SOILS OF TIPPERARY NORTH RIDING

National Soil Survey of Ireland

Teagasc
Agriculture and Food Development Authority

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SOILS OF TIPPERARY NORTH RIDING

by

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National Soil Survey of Ireland

Teagasc

(Agriculture and Food Development Authority)

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Yet meet him in his cabin rude
Or dancing with his dark-haired Mary
You'd swear they knew no other mood
But mirth and love in Tipperary

Thomas Davis

PREFACE

This publication, Soil Survey Bulletin No. 42, presents the Findings of the soil survey of Tipperary North Riding. It is one of a series of county soil surveys being carried out by the National Soil Survey of Teagasc (Agricultural and Food Development Authority) for the purpose of providing basic information which can be used in optimum land-use planning.

The field mapping was carried out at a scale of 1:10,560 (6 in. = 1 mile; 1 cm = 0.1 km) but due to scale limitation all the detail mapped on the field sheets is not shown on the published soil map.

Mr. T. F. Finch was mainly responsible for this survey and together with the late Dr. M. J. Gardiner compiled the report. Work in the Riding commenced in 1970 and the Field investigations were completed in 1984. Mr. S. Diamond gave assistance and advice in soil correlation, classification and land-use interpretation, and Dr. R. F. Hammond in peat classification. Dr. M. Bulfin and Mr. T. Radford contributed information on aspects of land-use in relation to forestry. Dr. M. J. Gardiner and Mr. T. F. Finch also wrote the chapter on suitability for grassland and cultivation.

Various members of the staff of the National Soil Survey and of the Soils Division of An Foras Taluntais (now Teagasc) contributed to the bulletin; Dr. G. A. Fleming and Mr. P. Parle wrote the chapter on trace elements and Dr. J. Lee the chapter on grazing capacity. The bulletin was edited by Dr. C. O'Rourke (who also took the aerial photographs) and typesetting was by Ms. Helen O'Donnell.

The analytical data in Appendix II were provided mainly 6 y the laboratory staff of the Soil Survey Department with assistance from the Soil Fertility and Chemistry Department, and the Plant Nutrition and Biochemistry Department, at Johnstown Castle.

The colour maps and various figures were prepared by the staff of the Cartographic Section, National Soil Survey, Johnstown Castle.

The colour printing of the maps was done by the Ordnance Survey which was also the source of base maps for the field mapping; the printed maps are based on the Ordnance Survey by permission of the Government.

Grateful acknowledgement is made to all those contributors mentioned here and to others who helped in various ways.

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September 1992

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These publications available from: Teagasc, Publications Office, 19 Sandymount Avenue, Dublin 4

*Out of print

CHAPTER 1

GENERAL DESCRIPTION OF THE AREA

Location and Extent

The North Riding of Tipperary* (Fig. 1.1), lies between 52° 35' and 53° 10' north latitude and 7° 35' and 8° 34' west longitude. The Riding occupies an area of 198,830 hectares (1988 km^2) and is included in the 0.5 inch (1:126,720) Ordnance Survey Sheets 15 and 18. Sheet 15 embraces the northern part of the Riding and includes the towns of Borrisokane, Cloghjordan and Roscrea. Sheet 18 covers the southern part and includes the towns of Nenagh, Thurles, Templemore and Borrisoleigh.

Topographic Features

Most of the Riding consists of limestone lowlands (Fig. 1.2). These are divided, for the most part, by the Silvermine Hills in which Keeper Hill rises to 694 metres. The northern limestone lowlands connect with the southern limestone lowlands at Roscrea. The Arra Mountains lie west of the Silvermine Hills and rise to approximately 450 metres. In the middle of the northern limestone lowland there is a fault-induced line of hills which reaches 210 metres in Knockshigowna (Photo 4.5). South east of Roscrea, a ridge of hills, the Black Hills, rises. Extending south from Urlingford in County Kilkenny there is an area of raised bog which is now being exploited for machine turf and turf briquettes (Photo 4.7).

River Systems

The northern limestone lowlands and the western part of the Silvermines drain into the Shannon at Lough Derg by the Nenagh river, the Ballyfinboy, the Kilmastulla and the Mulkeir rivers. Except for a small area between Roscrea and the Black Hills which is drained by the headwaters of the Nore, the rest of the Riding is drained by the Suir and its tributaries.

Climate

Ireland has a typical west maritime climate with relatively mild moist winters and cool cloudy summers. For most of the year, maritime air associated with the Gulf Stream helps to moderate the climate. The prevailing winds are westerly and south-westerly. Average humidity is high. Average annual precipitation is highest on the west coast and

*Referred to throughout the text as 'the Riding'

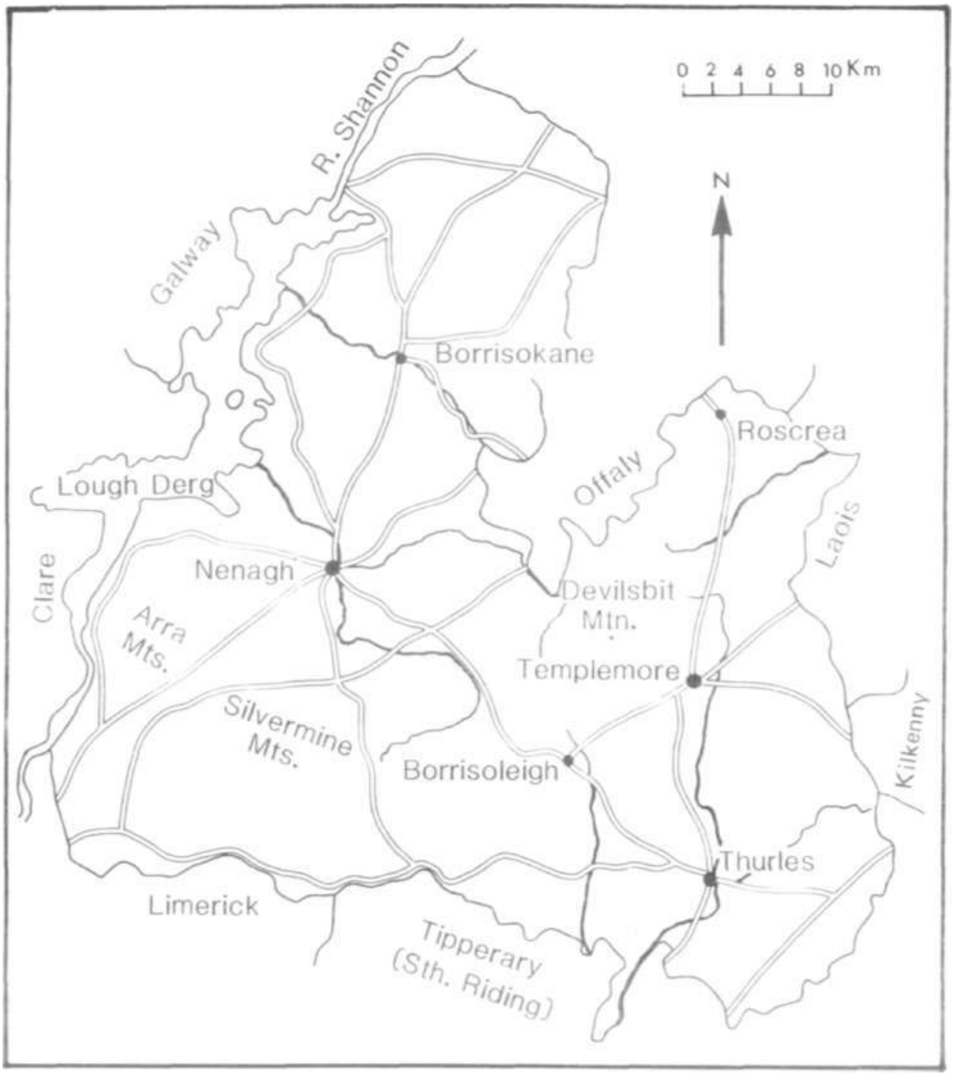

Fig. 1.1: The North Riding of County Tipperary.

in areas of high relief. The climatic information for the North Tipperary area presented in Tables 1.1 and 1.2 is based on records of the Meteorological Service.

Temperature

Thurles is the only meteorological station in the Riding which records temperature. The data for Birr, Co. Offaly are also relevant, however, since this station is just east of the Tipperary boundary. Mean daily minimum and maximum temperatures and mean monthly temperatures for Thurles and Birr are given in Table 1.1.

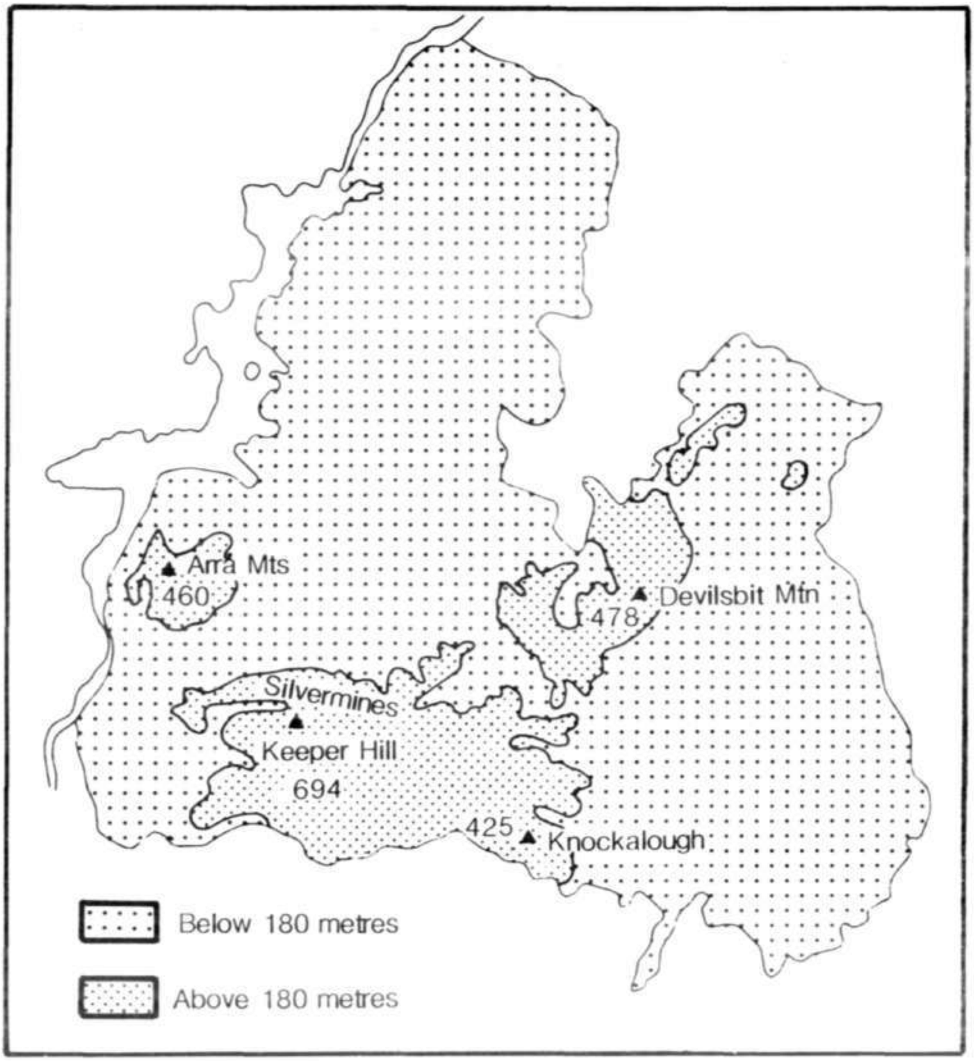

Fig. 1.2: Topography of Tipperary North Riding.

TABLE 1.1: Mean daily maximum, mean daily minimum and mean air temperature (°C) at Thurles and Birr, 1931-1960

County	Tipperary			Offaly		
Station	Thurles			Birr		
Latitude	52° 39'N			53° 05'N		
Longitude	7° 50"W			7° 53' W		
National Grid Reference	S 12 56			N 07 04		
Elevation above mean sea level	98 m			70 m		
	Mean Max.	Mean Min.	Mean	Mean Max.	Mean Min.	Mean
January	7.5	1.2	4.4	7.3	1.4	4.4
February	8.1	1.4	4.8	8.0	1.7	4.9
March	10.3	2.9	6.6	10.4	2.9	6.7
April	12.8	4.0	8.4	**12.7**	4.0	8.4
May	15.8	6.1	**11.0**	15.0	6.2	11.0
June	18.4	9.1	13.8	18.4	9.2	13.8
July	19.4	10.7	15.1	19.2	10.9	15.1
August	19.6	10.4	15.0	19.3	10.8	15.1
September	17.2	8.7	13.0	17.0	9.1	13.1
October	13.6	6.2	9.9	13.5	6.3	9.9
November	10.3	3.5	6.9	10.0	3.6	6.8
December	8.3	2.3	5.3	8.1	2.5	5.3
Spring	13.0	4.3	8.7	13.0	4.4	8.7
Summer	19.1	10.1	14.6	19.0	10.3	14.7
Autumn	13.7	6.1	9.9	13.5	6.3	9.9
Winter	8.0	1.6	4.8	7.8	1.9	4.9
Year	13.4	5.5	9.5	13.3	5.7	9.5

Rainfall

Table 1.2 shows the monthly and annual average rainfall from 1941 to 1970. All the stations with annual averages of over 1000 mm are associated with the hills or are situated in the foothills. Those of less than 1000 mm are situated on the limestone lowlands and frequently show figures of less than 900 mm.

TABLE 1.2: Rainfall (mm), Tipperary North Riding stations

Rainfall stations	Elevation **(m)**	Monthly and annual averages I(mm), 1941-1970												
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	[)ec	Year
Birdhill (Partecn Weir)	34	107	70	66	70	76	72	87	100	~105	103	106	130	1092
Borrisokane G.S.	59	87	61	54	56	65	59	73	83	87	84	83	99	891
Borrisoleigh G.S.[1]	108	127	85	80	71	79	63	77	88	104	102	109	128	1113
Cloghjordan G.S.[1]	94	93	63	58	60	68	60	76	89	94	89	87	104	941
Cloghjordan (Modreeny)	84	92	61	59	59	69	63	78	89	92	90	87	102	941
Dolla G.S.[1]	86	128	81	74	75	81	64	77	91	110	111	111	137	1140
Littleton	122	100	68	66	63	73	61	69	83	91	91	92	104	961
Lorrha G.S.[1]	45	84	59	53	53	63	62	74	87	87	87	80	94	883
Moyne G.S.[1]	128	97	62	61	56	66	59	70	80	89	86	89	98	913
Ncnagh (Castle Lough)	32	117	74	70	71	71	68	79	90	100	104	103	134	1081
Nenagh^	59	104	66	60	62	65	51	66	77	87	92	91	106	927
Ncnagh (Vocational School)	61	93	63	58	58	64	59	69	80	89	92	89	107	921
Newport G.S.[1]	59	107	67	70	68	82	70	89	98	105	105	**99**	; -2	**io;:**
Newport (Killoscully)	180	118	75	69	78	80	70	92	108	111	111	110	136	1158
Newport (Vocational School)	61	102	62	62	68	73	65	79	94	99	102	97	120	1023
Portroe G.S.[1]	160	119	77	70	70	70	70	84	95	107	104	105	129	1100
Puckaun G.S.[1]	65	86	57	53	52	65	53	69	79	90	86	83	99	872
Rear Cross G.S.	210	148	96	88	92	92	88	114	123	139	136	138	160	1414
Roscrea (Fanure)	64	87	63	58	57	68	57	71	81	86	86	78	93	885
Roscrea (Mt. St. Joseph)	76	90	62	58	58	69	56	70	79	85	84	77	95	883
Roscrea^	116	98	68	60	60	74	62	74	87	92	90	83	100	948
Tcmplederry G.S.[1]	141	139	94	84	80	83	68	81	93	112	113	117	145	1209
Tcmplcmore G.S.	116	104	69	64	58	75	51	75	80	90	89	88	106	949
Templetouhy (Bord na Mona)	131	95	65	58	59	66	61	66	76	88	85	85	96	900
Templetouhy G.S.	134	97	63	60	57	69	58	69	78	92	90	86	99	918
Thurles (Sugar factory)	101	96	63	60	62	69	58	67	80	91	88	90	101	925
Knockalough Mtn.	421	149	94	87	94	93	76	91	112	123	136	124	158	1337

Garda Sfochana Station; ^Electricity Transmitting Station

CHAPTER 2

GEOLOGY OF TTPPERARY NORTH RIDING

Solid Geology

Carboniferous limestone is found under most of the lowlands (Fig. 2.1). In the north, there is a series of shales interbedded in the limestone (Photo 4.5). As one moves south through Borrisokane the limestone becomes purer. Towards the southern extremity of a geological fault in the hill of Knockshigowna, Old Red Sandstone (Devonian) is raised together with Silurian shales. The other small area of hills, the Black Hills ridge, south east of Roscrea, is an Old Red Sandstone ridge rising out of the limestone. The Old Red Sandstone borders to the hills of the Arra Mountains are covered by limestone glacial drift but they can be traced along the shores of Youghal Bay in Lough Derg. The Arra Mountains themselves and the foothills are composed of Silurian or Ordovician shales, siltstones and grits. There is a geological fault across the limestone lowlands which is the source of successful heavy metal mining in the Silvermines village area. On the south eastern side of the fault, the rocks consist of Silurian and Ordovician shales. Sandstone and conglomerates of the Devonian (Old Red Sandstone) Period are found on top of the Silvermines ridge. The same rocks form the crest of Keeper Hill and the hills to its south west. The rest of the Silvermine Hills are composed of early Palaeozoic shales except for the extreme south east where sandstone and conglomerates appear again near Drumbane.

The rest of the Riding (lowlands) is composed of rock of Upper, Middle and Lower Carboniferous limestone.

Glacial Geology

The lowlands are all coated with drift left by a recent episode of the Midlandian glaciation (Fig. 2.2). This was the Drumlin Readvance but the drumlins are confined to only a few on the south side of the Arra Mountains. The Silvermine Hills formed a barrier to the ice movement which poured through the gaps in the southern hills and left moraines at Ballybeg, Sallypark, Inch and Milestone. There is no evidence available to date that this incursion into the hills is of the Drumlin Readvance or of the original Midlandian glaciation age. The small moraine at Sallypark, with its extensive area of outwash filling the valley to the south, suggests that it is of Midianaian age. This moraine would connect with the one to the north east, from Ballinlough to Cloncannon, and which is likely to be of the same age as that around Roscrea and extending from there to the north around Slieve Bloom. There is also another moraine stretching from Clonakenny to the Black Hills ridge.

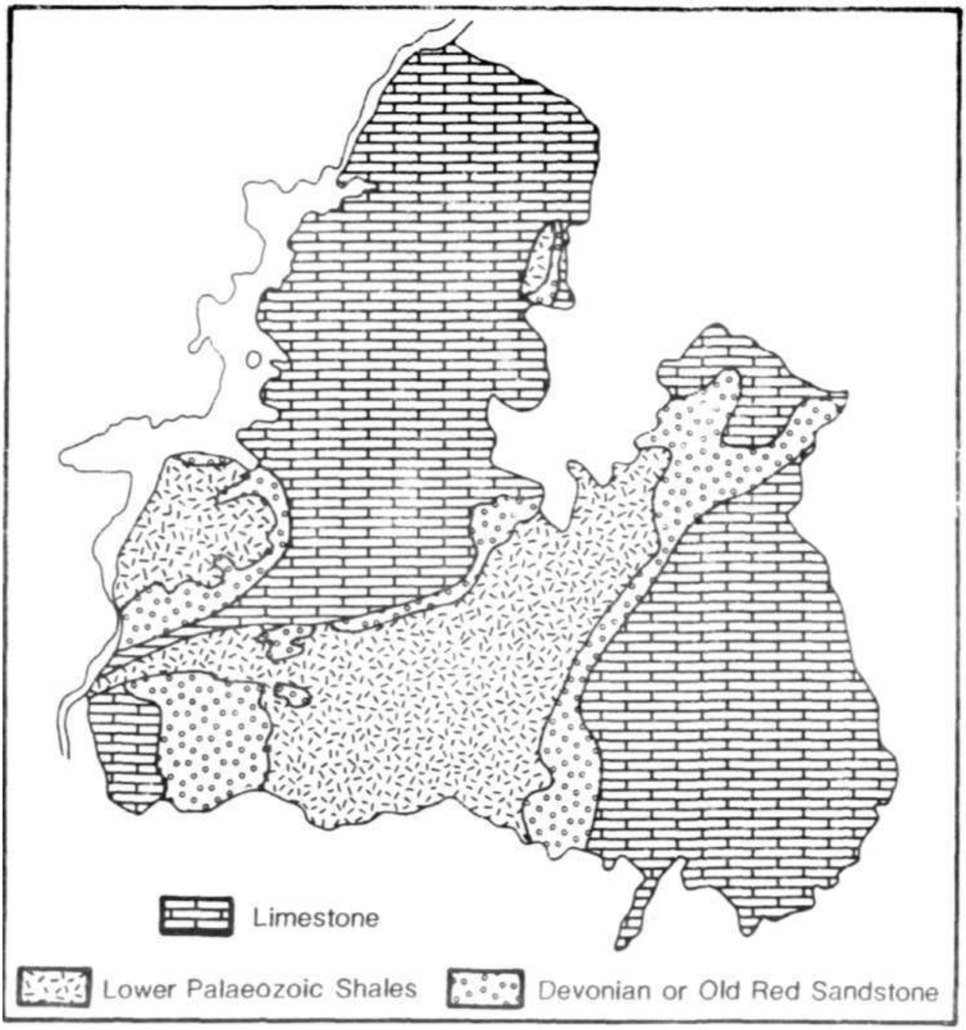

Fig. 2.1: Solid geology of Tipperary North Riding.

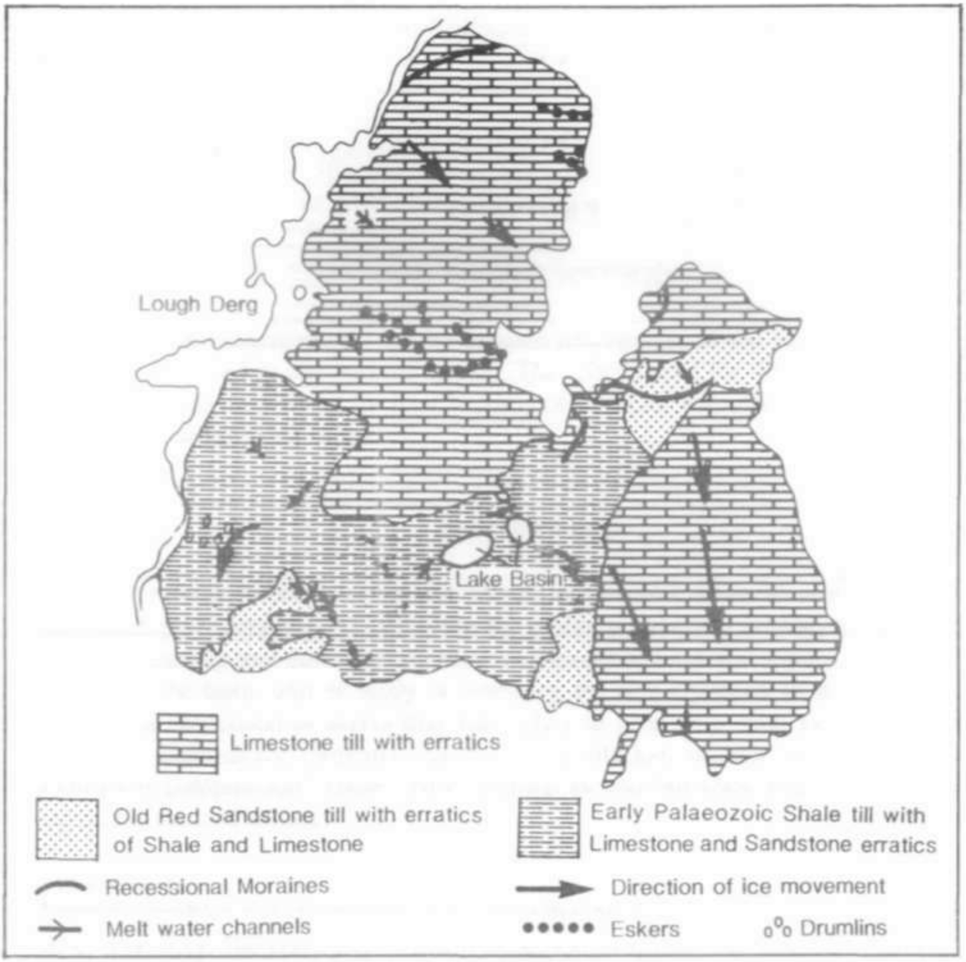

Fig. 2.2: Glacial geology of Tipperary North Riding.

CHAPTER 3

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 below.

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. 3.1). 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.

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, bacteria, fungi, earthworms, and small animals, is most abundant, and

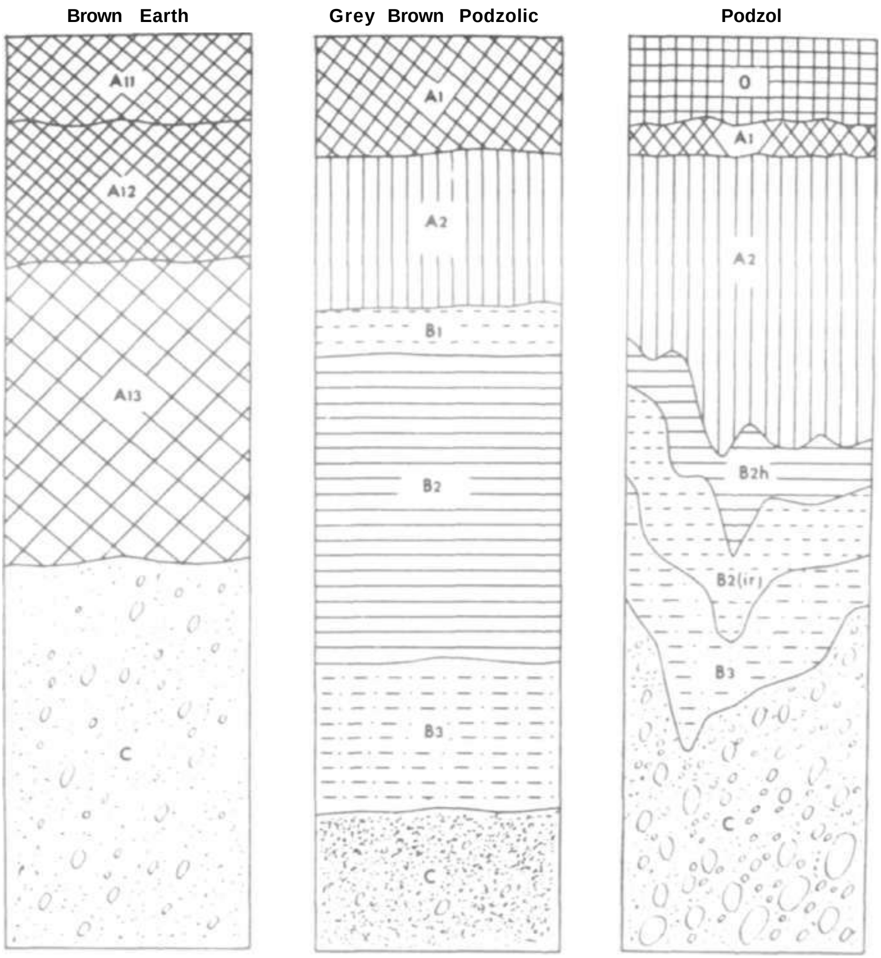

Fig. 3.1: Diagrammatic representation of three common soil profiles.

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 compounds and also in certain cases 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 also of other constituents . Two sub-divisions of the A horizon are commonly made, namely Al and A2. Either the Al or both Al and A2 may be represented in a profile. The Al is a surface mineral horizon that usually contains a higher proportion of organic matter incorporated with the mineral matter than any of the underlying horizons. In cultivated soils this horizon corresponds to the plough layer and may be designated Ap. 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 constituents, principally iron. The A2 signifies a transition zone between the A and B horizon.

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 horizon. 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., Bl, B2, 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. Bl and B3 denote transitional horizons from A and B and from B and 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 matter more usually associated with very poorly drained or very degraded (podzolised) mineral soils. Where little or no decomposition has taken place the symbol Oi is used; Oa denotes highly decomposed organic materials; Oe denotes an intermediate degree of 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 but in North Tipperary is usually about two metres. 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, elevation 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 Soils

Laboratory, Johnstown Castle Research Centre. The analytical data supplement many of the field observations and provide a more complete picture of the true soil character. The results of these analyses for representative profiles on each Soil Series are given in Appendix II.

Soil Mapping

The character of every soil can be attributed largely to the interaction of five major factors of soil formation: 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 and subsequent gains, losses and alterations within the profile. The relative influence of these factors is responsible for many of the differences in our soils. A sixth factor influencing many non-virgin soils is man's interference with the natural development processes and his modification of the soils for his own particular purposes.

None of the five 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 Series

The primary category used in mapping is the Soil Series, which comprises soils with similar type and arrangement of horizons, and developed from similar parent material. The Soil Series is also a basic category in soil classification.

A major problem in mapping soils is the delineation of boundaries between different Series. Typical profiles of two different Soil Series may differ widely but, where the Series are contiguous, it is usual for them to merge, sometimes over a considerable distance. Consequently, a line on the map very often defines the merging zone between soils rather than a sharp change in the soil character.

A Series is usually named after the original location in which the particular soils are best expressed or occur most widely.

Soil Variants

Variants are separate Soils Series that are too small in extent to be shown at certain scales of mapping. A soil which is recognised and defined as a variant in one survey area, however, may be designated as a separate Series later in another area, depending on its extent

Other Soil Units

Soils within a Series may be further sub-divided into soil types on the basis of surface textural differences. Different soil phases may also be mapped, covering variations in features such as slope, depth or stoniness, that are important in soil behaviour and land-use. Several such phases have been segregated in North Tipperary.

Scale of Mapping

Field mapping is carried out on a scale of 6 inches to 1 mile (1:10,560), 1 cm = 0.1 km but this detail is reduced to a scale of 0.5 inches to 1 mile (1:126,720), 1 cm = 1.26 km for publication. Since one 6-inch sheet covers an area of 24 square miles, to publish on this scale would necessitate, in the case of North Tipperary, at least 40 individual map sheets. Considerations such as the cost of colour printing, ease of handling and general use of the map warrant reduction to the smaller scale.

This reduction, however, introduces certain difficulties. It has been found necessary to consolidate and, in some cases, delete some of the less extensive soil separations shown on the larger scale. On a scale of 1:126,720 it is possible to show a minimum area of 10 hectares. This means that any uniformly-coloured area on the published map may include enclaves of less than 10 hectares. Where Soil Series are recognised but where their distribution pattern with contiguous Series is so intricate as to defy clear-cut delineation on the map a Soil Complex is mapped. The component Series within the Complex are named and, where possible, their relative proportions are given.

CHAPTER 4

THE SOILS AND THEIR USE RANGE

Thirty-six Soil Series ('Series' defined in Chapter 3) have been recognised in the Riding and are shown on the accompanying map. The different Series have been given geographic names based on the location in which the particular soils are best exemplified or are most widely distributed. Frequently, the Series names occurred in a previously-surveyed county, e.g. Elton Series occurs extensively near Elton in south east Limerick and is named after the area where it was typically developed. Eighteen Soil Complexes and eight phases have also been recognised and mapped. Soil variants are included with the Series to which they are related.

Soils can be classified on a broad scale into Great Soil Groups each of which consists of a collection of closely related Soil Series. Each Great Soil Group consists of soils having one or more distinguishing features in common. A certain latitude in profile variation is permissible at this level of classification but there is an overall similarity of quite a high order. The Great Soil Group is not confined to one particular geological parent material since soils are classified on the basis of profile characteristics.

The descriptions of Soil Series mapped in the Riding are arranged according to Great Soil Groups below. Soils derived from alluvial deposits, complexes and variants are treated separately. Table 4.1 shows the Soil Series grouped into Great Soil Groups. The extent of each Series and Group as a percentage of the total area surveyed is also given. Soil variants are also classified according to Great Soil Groups (Table 4.1). The main soil parent materials occurring within the Riding and the different Series found on each of them are shown in Table 4.2.

TABLE 4.1 Classification and extent of North Tipperary soils

Great Soil Group	Series and Phases	% Total Area
Regosol	Carney	0.01
	Milltownpass	0.06
Lithosol	Slievereagh	0.01
Brown Earth	Baggotstown	0.31
	Ballincurra	0.24
	Ballynalacken	1.26
	Dovea	0.34
	Kinvarra	0.04
	Knocknaskeha	0.64

TABLE 4.1 (Contd.): Classification and extent of North Tipperary soils

Great Soil Group	Series and Phases	% Total Area
Rendzina	Burren	0.17
	Burren Rocky Phase	0.92
	Kilcolgan	0.03
Grey Brown Podzolic	Elton	9.85
	Patrickswell	23.08
	Patrickswell Lithic Phase	1.34
	Patrickswell Bouldery Phase	1.22
Brown Podzolic	Borrisoleigh	10.91
	Borrisoleigh Steep Phase	0.40
	Cooga	0.94
	Doonglara	1.16
Podzol	Knockaceol	0.04
	Knockaceol Peaty Phase	0.03
	Knockastanna	1.66
	Knockastanna Peaty Phase	1.84
	See fin	0.02
Gley	Ballyshear	0.47
	Camoge	3.72
	Coolalough	0.15
	Derrygareen	0.05
	Drombanny	0.26
	Feale	2.40
	Gortaclareen	2.38
	Howardstown	0.95
	Kilcommon	6.15
	Kilcommon Peaty Phase	1.16
	Kilgory	0.03
	Mylerstown	2.15
	Puckane	0.27
	Puckane Peaty Phase	0.03
Peat	Allen	1.63
	Aughty	0.53
	Banagher	4.85
	Boora	1.47
	Pollardstown	0.18
	Gortnamona	0.79
	Turbary	4.74

TABLE 4.1 (Contd.): Classification and extent of North Tipperary soils

Great Soil Group	Series and Phases
	Soil Variant
Brown Earth	Baggotstown Deep Variant
Grey Brown Podzolic	Patrickswell Steep Variant Patrickswell Shallow Variant
Great Soil Group	*Other Soils**
Brown Earth	Ballyvorheen Scraggen
Rendzina	Crush
Lithosol	Knockshigowna
Grey Brown Podzolic	Mortarstown
Regosol	Rathborney Shannon

*Series mapped in other counties but not extensive enough in North Tipperary to show on the accompanying 1:126,720 scale map

TABLE 4.2: Parent materials of soils of North Tipperary

Soil Series	Parent Materials
Ballincurra Kinvarra Kilcolgan Elton Patrickswell Patrickswell Lithic Phase Patrickswell Bouldery Phase Ballyshear Howardstown Mylerstown	Glacial till of predominantly limestone composition
Baggotstown	Fluvioglacial materials of predominantly limestone composition
Burren Burren Rocky Phase	Limestone bedrock

TABLE 4.2 (Contd.): Parent material of soils of North Tipperary

Soil Series	Parent Materials
Carney Milltownpass Coolalough Drombanny	Limestone alluvium
Dovea	Glacial till composed of limestone and shale
Camoge	Alluvium of mixed limestone-sandstone composition
Ballynalacken Borrisoleigh Borrisoleigh Steep Phase Knockastanna Knockastanna Peaty Phase Kilcommon Kilcommon Peaty Phase	Glacial till of predominantly shale composition
Feale	Shale alluvium with some limestone influence
Doonglara	Glacial till of predominantly sandstone composition, some sandstone bedrock
Slievereagh Knockaceol Knockaceol Peaty Phase	Mainly sandstone bedrock
Seefin	Mainly sandstone colluvium (some sandstone till and bedrock)
Derrygareen	Fluvioglacial materials of predominantly sandstone composition
Gortaclareen Puckane Puckane Peaty Phase	Glacial till mainly of mixed sandstone-shale composition (with some limestone)
Cooga	Fluvioglacial materials of sandstone-shale composition
Kilgory	Sandstone alluvium
Knocknaskeha	Glacial till of mixed sandstone-shale composition

Regosol Group

This group comprises mineral soils which are immature and show no distinct horizon development. The soils occur mostly in lowlying flat areas along river courses and at river estuaries, but they are also found on young deposits such as aeolian (windblown) sands. Depending on the source of the deposits, such soils may vary in nutrient status and also in physical and drainage characteristics.

Carney Series
This Series cover 0.01% (22 hectares) of the Riding. It is a regosol which is being added to at present during winter floodings. The pH is 8.0 in the surface and 8.8 in the subsoil, reflecting the calcareous nature of the surrounding area. The texture is silty clay on the surface and this is underlain by marl.

Soil Suitability: This soil has a limited use range by reason of its high pH and the attendant trace element problems. Flooding during periods of heavy rainfall is another problem. Soil structure is weak and leads to poaching damage. The underlying marl causes difficulties in cultivation.

Milltownpass Series
This Series occupies 0.06% (129 ha) of the Riding. It is frequently associated with the Camoge Series along the lower course of the River Suir. It is classified as a well-drained regosol. It consists of a surface horizon of yellowish brown loamy sand over a loamy sand to sandy loam showing only single grain structure.

Soil Suitability: Due to the danger of flooding and coarse texture this soil has a limited use range. It has a moderately good potential for grass production provided that management and fertiliser use are appropriate.

Lithosol Group

This group consists of skeletal stony soils often with high organic matter overlying solid or shattered rock. There are usually frequent rock outcrops. Lithosols are normally found in the Riding on the crests of ridges and hills and are frequently associated with podzols and blanket peat. Their use range is limited to rough grazing.

Slievereagh Series
This Series occupies 0.01% (20 ha) of the Riding. Some of its occurrences are too small to be mapped. It is found on the summits of Old Red Sandstone ridges and consists typically of a slightly peaty A horizon over a sandy loam horizon less than 15 cm deep. Below this is shattered or solid Old Red Sandstone bedrock.

Soil Suitability: The use range of this soil is extremely limited and is confined to extensive grazing.

Brown Earth Group

The Brown Earths are mature, well-drained soils possessing a uniform profile with little differentiation into horizons. Since they have not been extensively leached or degraded there is no evidence in the profile of removal and deposition of materials such as iron oxides, humus or clay. However, as with all Irish soils some leaching has occurred, resulting in the downward movement of soluble bases, notably carbonates of calcium and magnesium.

Depending upon the parent materials there are three categories of Brown Earths. Those of low base status are developed from acid parent materials, others have developed from base-rich parent materials and these are high base status Brown Earths. An intermediate medium base status is also distinguished. Under conditions of high rainfall and excessive leaching even base-rich parent materials can give rise to Brown Earths of medium or even low base status.

Brown Earths are normally of medium texture, good structure, free drainage and good friability. Hence they tend to be well suited to arable farming. Although generally of low fertility they respond well to fertiliser application?. With good management they usually give good grassland and are also suited to forestry.

Baggotstown Series

This Series occurs over 0.31% (621 ha) of the Riding. It is also frequently found in isolated patches too small to be mapped. It is developed over fluvioglacial deposits of the Midlandian glaciation and occurs on dead ice features such as eskers and outwash gravels. A good example of the outwash gravels can be seen at Carrabaha on the Nenagh-Borrisoleigh road. In the case of moraines the area along the Little Brosna River and the moraine around Roscrea are fine examples. In this latter position, the Baggotstown Series occurs in a Complex with soils such as Patricks well, Elton and Banagher. On the eskers south of Nenagh, Baggotstown is the dominant soil in the Baggotstown-Crush Complex. Another extensive area of the Baggotstown Series is the outwash delta at Cloncannon and the recessional moraine running south from this to Ballybeg. The front of this moraine has slopes of up to 25°.

This soil is a shallow Brown Earth of high base status. The texture is characteristically gravelly sandy-loam to loam on the surface, becoming more gravelly sandy-loam to sand as the C horizon is reached. The pH ranges from around 6.4 in the Al to over 8.0 in the C horizon. The topography is strongly rolling with frequent steep slopes.

Soil Suitability: The soil has a moderately wide use-range. It is naturally well-drained and has a fairly well-developed structure. The finer matrix of the soil has a sandy loam texture, but the extensive distribution of gravels throughout the profile provides a loose consistency giving excessive drainage in many cases. In dry seasons, therefore, a moisture deficit may limit production.

This friable soil is moderately suitable for cultivated cropping, provided cultural and management practices are of a sufficiently high standard. To preserve soil structure and to maintain an adequate organic matter supply, tillage must be rotated with pasture. The lime status is fairly satisfactory. In the natural state, nutrient status is low and must be supplemented by the appropriate fertilisers. This is a moderately good grassland soil, capable of high levels of production under proper management, including adequate manuring. The main limitation is seasonal drought It responds well to nitrogen for early grass and the pastures can be grazed over a long season.

Baggotstown Series—Deep Variant

This variant occurs in the Baggotstown, Patrickswell and Elton complexes. It is found on kame-and-kettle topography south east of Roscrea. The normal sequence is the occurrence of this variant downslope from the Baggotstown Series at the kame crest. At the base the Patrickswell and Elton Series occur. The parent materials are fluvioglacial deposits of limestone composition with some shale and sandstone. The slopes are normally less than 8◇.

This variant has a solum (A + B horizon) depth of over 65 cm. The textures vary from gravelly loam in the surface to gravelly sandy loam in the B horizon. The pH varies from around 6.4 in the A1 to over 7.0 in the B horizon. The structure is good though weak and in the C horizon it becomes single grain. The drainage is excessive and rooting is very well developed.

Soil Suitability: The use range of this soil is wide. Because of its greater depth it is not so liable to drought.

Ballincurra Series

This Series occupies 0.24% (486 ha) of the Riding chiefly in the area north of Lorrha. It is also frequently found, however, in small areas especially north of Nenagh but these are too small for the map scale. It is associated with limestone bedrock thinly covered with limestone till with impurities of shale and sandstone. It is frequently less than 45 cm deep. In this area the topography is gentle and bedrock seldom protrudes. In some places, notably in the area south of Terryglass, it occurs in association with the Burren Series in pockets in the limestone. The texture of the A1 horizon is gravelly clay loam and the (B) horizon is gravelly clay loam to loam. The pH ranges from around 6.7 in the A to over 7 in the B horizon. Soil depth is shallow and bedrock is seldom over 40 cm from the surface.

Soil Suitability: Due to shallowness and rock outcrops this soil has a limited use range. Tillage is limited to only a few places but the land may be grazed over a long season.

Ballynalacken Series

This Series occurs on the shales of the Ordovician and Silurian formations in the Silvermine and Arra mountains. It covers 1.26% (2527 ha) of the Riding and occurs south and south east of Silvermines village and north of Templederry; it also occurs in smaller areas to the east of these. Its greatest extent lies to the south of Youghal Bay (Lough Derg). It is a brown earth of low base status. It is frequently found on kame-and-kettle topography and is associated with stony and bouldery soils. It is found frequently associated with the Borrisoleigh Series.

Photo 4.1. Outcroppings of limestone bedrock (Burren Rocky Phase, Rendzina) in limestone drift (Patrickswell Series, Grey Brown Podzolic), east shore of Lough Derg near Coolbaun.

Photo 4.2. Soils of the Elton Series (Grey Brown Podzolic) north-west of Templemore, with Devilsbit Mountain in background. This Series is the third-largest in the Riding, at 9.85% of the total land area. Suitability Class: Cultivation, II; Grassland, A.

This soil had low to moderately low pH values and is essentially loam textured. The normal depth of solum seldom exceeds 50 cm. Drainage and rooting depth are good.

Soil Suitability: This soil has a wide use range being suitable for tillage, grassland and forestry. It is used in Tipperary mainly for grass production and forestry. If adequately fertilised it is highly productive.

Dovea Series
This Series is of limited extent and covers only 0.34% (682 ha) of the Riding. It is found mainly on the north side of the village of Dovea. It is a brown earth of high base status. The texture is fine, ranging from silty clay loam to clay in the A1 horizon and becoming a loam below and then a silty clay loam again by 70 cm. The pH is normally high, varying between 6.1 to 7.4 in the surface and becoming pH 8.0 by 40 or 50 cm.

Soil Suitability: This soil has a relatively wide use range. Despite its heavy texture it is suitable for grass production and can also be used for some tillage crops. For grazing there is a liability to poaching damage if grazing is allowed too early in spring or too late in autumn.

Kinvarra Series
This Series occupies only 0.04% (79 ha) of the Riding. It is found sporadically throughout the area to the south of Nenagh. Areas large enough to be shown on the map occur some 3 km south west of Borrisokane and also about 6 km east of this town. It is associated with the Patrickswell Series. It is a brown earth of high base status with good to excessive drainage. Surface textures range from gravelly clay loam to gravelly loam. The soils are shallow and seldom exceed 45 cm in depth and more usually are 30 cm. Roots are found throughout the profile and the pH values are high since they occur over limestone.

Soil Suitability: This soil has a wide use range. It is well suited to tillage and grassland production but in very dry spells production can be reduced due to lack of moisture.

Knocknaskeha Series
This Series covers 0.64% (1284 ha) of the Riding and is found only at the northern edge of the sandstone ridge of Knock to the east of Roscrea. It occurs on areas of gentle relief at the foot of the ridges over glacial drift composed principally of Old Red Sandstone but with up to 50% limestone in places. As the limestone content increases it grades into the Patrickswell Series and as it decreases it grades into the Puckane or Gortaclareen Series. It is normally well to excessively drained. The natural pH is variable depending on the limestone content. The soil is a brown earth of medium base status.

Soil Suitability: This soil has a wide use range. It is suitable for tillage and is also a good grassland soil with good resistance to poaching.

Rendzina Group

These are shallow soils, usually less than 50 cm deep derived from parent material containing over 40% carbonates. The surface is dark in colour with moderately strong structure and neutral to alkaline reaction. A calcareous (B) horizon may be present. Drainage is always free to excessive.

Where they are of sufficient depth, rendzinas are suitable for tillage and pasture but in many places lack of soil depth precludes tillage. Where these soils are very shallow, the presence of rock outcrops makes them suitable only for extensive grazing.

Burren Series

This Series covers 0.17% (344 ha) of the area. However, it occurs frequently also in small enclaves throughout the Patrickswell Series north of Nenagh and to a lesser extent east of the Silvermines. These areas are frequently too small to be shown on the map. The soil profile is typified by a dark greyish brown A horizon of organic clay loam texture and of strong crumb structure.

Soil Suitability: Because of its shallowness this soil has a limited use-range. It is mainly suitable for grazing. Sometimes in association with the Patrickswell Series it is cultivated. On occasion it is found with much outcropping rock and broken topography in which case it can only be used for extensive grazing.

Burren Rocky Phase (Photo 4.1)

This phase occupies 0.92% (1834 ha) of the Riding. It is similar to the Series but has up to 25% of outcropping rock.

Therefore, its suitability for agriculture is even more restricted than the Series and it has a very limited use range.

Kilcolgan Series

This Series occupies only 0.03% (56 ha) of the Riding. It runs sporadically throughout the limestone lowland north of Nenagh. In many instances it occurs in enclaves too small to be mapped. It occurs over relatively un weathered limestone glacial till in gently rolling topography. It is similar to that of the Patrickswell Series with which it is closely associated.

The soil is shallow and well to excessively drained. The textures range from gravelly loam to clay loam. The structure is strong. Rooting is very well developed and the pH is high.

Soil Suitability: This soil has a moderately wide use range and may be tilled or grazed. With increased fertiliser application its potential is high. Although it may occasionally suffer from drought its depth is not so shallow as to critically restrict its water-holding capacity.

In general, the Grey Brown Podzolic soils possess a somewhat heavier texture than the Brown Earth or Brown Podzolic soils. They are well to moderately-well drained, possess a moderately well developed structure and are usually moderately acidic to neutral in reaction. The organic matter content in the soil is medium to high and the humus is of the desirable mull type.

The development of these soils is associated with leaching; the principal constituent accumulated in the B horizon is finely divided clay. To be classified as a Grey Brown Podzolic a soil must show a B horizon having a significantly higher clay content than the A or C horizons; this is then termed a textural B or Bt horizon.

The occurrence of clay skins on the structural ped surfaces within the Bt horizons is a further characteristic. These soils normally show a proportion of limestone in the parent material.

They are generally suited to most agricultural enterprises. The heavier-textured members have weaker structure and are more suitable to grassland production, responding well to good fertilising and management practices.

These soils are generally unavailable for forestry but should be highly productive for this purpose.

Elton Series (Photo 4.2)

This Series occupies 9.85% (19,650 ha) of the Riding. It is classified as a minimal grey brown podzolic since the clay content in the Bt horizon is rarely more than 2 to 3% greater than in the A1 horizon. It usually occurs downstream (ice-direction) from Old Red Sandstone or early Palaeozoic shales on limestone formations; therefore, it is found west of Templemore, Thurles and Holycross. It also stretches east-west, south of the recessional moraine from Knock village to the Black Hills. It is usually found on slopes of 5° or less. It occurs also in association with Patrickswell and Baggotstown as a Complex. That Complex occurs in the north of the Riding in the Little Brosna basin and also in the neighbourhood of Roscrea and is described below.

This soil is well-drained and of loam to clay loam texture. The A horizon is usually brown to dark brown in colour and at least 15 cm deep. There is little or no colour change down the profile but the B2t horizon is marked by clay skins on the peds and down the cracks in the soil. The pH values are usually high in the Bt horizon.

Soil Suitability: Because of its depth, friability and good moisture-holding capacity the Elton Series has a wide use range. Although its surface structure is weak compared to the Grey Brown Podzolic soils such as the Patrickswell Series it is highly suitable to grass production over a long season and responds well to fertiliser and lime applications. It is comparatively easily tilled and can produce very good crops of cereals, roots and vegetables. Its texture and good natural drainage make it highly suitable for growing winter cereals, especially wheat. The weak structure, when tilled for a few years, causes difficulties with seed bed preparation and weed infestation.

Photo 4.3. Soils of the Patrickswell Series (Grey Brown Podzolic), south from Gurteen Agricultural College, Ballingarry. This is the largest Series in the Riding (23.08% of the total land area) and predominates from Nenagh northwards. Suitability Class: Cultivation, I; Grassland, A.

Photo 4.4. ***Top:*** *Soils of the Borrisoleigh Series (Brown Podzolic) with village of Borrisoleigh at right. This Series is the second-largest in the Riding, at 10.91% of the total land area. Suitability Class: Cultivation,* ***III;*** *Grassland, A.*

Bottom: *Feale Series (Gley). Suitability Class: Cultivation, TV; Grassland, D.*

Patrickswell Series

This is the most widespread Grey Brown Podzolic Series in the Riding (Photos 4.1 and 4.3). It occupies 23.08% (46,055 ha) of the area. It also occurs as a member of four soil Complexes. It occurs on gently undulating to gently rolling topography. In its principal location from the Little Brosna river south to Nenagh, enclaves of the Burren and Ballincurra Series may occur in areas too small to be shown. Parent material consists of gravelly limestone till with some shale and sandstone. The soil is classified as a minimal Grey Brown Podzolic. Its solum is often close to 75 cm deep but sometimes it is 45-50 cm deep in the area mentioned above and on occasion is as shallow as 30-35 cm.

This soil is well drained, well structured and shows a friable brown to dark-brown gravelly loam surface. The texture can vary from clay loam to sandy clay loam in places. On occasion there is a high silt content (as in Co. Westmeath) but mostly the Series occurs (as in Co. Clare) without a high silt content. In the Bt horizon there is usually an increase of 3%-6% in clay content. Below this horizon there is a clear and relatively sharp transition to parent material.

Soil Suitability: This soil has a wide use range due to its depth, texture, friability and moisture-retention properties. Under good management it is highly productive for grassland. It is easily tilled and gives high crop yields provided the fertiliser and lime applications are correct. It is very suitable for winter cereals, particularly winter wheat

Where the Burren and Ballincurra Series occur in close association with the Patrickswell Series, yield potential is lower due to the susceptibility of these associated shallow soils to drought.

Patrickswell Lit hie Phase

This lithic phase of the Patrickswell Series occupies only 1.34% (2745 ha) of the riding. It is widespread in the area between Lorrha and Nenagh. It frequently occurs in association with the Patrickswell Series. In this part of Co. Tipperary the phase can be tilled because the irregular limestone outcrops as in Co. Clare and Co. Westmeath are replaced by a cover of till over smooth limestone bedrock. Average soil depth is about 50 cm. It is, therefore, similar to the Patrickswell Series except that it has no C horizon and the limestone bedrock is closer to the surface. In some small enclaves the bedrock comes close to plough depth.

Soil Suitability: The suitability of this phase is somewhat similar to that of the main Series. It has a moderately wide use range. It is suited to tillage and grassland. The underlying rock is fissured. This provides excellent drainage and consequently a long grazing season is possible.

Patrickswell Bouldery Phase

This phase covers 1.22% (2444 ha) of the Riding. It is similar to the Series except for the presence of many boulders. Therefore, although it can be used for grassland its use range is limited and it cannot be cultivated.

Patrickswell Steep Variant

This variant occurs frequently throughout the area covered by the Patrickswell Series in association with the Patrickswell Lithic Phase and the Baggotstown and Ballincurra Series. Principally it occurs on short steep slopes and the lower part of scarp faces. These areas are too small to be shown on the map. In most respects (except slope) this variant is similar to the Series.

Soil Suitability: This soil is limited in its use range by slope and is therefore suited to grazing only.

Patrickswell Shallow Variant
This variant occurs chiefly in the area north of Nenagh. It is usually less than 2 hectares in extent. Because of its shallower (approximately 35 cm) depth it has a greater liability to drought

Brown Podzolic Group

The Brown Podzolics are more intensely leached than the Brown Earths and, as a result, the upper horizons are more depleted of bases and other constituents. A characteristic feature of these soils is a sub-surface horizon of strong red-brown or yellowish-brown colour due to enrichment, principally by iron oxides leached from the upper horizons. They are more degraded generally and of a more acid nature than the Brown Earths.

Although the Brown Podzolics are more leached and of lower natural nutrient status than the Brown Earths, they closely resemble each other in behaviour and productive capacity. On account of their desirable texture, structure, drainage and friability, the Brown Podzolics are considered highly suitable for cultivated cropping, except where they occur on steep slopes or are somewhat shallow. Although lacking in natural nutrient and lime status, they respond well to fertilisers. Highly productive short-term leys can be obtained within the crop rotation, when fertilising and management are satisfactory. Like the Brown Earths, they are ideal forest soils under Irish climatic conditions but are generally unavailable for this use.

Borrisoleigh Series
This Series (Photos 4.4 and 4.5) covers 10.91% (21,772 ha) of the Riding. It is found in areas as far apart as Moneygall and the southern border with both Limerick and the South Riding. It is associated throughout with the Silvermines Hills. The topography varies from rolling to steep with slopes ranging from 5°-30°. On the steep slopes it tends to be found in a Complex with the Knockshigowna Series. The pH is normally acid (4.3 to 4.6), increasing with depth (5.7 to 6.0). The texture of the topsoil is a clay loam to silty clay loam, that of the B2 horizon is a clay loam and the C horizon is a loam.

Soil Suitability: This soil has a somewhat limited use range because of topography and high rainfall. Where the slope is favourable it will give good grass yields and be suitable for cultivation. Attention to lime and fertiliser application is essential. It can be grazed in spring and autumn with little danger of poaching.

Borrisoleigh Steep Phase
This phase occupies 0.40% (807 ha) of the riding. It is generally of shallow depth on slopes of 20° or more. Because of the shallowness, it is liable to drought. It occurs frequently on the sides of over-deepened melt water channels in the hills. It is similar in all other respects to the Borrisoleigh Series.

Soil Suitability: The use range of this soil is very limited by steepness and shallowness with its attendant liability to drought. It is only suitable for grass production and mainly as extensive grazing. Overgrazing could lead to erosion on these steep slopes.

Cooga Series
This Series covers 0.94% (1881 ha) of the Riding. It is found over till or fluvioglacial deposits of mixed shale and Old Red Sandstone composition. These deposits are found in the south west of the Riding, north and east of Newport. This soil is free draining and generally of sandy loam texture. The texture throughout is gravelly and the gravel percentage increases with depth. The soil is somewhat leached and generally of low base saturation.

Soil Suitability: Because of its free drainage and sandy loam texture this soil has a moderately wide use range. The principal handicap is proximity to the hills with their higher rainfall and hence greater risks with tillage crops.

Doonglara Series
This Series covers 1.16% (2314 ha) of the Riding. It is associated with the Old Red Sandstone. It is found from south of Borrisoleigh to the borders of the North and South Riding. Here it occurs in association with the Gortaclareen Series. Where slopes are favourable its drainage status is good and the surface structure is moderate to strong. The natural pH is low. The topography is normally rolling with slopes of at least 5°. The topsoil texture is sandy loam but texture becomes somewhat coarser with depth. South of Roscrea and north of Moneygall it is frequently found in a Complex with the Slievereagh and Knockaceol Series.

Soil Suitability: This soil has a somewhat limited use range due to its elevation and slope characteristics. Rainfall is relatively high. It can be used for tillage but it is more suitable for grass production. Because of its free drainage, poaching by grazing animals is not a serious problem. Low inherent lime and nutrient levels require attention.

Podzol Group

These soils are more intensely leached than the Brown Podzolics. They display well-defined horizons of depletion and accumulation in the profile and are considered to be degraded soils. They develop from parent materials of very low base reserves or under conditions which deplete the base reserves to a very low level. Granitic and Old Red Sandstone mountains, for instance, provide a situation in which both of these factors operate; with the acid nature of the geological parent materials, together with the high rainfall, considerable leaching of soil constituents, principally bases, iron and aluminium hydroxide and humus takes place. In more extreme conditions the surface becomes very acid making the environment for decomposition by micro-organisms unfavourable. A peat layer then accumulates on the surface, on which a heath-type vegetation develops.

Podzols are generally poor soils with high lime and fertiliser requirement. In their unreclaimed state they usually have a cover of semi-natural vegetation. In lowland areas, they have been successfully reclaimed for cultivated cropping and other purposes, but unless management is good they revert easily. The more extreme forms, which occupy hill and mountain areas throughout the country, have not been ameliorated to any extent. In most cases the terrain associated with these soils is such that mechanical reclamation and cultivation are not feasible. Here they are devoted mostly to rough grazing or forestry. Considerable improvement in stock-carrying capacity is possible by surface regeneration of the rough grazing, through fertilising and improved management

Where an iron pan occurs within the profile, it hinders root penetration (an important factor in forestry and in the agicultural use of these soils) and water percolation. For the latter reason drainage in the surface may be poor — a further unfavourable feature of many Podzols. Besides having a low level of major nutrients, these soils are usually very deficient in trace elements.

Podzols are the most widely available mineral soils for afforestation in the country and are usually planted with pines *{Pinus* spp.). However, with deep ploughing and the application of phosphorus fertiliser in particular, they can support other species such as Sitka spruce *(Picea sitchensis)* with relative ease.

Knockaceol Series

This Series covers only 0.04% (78 ha) of the Riding. It is found over Old Red Sandstone from Roscrea down to the Devilsbit mountain and more sporadically south of Borrisoleigh. It is seldom of great extent and in the area north of the Devilsbit is often associated with the Slievereagh and Doonglara Series. The topography is hilly.

The soil is well to excessively drained. Textures are sandy loam to loamy sand. The profile has an A2 horizon overlying a B2ir which in turn overlies the parent material. This may be either a solid sandstone stratum or discrete sandstone boulders. The pH values are low to very low.

Soil Suitability: This soil has a very limited use range caused in part by the hilly topography, the high rainfall and steep slopes. Machinery use is limited by the terrain so that the most suitable land use is pasture production. Forestry is practised successfully on this Series with spruce, larch and Scots pine the dominant species.

Knockaceol Peaty Phase

This phase covers 0.03% (54 ha) of the Riding. It occurs mainly around the footslopes of the Silvermines as well as on the lower slopes of Keeper Hill and Mauherslieve. It is also found throughout the Silvermine Hills in a topographic sequence between the Knockaceol and Aughty Series. I. is very similar to the Knockaceol Series except that there may be up to 30 cm of peat over the A2. This latter horizon may show slight mottling due to the presence of an iron pan beneath. The depths and textures of the horizons are similar to those of the Series.

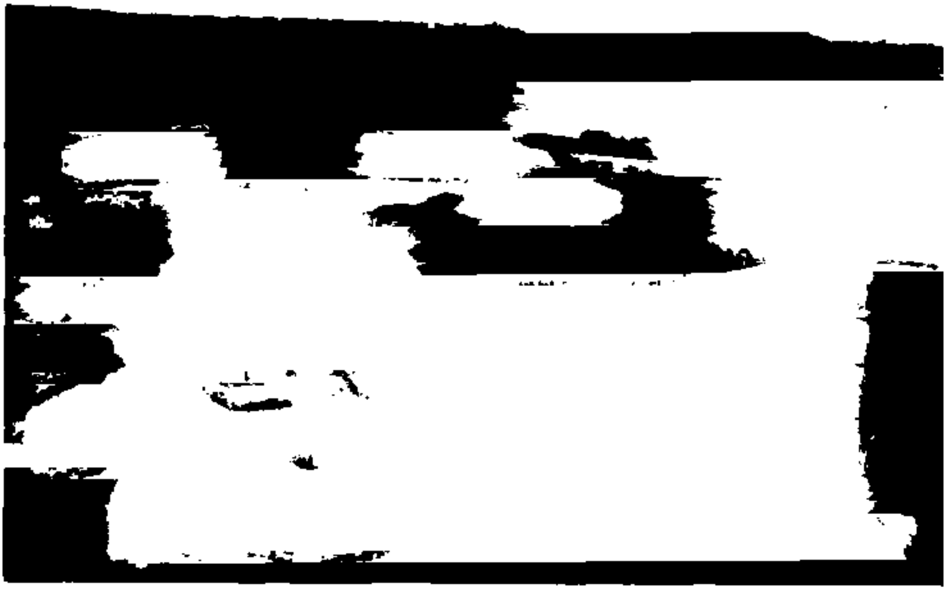

Photo 45. Ridge of Silurian shales (Borrisoleigh Series, Brown Podzolic) in limestone drift (Patrickswell Series, Grey Brown Podzolic), Knockshigowna, Ballingarry.

Photo 4.6. Limestone gleys (Ballyshear-Patrickswell Complex) at Redwood Castle, Lorrha, with lowland peat (Boora Complex) at right. River Shannon and Co. Galway in background.

Soil Suitability: This phase has an even more limited use range (extremely limited) than the main Series due to the presence of peat, the iron pan and high elevation. It is only suited to extensive grazing, recreation or forestry.

Knockastanna Series

This Series covers 1.66% (3315 ha) of the Riding. It can be found in enclaves from Moneygall in the north to the borders of the Riding in the Silvermine Hills in the south. It is classified as a Podzol and is found on the early Palaeozoic shales of the Silvermines. It generally occurs above 300 m elevation. Below this approximate level the Borrisoleigh Series is found.

The Series has a silty clay loam to clay loam surface texture. The A2 and B2ir horizons are usually silty clay loam to clay loam while the C horizon may be loam to clay loam. The structure is moderately strong crumb. The surface is strongly acid.

Soil Suitability: This soil has a very limited use range. The principal limitations are elevation, slope and topography. The high elevation limits its land use to grass production. Machinery use for fertiliser spreading is difficult because of the rolling topography.

Knockastanna Peaty Phase

This phase occupies 1.84% (3685 ha) of the Riding. It is found at elevations approximately 50 m higher than the Series (i.e. approximately above 350 m). There is an iron pan at 20-25 cm depth. This inhibits root penetration and water movement and causes gleying in the A2. Beneath the peat surface the texture is generally channery loam to sandy loam. The pH values are low.

Soil Suitability: The suitability of this soil is extremely limited by elevation and slope. Extensive grazing is the only feasible agricultural use.

See/in Series

This Series covers only 0.02% (40 ha) of the riding. It occurs mainly at high elevation (>300 m) over Old Red Sandstone and is usually associated with the Aughty and Knockaceol Series.

This Soil is characterised by a surface peaty layer (<30 cm) below which it is coarse-textured. The A2 horizon is a gravelly loam and the B2ir and the C horizons are mainly gravelly loams. An iron pan underlies the A2 horizon and it has a layer of impeded roots on its upper surface. Below the pan the B2ir horizon is iron-enriched. The C material overlies solid or shattered bedrock. The pH values are low to very low, varying from 4.2 to 4.8.

Soil Suitability: The use range of this soil is very limited. This is due to several factors such as elevation, inaccessibility, peaty surface causing trace element and fertility problems and the impermeable iron pan. It is unsuited to ullage, and is confined mainly to extensive grazing and forestry.

Gley Group

Gleys are soils in which drainage impedance is dominant and which have developed under conditions of permanent or intermittent waterlogging (Photo 4.6). This impeded condition may be caused by a high watertable or by a perched watertable caused by the relatively impervious nature of the subsoil or parent material or, as in many cases, by both conditions. Excess run-off from up-slope can also cause gleying. For these reasons gley soils can appear in both low-lying and elevated sites.

Where conditions of high watertables occur, the soils are referred to as ground-water gleys. Where the gleying is due to other factors they are referred to as surface-water gleys.

The mineral horizons of gleys are normally grey, or in more extreme cases, blueish grey, with distinct ochreous mottling apparent. Relative to the podzolic soil groups, the depletion of bases is not so pronounced. However, rooting area is limited, aeration is poor, rate of decomposition of organic matter is slow and other unfavourable conditions prevail. Podzolized gleys are soils in which there is evidence of a soil formation process similar to that described for Podzols and Brown Podzolics, whilst Podzolic Gleys refer to soils showing evidence of Grey Brown Podzolic characteristics.

The majority of gley soils have weak structure, are not friable and in the wet state tend to become sticky. Due to their poor physical properties, these soils, except in very favourable seasons, present difficulties in cultivation, especially in the development of desirable tilth. The poor drainage conditions retard growth in the spring. This is a decided disadvantage even for pasture production. The poor drainage aided by the characteristic weak structure of these soils render them susceptible to poaching under grazing. This factor curtails the length of the grazing season and the proportion of sward utilised. Despite these handicaps, the potential of these soils for grass production is good in many cases, provided drainage management and fertiliser application are satisfactory. Gleys are considered to be relatively productive as forest soils. However, wind-throw caused by poor root penetration is an ever-present hazard

Bally shear Series
This soil is of limited extent. It covers 0.47% (942 ha) of the Riding. It occurs between the Mylerstown Series and raised bog and is covered with a slightly peaty layer. Below this there is often a greyish brown A2 horizon with massive structure. The underlying Btg horizon has a gravelly clay loam texture and a weak structure. The pH is normally high.

Soil Suitability: This soil has a limited use range because of its poor drainage and landscape position. Its best use, i.e. grass production, requires good management as well as artificial drainage. This soil can be relatively productive in forestry.

Camoge Series
This Series covers 3.72% (7429 ha) of the Riding. It is formed from river alluvium in the limestone lowlands north of Nenagh and around Templemore and Thurles. There is also some shale and sandstone influence in the alluvium. The topography is typical of a river flood plain within a drift-covered landscape. Because of its origin and deposition patterns,

it has a varied profile. Usually, however, it consists of a clay loam to silty clay loam surface over a clay subsoil. This subsoil generally has a prismatic to massive structure and is extensively mottled. In some places the surface is peaty or slightly peaty.

Soil Suitability: This Series has a very limited use range due mainly to flooding hazards, poor drainage, weak structure and liability to poaching when grazed.

Coolalough Series
This Series occupies 0.15% (298 ha) of the Riding. It is formed from alluvium which was originally deposited in lake bottoms. Hence there are many small deposits which do not appear on the map because of scale limitations. The topography is flat. Normally pH values are high since the deposits are almost entirely of limestone composition. Being of alluvial origin this soil is liable to have an irregular textural profile.

Soil Suitability: This soil has a very limited use range. It is suited mainly to grass production. The principal limitations are poor drainage and liability to poaching damage.

Derrygarreen Series
This Series covers only 0.05% (103 ha) of the Riding. It is found in the Clare River valley where it emerges from the Silvermine Hills. It is classified as a podzolised gley. It is very similar to the Puckane Series but its parent material is fluvioglacial sand and gravel of sandstone composition with a mixture of shale and limestone. The pH is low (range 4.2 to 5.1 in the Al horizon).

Soil Suitability: This soil has a limited use range. It is suited mainly to grass production or to forestry. Its principal limitations are poor drainage and liability to poaching damage.

Drombanny Series
This Series occupies only 0.26% (513 ha) of the Riding. The soils occur on old lake beds within the limestone lowlands. They are poorly drained, of silt loam texture and of very high base status and have been classified as humic gleys. Below about 20 cm there is a layer of lime-marl of variable thickness — usually about 15 cm. Below this layer the effects of the high watertable are shown by the dominance of drab grey colours and subdued mottling. The structure, weak to moderate in the surface horizon, becomes weak below the marl layer. Rooting forms a dense mat down to the marl but is very sparse further down. The most common vegetation is rush-infested (usually *Juncus effusus)* old pasture.

Soil Suitability: This soil has a very limited use range. This is due mainly to its lowlying position which results in poor drainage. It is suited to grass production only and its grazing season is limited.

Feale Series (Photo 4.4)
This Series covers 2.40% (4790 ha) of the Riding. It is formed from alluvium that is associated with the valleys and glacial outwash channels of the shale formations of the

Photo 4.7. Briquette factory on lowland peat (Boora Complex), Littleton.

Photo 4.8. Sod turf workings and forestry on upland peat, Silvermines.

Silvermine Hills. It occurs in the associated river flood plains. A melt-water channel exiting from these hills at Borrisoleigh leaves a great expanse of this alluvium stretching southwards through Inch almost to the southern border of the Riding.

This Series has been classified as a ground-water gley. The surface horizon is plastic and sticky and has a loam to clay-loam texture with a weak crumb structure. This overlies a light grey silt loam with a weak subangular blocky structure. Below 35 cm the structure tends to become prismatic. The root channels down from 7-15 cm become much more mottled below 15 cm with manganese mottles prevalent and occasional manganese concretions.

Soil Suitability: This Series has a very limited use range. The principal limitations are heavy texture, poor drainage, high watertable and the risk of flooding. It is limited to grazing during the summer or to cutting of hay or silage, though this, in turn, may be difficult

Gortaclareen Series

This Series occupies 2.38% (4749 ha) of the Riding. It is found over till composed dominantly of Old Red Sandstone with some shale and limestone. The relief is variable and therefore this soil often occurs associated with the Puckane and Doonglara Series in Complexes. The drainage problem mostly arises from seepage and springs.

The texture is variable. The topsoil consists mostly of a gravelly sandy clay loam, but loam or sandy loam textures occur in some places. The soils are poorly drained and are mottled below 15 to 20 cm. These mottles rapidly become distinct to prominent with increasing depth. The structure is weak crumb in the A1 horizon and becomes massive to prismatic with increasing depth. Roots are mostly confined to the A1 horizon and pH values are medium to low.

Soil Suitability: This soil has a limited use range. The principal limitations are poor drainage and weak structure. However, the texture is not as fine as many other gleys and therefore improved drainage, good management and fertiliser applications can significantly increase output. It is mainly suited to grassland or forestry.

Howardstown Series

This Series covers 0.95% (1902 ha) of the Riding. In general, it is confined to the lowlands stretching from south of Roscrea towards Thurles. It is classified as a podzolic ground-water gley. It tends to be confined to the areas of glacial till over limestone and to be associated with the Elton Series. The till is composed mainly of limestone but there are some colluvial additions of shale and sandstone from the hills. The topography normally consists of gentle hollows or flat areas of till.

Textures vary from loams to gravelly loams on colluvium and from loams to clay loams on the till; clay content increases in the Bt horizon. Drainage is poor and colours are grey in the sub-surface; roots are mostly confined to the A horizon. The pH values are high.

Soil Suitability: This soil has a limited use-range and is suited only to grass production or forestry. Because of its heavy retentive nature poaching is a problem.

Kilcommon Series
This Series occupies 6.15% (12,279 ha) of the Riding. It is formed principally from Silurian shale on gentle slopes and flat positions in the Silvermine Hills and Arra Mountains and on their foothills. It occurs mostly from about 130 m to 700 m elevation. It is frequently found in association with the Knockastanna and Borrisoleigh Series and with the peaty phase of the Kilcommon Series.

The soil texture is usually a silty clay loam over slightly coarser textures. It is poorly drained but its drainage status is even worse on flat positions. The pH tends to be low in the surface and somewhat higher with depth. Except in very dry periods the consistency tends to be wet and sticky.

Soil Suitability: This soil has a very limited use range. The principal limitations are poor drainage and elevation. It is mainly suited to grass or forestry production.

Kilcommon Peaty Phase
This phase covers 1.16% (2309 ha) of the Riding. It is similar in most respects to the Series except that it has 5 to 30 cm of peat over it. It generally occurs at higher elevations (500 m) than the Series and therefore rainfall is higher and temperatures are lower.

Soil Suitability: This soil has a very limited use range. If the peaty layer is not too deep the soil can be reclaimed for grass production, otherwise it can only support extensive grazing or forestry.

Kilgory Series
This Series covers only 0.03% (54 ha) of the Riding. It occurs frequently within the area in enclaves too small to be shown on the map. It occurs some 6 km south of Roscrea and also east of The Pike close to the Offaly border. Its parent material is glacial till composed of Old Red Sandstone mixed with some limestone and it has a sandy loam texture. Because of its low position in the landscape the drainage status is poor despite the sandy loam texture. As with all alluvials this soil is stratified with layers varying in texture, iron content and pH values.

Soil Suitability: This Series has a very limited use range. Because of its landscape position it is liable to flooding and therefore its agricultural utilisation is confined mainly to grass production.

Mylerstown Series
This Series covers only 2.15% (4297 ha) of the Riding. It occurs chiefly on the edge of cut-over bogs where it originally developed under peat which has now been cut away. The parent material is a gravelly limestone till with a small admixture of shale and sandstone. The soil usually has a loam to clay loam surface texture and a weak structure. Depth varies from 30-70 cm and gleying is evident throughout

Soil Suitability: Similar to the Ballyshear Series.

Puckane Series
This Series occupies 0.27% (533 ha) of the Riding. It has been classified as a podzolized gley. It is formed over deep till composed mainly of Old Red Sandstone but with additions of shale and limestone. It is often mapped as a Complex with the Gortaclareen, Doonglara and Slievereagh Series. These are frequently found south east of the Old Red Sandstone hills stretching from Moneygall to Roscrea and south of the hills around Knock.

This soil has a weak-structured coarse-grained topsoil. Below the Al horizon there is an A2g horizon whose thickness varies from 6 to 30 cm. Below this there is a gleyed Bg horizon with dark-red mottles. The pH values are low. Roots, other than rush *(Juncus).* are mostly limited to the A1 horizon.

Soil Suitability: This soil has a limited use-range. It is poorly drained, and in many cases this condition prevails even on favourable slopes; weak structure is a further adverse feature. Cultivation and the development of a desirable tilth are very difficult unless the soil is at the ideal moisture balance. Natural lime and nutrient status in general is low.

The optimum agricultural use of this soil is in grass production, which can be satisfactory provided management is good. At present most pastures are dominated by poor grasses, rushes and weeds. Drainage, liming and manuring would increase grass production and utilisation. Management should include controlled grazing to avoid over-stocking in wet periods and thus alleviate poaching and rush infestation. It must include also the conservation of surplus summer grass for a long period of indoor feeding.

Puckane Peaty Phase
This phase occupies only 0.03% (63 ha) of the Riding. It occurs in association with the Puckane and Gortaclareen Series. The parent material is Old Red Sandstone drift with some impurities. The profile has a cover of acid peat about 15 cm deep.

Soil Suitability: The use range of this soil is very limited. It is suited mainly to extensive grazing or forestry.

Mineral Soil Complexes

Where the pattern of soils is so intricate as to defy clear-cut delineation of individual soils on the map, a soil Complex is shown. This situation is especially prevalent when glaciation has superimposed a pattern of soils on a landscape. Moraines (either recessional or terminal) give rise to Complexes, especially where a till different to the local rock type is deposited. This may be seen on the Old Red Sandstone ridge of Knock where the Complex Knocknaskeha-Doonglara has been deposited on sandstone, signifying a limestone influence.

Most of the areas mapped as Complexes are covered by kame-and-kettle topography which originated as recessional moraines, fluvioglacial deposits or dead ice features. These kames consist of small hills up to 20 m in height and of various shapes. They seldom cover more than 0.12 hectares. The kettle holes also vary in extent and shape and frequendy are the only outlet source for drainage water.

In this kame-and-kettle topography three or four different soils can occur in close proximity. In the Patrickswell-Baggotstown Complex, for example, a brown earth (Baggotstown Series) is formed on the kame together with a deeper variant. In the kettle holes the Patrickswell Series is usually present although occasionally the Elton Series occurs towards the centre.

Turbary-Knockastanna Complex
This Complex occupies 0.45% (901 ha) of the Riding. It occurs on hills at elevations greater than 300 m in the Silvermines. It consists principally of Aughty and Aughty cutover with relatively small but frequent islands of Knockastanna. The latter soil tends to occupy the steeper areas and the summits of the hills and comprises some 30% of the Complex.

Baggotstown-Crush Complex
This is a relatively minor Complex covering 0.24% (488 ha) of the Riding. It is formed mostly on eskers but occurs also on moraine features. Its greatest extent is found on a recessional moraine that parallels the Birr-Roscrea road. Some three miles from Roscrea it swings to the south west. Here the Crush Series is found on the kame crests and the Baggotstown Series occurs elsewhere on them. The Patrickswell Series may be found in some of the kettle holes. The Baggotstown Series covers approximately 75% of the Complex, the Crush Series 5% and the remainder consists of the Patrickswell Series. This Complex is also found on a number of eskers in the limestone lowland between Nenagh and the Little Brosna river but because of their shape they are difficult to show on the map.

Soil Suitability: Except for the Crush component, the use range of this Complex is comparatively wide. The narrow pattern of its distribution and sharp esker slopes are the mam handicaps.

Borrisoleigh-Ballynalackan Complex
This Complex occupies some 0.90% (1799 ha) of the Riding and is found on the lower slopes of the Silvermine Hills. Although the Borrisoleigh soil is usually dominant the proportions of the two Series can vary from 35% to 65%.

Soil Suitability: This Complex has a moderately wide use range. It is suitable for tillage as well as grassland but is somewhat restricted because of the frequent slopes.

Borrisoleigh-Knockshigowna Complex
This Complex covers 0.36% (719 ha) of the Riding. It is associated with early Palaeozoic shales of the Silvermine Hills and occurs typically on the over-steepened sides of melt water channels and on hillcrests. The Knockshigowna soil is found close to rock outcrops while the Borrisoleigh soil occurs on the surrounding steep slopes. The Knockshigowna Series and rock exposures occupy up to 30% of the area.

Soil Suitability: The suitability of this Complex is affected by the frequent rock exposures and by the limited use range of the Knockshigowna Series. Apart from these, the suitability of the Borrisoleigh component is similar to that of the Borrisoleigh Series.

Ballynalackan-Knockshigowna Complex
This Complex occupies 0.23% (456 ha) of the Riding. It occurs on the steep valley sides of the Silvermine Hills especially those of the numerous melt-water channels. These over-steepened valley sides are frequently occupied by the Knockshigowna soil. Ballynalackan and Borrisoleigh Steep Phase are the other principal members. Knockshigowna occupies from 30% to 50% of the area.

Soil Suitability: Same as the Borrisoleigh-Knockshigowna Complex.

Ballyshear-Patrickswell Complex
This Complex occupies 0.56% (1115 ha) of the Riding. It is found mainly in the extreme north (Photo 4.2) and consists of the lowlying Ballyshear and Mylerstown Series with ridges of Patrickswell Series in between. Ballyshear Series is normally dominant in the Complex and covers up to 50% of the area with the other two Series making up the other 50% in various proportions.

Soil *Suitability:* The use of this Complex is limited due to the prevalence of wet gleys. Although the agricultural potential of the Patrickswell Series is wide it comprises less than 30% of the Complex.

Camoge-Milltownpass Complex
This Complex occupies 0.21% (415 ha) of the Riding and is associated with the flood plain of the river Suir. Both main components are alluvial soils but Camoge is the most prevalent and covers approximately 60% of the Complex.

Soil Suitability: This Complex is suited mainly to summer grazing due to frequent winter flooding.

Howardstown-Baggotstown Complex
This Complex covers 0.07% (133 ha) of the Riding. It is a typical kame-and-kettle Complex with Baggotstown occupying the fluvioglacial kames and Howardstown the poorly-drained kettles. The Banagher Series (peat) is also found in some of the kettle holes.

Soil Suitability: The two main components differ widely in their suitability. These are described in some detail under each of the Series.

Howardstown-Patrickswell Complex
This Complex covers 0.41% (835 ha) of the Riding. It has an intricate pattern of soil distribution. Where the Howardstown and Patrickswell Series are dominant the Complex also contains peat such as Banagher, Gortnamona, Allen and Turbary. Amongst the mineral soils, Camoge, Mylerstown and Elton Series are also found. With such a variety of soils it is very difficult to assign exact proportions at the scale of mapping used.

Soil Suitability: This Complex has a very limited use range because of the presence of peat, alluvium and gleys. It can only be used for summer grazing, although with drainage its use may be improved.

Knockastanna-Knockshigowna Complex

This Complex occupies 0.29% (589 ha) of the Riding. It is similar to the Ballynalacken-Knockshigowna Complex but occurs at over 300 m in the Silvermine Hills. It is associated with glacial melt water valleys and steep slopes. It is also found on the crests of the lower hills in the south of the Silvermines. It is made up of almost equal proportions of the Knockastanna and Knockshigowna soils.

So/7 *Suitability:* This Complex is suited mainly to extensive grazing.

Knocknaskeha-Doonglara Complex

This Complex covers 0.26% (524 ha) of the Riding. It is found principally in two places, namely, (1) on the Old Red Sandstone ridge of Knock and (2) north of Drumbane where it is associated with the Gortaclareen Series. It is mostly well drained. Small enclaves of the Elton, Gortaclareen and Puckane soils also occur within the Complex.

Soil Suitability: The use range of this Complex is fairly wide. Both of the dominant soils have a wide use range. In some places where there are significant enclaves of the Gortaclareen or Puckane soils within the Complex the use range is restricted by poor drainage.

Patrickswell-Baggotstown Complex

This Complex covers 1.20% (2400 ha) of the Riding. It is found in and around the same areas as the Patrickswell-Baggotstown-Elton Complex and also in the extreme north of the Riding between Lorrha and the Little Brosna river. It has a similar kame-and-kettle topography with Patrickswell in the kettle holes and Baggotstown covering the kames. They occur in approximately equal proportions.

Soil Suitability: The use range of this Complex is wide since both of the component Series have wide use ranges. The Complex may be tilled or used for intensive grassland.

Patrickswell-Baggotstown-Elton Complex

This Complex covers 1.99% (3970 ha) of the Riding. It occurs both north and south-west of Roscrea. It is typically a kame-and-kettle complex. The Baggotstown Series is found on the kames and the Patrickswell Series on their lower slopes and in the kettle holes. In some of the kettle holes Elton Series is found where sufficient colluvial material has built up. The approximate proportion of the soils is Patrickswell 50%, Baggotstown 40% and Elton 10%.

Soil Suitability: This Complex has a wide use range. It can be cultivated and fertilised mechanically and will support intensive grazing. Intensive tillage may also be practiced.

Puckane-Gortaclareen Complex
This Complex covers 0.20% (389 ha) of the riding and is found most frequently on the east side of the Silvermine ridge from Roscrea south to the southern border. It is associated with mixed drift of predominantly Old Red Sandstone origin. The proportions of the two Series are approximately equal. They are both poorly-drained soils.

Soil Suitability: This Complex is limited in its use range mainly due to poor drainage and poor structure. It is suited mainly to grazing.

Puckane-Slievereagh Complex
This Complex occupies 1.11% (2217 ha) of the Riding. It occurs in two distinct areas of kame-and-kettle topography south-west of Roscrea as well as in part of the hills north of Keeper Hill. In this latter area it is composed mainly of Slievereagh interspersed with Puckane and Puckane Peaty Phase. The two areas south west of Roscrea are somewhat better because they occur on an Old Red Sandstone moraine over limestone bedrock. Therefore there are also some limestone-derived soils within the Complex, e.g. Knocknaskeha. Some of the Doonglara and Knockaceol soils also occur on the kames. In the kettle holes the Puckane and Gortaclareen Series can be found.

Soil Suitability: The use range of this Complex is limited to extensive grazing because of the difficulty of access, the poor drainage of some of the components, the presence of peat and the frequent occurrence of stones.

Shannon-Banagher Complex
This Complex covers 0.18% (362 ha) of the riding and is found in the flood plain of the river Shannon. The proportions of the Series are approximately equal. Drombanny also occurs within the Complex to the extent of about 5-10%.

Soil Suitability: These soils are all difficult to farm because of the high watertable associated with the river Shannon.

Other Soils

Some soils which are too limited in extent to be shown on the present map scale are described in this section. They have been established as Soil Series in other counties.

Ballyvorheen Series
This Series occurs sporadically in the area covered by the Cooga Series, usually on undulating but sometimes on rolling relief. It usually occurs in enclaves of less than 2 hectares in extent. It consists of a Brown Earth of low base status.

It occurs on glacial outwash fans of sands and gTavels, mainly of Old Red Sandstone origin with some shale and limestone admixture of Midlandian age.

This soil is well to excessively drained and usually of sandy loam texture. Though closely related to the soils of the Cooga Series, it displays a more uniform profile, devoid of brown podzolic features. The profile is friable or very friable throughout, and textures are coarse, becoming gravelly at sub-surface depths. Soil depth varies from 75 to 125 cm. Rooting is extensive, especially in the upper horizons. Vegetation is usually old pasture dominated by *Agrostis tenuis* (common bent-grass).

Soil Suitability: This Series is similar to the Cooga Series in its use range. However, because of its coarse texture it is liable to drought.

Crush Series

This Series occurs as a member of the Baggotstown-Crush Complex. It is found on the summits of the frequent small eskers north of Nenagh and on the summits of the kames of the recessional moraine north of Roscrea. It is classified as a Rendzina and has a pH of about 7.8 in the Al and 8.5 in the C horizon. The texture is usually sandy loam in the surface and loamy sand in the C horizon. This overlies fluvioglacial gravels of limestone composition.

Soil Suitability: This soil has a limited use-range, mainly because of the steep slopes and liability to drought in dry periods. For these reasons it is usually kept under pasture. Unless properly managed it reverts very quickly to scrub (hawthorn, gorse and hazel).

Knockshigowna Series

This Series occurs mainly as small enclaves which cannot be shown at the map scale and therefore occurs only as a member of Complexes. It is found mainly on the steeper slopes of the Silvermine hills. It occurs typically on the crests of the lower Palaeozoic shales. It is frequently found in Complexes with the Borrisoleigh and Knockastanna Series where it occurs on the steep slopes below the crests.

A typical profile consists of an organic to slightly peaty clay loam less than 15 cm thick over shattered or solid bedrock of Silurian or Ordovician shales. Bedrock is frequently exposed. The pH is low to medium.

Soil Suitability: This soil has an extremely limited use range, being confined to extensive grazing. Rock exposure and steepness means that cultivation or fertiliser application can only be done by hand.

Mortarstown Series

This Series is present throughout the Elton and Patrickswell Series in small hollows of 0.5 to 0.25 ha. It occurs on gently rolling topography and the elevation is always below 122 m. The parent material is limestone till with some shale and sandstone.

It has a heavy-textured clay loam to gravelly clay loam topsoil. It is well-drained to moderately well-drained. A marked clay increase occurs in the Bt horizon where clay skins are clearly evident on the peds. The structure is weak on the surface and changes to massive with depth. The Bt horizon merges gradually into the parent material. There is a well-developed root mat with roots extending well down the profile.

Soil Suitability: This soil has a moderately wide use range. When well managed it is a highly productive grassland soil but care must be taken to prevent poaching in wet conditions. It is only moderately suitable for tillage because of its heavy texture. Under frequent tillage, good soil management is necessary to preserve structure. Potatoes, root crops and vegetables yield well on this soil but cereals are inclined to lodge.

Rathborney Series (river alluvium)
This soil is found principally to the east of the Silvermine Hills and is associated on the landscape with the Elton and Patrickswell soils. Parent material is alluvium derived from shales and sandstones laid down in places where the rivers emerge from the Devilsbit Hills onto the valley bottoms in the limestone-based alluvial flat. This soil is poorly drained; texture varies but is usually silty clay, silty clay loam or silt loam; structure is fine crumb. The surface Al horizon is usually from 15 to 28 cm deep. The C horizon may be massive but is generally sub-angular blocky in structure and brown to light yellowish-brown in colour. Roots are abundant, but in some areas of temporary high watertable levels they may be confined to the surface horizon. The pH values are high.

Soil Suitability: This soil has a limited use range, being suited only to grazing in the summer months or perhaps to forestry.

Scraggen Series
This soil occurs only in the south west corner of the Riding. It occurs over fluvioglacial sands and gravels dominated by Old Red Sandstone with shale and limestone erratics. Its pH values are low. It is classified as a Brown Earth of low base status.

Soil Suitability: It has a relatively wide use range. Because of its parent material attention to fertility status is necessary. Its occurrence in the high rainfall areas of the Silvermine Hills means that it is suited mainly to grass production.

Shannon Series
This Series is found in the northwest along the shores of the Shannon river. It occurs in associauon with the Drombanny and Banagher Series and frequently occurs with layers of peat and marl within it. The soil is an alluvial gley whose parent material is predominantly of limestone origin.

This soil can range in topsoil texture from a silty clay to a loam. It tends to become coarser with depth. It is gleyed and each winter is flooded by the Shannon river. The pH tends to be high, 6.1 to 6.5 in the surface and 8.0 by 50 cm depth.

Soil Suitability: This soil has a limited use range and is confined to grassland production. Its principal limitations are flooding, poor drainage and liability to poaching damage.

Peat Soils

Peat soils are by definition comprised of peat materials with organic matter contents over 30% and at least 30 cm deep in the drained condition and 45 cm when undrained. The peat soils mapped within North Tipperary occur within the three landscape units, Fen, Raised Bog and Blanket Bog.

Fen

The peat materials which occur within this landscape unit developed in basin situations where watertables were at, near or above the land surface. They formed under the influence of base-rich ground waters and the plant remains which comprise these peat materials are reeds, sedges, non-sphagnum mosses, other semi-aquatic plants and woody remains of trees (willow, alder, etc.) The Fen landscape unit is characteristic of river flood plains, poorly-drained hollows in the landscape and areas contiguous to Raised Bogs. Within the Series differences can occur in botanical composition which can influence land use if considered for purposes other than grassland. Nutrient status and soil reaction are generally similar throughout. At the scale of mapping employed no separations are made with respect to botanical characteristics. However, two separations are made within the landscape unit on the basis of the drainage condition. In the drained state the reclaimed peat soil is mapped as Banagher Series and in the undrained state as Pollardstown Series.

Banagher Series

This Series occupies 4.85% (9686 ha) of the Riding. It occurs not only as large units in the landscape but also as small units within many of the soil Complexes which predominate in the kame-and-ketUe topography. The Banagher Series bounds many of the small streams which occur within these Complexes. The surface horizon of a typical profile, under permanent pasture, exhibits a well-developed granular structure and abundant rooting. Fine to medium gravels within this horizon indicate that "marling" was carried out in previous generations to improve soil fertility. In river valleys a thin surface layer of alluvium can also be present.

In the drained state the permanent watertable (recognised by the strong smell of sulphides) usually occurs about 70 cm below the surface.

Soil Suitability: These soils, depending on their physiographic position and drainage state can have a moderately wide use range. Frost hazard is a major factor when widening the land-use option and later sowing is advisable for frost-susceptible crops. In general, soil reaction is favourable but this requires checking prior to establishing a cropping programme. Grassland farming is the main land use in the Riding on permanent pastures of variable quality. The vegetation of rough grazing areas is dominated with sedges and rushes. Where a high level of land management is practised, drains cleaned and maintained and fertiliser applied, good levels of production can be achieved.

Pollardstown Series

This Series occupies only 0.18% (367 ha) of the Riding. It is very limited in extent, reflecting the effect of draining and reclaiming fen areas for agriculture in times past. Little or no soil development has taken place and watertables are at or near the land surface.

Soil Suitability: In its present condition this Series is not suitable for agriculture and remains as a wildlife habitat with potential for amenity and conservation purposes.

Raised Bog

The raised bog landscape unit is a characteristic feature of Central Ireland. The formation is a result of the combination of depressed topography, poor drainage gradients and climatic changes throughout the past 10,000 years of the post-glacial period. In their unmodified state they are extremely wet structures with 85% of their volume comprised of water. Their development was initiated under the influence of base-rich groundwaters and the basal layer of raised bogs within the Midland plain is without exception comprised of fen peat materials. Subsequently, however, the formation of peat materials of increasing thickness changed with soil water regime to one of less basicity. This, coupled with a change in climate to increased precipitation, favoured plant species suited to more acidic soil conditions and the growth of *Sphagnum* mosses, forming the characteristic raised dome shape typical of the landscape unit.

Allen Series

This Series occupies 1.63% (3248 ha) of the Riding. In general terms the profile is comprised of alternating layers of variably humified *Sphagnum* mosses interspersed with peat materials of *Calluna* and Cyperaceae origin. Little or no soil formation has taken place and the aerated layer extends only a few centimeters deep. The profile is extremely wet throughout in the natural state but near the edges, where drainage has been carried out to facilitate hand turf cutting, margins are somewhat drier. This is typified by the increased growth of *Calluna vulgaris* (heather).

Soil Suitability: This Series in its natural state is unsuited to any form of enterprise other than amenity and conservation value. With drainage, forestry and fuel production are the main uses. The complex geogenesis of the raised bog landscape unit is reflected in the selection of different bogs for moss peat or fuel peat in the course of exploitation of this once-widespread natural resource.

Gortnamona Series

This Series occupies 0.79% (1572 ha) of the Riding. It is mapped where the previously cutover surface of the Allen Series, used for drying hand-cut turf, has been reclaimed for agriculture. The Series is characterised by its bi-partite profile. An upper layer of peat materials, derived from the Allen Series by throwing down the top strippings which were considered poor fuel value, overlies a variable thickness of fen peat materials which were left behind after fuel extraction. Soil development has taken place within the acid layer. Depending on the age of land reclamation, the surface horizon can have physical characteristics very similar to those of the Banagher Series. If land reclamation has taken place within recent times "marling" has not been carried out and therefore the surface horizons of such soils have a lower ash content and do not show any strong structural development.

The age and intensity of land reclamation is reflected in the thickness of the surface horizon. Soil reaction in the sub-surface horizons is strongly acid and the morphology is that of the Allen Series.

Soil Suitability: This Series has potential for grassland, forestry and fuel production by tractor-mounted turf machines. In some areas wider land use options are possible but much depends on physiographic position, access and management potential. In these areas (as for the Banagher Series) frost hazard is a factor if field crops are to be considered. Optimum cropping potential depends on drainage outfall, access and the thickness of the surface horizon to maximise rooting potential. It is extremely important to check soil reaction and when amending with ground limestone to incorporate deeply and mix thoroughly. If land development programmes are carried out with strict control of the soil factors this Series is capable of good grass production for grazing systems. Silage production is not envisaged for this Series.

Peat Complexes

Turbary Complex

This mapping unit occupies 4.74% (9469 ha) of the Riding and results from hand cutting of peat fuels over past centuries. It occurs solely within the Raised Bog landscape unit and represents over 50% of the original area of Raised Bog within the Riding. Such areas in general have remained derelict for decades due to several factors; namely, limited access, poor drainage and uneven topography. The soils within the Complex are strongly acid and in general poorly to very poorly drained. The vegetation patterns within the Complex are good indicators of drainage status e.g. where there is a strong growth of *Calluna vulgaris* (heather) soils are relatively drier than areas where *Eriophorum* spp. predominate. Peat depths also vary widely depending on past management during the course of hand cutting for peat fuel.

Soil Suitability: In its present state the Turbary Complex is unsuited to agriculture but has a potential for forestry planting and in many areas is being developed for the production of peat fuels using tractor-mounted turf cutting machines.

Boora (1.47%, 2935 ha) and Clonsast Complexes

Since the late 1930s Bord na Mona (The Irish Peat Development Authority) has developed large expanses of raised bog (Allen Series) for the production of milled and machine peat (Photos 4.6 and 4.7). In earlier county surveys the peat soils present in industrial peat areas were defined on the basis of the method used i.e. milled turf — Boora Complex from Boora Bog, Co. Offaly, and sod turf — Clonsast Complex from Clonsast Bog, Co. Offaly.

Soil Character: Fuel production removes the greater part of the profile sequence (Allen Series) leaving behind a variable depth of peat materials depending on the topography of the underlying bog floor. In the milled peat method of production all future peat soils will develop from peat materials of a minerotrophic nature whereas in the sod turf production method a bipartite profile remains consisting of an upper layer of ombrotrophic peat materials over a sub-surface layer of minerotrophic peat materials. In recent years, however, fuel production technology has developed to allow milling of sod turf bogs to extend the bog's productive span, thus removing in the majority of areas the upper ombrotrophic layer.

Thus in future years soil parent materials in bog areas, irrespective of the type of fuel production, will be the same. The Clonsast Complex will, however, occur in smaller areas where further milling to extend the productive life of a sod turf bog is not economically feasible.

Soil Suitability: The suitability of the two Complexes is basically dependent on the depth and type of peat which remains after fuel production has ceased and on the type of sub-peat mineral "soil". Various enterprises are being experimentally valued at present to assess their suitability for forestry, grassland and horticultural enterprises e.g. vegetable field crops. However, the selection of a particular land-use enterprise to be followed will depend largely on the soil type and future social and economic circumstances. In the overall evaluation of this land type the amenity aspect warrants special consideration for alternative land-use systems.

Blanket Bog

Blanket peat accumulates under conditions of high rainfall and humidity. Such conditions prevail over much of the western part of Ireland at elevations greater than 300 m. Blanket bog occurs at the higher elevations on the Silvermine Hills in North Tipperary (Photo 4.8).

The climatic peat profile at the higher elevations varies from 1-2 m deep and is usually characterised by an upper layer dominated by fibrous roots, a sub-surface layer of pseudo-fibrous peat and a basal layer of highly humified peat within which pine stumps are to be found. The peat materials are comprised mainly of plants of cyperaceous origin embedded in a highly humified matrix. In the basal layer variations may occur in botanical composition due to topographic and edaphic conditions influencing past nutrient status.

Aughty Series

This Series occurs in the more elevated areas and occupies 0.53% (1056 ha) of the Riding. The depth varies from 40 cm to >200 cm. The profile is raw in nature with no evidence of soil development The peat is relatively homogeneous throughout and composed of cyperaceous remains embedded in a greasy well-humified matrix.

Soil Suitability: This soil has a very limited use range and is only suited to extensive rough grazing. Improved grass swards can be established through drainage, manuring and surface seeding.

CHAPTER 5

SOIL SUITABILITY*

Soil suitability classification is essentially a grouping of soils according to the potential use or uses to which they are most adaptable, and is based principally on the significance of the more permanent characteristics of the soil. A further step in the suitability classification consists of an assessment of the production potential of each soil, for the normal range of farm and forest crops, under defined management standards. This provides the essential link between the physical and economic aspects of the use of soils. However, for this purpose reliable quantitative data on the productive capacity of each soil are required; these can only be provided by detailed field experimentation and yield observations over a number of years on sample areas representative of the particular soil. So far, the only information of this nature available within Tipperary North Riding is confined to forestry on certain Soil Series and to pasture production. Quantitative assessments for grazing capacity are given in this Bulletin and in the accompanying map, but apart from this the system of soil suitability evaluation used is a qualitative, rather than a quantitative, appraisal of the potentialities of the different soils in the Riding.

Although the physical, chemical and biological properties of the soil merit foremost consideration in assessing soil suitability, environmental factors such as elevation, aspects and local climate must also be taken into account. For instance, local features such as exposure to strong winds and late spring frosts can limit forest tree growth no matter how deep and fertile the soils may be. In general statements concerning soil suitability one must bear in mind, therefore, that environmental and other factors can influence considerably the economics of production and hence can modify the use-range to which the soils are otherwise ideally suited.

Furthermore, the concept of land quality has changed radically in recent years. With modern fertiliser technology, natural nutrient fertility problems in soils have become subordinate to physical ones such as defective natural drainage, 'heavy' texture and poor structure, which are more difficult and more costly to rectify. Besides, farm labour is no longer abundant, and its replacement by mechanisation has drastically altered the feasible cultural and management practice of many soils.

Suitability for Grassland and Cultivation

Suitability Classification: A widely-used system for the interpretation of soil survey data from the point of view of land classification consists of assessing the capacity of each soil unit for permanent sustained production, and arranging the units according to the USDA (US Department of Agriculture) System of Land Capability Classification

•Compiled and written by M. J. Gardiner and T. F. Finch

(Klingebiel and Montgomery, 1961). This is a standard eight-class system in which Classes I to IV are suited to cultivated crops, Classes V to VII are suited to grazing and forestry and Class VIII is suited only to wildlife.

The US DA system emphasises the adaptability of a soil for a range of uses and implies a hierarchy of use capacity viz. cropping, grazing, forestry. In relation to land-use practice in Ireland this hierarchy is less relevant as the priority use of land is dairy livestock production which has a large grazing component. Since economic priorities change with time, value judgements based on economic criteria should be excluded as far as possible from a technical land classification.

The system adopted in Ireland (Finch, Culleton and Diamond, 1971) evaluates the degree of suitability of each soil unit for a set of uses, viz. cultivation and grassland, where all types of use have equal rank. This system could be extended to include suitability for forestry or urban development where appropriate. Choice of optimum use of a soil unit could be derived at any time from the suitability classification by assigning a weighting to each type of use based on the prevailing economic circumstances.

Soil suitability depends largely on the physical properties of the soil and the environment These are rarely ideal and the limitations affect productivity and cultural practices. The degree of limitation is assessed from such factors as wetness (w), drought (d), liability to flooding (0, slope (s), rockiness (r), boulders (b), textural and structural properties affecting tilth and susceptibility to poaching (t).

On the basis of these factors the soils are grouped into 5 classes designated A, B, C, D and E for grassland and I, II, HI, IV and V for cultivation. Productivity is the dominant criterion in the ranking of suitability for grassland and the suitability Classes A, B, C, D and E parallel the grazing capacity classification. In the case of cultivation the dominant criterion is the effect of soil properties on the ease of cultivation.

Suitability classes are divided into sub-classes by principal limiting factor. Sub-classes are indicated by a subscript which indicates the type of limitation, for example w = wetness, s = slope, etc. The degree of limitation increases from the higher to the lower categories.

Every map separation can be represented by the class letter for grassland, the class number for cultivation and the subscript letter for kind of dominant limitation e.g., (1) Aid indicates Class A for grassland, Class I for cultivation and liability to drought as the dominant limitation; (2) CIIIw indicates Class C for grassland, Class III for cultivation and wetness as the dominant limitation.

Suitability Classes: Tipperary North Riding (see accompanying maps and Table 5.1)

For grassland 46.98% of the soils are placed in Class A. Their principal limitations vary from slight drought in dry periods, slopes which make machinery use less easy and slight susceptibility to poaching. They are subdivided into Classes I, II and HI for cultivation, the only soils remaining in Class I being the Patrickswell Series which comprises 23.08% of the total land area and the Knocknaskeha Series which comprises 0.64%. The Dovea and Elton soils have been placed in Class II mainly because of somewhat heavy textures and consequently difficulties in readily obtaining a good tilth. The Ballynalackan and Borrisoleigh Series as well as the soils of the Borrisoleigh-Ballynalacken Complex have been placed in Class III mainly due to slope and slight elevation limitations. Some

7.31 % of the soils have been placed in Class B for grassland. The dominant limitations here are slope and drought but some of the soils have limitations due to flooding (Milltownpass), elevation (Doonglara) and rockiness (Patrickswell Lithic Phase and Ballincurra).

For cultivation the Baggotstown, Kinvarra and Kilcolgan Series as well as the Patrickswell-Baggotstown Complex have been placed in Class II due mainly to slope and drought limitations. The Cooga Series has been placed in Class III due to similar but more strongly expressed limitations. Also in Class III are the Milltownpass Series, the Patrickswell Lithic Phase and the Doonglara Series while the Ballincurra Series is placed in Class V due to rockiness and drought limitations.

Some 13.70% of the soils have been placed in Class C for grassland. Wetness is the most common limitation but slope, boulders and elevation are other limitations of individual soils. The Howardstown and Kilgory Series (0.98%) are placed in Class III for cultivation. Of the Class IV soils here (12.82%) the Knockaceol and Knockastanna Series are dominated by slope and elevation problems, while part of the Howardstown-Patrickswell Complex is placed in Class III for cultivation. The Gortaclareen, Mylerstown, Gortnamona, Banagher Series and the Puckane-Gortaclareen Complex are limited by wetness. The Baggotstown-Crush Complex is placed in Class V for cultivation, the main limitation being slope.

Some 18.33% of the soils are placed in Class D for grassland. Wetness, slope and elevation are the principal limitations. The poorly drained Ballyshear, Derrygarreen and Puckane Series are placed in Class IV for cultivation, the main limitation being wetness and elevation. Because of slope and elevation problems the peaty phases of the Knockaceol, Knockastanna, Kilcommon and Puckane soils are placed in Class V for cultivation. The Patrickswell Bouldery and Borrisoleigh Steep phases are placed in Class V for cultivation because of boulder and slope problems, respectively.

Some 10.13% of the soils are placed in Class E for grassland and all of these are placed in Class V for cultivation. These include the Carney Series limited by wetness and flooding, the Slievereagh and Seefin Series limited by rockiness, elevation and slope, the Burren Rocky Phase limited by rockiness and drought and the peat soils limited mainly by wetness.

A proportion (3.07% of the total Riding area) of the Soil Complexes have variable suitabilities and limitations because the individual Series from which they are composed differ widely. These are given a variable classification but the suitability of their component Series can also be discerned from Table 5.1.

Most soils have secondary as well as primary limitations and these can be seen in the soil suitability description for each soil Series. Sometimes these secondary limitations are important as for example drought (d) in the Baggotstown soils or poaching hazards (t) under grassland in soils such as Mylerstown, Howardstown and Ballyshear Series.

Wetness is a major limitation in soils of Classes C, D and E and almost rules out consideration of these for cultivation.

Slope and elevation are significant limitations in a number of the soils in North Tipperary. Slope problems militate against the easy use of machinery and elevation imposes a climatic disadvantage compared to more lowland soils.

*Suitability for Forestry**

The suitability of each soil Series along with their main limitations are given in Table 5.2. Suitability for both broadleaves and conifers are given separately to allow a more precise ranking for each type. Soils that are highly productive for conifers may not be as productive or may be totally unsuitable for broadleaves. It is also possible that two soils, which have equal ranking for grass production, may not be equally productive for tree growth. Elevation is a factor which also apparently influences tree productivity at a slightly more rapid rate than it influences grass growth. Broadleaves, with the exception of sycamore *(Acer pseudoplatanus)*, are particularly sensitive to exposed elevated sites. When considering the productivity of conifers and broadleaves it is better to assess each separately for each soil. This is the approach taken in Table 5.2.

Trees are measured in cubic volume. Small thinnings for pulp or fibre are measured by weight. The day-to-day decisions on crop management are based on the growth rate of the stand. Yield Class (YC, m^3/ha/annum)) is the method of measuring site productivity in forestry. This is the system used in the UK and Ireland and there are comprehensive sets of tables detailing the yield patterns of all the common forest trees.

Most trees growing in plantations will follow a certain growth pattern. The rate of growth is mostly determined by the quality and inherent fertility of the soil and the elevation and exposure of the site. Tree growth in any stand will follow a certain typical pattern. In the first few years of a plantation, trees put on little volume but as they grow taller and develop thicker stems they begin to accumulate volume. The rate of volume increment increases over the years, until a peak is reached and crop growth begins to slow down. The element of tree growth which combines all these factors, giving the best indiction of growth rate, is the top height of the stand. Top height is the height of the tallest trees in the stand. As these are most likely to form the final crop it makes sense to use them as the basis of crop performance. The height of a stand at any age will determine its Yield Class. Yield Class is basically an expression of the ability of the site to produce wood volume and is, therefore, a measure of a species' ability to grow on a particular site. Different species will react to a given site according to their own growth potential. The same site will have many different Yield Class ratings depending on the species planted.

Yield Class is expressed in cubic metres of wood produced per hectare per annum (m^3/ha/annum) and is quoted in increasing units of 2 cubic metres. A Yield Class of 20 m^3/ha/annum means that when the total volume production is divided by the length of the optimum rotation (50 years), the average production is 20 cubic metres per year. It is a measure which takes in not only soil productivity but other site factors such as elevation, aspect, and, indirectly, climatic factors such as rainfall, temperature and windspeed.

Yield Class for conifers, as detailed in Table 5.2, is based on the expected yield for Sitka spruce *(Picea sitchensis).* Sitka spruce is chosen as the criterion species because it is currently the major timber tree in Irish forestry. Sitka spruce is probably the chosen tree on between 80-90% of the area now being planted. It can be established easily and grows well on a very wide range of sites and is therefore a valuable measure of comparative site productivity. Its primary requirement is for adequate moisture and it rarely does well in areas which have annual precipitation less than 800 mm.

•Section on Suitability for Forestry compiled and written by M. Bulfin and T. Radford

TABLE 5.1: Tipperary North Riding — Soil suitability for grassland and cultivation

Suitability class		Principal			
Grassland	Cultivation	limitations*	Area (ha)	%	Mapping unit
A	I	d	47339	23.72	Patrickswell, Knocknaskeha
	n	t	20332	10.19	Dovea, Elton
	m	s,e	24299	12.17	Ballynalackan, Borrisoleigh
			1799	0.90	Borrisoleigh-Ballynalackcn Complex
B	n	s,d	756	0.38	Baggotstown, Kinvarra, Kilcolgan
			2400	1.20	Patrickswell - Baggotstown Complex
			3970	1.99	Patrickswell - Baggotstown-Elton Complex
	m	f	129	0.06	Milltownpass
		d,r	2745	1.34	Patrickswell - Lithic Phase
		s,d	1881	0.94	Cooga
		s,e	2314	1.16	Doonglara
	V	r.d	486	0.24	Ballincurra
C	m	w,t	1902	0.95	Howardstown
	m	w.f	54	0.03	Kilgory
	in (Also AI in part)	w,t,d,	835	0.41	Howardstown - Patrickswell Complex
	IV	w	13983	7.00	Banagher**, Mylerstown
	IV	w	1572	0.79	Gortnamona**
	IV	w	4749	2.38	Gortaclareen
	. IV	s,d	3393	1.70	Knockastanna, Knockaceol
	IV	w	389	0.20	Puckane - Gortaclareen Complex
	V	s	488	0.24	Baggotstown - Crush Complex

TABLE 5.1 (continued): Tipperary North Riding - Soil suitability for grassland and cultivation

Suiiabilit v class: Grassland	Cultivation	Principal limitations*	Area (ha)	%	Mapping unit
D	IV	w.f	13030	6.53	Camoge, Coolalough, Drombanny, Feale
	IV	w	1045	0.52	Bally shear, Derrygarreen
	IV	w	533	0.27	Puckane
	V	w.e	12279	6.15	Kilcommon
	V	b	2444	1.22	Patrickswell - Bouldcry Phase
	V	s	807	0.40	Borrisoleigh - Steep Phase
	V (Also CIV in part)	f.w	362	0.18	Shannon - Banagher Complex**
	V	s.e	6111	3.06	Knockaceol Peaty Phase, Knockastanna Peaty Phase, Kilcommon Peaty Phase, Puckane Peaty Phase
E	V	w.f	22	0.01	Carney
		r.e.s	60	0.03	Slievereagh, Seefin
		r.d	2178	1.09	Burren, Burren Rocky Phase
		w	7239	3.63	Allen, Aughty, Boora
		w	9836	4.92	Pollardstown, Turbary Complex
V	A n x B in	t.s.e	524	0.26	Knocknaskeha - Doonglara Complex
	cm xBn	w.t.s.d	133	0.07	Howardstown - Baggotstown Complex
	DIV x AI	w,d	1115	0.56	Ballyshear - Patrickswell Complex
	DIV xBH	w.f	415	0.21	Camoge-Milltownpass Complex
	A n x c iv	s.e	456	0.23	Ballynalacken - Knockshigowna Complex
	CIV xEV	w.r.e	2217	1.11	Puckane - Slievereagh Complex
	AID xEV	s.e.r,	719	0.36	Borrisoleigh - Knockshigowna Complex
	CIV xEV	s.e.r	589	0.29	Knockastanna - Knockshigowna Complex
	EVx CIV	w.s.e	901	0.45	Turbary - Knockastanna Complex

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*b = boulder; d = drought; e = elevation; f = liability to flooding; r = rockiness; s = slope; t = textural and structural properties affecting tilth and susceptibility to poaching; w = wetness

**It is assumed that these peat soils have been drained and reclaimed

TABLE 5.2: Soil suitability for forestry in Tipperary North Riding

Great Soil Group	Mapping unit	Suitability classification: Broadleaf — Category (see page 59)	Broadleaf — Limitations[1]	Conifer — Yield Class (m^3/ha/annum)	Conifer — Limitations[1]
Regosol	Carney	E	w.p.f	UP	P.f
	Milltownpass	B	**f**	14-20	f.P
Lithosol	Slievereagh	UP	**e j**	UP	e,r
Brown Earth	Baggotstown	B	**d**	14-20	d,P
	Ballincurra	C	r,d	**14-20**	r,d,p
	Ballynalacken <150 m	A		18-24	
	Ballynalacken >150 m	B	e	18-24	
	Dovea	A		**18-24**	P
	Kinvarra	B	d	14-20	d,p
	Knocknaskeha	A		18-24	
Rendzina	Burren	UP	r,d	UP	r,d
	Burren Rocky Phase	UP	r	UP	r
	Kilcolgan	B	d	14-20	**4p**
Grey Brown Podzolic	Elton	A		18-24	
	Patrickswell	A		18-24	
	Patrickswell Lithic Phase	B		14-20	d
	Patrickswell Bouldery Phase			14-20	b
Brown Podzolic	Borrisoleigh <150	A		18-24	
	Borrisoleigh > 150	B	**e**	18-24	
	Borrisoleigh Steep Phase	C	s,d	14-20	**s,d**
	Cooga	A		18-24	
	Doonglara <150 m	A		18-24	
	Doonglara <150 m	B	e	18-24	
Podzol	Knockaceol	D	e,s	14-20	e.s
	Knockaceol Peaty Phase	E	e,s	10-16	e,s
	Knockastanna	D	e,s	14-20	e,s
	Knockastanna Peaty Phase	E	e,s	10-16	e,s
	Seefin	E	e,s	10-16	

TABLE 5.2 (Continued): Soil suitability for forestry in Tipperary North Riding

Great Soil Group	Mapping unit	Broadleaf: Category (see page 59)	Broadleaf: Limitations[1]	Conifer: Yield Class (m^3/ha/annum)	Conifer: Limitations[1]
	Ballyshear	D	w	14-20	fr.p
	Camoge	C	w,f	14-20	f.fr.p
	Derrygareen	C	w	18-24	
	Coolalough	D	w,f	14-20	fr.f,p
	Drombanny	D	w,f	14-20	fr.f,p
	Feale	D	w,f	14-20	fr,f
	Gortaclareen < 150m	C	w	18-24	
	Gortaclareen > 150m	D	w.e	18-24	e
	Howards town	C	w,t	18-24	
	Kilcommon < 150m	C	w	18-24	
	Kilcommon <344m	D	w,e	18-24	e
	Kilcommon >344m	E	e,w	14-20	e
	Kilcommon Peaty Phase	E	e	10-16	e
	Kilgory	C	w.f.fr	18-24	f,fr
	Mylerstown	D	w.fir	14-20	fr.p
	Puckane	D	w.e	18-24	
	Puckane Peaty Phase	E	w,e	14-20	e
	Allen	UP		UP	
	Aughty	UP		6-12	e,w
	Banagher[2]	UP		14-20	fr.w
	Boor a[2]	UP		14-20	fr.w.d
	Pollards town	UP		UP	
	Gortnamona	UP		14-20	fr.w
	Turbary[3]	UP		Variable 0-20	fr.w

[1]b = bouldery; d = drought (due to shallowness, coarse texture or excessive drainage); e = elevation/exposure; f = liability to flooding; fr = liable to frost damage; p = high pH; r = rockiness; s = slope; t = heavy texture; w = wetness or poor drainage.

[2]Boora and Banagher are cutaway peat soils that may vary in depth and composition. They are variable in productivity. It may be possible to grow certain broadleaved species such as birch and alder and possibly willow but not for commercial purposes. Shallow thicknesses of Boora peat over mineral drift material may be subject to irreversible drying ouL

^Turbary areas are complex and very variable depending on the methods of turf-cutting used. They are, therefore, ranked as of variable productivity ranging from Yield Class 0-20.

Yield Classes are given in broad categories ranging from YC 6-12, which is regarded as very poor and not worth planting, to YC 18-24, which would be regarded as very good to excellent. Some areas are listed as implantable (UP) because they are almost incapable of supporting tree growth. While Sitka spruce grows well on a wide variety of soil types this does not exclude the use of other species. The choice of species really depends on the expected end use of the plantation, whether it is for timber, firewood, shelter, amenity or game development. Final choice of species should be taken on the advice of the local forestry advisor. Most foresters will be able to relate the growth and Yield Class of other conifers on any particular site to the Yield Class for Sitka spruce.

Much less is known about the growth rates of broadleaves on different soil types. In general, broadleaves require considerably better soils and climatic conditions than conifers for good growth. Also the variation in growth rate between broadleaves is considerably greater than with most of the commonly-used conifers. A soil which is rated A or very good for broadleaves means that it is capable of producing good crops of a wide range of species. This may mean that it can produce oak at YC 8, ash or sycamore at YC 12 and poplar at YC 18. Also the rotations will vary considerably with oak requiring rotations of 150-200 years, ash or sycamore 40-60 years and poplar 18-25 year rotations.

While certain soils will have very similar rankings for both conifers and broadleaves, with both ranked either very good or very poor, there are soils which are very different in their potential for both types of trees. The most outstanding example of this is in relation to gley soils. These poorly drained rush-infested grasslands are mostly unsuitable, or only poorly productive, for broadleaves, but are capable of very high production under Sitka spruce. Irish wet mineral lowland soils are some of the most productive in Europe for conifer — especially Sitka spruce — forestry. This high productivity is related to both the mildness of the climate, the relatively high rainfall and the fertility of these mineral soils for conifers.

Table 5.3 indicates that soils in Category A have a wide use range with no major limitation for broadleaf production. The soils are well-drained and occur chiefly below 150 m elevation. Soils in Category B have a moderately wide use range with limitations ranging from elevation (above 150 m), shallowness, drought, high pH and liabiliy to flooding. In Category C the soils have a somewhat limited use range mainly due to poor drainage. In Category D the main limitations are wetness, elevation and slope. The limitations of soils in Category E are very severe and are caused by high elevation, slope and wetness. The soils designated as unplantable (UP) are mainly the peats or very shallow, rocky or high elevation soils. With the conifers, because of their less demanding site requirements, a considerably larger proportion of soils is ranked as being of excellent productivity. This is more clearly seen in Tables 5.4 and 5.5.

Table 5.4 groups the soils into four broad use-range or production categories for broadleaves, showing 56.7% of soils having wide to moderately-wide use range for broadleaf production. Another 22.6% are placed in the somewhat limited to limited use range and approximately 3.7% are considered to be very limited. Almost 17.0% of the soils are classed as unplantable for commercial broadleaf forestry.

Table 5.5 indicates the very productive nature of most soils for conifer forestry. The major difference between the extent of the wide to moderately-wide category for broadleaf and conifer lies in the fact that the wet mineral soils are less suitable for broadleaved species.

TABLE 5.3: Percentage of Tipperary North Riding in each forestry production category

Category (see page 59)	Broadleaf		Conifer	
	Use range	%	Yield class	%
A	Wide	37.2	18-24	63.8
A/B		15.0		
B	Moderately wide	4.7	14-20	23.5
C	Somewhat limited	5.7	10-16	3.1
C/D		8.7		
D	Limited	8.2	6-12	0.9
E	Very limited	3.7	Variable	5.1
Unplan table		16.8	Implantable	3.6

TABLE 5.4: Extent of soil suitability categories for broadleaf species in Tipperary North Riding

Use range	Percentage of Riding
Wide to moderately wide	56.9
Somewhat limited to limited	22.6
Very limited	3.7
Unplantable	16.8

TABLE 5.5: Soil productivity for conifer species (based on the productivity of Sitka spruce) in Tipperary North Riding

Use range	Percentage of Riding
Wide to moderately wide	86.9
Somewhat limited	3.1
Limited	0.9
Variable	5.1
Unplantable	3.6

The wet mineral soils, which also present considerable problems for agriculture, should form the basis of any conifer forestry development programme.

North Tipperary is a very productive area for forestry. Both broadleaves and conifers will thrive there and give yields that are comparable to any other part of the country. In a well-planned land-use programme the poorer marginal lands would be planted to conifers while blocks of broadleaves would be planted on the better soils to ensure, at least, the continuity of our lowland scenery. With the improved quality of broadleaved trees that are now being researched it is possible that broadleaves grown on 25-45 year rotations, i.e. the same length as Sitka spruce, could be planted economically on some of the current Class III tillage soils.

References

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Klingebiel, A. A. and Montgomery, F. H. (1961). Land Capability Classification. US Department of Agriculture, Soils Conservation Agricultural Handbook No. 210.

CHAPTER 6

QUANTITATIVE GRAZING CAPACITY OF SOILS*

The objective of this part of the study is to determine the potential of North Tipperary and the different regions within it for livestock based on grass production and utilisation. Such quantitative measurements are possible only when the nature of the soil and climate is known and when pasture and animal production experimental data are available. The completion of the Soil Survey of North Tipperary has now made this possible. By comparing the potential targets thus obtained with present livestock numbers, the possible improvements in livestock density can be ascertained.

Trend in Grazing Livestock Numbers

Grazing livestock numbers for each of the years 1961 to 1986 were obtained from the agricultural returns of the Central Statistics Office. Stock numbers were converted to standardised livestock units (LU) according to the method described by Attwood and Heavey (1964). The results are shown in Table 6.1 The number of livestock units increased by 45% which is considerably higher than the national level of 32% for the same period. Over the same period tillage declined by 35% in North Tipperary compared with the national average decline of 26%.

The decline in tillage is estimated to account for only 13% of the livestock expansion which must therefore be attributed largely to grassland intensification.

TABLE 6.1: Grazing livestock units (LUs) in North Tipperary (1961-1986)

Year	No. of LUs (000)	Year	No. of LUs (000)
1961	151.2	1973	216.3
1962	153.3	1974	220.1
1963	164.0	1975	217.8
1964	167.1	1976	209.5
1965	177.8	1977	222.1
1966	180.7	1980	217.5
1967	175 8	1981	215.2
1968	179.5	1982	216.3
1969	176.7	1983	221.8
1970	187.3	1984	221.1
1971	196.4	1985	223.2
1972	200.8	1986	219.2

*Compiled and written by J. Lee and S. Ormonde

Present Grazing Livestock Numbers
In 1986 the number of grazing livestock in North Tipperary was 219,200 representing an average of 134 livestock units (LUs)/100 ha (54 LU/100 acres) on land devoted to livestock. Average stocking rate in the Silvermines area is about 60-95 LU/100 ha (25-40 LU/100 acres). Above-average stocking rates occur on the lowland mineral soils Elton, Patrickswell/Baggotstown/Elton Complex around Nenagh on District Electoral Divisions (DEDs) Ballylusky, Ardcrony, Knigh, Monsea, Carrigatogher and Burgesbeg, and in the Thurles area on DEDs Gortkelly, Ballycahill, Holycross, Littleton and Ballymurreen.

Table 6.2 compares stocking rate distribution in North Tipperary with the national position.

TABLE 6.2: Stocking rate distribution in North Tipperary compared with national stocking rate (% total area 1980)

	LUs/100 ha			
	<50	50-100	100-150	>150
North Tipperary	0	14	69	17
Ireland (Republic)	8	23	47	22

It is evident that North Tipperary displays a very high proportion in the 100-150 stocking rate, 69% compared with national figure of 47%. Ireland shows a higher proportion in the 50-100 and >150 stocking rates.

Table 6.3 compares land-use allocation in North Tipperary with national averages. Tillage is concentrated mainly on Patrickswell and Elton Series soils. Land under cattle is in line with the national average. Land under sheep is only half the national average while land under dairying is above average.

TABLE **6.3: Agricultural land-use allocation in North Tipperary and Republic of Ireland (% agricultural area 1986)**

	Total tillage	Tillage not devoted to livestock	Dairying	Other cattle	Sheep	Horses
North Tipperary	9	7	29	56	7	1
Ireland	8	5	25	56	13	1

Gross Grazing Capacity of Soils
The physical output data necessary for evaluation of the grazing capacity of the different soils in North Tipperary were extrapolated from experimental sites to related areas defined by soil and climate. The grazing capacity estimated for the Soil Series and Complexes are set out in Table 6.4 and are shown in the accompanying grazing capacity map. The estimates are based on nitrogenous fertiliser inputs of 48 kg and 230 kg/ha together wiUi

TABLE 6.4: Grazing capacity of soils of Co. Tipperary (North Riding)

			48 kg N/ha		230 kg N/ha	
Soil Series	Area (ha)	Grazing capacity Class	Capacity LU/100 ha	Gross grazing capacity (LU)	Capacity LU/100 ha	Gross grazing capacity (LU)
Patrickswell	46.055	A_2	220	101.321	274	126,191
Elton	19,650	A_2	220	43,230	274	53.841
Knocknaskeha	1,284	A2	220	2,825	274	3,518
Dovea	682	A_2	220	1,500	274	1,869
Borrisoleigh	21,772	A_2	220	47,898	274	59,655
Ballynalacken	2.527	A_2	220	5.559	274	6,924
Borrisoleigh/Ballinalackan Complex	1.799	A_2	220	3,958	274	4,929
Cooga	1.881	**Bl**	205	3,856	254	4,778
Baggotstown	621	**Bi**	205	1,273	254	1,577
Kinvarra	79	Bl	205	162	254	201
Kilcolgan	56	Bl	205	115	254	142
Patrickswell/Baggotstown Complex	2.400	Bl	205	4,920	254	6,096
Patrickswell/Baggotstown/Elton Complex	3,970	Bl	205	8,139	254	10,084
Milltownpass	129	Bl	205	264	254	328
Patrickswell - Lithic Phase	2,745	Bl	205	5,627	254	6,972
Doonglara	2,314	Bl	205	4,744	254	5,878
Ballincurra	486	Bl	205	996	254	1,234
Mylerstown	4,297	Cl	180	7,735	222	9,539

TABLE 6.4 (continued): Grazing capacity of soils of Co. Tipperary (North Riding)

Soil Series	Area (ha)	Grazing capacity Class	48 kg N/ha		230 kg N/ha	
			Capacity LU/100 ha	Gross grazing capacity (LU)	Capacity LU/100 ha	Gross grazing capacity (LU)
Baggotstown-Crush Complex	488	Cl	173	844	212	1,035
Howardstown	1,902	Cl	173	3,290	212	4,032
Banagher	9,686	Cl	173	16,757	212	20.534
Gortnamona	1,572	Cl	173	2,720	212	3.333
Kilgory	54	Cl	173	93	212	114
Howardstown-Patrickswell Complex	835	Cl	173	1,445	212	1,770
Gortaclareen	4,749	C2	161	7,646	198	9,403
Knockastanna	3,315	C2	161	5.337	198	6,564
Knockaceol	78	C2	161	126	198	154
Puckane-Gortaclareen Complex	389	C2	161	626	198	770
Ballyshear	942	Dl	158	1,488	198	1,865
Kilcommon	12,279	Dl	148	18,173	148	18,173
Camoge	7,429	Dl	148	10,995	148	10,995
Feale	4,790	Dl	148	7,089	148	7,089
Patrickswell - Bouldery Phase	2,444	Dl	148	3,617	148	3,617
Borrisoleigh - Steep Phase	807	Dl	148	1,194	148	1,194
Drombartny	513	Dl	148	759	148	759
Puckane	533	Dl	148	789	148	789
Coolalough	298	Dl	148	441	148	441

TABLE 6.4 (continued): Grazing capacity of soils of Co. Tipperary (North Riding)

Soil Scries	Area (ha)	Grazing capacity Class	48 kg N/ha		230 kg N/haᵢ	
			Capacil y LU/100 ha	Gross grazing capacity (LU)	Capacity LU/100 ha	Gross grazing capacity (LU)
Derrygarecn	103	Dl	148	152	148	152
Shannon-Banagher Complex	362	Di	148	536	148	536
Knockastanna - Peaty Phase	3,685	D_2	136	5,012	136	5,012
Kilcommon - Peaty Phase	2,309	D_2	136	3,140	136	3,140
Puckane - Peaty Phase	63	D_2	136	86	136	86
Knockaceol - Peaty Phase	54	D_2	136	73	136	73
Turbary Complex	9,469	E	<136 (49)	4,640	<136 (49)	4,640
Allen	3,248	E	<136 (49)	1,592	<136 (49)	1,592
Boora Complex	2,935	E	<136 (49)	1,438	<136 (49)	1,438
Burren - Rocky Phase	1,834	E	<136 (49)	899	<136 (49)	899
Seefin	40	E	<136 (49)	20	<136 (49)	20
Carney	22	E	<136 (49)	11	<136 (49)	11
Slievereagh	20	E	<136 (49)	10	<136 (49)	10
Aughty	1,056	E	<136 (49)	517	<136 (49)	517
Turbary-Knockastanna Complex	901	E	<136 (49)	441	<136 (49)	441
Pollardstown	367	E	<136 (49)	180	<136 (49)	180
Burren	344	E	<136 (49)	169	<136 (49)	169
Knocknaskeha-Doonglara Complex	524	Variable	-	-	-	-
Howardstown-Baggotstown Complex	133	Variable	-	-	-	.
B allyshear- Patricks well Complex	1,115	Variable	-	-	-	.
Camoge-Milltownpass Complex	415	Variable	-	-	-	-

TABLE 6.4 (continued): Grazing capacity of soils of Co. Tipperary (North Riding)

Soil Series	Area (ha)	Grazing capacity Class	48 kg N/ha Capacity LU/100 ha	48 kg N/ha Gross grazing capacity (LU)	230 kg N/ha Capacity LU/100 ha	230 kg N/ha Gross grazing capacity (LU)
Ballynalacken-Knockshigowna Complex	456	Variable				
Puckane-Slievereagh Complex	2,217	Variable				
Borrisoleigh-Knockshigowna Complex	719	Variable				
Knockastanna-Knockshigowna Complex	589	Variable				
Totals	198,830			346,467		415,303

TABLE 6.5: Extent and definition of grazing capacity classes in Co. Tipperary (North Riding)

Grazing capacity class	LU/100 ha		Area (ha)	Percent total area
	48 kg N/ha	230 kg N/ha		
A2	210-222	264-276	93,769	47.16
Bl	197-210	252-264	14.681	7.38
CI	173-185	220-227	18,834	9.47
C2	160-173	188-202	8,531	4.29
Dl	148-160	-	30,500	15.34
D2	135-148	-	6,111	3.07
E	<135	-	20,236	10.18
Variable	-	-	6,168	3.10

TABLE 6.6: Net grazing capacity of Co. Tipperary (North Riding) land

	Area (ha)	Grazing capacity (LU)	
		48 kg N/ha	230 kg N/ha
	198,830	346,467	415,303
Less urban, roads, fences, etc.	13,918	24,584	29,390
Tillage crops not devoted to livestock (1980)	8,623	18,324	22,765
Forest (1985)	11,221	5,498	5,498
Net	165,068	298,061	357,650

TABLE 6.7: Livestock numbers in Tipperary North Riding (1986) and possible stocking estimates

Livestock numbers	Possible total (LU)	
	48 kg N/ha	230 kg N/ha
219,200	298,061	357,650

adequate phosphorus and potassium. The low N level of 48 k ^ a assumes that the clover contribution is optimised in the grazed areas. Artificial drainage of wet soils is assumed. Pasture dry-matter production data from experimental sites in the Central Plain of Ireland provide the basis for the grazing capacity estimates for the well-drained Soil Series and Complexes. In addition to pasture data, animal production data from research centres were also used.

Grassland productivity research indicates that pastures on the well-drained soils in the south of Ireland have about a 5% advantage in annual dry-matter production over comparable pastures on soils such as the Patrickswell Series in North Tipperary. The southern part of the country has a climatic advantage for early growth of grass particularly.

The grazing capacity estimates for the gley soils are based on the extrapolation of animal production data from the former An Foras Taluntais Research Station at Mullinahone (South Tipperary) and Herbertstown (Co. Limerick), in addition to pasture output data from experimental sites in the Central Plain. The estimates for the reclaimed peats are based on animal production data from the former An Foras Taluntais Peatland Research Station at Lullymore, Co. Kildare.

The grazing potentials of soil Complexes are difficult to estimate. The grazing capacity estimates are of necessity averages for the Complexes and may not be applicable to the entire area of a Complex because of possible geographic variation in the balance of components within a particular Complex. Similarly, because of mapping limitations, the estimates of some Series, while applicable to the major extent of the Series, may not necessarily be applicable to the entire area.

Table 6.5 defines and shows the gross area of the grazing capacity classes in North Tipperary and Table 6.6 shows the net grazing capacity. Table 6.7 compares existing livestock numbers with potential carrying capacity.

Under a moderate level of grassland management (48 kg N/ha) livestock numbers in the Riding could be expanded by 36%, whereas under intensive management (230 kg N/ha) an increase of 63% in the number of livestock units is technically possible.

Reference

Attwood, E. A. and Heavey, J. (1964). Determination of grazing units. *Irish Journal of Agricultural Research* 3: 249-251. •

CHAPTER 7

TRACE ELEMENTS*

Levels of the following nutritionally-important trace elements have been determined in the soils of North Tipperary; boron, cobai', copper, manganese, molybdenum and zinc. With the exception of cobalt, all these elements are important for the growth of arable crops. For grassland they are also necessary and although Irish pastures rarely respond to trace element fertilisation, the levels of some trace elements may frequently be insufficient to meet the nutritional demands of grazing animals. Cobalt is a case in point For sheep and lambs in particular but also for cattle, pastures may not contain enough for optimum animal health and performance. Copper is also very important in this regard but here the picture is somewhat more complicated. Some soils may not contain sufficient copper to ensure a desirable level in pastures. This can be remedied by copper fertilisation. Situations exist, however, when the presence in pastures of other elements antagonistic to copper absorption by animals can cause problems. Under Irish conditions, molybdenum is probably the most important in this regard. Elevated levels of molybdenum in pastures militate against efficient copper absorption by animals, particularly ruminants. It is important, therefore, that the status of both elements be known.

Of the other elements mentioned, boron has not been confirmed as essential for animals and manganese and zinc have not, to date, been associated with animal health problems under normal farming conditions. However, zinc deficiency in cereals has been diagnosed in North Tipperary and the zinc status of pastures, from the point of view of the animal, should be kept under review. As in the case of copper, other factors are involved. For instance, zinc absorption by animals is affected by the level of both calcium and phytic acid in the diet.

With tillage crops, the soil pH is extremely important as most nutritionally-essential trace elements are rendered less available when soil pH is high. This is particularly so in the case of manganese. Boron, copper and zinc availability is also reduced by high pH but the effect is not so dramatic as in the case of manganese. At practical farm level the most serious disorders arising from manganese deficiency would probably arise with cereals but sugar beet can also be affected.

Molybdenum differs from the other trace elements insofar as an increase in soil pH is associated with an increase in Mo availability. This is not important in tillage crops but can be extremely serious in the case of grassland. As outlined above, excess molybdenum in herbage is associated with poor absorption of copper, particularly by ruminants.

Copper deficiency also affects horses but there the effect appears to be related to bone deformation, especially in the knee joint.

Compiled and written by G. A. Fleming and P. J. Parle

Interpretation of trace-element analyses

Total levels of trace elements in soils are of limited use in predicting the availability of the elements to growing plants and thus indirectly to the grazing animal. Where total levels are either extremely low or unduly high, it can be reasonably assumed that risks of deficiencies or toxicities are present but within these extremes total trace-element values are of little use in predicting problems in either plant or animal nutrition. It is necessary, therefore, that some index of trace-element availability to the plant be known. Such information has been obtained by extracting soils with various solutions, the premise being that these extractants simulate behaviour of the growing plant in terms of nutrient uptake. Because the basic soil chemistry of trace elements differs markedly, different solutions are required in the assessment of availability. Even when this is done, extractants must be calibrated against crop responses in the field and this may often vary for a given crop on different soils. Table 7.1 details the different extracting solutions employed at Johnstown Castle.

In the case of cobalt, the total value viewed together with a vaJue for total manganese gives a good indication of the likely cobalt status of herbage. Calibration trials in the field have shown that when total Mn values exceed about 500 mg/kg, cobalt availablity to pasture is severely limited.

TABLE 7.1: Summary of soil analytical methods for trace elements[1]

Element	Extraction method
Boron (B)	Extraction with boiling water
Copper (Cu)	Extraction with 0.05 molar EDTA
Manganese (Mn)	Extraction with a mixture of 0.5 molar calcium nitrate and 0.2% quinol
Molybdenum (Mo)	Extraction with Tamm's Reagent (Ammonium oxalate — oxalic acid buffered to pH 3.3)
Zinc (Zn)	Extraction with 0.05 molar EDTA

Cobalt (Co) and manganese (Mn) are extracted with HCl (specific gravity 1.12). Being a very strong extractant this gives values which are practically totals.

[1]Full details in Byrne, E. (1980). "Chemical Analyses of Agricultural Materials". An Foras Taliintais, Dublin, 194 pages. All soil analyses quoted are on air-dry soil. Herbage analyses where mentioned refer to oven-dry matter.

In the absence of response data from field calibration trials, trace-element analyses cannot provide definitite information regarding the occurrence of a crop or animal disorder. They can however be extremely useful in indicating likely problem areas. More intensive follow-up work is then necessary to establish the extent and severity of different disorders. It is with the above in mind that the data in Tables 7.2-7.10 and the accompanying comments should be viewed.

Regosols

The Regosols only occupy a total of 0.07% of the land area. The two Series occurring, the Carney and the Milltownpass, occupy only 22 and 129 hectares respectively.

TABLE 7.2: Regosols — trace element content

Soil Series	Soil PH	Available (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zn	Co	Mn
Carney	8.0	1.0	1.2	24	.07	3.3	2.0	210
Milltownpass	7.4	1.3	0.6	45	.07	1.2	1.6	160
	6.2	1.3	5.0	250	.14	3.5	8.4	1050
	6.3	1.5	4.9	35	.03	0.8	8.4	135

The pH of the Carney soil (8.0) is high, reflecting the limestone parent material. This is essentially a grassland soil and it may be necessary to fertilise with copper and cobalt to raise the levels of these elements in herbage.

On the Milltownpass soil the pH values are somewhat lower at 6.2-7.4. This soil is also only suitable for pasture. Cobalt and copper contents of herbage will probably be quite low and fertilisation with these elements may well be necessary.

Lithosols

Only one Lithosol, the Slievereagh Series, has been mapped. The area occupied is again very small - only 20 hectares - representing some 0.01% of the total land area.

TABLE 7.3: Lithosols — trace element content

Soil Series	Soil pH	Available (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zo	Co	Mn
Slievereagh	4.1	2.9	2.8	11	.14	35	0.8	35
	4.5	1.8	1.8	80	.14	11	0.8	85

The pH values of the soil are very low, boron contents are quite normal, copper contents are fairly low and manganese is very low in one sample (11 mg/kg) (Table 7.3). One high zinc value occurs and this is out of character with the nature of the parent material — it is possibly a reflection of some zinc mineralisation in the general area or some adventitious contamination. The very low cobalt values are consistent with the nature of the parent material (Old Red Sandstone bedrock).

The total area occupied by Brown Earth soils is quite small. Those examined for trace element content (Table 7.4) — Baggotstown, Ballincurra, Ballynalacken and Knocknaskeha — total less than 5000 hectares and comprise approximately 2.5% of the total land area.

TABLE 7.4: Brown Earths — trace element content

Soil Series	Soil PH	Available (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zn	Co	Mn
Baggotstown	7.8	1.0	4.6	350		3.4		940
	7.8	2.7	2.4			3.0		
Ballincurra	6.5	1.4	1.5	215	.17	1.4	2.8	400
	7.9	0.7	1.0		JO	0.8	6.8	390
Ballynalacken	8.0	1.3	6.0	55	.14	1.6	7.6	450
Knocknaskeha	6.4	1.4	5.5	45	.14	0.2	4.8	390
	6.0	1.0	2.3	205	.14	3.6	2.0	500
	6.0	2.4	7.2	210	-	11	6.4	500

The Baggotstown soil has quite a high pH, and generally trace element levels are adequate. This is fortunate because availability of most trace elements is reduced by high soil pH. Molybdenum is an exception, being more available under alkaline soil conditions. The molybdenum content recorded for Baggotstown av -4 mg/kg and the prevailing alkaline soil conditions might produce herbage with undesirably high Mi Vhen this happens there is danger of an induced copper del; ruminants and c< supplementation will then become necessary. Grassland farmers on this soil shouid I herbage monitored in spring and autumn for molybdenum content. Cobalt may be low in herbage on this soil as the soil manganese content is high (940 mg/kg). The possibility of cobalt deficiency in sheep should not be overlooked. Copper and zinc levels appear adequate for cereal growing but with the high soil pH the possibility of manganese deficiency in either cereals or sugar beet is very real.

The Ballincurra soil pH values are also quite high and variation may be due to recent liming. Trace element levels in general are variable but for cereals, deficiencies of copper, manganese or zinc are a distinct possibility. For grassland, trace element levels are reasonably good but cobalt deficiency in sheep might be a problem and copper levels in pasture should be kept under review.

The Ballynalacken soil occupies a somewhat larger area than either Baggotstown or Ballincurra. The soil pH is very high at 8.0 so manganese deficiency in cereals or sugar beet is likely. The copper level is quite good but zinc and cobalt contents are marginal.

The pH values of the Knocknaskeha soil are much lower than in the other Brown Earths. There is one very low value for zinc (0.2 mg/kg) and this should alert farmers to the possibility of zinc deficiency in cereals, especially barley. From the tillage point of view all other trace element levels appear satisfactory but the possibility of cobalt deficiency in sheep exists.

Rendzinas

Two Rendzinas, the Burren and Kilcolgan Series, were analysed (Table 7.5). Both Soil Series are very small, comprising 0.17 and 0.03% of the total land area, respectively. The Burren Series extends to 344 hectares and the Kilcolgan Series to only 56 hectares.

TABLE 7.5: Rendzinas — trace element content

Soil Series	Soil PH	Available (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zn	Co	Mn
Burren	6.9	1.3	9.7	500	.20	4.9	6.4	1500
	6.8	1.7	2.6	250	.40	2.8	7.2	815
Kilcolgan	7.5	1.6	5.6	440	.27	6.2	8.0	1130

The high pH of the Burren soil, coupled with an available molybdenum level of 0.4 mg/kg, may lead to undesirably high levels of molybdenum in herbage. Herbage analysis for molybdenum is advisable for grassland farmers on this soil. The total manganese contents are quire high and cobalt availability will therefore be low. Other trace element levels appear satisfactory.

The Kilcolgan soil may also give rise to herbage with elevated levels of molybdenum, but, as in the case of the Burren soil, cobalt availability will be poor, and thus pose problems in sheep farming.

Grey-Brown Podzolics

The Grey Brown Podzolic soils comprise two Series and occupy approximately one third of the map area. The Elton soil occupies some 10% of the area (approximately 20,000 hectares) and the Patricks well Series 23% (46,000 hectares).

Soil pH values in the Elton soil are relatively high (Table 7.6). Trace element levels for arable crops are generally satisfactory but a few low zinc contents are apparent These may give rise to zinc deficiency in cereals. Copper and manganese levels seem adequate, likewise boron contents. From the grassland point of view, molybdenum levels are satisfactory with just a few exceptions i.e. where the Mo content exceeds 0.3 mg/kg and the soil pH is over 7.0. Cobalt levels are reasonably high but because of the generally

TABLE 7.6: Grey Brown Podzolics — trace element content

Soil Series	Soil PH	Availabe (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zn	Co	Mn
Elton	6.0	1.0	2.3	430	.27	2.0	5.2	800
	7.4	1.7	2.2	205	.14	2.2	9.6	690
	7.3	1.1	2.3	245	.20	3.4	6.4	740
	6.7	0.9	4.1	360	.20	1.4	7.2	625
	7.3	1.2	3.4	110	.17	0.8	3.2	300
Patrickswell	6.5	0.9	2.6	65	.07	1.8	8.8	875
	6.9	1.1	3.3	225	.20	2.4	5.6	675
	6.8	2.7	3.2	390	.20	2.2	9.2	865
	6.6	1.5	3.8	370	.20	1.6	7.2	975
	6.1	1.0	4.9	195	.24	3.0	6.4	440
	6.9	1.3	2.7	225	.34	1.4	5.6	615
	6.7	2.7	5.9	360	.24	6.0	7.6	815
	7.2	1.4	2.7	380	.32	4.8	6.8	840
	6.9	1.5	1.0	195	.14	11	12	565
	6.1	2.0	1.4	195	.20	2.6	6.4	450
	7.6	1.5	7.8	340	.27	4.3	6.8	815
	6.5	0.7	2.8	360	.27	3.2	14	805
	7.7	1.1	4.7	390	.17	6.8	7.6	780
	7.7	1.2	5.0	440	.39	4.4	8.8	950
	6.9	1.5	3.3	300	.24	1.6	4.8	525
	7.3	1.4	9.0	460	.20	12	8.0	900
	7.7	1.0	1.7	110	-	1.8	6.4	575
	7.2	1.4	9.0	380	.20	3.0	7.2	790
	7.2	1.4	2.4	420	.34	5.9	8.8	940
	7.5	1.4	5.0	470	.17	9.4	6.4	965
	5.9	1.3	2.8	460	.17	1.6	2.8	1250

high values for manganese (440-1250 mg/kg) cobalt availability will be poor and as in the case of other soils, cobalt deficiency may pose a problem in sheep farming.

Twenty-one samples from the Patrickswell Series were taken representing a sampling density of approximately 1 sample per 2000 hectares (Table 7.6). Soil pH values on the whole are high with only three values less than 6.5. For tillage crops the trace element levels are generally satisfactory. A few low zinc values occur but there are also two high values which reflect some form of contamination or are possibly related to zinc mineralisation. Available Mn figures are high but, in view of the high pH values obtaining, manganese deficiency may occur in cereals especially in dry years. This possibility should be kept in mind. From the grassland point of view cobalt deficiency in sheep — especially lambs — may be encountered from time to time. As in the case of the Elton soil the total Mn figures are quite high — thus rendering soil Co relatively unavailable. Molybdenum levels are generally satisfactory and although pastures with elevated levels of molybdenum may occur, the area in general is not considered molybdeniferous.

Brown Podzolics

Two Brown Podzolic soils, the Borrisoleigh and Doonglara Series were analysed (Table 7.7). The Borrisoleigh Series occupies 10.9% of the total land area (21,772 hectares). The Doonglara Series is much less extensive occupying 2314 hectares and representing 1.16% of the total area.

TABLE 7.7: Brown Podzolics — trace element content

Soil Series	Soil PH	Available (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zn	Co	Mn
Borrisoleigh	4.6	3.9	2.8	350	.34	9.2	6.8	890
	5.3	1.6	1.4	70	.20	3.3	3.6	275
	5.0	2.9	2.2	140	.20	0.8	12	940
	4.3	1.7	3.2	17	.20	6.0	0.4	85
	6.8	1.3	3.5	65	.17	1.7	5.2	590
Doonglara	5.0	1.3	2.4	135	.17	2.9	3.2	340
	6.1	1.9	2.2	70	.14	2.4	5.2	185

In contrast to the Elton and Patrickswell soils discussed above, the soil pH values of both the Borrisoleigh and Doonglara soils are relatively low. In the case of the Borrisoleigh soil two extremely low values of 4.6 and 4.3 occur. The loss-on-ignition figures from these samples are 24 and 28%, respectively, indicating quite a high organic matter content. This to some extent explains the low pH values. The Borrisoleigh soils in general need lime and this will have repercussions in terms of reducing trace-element availability especially of manganese and boron. As these soils are primarily suitable for grassland, the addition of copper and cobalt may be necessary. Lime will also be needed for good grassland production and quality. This may have the effect of increasing the molybdenum content of swards and they should therefore be monitored for molybdenum content before and after liming. Liming will reduce cobalt availability and herbage analyses for cobalt are advisable especially if sheep are being grazed.

Podzols

Only one Podzol, the Knockaceol Series, was analysed (Table 7.8). This Series is very small in extent, occupying only 0.04 % of the land area (78 hectares).

TABLE 7.8: Podzol — trace element content

Soil Series	Soil pH	Available (mg/kg)					Total (mg/kg)	
		B	Cu	Mn	Mo	Zn	Co	Mn
Knockaceol	6.0	1.3	1.4	180	.14	3.1	0.8	340

Trace element levels in general are low with copper and cobalt being especially low. These low levels are consistent with the nature of the parent material (Old Red Sandstone). As this soil will in all probability be used for grassland, application of both copper and cobalt is advised as an aid in maintaining good stock health. Application of 10 to 20 kg/ha of copper sulphate and 2 to 3 kg/ha of cobalt sulphate will raise the herbage content of these elements and reduce the possibility of copper and cobalt deficiency in grazing stock.

Gleys

Fourteen Gley soils have been mapped in North Tipperary and 13 of these have been analysed for trace element content (Table 7.9). Only the Kilgory Series, which occupies but 0.3% of the area (54 hectares), was not analysed

The Ballyshear soil (0.47% of the total area - 942 hectares) has a relatively high pH and the trace element levels in general are satisfactory. One high figure for copper was recorded (19 mg/kg). There is no immediate explanation for this except that the area may have been used for potato growing in the past. On analysis, such soils often show a high copper content, consequent on applications of the fungicide Bordeaux mixture.

Considerable variation in soil pH is apparent in the Camoge soil. Values range from 5.3 to 7.7 but this may be merely a reflection of liming. Boron, copper and molybdenum contents are satisfactory. A few low values for zinc are apparent (1.6 and 1.8 mg/kg). Values for this element are quite variable with one rather high one occurring (1? mg/kg). Cobalt levels are also variable and, as some high manganese values occur, the risk of cobalt deficiency (especially in sheep) exists.

Only one sample was analysed from the Coolalough Series. The soil occupies only 0.15% of the total area and covers approximately 300 hectares. Trace element contents are satisfactory but with a soil pH of 7.3 the possibility of manganese deficiency, especially in cereals, must be considered.

Two samples were analysed from the Derrygarreen Series which again is very small, occupying a mere 0.05% of the total area. Here the soil pH is extremely low (4.2) and trace element levels in general are also very low. Obviously this soil needs lime and this will exacerbate trace-element deficiency problems. For crops such as cereals, copper, manganese and zinc supplementation would be necessary and for grassland, cobalt and possibly copper would need to be applied.

The Drombanny soil (513 hectares — 0.26% of land area) is low in manganese and slightly elevated in molybdenum content Liming of this soil should be accompanied by

TABLE 7.9: Gleys — trace element content

Soil Series	Soil pH	Available (mg/kg) B	Cu	Mn	Mo	Zn	Total (mg/kg) Co	Mn
Ballyshear	6.5	3.8	19	160	.07	11	5.6	375
	7.2	2.8	5.2	205	-	11	9.6	675
Camoge	5.5	1.7	6.2	210	.17	5.6	6.4	
	7.7	0.8	2.7	35	.03	1.6	4.0	
	7.4	3.7	9.4	60	.10	2.2	5.f	
	5.3	3.5	12	420	.17	12	7.2	790
	7.2	7.3	14	195	.55	7.6	7.6	765
	6.0	2.0	3.2	100	.07	1.8	2.8	160
	6.2	10	4.0	75	.20	2.9	6.0	300
	7.3	2.0	2.9	430	.10	2.0	8.0	1000
Coolalough	7.3	1.4	4.0	140	.10	4.6	4.0	400
Derrygarreen	4.2	1.9	1.4	5	.14	1.2	0.2	20
	-	1.6	0.6	25	.03	0.6	0.2	30
Drombanny	5.8	3.5	6.5	34	.52	20	3.6	100
Feale	4.8	1.0	11	65	.07	13	6.8	200
	7.3	l.t	22	95	.14	5.0	6.4	275
	5.6	1.6	1.9	165	.39	0.6	6.8	415
	5.2	1.5	0.8	210	.10	4.8	4.0	325
Gortaclareen	5.6	1.2	2.5	90	.07	3.9	2.4	135
Howardstown	5.7	2.1	3.2	90	.20	3.6	3.2	160
	6.0	1.2	3.0	100	.07	1.4	3.6	200
	6.9	1.2	3.7	85	0.3	1.4	3.2	175
Kilcommon	6.0	2.2	4.3	85	.24	1.4	3.6	285
	6.5	1.2	7.6	210	.14	1.4	4.8	390
	5.3	2.0	2.7	110	.10	2 8	7.6	360
	5.5	1.8	3.8	85	.17	4.0	5.6	175
	5.2	0.7	2.3	50	.10	1.8	8.0	200
Kilcommon (Peaty Phase)	4.8	2.5	8.4	85	.07	12	9.2	175
Mylerstown	7.2	0.5	1.9	150	.20	0.8	9.6	625
	7.8	0.7	2.1	175	.10	5.0	7.6	565
	7.5	1.2	6.3	48	.07	1.0	6.0	260
	7.2	3.3	2.7	140	-	8.4	5.6	590
Puckane	5.8	1.0	3.6	50	.07	2.8	1.1	85
Puckane (Peaty Phase)	4.8	1.2	1.2	6	.07	2.5	0.4	30

TABLE 7.10: Peat — trace element content

Soil Series	Soil pH	Available (mg/kg)				Total (mg/kg)	
		Cu	Mn	Mo	Zn	Co	Mn
Aughty	4.1	2.5	1.4	.07	1.6	0.8	20

TABLE 7.11: Interpretation of trace element data

Element	Soil content (mg/kg)	Practical agricultural significance
Copper (EDTA-soluble)	1.5	Risk of copper deficiency in cereals or of low Cu levels in herbage if below this level
Zinc (EDTA-soluble)	1.0	Risk of zinc deficiency in cereals and possibly some horticultural crops if Zn is below this level
Molybdenum (Ammonium oxalate-soluble)	0.01	Risk of molybdenum deficiency in brassicas if Mo is below this level.
	0.25	Risk of molybdenum-induced copper deficiency especially in young cattle if Mo value exceeds this level but other factors such as liming, soil moisture, sulphur content of feed and level of soil intake (i.e. stocking rate) are important.
Manganese (Ca(NC»3)2-quinol soluble)	40	Possibility of manganese deficiency in cereals and sugar beet if Mn value below this level.
Boron (Water-soluble)	1	Risk of boron deficiency in swedes and some horticultural crops — slight risk in sugar beet and oilseed rape if B value is below this level.
Cobalt (Total)	5	Risk of cobalt deficiency especially in lambs if Co figure below this level. For correction of cobalt-deficient pastures, application of cobalt sulphate works best when soil Mn level is below 400-500 mg/kg. Direct Co supplementation of animals is probably best when soil Mn is 700 mg/kg or higher but spring application of 3-4 kg/ha cobalt sulphate per ha will probably raise herbage Co to acceptable levels for one gTa/ing season.

manganese supplementation for cereals. Grassland would need to be monitored for molybdenum content as liming would increase available soil molybdenum.

The Feale Series, occupying 2.4% of the area, is variable both in pH and trace-element content. Some liming will be necessary. Cobalt levels are reasonably satisfactory and there should not be any severe problems from cobalt deficiency.

The Gortaclareen soil is similar in extent to the Feale. It too needs lime. As it is primarily a grassland soil, addition of cobalt will probably be necessary for sheep if soil physical conditions are such that sheep farming is practicable.

The Howardstown Series is reasonably well supplied with trace elements. Cobalt will be necessary for sheep farming. This soil is relatively small in extent — 0.95% of the land area or 1902 hectares.

The Kilcommon Series is reasonably extensive, occupying over 12,000 hectares (6.15%) of the total land area. Soil pH values are mostly low and lime application will be necessary. The cobalt status is reasonably good.

The Peaty Phase of the Kilcommon Series is extremely acid and liming is required. Levels of other trace elements are satisfactory for this essentially grassland soil.

The Mylerstown Series (4297 hectares, 2.15% of total area) has a high pH value. Copper and zinc levels are marginal but are probably sufficient for grassland.

The Puckane Series, with the low pH of 5.8, would require lime for barley or sugar beet For grassland, cobalt would probably be necessary; cobalt sulphate application will give a good response in terms of increasing the cobalt content of herbage.

The Peaty Phase of the Puckane Series is very acid and liming is necessary. The copper level is low and the manganese levels extremely low. The cobalt content is also very low and application of cobalt sulphate to grassland is advisable. Copper levels in pasture may also be low. After liming, manganese levels in grassland should be monitored.

Seven peat soils have been mapped but only one, the Aughty Series, was analysed for trace elements (Table 7.10). This Series occupies 0.53% of the land area (1056 hectares). For tillage crops or grassland liming is required. As expected on a peat soil, levels of most trace elements are low. On grassland, extra cobalt will be required for sheep but cattle may also require supplementation. This soil will respond very well to applied cobalt as the manganese level is very low. Copper levels in pasture are likely to be undesirably low.

APPENDIX I

DEFINITION OF TERMS USED IN PROFILE DESCRIPTIONS AND ANALYSES

Texture

Soil texture refers to the relative proportions ot the various size particles in the mineral fraction of a soil. More especially, it refers to the relative proportions oi clay sill sand in the mineral fraction less than 2 millimetres in diameter. Texture, which is one of the more important of the soil's physical characteristics, influences such factors as moisture retention, drainage and tilling properties of soils, their resistance to *daman* 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, silly clay and clay. Definitions of the basic classes in terms of clay (less than 0.002 mm), sill (0.002 to 0.05 mm) and sand (0.05 to 2.0 mm diameter size) are presented in graphic form (Fig. 1).

Field Estimation of Soil Textural Class

The estimation of soil textural class is made in the field by feeling the moist soil between the fingers. The field estimation is checked in the laboratory. In arriving ai an estimation in the field the following considerations are taken into account:

Sand- Sand is loose and single grained. The individual grains can readily be seen and felt. Pressed when moist, a weak cast may be formed which easily crumbles when touched.

Sandy Loam. A sandy loam contains much sand but has adequate silt and clay to make it somewhat coherent. If squeezed when moist, a cast can be formed that bears careful handling without breaking.

Loam: A loam has roughly equal proportions of sand, silt and clay. If squeezed when moist, a cast is formed which can be handled quite freely without breaking.

5/7/ *Loam: A* silt loam contains a moderate amount of sand, a relatively small amount of clay and more than half the particles of silt size. A cast can be formed which can be freely handled without breaking, but when moistened and squeezed between thumb and finger it does not 'ribbon' but gives a broken appearance.

•The terms and definitions used are are essentially those of the Soil Survey Manual, USDA Handbook No. 18, Washington, D.C., 1951.

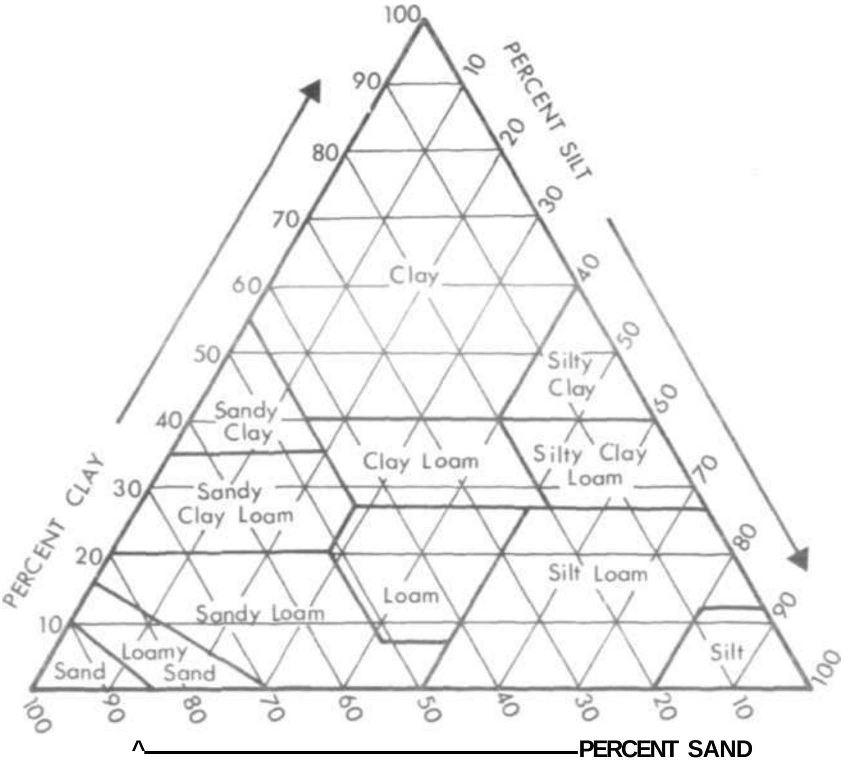

Fig. 1: Chart showing the percentages of clay (less than 0.002 mm) silt (0.002 to 0.05 mm) and sand (0.05 to 2.0 mm) in the basic soil texture classes (after Soil Survey Manual, USDA Handbook No. 18, Washington, DC, 1951).

Clay Loam: A clay loam contains more clay than a loam and usually breaks into clods or lumps that are hard when dry. In the moist state it is plastic and can be formed into a cast which can withstand considerable handling. When kneaded in the hand, it does not crumble readily, but tends to work into a heavy compact mass.
Clay: A clay has a preponderance of finer particles, contains more clay than a clay loam and usually forms hard lumps or clods when dry, but is quite plastic and sticky when wet When pinched out between thumb and finger in the moist state it forms a long, flexible 'ribbon'.

General Grouping of Soil Textwal Classes

Often it is convenient to refer to texture in terms of broad groups of textural classes. Although the terms 'heavy' and 'light' have been used for a long time in referring to fine- and coarse-textured soils, respectively, the terms are confusing as they do not bear any relation to the weight of soil; the terms arose from the relative traction power required for ploughing. An outline of acceptable terms is as follows:

General terms		•il texiural class
Sandy Soils	Coarse-textured soils	Sands
	Moderately coarse-textured soils	Loamy sands Sandy loams
Loamy Soils	Medium-textured soils	Loams Silt loams Sills
	Moderately fine-textured soils	Clay loams Sandy clay loams Silty clay loams
Clayey Soils	Fine-textured soils	Sandy clays Clays

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 responses 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.

Type

There are four primary types of structure:

a) Platy — with particles arranged around a plane and faces generally horizontal
b) Prismlike — with particles arranged around a vertical line and bounded by relatively flat vertical surfaces
c) Blocklike — with particles arranged around a point and bounded by relatively flat or curved surfaces that are not accommodated to the adjoining aggregates.

Each of the last three types has two subtypes:

Under prismlike, the two subtypes are prismatic (without rounded upper ends) and columnar (with rounded ends). The two subtypes of blocklike are angular blocky (with sharp-angled faces) and sub-angular blocky (with rounded faces). Spheroidal is subdivided into granular (relatively non-porous) and crumb (very porous).

Class

Five size-classes are recognised in each type,. The size limits of these vary for the four primary types given. A type description is generally qualified by one of the following class distinctions; very fine, fine medium, coarse and very coarse.

Grade

Grade is the degree of aggregation or strength of the structure. In field practice, it is determined mainly by noting the durability of the aggregates and me relative proportions of aggregated and non-aggregated material when the aggregates are disturbed or gently crushed.

Terms for grade of structure are as follows:

0. *Structureless* — No observable aggregation. This condition is described as massive if coherent and single grain if noncoherent.
1. *Weak* — Poorly-formed indistinct peds which, when disturbed, break down into a mixture comprising some complete peds, many broken units and much non-aggregated material.
2. *Moderate* — Many well-formed, moderately durable peds that are not so apparent in the undisturbed soil. When disturbed, however, a mixture of many complete peds, some broken peds and a little non-aggregated material is evident
3. *Strong* — Structure characterised by peds that are well formed in undisturbed soil, and that survive displacement to the extent that when disturbed, soil material consists mainly of entire peds, with few broken peds and a little non-aggregated material.

The appropriate terms describing type, class and grade of structure are combined in that order to give the structural description, e.g. moderate, medium sub-angular blocky, weak, fine crumb.

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 determine?, 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 evaluation of soil consistence is usually considered at three levels of soil moisture — wet, moist and dry.

Consistence When Wet

A. *Stickiness:* Stickiness expresses the extent of adhesion to other objects. To evaluate this feature in the field, soil material is pressed between thumb and finger and its degree of adhesion noted. Degrees of stickiness are expressed as follows:

   0. *Non-sticky:* On release after pressure, practically no soil material adheres to thumb or finger.
   1. *Slightly sticky:* After pressure, soil material adheres to thumb and finger but comes off one or the other rather clearly.
   2. *Sticky:* After pressure, soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pull free from either digit.
   3. *Very sticky:* After pressure, soil material adheres strongly to both thumb and finger and is decidedly stretched when they are separated.

B. *Plasticity:* Plasticity is the ability to change shape continuously under applied stress and to retain the impressed shape on removal of the stress. To evaluate in the field, the soil material is rolled between thumb and finger to form a 'wire'.

   0. *Non-plastic:* No wire formable
   1. *Slightly plastic:* Wire formable; soil mass easily deformed.
   2. *Plastic:* Wire formable; moderate pressure required to deform soil mass.
   3. *Very plastic:* Wire formable; much pressure required to deform soil mass.

Consistence When Moist

To evaluate in the field, an attempt is made to crush in the hand a mass of soil that appears moist.

0. *Loose:* Noncoherent.
1. *Very friable:* Soil material crushes under very gentle pressure but tends to cohere when pressed together.
2. *Friable:* Soil material crushes easily under gentle to moderate pressure between thumb and finger and tends to cohere when pressed together.
3. *Firm:* Soil material crushes under moderate pressure between thumb and finger but resistance is distinctly noticeable.
4. *Very firm:* Soil material crushes under strong pressure; barely crushable between thumb and finger.

Consistence When Dry

To evaluate, an air-dry mass of soil is broken in the hand.

0. *Loose:* Noncoherent
1. *Soft:* Soil is fragile and breaks to powder or individual grains under very slight pressure.

2. *Hard:* Soil can be broken easily in the hands but it is barely breakable between thumb and finger.
3. *Very hard:* Can normally be broken in the hands but only with difficulty.

Cementation

Cementation of soil material refers to a brittle, hard consistence caused by various cementing substances. Different degrees of cementation occur.

1. *Weakly cemented:* Cemented mass is brittle but harder than that which can be shattered in the hand.
2. *Strongly cemented:* Cemented mass is brittle but harder than that which can be shattered in the hand; it is easily shattered by hammer.
3. *Indurated:* Very strongly cemented; brittle; does not soften when moistened and is so extremely hard that a sharp blow with a hammer is required for breakage.

General Analyses

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

Cation Exchange Capacity (CEC)

The cation exchange capacity, 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, and of the crop response that can be expected to added nutrients in manurial amendments. The exchange capacity 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 to 40 mEq/100 g of soil). The cation exchange capacity of a soil low in, or devoid of, organic matter is generally less than 12 mEq/100 g; here it 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, a low potential for retaining applied plant nutrients; hence the necessity for 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 large quantities of applied nutrients especially calcium and potassium; the nutrients are slowly released to meet the needs of growing plants. On such soils, therefore, fertiliser and lime applications can be larger and less frequent.

Total Exchangeable Bases (TEB)

Extracted by method of Mehlich (1948). Ca, Na, K and Mg estimated by atomic absorption.

Percentage Base Saturation

The base saturation of the exchange complex of a soil is obtained by determining the total exchangeable bases (plant nutrients such as calcium, potassium, sodium, magnesium) and expressing the figure obtained as a percentage of the cation exchange capacity. As such it is an index of the base status of the soil.

The natural base status of a soil is inherited from the parent material but may be modified subsequently by weathering, leaching and other influences including cultural practices. Where the parent material is base-rich and leaching has not been excessive, the rate of release of bases by weathering is sufficient to offset losses through leaching, cropping and other outlets and to provide for a high base status profile. However, where rainfall is heavy and evapotranspiration low, or where the coarse nature of the soil permits excessive leaching, or where large amounts of bases are removed by intensive cropping, the base content of a soil may be considerably depleted. Low base status may also be an inherent characteristic of soils related to the acid nature of the parent material.

The base status of acid soils can be improved by liming, the amount necessary being determined by (a) the ability of the soil to adsorb bases — the cation exchange capacity — (b) the prevailing base status and (c) the desired base status. Certain fertilisers also supplement the base status of the soil. Many of the soils in North Tipperary are derived from base-rich parent materials, e.g. limestone-rich glacial drift, but due to leaching the bases have been removed in many cases and especially from the upper horizons. Others are inherently acid. Application of lime would be a prerequisite to increased crop production on these soils.

Total Neutralising Value (TNV)

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

Carbon and Nitrogen

The level of organic carbon indicates the amount of organic matter in a soil (C x 1.72 = organic matter). The content and nature of organic matter are of fundamental importance. Due to its high cation-exchange capacity, organic matter acts as a reservoir for 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; it 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 and, thus, 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 7 to 10% 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 to 6% organic carbon.

Nitrogen, which is normally present in soils in relatively small amounts, is extremely important as a plant nutrient. It is easiiy leached from the soil and supplies need to be constantly replenished. The ratio of carbon to nitrogen (C/N ratio) 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 (Bir horizon), as is evident in Brown-Podzolic and Podzol soils, indicates that leaching and podzolising processes have been operative. On the other hand, a uniform distribution of free iron throughout a profile, as is the case in the Brown Earths, indicates that the soils have not been strongly leached

Field Moisture (%) — moisture content at saturation
Unit weight at saturation expressed as the weight of water per unit weight of oven-dry soil on a percentage basis.

Bulk Density at Saturation (Db)
Dry weight of peat divided by saturated volume.

SPEC Index
The solubility of the organic fraction in a solution of sodium pyrosphosphate indicates the degree of oxidation or humification (Mackenzie and Dawson, 1962). Colour index expressed on the Munsell Notation using value-chroma e.g. 10 YR 6/3 = P.I.3

Summary of Analytical Methods

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

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

Total Neutralising Value (TNV): Determined on HC1 extract using phenolphthalein as indicator and titrating against NaOH. $CaC0_3$ is used as a 100% standard.

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

Total Nitrogen: Estimated by a modification of the method of Piper (1950) by digesting soil with concentrated H2SO4 using selenium as a catalyst, distilling into boric acid and titrating with HC1.

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

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APPENDIX II

PROFILE DESCRIPTIONS AND ANALYSES OF MODAL PROFILES

Regosol Group

CARNEY SERIES — MODAL PROFILE

Topography:	Flat lake bed
Slope:	0°
Elevation:	58 m
Drainage:	Well drained
Parent Material:	Lake alluvium derived from limestone
Great Soil Group:	Regosol

Horizon	*Depth (cm)*	*Description*
Al	0-12	Silty clay; very pale brown (10 YR ' subangular blocky structure; moist slightly friable, slightly plastic; few roots; clear, smooth boundary:
	12-100	White marl; massive; wet sticky; no roots.

TABLE 1: Carney Series — Profile Analyses

Horizon	Al	C
Depth (cm)	0-12	12-100
Mechanical analysis of mineral fraction (%)		
Coarse sand	2	2
Fine sand	4	5
Silt	47	58
Clay	47	35
pH	8.0	8.8
CEC, mEq/100 g	16.8	5.4
TEB, mEq/100 g	13.6	6.2
Base saturation, %	81	Sat.
Carbon, %	3.0	**0.5**
Nitrogen, %	0.2	
C/N ratio	15.0	
Free iron, %		0.0
TNV,%	87	97

MILLTOWNPASS SERIES — MODAL PROFILE

Topography:	River flat within gently rolling landscape
Slope	0°
Elevation:	50 m
Drainage	Well drained
Parent Material	Alluvium from limestone drift
Great Soil Group	Regosol

Horizon	*Depth (cm)*	*Description*
Al	0-16	Loamy sand; yellowish brown (10 YR 5/6 fine crumb structure; moist friable; root mat present; clear, gradual boundary:
132	16-48	Loamy sand; brown to dark brown (7.5 YR 4/4); single grain structure; moist loose; roots present; abrupt, smooth boundary:
B3	48-62	Loamy sand; light yellowish brown (10 YR 6/4); single grain structure; moist loose; very few roots; abrupt, smooth boundary:
CI	62-80	Sandy loam; brown (10 YR 5/3); single grain structure; moist loose; roots present.

TABLE 2: Milltownpass Series — Profile Analyses

Horizon Depth (cm)	Al 0-16	B2 16-48	B3 48-62	CI 62-80
Mechanical analysis of mineral fraction (%)				
Coarse sand	28	40	50	35
Fine sand	55	49	36	37
Silt	10	5	7	14
Clay	7	6	7	14
PH	7.4	7.8	7.3	7.5
CEC, mEq/100 g	13.6	9.4	4.4	8.2
TEB, mEq/100 g	7.7	4.5	3.4	6.1
Base saturation, %	57	48	77	74
Carbon, %	1.3	0.2	0.2	0.4
Nitrogen, %	0.2	-	-	-
C/N ratio	6.5	-	-	-
Free iron, %	0.8	0.8	1.0	1.1
TNV,%	0.2	0.2	0.2	31.2

Lithosol Group

SLIEVEREAGH SERIES — MODAL PROFILE

Topography:	Mountain v alleys ide
Slope:	1° to 4°
Elevation:	183 m
Drainage:	Excessive
Parent Material:	Devonian Old Red Sandstone
Great Soil Group:	Lithosol

Horizon	*Depth (cm)*	*Description*
Al	0-17	Peaty sandy loam; very dark crumb structure; moist friable; clear boundary:
	17+	Old Red Sandstone

TABLE 3: Slievereagh Series — Profile Analysis

Horizon	Al
Depth (cm)	0-17
Mechanical analysis of mineral fraction (%)	
Coarse sand	46
Fine sand	30
Silt	15
Clay	9
pH	4.5
CEC, mEq/100 g	34.4
TEB, mEq/100 g	7.0
Base saturation, %	20
Carbon, %	12.2
Nitrogen, %	0.6
C/N ratio	20.3
Free iron, %	0.2
TNV,%	

BAGGOTSTOWN SERIES — MODAL PROFILE

Topography:	Gently sloping
Slope:	2°
Elevation:	170 m
Drainage:	Excessive
Parent Material:	Limestone fluvioglacial material
Great Soil Group:	Brown Earth

Horizon	*Depth (cm)*	*Description*
Al	0-13	Gravelly clay loam to loam; di strong fine crumb structure; moist plastic, slightly sticky; few roots; clear, smooth boundary:
(B)	13-30	Gravelly clay loam; dark yellowish brown (10 YR 4/4); weak fine angular blocky structure; moist plastic; very few roots; clear, smooth boundary:
	30+	Gravelly clay loam to loam; greyish brown (10 YR 5/2); weak fine angular blocky structure; moist, slightly plastic; no roots.

TABLE 4: Baggotstown Series — Profile Analysis

Horizon	Al	(B)	C
Depth (cm)	0-13	13-30	30+
Mehanical analysis of mineral fraction (%)			
Coarse sand	14	14	15
Fine sand	12	11	12
Sill	47	45	45
Clay	27*	30	28
PH	7.8	8.0	8.4
CEC, mEq/100 g	25.2	14.0	2.8
TEB, mEq/100 g	23.2	19.4	5.9
Base saturation, *(%)*	92	Sat.	Sat.
Carbon, *%*	2.2	0.7	0.1
Nitrogen, *%*	0.3		
C/N ratio	7.3		
Free iron, *%*	2.3	2.6	1.0
TNV,%	3.7	5.4	59.0

*Slightly finer than usual Baggotstown profiles

BALLINCURRA SERIES — MODAL PROFILE

Topography:	Gentle hillslope
Slope:	4°
Elevation:	88 m
Drainage:	Excessive
Parent material:	Limestone glacial till
Great Soil Group:	Brown Earth of high base status

Horizon	*Depth (cm)*	*Description*
Al	0-10	Gravelly clay loam; dark yellowish brown (10 YR 4/4); moderate fine crumb structure; moist friable and non plastic; root mat; clear, smooth boundary:
(B)	10-50	Gravelly loam; brown to dark brown (7.5 YR 4/4); moderate fine crumb structure; moist friable; plentiful roots; abrupt, irregular boundary:
	50+	Limestone bedrock.

TABLE 5: Ballincurra Series — Profile Analyses

Horizon	Al	(B)
Depth (cm)	0-10	10-50
Mechanical analysis of mineral fraction (%)		
Coarse sand	18	17
Fine sand	19	20
Silt	35	38
Clay	28	25
PH	7.5	7.7
CEC, mEq/100 g	29.4	21.8
TEB, mEq/100 g	21.3	18.2
Base saturation, %	72	84
Carbon, %	4.1	3.2
Nitrogen, %	0.4	0.3
C/N ratio	10.3	10.7
Free iron, %	2.3	**2.4**
TNV,%	1.5	**3.0**

BALLYNALACKAN SERIES — MODAL PROFILE

Topography:	Gently rolling
Slope:	1°
Elevation:	105 m
Drainage:	Well drained
Parent Material:	Till of mixed shale, sandstone, limestone composition
Great Soil Group:	Brown Earth

Horizon	*Depth (cm)*	*Description*
All	0-10	Loam to clay loam; dark brown (10 YR 3/3); moderate fine crumb structure; moist slightly plastic and sticky; clear, gradual boundary:
A12	10-35	Loam; brown to dark brown (10 YR 4/3); fine to medium crumb structure; slightly plastic and sticky; clear, wavy boundary:
(B)	35-49	Gravelly loam; yellowish-brown (10 YR 5/4); weak fine sub-angular blocky structure; slightly friable but sticky; clear, abrupt boundary:
	49-100	Gravelly loam; yellowish-brown (10 YR 5/6); massive structure; moist, slightly sticky.

TABLE 6: Ballynalackan Series — Profile Analyses

Horizon Depth (cm)	All 0-10	A12 10-35	(B) 35-49	(C) 49-100
Mechanical analysis of mineral fraction (%)				
Coarse sand	15	14	14	17
Fine sand	17	19	17	18
Silt	42	44	47	44
Clay	26	23	22	21
pH	6.4	6.3	6.2	6.5
CEC, mEq/100 g	37.8	20.8	17.6	9.4
TEB, mEq/100 g	21.6	10.1	6.4	3.6
Base saturation, %	57	49	36	38
Carbon, %	6.6	1.5	0.9	0.2
Nitrogen, %	0.6	0.3	-	-
C/N ratio	11.0	5.0	-	-
Free iron, %	2.2	2.4	2.8	3.2
TNV,%	-	-	-	-

DOVEA SERIES — MODAL PROFILE

Topography:	Gently rolling hilltop
Slope:	2°
Elevation:	116 m
Drainage:	Well drained
Parent Material:	Glacial till of limestone and shale composition
Great Soil Group:	Brown Earth of high base status

Horizon	*Depth (cm)*	*Description*
Al	0-15	Clay; dark yellowish brown (10 YR 3/4); moderate fine crumb structure; slightly friable; slightly plastic; root mat to 10 cm and plentiful below; clear, smooth boundary:
(B)l	15-40	Silty clay loam; dark yellowish brown (10 YR 4/4); massive to coarse angular blocky structure; moist friable; roots present; clear, smooth boundary:
(B)2	40-50	Silty clay loam; dark greyish brown (10 YR 4/2); weak fine angular blocky structure; moist friable; few roots; clear, smooth boundary:
	50-120	Gravelly silty clay loam; very dark greyish brown (10 YR 3/2); massive structure; no roots; moist plastic.

TABLE 7: Dovea Series — Profile Analyses

Horizon Depth (cm)	Al 0-15	(B)l 15-40	(B)2 40-50	(C) 50-120
Mineral analysis of mineral fraction (%)				
Coarse sand	12	8	8	8
Fine sand	13	8	7	8
Silt	16	49	50	53
Clay	59	35	35	31
pH	7.4	7.6	8.2	8.0
CEC, mEq/100 g	32.8	26.6	13.0	8.4
TEB, mEq/100 g	24.9	20.6	10.7	10.0
Base saturation, %	76	77	82	Sat.
Carbon, %	5.0	1.7	0.4	0.4
Nitrogen, %	0.4	0.2	-	-
C/N ratio	12.2	8.5	-	-
Free iron, %	2.7	3.6	1.8	2.0
TNV,%	3.1	2.6	35.9	33.0

KINVARRA SERIES — MODAL PROFILE

Topography:	Gently rolling
Slope:	1°
Elevation:	70 m
Drainage:	Excessive
Parent Material:	Limestone till
Great Soil Group:	Brown Earth of high base status

Horizon	*Depth (cm)*	*Description*
All	0-18	Gravelly loam; brown (10 YR 4, structure; friable; clear, irregular boundary:
(B)	18-25	Gravelly loam; brown (10 YR 4/3); moderate fine to medium subangular blocky structure; friable; abrupt, irregular boundary:
	25+	Gravelly loam; light yellowish brown (10 YR 6/4); weak fine angular blocky structure; moist sticky.

TABLE 8: Kinvarra Series — Profile Analyses

Horizon	All	(B)	C
Depth (cm)	0-18	18-25	25+
Mechanical analysis of mineral fraction (%)			
Coarse sand	25	22	29
Fine sand	21	23	25
Silt	32	31	28
Clay	22	24	18
_	7.2	7.7	8.2
CEC mEq/lOOg	27.2	18.6	4.6
TEB mEq/100 g	18.7	15.1	4.9
Base saturation, %	69	81	Sat.
Carbon, %	3.8	1.7	0.3
Nitrogen, %	0.4	0.2	
C/N ratio	9.5	8.5	
Free iron %	2.1	2.5	1.0
TNV,%			

KNOCKNASKEHA SERIES — MODAL PROFILE

Topography:	Very gently rolling
Slope:	2°
Elevatioin:	70 m
Drainage	Well drained
Parent Mterial:	Old Red Sandstone with limestone and shale
Great Soil Group:	Brown Earth

Horizon	*Depth (cm)*	*Description*
Al	0-34	Loam; brown to dark brown (10 YR 4/3); moderate fine crumb structure; moist friable; clear, smooth boundary:
(B)	34-64	Sandy loam; strong brown (7.5 YR 5/6); weak fine subangular blocky structure; moist friable; clear smooth boundary:
	64-80	Gravelly sandy loam; brown to dark brown (7.5 YR 4/4); massive structure; moist friable; abrupt boundary with rock below.

TABLE 9: Knocknaskeha Series — Profile Analyses

Horizon	Al	(B)	C
Depth (cm)	0-34	34-64	64-80
Mechanical analysis of mineral fraction (%)			
Coarse sand	25	31	34
Fine sand	25	21	32
Silt	29	30	21
Clay	21	18	13
PH	5.9	6.4	6.4
CEC, mEq/100 g	19.4	10.6	9.4
TEB, mEq/100 g	8.8	5.4	2.3
Base saturation, %	45	51	25
Carbon, %	2.0	0.6	1.2
Nitrogen, %	0.2		
C/N ratio	10.0		
Free iron, %	1.7	2.0	1.2
TNV,%			

Rendzina Group

BURREN SERIES — MODAL PROFILE

Topography:	Undulating
Slope:	0°
Elevation:	70 m
Drainage:	Excessive
Parent Material:	Limestone bedrock with a trace of till
Great Soil Group:	Rendzina

Horizon	*Depth (cm)*	*Description*
Al	0-11	Clay loam to silty clay loam; dark gr< YR 4/2); strong fine crumb structure; compact, moist friable; root mat; abrupt, irregular boundary:
	11 +	Limestone bedrock

TABLE 10: Burren Series — Profile Analyses

Horizon	Al
Depth (cm)	0-11
Mechanical analysis of mineral fraction (%)	
Coarse sand	7
Fine sand	10
Silt	50
Clay	33
PH	6.9
CEC, mEq/100 g	51.6
TEB, mEq/100 g	42.1
Base saturation, °,	82
Carbon, %	11.0
Nitrogen, %	0.8
C/N ratio	13.8
Free iron, %	1.0
TNV,%	

KILCOLGAN SERIES — MODAL PROFILE

Topography:	Gently rolling
Slope:	1°
Elevation:	70 m
Drainage:	Excessive
Parent Material:	Limestone glacial till
Great Soil Group:	Rendzina

Horizon	*Depth (cm)*	*Description*
Al	0-15	Gravelly loam to clay loam; dark brown (10 YR 3/3); strong fine crumb structure; moist friable; root mat present; clear, smooth boundary:
	15-25	Gravelly clay loam; dark brown (10 YR 3/3); moderate fine crumb to subangular blocky structure; moist, friable and slightly plastic; plentiful roots; clear boundary:
	25-100	Gravelly loam; light yellowish brown (10 YR 6/4); weak, fine angular blocky structure; moist sticky.

TABLE 11: Kilcolgan Series — Profile Analyses

Horizon Depth (cm)	A 0-15	B 15-25	C 25-100
Mechanical analysis of mineral fraction (%)			
Coarse sand	15	14	24
Fine sand	13	13	19
Silt	45	45	35
Clay	27	28	22
pH	7.5	8.0	8.3
CEC, mEq/100 g	29.8	19.4	4.4
TEB, mEq/100 g	24.5	17.3	6.8
Base saturation, %	82	89	Sat.
Carbon, %	3.1	1.5	0.4
Nitrogen, %	0.4	0.2	-
C/N ratio	7.8	7.5	-
Free iron, %	2.1	1.8	1.0
TNV,%	0.0	11.3	54.5

Grey Brown Podzolic Group

ELTON SERIES — MODAL PROFILE

Topography:	Rolling
Slope:	2°
Elevation:	**100 m**
Parent Material:	**Limestone till with some sandstone and shale**
Great Soil Group:	**Grey Brown Podzolic**

Horizon	*Depth (cm)*	*Description*
Al	**0-18**	**Loam with gravel; very dark greyish brown (10 YR 3/2); moderate fine crumb structure; moist friable and slightly plastic; root mat to 10 cm and plentiful below; clear, smooth boundary:**
B2t	**18-53**	**Gravelly loam; brown to dark brown (10 YR 4/3); moderate fine to coarse sub-angular blocky structure; moist plastic; plentiful roots; clear, smooth boundary:**
B3	**53-95**	**Gravelly loam; brown (10 YR 5/3); weak fine angular blocky structure; moist plastic; few roots; clear, smooth boundary:**
	95+	**Gravelly sandy loam to loam; greyish brown (10 YR 5/2); massive structure; moist, slightly plastic; occasional roots.**

TABLE 12: Elton Series — Profile Analysis

Horizon	Al	B2t	B3	C
Depth (cm)	0-18	18-53	53-95	95+
Mechanical analysis of mineral fraction *{%)*				
Coarse sand	27	23	24	27
Fine sand	22	21	21	25
Silt	36	34	36	31
Clay	15	22	19	17
PH	6.0	7.3	8.2	8.3
CEC, mEq/100 g	20.0	7.4	4.6	3.4
TEB, mEq/100 g	5.8	7.0	5.6	6.0
Base saturation, *%*	29	95	Sat	Sat.
Carbon, *%*	2.1	0.5	0.2	0.2
Nitrogen, *%*	0.2	-	-	-
C/N ratio	10.5	-	-	-
Free iron, %	1.2	1.7	1.2	1.0
TNV,%	1.6	2.2	28.9	35.8

PATRICKSWELL SERIES — MODAL PROFILE

Topography:	Gently rolling
Slope:	2°
Elevation:	85 m
Drainage:	Well drained
Parent Material:	Limestone glacial till
Great Soil Group	Grey Brown Podzolic

Horizon	*Depth (cm)*	*Description*
Al	0-23	Gravelly loam; dark brown (10 YR 3/3); moderate fine crumb structure; moist, slightly plastic; root mat to 12 cm and plentiful below; clear, smooth boundary:
B2t	23-60	Gravelly loam; dark greyish brown (10 YR 4/2); weak to moderate sub-angular blocky structure breaking into crumb; moist plastic; plentiful roots; clear, smooth boundary:
	60-110	Gravelly loam; pale brown (10 YR 6/3); massive structure; moist friable; no roots.

TABLE 13: Patrickswell Series — Profile Analyses

Horizon Depth (cm)	A 0-23	B2t 23-60	C 60-110
Mechanical analysis of mineral fraction (%)			
Coarse sand	26	22	24
Fine sand	25	25	23
Silt	33	34	38
Clay	16	19	15
PH	6.9	7.3	8.3
CEC, mEq/100 g	14.4	11.4	3.2
TEB, mEq/100 g	7.8	5.3	5.5
Base saturation, %	54	46	Sat.
Carbon, %	1.6	0.3	0.2
Nitrogen, %	0.2	-	-
C/N ratio	8.0	-	-
Free iron, %	1.4	1.7	1.0
TNV,%	0.0	0.8	47.3

PATRICKSWELL LITHIC PHASE — MODAL PROFILE

Topography:	**Hilly**
Slope:	**4°**
Elevation:	**120 m**
Drainage:	**Well drained**
Parent Material:	**Limestone and calcareous shale till**
Great Soil Group:	**Grey Brown Podzolic**

Horizon	*Depth (cm)*	*Description*
All	0-12	Loam with occasional gravel; brown to dark brown (10 YR 4/3); moderate fine crumb to medium sub-angular blocky structure; moist friable; root mat; gradual boundary:
A12	12-19	Gravelly loam; yellowish brown (10 YR 5/6); moderate fine to medium crumb structure; dry hard; many roots; clear, smooth boundary:
A2	19-37	Gravelly sandy loam; dark yellowish brown (10 YR 4/4); weak medium sub-angular blocky structure; dry hard; some roots; clear, smooth boundary:
Bl	37-57	Gravelly loam; yellowish brown (10 YR 5/8); weak medium sub-angular blocky structure; dry hard; some roots present; gradual boundary:
B21t	57-75	Silty clay loam; brown to dark brown (10 YR 4/3); massive structure; moist, firm stiff; few roots present; clear, slightly wavy boundary:
B22t	75-90	Gravelly silty clay loam; this is an undulating zone where rock fragments and soil are intimately mixed; abrupt, irregular boundary:
R	90+	Limestone and calcareous shale bedrock.

TABLE 14: Patrickswell Lithic Phase — Profile Analysis

Horizon Depth (cm)	All 0-12	A12 12-19	A2 19-37	Bl 37-57	B21t 57-75	B22t 75-90
Mechanical analysis of mineral fraction *{%)*						
Coarse sand	25	26	29	18	8	5
Fine sand	22	22	27	24	11	7
Silt	32	34	29	41	52	59
Clay	21	18	15	17	29	29
pH	6.1	6.3	7.7	8.0	7.9	8.0
CEC, mEq/100 g	25.2	20.0	8.4	7.2	11.2	12.4
TEB, mEq/100 g	7.6	8.2	9.5	7.3	11.8	13.0
Base saturation, %	30	41	Sat.	Sat.	Sat.	Sat.
Carbon, %	4.3	2.2	0.2	0.2	0.3	0.4
Nitrogen, %	0.4	0.2	-	-	-	-
C/N ratio	10.8	11.0	-	-	-	-
Free iron, %	2.6	2.4	1.8	3.3	4.	5.9
TNV,%	1.0	0.7	1.7	0.5	0.7	2.2

PATRICKSWELL SHALLOW VARIANT — MODAL PROFILE

Topography:	Gently sloping
Slope:	3°
Elevation:	65 m
Drainage:	Well drained
Parent Material:	Limestone glacial till
Great Soil Group	Grey Brown Podzolic

Horizon	*Depth (cm)*	*Description*
Al	0-14	Gravelly clay loam; very dark brown (10 YR 2/2); strong fine to medium crumb structure; moist friable; root mat to 10 cm and well-developed rooting below this level; clear, smooth boundary:
Bt	14-35	Gravelly clay loam; dark greyish brown (10 YR 4/2); moderate fine subangular blocky structure; moist, friable to dry firm; many roots; clear, wavy boundary:
	35-80	Gravelly sandy loam; grey (10 YR 5/1); single grain structure; moist, very friable to loose.

TABLE 15: Patrickswell Shallow Variant — Profile Analyses

Horizon	Al	Bt	C
Depth (cm)	0-14	14-35	35-80
Mechanical analysis of mineral fraction (%)			
Coarse sand	14	16	38
Fine sand	8	7	14
Silt	46	40	29
Clay	32	37	19
PH	6.9	7.4	7.9
CEC, mEq/100 g	58.4	26.6	3.4
TEB, mEq/100 g	36.7	22.3	5.1
Base saturation, %	63	84	Sat.
Carbon, %	8.0	1.4	0.1
Nitrogen, %	0.8	0.2	
C/N ratio	10.0	7.0	
Free iron, %	2.1	3.0	0.6
TNV,%	16.4	19.8	60.4

PATRICKSWELL STEEP VARIANT — MODAL PROFILE

Topography:	Steep side of melt-water channel
Slope:	25°
Elevation:	61 m
Drainage:	Excessive
Parent Material:	Limestone glacial drift with sandstone erratics
Great Soil Group:	Grey Brown Podzolic

Horizon	*Depth (cm)*	*Description*
Al	0-15	Gravelly loam; dark yellowish brown (10 YR 4/4); moderate fine crumb structure; moist friable; root mat; cleat, smooth boundary:
Bl	15-29	Gravelly loam; yellowish brown (10 YR 5/8); weak fine sub-angular blocky structure; moist friable; slightly sticky; roots present; gradual, smooth boundary:
B2t	29-39	Gravelly clay loam; brown to dark brown (7.5 YR 4/4); moderate fine to medium sub-angular blocky structure; moist friable; slightly plastic; roots present; clear, wavy boundary:
	39+	Gravelly loam; light yellowish brown (10 YR 6/4); weak coarse angular blocky to massive structure; few, fine roots present.

TABLE 16: Patnckswell Steep Variant — Profile Analyses

Horizon Depth (cm)	Al 0-15	Bl 15-29	B2t 29-39	C 39+
Mechanical analysis of mineral fraction (%)				
Coarse sand	25	24	22	22
Fine sand	17	18	17	25
Silt	39	41	32	39
Clay	19	17	29	14
PH	7.2	7.2	7.1	8.0
CEC, mEq/100 g	24.6	9.4	15.0	5.0
TEB, mEq/100 g	17.4	8.2	11.0	5.1
Base saturation, %	71	87	73	Sat.
Carbon, %	2.7	0.5	0.7	0.3
Nitrogen, %	0.3	-	-	-
C/N ratio	9.0	-	-	-
Free iron, %	1.7	1.9	3.6	1.3
TNV,%	1.8	0.0	0.0	32.1

BORRISOLEIGH SERIES — MODAL PROFILE

Topography	**Mountain valley side with slopes between 5° and 20°**
Slope:	**6°**
Elevation:	**270 m**
Drainage:	**Well drained**
Parent Material:	**Silurian shale hillwash over rock**
Great Soil Group:	**Brown Podzolic**

Horizon	*Depth (cm)*	*Description*
Al	**0-19**	**Clay loam to silty clay loam: dark brown (7.5 YR 3/2); moderate fine crumb structure; moist friable; many roots; clear, smooth boundary:**
B2	**19-54**	**Channery clay loam; brown to dark brown (7.5 YR 4/40 moderate fine crumb structure; moist friable and slightly sticky; many roots; clear, smooth boundary:**
	54-88	**Channery gravelly loam; brown (7.5 YR 5/4); weak fine crumb structure; moist friable; some roots; abrupt, irregular boundary to shale bedrock:**
	88+	**Silurian shale bedrock.**

TABLE 17: Borrisoleigh Series — Profile Analyses

Horizon	**Al**	**B2**	**C**
Depth (cm)	**0-19**	**19-54**	**54-88**
Mechanical analysis of mineral fraction (%)			
Coarse sand	**6**	**16**	**26**
Fine sand	**14**	**10**	**15**
Silt	**43**	**40**	**37**
Clay	**37**	**34**	**22**
PH	**4.6**	**5.0**	**5.7**
CEC, mEq/100 g	**49.2**	**41.6**	**32.8**
TEB, mEq/100 g	**4.4**	**0.7**	**1.3**
Base saturation, %	**9**	**2**	**4**
Carbon, %	**8.5**	**3.1**	**1.8**
Nitrogen, %	**0.8**	**0.3**	**0.2**
C/N ratio	**10.6**	**10.3**	**9.0**
Free iron, %	**3.5**	**5.1**	2.8
TNV.%			

BORRISOLEIGH STEEP PHASE - MODAL PROFILE

Topography:	Steep hillside
Slope:	20°
Elevation:	175 m
Drainage:	Excessive
Parent Material:	Silurian Shales
Great Soil Group:	Brown Podzolic

Horizon	*Depth (cm)*	*Description*
Al	0-20	Channery clay loam; dark brown (10 YR 3/3); moderate fine crumb structure; moist plastic; slightly friable; root mat to 20 cm and plentiful below; clear, smooth boundary:
B2ir	20-31	Channery loam; brown (10YR 5/3); moderate fine crumb structure; moist plastic; plentiful roots; abrupt, irregular boundary:
	31+	Lower Palaeozoic shale bedrock.

TABLE 18: Borrisoleigh Steep Phase — Profile Analyses

Horizon	Al	B2ir
Depth (cm)	0-20	20-31
Mechanical analysis of mineral fraction (%)		
Coarse sand	20	27
Fine sand	12	11
Silt	38	37
Clay	30	25
pH	6.1	5.8
CEC, mEq/100 g	32.8	23.8
TEB, mEq/100 g	6.6	2.6
Base saturation, %	20	11
Carbon, %	7.3	2.3
Nitrogen, %	0.4	0.2
C/N ratio	18.3	11.5
Free iron, %	2.8	**3.3**
TNV,%		

COOGA SERIES — MODAL PROFILE

Topography:	Gently rolling
Slope:	0°
Elevation:	117 m
Drainage:	Well drained
Parent Material:	Old Red Sandstone glacial drift with Silurian shale
Great Soil Group:	Brown Podzolic

Horizon	*Depth (cm)*	*Description*
All	0-12	Sandy clay loam with occasional gravel; brown to dark brown (7.5 YR 4/4); moderate fine crumb structure; moist friable; root mat; clear, smooth boundary:
A12	12-20	Gravelly loam; brown to dark brown (7.5 YR 4/4); moderate fine crumb structure; moist friable; plentiful roots; clear, smooth boundary:
B2ir	20-45	Gravelly sandy loam to sandy clay loam; brown to dark brown (7.5 YR 4/4); weak fine subangular blocky structure; moist friable; clear, smooth boundary:
	45-100	Gravelly sandy loam; brown (7.5 YR 5/4); single grain structure; moist firm, slightly friable.

TABLE 19: Cooga Series — Profile Analyses

Horizon Depth (cm)	AH 0-12	A12 12-20	B2ir 20-45	C 45-100
Mechanical analysis of mineral fraction (%)				
Coarse sand	33	34	47	29
Fine sand	15	14	9	24
Silt	27	29	24	31
Clay	25	23	20	16
pH	5.5	5.6	5.5	5.8
CEC, mEq/100 g	24.6	19.4	19.0	4.4
TEB, mEq/100 g	7.9	4.7	3.4	1.6
Base saturation, %	32	24	18	36
Carbon, %	4.0	1.8	1.2	0.2
Nitrogen, %	0.4	0.1	0.1	-
C/N ratio	10.0	18.0	12.0	-
Free iron, %	2.5	2.9	3.2	1.5
TNV,%	-	-	-	-

DOONGLARA SERIES — MODAL PROFILE

Topography:	Kame
Slope:	7°
Elevation:	270 m
Drainage:	Well drained
Parent Material:	Old Red Sandstone-dominated glacial drift with shale and limestone
Great Soil Group:	Brown Podzolic

Horizon	*Depth (cm)*	*Description*
Al	0-20	Gravelly loam; brown to dark brown (7.5 YR *A* moderate fine crumb structure; moist friable; root mat to 10 cm, plentiful roots below; clear, smooth boundary:
B2ir	20-46	Gravelly loam; reddish brown (5 YR 4/4); weak to moderate fine crumb structure; moist friable; plentiful roots; abrupt, smooth boundary:
	46+	Gravelly stony loam; reddish brown (2.5 YR 5/4); massive to weak fine angular blocky structure; moist friable and slightly firm; no roots.

TABLE 20: Doonglara Series — Profile Analyses

Horizon	Al	B2ir	C
Depth (cm)	0-20	20-46	46+
Mechanical analysis of mineral fraction (%)			
Coarse sand	16	21	25
Fine sand	20	23	22
Silt	38	34	36
Clay	26	22	17
PH	5.0	5.8	6.0
CEC, mEq/100 g	34.4	26.6	12.2
TEB, mEq/100 g	7.1	4.3	2.7
Base saturation, %	21	16	22
Carbon, %	6.4	2.7	0.7
Nitrogen, %	0.6	0.2	-
C/N ratio	10.7	13.5	.
Free iron, %	2.3	2.9	2.1
TNV.%			

Podzol Group

KNOCKACEOL SERIES — MODAL PROFILE

Topography:	Mountainous
Slope:	**9°**
Elevation:	420 m
Drainage:	Excessive
Parent Material:	Devonian Old Red Sandstone
Great Soil Group:	Podzol

Horizon	*Depth (cm)*	*Description*
Al	0-12	Gravelly sandy loam; dai moderate fine crumb structure; moist friable; root mat; clear, irregular boundary:
A2	12-28	Gravelly stony sandy loam; brown (7.5 YR 5/4); massive to weak fine sub-angular blocky structure; moist friable, slightly firm; many roots; clear, irregular boundary:
B2ir	28-65	Gravelly stony sandy clay loam; brown to dark brown (7.5 YR 4/4); weak fine crumb structure; moist friable; plentiful roots; abrupt, smooth boundary:
R	65+	Old Red Sandstone bedrock.

TABLE 21: Knockaceol Series — Profile Analyses

Horizon	Al	A2	B2ir
Depth (cm)	0-12	12-28	28-65
Mechanical analysis of mineral fraction (%)			
Coarse sand	56	55	49
Fine sand	18	16	13
Silt	13	14	17
Clay	13	15	21
PH	6.0	4.7	5.0
CEC, mEq/100 g	19.4	13.0	13.6
TEB, mEq/100 g	1.7	0.3	0.4
Base saturation, %	9	2	3
Carbon, %	4.6	**0.5**	0.8
Nitrogen, %	0.4		
C/N ratio	11.5		
Free iron, %	2.8	**3.0**	6.0
TNV,%			

KNOCKASTANNA SERIES — MODAL PROFILE

TopogTaphy:	Hilly
Slope:	16°
Elevation:	285 m
Drainage:	Well drained
Parent Material:	Silurian shale hill wash
Great Soil Group	Podzol

Horizon	*Depth (cm)*	*Description*
Al	0-10	Clay loam to silty clay (10 YR 4/3); moderate fine crumb structure; moist plastic, slightly friable; many roots; clear, smooth boundary:
A2	10-20	Channery clay loam; brown to dark brown (7.5 YR 4/2); very weak sub-angular blocky structure, almost massive; moist plastic; few roots; clear, smooth boundary.
B2ir	20-44	Channery clay loam; yellowish red (5 YR 5/6); weak fine to very fine sub-angular blocky structure: moist plastic; many roots: gradual boundary:
	44-70	Channery clay loam; dark yellowish brown (10 YR 4/4); fine sub-angular blocky structure; moist plastic; no roots; abrupt, irregular boundary:
	70+	Silurian shale bedrock.

TABLE 22: Knockastanna Series — Profile Analyses

Horizon Depth (cm)	Al 0-10	A2 10-20	B2ir 20-44	C 44-70
Mechanical analysis of mineral fraction (%)				
Coarse sand	7	11	17	25
Fine sand	13	11	10	10
Silt	41	42	39	35
Clay	39	36	34	30
PH	4.8	5.2	*52*	6.0
CEC. mEq/100 g	30.6	31.4	29.2	23.8
TEB. mEq/100 g	5.2	5.0	2.6	2.1
Base saturation, %	17	16	9	9
Carbon, %	5.8	3.3	2.2	1.8
Nitrogen, %	0.5	0.4	0 3	0.2
C/N ratio	11.6	8.3	7.3	9.0
Free iron, %	2.6	3.7	5.1	3.0
TNV.%	-	-	-	-

KNOCKASTANNA PEATY PHASE — MODAL PROFILE

Topography:	Mountainous
Slope:	4°
Elevation:	385 m
Drainage:	Excessive
Parent Material:	Silurian shale
Great Soil Group:	Peaty Podzol

Horizon	*Depth (cm)*	*Description*
02	10-0	Well humified peat; blocky structure; moist friable; clear, smooth boundary:
Al	0-5	Organic silty clay loam; very dark grey (10 YR 3/1); moderate fine crumb structure; moist firm; plentiful dead and living roots; clear, smooth boundary:
A2	5-10	Gravelly silty clay loam; greyish-brown (10 YR 5/2); massive structure; roots vertical; moist plastic; clear, smooth boundary:
A3	10-22	Gravelly silty clay loam; yellowish-brown (10 YR 5/4); weak fine crumb structure; moist friable; plentiful, diffuse roots; clear, smooth boundary:
B2ir	22-47	Gravelly silty clay loam; dark yellowish-brown (10 YR 3/4); weak fine crumb structure; moist friable; gradual boundary through shattered rock to bedrock.

TABLE 23: Knockastanna Peaty Phase - Profile Analyses

Horizon Depth (cm)	02 10-0	Al 0-5	A2 5-10	A3 10-22	B2ir 22-47
Mechanical analysis of mineral fraction (%)					
Coarse sand		2	1	5	12
Fine sand		5	2	2	6
Silt		57	69	62	46
Clay		36	28	31	36
pH	4.1	4.0	4.2	4.9	5.1
CEC. mEq/100 g	116.8	58.8	48.2	34.4	40.0
TEB. mEq/100 g	12.1	2.9	1.2	0.8	0.4
Base saturation, %	10	5	2	2	1
Carbon, %	36.4	18.2	9.0	2.6	3.0
Nitrogen, %	1.2	0.9	0.5	0.2	0.2
C/N ratio	30.3	20.2	18.0	13.0	15.0
Free iron, %	1.2	0.7	1.1	3.6	5.0
TNV.%	-	-	-	-	-

SEEFIN SERIES — MODAL PROFILE

Topography:	Mountainous
Slope:	10°
Elevation:	330 m
Drainage:	Well drained below iron pan
Parent Material:	Old Red Sandstone
Great Soil Group:	Podzol

Horizon	*Depth (cm)*	*Description*
02	23-0	Peat; black (N2/0); weak moist, slightly sticky and plastic; plentiful dead and living roots:
A2	0-8	Gravelly sandy loam; brown (10 YR 5/3); massive, breaking to weak fine sub-angular blocky structure; very few roots; abrupt, smooth boundary:
B21ir	8	A thin iron pan:
B22ir	8-28	Gravelly clay loam; strong brown (7.5 YR 5/8); fine to coarse sub-angular blocky structure; moist plastic, slightly friable; plentiful roots; clear, regular boundary:
	28-57	Channery loam; brown to dark brown (7.5 YR 4/4); weak Fine sub-angular blocky structure.

TABLE 24: Seefin Series — Profile Analyses

Horizon Depth (cm)	02 23-0	A2 0-8	B22ir 8-28	C 28-57
Mechanical analysis of mineral fraction (%)				
Coarse sand		40	30	16
Fine sand		17	12	16
Silt		27	31	44
Clay		16	27	24
pH	4.4	4.2	4.6	4.8
CEC, mEq/100 g	80.0	27.4	21.8	13.4
TEB, mEq/100 g	4.0	2.7	4.4	1.3
Base saturation, %	5	10	20	10
Carbon, %	27.8	3.1	1.1	0.4
Nitrogen, %	2.5	0.2	0.2	-
C/N ratio	11.1	15.5	5.5	-
Free iron, %	1.0	1.7	5.0	2.1
TNV,%	-	-	-	-

Gley Group

BALLYSHEAR SERffiS — MODAL PROFILE

Topography:	Almost level
Slope:	0°
Elevation:	60 m
Drainage:	Poorly drained
Parent Material:	Limestone, shale and Old Red Sandstone glacial till
Great Soil Group:	Gley

Horizon	*Depth (cm)*	*Description*
Al	0-12	Black (10 YR 2/1); organic; weak fine crumb structure; clear, smooth boundary:
B2g	12-50	Silty clay; grey (10 YR 5/1), with light yellowish-brown (10 YR 6/4), fine, few distinct mottles; moist plastic; few roots; clear, smooth boundary:
Cg	50+	Silty clay; dark grey (10 YR 4/1) with fine, few, distinct brownish yellow (10 YR 6/6) mottles.

TABLE 25: Ballyshear Series — Profile Analyses

Horizon Depth (cm)	Al 0-12	B2g 12-50	Cg 50+
Mechanical analysis of mineral fraction (%)			
Coarse sand		1	8
Fine sand		4	7
Silt		43	43
Clay		52	42
pH	7.2	7.9	8.0
CEC, mEq/100 g	131.2	13.4	8.8
TEB, mEq/100 g	122.0	14.7	10.8
Base saturation, %	93	Sat.	Sat.
Carbon, %	22.0	0.7	0.6
Nitrogen, %	1.6	-	-
C/N ratio	13.8	-	-
Free iron, %	1.9	2.1	1.5
TNV,%	14.6	27.6	53.3

CAMOGE *SERIES* — MODAL PROFILE

Topography:	River flat in gently rolling landscape
Slope:	0°
Elevation:	50m
Drainage:	Poorly drained
Parent Material:	Alluvium of dominantly limestone composition
Great Soil Group:	Gley

Horizon	*Depth (cm)*	*Description*
Al	0-10	Clay loam; brown to dark brown (10 YR 4/3); moderate fine crumb structure; moist friable; root mat; clear, smooth boundary:
Clg	10-40	Sandy loam; greyish brown (10 YR 5/2) with fine, few, distinct yellowish brown (10 YR 5/8) mottles; massive to prismatic structure; moist firm; clear, wavy boundary:
C2g	40-75	Sandy loam with river gravel; grey (10 YR 5/1); massive to single grain structure; non-sticky; no roots present.

TABLE 26: Camoge Series — Profile Analyses

Horizon	Al	Clg	C2g
Depth (cm)	0-10	10-40	40-75
Mechanical analysis of mineral fraction (%)			
Coarse sand	7	26	59
Fine sand	22	29	18
Silt	39	29	13
Clay	32	16	10
PH	5.5	6.6	7.8
CEC, mEq/100 g	43.6	21.4	4.6
TEB, mEq/100 g	21.6	15.6	5.9
Base saturation, %	50	73	Sat.
Carbon, %	7.1	1.7	0.4
Nitrogen, %	0.7	0.2	
C/N ratio	10.1	8.5	
Free iron, %	2.0	1.7	0.4
TNV,%			20

COOLALOUGH SERIES — MODAL PROFILE

Topography:	Flat in gently rolling landscape
Slope:	0°
Elevation:	60m
Drainage:	Poorly drained
Parent Material:	Alluvium of limestone origin
Great Soil Group:	Gley

Horizon	*Depth (cm)*	*Description*
Alg	0-40	Clay loam; brown to dark brown (10 YR 4/3); moderate fine crumb structure; moist friable; root mat to 10 cm, plentiful below this level; shell fragments; clear, smooth boundary:
Bg	40-80	Clay loam; light yellowish brown (10 YR 6/4) with light grey to grey (N6/0) in fine, frequent, faint mottles; very weak prismatic structure, moist plastic.

TABLE 27: Coolalough Series — Profile Analyses

Horizon	Alg	Bg
Depth (cm)	0-40	40-80
Mechanical analysis of mineral fraction (%)		
Coarse sand	14	10
Fine sand	11	12
Silt	44	48
Clay	31	30
pH	7.3	7.7
CEC, mEq/100 g	54.8	15.0
TEB, mEq/100 g	47.2	14.7
Base saturation, %	86	98
Carbon, %	13	0.7
Nitrogen, %	0.8	
C/N ratio	9.1	
Free iron, %	1.6	0.5
TNV,%	34.5	17.6

DERRYGAREEN SERIES — MODAL PROFILE

Topography:	Hilly
Slope	10°
Elevation:	240 m
Drainage:	Poorly drained
Parent Material:	Fluvioglacial drift, predominantly Old Red Sandstone
Great Soil Group:	Podzolised Gley

Horizon	*Depth (cm)*	*Description*
Al	0-15	Slightly peaty sandy loam; black (10 YR 2/1); w fine crumb structure; moist friable; peat well humified with many roots; clear, smooth boundary:
A2	15-35	Sandy loam; brown (7.5 YR 5/3); single grain structure; moist friable; few roots; clear, smooth boundary:
Bg	35-55	Gravelly sandy loam; brown (7.5 YR 5/3) with fine, frequent, dark red mottles (2.5 YR 3/6); single grain structure; abrupt, irregular boundary:
	55+	Old Red Sandstone rock,

TABLE 28: Derrygareen Scries — Profile Analyses

Horizon	Al	A2	
Depth (cm)	0-15	15-35	35-55
Mechanical analysis of mineral fraction (%)			
Coarse sand	36	44	35
Fine sand	28	29	28
Silt	23	21	25
Clay	13	6	12
PH	4.2	4.3	4.7
CEC, mEq/100 g	56.0	6.2	13.6
TEB, mEq/100 g	2.1	0.4	0.6
Base saturation, %	4	6	4
Carbon, %	15.6	0.4	0.7
Nitrogen, %	0.7		
C/N ratio	22.3		
Free iron, %	0.6	0.1	0.6
TNV,%			

DROMBANNY SERIES — MODAL PROFILE

Topography:	**Level (old lake bed)**
Slope	0°
Elevation:	**37 m**
Drainage:	**Poor**
Parent Material:	**Organic deposits over marl**
Great Soil Group:	**Peaty Gley**

Horizon	*Depth (cm)*	*Description*
02	**0-29**	**Peat; black (10 YR 2/1); su dry firm; clear, abrupt boundary:**
	29-50	**Silt loam; very pale brown (10 YR 8/4); massive structure; wet sticky.**

TABLE 29: Drombanny Series — Profile Analyses

Horizon	**02**	**C**
Depth (cm)	**0-29**	**29-50**
Mechanical analysis of mineral fraction *{%)*		
Coarse sand	-	**4**
Fine sand	-	**15**
Silt	-	**65**
Clay	-	**16**
PH	**5.8**	**7.8**
CEC, mEq/100 g	**202.0**	**18.4**
TEB, mEq/100 g	**70.1**	**15.4**
Base saturation, *%*	**34**	**84**
Carbon, *%*	**36.0**	**4.0**
Nitrogen, *%*	**2.1**	**0.3**
C/N ratio	**17.1**	**13.3**
Free iron, *%*	**1.0**	**0.2**
TNV,%		**0.0**

FEALE SERIES — MODAL PROFILE

Topography:	**Level**
Slope:	**2°**
Elevation:	**110 m**
Drainage:	**Poor**
Parent Material:	**Alluvium of predominantly shale origin with limestone and sandstone**
Great Soil Group:	**Gley**

Horizon	*Depth (cm)*	*Description*
Al	**0-15**	**Loam to clay loam; brown to dark brown 4/3); weak fine crumb structure; moist friable; many roots in mat; clear, smooth boundary:**
A12g	**15-35**	**Loam; dark greyish brown (10 YR 4/2) with few, fine, faint mottles of yellowish brown (10 YR 5/8); weak fine crumb structure; moist friable; slightly plastic; frequent roots; clear, smooth boundary:**
Big	**35-45**	**Silt loam; grey (10 YR 6/1) with fine, frequent, distinct mottles of yellowish-brown (10 YR 5/8); massive to weak coarse prismatic structure; moist friable; very few roots; clear, gradual boundary:**
B2g	**45-100**	**Silt loam; yellowish-brown (10 YR 5/6); massive to weak coarse prismatic structure; moist plastic; water below.**

TABLE 30: Feale Series — Profile Analyses

Horizon Depth (cm)	Al 0-15	A12g 15-35	Big 35-45	B2g 45-100
Mechanical analysis of mineral fraction *(%)*				
Coarse sand	13	13	9	5
Fine sand	15	16	14	9
Silt	45	48	62	61
Clay	27	23	15	25
pH	53	5.8	6.6	6.8
CEC, mEq/100 g	31.2	16.8	10.8	13.8
TEB, mEq/100 g	93	5.3	4.4	7.3
Base saturation, *%*	30	37	41	53
Carbon, *%*	4.2	0.9	0.2	0.2
Nitrogen, %	0.4	-	-	-
C/N ratio	10.5	-	-	-
Free iron, %	2.0	2.2	23	3.9
TNV,%	-	-	-	-

GORTACLAREEN SERIES — MODAL PROFILE

Topography:	**Level area in kame and kettle landscape**
Slope:	**1°**
Elevation:	**150 m**
Drainage:	**Poor**
Parent Material:	**Mixed till, predominantly Old Red Sandstone**
Great Soil Group:	Gley

Horizon	*Depth (cm)*	*Description*
All	**0-17**	**Sandy clay loam with boulders; dark yellowish brown (10 YR 3/4); weak fine crumb structure; moist plastic; root mat; gradual boundary:**
A12g	**17-29**	**Bouldery sandy clay loam; dark yellowish brown (10 YR 3/4), and dark grey (10 YR 4/1) fine, frequent, faint mottles; weak crumb structure; moist plastic; many roots; clear, smooth boundary:**
Big	**29-35**	**Bouldery sandy clay loam; dark yellowish brown (10 YR 4/4) with dark grey (10 YR 4/1) and yellowish red (5 YR 5/8) fine, frequent, distinct mottles; weak fine sub-angular blocky structure; moist plastic; clear boundary:**
B2g	**35-105**	**Bouldery stony gravelly loam; strong brown (7.5 YR 5/8) with reddish brown (5 YR 4/3) medium, frequent, distinct mottles; massive to single grain structure; moist friable, dry loose; few roots.**

TABLE 31: Gortaclareen Series — Profile Analyses

Horizon **Depth (cm)**	**All** **0-17**	**Al2g** **17-29**	**Big** **29-35**	**B2g** **35-105**
Mechanical analysis of mineral fraction *(%)*				
Coarse sand	**37**	**37**	**54**	**26**
Fine sand	**11**	**10**	**10**	**24**
Silt	**23**	**21**	**15**	**32**
Clay	**29**	**32**	**21**	**18**
PH	**5.6**	**5.6**	**5.6**	**4.4**
CEC. mEq/100 g	**46.4**	**32.4**	**16.8**	**18.4**
TEB, mEq/100 g	**23.0**	**15.9**	**6.5**	**0.4**
Base saturation, %	**50**	**49**	**39**	**2**
Carbon, %	**9.8**	**7.6**	**2.2**	**1.6**
Nitrogen, %	**0.6**	**0.4**	**0.1**	**0.1**
C/N ratio	**16.3**	**19.0**	**22.0**	**16.0**
Free iron, %	**0.8**	**1.5**	\2	**1.8**
TNV,%	-	-	•	-

HOWARDSTOWN SERIES — MODAL PROFILE

Topography	**Gently rolling**
Slope	1°
Elevation:	**80 m**
Drainage:	**Poor**
Parent Material:	**Limestone till with some shale and sandstone**
Great Soil Group	**Gley**

Horizon	*Depth (cm)*	*Description*
Al	**0-20**	**Gravelly sandy loam to loam; very dark i brown (10 YR 3/2); weak fine crumb structure; moist friable; root mat to 10 cm and plentiful below; clear, wavy boundary:**
Big	20^5	**Loam; light-grey (10 YR 7/2) with moderate prominent yellowish brown (10 YR 5/6) mottles; massive structure; moist plastic; few roots; clear smooth boundary:**
B2tg	**45-82**	**Loam; light grey (10 YR 7/2) with fine prominent yellowish brown (10 YR 5/6) and pale brown (10 YR 6/3) mottles; massive structure; no roots; moist plastic; clear, smooth boundary:**
Cg	**82+**	**Loam; light brownish-grey (10 YR 6/2) with fine prominent yellowish brown (10 YR 5/6) mottles; massive structure; moist plastic.**

TABLE 32: Howardstown Series — Profile Analyses

Horizon **Depth (cm)**	**Al** **0-20**	**Big** **20-45**	**B2tg** **45-82**	**Cg** **82+**
Mechanical analysis of mineral fraction (%)				
Coarse sand	**27**	**24**	**17**	**22**
Fine sand	**25**	**21**	**24**	**29**
Silt	**34**	**34**	**34**	**34**
Clay	**14**	**21**	**25**	**15**
PH	**6.9**	**7.7**	**8.0**	**8.4**
CEC, mEq/100 g	**30.6**	**7.4**	**6.8**	**2.4**
TEB, mEq/100 g	**15.1**	**5.7**	**7.0**	**4.9**
Base saturation, %	**49**	**77**	**Sat.**	**SaL**
Carbon, %	**3.0**	**0.2**	**0.2**	**0.1**
Nitrogen, %	**0.3**	-	-	-
C/N ratio	**10.0**	-	-	-
Free iron, %	**0.9**	**1.2**	**\5**	**1.0**
TNV,%	**0.0**	**0.0**	**83**	**46.6**

KTLCOMMON SERIES — MODAL PROFILE

Topography:	**Level**
Slope:	**0°**
Elevation:	**60 m**
Drainage:	**Poor**
Parent Material:	**Shale till with some sandstone**
Great Soil Group:	**Gley**

Horizon	*Depth (cm)*	*Description*
All	0-5	Silty clay loam; very dark grey (10 YR 3/1); moderate fine crumb structure; moist plastic; clear, smooth boundary:
A12	5-15	Clay loam; dark yellowish-brown (10 YR 4/4); weak fine to medium crumb structure; dry and firm; abundant roots; clear, smooth boundary:
A2g	15-33	Gravelly clay loam; pale-brown (10 YR 6/3) with few fine brownish yellow (10 YR 6/6) mottles; weak fine to medium, sub-angular blocky structure; dry firm; few roots; clear, smooth boundary:
B2g	33-65	Gravelly loam; very pale brown (10 YR 7/3) with large yellowish red (5 YR 5/8) mottles; moist friable; no roots; clear, smooth boundary:
Cg	65-80	Gravelly loam; yellowish-brown (10 YR 5/8) with many, distinct pale brown (10 YR 6/3) and black (10 YR 2/1) mottles; moist stiff; no roots.

TABLE 33: Kilcommon Series — Profile Analyses

Horizon Depth (cm)	All 0-5	A12 5-15	A2g 15-33	B2g 33-65	Cg 65-80
Mechanical analysis of mineral fraction (%)					
Coarse sand	6	9	16	15	19
Fine sand	12	12	13	18	20
Silt	47	44	38	41	37
Clay	35	35	33	26	24
PH	4.2	4.6	4.9	53	5.7
CEC, mEq/100 g	56.8	20.8	16.8	6.6	8.2
TEB, mEq/100 g	3.9	1.2	0.9	1.6	3.6
Base saturation, %	7	6	5	24	44
Carbon, %	6.9	2.7	1.7	0.2	0.4
Nitrogen, %	0.6	0.3	0.2	-	-
C/N ratio	11.5	9.0	8.5	-	-
Free iron, %	2.2	3.4	3.3	2.4	2.3
TNV.%	-	-	-	-	-

KILGORY SERIES — MODAL PROFILE

Topography:	River flat
Slope:	1°
Elevation:	30 m
Drainage:	Poorly drained
Parent Material:	Alluvium derived from Old Red Sandstone-limestone with some Silurian shale
Great Soil Group:	Regosol

Horizon	*Depth (cm)*	*Description*
All	0-8	Sandy loam; dark greyish brown (10 YR 4/2); weak, very fine crumb structure; moist, slightly plastic; root mat; diffuse, smooth boundary:
A12	8-30	Sandy loam; dark greyish-brown (10 YR 4/2); **weak,** very fine crumb structure; moist; slightly plastic; plentiful roots; clear, smooth boundary:
CI	30-43	Sand; light grey (10 YR 7/1); single grain structure, moist, very friable; few roots; clear, smooth boundary:
C2	43-69	Sand; grey and yellow (10 YR 5/1 and 7/6) in common. fine, distinct mottles; single grain structure; moist, very friable and slightly loose; abundant roots; clear, smooth boundary:
C3	69-102	Sand; light grey (10 YR 7/2); single grain structure; moist, very friable; few roots; diffuse, smooth boundary:
C4g	102-127	Sandy; light grey (10 YR 7/2) with occasional prominent red mottles; single grain structure; very friable; no roots; calcareous.

TABLE 34: Kilgory Series — Profile Analyses

Horizon	**All**	A12	CI	C2	C3	C4g
Depth (cm)	0-8	8-30	30-43	43-69	69-102	102-107
Mechanical analysis of mineral fraction (%)						
Coarse **sand**	29	33	52	48	37	23
Fine sand	32	34	41	45	60	72
Silt	26	22	4	4	1	4
Clay	13	11	3	3	2	1
PH	5.7	5.8	6.2	6.6	7.1	7.5
CEC, mEq/100 g	25.6	16.1	6.2	6.4	3.6	3.0
TEB. mEq/100 g	**nd**	nd	**nd**	nd	nd	nd
Base saturation, %						
Carbon, %	3.8	2.4	0.4	0.4	0.1	0.1
Nitrogen, %	0.3	0.2	nd	nd	nd	nd
C/N ratio	13.6	**11.4**				
Free iron, %	1.3	1.1.	0.1	0.4	0.2	0.1
TNV.%					0.1	14.8

MYLERSTOWN SERIES — MODAL PROFILE

Topography:	Level
Slope:	0°
Elevation:	60 m
Drainage:	Poor
Parent Material:	Limestone glacial till with shale
Great Soil Group:	Gley

Horizon	*Depth (cm)*	*Description*
Al	0-15	Silty clay loam; dark brown (10 YR 3/3); weak fine crumb structure; moist plastic; root mat present; clear, smooth boundary:
Bg	15-33 to 80	Gravelly silty clay; grey (10 YR 5/1) with many, fine, distinct yellowish red (5 YR 4/6) mottles; weak fine sub-angular blocky to massive structure; moist plastic; few roots; clear, irregular boundary:
	80+	Gravelly silt loam; dark grey (10 YR 4/1); single grain structure; moist friable; no roots.

TABLE 35: Mylerstown Series — Profile Analyses

Horizon Depth (cm)	Al 0-15	Bg 15-33 to 80	C 80+
Mechanical analysis of mineral fraction (%)			
Coarse sand	4	5	15
Fine sand	6	8	16
Silt	51	45	51
Clay	39	42	18
PH	7.2	7.8	8.6
CEC, mEq/100 g	35.8	17.2	1.8
TEB, mEq/100 g	31.0	16.5	4.1
Base saturation, %	87	96	Sat.
Carbon, %	5.2	0.9	0.1
Nitrogen, %	0.5	-	-
C/N ratio	10.4	-	-
Free iron, %	2.6	3.7	2.1
TNV,%	3.0	2.4	67.2

PUCKANE SERIES — MODAL PROFILE

Topography:	Lower slope of hillside
Slope:	2°
Elevation:	135 m
Drainage:	Poor
Parent Material:	Old Red Sandstone and Silurian shale glacial ti
Great Soil Group:	Podzolised Gley

Horizon	*Depth (cm)*	*Description*
Al	0-14	Sandy loam; very dark grey (10 YR 3/1); crumb structure; moist plastic, slightly sticky; root mat in surface 10 cm, few below; clear, smooth boundary:
A2g	14-44	Gravelly sandy loam; brown to dark brown (10 YR 4/3) with fine frequent mottles of grey to light grey (10 YR 6/1); weak fine sub-angular blocky structure; moist slightly friable and slightly plastic: few roots of rush present; clear, smooth boundary:
B2g	44-100	Gravelly stony sandy loam; grey (10 YR 5/1) with few medium faint mottles of dark red (2.5 YR 3/6); massive breaking to fine sub-angular blocky structure; moist plastic, slightly sticky; occasional rush root.

TABLE 36: Puckane Series — Profile Analyses

Horizon	Al	A2g	B2g
Depth (cm)	0-14	14-44	44-100
Mechanical analysis of mineral fraction (%)			
Coarse sand	32	40	30
Fine sand	25	19	27
Silt	25	25	26
Clay	18	16	17
pH	5.8	5.5	4.9
CEC, mEq/100 g	32.8	16.2	9.0
TEB,. mEq/100 g	**11.0**	4.2	0.6
Base saturation, %	34	26	7
Carbon, %	8.0	1.4	0.4
Nitrogen, %	0.5	0.1	-
C/N ratio	16.0	14	-
Free iron, %	0.8	0.2	1.3
TNV, %	-	-	-

PUCKANE PEATY PHASE — MODAL PROFILE

Topography:	Hilly
Slope:	5°
Elevation:	240 m
Drainage:	Poor
Parent Material:	Glacial till, predominantly Old Red Sandstone
Great Soil Group:	Peaty Podzolised Gley

Horizon	*Depth (cm)*	*Description*
Ol	15-0	Silty peat; weakly decomposed; black (10 YR 2/1); wet sticky; plentiful roots; clear, smooth boundary:
A2g	0-23	Gravelly sandy loam; grey (10 YR 5/1) with few, faint, medium mottles of dark red (2.5 YR 3/6); massive structure; wet plastic and slightly sticky; very few roots; clear, smooth boundary:
B2g	23-104	Gravelly sandy loam; dark red (2.5 YR 3/6) with few, distinct, coarse mottles of grey (10 YR 5/1); massive structure; wet plastic; slightly sticky; no roots.

TABLE 37: Puckane Peaty Phase — Profile Analysis

Horizon Depth (cm)	Ol 15-0	A2g 0-23	B2g 23-104
Mechanical analysis of mineral fraction (%)			
Coarse sand	1	35	37
Fine sand	3	28	34
Silt	74	23	19
Clay	22	14	10
PH	4.8	4.8	4.7
CEC, mEq/100 g	41.6	10.2	3.6
TEB, mEq/100 g	5.8	1.4	0.9
Base saturation, %	14	14	25
Carbon, %	18.4	0.8	0.2
Nitrogen, %	0.9	-	-
C/N ratio	20.4	-	-
Free iron, %	1.4	0.3	0.9
TNV,%			

BALLYVORHEEN SERIES — MODAL PROFILE

Topography:	**Gently rolling**
Slope:	**2°**
Elevation:	**125 m**
Drainage:	**Well to excessively drained**
Parent Material:	**Glacial drift of Old Red Sandstone and Silurian shale composition**
Great Soil Group:	**Brown Earth**

Horizon	*Depth (cm)*	*Description*
All	**0-10**	**Gravelly sandy clay loam to sandy loam;** reddish brown (5 YR 4/3); moderate fine crumb structure; moist friable; root mat; clear smooth boundary:
A12	10-25	Sandy clay loam; reddish brown (5 YR 4/3); moderate fine crumb structure; moist friable; plentiful roots; clear, smooth boundary:
(B)	2545	Gravelly sandy loam; yellowish red (5 YR 4/8); moderate fine to medium sub-angular blocky structure; moist plastic, slightly sticky; roots present; clear, smooth boundary:
CI	45-95	Gravelly sandy loam; yellowish red (5 YR 4/6); weak fine sub-angular blocky structure; moist friable, slightly sticky; occasional roots present; clear, smooth boundary:
C2	95-120	Gravelly sandy clay loam; yellowish red (5 YR 4/8); massive to single grain structure; moist plastic, slightly friable; no roots.

TABLE 38: Ballyvortieen Series — Profile Analyses

Horizon	All	A12	(B)	CI	C2
Depth (cm)	0-10	10-25	25-45	45-95	95-120
Mechanical analysis of mineral fraction (%)					
Coarse sand	35	**30**	**33**	**43**	**30**
Fine sand	23	**25**	**30**	**18**	**23**
Silt	22	**23**	**23**	**23**	**25**
Clay	20	**22**	**14**	**16**	**22**
pH	50	**5.1**	**5.3**	**5.1**	**53**
CEC, mEq/100 g	20.8	**13.0**	**6.2**	**3.2**	**3.2**
TEB, mEq/100 g	3.7	**1.7**	**1.0**	**0.8**	**0.9**
Base saturation, ^l	18	**13**	**16**	**25**	**28**
Carbon, %	3.4	0.9	**0.2**	**0.2**	0.1
Nitrogen, %	0.3				
C/N ratio	11.3				
Free iron, %	1.6	**2.0**	1.5	1.8	**2.4**
TNV,%					

CRUSH SERIES — MODAL PROFILE

Topography:	Kame crest
Slope:	**3°**
Elevation:	100 m
Drainage:	Excessive
Parent Material:	Fluvioglacial sand and gravel of limestone composition
Great Soil Group:	Rendzina

Horizon	*Depth (cm)*	*Description*
Al	0-16	Sandy loam with gravel; black (10 YR 2/1 fine crumb structure; moist plastic; root mat to 13 cm; clear, smooth boundary:
	16-60	Gravelly loamy sand; light brownish grey (10 YR 6/2); single grain structure; moist friable; no roots.

TABLE 39: Crush Series — Profile Analyses

Horizon	Al	C
Depth (cm)	0-16	16-60
Mechanical analysis of mineral fraction (%)		
Coarse sand	28	25
Fine sand	39	59
Silt	24	8
Clay	9	8
pH	7.8	8.5
CEC. mEq/100 g	34.4	2.2
TEB, mEq/100 g	31.4	3.5
Base saturation, %	91	
Sat.		
Carbon, %	5.1	0.2
Nitrogen, %	0.5	
C/N ratio	10.2	
Free iron, %	1.5	0.4
Tisrv,%	19.6	37.0

RATHBORNEY SERIES — MODAL PROFILE

Topography:	**River flat in gently rolling landscape**
Slope:	0°
Elevation:	50 m
Drainage:	**Poorly drained**
Parent Material:	**Alluvium derived from shales of Upper Carboniferous and Carboniferous limestone**
Great Soil Group:	**Regosol**

Horizon	*Depth (cm)*	*Description*
All	**0-14**	**Organic silty clay; dark greyish-brown (10 YR 4/2); moderate, fine crumb structure; moist, slightly plastic; root mat; calcareous; clear boundary:**
A12	14-27	**Silty clay; brown to dark brown (10 YR 4/3); moderate fine crumb structure; moist, slightly plastic; plentiful roots; gradual, smooth boundary:**
Cll	**27-38**	**Silty clay; brown (10 YR 5/3): weak, fine crumb to sub-angular blocky structure; moist plastic; gradual, smooth boundary:**
C12	**38-81**	**Silty clay to silty loam; brown (10 YR 5/3); weak, fine sub-angular blocky structure; moist plastic; many roots, gradual, irregular boundary:**
C13	**81-107**	**Stony clay with lenses of fine, gravelly sandy clay loam; light yellow-brown (10 YR 6/4); weak fine sub-angular blocky structure; moist sticky; few roots; calcareous.**

TABLE 40: Rathborney Series — Profile Analyses

Horizon **Depth (cm)**	**All** **0-14**	**A12** **14-27**	**Cll** **27-38**	**C12** **38-81**	**C13** **81-107**
Mechanical analysis of mineral fraction (%)					
Coarse sand	**4**	**4**	**2**	**2**	**9**
Fine sand	**10**	**10**	**12**	**10**	**15**
Silt	**43**	**43**	**45**	**48**	**34**
Clay	**43**	**43**	**41**	**40**	**42**
pH	**7.2**	**7.4**	**7.4**	**7.3**	**7.6**
CEC. mEq/100 g	**52.8**	**39.0**	**32.0**	**21.4**	**20.8**
TEB, mEq/100 g	**nd**	**nd**	**nd**	**nd**	**nd**
Base saturation, %	-	-	-	-	-
Carbon, %	**8.3**	**4.4**	**2.0**	**13**	**1.1**
Nitrogen, %	**0.9**	**0.6**	**0.3**	**0.2**	**0.2**
C/N ratio	**9.2**	*13*	**6.7**	**6.5**	**5.5**
Free iron, %	**2.3**	**2.7**	**2.6**	**2.1**	**2.0**
TNV,%	**4.0**	**0.0**	**0.0**	**0.0**	**11.8**

SHANNON SERIES — MODAL PROFILL

Topography:	Very gently undulating
Slope:	1°
Elevation:	50 m
Drainage:	Poorly drained
Parent Material:	Alluvium of dominantly limestone origin
Great Soil Group:	Alluvia] Gley

Horizon	*Depth (cm)*	*Description*
Al	0-30	Silty clay; dark grey (10 YR 4/1); moderate fine crumb structure; moist friable; root mat to 10 cm with few below; clear, smooth boundary:
Bg	30-51	Silty clay; brownish yellow (10 YR 6/8) with light brownish grey (10 YR 6/2) and dark greyish brown (10 YR 4/2) fine, frequent indistinct mottles; weak fine subangular blocky structure; moist friable, slightly stiff; very few roots; clear, smooth boundary:
Cg	51-80	Clay; grey (N 5/0) with pale brown (10 YR 6/3) fine, frequent, indistinct mottles; wet sticky; no roots.

TABLE 41: Shannon Series — Profile Analyses

Horizon	Al		Cg
Depth (cm)	0-30	30-51	51-80
Mechanical analysis of mineral fraction (%)			
Coarse sand	5	3	10
Fine sand	3	2	10
Silt	47	42	39
Clay	45	53	41
pH	6.5	*15*	7.9
CEC, mEq/100 g	37.2	25.2	5.6
TEB, mEq/100 g	28.4	21.3	7.5
Base saturation, %	76	85	Sat.
Carbon, %	4.6	1.6	0.4
Nitrogen, %	0.5	0.2	
C/N ratio	9.2	8.0	
Free iron, %	2.6	3.6	1.2
TNV,%			

Peat Soils

Fen

BANAGHER SERIES — MODAL PROFILE

Classification:	Terric Medisaprist
Parent Material:	Minerotrophic peat of *Carex* sedge origin
Vegetation:	Ryegrass ley
Topography:	Rat
Slope:	0°

Horizon	*Depth (cm)*	*Description*
Oap	0-50	Peat; black (5 YR 2/1) amorphous we identifiable plant remains; humification vPlll (KB); presence of very fine gravel; distinct boundary to:
Oa2	50-70	Peat; dark reddish brown (5 YR 2/2) amorphous well humified matrix with sedge *(Carex)* and very fine wood debris (1-2 mm); humification vPlll (H7); clear boundary to:
Oa3	70-80	Peat, dark reddish brown (5 YR 2/2) well humified amorphous matrix with sedge *(Carex)* and rootlet materials; humification vPl 11 (H7).

TABLE 42: Banagher Series — Profile Analyses

Horizon	Oap	Oap	Oap	Oa2	Oa3
Depth (cm)	0-12	12-30	30-50	50-70	70-80
Field moisture *(%* DM)	368	nd	415	587	681
Ash (% DM)	18.7	23.7	20.2	14.4	14.5
Db(g/ml)	0.26	nd	0.22	0.15	0.14
SPEC index	1	1	1	3	5
Rubbed fibre (%)	1	2	2	4	6
N (% DM)	2.42	1.98	2.02	2.16	2.48
Exch. Ca/Mg ratio	25.0	26.7	27.7	24.4	21.2
pH (H_20)	5.8	6.4	6.5	6.0	4.4

ALLEN SERIES — MODAL PROFILE

Classification:	Hemic Sphagnofibrist
Parent Material:	Ombrotrophic peat of *Sphagnum* origin
Vegetation:	Raised bog species
Topography:	Edge of raised bog
Slope:	2°

Horizon	*Depth (cm)*	*Description*
Oal	0-13	Peat; very dusky red (2.5 YR 2/2) humif **peat with *Calluna* remains; humification vPH (H5); recent roots in the surface; distinct boundary to:**
Oa2	**13-30**	**Peat; dark reddish brown (5 YR 2/2) humified *Sphagnum* with cyperaceous fibres; humification vPll (H6); clear boundary to:**
Oal	**30-37**	**Peat; dark reddish brown (5 YR 2/2) *Eriophoruml Sphagnum* with *Calluna* stems; humification vPl 1 (H4); distinct boundary to:**
Oil	37-50	**Peat: dark reddish brown (5 YR 3/2) *Sphagnum;* poorly humified, humification vPl (H2); clear boundary to:**
Oa3	**50-70**	**Peat; dark reddish brown (5 YR 2/2) humified *Sphagnum* with *Eriophorum;* humification vPll (H5); clear boundary to:**
Oa4	**70-80**	**Peat; black (N 2/0) humified *Sphagnum!Calluna;* humification vPl 1 (H5); distinct boundary to:**
Oi2	**80+**	**Peat; dark reddish brown (5 YR 2/2) matrix with very dusky red (2.5 YR 2/2) *Sphagnum;* humification vPll (H2).**

TABLE 43: Allen Series — Profile Analyses

Horizon Depth (cm)	Oal 0-13	Oa2 13-30	Oal 30-37	Oil 37-50	Oa3 50-70	Oa4 70-80	Oi2 80+
Field moisture *(%* DM)	898	1036	1461	2044	1298	1443	1924
Ash (% DM)	24.6	3.1	1.6	2.3	1.8	1.6	1.1
D_b(g/ml)	0.10	0.09	0.20	0.05	nd	nd	nd
SPEC index	6	6	7	7	7	7	7
Rubbed fibre (%)	12	10	32	44	18	6	40
N (% DM)	1.66	1.06	0.84	0.84	0.72	0.92	0.86
Exch. Ca/Mg ratio	1.3	0.8	0.5	0.3	0.1	0.3	0.3
pH (H_20)	3.8	3.9	4.0	4.1	4.0	4.0	4.2

GORTNAMONA SERIES — MODAL PROFILE

Classification:	Terric Medisaprist
Parent Material:	Ombrotrophic peat of *Calluna* origin
Vegetation:	Pasture
Topography:	Flat
Slope:	0°

Horizon	*Depth (cm)*	*Description*
Oap	0-20	Peat; dark reddish brown (5 YR *1* humified amorphous matrix with *Sphagnum* remains; humification vPlll (H7); clear boundary to:
Oa2	20-43	Peat; dark reddish brown (5 YR 2/2) humified matrix of *Calluna* origin with reddish brown (5 YR 4/3) *Sphagnum* and with straplike dark reddish brown (5 YR 3/2) *Phragmites* remains; humification vPll (H6); clear boundary to:
Oa3	43-55	Peat; dark reddish brown (5 YR 2/2) humified matrix with *Sphagnum* and reddish brown (5 YR 4/3) *Phragmites* stems; humification vPl 1 (H6); clear boundary to:
Oa4	55+	Peat; dark reddish brown (5 YR 2/2) as for horizon above with *non-Sphagnum* moss remains.

TABLE 44: Gortnamona Series — Profile Analyses

Horizon Depth (cm)	Oap 0-5	Oap 5-20	Oa2 20-30	Oa2 30-43	Oa3 43^5	Oa4 55+
Field moisture (% DM)	806	2699	736	915	1106	1064
Ash (% DM)	4.2	4.3	3.4	4.1	3.9	5.6
Db(g/ml)	0.10	nd	0.11	0.10	0.08	nd
SPEC index	7	6	6	8	8	6
Rubbed fibre (%)	22	24	12	14	12	20
N (% DM)	1.04	1.50	1.00	0.84	1.60	1.62
Exch. Ca/Mg ratio	3.9	3.9	5.4	5.6	7.2	8.5
pH (H_20)	4.1	4.2	4.4	4.5	4.8	4.7

TURBARY COMPLEX — MODAL PROFILE

Classification:	Sapric Sphagnofibrist
Parent Material:	Ombrotrophic peat of *Sphagnum* origin
Topography:	Alluvial flat
Elevation:	83 m

Horizon	*Depth (cm)*	*Description*
Oal	0-10	Dark reddish brown (5 YR 2/2); *Calluna* peat with humified *Sphagnum;* sapric H6, vPII; clear smooth boundary to:
Oa2	10-40	Dark reddish brown (5 YR 3/2) band with dark reddish brown (5 YR 3/4); cyperaceous *Sphagnum* peat with some *Calluna;* sapric; greasy compact very finely layered vPrH; clear, smooth boundary to:
Oa3	40-65	Dark reddish brown (5 YR 2/2); *Sphagnum-Calluna* peat; sapric; wet non-greasy; H 4/5, vPIII; clear, smooth boundary to:
Oil	65-200	Dark reddish brown (5 YR 2/2); *Sphagnum* peat; fibric; wet non-greasy; H3, vPI.

TABLE 45: Turbary Complex — Profile Analyses

Horizon Depdi (cm)	Oal 0-10	Oa2 10-40	Oa3 40-65	Oil 65-200
Field Moisture (% DM)	525	718	1109	1395
Ash *(%* DM)	2.5	3.5	1.2	1/3
DbCg/ml)	nd	nd	nd	nd
SPEC index	7	3	7	7
Rubbed fibre	17	9	8	30
N (% DM)	1.54	1.90	1.16	1.10
Exch. Ca/Mg ratio	0.6	0.4	nd	0.4
pH (H_20)	3.74	3.62	4.00	4.29

BOORA COMPLEX — MODAL PROFILE

Classification:	Terric Medisaprist
Complex:	Boora
Parent Material:	Minerotrophic peat - woody fen origin
Vegetation:	Fallow after cereals
Topography:	Flat to gently undulating
Elevation:	c. 75 m

Horizon	*Depth (cm)*	*Description*
Oap	0-15	Peat; black (5 YR 2/1); sapric; very friable; well decomposed matrix material with woody debris; sharp smooth boundary to:
Oa2	15-100	Peat; dark reddish brown (5 YR 3/3-2/2); colour changes on exposure; sapric; well decomposed matrix with woody debris and *Car ex* remains:
Alb	100+	Loam; dark grey (10 YR 4/1); wet; compact; non-calcareous.

TABLE 46: Boora Complex — Profile Analyses

Horizon	Oa	Oa2	Alb
Depth (cm)	0-15	15-100	100+
Field moisture (% DM)	306	534	626
Ash (% DM)	21.6	10.7	11.2
D_b(g/ml)	0.23	0.15	0.13
SPEC index	2	3	3
Rubbed fibre	10	10	10
N (% DM)	nd	2.40	nd
Exch. Ca/Mg ratio	nd	nd	nd
pH (H_20)	5.42	5.40	5.59

AUGHTY SERIES — MODAL PROFILE

Classification:	Terric Medisaprist
Parent Material:	Ombrotrophic peat of cyperaceous origin
Vegetation:	Blanket bog species
Topography:	Gently undulating
Slope:	4o

Horizon	*Depth (cm)*	*Description*
Oal	0-20	Peat; dark reddish brown (2.5 YR 2/4) w matrix with *Sphagnum* and occasional *Calluna* remains; humification vPl 1 (H6); common recent roots in surface decreasing rapidly with depth; clear boundary to:
Oa2	20-40	Peat; dark reddish brown (5 YR 2/2) well humified matrix with some *Sphagnum* and *Calluna* remains: humification vPlll (H7); clear boundary to:
Oa3	40-75	Peal; dark reddish brown (5 YR 2/2) well humified matrix with cyperaceous debris and some *Sphagnum;* humification vPlll (H7).

TABLE 47: Aughty Series — Profile Analysis

Horizon Depth (cm)	Oal 0-20	Oa2 20-40	Oa3 40-60	Oa3 60 75
Field moisture (% DM)	403	861	1081	1407
Ash (% DM)	3.3	1.7	1.7	1.8
D_b(g/ml)	0.19	0.11	0.09	0.07
SPEC index	1	3	6	7
Rubbed fibre (%)	16	8	8	8
N (% DM)	1.44	1.08	0.98	1.14
Exch. Ca/Mg ratio	0.7	0.2	0.1	0.1
pH (H_20)	3.4	3.4	3.3	3.6

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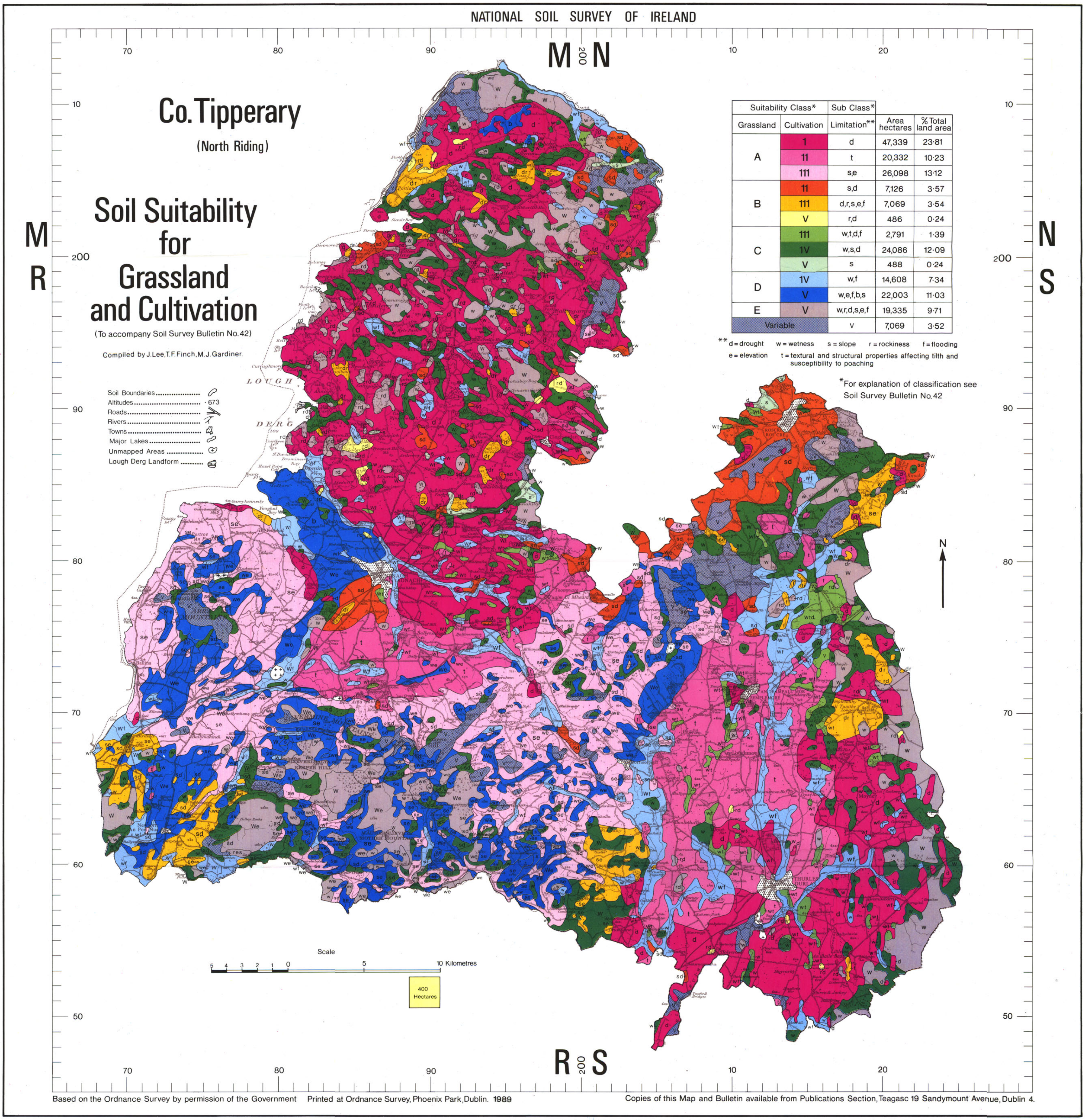
SOIL SERIES

SOIL COMPLEXES



Suitability Class*		Sub Class*		
Grassland	Cultivation	Limitation**	Area hectares	% Total land area
A	1	d	47,339	23·81
	11	t	20,332	10·23
	111	s,e	26,098	13·12
B	11	s,d	7,126	3·57
	111	d,r,s,e,f	7,069	3·54
	V	r,d	486	0·24
C	111	w,t,d,f	2,791	1·39
	1V	w,s,d	24,086	12·09
	V	s	488	0·24
D	1V	w,f	14,608	7·34
	V	w,e,f,b,s	22,003	11·03
E	V	w,r,d,s,e,f	19,335	9·71
Variable		v	7,069	3·52

** d = drought w = wetness s = slope r = rockiness f = flooding
e = elevation t = textural and structural properties affecting tilth and susceptibility to poaching

*For explanation of classification see Soil Survey Bulletin No. 42

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NATIONAL SOIL SURVEY OF IRELAND

Co. Tipperary

(North Riding)

Grazing Capacity of Soil Series

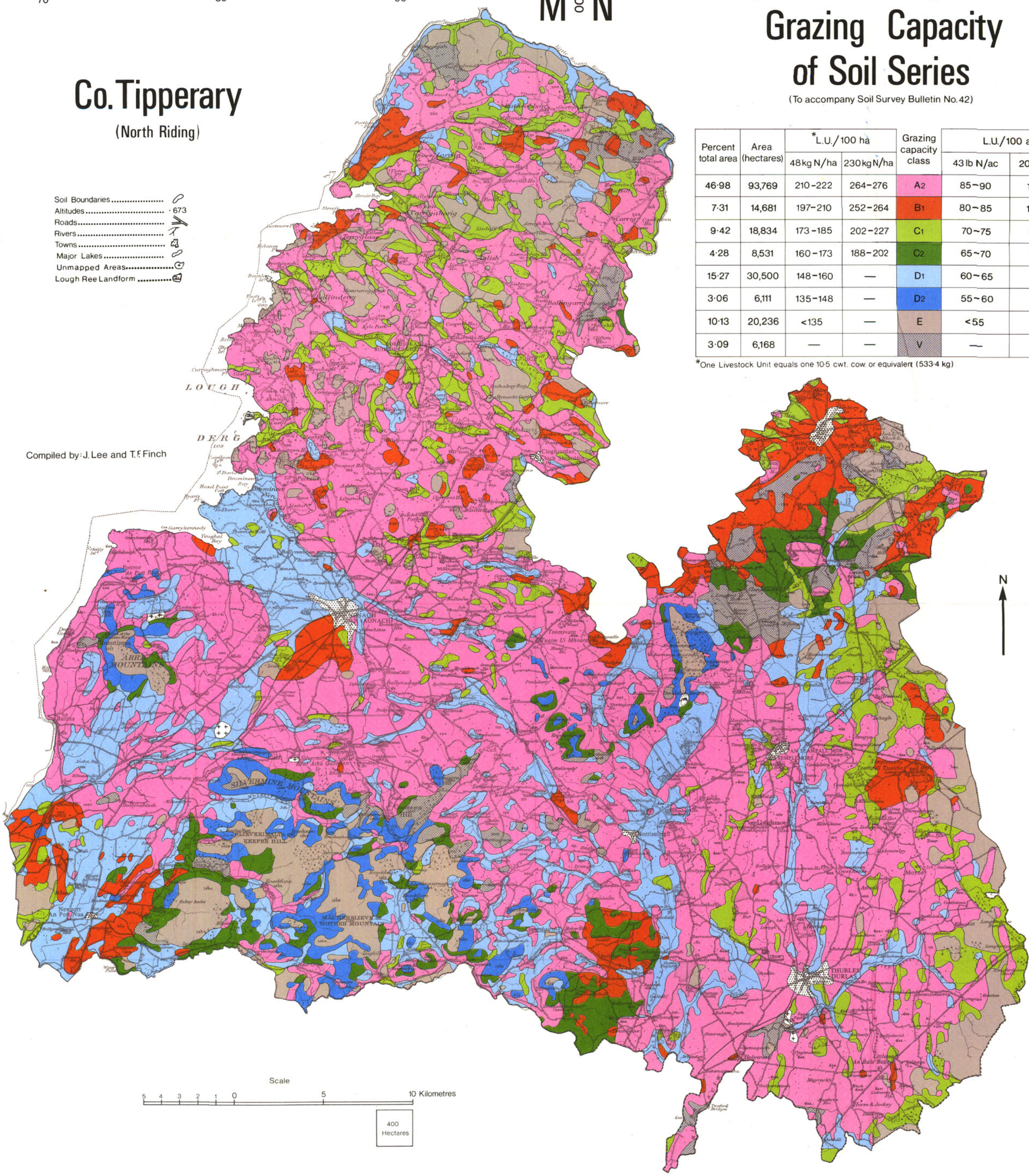
(To accompany Soil Survey Bulletin No. 42)

Percent total area	Area (hectares)	*L.U./100 ha		Grazing capacity class	L.U./100 ac	
		48 kg N/ha	230 kg N/ha		43 lb N/ac	206 lb N/ac
46·98	93,769	210–222	264–276	A2	85–90	107–112
7·31	14,681	197–210	252–264	B1	80–85	102–107
9·42	18,834	173–185	202–227	C1	70–75	82–92
4·28	8,531	160–173	188–202	C2	65–70	72–82
15·27	30,500	148–160	—	D1	60–65	—
3·06	6,111	135–148	—	D2	55–60	—
10·13	20,236	<135	—	E	<55	—
3·09	6,168	—	—	V	—	—

*One Livestock Unit equals one 10·5 cwt. cow or equivalent (533·4 kg)

Soil Boundaries
Altitudes · 673
Roads
Rivers
Towns
Major Lakes
Unmapped Areas
Lough Ree Landform

Compiled by: J. Lee and T. F. Finch



Scale

5 4 3 2 1 0 5 10 Kilometres

400 Hectares

M N
M R
N S
R S

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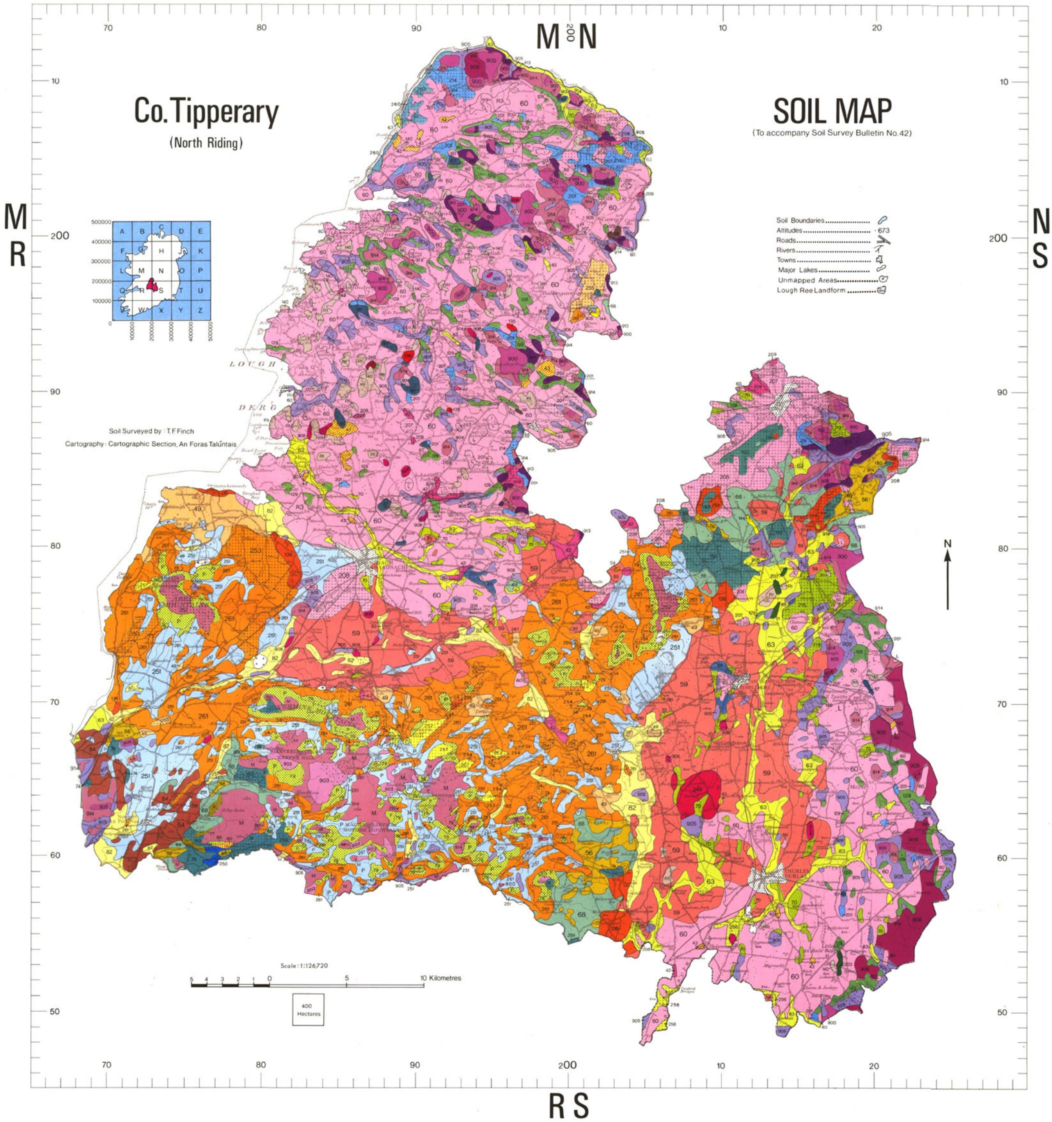
NATIONAL SOIL SURVEY OF IRELAND



Great Soil Group	Regosol		Lithosol	Brown Earth						Rendzina			Grey Brown Podzolic				Brown Podzolic			
Soil Series	248 Carney	203 Milltown-pass	85 Slievereagh	42 Baggots-town	43 Ballincurra	49 Ballyna-lacken	249 Dovea	135 Kinvarra	136 Knockna-skeha	140 Burren	R1 Burren Rocky Phase	141 Kilcolgan	59 Elton	60 Patrickswell	L Patrickswell Lithic Phase	R3 Patrickswell Bouldery Phase	261 Borrisoleigh	S4 Borrisoleigh Steep Phase	54 Cooga	56 Doonglara
Parent Material	Limestone Lake Alluvium	Limestone River Alluvium	Sandstone Mainly Bedrock	Limestone Fluvioglacial Drift	Shallow Limestone Till	Shale Till or Colluvium	Limestone/ Shale Till	Limestone Till	Sandstone/ Limestone/ Shale Till	Mainly Limestone Bedrock		Limestone Till	Limestone Till, some Sandstone and Shale				Shale Till and Colluvium		Sandstone Fluvioglacial Drift, some Shale	Sandstone Till or Colluvium
% Total* Land Area	·01	·06	·01	·31	·24	1·26	·34	·04	·64	·17	·92	·03	9·85	23·08	1·34	1·22	10·91	·40	·94	1·16
Hectares	22	129	20	621	486	2,527	682	79	1,284	344	1,834	56	19,650	46,055	2,745	2,444	21,772	807	1,881	2,314

*Urban areas etc. = 1062 ha 0·53 %

Great Soil Group	Podzol					Gley													
Soil Series	77 Knockaceol	P Knockaceol Peaty Phase	79 Knock-astanna	P Knock-astanna Peaty Phase	80 Seefin	201 Ballyshear	63 Camoge	65 Coolalough	250 Derry-garreen	67 Drombanny	82 Feale	68 Gortaclareen	70 Howards-town	251 Kilcommon	P Kilcommon Peaty Phase	144 Kilgory	129 Mylerstown	74 Puckane	P Puckane Peaty Phase
Parent Material	Sandstone Bedrock some Till and Colluvium		Shale Till and Colluvium		Sandstone Colluvium and Till	Limestone Till	Limestone/ Sandstone/ Shale-River All	Limestone Lake Alluvium	Sandstone Fluvioglacial Drift	Limestone Lake Alluvium	Shale River Alluvium	Sandstone/ Shale Till	Limestone Till	Shale Till and Colluvium		Sandstone River Alluvium	Limestone Till with some Shale	Sandstone/ Shale Till	
% Total Land Area	·04	·03	1·66	1·84	·02	·47	3·72	·15	·05	·26	2·40	2·38	·95	6·15	1·16	·03	2·15	·27	·03
Hectares	78	54	3,315	3,685	40	942	7,429	298	103	513	4,790	4,749	1,902	12,279	2,309	54	4,297	533	63

	Peat						
Soil Series	900 Allen	903 Aughty	905 Banagher	906 Boora (Complex)	908 Pollardstown	913 Gortnamona	914* Turbary (Complex)
% Total Land Area	1·63	·53	4·85	1·47	·18	·79	4·74
Hectares	3,248	1,056	9,686	2,935	367	1,572	9,469

R1 2–10% Rockiness
R3 25–50% Rockiness
S4 13°–19° Slopes
L Lithic
M* Mountainous
P Peaty
Large rock outcrop

	Complex														
Soil Series	252 Turbary Knock-astanna	209 Baggotstown Crush	253 Borrisoleigh Ballynalacken	254 Borrisoleigh Knockshigowna	255 Ballynalacken Knockshigowna	214 Ballyshear Patrickswell	256 Camoge Milltownpass	213 Howardstown Baggotstown	215 Howardstown Patrickswell	257 Knockastanna Knockshigowna	258 Knocknaskeha Doonglara	207 Patrickswell Baggotstown	208 Patrickswell Baggotstown Elton	259 Puckane Gortaclareen	150 Puckane Slievereagh	260 Shannon Banagher
% Total Land Area	·45	·24	·90	·36	·23	·56	·21	·07	·41	·29	·26	1·20	1·99	·20	1·11	·18
Hectares	901	488	1,799	719	456	1,115	415	133	835	589	524	2,400	3,970	389	2,217	362

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