt horizon contains about 27% clay and 40% silt.

The main associated soil (20%) is a ground water Gley found in poorly drained basins. It has a heavy texture (loam to silt loam), weak structure and plastic consistence. Shallow Brown Earths (5%) are also found in places throughout this association. They occur on kames composed of shales, chert and limestone with a surface texture of silty clay loam to loam.

Suitability

This soil has a moderately wide use-range. It is suited to pasture production and also to tillage. However, because of the weak structure and high water holding capacity, good grassland management is essential. The soil is liable to poaching and compaction if grazed when wet. Crops such as barley, wheat and roots can be successfully grown but it does not cultivate as well as "tillage" soils and has to be worked under good weather conditions for best results. This is especially true in the northern areas of Westmeath and Meath where rainfall is somewhat higher.

The associated Gley soil has a limited use range, being confined mainly to grassland. Improvement can be obtained through drainage but good management is required to avoid poaching and pasture damage by livestock. The Brown Earths are excessively drained and are mostly suited to grass production.

ASSOCIATION 38:

GREY BROWN PODZOLICS 75%, GLEYS 25%

This association occupies 1.14% of the country (193,551 ac.; 78,329 ha.). It occurs mainly in east Meath and in Dublin. The topography is mostly flat to gently undulating, with slopes seldom more than 3° and elevations mainly 30 to 90 m. (In the Ardcath area of Meath, and in south Dublin, where this soil merges with Association 8, however, the topography is more rolling and elevations are somewhat higher, reaching 137 m in places). The soil parent material is a calcareous glacial till which was carried in from the Irish Sea and intermixed with the local limestone and shale.

Principal Soil — Association 38: Grey Brown Podzolic

Topography: Flat to gently undulating
Slope: 0°-l°
Altitude; 32 m O.D.
Drainage: Moderately well drained
Parent Material: Till of Irish Sea origin with limestone and shale

Horizon	*Depth (cm)*	*Description*
A11	0-23	Loam; dark brown (10 YR 3/3); moderate, medium sub-angular blocky structure with some crumb; moist friable, slightly plastic; roots medium to 10 cm; plentiful below this; common, very fine, continuous pores; clear smooth boundary:
A12	23-40	Gravelly loam; dark brown (10 YR 3/3); weak, coarse sub-angular blocky structure; moist slightly plastic, slightly friable; plentiful roots to 30 cm with a few branched roots below; clear smooth boundary:
B2tl	40-67	Gravelly clay loam; brown to dark brown (7.5 YR 5/4 to 4/4); prismatic breaking down into weak sub-angular blocky structure; moist plastic; few branched roots; indistinct boundary:
B2t2	67-82	Clay loam inclusion up to 10 cm diameter in a sandy clay loam; dark brown (10 YR 3/3); massive, moist plastic slightly friable; few branched roots; clear smooth boundary:
C	82-100	Gravelly sandy clay loam; dark yellowish brown (10 YR 3/4) with fine, few, faint mottles, strong brown (7.5 YR 3/8); massive structure; wet plastic and slightly sticky; no roots apparent.

Analytical data

Hor.	Coarse sand %	Fine sand	Silt %	Clay %	pH	C%	N%	C/N	Free iron %
A11	22	22	32	24	5.8	2.4	0.29	8.3	1.1
A12	21	20	35	24	6.9	0.9	n.a.	—	1.4
B2t1	18	22	27	33	7.2	0.5	n.a.	—	2.1
B2t2	14	20	27	39	7.2	0.5	n.a.	—	1.9
C	18	37	18	27	7.5	0.5	n.a.	—	1.9

Trace elements — total contents (ppm)

Horizon	Sn	Pb	Ga	Mo	V	Cu	Zn	Ni	Co	Cr	Ti	Mn
A11	2	4	3	nd	25	7	35	20	6	20	600	350
A12	2	15	5	2	80	10	80	40	8	35	1,200	300
B1	2	15	5	1	50	7	65	35	6	25	750	200
B2t	2	4	1	1	20	5	25	18	3	20	450	150
C	2	2	1	1	50	2	25	2	1	10	250	75

The principal soil within the association consists of a moderately well drained Grey Brown Podzolic of loam to clay loam texture and of medium to high base status. The profile is characterised by a slightly plastic consistency and weak structure which becomes massive in the lower part of the B horizon at about 65 cm. Clay and silt contents in the surface horizon are about 25% and 30% respectively but the clay content increases to over 30% in the B horizon.

The principal soil gives way very quickly to a less well-drained soil in the flatter areas, which comprise about 25% of the association. (This soil has been mapped as Association 40 where it occurs extensively). This associated soil has a clay loam surface horizon and a clay loam to silty clay loam Btg horizon with silt content in the B horizon generally greater than 40%. It usually has a very high base status. Some gravelly Brown Earths and minimal Grey Brown Podzolics are also present in places to a small extent in this association. These latter soils are found generally on kames, crests of hillocks and terraces. They are mostly formed from fluvioglacial material. Surface texture is sandy loam to loam, and the soils are moderately shallow with rapid permeability.

Suitability

The principal soil has a moderately wide use range. It is suitable for grassland but is also used for tillage, including intensive production of vegetables for the Dublin market. The soil is not ideal for tillage because of its heavy texture, weak structure and sticky consistency but, because it occurs in an area of low rainfall, it can be successfully used for these purposes. In grassland, poaching by livestock can be a problem in spring and autumn but this can be overcome by good grassland management.

The more poorly drained associated Gley (25%) presents greater problems for tillage and has to be worked when moisture conditions are optimum.

The use range of the associated Brown Earths and Grey Brown Podzolics is moderately good but restricted somewhat by slope, shallowness and drought. Due to scale limitation these latter soils are not shown separately on the soil map.

ASSOCIATION 39:

GLEYS 90%, GREY BROWN PODZOLICS 10%

The soils of this association occupy 3.45% of the country (583,630 ac.; 236,192 ha.). They occur widely throughout the limestone till areas of the country where they occupy the more lowlying positions. The principal soil is a poorly drained Gley of clay loam to clay texture and of high base status. It is found mainly in Limerick, Roscommon, Galway, Tipperary, Laois, Kilkenny, Kildare, Cork and other counties to a more limited extent. In many places, however, it is not possible to show it separately on the map because of its occurrence in small enclaves. But it constitutes the main associated soil in Associations 31 and 34 especially.

The profile is characterised by a thick, strongly gleyed textural B horizon which merges with the parent material at approximately 150 cm depth. Clay content is high, ranging from about 40% in the surface to almost 50% in the parent material, while silt contents range from about 30% in the surface to 40% in the parent material.

Plate 17: *The heavy-textured Gley soils of Association 39 have a serious drainage problem.*

Structure is weak in the upper horizons and becomes massive with depth; only the upper horizons are friable. The poor drainage is caused by the heavy texture and by the slow run-off due to the relief, which is aggravated by the poor permeability of the soils themselves.

In Laois, where this soil is relatively extensive (Mountmellick, Portlaoise, Mountrath area), there is a strong influence of sandstone in the parent material and the entire profile is more sandy (organic sandy loam). The well-drained associated soil in this area is similar to the principal soil of Association 36 which occurs immediately to the east.

Suitability

Because of their poor drainage, these soils have a limited use range and are suited mainly to pasture. Susceptibility to poaching is a problem and good management is necessary to sustain maximum production. If a suitable outfall can be obtained they can be successfully drained.

As indicated above, this soil is often associated on the landscape with Associations 34 and 31. The well-drained associated soil within this association (10%) is a Grey Brown Podzolic similar to the principal soils of Associations 31 and 34. The use range is also similar.

Principal Soil — Association 39: Gley

Topography:	Flat
Slope:	1°
Altitude:	79 m O.D.
Vegetation:	Old pasture *(Junco Molinietum* sub-association of *Trifoluim repens)*
Drainage:	Poorly drained
Parent material:	Glacial till predominantly of limestone compostion with admixture of shale, sandstone and volcanics; of Midlandian age.

Horizon	*Depth (cm)*	*Association*
A11g	0-15	Clay to clay loam, dark-brown (10 YR 3/3) with many, fine, faint, yellowish-red (5 YR 4/8) mottles; weak, fine crumb structure; friable; abundant, diffuse roots; gradual, smooth boundary to:
A12g	15-25	Clay to clay loam; light-grey to grey (10 YR 6/1) with many, fine, distinct, strong-brown (7.5 YR 5/6) mottles; moderately weak, medium sub-angular blocky structure; friable; plentiful, diffuse roots; gradual, smooth boundary to:
A2g	25-45	Clay loam; light brownish-grey (10 YR 6/2) with many, fine, distinct reddish-yellow (7.5 YR 6/6) mottles; massive structure; wet, slightly plastic; few roots; gradual, smooth boundary to:
B2tg	45-60	Clay; light brownish-grey (10 YR 6/2) with common, medium, distinct, strong-brown (7.5 YR 5/6) mottles; massive structure; wet, plastic; few roots; diffuse, smooth boundary to:
B3g	60-112	Silty clay; strong-brown (7.5 YR 5/6) with common, medium, prominent, light-grey to grey (10 YR 6/1) mottles; massive structure; wet, plastic; very few roots
CG	Below 112	Silty clay; grey (10 YR 6/1) massive structure, moist, sticky and slightly plastic.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11g	12	13	33	42	5.8	29.8	22.7	76	8.6	0.81	10.6	1.8
A12g	10	14	33	43	6.0	18.8	16.8	89	3.7	0.43	8.6	1.8
(A2)g	11	15	35	39	6.8	11.8	—	Sat.	0.9	0.14	6.4	1.2
B2tg	6	8	38	48	7.9	10.5	—	Sat.	0.3	0.04	—	2.0
B3g	6	6	41	47	8.3	8.5	—	Sat.	0.3	0.03	—	1.7

ASSOCIATION 40:

GLEYS 80%, GREY BROWN PODZOLICS 20%

The soils of this association occupy 1.89% of the country (318,878 ac.; 129,048 ha.). They occur mainly in Meath, Louth, Dublin, north Kildare, south Wexford and southeast Waterford. Topography is flat to gently undulating with elevations between 30 and 90 m O.D. The parent material, which is similar to that of Association 38, consists of a calcareous glacial till which was carried from the Irish Sea and intermixed with local limestone and shale. Some soils derived from predominantly shale till in south-west Wexford and east Waterford are also included in this category. In the south Wexford area Cambrian shale is an important constituent in the parent material.

The predominant soil is an imperfectly to poorly drained Gley. It has a clay loam texture in the surface and a clay loam to silty clay loam texture in the lower horizons. Base status is medium to high. The profile is characterised by a relatively high clay and silt content (35 and 40% respectively) and weak structure. On this fine grained, compact

Principal Soil — Association 40: Gley

Topography:		Flat to indicating
Slope:		0°-5°
Altitude:		107 m O.D.
Drainage:		Imperfect to poor
Parent material:		Till of Irish Sea origin with limestone and shale
Horizon	*Depth (cm)*	*Description*
A11	0-18	Clay loam; dark brown (10 YR 3/3); fine, moderate crumb structure; moist plastic; plentiful roots; clear, smooth boundary:
A12g	18-31	Silty clay loam to silty clay; brown and yellowish brown (10 YR 5/3 to 5/4); many, fine, faint mottles; fine, weak, sub-angular blocky structure, moist plastic; few roots; clear, smooth boundary:
B1g	31-52	Gravelly clay loam; grey, brownish yellow and yellowish brown (10 YR 5/1, 6/6 and 5/4) many, fine, faint mottles; fine, weak sub-angular blocky structure; moist friable slightly plastic; many fine roots; clear, smooth boundary:
B2g	52-58	Clay loam; grey, brownish yellow, and dark grey (10 YR 5/1, 6/6 and 2.5Y N4/—) many fine and distinct mottles; massive or columnar breaking into fine, weak sub-angular blocky structure; moist plastic; few roots; abrupt, smooth boundary:
Cg	58-99	Gravelly clay loam to silty loam; brownish yellow and dark grey (10 YR 6/6 and 2.5Y N4/–) and a small area of grey (10 YR 5/1) many, medium and distinct mottles; massive; most plastic; no roots.

Analytical data

Horizon	Coarse sand %	Fine sand %	Silt %	Clay %	pH	C%	N%	C/N	Free iron %
A11	7	19	38	36	6.2	4,8	0.47	10.2	2.0
A12g	5	11	44	40	7.7	1.6	0.20	8.0	1.1
B1g	12	11	46	31	7.6	0.9	nd	—	0.7
B2g	10	13	45	32	7.7	0.6	nd	—	2.5
Cg	9	11	42	38	8.5	0.5	nd	—	1.7

till, poor drainage tends to prevail even on favourable slopes. In places, a brown horizon occurring beneath the grey and mottled horizons indicates the presence of a "perched" water-table. In the south Wexford area, these soils have a somewhat indurated, stony, subsoil. A poorly drained Gley occupies approximately 10% of this association. This soil is found interspersed through the principal association. It covers quite a wide area in south west Louth and parts of south Wexford. The surface texture varies from clay loam to silty clay loam, while the soil generally has a weak structure and slow permeability.

Suitability

Because of their imperfect drainage, heavy texture and weak structure, these soils have a somewhat limited use range. They are suitable mainly for grassland but they have been used rather intensively also for tillage, due mainly to the favourable climatic conditions in these areas. However, cultivation and the development of a desirable tilth can prove difficult unless the soils are at the ideal moisture balance. Their optimum land use is grass production which can be highly satisfactory where drainage and good management are applied.

The main associated soil (20%) is a Grey Brown Podzolic similar to the principal soil of Association 38. It occurs throughout this association in small pockets on the slightly more elevated parts of the landscape. Some small pockets (< 5%) of Brown Earths formed over gravel and sands occur in this association. This soil is usually well to excessively drained with a gravelly loam surface texture. In has a reasonably wide use range for a wide variety of agricultural crops.

The use range of the more poorly drained Gley soil is limited mainly to grassland but the wet impervious nature of the soil can cause serious poaching problems.

ASSOCIATION 41:

GLEYS 75%, ACID BROWN EARTHS 15%, PEATY GLEYS 10%

The soils of this association are found only in Northern Ireland, mainly in an area north of Lough Neagh. They are generally found in flat or gently undulating terrain on deep basaltic glacial till. The principal soil is very heavy in texture (clay to clay loam) in the surface and to clay in the subsoil. Mottling is evident even at the surface, with strong gleying in the subsoil. Cation exchange capacity and exchangeable magnesium levels are high. The associated soils are Brown Earths (15%) and Peaty Gleys (10%).

Suitability
Because of drainage impedance, the Gleysand Peaty Gley soils of this association have a limited use range. They are suited mainly to grassland, but good management is essential to avoid poaching damage by livestock.

Principal Soil — Association 41: Gley*

Horizon	*Depth (cm)*	*Description*
A11	0-55	Clay loam to clay; grey-brown with brown and rusty mottlings and rusty streaks in old root channels; cloddy structure; a few stones; merges into
A12	15-25	Brownish-grey layer, cheesy, with rusty mottling; some stones; roots along cleavage planes; changes sharply to:
Bg	25-41	Sandy or gravelly clay, stony; yellowish brown with intense mottling: orange, rust, grey, green, and ochre; very few roots; massive structure.
Cg	Below 41	Gravelly clay; yellow-brown, strongly mottled; with some stones and a few boulders.

Analytical data

	Coarse	Fine					Exchangeable cations (meq/100g)					CEC
Horizon	sand %	sand %	Silt %	Clay %	C%	pH	Ca	Mg	K	Na	H	meq/100g
A11	7	19	25	44	3.7	6.3	38.8	4.2	0.35	0.54	0.2	49.9
A12	—	—	—	—	—		—	—	—	—	—	—
Bg	5	19	24	52	1.8	6.6	34.6	4.8	0.17	0.56	6.7	47.8
Cg	3	32	39	26	0.2	6.7	32.1	13.9	0.13	0.90	4.3	52.5

*Reference: McConaghy, S and McAleese, D.M. 1957. The basaltic soils of Northern Ireland. JI. Soil

ASSOCIATION 42:

GLEYS 90%, GREY BROWN PODZOLICS 10%

The soils of this association occupy 0.49% of the country (82,109 ac.; 33,229 ha.). They occur mainly in a 4 to 5 mile wide strip along the east coast in Wexford, Wicklow and Louth. The topography is flat to gently undulating with elevations mainly less than 75 m O.D. The parent material consists of dense, calcareous, marine muds which were removed from the bed of the Irish Sea and deposited inland by ice.

Plate 18: Profiles of the poorly-drained Gley soils of Association 42 display a massive or weak coarse prismatic structure as well as a grey leached A2 horizon overlying a Btg horizon in which there is a significant increase in clay content.

The principal soil is a poorly drained surface-water Gley of high base status. The profile is characterised by a dark greyish-brown surface horizon of loam to sandy clay loam texture overlying deeper horizons of heavier texture which are generally grey and strongly mottled. The surface horizon contains about 20% clay and 27% silt but the clay and silt contents in the B and C horizons increase to about 45 and 30% respectively. Weak structure and heavy texture are mainly responsible for the poor drainage, which is evident even on favourable slopes.

The main associated soil is a moderately well to imperfectly drained Grey Brown Podzolic which is associated with a somewhat lighter texture. This soil occurs only to a limited extent (10%).

Suitability

These soils have a limited use range. They are not generally suited to tillage and their best use is in grass production. Even for this purpose they tend to be rush *(Juncus)* dominated and to be badly poached unless well managed. For this reason the grazing season has to be very short. Because of its better drainage, the associated soil, although mainly suited to grassland, has a somewhat longer grazing season with less liability to poaching damage.

These soils can be improved by drainage but because of their slow permeability special drainage techniques such as gravel-filled moles must be used.

Principal Soil — Association 42: Gley

Topography:		Flat
Slope:		2°
Altitude:		61 m O.D.
Vegetation:		Old pasture — rush *(Juncus)* dominant
Drainage:		Poorly-drained
Parent material:		Dense, calcareous glacial drift of Irish Sea origin, of Munsterian age
Horizon	*Depth (cm)*	*Description*
A1g	0-20	Sandy loam to sandy clay loam; dark grayish-brown (10 YR 4/2); weak, medium crumb structure; friable; many, coarse, prominent, yellowish-brown (10 YR 5/4) mottles especially along root channels; abundant, diffuse roots; gradual, smooth boundary to:
(A2)g	20-37	Sandy clay loam to sandy loam; dark-grey (10 YR 4/1); weak, fine to medium crumb structure; friable, roots not so abundant as above; many, coarse, prominent dark yellowish-brown (10 YR 4/4) mottles, abrupt, smooth boundary to:
B2tg	37-90	Clay; olive-grey (5 Y 5/2); weak, coarse, prismatic structure; firm; few roots; clay skins evident; many, coarse, prominent, strong-brown (7.5 YR 5/6) mottles; clear, smooth boundary to:
Cg	Below 90	Clay; pale-brown (10 YR 6/3); massive structure; firm; many, medium, prominent yellowish-brown (10 YR 5/6) mottles; no roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
Alg	38	18	26	18	5.5	16.6	10.1	61	3.3	0.27	12.2	1.1
(A2)g	34	23	22	22	5.9	14.0	7.3	52	1.6	0.16	10.0	1.2
B2tg	11	11	31	46	6.8	16.1	10.8	67	0.5	0.07	—	2.1
CG	7	10	32	51	7.7	13.1	11.1	85	0.3	0.07	—	1.4

ASSOCIATION 43:

GLEYS 60%, BROWN EARTHS 20%, PEATY GLEYS 20%

The soils of this association occupy 1.34% of the country (226,374 ac.; 91,612ha.). They are formed from alluvial deposits and occur mainly in the following locations; close to the estuary of Wexford harbour, close to Kilmore Quay, Co. Wexford, close to Burnfoot, Co. Donegal, on the shores of Lough Swilly, from west of Limavaddy to Magilligan Point, along the western shore of Lough Foyle and south of Greystones to Wicklow town. They also occur inland on river and lake alluvial materials.

The topography is flat and elevation is close to or below sea level. For this reason many of these areas have been reclaimed by a system of pumps and sluices, so that the water table, which was originally very high, can now be controlled. The parent material consists mainly of heavy textured, calcareous alluvium.

The predominant soil is a poorly drained Gley of silty clay loam texture and of medium to high base status, but surface textures may be lighter in places. The profile is characterised by a somewhat organic, surface horizon overlying dark-grey and mottled subsurface horizons of massive structure, with sticky consistency when wet. There is a high silt content throughout the profile with a range of 50 to 60%. Clay content is about 28% in the surface and 20% in the lower horizons.

Inland where these soils are formed mainly from lake and river alluvium, they are variable in texture and tend to be stratified. They are mostly Peaty Gleys and Gleys and are generally only suitable for summer grazing. These can often be brought into good use where arterial drainage is feasible, as for example in parts of the River Boyne catchment.

Suitability

Because the water table can be controlled, in many of these locations the soils can be used for the production of a wide range of tillage crops and for pasture production. They can be highly productive provided good management is practised. A particular problem encountered in the Wexford area is that of high soil and herbage molybdenum levels. Here, grazing livestock have been seriously affected by induced copper deficiency and it has been found necessary to dose the animals regularly with copper sulphate. In the Magilligan Point area the surface is a very friable loamy sand, overlying a gleyed coarse sandy material at about 40 cm. Because of this, these soils are more suited to the production of tillage and vegetable crops, especially carrots.

Brown Earths (20%) occur within the association also. These soils were recently formed from river or marine deposits. Since they are immature soils only weak soil horizons have developed. They are moderately deep, well drained and variable in surface texture. The use range is moderately wide, being suited to a wide range of agricultural crops, but flash flooding may cause problems.

Principal Soil — Association 43: Gley

Topography:	Flat
Slope:	0°
Altitude:	Below sea-level
Vegetation:	Rush *(Juncus)* dominated pasture
Drainage:	Poorly-drained
Parent material:	Estuarine alluvium (fine texture)

Horizon	*Depth (cm)*	*Description*
A11	0-5	Slightly peaty, silty clay loam to silt loam; dark-brown (10 YR 3/3); moderate, fine crumb structure, held in sod by roots; friable; clear, smooth boundary to:
A12g	5-30	Silty clay loam to clay loam; grey (5 Y 6/1); moderate, medium crumb structure; friable; many, coarse, prominent dark reddish-brown (5 YR 3/4) mottles; plentiful roots; gradual, smooth boundary to:
A/Cg	30-75	Silt loam; grey (5 Y 5/1); massive tending towards weak, coarse prismatic structure; rather firm; many medium, distinct dark-brown (7.5 YR 4/4) mottles; gradual, smooth boundary to:
CG	Below 75	Silt loam to loam; dark-grey (5 Y 4/1); massive structure; sticky in wet state; few, dark-brown (7.5 YR4/4) mottles on root channels and around marine shells; occasional roots.

Analytical data

Hor.	Coarse sand %	Fine sand %	Silt %	Clay %	pH	CEC meq/100g	TEB meq/100g	Base sat. %	C%	N%	C/N	Free iron %
A11	4	14	54	28	6.3	35.1	19.3	55	11.7	1.15	10.2	1.1
A12g	4	14	50	32	6.6	14.9	13.0	87	2.8	0.20	14.0	1.8
A/Cg	4	10	65	21	7.7	11.6	—	Sat.	1.9	0.13	—	1.1
CG	2	28	50	20	7.5	8.8	—	Sat.	2.5	0.09	—	1.9

ASSOCIATION 44:

BASIN PEATS

This Basin Peat association occupies 5.79% of the country (978,156 ac; 395,854 ha.). It occurs extensively from the Central Plain to east Galway, east Mayo and Sligo. It also occurs in West Clare, north Kerry and in Antrim and Tyrone. Rainfall varies from less than 1,000 mm in the Midlands to over 1,250 mm in the more western areas. The depth of organic material can vary from 3 to 8 m and it comprises a layer of acid peat over a peat formed under base-rich conditions. The vegetation on the surface consists of *Sphagnum* species and, depending on the drainage regime, *Calluna vulgaris* (heather), *Erica telralix* (cross leaved heath), *Narthesium ossifragum* (bog asphodel), *Trichophorum caespitosum* (deer grass), *Eriophorum angustifolium* and *vaginatum* (bog cottons).

It is always associated with wet surface conditions. A typical profile shows a tripartite layering which consists of a poorly humified *Sphagnum* surface layer over variable depths of humified *Sphagnum* peat with *Calluna* remains and *Eriophorum* fibres. This in turn overlies a basal layer comprised of woody and fen plant remains.

Variations in the composition of this basal layer depend on the topography of the glacial drift floor. On the higher elevations, the peat contains a high content of woody

Principal Soil — Association 44: Basin Peat (Raised Bog)

Topography:	Flat
Slope:	1°
Altitude:	100 m O.D.
Drainage:	Poor
Permeability:	Slow
Parent material:	Ombrotrophic peat
Vegetation:	Heather and moss
Root distribution:	Roots to 58 cm

Horizon	Depth (cm)	Description
A1	0-27	Dark reddish brown (5 YR 3/4); *Calluna-Sphagnum* peat; fibric; poorly humified; dominantly *Calluna* remains, twigs and flower heads etc., clear wavy boundary to:
A12	27-58	Dark reddish brown (5 YR 3/4); *Sphagnum* peat; fibric; poorly humified; on washing dark colour well preserved 100% *Sphagnum*; clear, slightly wavy boundary to:
C1	58-87	Dark reddish brown (2.5 YR 2/4); *Sphagnum* peat; fibric; poorly humified; on washing dominantly dark coloured *Sphagnum* with *Eriophorum* remains; abrupt wavy boundary to:
C2	87-118	Black (5 YR 2/1); *Calluna-Sphagnum* peat; fibric; poorly humified; on washing *Calluna* debris with *Sphagnum* and some *Eriophorum*.

Analytical data

Horizon	Moisture %	PH (H_2O)	Ash %	Db g/cc	Fibre %	Pyrophosophate extract colour
A1	88.86	3.42	3.0	0.061	69.1	10 YR 7/3
A12	—	3.40	1.0	—	69.8	10 YR 8/1
C1	93.07	3.35	0.6	0.055	60.7	10 YR 8/1

debris, while in the depressions, fen peat, consisting of a high proportion of herbaceous plant remains has developed.

Past turf-cutting practices by the local population have given rise to uneven microtopography, especially on the periphery of the raised bogs. It has been estimated that over 70% of them have been modified by man in this way and that fen peat now occupies nearly 30% of the total area.

Suitability

The raw bog has a very limited use range and can only be brought into viable use if extensively drained. After such drainage the level cut-over areas (especially industrial areas) have a definite potential for grassland and for a range of crops such as cereals, carrots or celery. Potential depends on the proximity of a drainage outfall and cropping is often, therefore, restricted to the outer edges of these areas.

11

Potential Land Use of Irish Soils

This chapter attempts to interpret for practical use the basic data derived from the Soil Map. It concentrates on four major aspects: (i) the range of uses to which the different soils are suited, (ii) the extent and kind of marginal land occurring, (iii) the major limitations of the different soils and (iv) the extent and distribution of "tillage" land.

Where possible, these soil groupings have been done on a county, provincial and country basis. In the case of the use-range categories, it has also been done on the basis of the planning regions delineated by the Industrial Development Authority (IDA).

Physiographic Divisions and Extent of Different Soils

The extent of each of the 44 soil associations, as well as their grouping into physiographic divisions, is shown in Table 3.*It can be seen that the range of extent of individual soil associations is from less than 0.02 to 7.3%, whilst their grouping into physiographic divisions gives the following breakdown — (1) Mountain and Hill Soils (16%, 2.6 m ac, 1.1m ha), (2) Hill Soils (6%, 1.0 m ac, 0.4 m ha), (3) Rolling Lowland Soils (31%, 5.2 m ac, 2.1 m ha), (4) Drumlin Soils (11%, 1.9 m ac, 0.8 m ha), (5) Undulating Lowland Soils (36%, 6.2 m ac, 2.5 m ha).**

Mountain and Hill soils (excluding high level blanket peat) occur mostly above 365 m and cover about 1.7 million acres (0.7 m ha). Steep (12°-17°) and very steep (> 24°) slopes are common, but the normal range is 8° to 12°.

Hill soils occur mainly between 150 and 365 m and occupy almost 1.0 m acres (0.4 m ha). Excluding the Burren (136,192 ac, 55,116 ha) and the wet hill soils in the vicinity of Collon, County Louth (59,004 ac, 23,879 ha), the remaining soils (781,446 ac, 316,247 ha) in this category are essentially dry soils which have a moderately good agricultural potential. They are mainly acidic, being formed from shale, sandstone or granite. The largest of these areas is the Old Red Sandstone Uplands of Munster. These range in altitude from 122 to 274 m O.D. and, for the most part, have easy slopes. Slopes can be found up to 24° in places but most slopes are below 12°. Up to recently, quite a large proportion of this area was covered by shallow peat or heath vegetation but much of it has now been successfully reclaimed for agriculture.

The Rolling Lowland soils occur mainly at elevations below 150 m and (excluding low level Blanket Peat) occupy about 4.3 million acres, 1.7 m ha (25%). Many of the soils in

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* Figures given in all cases are for the Republic of Ireland only.

** Here the peat soils are distributed as follows: High Level Blanket Peat (5.7%) is in the Mountain and Hill category, Low Level Blanket Peat (5.1%) is in the Rolling Lowland category and Basin Peat (5.8%) is in the Undulating Lowland category.

TABLE 3: Extent of each Soil Association and its grouping within Physiographic Divisions

Soil Assoc.	Extent Acres	Hectares	%	Physiographic Division	%	Acres	Hectares
1	1,235,571	500,029	7.31				
2	50,602	20,478	0.30	Mountain			
3	—	—	—	and	15,58	2,633,384	1,065.675
4	389,163	157,492	2.30	Hill			
5	957,948	387,676	5.67				
6	317,733	128,585	1.88				
7	136,192	55,116	0.81				
8	87,920	35,581	0.52	Hill	5.78	976,642	395,242
9	313,274	126,780	1.85				
10	62,519	25,301	0.37				
11	59,004	23,879	0.35				
12	190,831	77,228	1.13				
13	286,389	115,900	1.69				
14	712,885	288,501	4.22				
15	1,065,864	431,349	6.31				
16	70,842	28,669	0.42				
17	3,876	1,569	0.02	Rolling	30.97	5,233,603	2,118,010
18	124,577	50,416	0.74	Lowland			
19	130,857	52,957	0.77				
20	237,583	96,149	1.41				
21	499,030	201,955	2.95				
22	820,563	332,077	4.86				
23	221,376	89,590	1.31				
24	868,930	351,651	5.14				
25	435,163	176,108	2.57				
26	—	—	—				
27	637,388	257,947	3.77	Drumlin	10.93	1,849,677	748,554
28	580,383	234,878	3.43				
29	196,743	79,621	1.16				
30	445,567	180,319	2.64				
31	755,115	305,591	4.47				
32	520,335	210,577	3.08				
33	541,965	219,330	3.21				
34	1,016,393	411,329	6.02				
35	107,677	43,576	0.64	Undul-			
36	118,186	47,829	0.70	ating	36.28	6,128,298	2,480,088
37	240,754	97,432	1.42	Lowland			
38	193,551	78,329	1.14				
39	552,419	223,561	3.27				
40	349,697	141,520	2.07				
41	—	—	—				
42	82,109	33,229	0.49				
43	226,374	91,612	1.34				
44	978,156	395,854	5.79				

Refers to Republic of Ireland only.

this category are formed from shales, sandstone,granite or mica schist. They have slopes ranging mostly between 3° to 9° which are suitable, as far as slope is concerned, for all types of farm machinery. They can be used successfully except in exceptional positions where difficulties may be encountered. For example, in Association 23, rock outcrops and microtopography, with slopes up to 18°, are serious hazards to machinery use.

Drumlin soils occupy about 1.9 million acres, 0.8 m ha (11 %) and are located mainly in the north-west "drumlin-belt" as well as in parts of Clare, west Cork and west Mayo. Most slopes are between 0° and 12° and here, although some difficulties may be encountered, machinery can be used. However, about 25% of drumlin topography has slopes greater than 12° and this can cause serious problems for machinery use, especially if the slope hazard is accentuated by wet soil conditions.

The drumlin soils can be sub-divided into predominantly free-draining (0.8 mac., 0.3 m ha, 4.6%) and predominantly impermeable types (1.1 million ac, 0.5 m ha, 6.3%).

TABLE 4: Drumlin soils grouped according to their drainage status

Category	Extent		
	Acres (millions)	Hectares	%
1. Well drained soils	0.8	0.3	4.59

Undulating Lowland soils have dominant slopes which range from 0 to 5°. Here ordinary agricultural machinery can operate without difficulty, insofar as slope is concerned. They occupy (excluding Basin Peat) some 5.2 million acres (2.1 m ha, 30%) and are located mainly throughout the midlands and east.

A further breakdown of the lowland soils (Rolling and Undulating categories) on the basis of parent material composition and drainage status is given in Table 5.

TABLE 5: Lowland soils grouped according to parent material composition and drainage status

Category	Extent		
	Acres (millions)	Hectares	%
Well drained lowland limestone soils	3.9	1.6	23
Well drained lowland acid soils*	2.6	1.1	15
Poorly drained lowland mineral soils	2.5	1.0	15

*Formed from non-calcareous parent material.

Well-drained mineral soils of limestone origin are predominant. These also belong mainly to the Undulating Lowland category and occupy some 3.9 million acres, 1.6 m ha. Well-drained acid soils (of Rolling Lowland) occupy a further 2.6 million acres, 1.1 m ha., while poorly drained mineral soils (of Undulating and Rolling Lowland) cover about 2.5 million acres, 1.0 m ha.

Peats cover about 2.8 million acres, 1.1m ha., or 17% of the country and are comprised of three associations, namely, High Level Blanket Peat (Association 5) 5.7% 957,948 acres; 387,676 ha, Low Level Blanket Peat (Association 24) 5.1 %; 868,930 acres; 351,651 ha., and Basin Peat (Association 44) 5.8%; 978,156 acres; 395,854 ha.

Land Use Range

Land use range is a qualitative as distinct from a quantitative method by which the range of potential uses to which the soils are suited can be expressed. Usually there are six use-range classes (see below) varying from wide to extremely limited. Good management is assumed. The soils are grouped for the country and the provinces on this basis in Table 6.

TABLE 6: Extent of use range classes (%)

Region	Wide	Moderately Wide	Somewhat limited	Limited	Very limited	Extremely limited
	1	2	3	4	5	6
Rep. of Ireland	23.4	11.7	15.0	21.0	25.5	3.1
Connacht	3.6	13.8	18.5	21.8	37.7	4.6
Leinster	32.9	21.4	16.9	15.0	12.5	1.5
Munster	36.4	3.1	11.3	22.8	22.7	3.7
Ulster	2.6	9.8	14.2	29.7	41.2	2.5

Class 1 — Wide Use Range
Soils of wide use range have no limitations which cannot be overcome by normal management practices.

Class 2 — Moderately Wide Use Range
Moderately wide use-range refers to soils with minor limitations such as coarse texture, moderately high altitude, less favourable climatic conditions, somewhat shallow depth, hummocky topography and somewhat weak structure.

Class 3 — Somewhat Limited Use Range
The somewhat limited use range category is used for soils with similar limitations to those of Class 2 but these are present to a greater degree. For example, soils with altitude limitations in this category usually occur between 150 m and 365 m, whereas those of the moderately wide use range with altitude limitations are at elevations mostly between 90 and 150 m. The more free-draining drumlin associations are also included in this category because of slope limitations which inhibit the use of machinery. So also are the imperfectly drained soils (Association 40) of north Dublin, east Meath and south Wexford, because of poor structure and fine texture.

Class 4 — Limited Use Range
Soils in this category-are generally unsuited to tillage but suited to a permanent grassland system. The predominant limitation is poor drainage, except for Association 8 which is placed in this class because of a somewhat high altitude (150-365 m) combined with rock outcrops and boulders.

Class 5 — Very Limited Use Range
This class contains those soils whose agricultural potential is greatly restricted. They are widespread in the western and north-western regions, particularly in the mountain zones where high altitude and steep slopes are major limitations.

Class 6 — Extremely Limited Use Range
This class contains soils in which agricultural potential is virtually non-existent. These are mostly mountain-top areas where steep slopes have contributed to the existence of very shallow soils with many boulders and rock outcrops. Because of these factors, the Burren, Co. Clare, has been included in this category although some extensive summer grazing is possible in the area.

Republic of Ireland
Taking Classes 1, 2 and 3 as representing good agricultural land* it can be seen that 50.1%, (8.5 m acres, 3.4 m ha.) of the country falls into these categories. Some 28.6% (4.8 m acres, 2.0 m ha) of the land is very poor (Classes 5 and 6) whilst the remaining 21.0% (3.5 million acres; 1.4 m ha) is limited in its range of potential uses (to permanent grassland) mainly because of poor drainage.

Connacht
Good agricultural land (Classes 1, 2 and 3) occupies only 35.9% (1.5m acres, 0.6 m ha) of Connacht. Some 42.3% (1.8 m acres, 0.7 m ha) is very poor while approximately 21.8% (0.9 million acres, 0.4 m ha) is limited in its use (mainly to permanent grassland) because of drainage problems.

Leinster
Good agricultural land (Classes 1, 2 and 3) occupies 71.2% (3.4 m acres, 1.4 m ha) of the province, some 13.9% (0.7 m acres, 0.3 m ha) is very poor, while 15.0% (0.7 m acres, 0.3 m ha) is limited in its range of uses to permanent pasture mainly because of poor drainage.

Munster
Some 50.6% (3.0 m acres, 1.2 m ha) of the land area of Munster is good agricultural land while some 26.4% (1.6 m acres, 0.6 m ha) has a very poor potential. In the intermediate category (mainly suited to permanent pasture) some 22.8% (1.4 m acres, 0.6 m ha) of the land of the province is found.

Ulster
Only 26.5% (0.5 m acres, 0.2 m ha) of the three counties of Ulster (Donegal, Cavan and Monaghan) is good agricultural land. Some 43.6% (0.9 m acres, 0.3 m ha) is very poor whilst in the intermediate (Class 4) category some 29.6 (0.6 m acres, 0.2 m ha) is found.

Land Resources of the Development (IDA) Regions

Because the Development Regions (IDA) are used for development purposes, an estimate of their individual land resources is given in Table 7 in terms of use range categories.

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*Suitable for tillage and grassland.

TABLE 7: Land resources of the Development (I.D.A.) Regions.

Use Range:		South West	West	North West Donegal	North East	Midlands	East	South East	Mid West
		Cork, Kerry	Galway, Mayo	Sligo, Leitrim Donegal	Cavan, Monaghan, Louth	Roscommon, Longford, Westmeath, Offaly, Laois	Meath, Dublin Kildare, Wicklow	Wexford, Carlow, Kilkenny, S. Tipp, Waterford	Clare, N. Tipp, Limerick
Class 1 Wide	Ha Ac %	468,981 1,158,852 38.7	2,237 5,527 0.2	5,296 13,087 1.6 3,809 9,413 0.8	55,620 137,436 14.1	276,036 682,084 30.9	128,063 316,443 18.4	465,459 1,150,150 49.6	195,004 481,855 24.9
Class 2 Moderately Wide	Ha Ac %	Nil	206,117 509,316 18.4	3,326 8,218 1.0 76,046 187,910 16.0	8,294 20,494 2.1	157,172 388,372 17.6	192,363 475,328 27.7	107,097 264,637 11.4	41,545 103,657 5.4
Class 3 Somewhat Limited	Ha Ac %	88,283 218,146 7.3	209,139 516,783 18.7	77,544 191,601 23.6 13,380 33,063 2.8	105,153 259,832 26.7	79,666 196,855 8.9	165,815 409,728 23.9	158,107 390,683 16.9	119,331 294,866 15.2
Class 4 Limited	Ha Ac %	191,680 473,640 15.8	145,310 359,060 13.0	135,687 335,283 41.4 55,189 136,373 11.6	198,912 491.511 50.6	177,443 438,462 19.9	88,851 219,553 12.8	144,600 357,306 15.4	294,988 728,915 37.7
Class 5 Very Limited	Ha Ac %	415,913 1,027,720 34.3	484,229 1,196,529 43.3	98,856 244,273 30.1 303,709 750,464 63.8	20,673 51,084 5.3	202,716 500,912 22.7	83,691 206,800 12.1	44,440 109,811 4.7	91,054 224,994 11.6
Class 6 Extremely Limited	Ha Ac %	42,122 104,084 3.5	71,085 175,652 6.4	7,257 17,933 2.2 18,857 46,595 4.0	4,589 11,339 1.2	Nil	14,298 35,331 2.1	14,905 36,831 1.6	39,494 97,591 5.1
Urban							3.0		

It can be seen that in terms of soils of Wide Use Range, the south-east region is highest with 49.6%, whilst the south-west region has 38.7%, the Midlands 30.9% and the Mid-West 24.9%.

On the other hand, the regions with highest percentages of Very Limited Use Range soils are Donegal (63.8%), West (43.3%), South-West (34.3%) and the North West (30.1%).

By combining categories 1, 2 and 3 into Good Land, categories 5 and 6 into Poor Land and referring to category 4 as Moderate Land, a better overall view of the potential of the land resources of each region may be obtained (Table 8).

TABLE 8: Use range of soils of the IDA Development regions (%)

Use range	SW	W	NW	Donegal	NE	Mid	E*	SE	MW
Good	46	37	26	20	43	57	70	78	45
Moderate	16	13	41	12	51	20	13	16	38
Poor	38	50	33	68	6	23	14	6	17

* Approximately 3% of the eastern region is urban land (Dublin)

Land in the Good category is generally suitable for tillage as well as for grassland. Land in the Moderate category is generally not suited to tillage but is mainly suitable for permanent pasture. Its main limitation is poor drainage and elevation. Land in the Poor category is generally of a marginal nature with many limitations to agricultural use such as weak structure, wetness, shallow depth, steep slopes and high altitude.

The Southeast (78%), East (70%) and Midland (57%) regions have the highest percentage of Good land, whilst the Donegal (20%), Northwest (26%) and West (37%) regions are lowest.

Significant percentages of Moderate land occur in the Northeast (51%), Northwest (41%) and the Midwest (38%) regions.

The percentage of land in the Poor category is highest in Donegal (68%), the West (41%) and the Southwest (38%) regions.

Marginal Land

Areas of land maybe referred to as marginal for particular types of use. Such areas fall either at or below the no rent (or extensive) margin for the particular uses considered. In the present context the term marginal is taken to be synonymous with those areas beset by natural limitations imposed by soil, topography or climate.

Using this definition the extent and distribution of the marginal land areas have been determined for the country, the provinces and for each county. This has been done by combining the soils in the extremely limited, very limited and limited use range classes.

The results for country and province are presented in Table 9 while those on a county basis are outlined in Table 10.

TABLE 9: Extent of marginal land by country and province

Region	Percent*	Acres*	Hectares
Republic of Ireland	49.5	8,355,859	3,381,570
Connacht	64.1	2,676,802	1,083,287
Leinster	27.6	1,337,903	541,442
Munster	49.2	2,918,903	1,181,264
Ulster (part of)	73.1	1,422,244	575,574

*These figures have not been adjusted upwards and downwards for associated soils.

It can be seen that in the Republic there are 8.4 million acres; 3.4 m ha., or 49.5% of marginal land and that this is distributed mainly in Connacht (2.7 million acres; 1.1m ha) and Munster (2.9 million acres; 1.2 m ha) with 1.4 million acres; 0.6 m ha in Ulster and 1.3 million acres; 0.5 m ha in Leinster. As a percentage of land area, the greatest extent of marginal land occurs in Ulster (73%) with 64% in Connacht, 49% in Munster and only 28% in Leinster.

TABLE 10: Extent of marginal land by county

County	%	Acres	Hectares
Leitrim	97	358,614	145,129
Kerry	80	930,215	376,453
Donegal	79	929,548	376,183
Cavan	77	349,774	141,552
Mayo	73	955,392	386,642
Clare	70	544,143	220,212
Roscommon	58	348,074	140,864
Galway	54	775,846	313,981
Sligo	54	238,026	96,328
Limerick	52	345,493	139,819
Laois	52	220,110	89,887
Wicklow	47	234,112	94,744
Monaghan	44	139,039	56,268
Longford	41	104,220	42,177
Cork	37	675,229	273,262
Tipperary	37	389,932	157,803
Offaly	35	173,557	70,237
Kildare	32	131,539	53,233
Carlow	22	47,921	
Westmeath	21	91,413	36,944
Kilkenny	20	102,593	41,519
Wexford	17	99,299	40,186
Louth	17	35,107	14,208
Meath	12	71,028	28,745
*Dublin	11	25,006	10,120
Waterford	8	33,899	13,719

*Approximately 20% of Dublin is urban land.

County Basis

On a county basis (Table 10) Leitrim with 97% has the highest percentage of marginal land whilst Waterford has the lowest with 8%. In terms of area (million) however, the order of magnitude is Mayo (0.96 ac, 0.39 ha), Donegal (0.93 ac, 0.38 ha), Kerry (0.93 ac, 0.38 ha), Galway (0.78 ac, 0.32 ha) and Cork (0.68 ac, 0.28 ha). At the other end of the scale, the counties with the lowest area (million) of marginal land are Dublin (0.025 ac, 0.01 ha), Waterford (0.034 ac, 0.01 ha), Louth (0.035 ac, 0.01 ha), Carlow (0.048 ac, 0.02 ha) and Meath (0.071 ac, 0.03 ha).

Kinds of Marginal Land

The marginal land occurring in the country can be divided into different kinds as shown in Table 11.

TABLE 11: Extent of different kinds of marginal land

	Extent		
Category	Ac	Ha	%
Mountain and Hill Land	1,675,336	677,999	9.9
Hill land	283,116	114,576	1.7
Wet mineral lowland	3,589,218	1,452,536	21.3
Blanket Peat			
High Level	957,948	387,676	5.7
Low Level	868,930	351,651	5.1
Basin Peat	978,156	395,854	5.8
TOTAL:	8,352,704	3,380,292	49.5

Limitations* of the Marginal Land

Mountain and Hill Category

This category includes predominantly land above 365 m, 1200 ft. All the soils have severe limitations made up of high altitude, rock outcrop, shallow depth, steep slopes, wetness and inaccessability.

The farming system usually consists of extensive grazing with cattle and/or sheep. Output is very low. For example, lamb liveweight has been estimated at approximately 17 kg/ha but may be as low as 8 kg/ha on the poorer areas. This compares unfavourably with 560 kg/ha under intensive lowland management.

Hill Land

This category generally includes land ranging from 150-365 m O.D. There is an altitude limitation but sharp slopes, broken topography, shallow depth, rock outcrops, boulders and poor drainage are also common. Soil Associations 7, 8 and 11 compose this marginal land category. Association 7 (Burren) has much rock outcrop and is shallow. Association 8 has an appreciable number of boulders, rock outcrop and sharp slopes, while Association 11 suffers mainly from a drainage problem due to impermeability.

*This refers to permanent physical limitations, e.g., altitude, depth, slope, wetness, etc:

Wet Mineral Lowland

This category is widely distributed throughout the country both as associated soils in otherwise well-drained associations as well as in extensive areas of north-central Ireland (drumlin belt), in west Limerick and Clare, on the Castlecomer Plateau and in the east coastal area of Wexford known locally as the Macamores.

The principal limitation is poor drainage. About two-thirds of these soils have an impermeability problem associated with heavy texture and weak structure, whilst in the remaining one-third, the drainage problem arises from either a high water-table, seepage or springs. Compounding the problem in many of the poorly drained soils is the presence of sharp slopes. This is particularly so in the Drumlin Region.

Whilst it is usually feasible to alleviate poor drainage caused by ground water, seepage or springs, problems of impermeability are usually more difficult.

It has been suggested that the best approach to the latter problem is a combination of the disposal of surface water, through the installation of shallow gravel drains across the slope and mole drains across main tile drains. In other cases, subsoiling may be needed in order to disrupt impermeable or compacted layers.

Blanket Peat

For High Level Blanket Peat, the main limitations to agricultural development are altitude, slope, aspect, high moisture content, peat depth, rock outcrop and accessibility.

On low level Blanket Peat, the limitations consist mainly of very poor drainage, extremely low nutrient status, strong acidity and high rainfall. Research work at the Peatland Experimental Station, Glenamoy, Co. Mayo, has shown that grass production is possible on this type of peat but that utilisation is difficult due to high rainfall and the high moisture content.

Basin Peat

Main limitations of this peat type are the very poor drainage, extremely low nutrient status, high water holding capacity, lack of drainage outfalls and incidence of turf bank remnants and bog holes in many places. In the unreclaimed raised bog, acidity is another limitation.

Yet, research work on basin peats in Ireland has shown a considerable potential for agriculture and horticulture (An Foras Taluntais — Annual Research Reports). This research work has now been translated into commercial practice (Bord na Mona, Annual Reports 1975-76, 1976-77, 1977-78).

Tillage Land

The following soil associations are generally suited to tillage:— 6, 9, 10, 12, 13. 14, 15, 16, 19, 20, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38 and 40. However, because of different kinds and degree of limitations, the tillage soils can be grouped into four different classes (Table 12).

TABLE 12: Soils suitable for tillage in Ireland

Class	Association No.	Acres	Hectares	% of country
1. Highly suitable	12, 13, 14,15*, 35, 36	2,481,832	1,004,384	14.7
2. Suitable	16, 20, 30, 31, 34	2,525,500	1,022,056	15.0
3. Moderately suitable	29, 33, 37, 38	1,173,013	474,712	6.9
4. Marginally suitable	6, 9, 10, 19, 28, 32, 40	2,273,994	920,273	13.5
TOTAL:		8,454,339	3,421,425	50.1

***** Where small enclaves of these soils occur in some western and northern counties, they have not been placed in Class 1 due to less favourable climate.

Some 8.5 million acres (50.1%) of the soils of the country are generally suitable for tillage and these can be broken down into 2.5 million acres; 1.0 m ha (14.7%) Class 1, 2.5 million acres, 1.0 m ha (15.0%) Class 2, 1.2 million acres, 0.5 m ha (6.9%) Class 3 and 2.3 million acres, 0.9 m ha (13.5%) Class 4.

Class 1 — Highly Suitable Tillage Soils

Soils of Class 1 are typical tillage soils having a light to medium texture, friable consistence and free drainage. They are, therefore, easily tilled. They are found predominantly in the east and south of the country and therefore they also enjoy a climatic advantage. They are suitable for the production of a wide range of tillage crops including malting barley and sugar beet as well as wheat, potatoes, roots and peas.

Class 2 — Suitable Tillage Soils

Soils of this class have certain shortcomings compared to those of Class 1. Associations 16 and 30 are somewhat coarse textured. Although easily tilled they can suffer drought in dry periods. Uneven ripening may also be a problem with certain crops especially malting barley where uniform ripening is important to grain quality.

Soils of Association 20 may be somewhat shallow in places. They also occur at slightly high elevations i.e. 100-150 m O.D. In addition, a significant part of this association occurs in east Donegal where climate limits the possible range of crops e.g., sugar beet would not yield well because of relatively low temperatures.

Association 31 has slight machinery-use difficulties because of slopes or hummocks. It also occurs predominantly outside the area which has a significant climatic advantage for crops such as sugar beet in particular and for early ripening of wheat crops. The major exception to this would be the Thurles-Cashel area which would be closer to Class 1.

The soils of Association 34 are well suited to cultivation but are heavier in texture than those of Class 1. They, therefore, tend to have a slight tilth problem. Nevertheless, they are well suited to the production of cereals, especially wheat. They are not so suited for malting barley since their moisture holding capacity is high.

Class 3 — Moderately Suitable Tillage Soils

Association 29 occurs on drumlin topography and therefore has certain slope limitations for machinery use. In addition, interdrumlin areas tend to be poorly drained whilst climate in the drumlin belt is not as favourable for certain tillage crops as in more southern areas.

Plate 19: *Soils placed in Class 1 for tillage have a light to medium texture, free drainage, and friable consistence. They have no slope or micro-topographic problems and are found predominently in the east and south of the country where they also have a climate advantage for crops such as sugar-beet.*

Although shallow depth leading to drought in dry seasons, is the predominant limitation within Association 33, many of the soils are sufficiently deep for tillage crops. However, slopes are often uneven, textures can be coarse and because the soils occur mainly in the west, there is also a climatic limitation for certain crops. For example, although sugar beet can be grown, yields are significantly lower than in more southern areas.

Association 37 has a somewhat heavy texture and weak structure. In addition, it occurs on a wide range of slopes ranging from 0-12°. These considerations, together with a climatic limitation, compared to more southern soils, impose limitations to its use in tillage. Nevertheless, it can be successfully used for cereals (especially feeding barley because of its shorter growing season) and for roots. Sugar beet is not well suited because of insufficient annual accumulated degree days in the area.

The main limitations of Association 38 are its heavy texture and weak structure. These make tillage operations more difficult in spring and autumn. Nevertheless, because of the proximity of Dublin, these soils are used for a wide range of crops especially vegetables, wheat, barley and potatoes. One of the main reasons for their successful use in tillage is the low average annual rainfall of this north-Dublin-east Meath region.

Class 4 — Marginally suitable tillage soils

Soils of Associations 6, 9 and 10 occur at relatively high elevations (150-365 m). Consequently, although they can be cultivated, they have certain climatic

disadvantages. The growing season is shorter and crops tend to be late in ripening. Slope and somewhat shallow depth in places are other limitations in these soils.

Association 19 is rather heavy in texture and occurs at relatively high elevations in places (100-300 m). Although they can be used for cereals and roots, the soils are generally more suited to grassland.

Association 28 occurs on drumlin topography and has slope problems for machinery use. In addition, a significant proportion (40%) of the soils of the association are poorly drained. Hence, the association is only marginally suitable for tillage.

Association 32 has a number of limitations for tillage. These are — hummocky and broken topography, intricate distribution pattern with associated poorly drained soils, peats and shallow Brown Earths; excessive permeability leading to podzolisation in places. (Small holdings and small fields which are features of this area are some of the problems facing agricultural intensification).

Soils of Association 40 are heavy in texture, have a weak structure and are imperfectly drained. Nevertheless, because they occur mainly in north Dublin, east Meath and south Louth, they are used (with soils of Association 38) for vegetables, potatoes and cereals. They have also been used for tillage crops in south Wexford in the recent past but their land use in that region is now mainly in grassland. Continuous cropping on these soils can lead to physical problems such as compaction and structure deterioration.

Distribution of Tillage Soils

The extent of tillage land on a provincial basis is shown in Table 13.

TABLE 13: Extent of suitable tillage land by province

Province	Acres	Hectares	% of total tillage land (Ireland)	% of Province
Connacht	1,498,458	606,418	17.7	35.8
Leinster	3,440,030	1,392,161	40.7	71.2
Munster	3,004,575	1,215,935	35.5	50.6
Ulster	511,276	206,911	6.1	26.2
TOTAL:	8,454,339	3,421,425	100.0	

Leinster has the greatest proportion of land suitable for tillage with 3.4 million acres, 1.4 m ha, or 71.2% of the area. Munster has over 3 million acres, 1.2 m ha, or 51.0% of the area suitable for tillage. Connacht has almost 1.5 million acres, 0.6 m ha (35.7% of the area) and Ulster over 0.5 million acres, 0.2, ha, or 25.4% of the area.

Quality of Tillage Land by Province

An indication of the quality of the tillage land occurring can be obtained by grouping the soils into the four tillage classes shown in Table 14.

TABLE 14: Quality of tillage land by province

Province	Class 1	Class 2	Class 3	Class 4	% of Province
Connacht	0.0	6.2	11.2	18.4	35.8
Leinster	20.0	25.8	9.8	15.6	71.2
Munster	21.4	17.1	1.4	10.7	50.6
Ulster	0.0	12.8	7.7	5.7	26.2

It can be seen that in Connacht no tillage land is in Class 1 and 6.2% is in Class 2 while most of it (18.4%) occurs in Class 4, i.e., marginally suitable. A somewhat similar pattern is seen for Ulster although in this case 12.8% of the province is in Class 2. In Leinster and Munster, on the other hand, most of the tillage land is either highly suitable or suitable, i.e. Classes 1 and 2, although in Leinster, a singificant proportion (15.6%) is in Class 4, i.e., marginally suitable. This is accounted for because of the placing in this class of Association 28 which occurs extensively in County Longford in particular, and of Association 40 which occurs extensively in Dublin, Meath, Louth, north Kildare and Wexford.

County Basis

The extent of land suitable for tillage on a county basis is shown in Table 15.

On the basis of percentage by county, Waterford (92%), Meath (88%), Wexford (83%) and Louth (83%) are highest while Leitrim (3%), Kerry (20%), Donegal (21%) and Cavan (23%) are lowest. On an acreage basis, however, the counties with the greatest amount of land suitable for tillage are Cork, with over 1.2 million acres, 0.5 m ha, Tipperary with 0.7 million acres, 0.3 m ha, Galway with 0.7 million acres, 0.3 m ha, with Meath 0.5 million acres, 0.2 m ha. Counties with lowest amounts are Leitrim (11,000 acres, 4,500 ha), Cavan (100,000 acres, 43,000 ha), Longford (152,000 acres, 62,000 ha) and Dublin (157,000 acres, 63,500 ha).

Since an overall percentage or acreage of land suitable for tillage by county can be misleading in terms of whether the land is highly suitable, suitable, moderately suitable or only marginally suitable, a breakdown of these tillage classes on a county basis is presented in Table 16.

Thus, it can be seen that marginally suitable tillage land (Class 4) occurs to a significant extent in a number of counties, notably — Sligo (43%), Longford (30%), Dublin (28%), Waterford (27%), Wicklow (26%), Meath (25%) and Clare (22%). Meath also has an additional 39% only moderately suitable (Class 3). On the other hand, extensive areas of highly suitable tillage land, Class 1, occur in Waterford (65%), Carlow (56%), Louth (50%), Cork (49%) and Wexford (47%).

The marginally suitable tillage land (Class 4) in Sligo is made up mainly of Associations 28 and 32 whose limitations have been outlined earlier. In Longford the marginally suitable tillage land consists entirely of Association 28 which is a fine

TABLE 15: Extent of suitable tillage land by county*

County	%	Acres	Hectares
Waterford	92	418,701	169,446
Meath	88	504,565	204,195
Wexford	83	479,706	194,134
Louth	83	167,005	67,586
Kilkenny	80	406,299	164,427
Westmeath	79	341,412	138,168
Carlow	78	173,015	70,018
**Dublin	69	157,108	63,580
Kildare	68	285,251	115,440
Offaly	65	318,244	128,972
Cork	63	1,162,129	470,307
Tipperary	63	659,996	267,097
Longford	59	152,100	61,554
Monaghan	56	174,465	70,605
Wicklow	53	263,469	106,624
Limerick	48	316,245	127,983
Laois	48	202,250	81,850
Galway	46	671,088	271,586
Sligo	46	202,762	82,057
Roscommon	42	254,338	102,929
Clare	30	234,094	94,737
Mayo	27	362,027	146,510
Cavan	23	106,612	43,145
Donegal	21	247,095	99,998
Kerry	20	226,769	91,772
Leitrim	3	11,091	4,489

*Includes marginally suitable tillage land category.

**Approximately 20% of Dublin is urban land.

textured, moderately well drained soil, occurring on drumlin topography. In Dublin and Meath, the marginally suitable tillage land is made up almost entirely of Association 40 which has texture, drainage and structure problems, while in Waterford and Wicklow they consist mainly of Associations 6 and 9, the sandstone and shale uplands respectively.

The highly suitable tillage land of Wexford and Louth consists mainly of Association 14, i.e., the well-drained acid brown earth soils formed from Ordovician and Silurian shale; in Carlow, it consists of the granite soils of Association 12 as well as the limestone soils of Association 36. In Waterford, the highly suitable tillage land is made up mainly of Associations 12, 13, 14 and 15, i.e., the rolling and gently undulating

TABLE 16: Tillage suitability classes on a county basis

	% of County				
County	Class 1	Class 2	Class 3	Class 4	Total
Waterford	64.8	0.8	Nil	26.8	92
Meath	9.7	12.6	38.9	25.4	87
Wexford	47.1	16.7	Nil	19.2	83
Louth	49.9	5.5	7.9	19.3	83
Kilkenny	26.9	35.4	Nil	17.5	80
Westmeath	Nil	53.0	20.1	5.8	79
Carlow	56.2	19.2	Nil	2.9	78
*Dublin	Nil	0.8	39.9	28.1	69
Kildare	18.4	30.7	4.7	14.3	68
Offaly	1.3	63.1	Nil	0.2	65
Cork	48.6	3.7	Nil	10.3	63
Tipperary	6.8	46.7	Nil	9.3	63
Longford	Nil	17.6	12.1	29.6	59
Monaghan	Nil	0.3	38.0	17.4	55
Wicklow	19.6	6.3	1.3	25.7	53
Limerick	1.5	35.2	6.1	4.9	48
Laois	20.4	24.7	Nil	2.5	48
Sligo	Nil	2.5	0.1	43.3	46
Galway	Nil	4.1	21.5	20.7	46
Roscommon	Nil	29.2	1.9	11.0	42
Clare	Nil	3.1	5.1	21.9	30
Mayo	Nil	1.0	10.4	16.0	27
Cavan	Nil	8.7	6.8	7.8	23
Donegal	Nil	17.8	Nil	1.8	20
Kerry	Nil	17.1	Nil	2.5	20
Leitrim	Nil	0.8	2.1	Nil	3

* Approximately 20% of Dublin is urban land.

lowland soils formed from rhyolite, sandstone/limestone, shale and sandstone respectively. In Cork the highly suitable tillage land is made up mainly of Association 15, i.e., the well-drained Brown Podzolics formed from sandstone, sandstone-shale glacial till.

Comparison between Actual Tillage Acreage and Potential Tillage Land

A comparison between the actual tillage acreage and the extent of land deemed suitable for tillage gives an estimate of the potential for expansion of the tillage acreage.

The estimated total area of land in Ireland generally suitable for tillage approximates to 8.5 million acres (Table 17). If the marginally suitable category is omitted, there are some 6.2 million acres of highly suitable to moderately suitable tillage land.

The most recent statistics available show (Table 17) that the total acreage in the Republic devoted to corn, root, green crops and fruit amounted to 1.1 million acres — i.e., only 18% of the highly suitable to moderately suitable tillage land or only 13% of the total suitable tillage land, including marginally suitable tillage land.

TABLE 17: Total corn, roots, green crops and fruit tillage and. (1977) compared to total suitable tillage land.

		Actual tillage extent		Total suitable tillage land	
	%	ac	ha	ac	ha
Ireland	100	1,135,693	459,609	8,454,339	3,421,425
Leinster	55	624,631	252,785	3,440,030	1,392,161
Munster	31	352,065	142,479	3,004,575	1,215,935
Connacht	8	90,855	36,769	1,498,458	606,418
Ulster	6	68,142	27,577	511,276	206,911

On a provincial basis, although Leinster has the greatest amount of tillage at 624,631 acres (252,785 ha) this only constitutes some 18% of the suitable tillage land in the province. Similarly, the actual tillage acreage as a percentage of the total suitable land is 12% for Munster, 6% for Connacht and 13% for Ulster.

It is obvious, therefore, that suitable land is not a constraint to the expansion of the tillage acreage. Nevertheless, Leinster and Munster have the greatest potentials with 41% and 36% of the total potential tillage land respectively, with Connacht having 18% and Ulster 16% (Table 13).

At county level the statistics also indicate that there is considerable soil potential for tillage expansion. For example, taking the four counties with highest tillage acreage, Cork uses only 18% of its potential tillage area, Wexford 28%, Kilkenny 17% and Tipperary 9%.

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