NEW ZEALAND SOIL CLASSIFICATION

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FOREWORD

Many technical terms are used throughout this report in the keys and definitions. These technical terms, printed here in italics, are defined in this book in the section "Diagnostic Horizons and other Differentiae".

Other technical terms are defined in other books:

- *Horizon notations* are defined by Clayden and Hewitt (1989).
- *Soil morphology* terms are defined by Milne *et al.* (1991).
- C*lasses of the US Soil Taxonomy* are defined by Soil Survey Staff (1999).
- S*oil colours* are defined by Munsell Color Company (1975).
- S*oil mineralogy classes* are defined by Whitton and Childs (1989) or Childs and Whitton (1990). Note that the soil mineralogy class names given here are based on the following control section: 25 cm to 100 cm or to a lithic or paralithic contact if shallower.
- S*oil chemical terms* are explained and the analytical methods are described by Blakemore *et al.* (1987). Note that soil pH measurements are made in water with a ratio of 1 part of soil to 2.5 parts of water, by weight.
- S*oil physical terms* are explained and the analytical methods are described by Gradwell and Birrell (1979).
- Many other soil science concepts and technical terms are explained, in a New Zealand context, by McLaren and Cameron (1990).

The following abbreviations are used for soil chemical terms.

CEC – Cation exchange capacity.

ECEC – Effective cation exchange capacity, which is the CEC at natural field pH, estimated by the sum of basic cations + KCl-extractable aluminium.

P retention – Phosphate retention.

INTRODUCTION

Version 3.0 of the Zealand Soil Classification is the culmination of a period of development from its initiation in 1983 to wide circulation of versions 1.0 and 2.0 (Hewitt 1989) for comment and testing. It represents the best attempt, given the current state of knowledge, to classify New Zealand soils. As the knowledge and understanding of New Zealand soils grows, further revisions will be necessary. Accounts of the methods used in developing the soil classification and the rationale for the classes and differentia used are in preparation.

The New Zealand Soil Classification is a national soil classification intended to replace the New Zealand Genetic Soil Classification (Taylor 1948; Taylor and Cox 1956; Taylor and Pohlen 1962). The New Zealand Genetic Soil Classification grew out of the need for reconnaissance mapping of the nation's soil resources. It was successful as a unifying factor in New Zealand soil science, and it played a vital role in the development of pastoral agriculture. However, modern soil surveys and land evaluations required precise definition of classes and keys for their recognition. Furthermore, a new synthesis was needed of the large body of information collected since the 1950s. The present work has grown out of the New Zealand Genetic Soil Classification and, where possible, preserves successful parts of that classification. It has also been influenced by experience in testing the US Soil Taxonomy (Leamy *et al.* 1983).

OBJECTIVES

The objectives of the New Zealand Soil Classification are:

1. to provide a better means of communication about New Zealand soils and their utilisation;
2. to provide an efficient vehicle for soil identification, soil series recognition and correlation, and soil map legend establishment in soil surveys;
3. to enable an efficient stratification of soil database information;
4. to draw together knowledge of the properties of New Zealand soils and important similarities and differences among them.

A discussion of these objectives is given by Hewitt (1984).

PRINCIPLES

To accomplish the objectives, the following principles have guided the development of this proposal. These are explained further by Hewitt (1984).

1. The classification should be hierarchical, providing ascending levels of generalisation.

2. The grouping of soils into classes should be based on similarity of measurable soil properties rather than presumed genesis.

3. Classes must be designed to allow the greatest number and most precise accessory statements to be made about them consistent with their level in the hierarchy.

4. Differentia should be based on soil properties that can be reproducibly and precisely measured or observed.

5. Differentia should where possible allow field assignment of soils to classes, either directly, or by tested inferences.

6. The nomenclature of higher categories should be based where possible on connotative English words chosen for their acceptability to non-specialists.

7. Where possible, continuity with successful parts of the New Zealand Genetic Classification should be maintained.

8. The soil classification must be valid for the main islands of New Zealand. Classes must be correlated with Soil Taxonomy (Soil Survey Staff 1990) to support international extension.

THE SOIL INDIVIDUAL

The soil individual is the fundamental unit of soil which is assigned to classes. Cline (1949) defined an individual as "the smallest natural body that can be defined as a thing complete in itself".

Soil Taxonomy (Soil Survey Staff 1975) regards the polypedon as the soil individual. This is rejected here because, as discussed by Hewitt (1982), it does not fulfil Cline's (1949) or Johnson's (1963) requirements for a soil individual.

In New Zealand, the soil individual has traditionally been the soil profile. Usually conceived as a two-dimensional section exposed by a soil pit, it is in fact a three-dimensional slice sufficiently thick to sample and examine hand specimens. It should therefore be termed a “soil profile slice”. With the realisation that soils should be examined in successive horizonal sections as well as the vertical profile, there is increasing acceptance that a volume of soil the size of the pedon (Soil Survey Staff 1975) represents a better soil individual than the soil profile slice.

Accordingly, the pedon as defined in Soil Taxonomy (Soil Survey Staff 1975) is recommended as the soil individual for the New Zealand Soil Classification. It is understood that assignments are often made from the examination of volumes of soil smaller than a complete pedon, where they are assumed representative of the pedon.

HOW TO ASSIGN A SOIL TO SUBGROUP LEVEL

Normally, a soil pit must be dug of sufficient size to expose the soil horizons to about 1 m depth, or to rock if shallower.

The soil horizons are examined and the assignment is then made by following the key, starting with the key to orders on page 35. The “Diagnostic Horizons and Other Differentiae” section is consulted as necessary to identify diagnostic horizons and other differentia. For some classes, pH or other chemical measurements must be made. These should be performed on samples taken between the specified depths, and bulked from at least four places in the pit. The characteristics of the soil are compared with the key statements of each soil order, starting with Organic Soils and passing down the key to the first

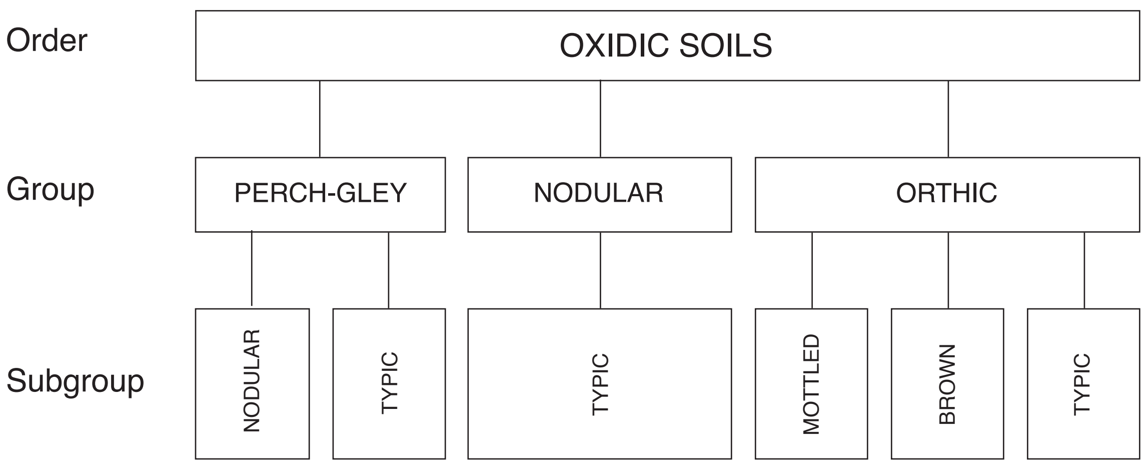

Figure 1. *The hierarchy of the Oxidic Soils as an example of the hierarchical relationships between orders, groups and subgroups. As the diagram suggests, the range of soil properties for each class is related to hierarchical position.*

soil order that fits them. When a soil order is identified, the chapter concerning that order is consulted and the keys to soil groups and soil subgroups are followed in the same manner to identify the appropriate soil group and subgroup.

The name given to a soil assigned to a subgroup is made up of three elements in the sequence: subgroup, group, and order (for example, Nodular Perchgley Oxidic Soils). Figure 1 illustrates the relationships between subgroups and groups in the Oxidic Soils order.

MISCLASSIFICATION

The classes are the most important part of the soil classification. The key is merely a means of allocating soils to these classes, and by its nature is imperfect because only a sample of all the possible soils that might potentially be allocated were used in developing the key. Consequently, soils will be found that are not allocated to the appropriate class by the key. This will be apparent when a soil, allocated to a class, does not conform to the concept and accessory statements that can normally be made about that class. Because the key is the servant of the classes, the allocator is justified in placing the soil misfit into a more appropriate class. If this is done, however, it must be registered with the person with responsibility for the national soil classification system, so that appropriate adjustments may be made to the key when the soil classification is next revised. An allocation contrary to the key must also be noted in any records or publication of the allocation.

JUSTIFICATION OF NEW SUBGROUPS

Justification for new subgroups may be made in two ways. First, if a soil is judged to be misclassified, and a more appropriate class is not available, then a new subgroup may be justifiable. Second, an existing subgroup may encompass a set of soils with properties that are too wide in range. The old subgroup could be split into two new ones. Splitting may be justified if it will significantly increase the number and precision of accessory statements that can be made about both of the new classes.

CORRELATIONS WITH OTHER SOIL CLASSIFICATION SYSTEMS

Classes of the New Zealand Soil Classification do not correspond precisely with classes of other soil classification systems. Despite this, correlations can be made where classes are substantially equivalent. In Table 1, classes of the Zealand Soil Classification are correlated with the New Zealand Genetic Soil Classification (Taylor and Pohlen 1962) and Soil Taxonomy (Soil Survey Staff 1990).

Table 1. Correlation of soil groups with the Genetic New Zealand Soil Classification (Taylor and Pohlen 1962) and the US Soil Taxonomy (Soil Survey Staff 1999). The correlations with Soil Taxonomy provide only the nearest equivalents, as criteria differ between the two systems. The lowest category of Soil Taxonomy is given (order, suborder or great group) that can be best related to soil groups of the NZ Soil Classification.

NZ Soil Classification (version 3)	NZ Genetic Soil Classification	Soil Taxonomy
ALLOPHANIC SOILS		
Perch-gley Allophanic Soils	gley soils	Aquands
Gley Allophanic Soils	gley soils	Aquands
Impeded Allophanic Soils	YB*loams	Cryands and Udands
Orthic Allophanic Soils	YB loams	Cryands and Udands
ANTHROPIC SOILS		
Truncated Anthropic Soils	anthropic soils	Arents
Refuse Anthropic Soils	anthropic soils	Arents or unclassified
Mixed Anthropic Soils	anthropic soils	Arents
Fill Anthropic Soils	anthropic soils	Arents

* YB = yellow-brown

Table 1. *(continued)*

NZ Soil Classification (version 3)	NZ Genetic Soil Classification	Soil Taxonomy
BROWN SOILS		
Allophanic Brown Soils	YB earths (upland & high country)	Dystrudepts
Sandy Brown Soils	YB sands	Dystrustepts, Dystrudepts and Psamments
Oxidic Brown Soils	YB earths (northern)	Dystrudepts
Mafic Brown Soils	BG* loams and clays	Dystrudepts
Acid Brown Soils	podzolised YB earths or YB earths	Dystrudepts
Firm Brown Soils	YB earths, YB shallow and stony soils	Dystrudepts and Dystrustepts
Orthic Brown Soils	YB earths, YB shallow and stony soils	Dystrudepts and Dystrustepts
GLEY SOILS		
Sulphuric Gley Soils	gley soils	Sulphaquepts
Sandy Gley Soils	gley soils	Aquepts or Aquents
Acid Gley Soils	gley soils	Aquepts
Oxidic Gley Soils	gley soils	Aquox
Recent Gley Soils	gleyed recent soils	Aquents
Orthic Gley Soils	gleyed recent soils	Aquepts or Aquents

* BG = brown granular

Table 1. *(continued)*

NZ Soil Classification (version 3)	NZ Genetic Soil Classification	Soil Taxonomy
GRANULAR SOILS		
Perch-gley Granular Soils	BG loams or BG clays	Aquults
Melanic Granular Soils	BG loams or BG clays	Humults and Udalfs
Oxidic Granular Soils	BG loams or BG clays	Humults
Orthic Granular Soils	BG loams or BG clays	Humults
MELANIC SOILS		
Vertic Melanic Soils	BG loams and clays	Ustolls or Vertisols
Perch-gley Melanic Soils	gley soils	Aquolls
Rendzic Melanic Soils	rendzinas	Rendolls
Mafic Melanic Soils	BG loams and clays	Haplustepts, Ustolls or Udolls
Orthic Melanic Soils	rendzinas and rendzic intergrades	Ustolls, Udolls, Haplustepts or Calciustepts
ORGANIC SOILS		
Litter Organic Soils	unclassified	Folists or unrecognised
Fibric Organic Soils	organic soils	Fibrists
Mesic Organic Soils	organic soils	Hemists
Humic Organic Soils	organic soils	Saprists

Table 1. *(continued)*

NZ Soil Classification (version 3)	NZ Genetic Soil Classification	Soil Taxonomy
OXIDIC SOILS		
Perch-gley Oxidic Soils	gley soils	Aquox
Nodular Oxidic Soils	strongly weathered red loams,	Udox
Orthic Oxidic Soils	brown loams, or BG loams or BG clays	Udox
PALLIC SOILS		
Perch-gley Pallic Soils	yellow-grey earths	Aquepts, Aqualfs
Duric Pallic Soils	yellow-grey earths	Duraqualfs
Fragic Pallic Soils	yellow-grey earths	Fragiudalfs, Fragiochrepts
Laminar Pallic Soils	yellow-grey earths	Haplustalfs, Hapludalfs
Argillic Pallic Soils	yellow-grey earths	Haplustalfs, Hapludalfs
Immature Pallic Soils	yellow-grey earths or recent soils	Haplustepts
PODZOLS		
Densipan Podzols	podzols	Aquods, Orthods
Perch-gley Podzols	gley podzols	Aquods
Groundwater-gley Podzols	gley podzols	Aquods
Pan Podzols	podzols	Orthods
Orthic Podzols	podzols	Orthods

Table 1. *(continued)*

NZ Soil Classification (version 3)	NZ Genetic Soil Classification	Soil Taxonomy
PUMICE SOILS		
Perch-gley Pumice Soils	gley soils	Vitraquands
Impeded Pumice Soils	YB pumice soils	Vitrands, Vitricryands
Orthic Pumice Soils	YB pumice soils	Vitrands, Vitricryands
RAW SOILS		
Gley Raw Soils	unclassified	Entisols or not-soil
Hydrothermal Raw Soils	hydrothermal soils	Entisols or not-soil
Rocky Raw Soils	unclassified	Entisols or not-soil
Sandy Raw Soils	unclassified	Entisols or not-soil
Fluvial Raw Soils	unclassified	Entisols or not-soil
Tephric Raw Soils	unclassified	Entisols or not-soil
Orthic Raw Soils	unclassified	Entisols or not-soil
RECENT SOILS		
Hydrothermal Recent Soils	recent soils	Aquents, Orthents
Rocky Recent Soils	lithosols	Orthents
Sandy Recent Soils	recent soils	Psamments
Fluvial Recent Soils	recent soils	Fluvents, Udepts, Ustepts
Tephric Recent Soils	recent soils	Orthents, Cryands, Udands
Orthic Recent Soils	recent soils	Orthents, Udepts, Ustepts

Table 1. *(continued)*

NZ Soil Classification (version 3)	NZ Genetic Soil Classification	Soil Taxonomy
SEMIARID SOILS		
Aged-argillic Semiarid Soils	brown-grey earths	Haplargids
Solonetzic Semiarid Soils	solonetz	Natragids
Argillic Semiarid Soils	brown-grey earths	Haplargids
Immature Semiarid Soils	brown-grey earths	Haplocambids, Aquicambids
ULTIC SOILS		
Densipan Ultic Soils	YB earths or podzols	Aquults
Albic Ultic Soils	YB earths	Aquults, Humults or Udults
Perch-gley Ultic Soils	YB earths	Aquults
Sandy Ultic Soils	YB earths or YB sands	Hapludults
Yellow Ultic Soils	YB earths	Hapludults

DIAGNOSTIC HORIZONS AND OTHER DIFFERENTIAE

Diagnostic horizons and other differentiating criteria are defined to facilitate the assignment of soils to classes. The definitions are not intended to represent a comprehensive classification of horizons. A summary of these is given in Table 2.

Table 2. Summary of diagnostic horizons and other differentiae.

Horizons, Pans and Layers:	**Soil Materials and Contacts:**
Argillic horizon	Allophanic soil material
Brittle-B horizon	Lithic contact
Calcareous horizon	Organic soil material
Cutanic horizon	Paralithic contact
Cutanoxidic horizon	Tephric soil material
Densipan	Vitric soil material
Duripan	
Distinct topsoil	**Profile Forms:**
Fragipan	Gley profile form
Humus-pan	Mottled profile form
Ironstone-pan	
Nodular horizon	**Features:**
Ortstein-pan	Fluvial features
Oxidic horizon	Perch-gley features
Peaty topsoil	Sodic features
Placic horizon	
Podzolic-B horizon	**Other Differentiae:**
Reductimorphic horizon	Crumb structure
Redox-mottled horizon	Reactive-aluminium test
Slowly permeable layer	Redox segregations
Weathered-B horizon	

The following diagnostic horizons and soil characteristics have been modified from Soil Taxonomy (Soil Survey Staff 1975): argillic horizon, duripan, fragipan, lithic contact, paralithic contact and placic horizon.

ALLOPHANIC SOIL MATERIAL

Allophanic soil material has soil properties dominated by minerals with short-range order, especially allophane, imogolite and ferrihydrite. Other terms such as "amorphous", "poorly crystalline" and "non-crystalline", have been, or are, sometimes used for such minerals. Their chief characteristics are reactive variable-charge surfaces, and a very high specific surface area (several hundreds of m^2/g). Allophanic soil material has BOTH

1. ***Either***

   (a) All of the following (in a fresh sample):

   (i) Sensitive or strongly sensitive sensitivity class (distinctly greasy or smeary feel except in some sandy soils), *and*

   (ii) Very weak or weak unconfined soil strength class (when moist), *and*

   (iii) Non-sticky or slightly sticky stickiness class, *and*

   (iv) Strong or very strong reactive-aluminium test.

   or

   (b) P retention of 85% or more;

AND

2. Dry bulk density of the fine-earth fraction (where the volume is determined on a field-moist soil) of less than 0.9 Mg/m^3.

Layers meeting the requirements of allophanic soil material may also meet the requirements of vitric soil material.

Accessory chemical properties relate to variable-charge characteristics, P retention, and high organic-matter contents. Accessory physical properties include high total available water capacity and readily available water capacity, and low penetration resistance. In addition, allophanic soil material undergoes irreversible changes upon drying, for example, in plastic and liquid limits and in apparent particle-size distribution. It should be noted that minerals other than allophane (e.g. ferrihydrite) can give rise to allophanic soil material.

ARGILLIC HORIZON

An argillic horizon is a clay-enriched horizon. It is indicated by a "Bt" horizon notation as in Btg, BCt, etc. It has ONE of the following:

1. It is vertically continuous and is 10 cm or more thick. Clay coatings occur that have a waxy lustre when dry and sufficient thickness to envelop fine sand grains. Coatings occur either on peds (10% or more of the ped surfaces), or in pores (in more than one-third of the observed tubular pores) or as bridges between sand grains (in more than half of the horizon); OR

2. It is composed of clay-enriched lamellae (clay bands), that within 90 cm of the mineral soil surface have a combined thickness of 15 cm or more; OR

3. It contains sufficiently more clay than the overlying horizon, as detected by hand texturing (5% or more) , excluding any differences which result from a lithological discontinuity, and **either**
   (a) it is overlain by an eluvial horizon (Ew or Eg) and the upper boundary of texture contrast is abrupt or sharp, **or**
   (b) clay coatings occur on ped or pore surfaces.

Horizons having coatings which do not meet the requirements of an argillic horizon are likely to meet the requirements of a cutanic horizon.

BRITTLE-B HORIZON

A brittle-B horizon is a B or BC horizon that has ALL of the following:

1. Brittle failure (the horizon may be gravelly, but the fine-earth fraction must be sufficiently coherent to allow brittle failure); AND

2. It is apedal-massive. Extremely coarse or gross prisms may be present, if the interior of the prisms is apedal-massive; AND

3. Few or less fine roots occur throughout the horizon.

The brittle-B horizon differs from the fragipan by having either lower soil strength or lower penetration resistance. Extremely coarse prism faces, if present, are not defined by low chroma colours as they are in a fragipan. The horizon commonly has some roots throughout, in contrast to the fragipan in which roots are confined to cracks. A brittle-B horizon is usually given the horizon notation suffix (x).

CALCAREOUS HORIZON

A calcareous horizon is an horizon in which calcium carbonate occurs in the fine-earth fraction. The concentration may be as low as 1%, but its presence can be detected by effervescent reaction with 10% HCl on samples from a freshly exposed profile. The calcium carbonate may be inherited from a calcareous parent material, or it may be formed in the soil and occur as coatings on stones, filamentous deposits in pores, or as nodules.

The calcareous horizon includes horizons with the more stringent requirements of the calcic horizon of Soil Taxonomy (Soil Survey Staff 1975). The less stringent limits of the calcareous horizon are needed to distinguish the calcium-carbonate-accumulating horizons in the Semiarid Soils which have developed by weathering of calcium ions from silicate minerals in non-calcareous parent materials. Calcium carbonate dusts, which have contributed to calcium carbonate enriched horizons in other countries, have not been identified in New Zealand.

CRUMB STRUCTURE

Crumb structure is defined as an earthy apedal material (Milne *et al*. 1991) with very friable failure class. Soil with crumb structure in situ has the gross appearance of massive soil material, but when disaggregated or disturbed, microfragments are produced with a superficial resemblance to breadcrumbs. When examined with a ×10 power hand-lens, these prove to be loosely packed aggregates of spheroidal micropeds (< 0.5 mm) with packing voids forming a prominent part of the aggregate.

CUTANIC HORIZON

A cutanic horizon is a B or BC horizon containing translocated material forming dark-coloured coatings on ped faces, in pores or on coarse fragments. The coatings fail to meet the requirements for coatings of an argillic horizon or a Bh horizon.

It meets BOTH of the following:

1. The coatings do not have a waxy lustre when dry or are not sufficiently thick to envelop fine sand grains. Silt coatings are excluded. (Silt coatings have similar colour to the matrix, or have higher value and/or lower chroma than the matrix. On drying they may be thick enough to meet argillic horizon requirements, and have flow-like surfaces, but they have a matt rather than a waxy lustre.) AND

2. The coatings have moist colour values of 4 or less, or value 5 and chroma 3 or less.

Many soils have horizons with coatings on peds or in pores which are very thin, do not have a waxy lustre when dry and have lower colour value than the matrix. It is difficult in the field to decide whether these coatings are inorganic or organic, and whether they are derived by illuviation from overlying horizons, by movement within horizons or by in-situ weathering. The cutanic horizon is designed to recognise such horizons. A cutanic horizon is usually given the horizon notation suffix (h).

CUTANOXIDIC HORIZON

A cutanoxidic horizon (Wilson 1987) is a strongly weathered, clayey, low-activity-clay horizon. The dominant clays are kaolin group minerals, and clay coatings occur on less than 10% of ped faces. Exchangeable aluminium, as a percentage of CEC, is usually greater than 25% (and is frequently more than 50% in some part of the horizon). It meets the requirements of a cutanic horizon, and has ALL the following characteristics:

1. It is a B horizon that is clayey and has fine polyhedral peds; **AND**
2. It has a failure class of friable only at water contents close to field capacity. Small changes in water content from field capacity result in large changes in soil strength and failure. Semi-deformable failure occurs at water contents wetter than field capacity. Very firm or stronger ped strength with brittle failure occurs at soil water matric potentials drier than about 30 kPa. Soil materials lack the characteristic friable failure over a wide range in moisture contents that is exhibited by oxidic horizons; **AND**
3. Soil materials are sticky and very plastic, in comparison to oxidic materials which are only slightly sticky in relation to their clay content; **AND**
4. Peds are larger than 2 mm and have smooth faces with silt-sized aggregates of iron oxide crystallites which give the ped faces a dusty appearance when dry. The latter property in particular distinguishes this horizon from horizons developed in well-drained Brown Soils.

The significance of this horizon lies in the combination of low ECEC, clay illuviation, acidity and "non-oxidic" physical properties.

DENSIPAN

A densipan is a non-cemented E horizon of very high soil strength and bulk density. It meets BOTH of the following:

1. *Either*

   (a) Unconfined strength, as measured by a resistance-to-crushing test, is hard or very hard at soil water states from near wet to dry,

   or

   (b) Soil penetration resistance measured by a 6.5 mm flat-tipped penetrometer exceeds 4000 kPa at soil water states from near wet to dry;

   AND

2. Moist and dry samples slake in water.

Densipans occur in soils with siliceous parent materials. The strength is due to a close-fit arrangement of sand and silt-sized quartz particles. It differs from a duripan by lack of cementation.

DISTINCT TOPSOIL

A distinct topsoil (modified from Avery 1980) is normally designated an A horizon and has BOTH of the following:

1. Moist colour value and/or chroma is less than that of the horizon below; AND

2. Thickness is 5 cm or more (including any F, H or O topsoil layer). The distinct topsoil is used to distinguish minimal soil development in the distinction between Recent Soils and Raw Soils.

DURIPAN

A duripan is a subsurface horizon that is cemented by silica or other opaque or uncoloured material. It has ALL of the following requirements, but does **not** meet the requirements of the calcareous horizon:

1. Dry fragments do not slake in water even during prolonged wetting; AND

2. It does not react visibly with 10% HCl; AND

3. The average lateral distance between any fractures is 100 mm or more.

The duripan is recognised in Pallic Soils where the cementing materials are apparently related to the presence of siliceous tephra in the parent material or high exchangeable sodium in the soil.

FLUVIAL FEATURES

The intention of the term 'fluvial features' is to recognise soils with parent materials that result from transportation, sorting and deposition by water. Fluvial features are used to differentiate Recent Soils, Raw Soils and parent material classes of soil series that occur on landforms formed through fluvial processes.

Relevant landforms include floodplains, estuarine surfaces, lacustrine surfaces, aggregating fan surfaces, levees, backplains, bars, channels, deltas, floodplain benches, outwash plains and swamps (all defined by Milne *et al*. 1991).

Confirming soil characteristics include:

1. A buried A horizon or some other field indication of an irregular change in carbon with depth (such as sedimentary plant-leaf material).

2. Sedimentary bedding in C horizons, indicating deposition in water (such as scoured surfaces, cross-stratification, sedimentary laminations, current ripples or foreset beds).

3. An unripened horizon with fluid, or very fluid, fluidity class in some layer with an upper surface within 120 cm of the soil surface.

4. In tephric soil materials
   a. disturbance or overthickening of the regional sequence of tephras;
   b. rounded or subrounded gravel;
   c. presence of non-volcanic rock fragments.

The emphasis here on genetic landform criteria is not consistent with the principle that soils should be classified on the basis of similarity of measurable soil properties rather than presumed genesis (see Introduction). Measurable soil properties that will group together the required soils have not been recognised. The confirmatory soil properties, however, will aid class assignment decisions in many cases.

FRAGIPAN

A fragipan is an apparently non-cemented horizon that has high bulk density (usually 1.5 Mg/m^3) with high strength when dry. It has ALL of the following:

1. An air-dried clod must slake when fully immersed in water; AND

2. Brittle failure when moist (the horizon may be gravelly but the fine-earth material must be sufficiently coherent to allow brittle failure); AND

3. It has at least slightly firm moist soil strength; AND

4. *Either*

    (a) Extremely coarse or gross prismatic peds: the prisms have apedal-massive interiors, or break to secondary peds with horizontal dimensions of 100 mm or more, and the prism faces are defined by colours of chroma 3 or less, ***or***

    (b) The horizon is apedal-massive throughout, or has extremely coarse or gross prismatic peds, and the moist soil strength is very firm; AND

5. If roots are present, they are confined predominantly to planar voids between prisms or to worm galleries; AND

6. Moist penetration resistance measured by a 6.5 mm flat-tipped penetrometer is 3100 kPa or more; AND

7. It does not occur within an E horizon.

GLEY PROFILE FORM

A gley profile form is defined by the presence of a reductimorphic horizon with an upper boundary within either 15 cm of the base of the A horizon (excluding an AB or A/B horizon) or 30 cm of the mineral soil surface.

Soils with a gley profile form have usually been recognised as poorly or very poorly drained soils in the soil drainage classification of Taylor and Pohlen (1962).

HUMUS-PAN

A humus-pan is a B horizon that is 10 mm or more thick and is normally given the horizon designation Bhm.

It has ALL of the following requirements:

1. It is apedal (massive); **AND**
2. It has either firm or stronger moist soil strength, brittle failure when moist, or moist penetration resistance of 3100 kPa or more; **AND**
3. It has dominant moist colour value in the matrix of 3 or less, or moist colour value of 4 if the chroma is 2; **AND**
4. It contains more than 1.0% organic carbon.

IRONSTONE-PAN

An ironstone-pan is an indurated horizon dominantly composed of iron oxides with or without manganese oxides. It has ALL of the following characteristics:

1. The upper boundary is distinct, abrupt or sharp; **AND**
2. It is weakly or strongly indurated; **AND**
3. Fresh fracture surfaces are black and have a metallic lustre; **AND**
4. It forms a continuous horizon, or it is fractured into blocks of 100 mm (in horizontal dimension) or more; **AND**
5. It is 10 mm or more thick.

Ironstone-pans commonly occur at a textural discontinuity, in the fluctuating zone of a water-table. It is likely that the iron has been precipitated from iron-rich groundwater moving laterally. In Taranaki (Childs *et al.* 1990), the pans are porous and some appear to have formed as iron-oxide rhizomorphs, which have been progressively infilled and welded together by further precipitations of iron oxide. In these pans the mineralogy is dominated by varying proportions of goethite and ferrihydrite.

Ironstone-pans are not usually associated with eluvial horizons and do not occur in Podzols. They differ from ortstein-pans and placic horizons which are often associated with eluvial horizons in Podzols or Brown Soils, and which have high organic carbon levels. Ironstone pans meet the requirements of the material below a petroferric contact of Soil Taxonomy.

The pans are a barrier to plant roots. Heavy machinery is required to break them up for the installation of drains. The permeability of the pans is likely to be slow.

LITHIC CONTACT

A lithic contact occurs at the contact of soil with underlying rock. The rock is hard or very hard and is impracticable to dig with a spade.

In situ rocks in New Zealand are commonly jointed at intervals of less than 100 mm, and consequently the lithic contact definition of Soil Taxonomy often fails to apply (Laffan 1979). The lithic contact is defined here as follows:

At a lithic contact, rock fragments accommodate one another with non-random orientation with respect to any geological structure that may be present, and cracks or joints are mostly less than 5 mm wide.

The lithic contact may be subdivided into coherent-lithic or shattered-lithic materials.

Coherent-lithic materials are equivalent to materials beneath the lithic contact of Soil Taxonomy. Cracks or joints occur at horizontal intervals of more than 100 mm. These materials occur on the ignimbrites, Otago schists, basalt flows of the Dunedin complex, and Fiordland granites. They often cause drainage impedance.

Shattered-lithic materials are similar except that joints or cracks may occur at intervals of less than 100 mm. Shattered-lithic materials differ from fragmental or skeletal materials in which there is no continuity of geological structure between adjacent rock fragments, and rock fragment faces do not accommodate one another. Shattered-lithic materials are more permeable than coherent-lithic materials, and offer a significant rooting volume.

MOTTLED PROFILE FORM

A mottled profile form is defined by EITHER

1. A redox-mottled horizon with an upper boundary within 15 cm of the base of the A horizon, or within 30 cm of the mineral soil surface; OR

2. A reductimorphic horizon with an upper boundary between 30 and 60 cm of the mineral soil surface.

Soils with a mottled profile form have usually been recognised as imperfectly drained soils in the soil drainage classification of Taylor and Pohlen (1962). Redox mottles are formed as a result of the reduction and solubilisation of iron and/or manganese, their translocation and concentration, and their oxidation and precipitation in the form of oxides. Mottles that have originated in some other way (e.g. rock colour patterns or skeletans) are excluded.

NODULAR HORIZON

A nodular horizon has more than 15% (by volume) nodules, as segregations of iron or aluminium oxyhydroxides, with some kaolinite, in a layer more than 10 cm thick.

The nodules are common features in Oxidic Soils and some Granular Soils (Wilson 1987). The frequency distribution of nodules is clustered in the < 2% range and the > 15% range. Few profiles are known to lie in between.

The nodular horizon limit is intended to exclude thin layers of rewashed nodules on colluvial footslopes, and also infrequent localised concentrations in soils with characteristically few nodules.

ORGANIC SOIL MATERIAL

Organic soil material is soil material dominated by organic matter, excluding fresh litter (L horizons) and living plant material. Organic soil material usually has at least 18% organic carbon (approximately 30% organic matter) but it is defined here using morphology and simple analyses for easier recognition. (For most New Zealand soils, organic carbon may be estimated by total carbon.)

Organic soil material has EITHER

1. ***All*** of the following:
   (a) Colour value moist of 3 or less (after exposure to air) and colour value dry of 4 or less, ***and***

(b) Deformable failure, ***and***

(c) Weight loss of 65% or more by oven-drying a field-saturated sample;

OR

2. More than 20% (by volume) unrubbed fibre content;

OR

3. More than 35% (by weight) loss on ignition except in materials dominated by allophanic soil material or by limestone.

OR

4. 18% or more total carbon.

Organic soil materials that have been accumulated under wet conditions are subdivided into three classes, based on evidence of decomposition (Clayden and Hewitt 1989). These classes are used to distinguish soil groups of Organic Soils.

Fibric soil material (Of horizon) consists mainly of well preserved plant remains that are readily identifiable in terms of botanical origin. The fibre content after rubbing is at least 75% by volume.

Fibres are pieces of plant tissue large enough to be retained on a 100-mesh (0.15 mm) sieve, except for wood fragments that cannot be crushed or shredded in the hand and are larger than 2 cm in the smallest dimension. Rubbed fibre is the fibre that remains after rubbing a wet sample 10 times between the thumb and forefinger, or kneading a ball in the palm 10 times using firm pressure.

Mesic soil material (Om horizon) consists mainly of partially decomposed plant remains (semi-fibrous peat or hemic soil material) and does not meet the requirements of either fibric soil material or humified soil material.

Humified soil material (Oh horizon) consists of strongly decomposed organic material (humified peat or sapric soil material) with few or no identifiable plant remains other than resistant woody fragments >20 mm that cannot be reduced to fibres by crushing and shredding between the fingers. The fibre content is less than 15% after rubbing.

ORTSTEIN-PAN

An ortstein-pan is a B horizon that is normally given the horizon notation Bsm. It has ALL of the following requirements:

1. Thickness of more than 10 mm; AND

2. The upper boundary is sharp or abrupt; AND

3. It is massive and has either firm or stronger moist soil strength, or has moist penetration resistance of 3100 kPa or more; AND

4. It does not meet the requirements of a humus-pan, and does not have the metallic lustre of fresh fracture surfaces of an ironstone-pan.

OXIDIC HORIZON

The oxidic horizon is a strongly weathered B horizon consisting of mixed crystalline iron and aluminium oxides and kaolin group minerals, with low activity clay properties. It has ALL the following requirements:

1. Weak or very weak primary ped strength and soil strength as determined by the unconfined resistance-to-crushing test at moist to dry soil water states; AND

2. Unconfined failure is friable or very friable over very moist to dry soil water states. Materials fail to predominantly 3 mm or smaller peds comprising silt- and sand-sized polyhedra and spheroids; AND

3. Primary peds slake rapidly in water to stable microaggregates which show no dispersion or slight dispersion after 100 inversions using the method of McQueen (1981); AND

4. Non-reactive or very weakly reactive to the reactive-aluminium test (Fieldes and Perrott 1966).

Oxidic horizons are clayey, with measured clay contents commonly exceeding 60%. The measured clay percentage is usually larger than in overlying A horizons, but clay increase is not a defining criterion because of the problem of quantifying clay contents in materials that are frequently difficult to disperse.

Materials are only slightly sticky and plastic in relation to clay content. Clay coatings are either visually absent or only present at frequencies of about 1%. The oxidic horizon has low activity clay accessory properties with ECEC and CEC less than 12 and 16 cmol/100g clay respectively.

PARALITHIC CONTACT

A paralithic contact is the upper surface of rock or regolith material that has ALL of the following requirements

1. It can be cut with difficulty with a spade; AND
2. Wet penetration resistance exceeds 2600 kPa; AND
3. Roots if present are few and confined to cracks; AND
4. If the overlying horizon is a reductimorphic or redox-mottled horizon, low chroma or high chroma mottles are less common below the contact.

The paralithic contact meets the definition of a paralithic contact of Soil Taxonomy, but without the restrictive requirement for spacing of cracks. The horizon beneath the contact is given the horizon designation CR. Paralithic contacts may occur either on weakly weathered or unweathered rocks which are not strongly lithified, or on saprolites which have become soft by strong weathering.

PEATY TOPSOIL

A peaty topsoil is 10 cm or more thick and is saturated for 30 or more consecutive days in most years (unless it is artificially drained), and has EITHER

1. Peat, sandy peat or loamy peat texture, OR
2. Slightly peaty texture (17–30% organic matter) if the clay content is less than 18%.

In some subgroups a peaty topsoil may be buried by a surface mantle of new material of up to 60 cm in thickness.

PERCH-GLEY FEATURES

Perch-gley features are the morphologic indicators of saturation and reducing conditions caused by a water-table perched on a slowly permeable layer within the soil profile.

A horizon with perch-gley features EITHER

1. Has redox-segregations that occur mainly within peds, or in the case of an apedal soil, mainly within the soil matrix. Macro-void surfaces, either partings or pores, are dominated by greyish colours (moist chroma 2 or less, or moist chroma 3 and value 6 or more). Iron and manganese precipitates occur either adjacent to the greyish void surfaces as a selvedge or as discrete mottles within the soil mass; OR

2. Overlies a horizon that is less gleyed (e.g. less redox-segregations) with a matrix that is not dominated by greyish colours.

PLACIC HORIZON

A placic horizon is a thin iron pan that is normally designated Bfm. It has ALL of the following:

1. It is 10 mm or less thick; AND

2. It is at least weakly indurated, and is black to reddish brown or dark red in colour. A black upper part can often be distinguished from a reddish brown lower part; AND

3. The upper and lower boundaries are sharp, and may be smooth, wavy or convolute in shape.

The placic horizon usually occurs as a single pan but in places can be bifurcated. It is equivalent to the placic horizon of Soil Taxonomy except that New Zealand iron pans are enriched in iron and organic matter without significant accumulations of manganese (Clayden *et al*. 1990).

PODZOLIC-B HORIZON

A podzolic-B horizon is a B horizon that meets ONE of the following:

1. It meets the requirement of a Bh horizon (because it has colour value and chroma of 3 or less, or value 4 and chroma 2, dominant in the matrix, and contains more than 1% organic carbon). The fabric has sand- or silt-size pellet-like aggregates, coats on mineral grains, or both.

OR

2. (a) It is associated with an overlying (but not necessarily immediately overlying) E horizon (i.e. Ea horizon) in which weathered films on sand and silt particles are either absent, very thin or discontinuous, so that the colour of the horizon is mainly determined by the colours of the uncoated grains. The moist colour value is 4 or more (or a dry colour value is 5 or more). It has higher colour value or lower chroma and less well developed pedality than an underlying B horizon;

   and

   (b) The B (or some subhorizon of the B) horizon is 5 cm or more thick and meets the requirements of a Bs (or Bs(g) or Bs(f)) horizon because it has a strong or very strong reactive-aluminium test, and at least *one* of the following:

      (i) Reddish hue and highest chroma at the top of the horizon, *or*

      (ii) Earthy apedal with fine spheroids, or weakly developed blocks or polyhedra, *or*

      (iii) Very weak or weak soil strength when moist or dry, *or*

      (iv) Sand- or silt-sized pellet-like aggregates;

OR

3. It meets the definition of a Bs horizon (part 2(b) above) and has in addition, coatings of value 4 or less ***either***

   (a) On 50% or more ped faces, ***or***

   (b) As patches covering 20% or more of cut faces.

REACTIVE-ALUMINIUM TEST

This test indicates the presence of reactive hydroxy-aluminium groups, as occur for example in allophane and aluminium-humus complexes (Milne *et al*. 1991).

Using the procedure of Fieldes and Perrott (1966), 1 drop of saturated sodium fluoride solution is placed on a small test sample of soil, which has been smeared on to a filter paper treated with phenolphthalein indicator. The soil sample must be field moist. For classification, the reactivity of the soil sample is placed into one of the following classes.

Reactivity Class		*Class Definition*
0	non-reactive	No colour within 2 minutes.
1	very weak	Pale red or light red (5R 6/1) just discernible within 2 minutes.
2	weak	Pale red or light red (5R 6/1) within 1 minute.
3	moderate	Red or weak red (5R 4 or 5/-) within 1 minute.
4	strong	Dusky red or dark red (5R 3/-) after 10 seconds.
5	very strong	Dusky red or dark red (5R 3/-) within 10 seconds.

REDOX-MOTTLED HORIZON

A redox-mottled horizon is an horizon affected in parts by reducing conditions as indicated by the presence of redox-segregations. These usually indicate intermittent saturation of the soil by water.

A redox-mottled horizon has 2% or more redox segregations. If low chroma colours (moist chroma 2 or less, or moist chroma 3 with value 6 or more) occur, they must occupy less than 50% of the matrix exposed in a cut face of the horizon and are not dominant on ped faces.

The intermittent wetness may be caused by intermittent perched water, or by the fluctuating upper limits of deeper more prolonged groundwater. A redox-mottled horizon may represent more prolonged saturation and reduction in parent materials that are predominantly andesitic or basaltic compared with other parent materials.

REDOX SEGREGATIONS

Redox segregations are mottles or concretions formed as a result of the reduction and solubilisation of iron and/or manganese, their translocation, concentration, and their oxidation and precipitation in the form of oxides (Clayden and Hewitt 1989). They may occur as low or high chroma colours, or both.

The nature of the water table is indicated by the association of low and high chroma colours. If subject to reduction by perched water, the low chroma colours are likely to be at ped or pore surfaces and the high chroma colours are likely to be within the soil matrix. If the soil is subject to reduction by groundwater, the low chroma colours are likely to be within the soil matrix and the high chroma colours are likely to be at ped or pore surfaces. Reducing conditions may also be indicated by the presence of sufficient ferrous iron to give a positive reaction to α,α'-dipyridyl (Childs 1981).

REDUCTIMORPHIC HORIZON

A reductimorphic horizon has a slightly peaty texture class, or low chroma colours (moist chroma 2 or less, or moist chroma 3 with value 6 or more) that occupy 50% or more of the matrix exposed in a cut face of the horizon or are dominant on ped faces. A reductimorphic horizon includes any subjacent layers or interlayers of peaty soil material.

A reductimorphic horizon is an horizon strongly affected by reducing conditions as indicated by greyish colours consistent with long saturation by water. The prolonged wetness may be caused by a water-table perched on a slowly permeable layer within the soil profile or by a groundwater-table.

SLOWLY PERMEABLE LAYER

A slowly permeable layer is one in which the vertical saturated hydraulic conductivity is less than 4 mm/h (1.0×10^{-6} m/s) as measured by a standard method. If no measurement is available then the horizon can be identified by the following morphological characteristics (Griffiths 1991):

A slowly permeable layer meets **EITHER**

1. (a) The soil material is pedal; ***and***

   (b) More than half of the peds are coarser than 10 mm (mean of the x and y axes in a horizontal plane) and meet *one* of the following:
   - (i) Peds 20 to 50 mm, with degree of packing at least extremely high; *or*
   - (ii) Peds 50 to 100 mm with degree of packing at least very high; *or*
   - (iii) Peds 100+ mm with degree of packing at least high;

OR

2. *Either*
   (a) The soil material is sand or loamy sand and has an extremely high degree of packing; ***or***
   (b) The soil material has a particle-size group other than sandy and has at least a high degree of packing.

A slowly permeable layer is significant for the land use, genetic and hydrological understanding of soils. It may overlap a number of other diagnostic horizons — for example, the fragipan, argillic horizon, densipan, humus-pan or ortstein horizons and lithic or paralithic contacts.

SODIC FEATURES

A horizon with sodic features has significant exchangeable sodium (not necessarily related to a high soluble salt content). It has **BOTH**

1. *Either*
   (a) Exchangeable sodium percentage of 6% or more (or exchangeable sodium is 0.7 cmol/kg or more); ***or***
   (b) When a 10 mm diameter sample which has been air-dried is placed in distilled water or salt free water a cloud of dispersed clay will form within 10 minutes around the sample. This test will not apply if the soil is in any degree cemented; **AND**

2. *Either*
   (a) Clay or clay/organic coatings have colour value 4 or less;
   (b) Prismatic or blocky peds; ***or***
   (c) It may be overlain by an Ew, Ew(g) or Ew(f) horizon, or have skeletans (visible on dry ped faces) near the top of the horizon.

TEPHRIC SOIL MATERIAL

Tephric soil material occurs in or below the soil solum. It includes:

1. Tephra — unconsolidated, primary pyroclastic products of volcanic eruptions (Froggatt and Lowe 1990) (including ash, cinders, lapilli, pumice, pumice-like vesicular pyroclastics, blocks, or volcanic bombs), and

2. Tephra deposits — material derived at least partly from tephra that has been reworked and mixed with material from other sources. They include tephric loess, tephric blown sand and volcanogenic alluvium. As a general guide, tephric deposits from andesitic sources have more than 10% volcanic glass in the sand fraction and those from rhyolitic sources have more than 40% volcanic glass in the sand fraction.

Tephric soil material may include soil materials that meet the requirements of allophanic soil material or vitric soil material. It is used to distinguish soil groups of the Raw Soils and Recent Soils, and parent material classes at soil series level.

VITRIC SOIL MATERIAL

Vitric soil material (Parfitt 1985) has more than 35% coarse-fraction (2 mm or greater, by volume) of which 60% is pumice or cinders, or there is more than 40% sand of which more than 30% is volcanic glass (or crystals coated with glass) (Eden 1990).

WEATHERED-B HORIZON

A weathered-B horizon shows evidence of alteration and is normally designated Bw, Bw(g), Bw(f), etc. It has at least ONE of the following:

1. Redder hue or higher chroma than an underlying horizon in similar materials; OR

2. Have spheroidal, blocky, polyhedral, tabular, prismatic, columnar or platy pedality which distinguish the horizon from a BC or C horizon below; OR

3. Evidence of either partial or complete decalcification, i.e. less $CaCO_3$ than the underlying horizon which may contain redeposited carbonates.

A weathered-B horizon may also meet the requirements of a redox-mottled horizon, argillic horizon, cutanic horizon, or brittle-B horizon.

KEY TO SOIL ORDERS

In the keys to orders, groups or subgroups, any surface mantle of new material, e.g. fresh alluvium, that is less than 30 cm thick, is not considered as part of the soil for assignment to orders, groups or subgroups, except in the Recent Soils or Raw Soils, or Sulphuric Gley or Recent Gley groups of the Gley Soils. A surface mantle of new material can be recognised because it will not meet the requirements of the key for any order or group except those specified above.

If any soil has an overthickened A horizon with its base at 45 cm or more from the mineral soil surface and is not mottled within 30 cm of the mineral surface, the key should be entered directly at Recent Soils.

O. Soils that have horizons that consist of organic soil material (including soils that have skeletal layers in which the matrix of the gravel consists of organic soil material) that within 60 cm of the soil surface are EITHER

1. 30 cm or more thick (cumulative) and are entirely formed from peat or other organic soil materials that have accumulated under wet conditions (they are saturated with water for at least 30 consecutive days in most years, or have been artificially drained) (O horizons), OR
2. 40 cm or more thick and are formed from partly decomposed or well decomposed litter (F and H horizons).

ORGANIC SOILS (p.80)

G. Other soils that have EITHER

1. a gley profile form in which the reductimorphic horizon (but not including soils with pedal horizons in which the defined greyish colours occur on ped faces but not in 50% or more of the matrix) meets ***all*** of the following:
   - (a) it has a lower boundary 90 cm or more from the mineral soil surface, or to a lithic or paralithic contact if shallower, or rests upon a permeable sandy-skeletal layer with a base that extends to 90 cm or more from the mineral soil surface, or to the base of the B horizon, ***and***
   - (b) there is no underlying fragipan with matrix of chroma 3 or more dominant, duripan or underlying podzolic-B horizon, ***and***

(c) a distinct topsoil occurs at the surface or is buried with its upper surface within 60 cm of the mineral soil surface, ***and***

(d) there is no horizon with a moderately fluid or very fluid fluidity class within 30 cm of the mineral soil surface, **OR**

2. an ironstone pan with an upper surface 30 cm or less from the mineral soil surface, and has sufficient ferrous iron to give a positive reaction to α,α'-dipyridyl at some time of the year.

GLEY SOILS (p.62)

U. Other soils that meet **ALL** of the following

1. pH of less than 5.5 in the major part[1] from the base of the A horizon to 60 cm from the mineral soil surface, **AND**

2. a B horizon which in the major part:

(a) is pedal with clay or humus coatings present on 10% or more ped faces, ***and***

(b) has slightly firm or stronger soil strength when moist unless the texture is sandy loam or sandy clay loam, ***and***

(c) has less silt than clay, unless there are weathered stones, ***and***

(d) has sandy loam or finer texture, ***and***

(e) has base deeper than 100cm, **AND**

3. do not have

(a) an oxidic or cutanoxidic horizon, ***nor***

(b) a layer or layers of allophanic soil material that totals 35 cm or more thick within 60 cm of the mineral soil surface, ***nor***

(c) stones, other than quartz stones, that are strongly or very strongly indurated, **AND**

4. have either an E horizon, or the uppermost subhorizon of the B has colour value of 5 or more.

ULTIC SOILS (p.123)

Z. Other soils that have either a podzolic-B horizon, or an ortstein-pan, that has pH less than 5.5 in some part or a humus-pan.

PODZOLS (p.96)

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[1] "the major part" means that the requirement must be met over more than half the specified thickness (in this case from the base of the A horizon to 60 cm from the mineral soil surface). Analyses or estimates should be used from subhorizons that subdivide the thickness, or if the subhorizons are not recognised, then from subsamples of the relevant horizons.

L. Other soils that have a layer or layers of allophanic soil material, that total 35 cm or more thick, and occur within 60 cm of the mineral soil surface.

ALLOPHANIC SOILS (p.41)

M. Other soils that have BOTH

1. a layer of vitric soil material extending from the mineral soil surface to 25 cm or more, or 35 cm or more thick occurring within 60 cm of the mineral soil surface, AND
2. a weathered-B horizon 5 cm or more thick.

PUMICE SOILS (p.102)

E. Other soils that have ALL the following

1. an A horizon that in the major part has ***both***
   (a) moist colour value of 3 or less, ***and***
   (b) *either* moderate or strong pedality(with peds that are less than 60 mm in size), is earthy apedal, or has cracks 4 mm or more wide that extend to a depth of 30 cm or more at some time of the year, *or* is peaty, AND
2. has ***either***
   (a) a visible reaction to 10% HCl in the soil matrix at 60 cm or less from the mineral soil surface, ***or***
   (b) has a weathered-B, argillic or cutanic horizon (more than 10 cm thick) in which the major part (to 60 cm from the mineral soil surface or to its base, whichever is less) has pH of 5.9 or more, moderate or strong pedality, and is sticky or very sticky, AND
3. has in some part of the B horizon to its base, or to 90 cm from the mineral soil surface, whichever is less, ***either***
   (a) gravel that is not very highly weathered or completely weathered, ***or***
   (b) a subhorizon that is not clayey, ***or***
   (c) the uppermost subhorizon of the B has colour value of 5 or more.

MELANIC SOILS (p.74)

S. Other soils that have ALL of the following

1. no fragipan, AND
2. a weathered-B horizon 10 cm or more thick, or a calcareous horizon (with evidence of pedogenic carbonate), AND
3. no primary calcium carbonate minerals in the sand fraction of the B horizon, AND

4. *either*
   (a) a calcareous horizon, or a horizon with pH of 7.5 or more, within 90 cm of the soil surface (or within 150 cm if the particle-size class is dominantly sandy or sandy-skeletal), ***or***
   (b) P retention of 15% or less in the major part of the B horizon to 60 cm depth, and any worm mixed horizon at the base of the A horizon is less than 5 cm thick.

SEMIARID SOILS (p.118)

X. Other soils that have an oxidic horizon more than 30 cm thick with an upper boundary between 20 and 60 cm from the mineral soil surface.

OXIDIC SOILS (p.85)

N. Other soils that have **BOTH**

1. a B horizon which to its base, or to 90 cm from the mineral soil surface, whichever is less, is ***both***
   (a) clayey throughout; ***and***
   (b) if any coarse-fragments of rock material occur they are either very highly weathered or completely altered, **AND**
2. a cutanoxidic horizon, or a moderately or strongly pedal cutanic or argillic horizon occurs that has ***either***
   (a) an overlying or overlapping reductimorphic horizon within 15 cm of the base of the A horizon, or 30 cm of the mineral soil surface; ***or***
   (b) polyhedral peds 20 mm or less in size in most of the B horizon within 60 cm of the mineral soil surface.

GRANULAR SOILS (p.69)

P. Other soils that have textures of loamy fine sand or finer in some part from the base of the A horizon to 60 cm from the mineral soil surface, and have **EITHER**

1. a reductimorphic horizon or E horizon, that overlies a fragipan, duripan or argillic horizon; **OR**

2. ***both***

   (a) between the base of the A horizon to 60 cm from the mineral soil surface the matrix throughout is *either*

      (i) hue 10YR or yellower with chroma 3 or less and value 4 or more (all colours moist), *or*

      (ii) hue 10YR or yellower with chroma 4 or 5 or chroma 3 with value 3, or hue 2.5Y or yellower with chroma 6 or more (all colours moist, see Figure 2); and P retention is less than 30% in the uppermost subhorizon (10 cm or more thick) of the B horizon.

   and

   (b) a B horizon that is 10 cm or more thick, and has *either*

      (i) a fragipan, duripan or brittle-B horizon, *or*

      (ii) a weathered-B horizon that has in part a moderately or strongly pedal subhorizon with blocky, polyhedral or prismatic peds and slightly firm or greater soil or ped strength, *or*

      (iii) argillic horizon, calcareous horizon, or a cutanic horizon that has sodic features either within or immediately beneath it, *or*

      (iv) eluvial features including an E horizon, skeletans on B horizon peds, or skeletans as apparent segregations of relatively higher colour value in B or BC horizons ("two-tone").

PALLIC SOILS (p.89)

B. Other soils that have BOTH

1. a weathered-B, argillic or cutanic horizon 10 cm or more thick with a lower boundary at 30 cm or more from the mineral soil surface, AND

2. in the B horizon, a subhorizon that has in the matrix ***either***

   (a) hue 7.5YR or redder, or hue 10YR and chroma 6 or more; ***or***

   (b) hue 10YR or yellower with chroma 4 or 5 or chroma 3 with value 3, or hue 2.5Y or yellower with chroma 6 or more (all colours moist, see Figure 2); and P retention is 30% or more, or the reactive-aluminium test is at least moderate, in the uppermost subhorizon (10 cm or more thick) of the B horizon, ***or***

   (c) the texture is sand or loamy sand in the B horizon to its base, or to 60 cm from the mineral soil surface, which ever is less.

BROWN SOILS (p.51)

A. Other soils that have been formed by the direct action of people by either truncation, drastic mixing or by deposition of material 30 cm or more thick.

ANTHROPIC SOILS (p.47)

R. Other soils that BOTH

1. have a distinct topsoil at the surface or buried with its upper surface within 60 cm of the mineral soil surface, or a weathered-B horizon; AND
2. do not have any horizon with a moderately fluid or very fluid fluidity class within 30 cm of the mineral soil surface.

RECENT SOILS (p.111)

W. Other soils.

RAW SOILS (p.106)

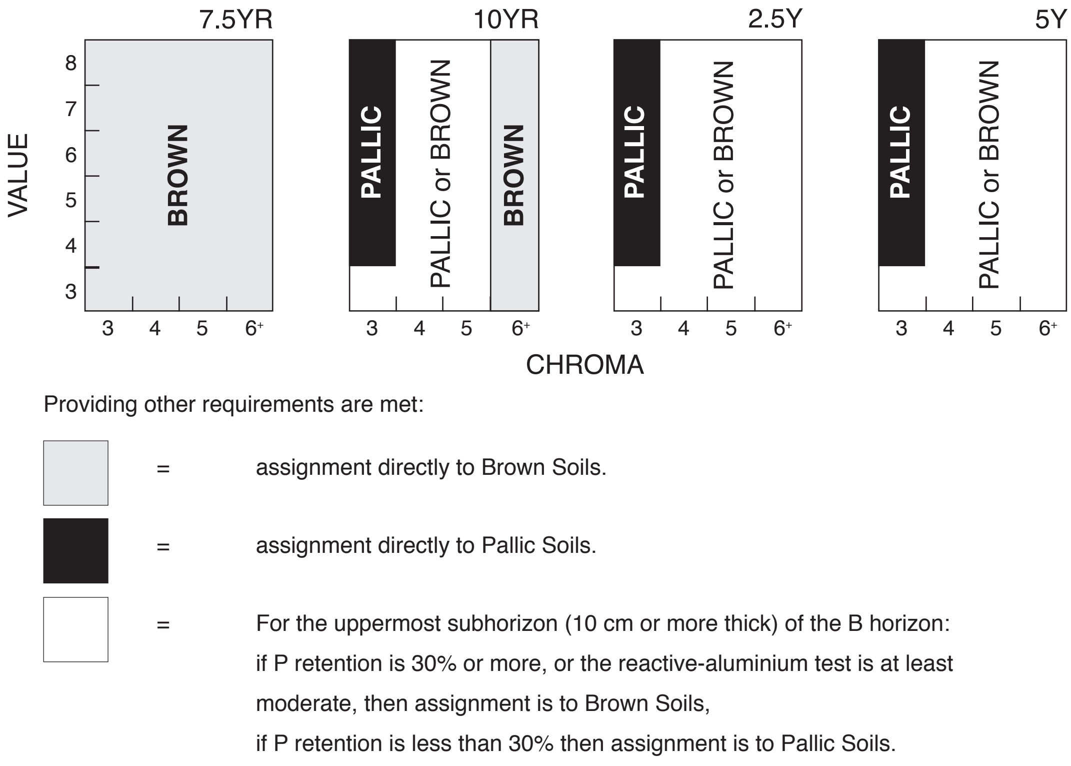

Figure 2. *Colour criteria, and colours where P retention and the reactive-aluminium test is used to differentiate Brown Soils from Pallic Soils and Recent Soils. See part 2(a) of the Pallic Soils, and part 2(a) and 2(b) of the Brown Soils in the key to orders.*

ALLOPHANIC SOILS

CONCEPT OF THE ORDER

Allophanic Soils have properties that are strongly influenced by minerals with short-range order, especially allophane, imogolite and ferrihydrite. They are characteristically weak in strength and sensitive, with very low bulk density. They occur mostly in volcanic parent materials, especially ash and basaltic scoria, but occur also in quartzo-feldspathic and tuffaceous (greywacke) sandstone.

CORRELATION

The order comprises mainly yellow-brown loams but also includes weakly weathered red loams and brown loams and some upland and high country yellow-brown earths of the NZ Genetic Soil Classification. The soils correlate predominantly with the Aquands, Cryands and Udands of Soil Taxonomy.

OCCURRENCE

Allophanic Soils occur predominantly in North Island volcanic ash, and in the weathering products of other volcanic rocks. They also occur in the weathering products of greywacke and schist in the South Island high country.

ACCESSORY PROPERTIES OF THE ORDER

1. *Short-range-order minerals.* The soil matrix as well as pore surfaces are dominated by the clay minerals allophane, imogolite and ferrihydrite, and/or aluminium-humus complexes. The soil materials have very high specific surface area. Measured clay contents generally range from 10 to 25% though particle-size measurement is difficult because of aggregation and the "true" or primary clay contents may often be considerably higher. P retention is high or very high.

2. *Low bases.* Sum of bases are low to very low and range from less than 1 to 10 cmol/100 g , in subsoils and unfertilised topsoils.

3. *Volcanic or greywacke parent materials*. Predominantly in andesitic, rhyolitic or mixed tephra, they also occur in soil materials from sandstone (greywacke) of humid uplands and high country and basalt scoria or pumice.

4. *Rapidly weatherable minerals.* Volcanic glass and feldspar dominate the sand fractions of soils in igneous parent materials, and are the primary source of the short-range-order minerals. Feldspars are most likely the primary source in non-igneous parent materials. Typically they have an Amorphic mineralogy class.

5. *Rapid permeability and high water retention*. The macroporosity is very high and rapid drainage occurs at low soil moisture tensions. Water contents at 1500 kPa soil moisture tension are very high.

6. *Well drained.* Although poorly, imperfectly and moderately well drained soils occur, well drained soils are predominant

7. *Good rooting medium.* Bulk density is very low and there is little resistance to root extension. In many soils the potential root depth is very deep.

8. *Active soil fauna.* Microbial biomass is generally high.

9. *Stable topsoils.* Soils resist puddling under the impact of machinery or grazing animals in wet weather. The water content at field capacity is less than the plastic limit. Topsoil and subsoil horizons are friable, and organic/mineral complexes are stable. Carbon contents are medium to high. Exposed topsoil may be subject to wind erosion.

10. *High shrinkage potential*. Soil materials have high potential to shrink on drying. Rewetting may not achieve the original volume.

11. *Slight to insignificant erosion under pasture.* Generally the erosion potential is low, except on steep slopes or exposed sites and under cultivation on rolling slopes.

12. *Sensitive.* A pronounced loss of strength occurs on disturbance.

13. *Limited fertility.* There are usually requirements for phosphorus, potassium and magnesium on dairy farms. There are no significant trace element deficiencies although cobalt is marginal in more strongly leached Allophanic Soils. Pasture may respond to lime where pH is less than 5.3. Sulphate reserves are held in B horizons. P retention and phosphate fixation are high in topsoils.

14. *Moist climate.* Precipitation exceeds 1000 mm and soil moisture deficits are either absent or occur for only short periods.

SUMMARY OF ALLOPHANIC SOILS HIERARCHY

Group		Subgroup	Example of series
LP	Perch-gley	Ironstone	-
		Typic	Awatuna
LG	Gley	Peaty	Rahotu var.
		Typic	Glenn
LI	Impeded	Mottled-ironstone	pt. Okato var.
		Mottled	Tipoka
		Typic	Bruntwood
LO	Orthic	Mottled	Oeo
		Vitric-acidic	Rowan
		Vitric	Lepperton
		Acidic	Patua
		Typic	Tirau

KEY TO GROUPS OF ALLOPHANIC SOILS

LP Allophanic Soils that have *both*

1. Perch-gley features, *and*
2. Either a peaty topsoil, or within 15 cm of the base of the A horizon or 30 cm of the mineral soil surface, have
   (a) a reductimorphic horizon, or
   (b) a redox-mottled horizon if the parent material is predominantly andesitic or basaltic.

PERCH-GLEY ALLOPHANIC SOILS

LG Other Allophanic Soils that have a peaty topsoil, or within 15 cm of the base of the A horizon or 30 cm of the mineral soil surface, have *either*

1. a reductimorphic horizon, *or*
2. a redox mottled horizon if the parent material is predominantly andesitic or basaltic.

GLEY ALLOPHANIC SOILS

LI Other Allophanic Soils that have a slowly permeable layer, or horizon that is at least weakly indurated, within 90 cm of the mineral soil surface.

IMPEDED ALLOPHANIC SOILS

LO Other Allophanic Soils.

ORTHIC ALLOPHANIC SOILS

KEY TO SUBGROUPS OF ALLOPHANIC SOILS

LP PERCH-GLEY ALLOPHANIC SOILS

Perch-gley Allophanic Soils occur in sites that are periodically saturated (unless artificially drained). Wetness and associated reducing conditions are indicated by brownish or reddish mottles. The wetness is caused by the perching of water on a slowly permeable subsurface layer, although a groundwater-table may also be present.

LPI Perch-gley Allophanic Soils that have an ironstone-pan within 90 cm of the mineral soil surface.

Ironstone Perch-gley Allophanic Soils

LPT Other soils.

Typic Perch-gley Allophanic Soils

LG GLEY ALLOPHANIC SOILS

Gley Allophanic Soils occur in sites that are periodically saturated (unless artificially drained). Wetness and associated reducing conditions are indicated by brownish or reddish mottles. The wetness is caused by a groundwater-table.

LGO Gley Allophanic Soils that have a peaty topsoil.

Peaty Gley Allophanic Soils

LGT Other soils.

Typic Gley Allophanic Soils

LI IMPEDED ALLOPHANIC SOILS

Impeded Allophanic Soils have a subsurface horizon that acts as a barrier to the movement of water or penetration of roots.

LIMI Impeded Allophanic Soils that have an ironstone-pan within 90 cm of the mineral soil surface and that have a mottled profile form.

Mottled-ironstone Impeded Allophanic Soils

LIM Other soils that have a mottled profile form.

Mottled Impeded Allophanic Soils

LIT Other soils.

Typic Impeded Allophanic Soils

LO ORTHIC ALLOPHANIC SOILS

Orthic Allophanic Soils are permeable soils without barriers to deep penetration of roots. They are moderately well, well or imperfectly drained.

LOM Orthic Allophanic Soils that have a mottled profile form.

Mottled Orthic Allophanic Soils

LOVA Other soils that have *both*

1. either
   - (a) coatings on pores (excluding root linings), or gel-like masses bridging sand grains or coating coarse-fragments, that have hue 7.5YR or redder, value 5 or less and chroma 3 or more, or
   - (b) pH less than 5.5 in some part of the B horizon to 60 cm from the mineral soil surface, *and*
2. allophanic soil material that is formed predominantly from tephric soil material and has 50% or more sand (by weighted average).

Vitric-acidic Orthic Allophanic Soils

LOV Other soils in which allophanic soil material layers are formed predominantly from tephric soil material and have 50% or more sand (by weighted average).

Vitric Orthic Allophanic Soils

LOA Other soils that have, in some part of the B horizon to 60 cm from the mineral soil surface, *either*

1. coatings on pores (excluding root linings), or gel-like masses bridging sand grains or coating coarse-fragments, that have hue 7.5YR or redder, value 5 or less and chroma 3 or more, *or*
2. pH less than 5.5 in some part of the B horizon to 60 cm from the mineral soil surface.

Acidic Orthic Allophanic Soils

LOT Other soils.

Typic Orthic Allophanic Soils

ANTHROPIC SOILS

CONCEPT OF THE ORDER

Anthropic Soils are soils that have been made by the direct action of people, including truncation of natural soils by earth-moving equipment, drastic mixing of natural soils so that their original character is lost, or by deposition of thick layers of organic or inorganic material. Anthropic Soils occur in land surfaces that are made by people. Their classification reflects the way in which they were made and the kinds of materials used.

Note that soils that have been drastically disturbed but have been restored to the extent that they will meet the requirements of orders other than Recent Soils or Raw Soils, will not be assigned to Anthropic Soils. For this reason Anthropic soils are placed late in the Key to Orders but before Recent Soils and Raw Soils.

CORRELATION

Anthropic Soils were not formally part of the NZ Genetic Soil Classification although anthropic soils were described in some soil survey reports. The soils either correlate with Entisols or are unclassified in Soil Taxonomy.

OCCURRENCE

Anthropic Soils are most extensive in urban areas and areas that have been mined.

ACCESSORY PROPERTIES OF THE ORDER

1. Soil characteristics and the relationships between soils and landforms do not have the orderliness of natural soils.
2. Drainage has often been changed significantly from the original state.
3. Soil properties depend upon both the nature of the manufactured or natural materials and the nature of the soil manipulation.
4. Land surfaces are artificial.

SUMMARY OF ANTHROPIC SOILS HIERARCHY

Group		Subgroup
AT	Truncated	Rocky Typic
AR	Refuse	Buried Typic
AM	Mixed	-
AF	Fill	Compacted Wet Stony-tailings Artifact Earthy

KEY TO GROUPS OF ANTHROPIC SOILS

AT Anthropic Soils in which natural in-situ materials occur at or within 30 cm of the soil surface, which result from truncation of the solum of the original soil by the action of people.

TRUNCATED ANTHROPIC SOILS

AR Other Anthropic Soils that have *either*

1. a layer comprising natural organic waste, or manufactured organic material, that is at least 30 cm thick and has an upper boundary at the land surface or buried within 90 cm of the land surface, *or*

2. has a methane content sufficient to be detected by odour, or if trapped, by ignition.

REFUSE ANTHROPIC SOILS

AM Other Anthropic Soils in which the original soil horizons have been destroyed by deep ripping, deep subsoil lifting, or some similar practice.

MIXED ANTHROPIC SOILS

AF Other Anthropic Soils.

FILL ANTHROPIC SOILS

KEY TO SUBGROUPS OF ANTHROPIC SOILS

AT TRUNCATED ANTHROPIC SOILS

Truncated Anthropic Soils result from cutting away any existing soil, by mechanical equipment, leaving material that would be recognised as a BC, C or R horizon. The scalped surface maybe overlain by up to 29 cm of soil, deposited for landscaping purposes.

ATX Soils with a lithic contact within 60 cm of the soil surface.

Rocky Truncated Anthropic Soils

ATT Other soils.

Typic Truncated Anthropic Soils

AR REFUSE ANTHROPIC SOILS

Refuse Anthropic Soils occur in sites where household, land management, urban or industrial waste has been dumped and which have significant organic matter, comprising vegetation, animal or manufactured material such as plastics, paper or timber.

ARB Soils in which organic refuse is buried beneath an overburden of soil or rock material greater than 30 cm thick.

Buried Refuse Anthropic Soils

ART Other Soils.

Typic Refuse Anthropic Soils

AM MIXED ANTHROPIC SOILS

Mixed Anthropic Soils occur in sites where the original soil has been drastically disturbed by mechanical procedures such as deep ripping.

No subgroups are defined, but the original soil if known may be appended to the name in parentheses, for example Mixed Anthropic Soils (Perch-Gley Pallic Soils).

AF FILL ANTHROPIC SOILS

Fill Anthropic Soils result from the deposition of dominantly inorganic material including soil, rock debris, dredged sediments or manufactured material such as bricks, concrete, or metals.

AFC Soils that have been compacted and have bulk density of 1.5 Mg/m^3 or more.

Compacted Fill Anthropic Soils

AFW Other soils that are wet within 60 cm of the mineral soil surface at some time of the year.

Wet Fill Anthropic Soils

AFST Other soils that have a gravel or bouldery layer more than 30 cm thick in which there is insufficient fine-earth to fill more than half the interstices between the gravel or boulder clasts, with an upper boundary within 60 cm of the mineral soil surface.

Stony-tailings Fill Anthropic Soils

AFA Other soils showing evidence of pre-European additions of material.

Artifact Fill Anthropic Soils

AFE Other soils.

Earthy Fill Anthropic Soils

BROWN SOILS

CONCEPT OF THE ORDER

Brown Soils usually contain 2:1 clay minerals. Secondary iron oxides tend to be evenly dispersed through the soil and give a yellowish brown colour to the upper part of the B horizon. Base saturation values are usually moderate to very low.

CORRELATION

The order comprises moderately and weakly weathered yellow-brown earths, yellow-brown sands, southern brown-granular loams and clays, and intergrades from yellow-brown earths to yellow-grey earths, podzols, brown-granular soils, and recent soils, as well as associated steepland soils of the NZ Genetic Soil Classification. The soils predominantly correlate with the Dystrochrepts of Soil Taxonomy, except for some stony and sandy soils which are Ustochrepts or Psamments.

OCCURRENCE

Brown Soils occur in places in which summer dryness is uncommon and that are not waterlogged in winter. They are the most extensive New Zealand soils.

ACCESSORY PROPERTIES OF THE ORDER

1. *Dispersed secondary oxides*. Secondary iron and aluminium oxides are dispersed throughout the soil mass. The soil is brunified (i.e. iron and aluminium oxides form coatings around phyllosilicate clay particles and form bridges between these particles and humus). P retention is moderate to very high.

2. *Low to moderate base saturation*. Base saturation values in subsoils are usually less than 50%, and KCl-extractable aluminium levels are usually more than 1.5 cmol(+)/kg except where clay contents are relatively low.

3. *Parent materials are mostly weakly weathered*. Mafic Brown Soils are derived from weakly weathered intermediate or basic igneous rocks (e.g. phonolite and basalt). Other groups are derived dominantly from acid quartzo-feldspathic sedimentary rocks (schist and greywacke) or acid igneous rocks (e.g. rhyolites and granites).The alteration status of gravel or hard rock substrates is usually fresh to moderately weathered and occasionally highly weathered.

4. *Mica/illite and vermiculite are common clay minerals*. Profiles tend to be mineralogically uniform with depth. Brown soils cover a wide range of mineralogy classes. Mixed, Illitic, Vermiculitic and Clay-mineralic (involving vermiculite and mica-vermiculite) are common. Some Allophanic Brown Soils have an Amorphic mineralogy class.

5. *Good Drainage*. No poorly drained or very poorly drained soils are included. Macroporosity is generally moderate (10–14%) except in subsurface horizons of Firm Brown Soils.

6. *Biologically active*. Except in soils that are limited by coldness or acidity, cast spheroidal peds are common in topsoils and C/N ratios are moderate to low. The roots of native plants penetrate deeply.

7. *Relatively stable topsoils*. Aggregates are not readily dispersed.

8. *Moist climate or low available-water capacity*. Most soils occur in areas with mean annual precipitation more than 1000 mm. Others have low available-water capacity (usually less than 75 mm as in some Stony Brown Soils and Sandy Brown Soils), or are in sites with low evapotranspiration.

SUMMARY OF BROWN SOILS HIERARCHY

Group		Subgroup	Example of series
BL	Allophanic	Mottled	-
		Acidic	Tekoa
		Firm	Te Anau
		Acidic-mafic	Stewart
		Typic	Craigieburn
		Acidic-pedal	Kaiuma
		Pedal	Levin

BS	Sandy	Mottled-Placic	-
		Mottled	Awahou
		Acidic	Koputaroa
		Pallic	pt. Halkett
		Pan	ToeToes
		Typic	Foxton
BX	Oxidic	Typic	-
BM	Mafic	Mottled-magnesic	Croisilles var.
		Magnesic	pt. Dun
		Mottled	-
		Acidic	Cargill
		Typic	Pipikaretu
BA	Acid	Peaty	pt. Spenser
		Mottled-placic	Lammerlaw
		Mottled	Mackley
		Placic	pt. Tautuku
		Pan	Whiterig
		Typic	Carrick
BF	Firm	Mottled-acidic	-
		Mottled-cemented	Harwarden
		Mottled-weathered	-
		Mottled-Pallic	-
		Mottled	Mahinerangi
		Acidic-cemented	Whiterig
		Cemented	Steward
		Acidic-allophanic	Judgeford
		Allophanic	Belmont
		Weathered	-
		Pallic	Pinelheugh
		Acidic	Porteous
		Typic	Waikiwi
BO	Orthic	Mottled - weathered	-
		Mottled-acidic	-
		Mottled	-
		Humose	Pukaki
		Immature	Grassmere
		Pallic	-
		Acidic	Pelorus
		Weathered	-
		Calcareous	-
		Typic	Ruahine

KEY TO GROUPS OF BROWN SOILS

BL Brown soils that have within the B horizon a subhorizon that meets the requirements of allophanic soil material but not necessarily the requirement for bulk density, and that is 10 cm or more thick and occurs with its upper surface at 60 cm or less from the mineral soil surface.

ALLOPHANIC BROWN SOILS

BS Other Brown Soils that from the base of the A horizon to 60 cm from the mineral soil surface, have

1. sand or loamy sand texture and less than 35% gravel (by volume), in all horizons (except for sandy loam laminations that do not meet the requirements of an argillic horizon), *and*

2. do not have a placic horizon.

SANDY BROWN SOILS

BX Other Brown Soils that in some part of the B horizon within 60 cm of the mineral soil surface, have

1. matrix colour value 4 or less, *and*
2. friable or very friable unconfined failure from very moist to dry, *and*
3. fine or finer polyhedral peds.

OXIDIC BROWN SOILS

BM Other Brown Soils that, in a subhorizon of the B at 60 cm from the mineral soil surface, or at the base of the B if shallower, have

1. matrix colour value 4 or less and moderately or strongly pedal polyhedral peds (20 mm or less in size), *or*
2. 5% (by volume) or more gravel that consists mainly of mafic or ultramafic rocks (but not tuffaceous greywacke), *or*
3. an exchangeable calcium/magnesium ratio of 0.2 or less and exchangeable magnesium of 1.5 cmol/kg or more.

MAFIC BROWN SOILS

BA Other Brown Soils that have *either*

1. pH of 4.8 or less in some part between 20 and 60 cm from the mineral soil surface, *or*
2. a placic horizon.

ACID BROWN SOILS

BF Other Brown Soils that have a fragipan, or an apedal subhorizon with a slightly firm or stronger moist soil strength in the B horizon, with an upper boundary within 90 cm of the mineral soil surface.

FIRM BROWN SOILS

BO Other Brown Soils.

ORTHIC BROWN SOILS

KEY TO SUBGROUPS OF BROWN SOILS

BL ALLOPHANIC BROWN SOILS

Allophanic Brown Soils occur in soils that have a horizon with properties dominated by the presence of minerals with short-range order and aluminium-humus complexes. Such horizons are weak in strength, sensitive, and have low bulk density. They occur in quartzo-feldspathic and tuffaceous (greywacke) sandstone and argillite, and in volcanic-ash parent materials.

BLM Allophanic Brown Soils that have a mottled profile form.

Mottled Allophanic Brown Soils

BLA Other soils that have, in some part[2] of the B horizon to 60 cm from the mineral soil surface, *both*

1. crumb (or earthy) structure, or bulk density of the fine-earth fraction less than 1.1 Mg/m^3 with weakly pedal or apedal fabric, *and*
2. pH less than 5.5.

Acidic Allophanic Brown Soils

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[2] "in some part" means that the requirement must be met in some subhorizon or some subsample that is 10 cm or more thick within the specified thickness.

BLF Other soils that have *both*

1. in some part of the B horizon to 60 cm from the mineral soil surface, crumb (or earthy) structure, or bulk density of the fine-earth fraction less than 1.1 Mg/m^3, *and*
2. an underlying layer that meets the requirements of a fragipan except for pedality, or an apedal subhorizon with a slightly firm or stronger moist soil strength, with an upper boundary within 90 cm of the mineral soil surface.

Firm Allophanic Brown Soils

BLAM Other soils that have *both*

1. pH less than 5.5 in some part of the B horizon to 60 cm from the mineral soil surface, *and*
2. in a subhorizon at 60 cm from the mineral soil surface, or at the base of the B horizon if shallower, either
   (a) matrix colour value 4 or less and moderately or strongly pedal polyhedral fabric, or
   (b) 5% (by volume) or more gravel consisting mainly of mafic rocks.

Acidic-mafic Allophanic Brown Soils

BLT Other soils that have, in some part of the B horizon to 60 cm depth from the mineral soil surface, crumb (or earthy) structure, or bulk density of the fine-earth fraction less than 1.1 Mg/m^3 with weakly pedal or apedal fabric.

Typic Allophanic Brown Soils

BLAD Other soils that have pH less than 5.5 in some part of the B horizon at 60 cm or less from the mineral soil surface.

Acidic-pedal Allophanic Brown Soils

BLD Other soils.

Pedal Allophanic Brown Soils

BS SANDY BROWN SOILS

Sandy Brown Soils occur in sand deposits which are usually of aeolian origin, but may also be of alluvial origin. Subsurface horizons are sand or loamy sand.

BSMP Sandy Brown Soils that have a mottled profile form and a placic horizon

Mottled-placic Sandy Brown Soils

BSM Other soils that have a mottled profile form.

Mottled Sandy Brown Soils

BSA Other soils that have pH less than 5.5 in some part of the B horizon, to its base, or to 60 cm from the mineral soil surface (whichever is shallower).

Acidic Sandy Brown Soils

BSP Other soils that have *either*

1. an argillic horizon composed of lamellae, *or*
2. eluvial features, including an E horizon, or skeletans as apparent segregations of relatively higher colour value in B or BC horizons ("two-tone").

Pallic Sandy Brown Soils

BSX Other soils that have either a placic or orstem pan

Pan Sandy Brown Soils

BST Other soils.

Typic Sandy Brown Soils

BX OXIDIC BROWN SOILS

Oxidic Brown Soils occur in strongly weathered soil materials similar to those of Oxidic Soils except that Oxidic Brown Soils have more weatherable minerals and higher values of reserve magnesium. They usually occur in association with Oxidic Soils, Ultic Soils or Granular Soils but on younger land surfaces.

BXT Oxidic Brown Soils (only one subgroup).

Typic Oxidic Brown Soils

BM MAFIC BROWN SOILS

Mafic Brown Soils occur in soil materials weathered from ultrabasic, basic or intermediate igneous rocks or tuffs. They have relatively high proportions of dark magnesium and iron-rich (mafic) silicate minerals, and have relatively large contents of iron oxides.

BMMG Mafic Brown Soils that have *both*

1. a mottled profile form, *and*
2. either
   (a) 5% (by volume) or more gravel consisting mainly of ultramafic rocks, or
   (b) have an exchangeable calcium/magnesium ratio of 0.2 or less in some part of the B horizon to 60 cm from the mineral soil surface.

Mottled-magnesic Mafic Brown Soils

BMG Other soils that have *either*

1. 5% (by volume) or more gravel consisting mainly of ultramafic rocks, *or*
2. have an exchangeable calcium/magnesium ratio of 0.2 or less in some part of the B horizon to 60 cm from the mineral soil surface.

Magnesic Mafic Brown Soils

BMM Other soils that have a mottled profile form.

Mottled Mafic Brown Soils

BMA Other soils that have pH less than 5.5 in some part of the B horizon to 60 cm from the mineral soil surface.

Acidic Mafic Brown Soils

BMT Other soils.

Typic Mafic Brown Soils

BA ACID BROWN SOILS

Acid Brown Soils are strongly or extremely acid soils, many of which occur in very moist or cold mountain environments. Many have a placic horizon.

BAO Acid Brown Soils that have a peaty topsoil.

Peaty Acid Brown Soils

BAMP Acid Brown Soils that have *both*

1. a placic horizon at 60 cm or less from the mineral soil surface, *and*
2. a mottled or gley profile form.

Mottled-placic Acid Brown Soils

BAM Other soils that have a mottled profile form.

Mottled Acid Brown Soils

BAP Other soils with a placic horizon.

Placic Acid Brown Soils

BAX Other soils that in the B have a subhorizon, that meets the strength requirements of an ortstein-pan, within 90 cm of the mineral soil surface.

Pan Acid Brown Soils

BAT Other soils.

Typic Acid Brown Soils

BF FIRM BROWN SOILS

Firm Brown Soils have an apedal subsurface horizon with strong moist soil strength which shares some of the characteristics of a fragipan or an ortstein-pan. The soils occur on relatively stable sites and are most commonly on flat, rolling or moderately hilly slopes.

BFMA Firm Brown Soils that have *both*

1. a mottled profile from, *and*
2. pH less than 5.5 in some part between the base of the A horizon and within 60 cm of the mineral soil surface.

Mottled-acidic Firm Brown Soils

BFMC Other soils that have *both*

1. a mottled profile form, *and*
2. a horizon that is cemented to the degree that it is at least weakly indurated, within 90 cm of the mineral soil surface.

Mottled-cemented Firm Brown Soils

BFMW Other soils that have *both*

1. a mottled profile form, *and*
2. gravel that in the majority is weathered to the extent that clasts may easily be broken by hammer or spade.

Mottled-weathered Firm Brown Soils

BFMP Other soils that have *both*

1. a mottled profile form, *and*
2. that have in some part of the B or BC horizon to 90cm in from the mineral soil surface, either matrix hue of 2.5Y or yellower or matrix hue of 10YR and chroma 4 or less with either
   (a) non-reactive, very weak or weak reactive-aluminium test, or
   (b) a cutanic horizon, or
   (c) P retention less than 30%.

Mottled-pallic Firm Brown Soils

BFM Other Soils that have a mottled profile form.

Mottled Firm Brown Soils

BFAC Other soils have *both*

1. pH less than 5.5 in some part between the base of the A horizon and within 60 cm of the mineral soil surface, *and*
2. a horizon that is cemented to the degree that it is at least weakly indivated, within 90 cm of the mineral soil surface.

Acidic-cemented Firm Brown Soils

BFC Other soils that have a horizon that is cemented to the degree that it is at least weakly indurated, within 90 cm of the mineral soil surface.

Cemented Firm Brown Soils

BFAL Other soils that have in some part of the B horizon to 90 cm or less from the mineral soil surface *both*

1. P retention 85% or more, or strong or very strong reactive-aluminium test, *and*
2. pH of less than 5.5.

Acidic-allophanic Firm Brown Soils

BFL Other soils that have P retention 85% or more, or strong or very strong reactive-aluminium test, in some part of the B horizon to 90 cm or less from the mineral soil surface.

Allophanic Firm Brown Soils

BFW Other soils in which the majority of the gravel is weathered to the extent that clasts may easily be broken by hammer or spade.

Weathered Firm Brown Soils

BFP Other soils that have in some part of the B or BC horizon to 90 cm from the mineral soil surface, *either*

1. matrix hue of 2.5Y or yellower, *or*
2. matrix hue of 10YR and chroma 4 or less with either
   (a) non-reactive, very weak or weak reactive-aluminium test, or
   (b) a cutanic horizon, or
   (c) P retention less than 30%.

Pallic Firm Brown Soils

BFA Other soils that have in some part of the B horizon above the apedal horizon with a slightly firm or stronger strength class, *either*

1. pH less than 5.5, *or*
2. a subhorizon with 10% or more humus or humus-clay coatings of moist colour value 4 or less or colour value 5 and chroma 3.

Acidic Firm Brown Soils

BFT Other soils.

Typic Firm Brown Soils

BO ORTHIC BROWN SOILS

Orthic Brown Soils have B horizon peds or have weak or very weak soil strength to depth. They most commonly occur on hilly or steep slopes, or on Holocene land surfaces.

BOMW Orthic Brown Soils that have *both*

1. a mottled profile form, *and*
2. gravel that in the majority is weathered to the extent that clasts may easily be broken by hammer or spade

Mottled-weathered Orthic Brown Soils

BOMA Other soils that have *both*

1. a mottled profile form, *and*
2. pH less than 5.5 in some part between the base of the A horizon and within 60 cm of the mineral soil surface.

Mottled-acidic Orthic Brown Soils

BOM Other soils that have a mottled profile form.

Mottled Orthic Brown Soils

BOH Other soils that have *both*

1. colour value of the matrix 4 or less and hue 2.5Y or redder, or 10% or more coatings of colour value 4 or less in the greater part of the B horizon, *and*
2. 10% or less clay within 90 cm of the mineral soil surface

Humose Orthic Brown Soils

BOI Other soils that have *either*

1. a buried A horizon within 120 cm of the mineral soil surface, *or*
2. a weathered-B horizon 30 cm or less thick that, throughout,
   (a) has chroma less than 6, and
   (b) is either apedal massive or apedal single-grain and has weak or very weak moist soil strength.

Immature Orthic Brown Soils

BOP Other soils that have in some part of the solum within 90 cm from the mineral soil surface *either*

1. matrix hue of 2.5Y or yellower, *or*
2. matrix hue of 10YR and chroma 4 or less with either
   (a) non-reactive, very weak or weak reactive-aluminium test, or
   (b) a cutanic horizon, or
   (c) P retention less than 30%.

Pallic Orthic Brown Soils

BOA Other soils that have pH less than 5.5 in some part of the B horizon to 60 cm from the mineral soil surface.

Acidic Orthic Brown Soils

BOW Other soils with gravel that in the majority is weathered to the extent that clasts may easily be broken by hammer or spade

Weathered Orthic Brown Soils

BOC Other soils that have in part of the B horizon a calcareous horizon within 60 cm of the mineral soil surface.

Calcareous Orthic Brown Soils

BOT Other soils.

Typic Orthic Brown Soils

GLEY SOILS

CONCEPT OF THE ORDER

Gley Soils are poorly-drained and very poorly-drained soils. In their undrained state, saturation occurs during prolonged periods, oxygen is limited and reducing conditions occur (typically affecting iron, manganese, nitrates, and sometimes sulphates). Greyish colours are dominant throughout the solum or to a depth of 90 cm or more.

CORRELATION

The order comprises gley soils and gleyed recent soils of the NZ Genetic Soil Classification. The soils correlate predominantly with the Aquents, Aquepts and Aquox (Oxidic Gley Soils) of Soil Taxonomy.

OCCURRENCE

Gley Soils occur throughout New Zealand, usually in low parts of the landscape where there are high groundwater-tables, or in places where there are seepages. Large areas of Gley Soils have been artificially drained to form productive agricultural land.

ACCESSORY PROPERTIES OF THE ORDER

1. *Segregation of iron and manganese oxides.* Particles in reduced parts of the soil are not coated by secondary oxides. Redox segregations of iron and manganese oxides, however, are usually present elsewhere in the soil and may occupy large volumes.
2. *Commonly formed in alluvial or colluvial parent materials*. Soils most frequently occur in relatively low parts of the landscape, in hollows or associated with flushes.
3. *Wide range of clay minerals*. The clay mineralogy commonly reflects the mineralogy of the ungleyed material from which the soils are derived. Gley Soils cover a wide range of mineralogy classes with Mixed, Illitic, and Smectitic being the most common.
4. *Poorly or very poorly drained*. Topsoils have relatively high levels of organic matter and some are peaty. Subsurface horizons to depth are dominantly grey or bluish grey in colour with strong brown to dark brown redox segregations.

5. *High groundwater-tables*. Most are affected by high groundwater-tables, at least throughout winter months. Soils with slowly permeable layers may also be subject to perching.
6. *Shallow potential rooting depth*. Potential rooting depth is limited by poor aeration. Even after drainage, root extension may be limited in some horizons.
7. *Relatively high bulk densities*. Bulk densities are likely to be higher than in well drained soils in similar soil materials.
8. *Limited trafficability*. Trafficability is limited in most soils when wet and pugging damage by stock is likely.
9. *Response to drainage*. Crops, not adapted to wetness, respond well to drainage.
10. *Minimal erosion*. Flooding or ponding of water is likely on low-lying sites, especially on floodplains. Deposition of fresh sediment is possible in these sites.
11. *Nitrogen requirement*. Nitrogen requirements are likely to be higher than for associated well drained soils.

Group		Subgroup	Example of series
GU	Sulphuric	Fluid-saline	pt. Takahiwai
		Fluid	pt. Takahiwai
		Peaty	Te Kowiwi
		Sandy-saline	Muriwai
		Typic	-
GT	Tephric	Peaty	-
		Acidic	-
		Typic	-
GS	Sandy	Peaty	-
		Saline	-
		Concretionary	Carnarvon
		Acidic	Berwick
		Typic	Pukepuke
GX	Oxidic	Nodular	pt. Kapiro
	Typic	pt. Waipapa	
GR	Recent	Peaty	Kakawa
		Fluid	-
		Saline	Pauatahanui
		Calcareous	Ahuriri

GA	Acid	Peaty	-
		Granular	Te Hihi
		Ultic	pt. Waikare
		Placic-humose	pt. Flagstaff
		Humose	pt. Flagstaff
		Typic	Dacre
		Acidic	Virgin
		Typic	Hastings
GO	Orthic	Peaty	Waimairi
		Saline	-
		Calcareous	Wainui
		Ironstone	Okato
		Melanic	Netherton
		Argillic	pt. Waterton
		Acidic	Bidois
		Typic	Invermay

KEY TO GROUPS OF GLEY SOILS

GU Gley Soils that within 60 cm of the mineral soil surface have *both*

1. a horizon with pH less than 4.8, *and*
2. either straw-yellow jarosite mottles or moderately fluid or very fluid fluidity class.

SULPHURIC GLEY SOILS

GT Other Gley Soils in tephric soil material from the mineral soil surface to 30 cm depth or more

TEPHRIC GLEY SOILS

GS Other Gley Soils that have a sand or loamy sand texture, and less than 35% (by volume) gravel, in all horizons from the base of the A horizon to 60 cm from the mineral soil surface.

SANDY GLEY SOILS

GX Other Gley Soils that have an oxidic horizon more than 30 cm thick with an upper boundary between 20 and 60 cm from the mineral soil surface.

OXIDIC GLEY SOILS

GR Other Gley Soils that have

1. either of the following
   - (a) fine sedimentary stratification at 60 cm or less, or
   - (b) a buried A horizon with its upper surface deeper than 30 cm but within 120 cm of the mineral soil surface, or some other indication of an irregular carbon profile such as sedimentary plant leaf material, *and*
2. have none of the following
   - (a) a buried B horizon with an upper surface at 60 cm or less from the mineral soil surface, nor
   - (b) a B or BC horizon with base deeper than 30 cm from the mineral soil surface, nor
   - (c) a thin iron pan, nor
   - (d) a horizon with more than 2% concretions or nodules coarser than sand size within 60 cm of the mineral soil surface.

RECENT GLEY SOILS

GA Other Gley Soils that have pH of 4.8 or less in some part between 20 and 60 cm from the mineral soil surface.

ACID GLEY SOILS

GO Other Gley Soils.

ORTHIC GLEY SOILS

KEY TO SUBGROUPS OF GLEY SOILS

GU SULPHURIC GLEY SOILS

Sulphuric Gley Soils occur in marine estuarine sites in which sufficient oxidation of ferrous sulphides has occurred to produce either sulphuric acid, or the mineral jarosite, or both.

GUFQ Sulphuric Gley Soils that within 60 cm of the mineral soil surface have *both*

1. moderately fluid or very fluid fluidity class, *and*
2. electrical conductivity of 0.8 mS/cm or more.

Fluid-saline Sulphuric Gley Soils

GUF Other soils that within 60 cm of the mineral soil surface have moderately fluid or very fluid fluidity class.

Fluid Sulphuric Gley Soils

GUO Other soils that have a peaty topsoil either at the surface or buried with its upper surface within 60 cm of the soil surface.

Peaty Sulphuric Gley Soils

GUSQ Other soils that are sandy by weighted average to 90 cm from the mineral soil surface and have electrical conductivity of 0.8 mS/cm or more within 60 cm of the mineral soil surface.

Sandy-saline Sulphuric Gley Soils

GUT Other soils

Typic Sulphuric Gley Soils

GT TEPHRIC GLEY SOILS

Tephric Gley Soils occur in unconsolidated sediment of volcanic origin including ash, cinders, lapilli, pumice and other pyroclastics.

GTO Tephric Gley Soils that have a peaty topsoil either at the surface or buried with its upper surface within 60 cm of the soil surface.

Peaty Tephric Gley Soils

GTA Other soils that have pH of less than 5.5 in some part from the base of the A horizon to 60 cm from the mineral soil surface.

Acidic Tephric Gley Soils

GTT Other soils

Typic Tephric Gley Soils

GS SANDY GLEY SOILS

Sandy Gley Soils occur in sand deposits which are usually aeolian, but may also be of alluvial origin. Subsurface horizons are sand or loamy sand.

GSO Sandy Gley Soils that have a peaty topsoil either at the surface or buried with its upper surface within 60 cm of the mineral soil surface.

Peaty Sandy Gley Soils

GSQ Other soils that within 60 cm of the mineral soil surface have electrical conductivity of 0.8 mS/cm or more

Saline Sandy Gley Soils

GSC Other soils that have more than 2% concretions in some horizon at a depth of 60 cm or less from the mineral soil surface.

Concretionary Sandy Gley Soils

GSA Other soils that have pH of less than 5.5 in some part from the base of the A horizon to 60 cm from the mineral soil surface

Acidic Sandy Gley Soils

GST Other soils.

Typic Sandy Gley Soils

GX OXIDIC GLEY SOILS

Oxidic Gley Soils have variable charge properties and contain low-activity clays. The mineralogy is dominated by kaolin group clay minerals. Iron oxides are less common than in the Oxidic Soils.

GXN Oxidic Gley Soils that have a nodular horizon with an upper boundary within 60 cm of the mineral soil surface.

Nodular Oxidic Gley Soils

GXT Other soils.

Typic Oxidic Gley Soils

GR RECENT GLEY SOILS

Recent Gley Soils occur on young land surfaces, usually in fluvial or estuarine sediments. In many sites there is a significant flood risk.

GRO Recent Gley Soils that have a peaty topsoil either at the surface or buried with its upper surface within 60 cm of the soil surface.

Peaty Recent Gley Soils

GRF Other soils that within 60 cm of the mineral soil surface have moderately fluid or very fluid fluidity class

Fluid Recent Gley Soils

GRQ Other soils that within 60 cm of the mineral soil surface have electrical conductivity of 0.8 mS/cm or more.

Saline Recent Gley Soils

GRC Other soils that have a calcareous horizon or a shelly layer within 60 cm of the mineral soil surface.

Calcareous Recent Gley Soils

GRA Other soils that have pH less than 5.5 in some part from the base of the A horizon to 60 cm of the mineral soil surface.

Acidic Recent Gley Soils

GRT Other soils.

Typic Recent Gley Soils

GA ACID GLEY SOILS

Acid Gley Soils occur on relatively stable land surfaces, and have been subject to a fluctuating groundwater-table, or a deep layer of perched water. Plants grown are susceptible to aluminium toxicity.

GAO Acid Gley Soils that have a peaty topsoil at the surface or buried within 60 cm of the surface.

Peaty Acid Gley Soils

GAG Other soils that have a clayey, moderately or strongly pedal cutanic or argillic horizon and polyhedral peds 20 mm or less in the major part of the B horizon to 60 cm of the mineral soil surface.

Granular Acid Gley Soils

GAY Other soils that have a B horizon which has in the major part, *both*

1. 10% or more clay or humus coatings on ped faces, *and*
2. less silt than clay.

Ultic Acid Gley Soils

GAPH Other soils that have both a placic horizon and a B horizon with 10% or more dark-coloured coats on ped faces, in pores or on gravel, with moist colour value 4 or less or colour value 5 and chroma 3.

Placic-humose Acid Gley Soils

GAH Other soils that have a B horizon with 10% or more dark-coloured coats on ped faces, in pores or on gravel, with moist colour value 4 or less or colour value 5 and chroma 3.

Humose Acid Gley Soils

GAT Other soils.

Typic Acid Gley Soils

GO ORTHIC GLEY SOILS

Orthic Gley Soils occur on relatively stable land surfaces in sites affected by groundwater. Sediment deposition is unlikely if flooding occurs. They are neither strongly acid, sandy nor sulphuric and have no oxidic horizon.

GOO Orthic Gley Soils that have a peaty topsoil either at the surface or buried with its upper surface within 60 cm of the soil surface.

Peaty Orthic Gley Soils

GOQ Other soils that within 60 cm of the mineral soil surface have electrical conductivity of 0.8 mS/cm or more.

Saline Orthic Gley Soils

GOC Other soils that have a calcareous horizon at 60 cm or less from the mineral soil surface.

Calcareous Orthic Gley Soils

GOI Other soils that have an ironstone layer at 90 cm depth or less from the mineral soil surface.

Ironstone Orthic Gley Soils

GOE Other soils that have a B horizon, in which the major part to 60 cm from the mineral soil surface or to its base (whichever is less)

1. has moderate or strong pedality, *and*
2. is sticky or very sticky, *and*
3. has pH of 5.9 or more, or coefficient of linear expandibility of 0.09 or more.

Melanic Orthic Gley Soils

GOJ Other soils that have an argillic horizon.

Argillic Orthic Gley Soils

GOA Other soils that have pH of less than 5.5 in some part from the base of the A horizon to 60 cm from the mineral soil surface.

Acidic Orthic Gley Soils

GOT Other soils.

Typic Orthic Gley Soils

GRANULAR SOILS

CONCEPT OF THE ORDER

Granular soils are clayey soils in which kaolin-group minerals are dominant, and are usually associated with vermiculite and hydrous-interlayered vermiculite. The soil fabric comprises polyhedral peds with strength characteristics which change rapidly with water content. Consistence is sticky and plastic. The presence of vermiculite gives these soils a moderate buffer capacity. The soils lack the weak strength, friable failure, low plasticity, and low-activity-clay properties which either define or are accessory to Oxidic soils. Clay coatings where they occur are thin.

CORRELATION

The order comprises many soils previously classified as brown granular loams and moderately to strongly leached brown granular clays of the NZ Genetic Soil Classification. Most are correlated with the Ultisols but a few with the Alfisols of Soil Taxonomy.

OCCURRENCE

Granular Soils are only known to occur in the northern North Island, particularly in the lowlands of the Waikato and South Auckland regions.

ACCESSORY PROPERTIES OF THE ORDER

1. *Moderate activity clay*. CEC is greater than 16 cmol/kg (clay) and ECEC ranges from about 8 to 16 cmol/kg (clay).

2. *Parent materials*. The soils are derived predominantly from strongly weathered tephras mostly older than 50 000 years, but also from basaltic and andesitic rocks with possible additions from aeolian material.

3. *Kandic mineralogy.* Granular Soils usually belong to the Kandic mineralogy class.

4. *Slowly permeable*. Saturated hydraulic conductivity is slow or marginally slow somewhere in the profile, resulting in periods of perching of water.
5. *Limited root depth*. The extension of plant roots in subsoils is commonly limited by either high penetration resistance, wetness or aluminium toxicity.
6. *Limited workability when wet*. Workability and trafficability is constrained by stickiness and plasticity after heavy rainfall, particularly in contrast to Oxidic Soils.
7. *Low phosphorus status*. Phosphorus fixation may be high, as indicated by high P retention levels.
8. *Strongly weathered with low nutrient reserves*. Reserves of phosphorus, potassium and magnesium are low, particularly in the Oxidic group.
9. *Sulphate in B horizons*. Sulphate tends to be strongly adsorbed in B horizons.

SUMMARY OF GRANULAR SOILS HIERARCHY

Group		Subgroup	Example of series
NP	Perch-gley	Oxidic	Rangiuru var.
		Acidic	Tutamoe
		Typic	Kohumaru
NE	Melanic	Mottled	-
		Allophanic	pt. Morrinsville
		Typic	Morrinsville
NX	Oxidic	Mottled-acidic	Awarua var.
		Mottled	pt. Waimatenui
		Allophanic	pt. Naike
		Acidic	Awarua
		Typic	Naike
NO	Orthic	Mottled-acidic	Waipoua var.
		Mottled	pt. Hamilton
		Allophanic	-
		Acidic	Waipoua
		Typic	Hamilton

KEY TO GROUPS OF GRANULAR SOILS

NP Granular soils that have *both*

1. a gley profile form, *and*
2. perch-gley features.

PERCH-GLEY GRANULAR SOILS

NE Other Granular soils that have pH of 5.9 or more in the major part of the B horizon to 60 cm from the mineral soil surface.

MELANIC GRANULAR SOILS

NX Other Granular soils that have a cutanoxidic horizon more than 30 cm thick with an upper boundary at 25 cm or more from the mineral soil surface.

OXIDIC GRANULAR SOILS

NO Other Granular soils.

ORTHIC GRANULAR SOILS

KEY TO SUBGROUPS OF GRANULAR SOILS

NP PERCH-GLEY GRANULAR SOILS

Perch-gley Granular Soils occur in sites that are periodically saturated (if undrained). Wetness and associated reducing conditions are indicated by grey colours and reddish mottles. The wetness is caused by perching of water on a clay-enriched slowly permeable layer, although a groundwater-table may also be present.

NPX Perch-gley Granular Soils that have a cutanoxidic horizon more than 30 cm thick with an upper boundary below 25 cm from the mineral soil surface.

Oxidic Perch-gley Granular Soils

NPA Other soils that have pH 5.1 or less in some part of the B horizon to 60 cm from the mineral soil surface.

Acidic Perch-gley Granular Soils

NPT Other soils.

Typic Perch-gley Granular Soils

NE MELANIC GRANULAR SOILS

Melanic Granular Soils are less acid and more fertile than other Granular Soils. Base saturation exceeds 50% in part of the root zone.

NEM Melanic Granular Soils that have a mottled profile form.

Mottled Melanic Granular Soils

NEL Soils that have a horizon that is 10 cm or more thick within 60 cm of the mineral soil surface that meets all the requirements of allophanic soil material, but not necessarily the requirement for bulk density.

Allophanic Melanic Granular Soils

NET Other soils.

Typic Melanic Granular Soils

NX OXIDIC GRANULAR SOILS

Oxidic Granular Soils have low ECEC (marginal to Oxidic Soils), have low fertility and are acid. Some plants may be susceptible to aluminium toxicity.

NXMA Oxidic Granular Soils that have *both*

1. a mottled profile form, *and*
2. pH of less than 5.1 in some part of the B horizon to 60 cm from the mineral soil surface.

Mottled-acidic Oxidic Granular Soils

NXM Other soils that have a mottled profile form.

Mottled Oxidic Granular Soils

NXL Other soils that have a layer that meets the requirements of allophanic soil material except for bulk density, and is 10 cm or more thick, within 60 cm of the mineral soil surface.

Allophanic Oxidic Granular Soils

NXA Other soils that have pH of less than 5.1 in some part of the B horizon to 60 cm from the mineral soil surface.

Acidic Oxidic Granular Soils

NXT Other soils.

Typic Oxidic Granular

NO ORTHIC GRANULAR SOILS

Orthic Granular Soils are well, moderately well or imperfectly drained soils that are sticky or very plastic with clay-enriched B horizons. Their fertility is intermediate between Oxidic and Melanic groups.

NOMA Orthic Granular Soils that have *both*

1. a mottled profile form, *and*
2. pH of less than 5.1 in some part of the B horizon to 60 cm from the mineral soil surface.

Mottled-acidic Orthic Granular Soils

NOM Other soils that have a mottled profile form.

Mottled Orthic Granular Soils

NOL Other soils that have a layer that meets the requirements of allophanic soil material except for bulk density, and is 10 cm or more thick within 60 cm of the mineral soil surface.

Allophanic Orthic Granular Soils

NOA Other soils that have pH of less than 5.1 in the major part of the B horizon to 60 cm from the mineral soil surface.

Acidic Orthic Granular Soils

NOT Other soils.

Typic Orthic Granular Soils

MELANIC SOILS

CONCEPT OF THE ORDER

Melanic Soils are soils with high base saturations, well structured, very dark A horizons, and with weakly alkaline or weakly acid subsurface horizons. Their parent materials are rich in calcium and/or magnesium.

CORRELATION

The Melanic Soils include the rendzinas and rendzic intergrades to yellow-grey earths and yellow-brown earths. They also include the weakly weathered and drier brown-granular loams and clays of the NZ Genetic Soil Classification. Most correlate with Mollisols and a few with Vertisols and Inceptisols of Soil Taxonomy.

OCCURRENCE

Melanic Soils are scattered throughout New Zealand in association with calcareous or basaltic rocks.

ACCESSORY PROPERTIES OF THE ORDER

1. *Swelling clays*. Most soils have smectite, or minerals with interstratifications of smectite, in the clay mineral assemblage. Melanic Soils usually have a Smectitic, Illitic or Kandic mineralogy class.

2. *High base saturations*. Base saturations are usually more than 50%, and KCl-extractable aluminium values are usually very low.

3. *Stable structure*. Structural stability of topsoils is high with relatively large amounts of organic carbon intimately associated with clay minerals. The soils are likely to have relatively high resistance to structural damage under heavy cropping unless organic matter is reduced significantly. The porosity is stabilised by divalent ion/organic matter/clay complexes.

4. *High shrink/swell*. The soil materials are sticky and plastic. They are expected to have significant shrink/swell potential, expressed in high coefficient of linear expandibility values. This is reflected in strong polyhedral, blocky or prismatic pedality. Pretentions are moderate to high.

5. *Fertile*. Exchangeable calcium and magnesium values are high, particularly at the base of profile.
6. *Parent materials*. The soils are derived from calcareous rocks or from mafic or ultramafic rocks (e.g. basalt or peridotite).
7. *Deep rooting*. Except for shallow soils on rock or soils affected by high water-tables, potential rooting depths are relatively large.
8. *Biologically active*. Carbon/nitrogen ratios are low (except in areas with very high precipitation).

SUMMARY OF MELANIC HIERARCHY

Group		Subgroup	Example of series
EV	Vertic	Mottled - calcareous	-
		Mottled	pt. Waiareka
		Calcareous	Te Aneraki
		Typic	Waiareka
EP	Perch-gley	Vertic	Awapuni
		Argillic	Okoia
		Typic	-
ER	Rendzic	Peaty	Chalky
		Mottled	-
		Weathered	Te Matai
		Typic	Oamaru
EM	Mafic	Magnesic	Dun
		Mottled	pt.Awapuku
		Typic	Rapaki
EO	Orthic	Mottled-calcareous	pt. Waikakahi
		Argillic-calcareous	Kauana
		Pedal-calcareous	pt. Waikakahi
		Calcareous	pt. Pikikiruna
		Mottled-argillic	-
		Mottled	-
		Argillic	Kaihiku
		Typic	Bishopdale

KEY TO GROUPS OF MELANIC SOILS

EV Melanic Soils that have *both*

1. Either
   (a) cracks at least 4 mm wide in some part, either in the B horizon and infilled with A horizon material, or open to a depth of 30 cm or more from the mineral soil surface, or
   (b) coefficient of linear extensibility of 0.09 or more with moderate or strong blocky or prismatic pedality in the major part of the B horizon, *and*

2. No redox segregations within 30 cm of the mineral soil surface.

VERTIC MELANIC SOILS

EP Other soils that have *either*

1. a peaty topsoil or a gley profile form, *and*

2. perch-gley features.

PERCH-GLEY MELANIC SOILS

ER Other soils that have limestone or other calcareous material either in the form of a lithic or paralithic contact, or as an extremely gravelly layer (70% or more by volume) in the form of rock rubble, with an upper boundary at 60 cm or less and which continues to more than 90 cm from the mineral soil surface.

RENDZIC MELANIC SOILS

EM Other soils that, in a subhorizon of the B horizon at 60 cm from the mineral soil surface, or at the base of the B if shallower, have

1. matrix colour value 4 or less and chroma 3 or more, *or*

2. 5% (by volume) or more gravel that consist mainly of mafic or ultramafic rocks (but not tuffaceous greywacke), *or*

3. an exchangeable calcium/magnesium ratio of 0.2 or less and exchangeable magnesium of 1.5 cmol/kg or more.

MAFIC MELANIC SOILS

EO Other soils.

ORTHIC MELANIC SOILS

KEY TO SUBGROUPS OF MELANIC SOILS

EV VERTIC MELANIC SOILS

Vertic Melanic Soils occur in clayey soil materials dominated by clay minerals with high capacity to shrink on drying and swell on rewetting.

EVMC Vertic melanic soils that have *both*

1. redox segregations within 60 cm of the mineral soil surface, *and*

2. a calcareous horizon within 90 cm of the mineral soil surface

Mottled-calcareous Melanic Soils

EVM Other soils that have redox segregations within 60 cm of the mineral soil surface.

Mottled Vertic Melanic Soils

EVC Other soils with a calcareous horizon within 90 cm of the mineral soil surface.

Calcareous Vertic Melanic Soils

EVT Other soils.

Typic Vertic Melanic Soils

EP PERCH-GLEY MELANIC SOILS

Perch-gley Melanic Soils occur in sites that are periodically saturated (unless artificially drained). Wetness and associated reducing conditions are indicated by grey colours in horizons subjacent to the topsoil, and is caused by perching of water on a slowly permeable subsurface layer, although a groundwater-table may also be present.

EPV Perch-gley Melanic Soils that have *either*

1. cracks at least 4 mm wide in some part, either in the B horizon and infilled with A horizon material, or open to a depth of 30 cm or more, from the mineral soil surface, *or*

2. coefficient of linear expandibility of 0.09 or more with moderate or strong, blocky or prismatic pedality in the major part of the B horizon.

Vertic Perch-gley Melanic Soils

EPJ Other soils with an argillic horizon.

Argillic Perch-gley Melanic Soils

EPT Other soils.

Typic Perch-gley Melanic Soils

ER RENDZIC MELANIC SOILS

Rendzic Melanic Soils occur in soils in which limestone or calcareous sedimentary rocks or rock debris occur at shallow depths.

ERO Rendzic Melanic Soils that have a peaty topsoil.

Peaty Rendzic Melanic Soils

ERM Rendzic Melanic Soils that have a mottled profile form

Mottled Rendzic Melanic Soils

ERW Other soils that have a weathered-B or cutanic horizon 10 cm or more thick.

Weathered Rendzic Melanic Soils

ERT Other soils.

Typic Rendzic Melanic Soils

EM MAFIC MELANIC SOILS

Mafic Melanic Soils occur in soil materials weathered from ultrabasic, basic or intermediate igneous rocks or tuffs. They have relatively high proportions of dark-coloured magnesium- and iron-rich (mafic) silicate minerals.

EMG Mafic Melanic Soils that have, in some part of the B horizon to 60 cm from the mineral soil surface, *either*

1. 5% (by volume) or more gravel that consist mainly of ultramafic rocks, *or*
2. have an exchangeable calcium/magnesium ratio of 0.2 or less and exchangeable magnesium of 1.5 cmol/kg or more.

Magnesic Mafic Melanic Soils

EMM Other soils that have a mottled profile form.

Mottled Mafic Melanic Soils

EMT Other soils.

Typic Mafic Melanic Soils

EO ORTHIC MELANIC SOILS

Orthic Melanic Soils occur in soil materials containing calcium carbonate or that have high calcium contents.

EOMC Orthic Melanic Soils that have both a calcareous horizon with an upper surface at 90 cm or less from the mineral soil surface, and a mottled profile form.

Mottled-calcareous Orthic Melanic Soils

EOJC Other soils that have an argillic horizon and a calcareous horizon with an upper surface at 90 cm or less from the mineral soil surface.

Argillic-calcareous Orthic Melanic Soils

EODC Other soils that have a moderately or strongly pedal weathered-B horizon 15 cm or more thick occurring immediately beneath the A horizon, and a calcareous horizon with an upper surface at 90 cm or less from the mineral soil surface.

Pedal-calcareous Orthic Melanic Soils

EOC Other soils that have a calcareous horizon with an upper surface at 90 cm or less from the mineral soil surface.

Calcareous Orthic Melanic Soils

EOMJ Other soils that have a mottled profile form, and an argillic horizon

Mottled-argillic Orthic Melanic Soils

EOM Other soils that have a mottled profile form.

Mottled Orthic Melanic Soils

EOJ Other soils that have an argillic horizon.

Argillic Orthic Melanic Soils

EOT Other soils.

Typic Orthic Melanic Soils

ORGANIC SOILS

CONCEPT OF THE ORDER

Organic Soils are soils that occur in the partly decomposed remains of wetland plants (peat) or forest litter. Mineral soil material is commonly present but organic soil material is dominant. The soils occur in sites where rates of organic-matter decomposition are balanced or exceeded by rates of plant biomass production and accumulation.

CORRELATION

The order corresponds with the organic soils group of the NZ Genetic Soil Classification. It correlates in the most part with the Histosols of Soil Taxonomy.

OCCURRENCE

Organic Soils occur in wetlands in most parts of New Zealand or under forest-produced acid litter in areas with high precipitation.

ACCESSORY PROPERTIES OF THE ORDER

1. *Low bulk density*. Bulk densities are very low, usually in the range of 0.03 to 0.4 Mg/m^3. Organic Soils may contain up to 70% organic matter. Too few data are yet available to allow mineralogy classes to be stated.

2. *High cation exchange capacity*. The organic components of Organic Soils have high surface area, and high negative charge that varies markedly with pH. CEC values are very high, mostly ranging from 40 to 170 cmol/kg.

3. *High carbon/nitrogen ratios*. C/N ratios range from 18 to as high as 70 in unfertilised and uncultivated Organic Soils.

4. *Low bearing strength*. Construction of buildings or roads requires special foundation design.

5. *Very low thermal conductivity*. Soils warm and cool slowly. Bare soil surfaces, however, have high radiance.

6. *High shrinkage potential*. The soils shrink markedly upon drying, and loose organic matter due to oxidation. Consequently, following drainage, the classification may change.

7. *High total available-water capacity*. While total available-water capacity is high, plant-available-water capacity may only be moderate.

8. *Common nutrient deficiencies*. The major nutrients nitrogen, phosphorus, potassium and sulphur, and the trace elements copper, selenium and molybdenum, are frequently deficient for crops and pasture.

9. *Peats are very poorly drained, litters are variable*. Organic Soils formed in peats are very poorly drained and those formed from litters may range from well drained to very poorly drained.

SUMMARY OF ORGANIC SOILS HIERARCHY

Group		Subgroup	Example of series
OL	Litter	Buried-podzol	pt. Waitutu
		Buried-gleyed	-
		Orthic	pt. Waipoua
OF	Fibric	Sphagnic	Kaherekoau
		Acid	pt. Rukuhia
		Mellow	pt. Otanomomo
OM	Mesic	Acid	Otautau
		Mellow	Kaipaki
OH	Humic	Acid	Ardmore
		Mellow	Pukehina

KEY TO GROUPS OF ORGANIC SOILS

OL Organic Soils that occur entirely in partly or fully decomposed forest litter and that are not almost continually saturated in the natural state (F and H horizons).

LITTER ORGANIC SOILS

OF Other soils that, from the upper surface of the organic soil material to 60 cm depth, or to the base of the organic soil material if shallower, have horizons dominated (by accumulated thickness) by fibric organic soil material (Of horizons).

FIBRIC ORGANIC SOILS

OM Other soils that, from the upper surface of the organic soil material to 60 cm depth, or to the base of the organic soil material if shallower, have horizons dominated (by accumulated thickness) by mesic organic soil material (Om horizons).

MESIC ORGANIC SOILS

OH Other soils that, from the upper surface of the organic soil material to 60 cm depth, or to the base of the organic soil material if shallower, have horizons dominated (by accumulated thickness) by humified organic soil material (Oh horizons).

HUMIC ORGANIC SOILS

KEY TO SUBGROUPS OF ORGANIC SOILS

OL LITTER ORGANIC SOILS

Litter Organic Soils occur under forest beneath a canopy of acid litter or mor-forming species. The organic material is derived predominantly from leaves and twigs and is normally not saturated except for a few days following heavy rain.

OLBZ Litter Organic Soils in which an underlying mineral soil, with an upper boundary at less than 90 cm from the soil surface, has a podzolic-B or placic horizon.

Buried-podzol Litter Organic Soils

OLBG Other soils in which a reductimorphic horizon, occurs at less than 30 cm beneath the upper surface of the underlying mineral soil.

Buried-gley Litter Organic Soils

OLO Other soils.

Orthic Litter Organic Soils

OF FIBRIC ORGANIC SOILS

Fibric Organic Soils occur in sites that are saturated to the surface for extended periods (or in sites that have been artificially drained) in which the peat materials are only weakly decomposed. The wetland plant constituents are so little decomposed that their botanic origin may be readily determined and fibres are not destroyed by rubbing.

OFS Fibric Organic Soils in which the organic fibres, to a depth of 60 cm from the soil surface, or to the base of organic soil material if shallower, are more than 70% *Sphagnum* species.

Sphagnic Fibric Organic Soils

OFA Other soils in which the organic soil material to a depth of 60 cm from the soil surface, or to its base if shallower, has pH of 4.5 or less throughout the major part.

Acid Fibric Organic Soils

OFM Other soils.

Mellow Fibric Organic Soils

OM MESIC ORGANIC SOILS

Mesic Organic Soils occur in very wet sites (or in sites that have been artificially drained) in which the peat materials are moderately decomposed. The remains of up to two-thirds of the original wetland plants that make up the bulk of the soil are unrecognisable or are largely destroyed by rubbing between the fingers.

OMA Other soils in which the organic soil material to a depth of 60 cm from the soil surface, or to its base if shallower, has pH of 4.5 or less throughout the major part.

Acid Mesic Organic Soils

OMM Other soils.

Mellow Mesic Organic Soils

OH HUMIC ORGANIC SOILS

Humic Organic Soils occur in very wet sites (or in sites that have been artificially drained). The peat materials are strongly decomposed to the extent that the original wetland plant remains cannot be recognised throughout most of the soil profile.

OHA Humic Organic Soils in which the organic soil material to a depth of 60 cm from the soil surface, or to its base if shallower, has pH of 4.5 or less throughout the major part.

Acid Humic Organic Soils

OHM Other soils.

Mellow Humic Organic Soils

OXIDIC SOILS

CONCEPT OF THE ORDER

Oxidic Soils contain low-activity phyllosilicate clays and secondary oxides which give rise to variable charge properties. They form in the clayey weathering products of basic rocks. The soils have a fine or very fine polyhedral fabric with friable failure to stable microaggregates of 2 mm or less, and low plasticity in relation to clay content. Surface horizons are clayey, and an increase in clay content occurs with depth although clay illuvial features are generally not apparent.

CORRELATION

The order comprises most of the strongly weathered red loams and brown loams, many northern brown granular clays, and a few brown granular soils from ash beds and basaltic and andesitic rocks of the NZ Genetic Soil Classification. It correlates with the Oxisols of Soil Taxonomy.

OCCURRENCE

Oxidic Soils are only known to occur in the Auckland and Northland regions.

ACCESSORY PROPERTIES OF THE ORDER

1. *Low-activity clay*. CEC is low at field pH. ECEC is less than 12 cmol/kg (clay), and CEC less than 16 cmol/kg (clay). The soils are weakly buffered. Some subhorizons have a net positive charge. Oxidic Soils usually have the following mineralogy classes: Kandic, Ferritic or Aluminitic.

2. *High phosphate retention*. P retention ranges from 60 to 90%. High sulphate adsorption occurs in B horizons.

3. *Parent materials*. The soils are derived from andesites, dolerites and basalts of Tertiary to Upper Cretaceous age.

4. *Limited root depth*. The extension of plant roots is limited by high dry bulk density and high penetration resistance, particularly in well drained soils. Plant root depths are shallow to medium.

5. *Moderate or rapid infiltration*. Hydraulic conductivity of surface horizons and upper B horizons is moderate or faster, giving excellent trafficability and workability immediately after rain.

6. *Slow permeability*. Hydraulic conductivity decreases to slow or marginally slow values with depth, such that perching of water occurs within the root zone after high intensity rainfalls. The duration of wetness varies from 1 to 2 days in well drained soils to 4 days or more in poorly drained soils.

7. *Soil water deficit*. Deficits occur in summer and are exacerbated by low readily available water capacities and shallow rooting depths.

8. *High clay contents*. Clay content ranges from 50 to 90%.

9. *Well developed structure*. Topsoils have mostly well developed spheroidal or polyhedral peds. Topsoil bulk densities are low.

10. *Strongly weathered with very low nutrient reserves*. The soils have very low reserves of potassium, magnesium, calcium and phosphorus.

SUMMARY OF OXIDIC SOILS HIERARCHY

Group		Subgroup	Example of series
XP	Perch-gley	Nodular	Kapiro
		Typic	Otaha
XN	Nodular	Typic	Okaihau
XO	Orthic	Mottled	Puketotara
		Brown	Tanekaha
		Typic	Kerikeri

KEY TO GROUPS OF OXIDIC SOILS

XP Oxidic soils that have *both*

1. a gley profile form, *and*
2. perch-gley features.

PERCH-GLEY OXIDIC SOILS

XN Other Oxidic soils that have a nodular horizon with an upper boundary within 60 cm of the mineral soil surface.

NODULAR OXIDIC SOILS

XO Other Oxidic soils.

ORTHIC OXIDIC SOILS

KEY TO SUBGROUPS OF OXIDIC SOILS

XP PERCH-GLEY OXIDIC SOILS

Perch-gley Oxidic Soils occur in sites that are periodically saturated (unless artificially drained). Wetness and associated reducing conditions are indicated by grey colours, and are caused by perching on a slowly permeable layer.

XPN Perch-gley Oxidic soils that have a nodular horizon with an upper boundary within 60 cm of the mineral soil surface.

Nodular Perch-gley Oxidic Soils

XPT Other soils.

Typic Perch-gley Oxidic Soils

XN NODULAR OXIDIC SOILS

Nodular Oxidic Soils occur in clayey soil materials derived from Pliocene or early Pleistocene basalts. They have clay-enriched B horizons and a prominent layer of iron oxide nodules. The soils have extremely low CEC (at natural pH) and natural fertility. Intermittent wetness is usual.

XNT Only one subgroup is recognised.

Typic Nodular Oxidic Soils

XO ORTHIC OXIDIC SOILS

Orthic Oxidic Soils occur in clayey soil materials derived from early to mid-Pleistocene basalts. They have clay-enriched B horizons but lack prominent nodules, although up to 2% may be present in some horizons.

XOM Orthic Oxidic Soils that have a mottled profile form.

Mottled Orthic Oxidic Soils

XOB Other soils that have within 90 cm of the mineral soil surface, *either*

1. a clay decrease with depth of more than one-fifth of the clay percentage of the horizon with maximum clay, *or*
2. more than 5% weathered gravel, within 90 cm of the mineral soil surface.

Brown Orthic Oxidic Soils

XOT Other soils.

Typic Orthic Oxidic Soils

PALLIC SOILS

CONCEPT OF THE ORDER

Pallic Soils are soils with moderate to high base status and low contents of secondary iron oxides. They have pale colours, high slaking potential and high density in subsurface horizons. Pallic Soils have water deficits in summer, and soil water surpluses in winter or spring.

CORRELATION

The order comprises most yellow-grey earths, associated steepland soils, intergrades between yellow-grey earths and yellow-brown earths, and intergrades between yellow-grey earths and brown-grey earths of the NZ Genetic Soil Classification. Most Pallic Soils are either Aqualfs, Aquepts, Ustalfs, Udalfs or Ochrepts.

OCCURRENCE

Pallic Soils occur predominantly in the seasonally dry eastern part of North and South Islands and in the Manawatu.

ACCESSORY PROPERTIES OF THE ORDER

1. *Low concentrations of secondary oxides*. P retention is less than 30% in topsoils and, usually, in subsoils. Extractable iron and aluminium values are low or moderate with a significant proportion of secondary iron oxides occurring in redox segregations.

2. *High base status*. Base saturation values in subsoils are high (more than 50%) except in perch-gleyed soils, where values may be lower in horizons overlying fragipans.

3. *Siliceous parent materials*. Parent materials are predominantly loess or sediments derived from quartzo-feldspathic rocks (schist or greywacke).

4. *Mica/illite clay minerals*. Pallic Soils usually belong either to the Illitic or to a Clay-mineralic mineralogy class.

5. *Slow permeability*. Subsurface horizons have restricted permeability, particularly in soils with fragipans or duripans in which the permeability is very slow.

6. *Perched water-tables*. Soils that are poorly or moderately well drained have water-tables perched on slowly permeable layers.

7. *Limited root depth*. Potential rooting depth in most soils is limited by a subsurface horizon of high bulk density at shallow depths or by brittle silty cappings on stones.

8. *Strongly worm-mixed*. Topsoils generally have a significant proportion of worm casts and a distinct worm-mixed horizon occurs in the transition from A to B horizons. Topsoil worm activity is greatly reduced during summer periods of soil moisture deficit.

9. *High slaking and dispersion potential*. Soil material, particularly in B horizons, is strongly dispersive and will readily slake. Topsoil structures may break down under prolonged impact by heavy machinery or by continuous tillage.

10. *Droughty summers, moist winters*. Precipitation ranges from about 500 to 1000 mm per year. A spring surplus of soil water is common but the annual surplus is less than about 200 mm. The average annual deficit is approximately 90–200 mm/year.

11. *Phosphorus status*. A high proportion of the inorganic phosphorus is non-occluded and a relatively high proportion of total phosphorus is in an organic form.

12. *Sulphur status*. Levels of extractable sulphate are low.

SUMMARY OF PALLIC SOILS HIERARCHY

Group		Subgroup	Example of series
PP	Perch-gley	Duric	pt. Poporangi
		Argillic-fragic	Tokomaru
		Fragic	Otokia
		Weathered-argillic	Nalder
		Argillic	Marton
		Cemented	Caroline
		Typic	pt. Salix

PU	Duric	Mottled	pt. Matapiro
		Argillic-sodic	-
		Argillic	pt. Matapiro
		Typic	-
PX	Fragic	Argillic-sodic	Wither
		Argillic-mottled	-
		Argillic-calcareous	Grampians
		Argillic	Seaview
		Mottled-calcareous	pt. Cluden
		Mottled	Timaru
		Calcareous-sodic	pt. Grampians
		Calcareous	pt. Takahe
		Typic	Tima
PL	Laminar	Mottled	Pukeuri
		Calcareous	-
		Typic	Otama
PJ	Argillic	Mottled-weathered	Okuku
		Mottled	Halcombe
		Aged	Naseby
		Mottled-ultic	-
		Ultic	Rosedale
		Sodic	-
		Weathered	-
		Calcareous	-
		Typic	Abbotsford
PI	Immature	Mottled-pedal	-
		Mottled	Wakanui
		Calcareous	-
		Pedal	Kiwi
		Typic	Templeton

KEY TO GROUPS OF PALLIC SOILS

PP Pallic Soils that have both a gley profile form and perch-gley features.

PERCH-GLEY PALLIC SOILS

PU Other soils that have a duripan.

DURIC PALLIC SOILS

PX Other soils that have a fragipan.

FRAGIC PALLIC SOILS

PL Other soils that have a brittle-B horizon and an argillic horizon that is predominantly in the form of lamellae.

LAMINAR PALLIC SOIL

PJ Other soils that have an argillic horizon, or a cutanic horizon with sodic features within it or immediately beneath it.

ARGILLIC PALLIC SOILS

PI Other soils.

IMMATURE PALLIC SOILS

KEY TO SUBGROUPS OF PALLIC SOILS

PP PERCH-GLEY PALLIC SOILS

Perch-gley Pallic soils occur in sites that are periodically saturated (if undrained) in winter and spring, but dry out in summer. The wetness and associated reducing conditions are indicated by grey colours on ped surfaces in horizons subjacent to the topsoil. Wetness is caused by perching of water on a slowly permeable subsurface layer, either a fragipan, argillic horizon, duripan, some combination of these horizons or other slowly permeable layer. The reductimorphic horizons are commonly acidic (pH less than 5.5).

PPU Perch-gley Pallic Soils that have a duripan.

Duric Perch-gley Pallic Soils

PPJX Other soils that have both an argillic horizon and a fragipan.

Argillic-fragic Perch-gley Pallic Soils

PPX Other soils that have a fragipan.

Fragic Perch-gley Pallic Soils

PPWJ Other soils in which the majority of the gravel is weathered to the extent that clasts may easily be broken by hammer or spade, and have an argillic horizon.

Weathered-argillic Perch-gley Pallic Soils

PPJ Other soils that have an argillic horizon.

Argillic Perch-gley Pallic Soils

PPC Other soils that have a horizon that is cemented to the degree that it is at least weakly indurated, within 90 cm of the mineral soil surface..

Cemented Perch-gley Pallic Soils

PPT Other soils.

Typic Perch-gley Pallic Soils

PU DURIC PALLIC SOILS

Duric Pallic Soils occur in areas with pronounced soil moisture deficits and often have some proportion of tephra in the soil parent material or high exchangeable sodium. The total silica contents are not high but sufficient silica has been mobilised to form a pan that impedes roots and water.

PUM Duric Pallic Soils that have a mottled profile form.

Mottled Duric Pallic Soils

PUJN Other soils that have an argillic horizon, or a cutanic horizon that within or immediately beneath has sodic features.

Argillic-sodic Duric Pallic Soils

PUJ Other soils that have an argillic horizon.

Argillic Duric Pallic Soils

PUT Other soils.

Typic Duric Pallic Soils

PX FRAGIC PALLIC SOILS

Fragic Pallic Soils occur in soil materials that are predominantly silty. A fragipan which severely restricts the movement of water and penetration of roots occurs below the base of the B horizon.

PXJN Fragic Pallic Soils that have *both*

1. an argillic or cutanic horizon overlying the fragipan, *and*
2. sodic features within or immediately above the fragipan.

Argillic-sodic Fragic Pallic Soils

PXJM Other soils that have *both*

1. an argillic horizon overlying the fragipan, *and*
2. a mottled profile form.

Argillic-mottled Fragic Pallic Soils

PXJC Other soils that have *both*

1. an argillic horizon, *and*
2. a calcareous horizon

Argillic-calcareous Fragic Pallic Soils

PXJ Other soils with an argillic horizon overlying the fragipan.

Argillic Fragic Pallic Soils

PXMC Other soils that have *both*

1. a mottled profile form, *and*
2. a calcareous horizon immediately beneath the fragipan or calcareous material within prism interiors of the fragipan.

Mottled-calcareous Fragic Pallic Soils

PXM Other soils that have a mottled profile form.

Mottled Fragic Pallic Soils

PXCN Other soils that have *both*

1. a calcareous horizon immediately beneath the fragipan or calcareous material within prism interiors of the fragipan, *and*
2. sodic features within or immediately beneath the fragipan.

Calcareous-sodic Fragic Pallic Soils

PXC Other soils that have a calcareous horizon immediately beneath the fragipan or calcareous material within prism interiors of the fragipan.

Calcareous Fragic Pallic Soils

PXT Other soils.

Typic Fragic Pallic Soils

PL LAMINAR PALLIC SOILS

Laminar Pallic Soils occur predominantly in fine sandy or silty loess or alluvium. Although rooting is impeded in the subsurface horizons it is not restricted to the degree that it is in a fragipan. The soils are generally slowly permeable.

PLM Laminar Pallic Soils that have a mottled profile form.

Mottled Laminar Pallic Soils

PLC Other soils that have a calcareous horizon.

Calcareous Laminar Pallic Soils

PLT Other soils.

Typic Laminar Pallic Soils

PJ ARGILLIC PALLIC SOILS

Argillic Pallic Soils have no fragipan or duric horizon but have a clay-enriched B horizon in which clay coatings occur predominantly on polyhedral, blocky or prismatic ped surfaces, on gravel surfaces, or within tubular pores.

PJMW Mottled-weathered Argillic Pallic soils that have *both*

1. a mottled profile form, *and*
2. gravel in which the majority is weathered to the extent that clasts may easily be broken by hammer or spade

Mottled-weathered Argillic Pallic Soils

PJM Other soils that have a mottled profile form.

Mottled Argillic Pallic Soils

PJA Other soils that have hue 7.5YR or redder or hue 10YR and chroma 6 or more in some part of the argillic horizon.

Aged Argillic Pallic Soils

PJMU Other soils that have *both*

1. an E horizon and pH less than 5.5 in some part of the argillic horizon, *and*
2. a mottled soil profile form.

Mottled-ultic Argillic Pallic Soils

PJU Other soils that have an E horizon and pH less than 5.5 in some part of the argillic horizon.

Ultic Argillic Pallic Soils

PJN Other soils that have sodic features within or immediately beneath the argillic horizon.

Sodic Argillic Pallic Soils

PJW Other soils that have gravel in which the majority is weathered to the extent that clasts may easily be broken by hammer or spade

Weathered Argillic Pallic Soils

PJC Other soils that have a calcareous horizon with an upper surface occurring within 90 cm of the mineral soil surface, or occurring within or immediately below the argillic horizon.

Calcareous Argillic Pallic Soils

PJT Other soils.

Typic Argillic Pallic Soils

PI IMMATURE PALLIC SOILS

Immature Pallic Soils are insufficiently developed to have fragipans, duripans or argillic horizons. They have either a brittle-B horizon, eluvial features, a cutanic horizon, or slightly firm or stronger blocky, polyhedral or prismatic peds.

PIMD Immature Pallic Soils that have *both*

1. a mottled profile from, *and*
2. are moderately or strongly pedal, with peds 100 mm or less in horizontal diameter, throughout the major part of the B horizon to 60 cm from the mineral soil surface, or to the base of the B horizon if shallower.

Mottled-pedal Immature Pallic Soils

PIM Other soils that have a mottled profile form.

Mottled Immature Pallic Soils

PIC Other soils that have a calcareous horizon with an upper surface within 90 cm of the mineral soil surface.

Calcareous Immature Pallic Soils

PID Other soils that are moderately or strongly pedal, with peds 100 mm or less in horizontal diameter, throughout the major part of the B horizon to 60 cm from the mineral soil surface, or to the base of the B horizon if shallower.

Pedal Immature Pallic Soils

PIT Other soils.

Typic Immature Pallic Soils

PODZOLS

CONCEPT OF THE ORDER

Podzols are acid soils with low base saturation. Podzols have an horizon of accumulation of aluminium occurring as complexes with organic matter and/or as short-range-order minerals (typically with silicon as allophane/imogolite). Iron (typically as ferrihydrite) may or may not be accumulated with aluminium. This horizon is usually associated with an overlying E horizon indicating translocation. The E horizon may be missing as a result of erosion, ploughing or bioturbation or it may be masked by organic matter.

CORRELATION

Podzols correspond to the podzols and some podzolised yellow-brown earths of the NZ Genetic Soil Classification. They mostly correspond with the Spodosols of Soil Taxonomy.

OCCURRENCE

Podzols occur in areas of high precipitation and are usually associated with forest species which produce an acid litter. They are most common in Northland, North Island high country and the West Coast and high country of the South Island.

ACCESSORY PROPERTIES OF THE ORDER

1. *Secondary oxides strongly differentiated between horizons*. In A and E horizons, sand and silt grains are uncoated. In B horizons they are coated, and in some soils cemented, by short-range-order minerals and/or organic matter.

2. *Low base saturation*. Base saturations are very low and the soils are extremely acid in A and E horizons. KCl-extractable-aluminium levels are high, and aluminium in soil solution may be toxic to some plants.

3. *Parent materials*. The soils occur mainly in materials from silica-rich rocks such as granite, greywacke, schist or rhyolite.
4. *Mineralogically differentiated*. Mica-smectite or smectite often occur in A and E horizons, and hydroxy-coated or interlayered minerals or allophane often occur in the B horizon. In some Northland soils, silica is dominant in B horizons. Podzols cover a wide range of mineralogy classes.
5. *Limited rooting depth*. The rooting depth is limited for many introduced plants by low pH or aluminium toxicity, or by pans which often cause problems of wetness.
6. *Low biological activity*. Low levels of faunal activity occur with a low rate of mineralisation. Carbon/nitrogen ratios are very high. The accumulation of weakly decomposed humus and minimal incorporation of humus into the upper mineral soil results in a mor-like humus form.
7. *Mor-forming vegetation*. The soils have been associated with vegetation producing an acid litter of low nutrient content.
8. *Infertile*. The soils have very low natural fertility with high nitrogen, phosphorus, potassium and lime requirements.
9. *Wet climate*. The soils occur mainly in areas with a precipitation of 1400 mm or more and unless sandy, are likely to have a soil water surplus for a considerable part of the year.

SUMMARY OF PODZOLS HIERARCHY

Group		Subgroup	Example of series
ZD	Densipan Podzols	Humus-pan	pt. Te Kopuru
		Ultic-humose	pt. Te Kopuru
		Humose	-
		Ortstein	-
		Typic	Parahaki
ZP	Perch-gley Podzols	Fluid	Hukarere var.
		Peaty-silt-mantled	pt. Okarito
		Silt-mantled	pt. Okarito
		Humus-pan	Addison
		Humose-ortstein	Rutherglen
		Humose-placic	Rakiura
		Humose	Maimai
		Ortstein	pt. Charleston
		Placic	Maungatua
		Typic	Rowallan

ZG	Groundwater-gley Podzols	Humose	-
		Typic	-
ZX	Pan Podzols	Humus-pan	Kairua
		Humose	Tautuku
		Fragic	Nevis
		Ortstein	Spencer
		Placic	Pukepahi
		Firm	-
ZO	Orthic Podzols	Humose	Borland
		Typic	Shewell

KEY TO GROUPS OF PODZOLS

ZD Podzols that have a densipan (Ed horizon).

DENSIPAN PODZOLS

ZP Other Podzols that have *both*

1. an E horizon with either the greyish colours of a reductimorphic horizon, a peaty topsoil, or a placic horizon together with redox-segregations in the E horizon, *and*
2. a slowly permeable layer or perch-gley features.

PERCH-GLEY PODZOLS

ZG Other Podzols that have *both*

1. either an E horizon with the greyish colours of a reductimorphic horizon or a peaty topsoil, *and*
2. a BC or C horizon that has the greyish colours of a reductimorphic horizon, that either
   (a) extends to more than 90 cm from the mineral soil surface, or
   (b) has redox-segregations that occur mainly as coatings on voids and/or skeletan grains.

GROUNDWATER-GLEY PODZOLS

ZX Other Podzols that have a subhorizon in the B horizon that is *both*

1. massive, *and*
2. has slightly firm or greater moist soil strength or has moist or wet penetration resistance of 3100 kPa or more.

PAN PODZOLS

ZO Other Podzols.

ORTHIC PODZOLS

KEY TO SUBGROUPS OF PODZOLS

ZD DENSIPAN PODZOLS

Densipan Podzols have a high density but uncemented pan within the E horizon at shallow depths which severely limits root penetration and water movement.

ZDU Densipan Podzols that have a humus-pan.

Humus-pan Densipan Podzols

ZDYH Other soils that have a Bh horizon more than 5 cm thick that occurs within the top of a clayey prismatic B horizon.

Ultic-humose Densipan Podzols

ZDH Other soils that have a Bh horizon 5 cm or more thick.

Humose Densipan Podzols

ZDQ Other soils that have an ortstein-pan.

Ortstein Densipan Podzols

ZDT Other soils.

Typic Densipan Podzols

ZP PERCH-GLEY PODZOLS

Perch-gley Podzols occur in periodically or predominantly saturated sites (unless artificially drained) in which wetness is indicated by grey colours along with brownish or reddish mottles or peaty topsoils. The wetness is caused by the perching of water on a slowly permeable subsurface layer, although a groundwater-table may also be present.

ZPF Perch-gley Podzols that have a moderately fluid or very fluid failure in some part above the podzolic-B horizon.

Fluid Perch-gley Podzols

ZPOZ Other soils that have *both*

1. an E horizon that
   (a) has slightly firm or greater moist soil strength, and

(b) is apedal massive or has very coarse to extremely coarse prismatic pedality, and

(c) occurs within a layer that is silty through a thickness of at least 15 cm, *and*

2. a peaty topsoil.

Peaty-silt-mantled Perch-gley Podzols

ZPZ Other soils that have an E horizon that has slightly firm or greater moist soil strength, is apedal massive or has very coarse to extremely coarse prismatic pedality, and occurs within a layer that is silty through a thickness of at least 15 cm.

Silt-mantled Perch-gley Podzols

ZPU Other soils that have a humus-pan.

Humus-pan Perch-gley Podzols

ZPHQ Other soils that have a Bh horizon thicker than 5 cm, and an ortstein horizon.

Humose-ortstein Perch-gley Podzols

ZPHP Other soils that have a Bh horizon thicker than 5 cm, and a placic horizon.

Humose-placic Perch-gley Podzols

ZPH Other soils that have a Bh horizon thicker than 5 cm.

Humose Perch-gley Podzols

ZPQ Other soils with an ortstein-pan.

Ortstein Perch-gley Podzols

ZPP Other soils that have a placic horizon.

Placic Perch-gley Podzols

ZPT Other soils.

Typic Perch-gley Podzols

ZG GROUNDWATER-GLEY PODZOLS

Groundwater-gley Podzols occur in periodically or predominantly saturated sites (unless artificially drained) in which the wetness is indicated by brownish or reddish mottles or peaty topsoils. The wetness is caused by a groundwater-table.

ZGH Groundwater-gley Podzols that have a Bh horizon thicker than 5 cm.

Humose Groundwater-gley Podzols

ZGT Other soils.

Typic Groundwater-gley Podzols

ZX PAN PODZOLS

Pan Podzols have a firm or indurated layer which restricts the penetration of roots and reduces permeability.

ZXU Pan Podzols that have a humus-pan.

Humus-pan Pan Podzols

ZXH Other soils that have a Bh horizon, and either an ortstein or placic horizon.

Humose Pan Podzols

ZXX Other soils that have a fragipan.

Fragic Pan Podzols

ZXQ Other soils that have an ortstein-pan.

Ortstein Pan Podzols

ZXP Other soils that have a placic horizon.

Placic Pan Podzols

ZXF Other soils.

Firm Pan Podzols

ZO ORTHIC PODZOLS

Orthic Podzols are moderately well or well drained and do not have a cemented or high density pan.

ZOH Orthic Podzols with a Bh horizon thicker than 5 cm.

Humose Orthic Podzols

ZOT Other soils.

Typic Orthic Podzols

PUMICE SOILS

CONCEPT OF THE ORDER

Pumice soils are soils that have properties dominated by a pumiceous and glassy skeleton with a low content of clay (which typically contains allophane). They occur in sandy or pumiceous tephra ranging from 700 to 3500 years in age.

CORRELATION

Pumice Soils include the yellow-brown pumice soils of the NZ Genetic Soil Classification, and a few yellow-brown loams with high glass content and moderate P retention. They correlate mainly with the Vitrands, Vitricryands or Vitraquands of Soil Taxonomy.

OCCURRENCE

Pumice Soils occur in sandy or pumiceous volcanic ashes which are relatively young. They are distributed in the central North Island, particularly in the Volcanic Plateau.

ACCESSORY PROPERTIES OF THE ORDER

1. *Short-range-order clay minerals*. Clay contents are low, generally less than 10%. The clay minerals are dominantly allophane and imogolite and occur as coatings around glass or pumice particles. Phosphate-retention is moderate or high. Most Pumice Soils belong to the Glassy or Amorphic mineralogy classes.

2. *Low soil strengths*. Soil strength is weak or very weak. The soils are apedal earthy or single-grain or extremely fine spheroidal, except in welded layers which are massive and may have higher strength.

3. *Pumice is not strongly altered*. The alteration status of pumice gravel ranges from fresh to moderately weathered. Glass is predominant in sand fractions.

4. *Deep rooting*. The soils provide a deep rooting medium except in welded flow tephras.

5. *Very high macroporosity*. The macroporosity enables rapid drainage at low soil-water tensions. The available water content is high.

6. *Sensitive*. The soils are non-plastic and are sensitive, with low strength when disturbed.

7. *Resistant to pugging*. Water contents at field capacity are less than the plastic limit. Pumice Soils may, however, be susceptible to compaction on loading, with consequent reduced infiltration.

8. *Low reserves of major nutrient elements*. Sulphur, potassium, nitrogen, phosphorus and magnesium are usually required for agricultural or horticultural crops. Reserve potassium (Kc) is low and exchangeable magnesium is very low, particularly in subsoils.

9. *Trace elements are likely to be deficient*. Trace elements that are possibly deficient include cobalt, copper, molybdenum, boron, iodine and selenium.

10. *Erosive*. The potential for erosion by water is high.

SUMMARY OF PUMICE SOILS HIERARCHY

Group		Subgroup	Example of series
MP	Perch-Gley	Duric	Mangawhero
		Typic	-
MI	Impeded	Mottled-welded	pt Atiamuri
		Welded	Atiamuri
		Mottled	-
		Typic	-
MO	Orthic	Mottled	-
		Podzolic	Rangipo
		Allophanic	Lowgarth
		Buried-allophanic	Paengaroa
		Immature	Taupo
		Typic	Turangi

KEY TO GROUPS OF PUMICE SOILS

MP Pumice Soils that have *both*

1. a gley profile form, *and*
2. perch-gley features.

PERCH-GLEY PUMICE SOILS

MI Other Pumic Soils that have a slowly permeable layer, or a compacted welded layer that has brittle failure and no roots, within 90 cm of the mineral soil surface.

IMPEDED PUMICE SOILS

MO Other Pumice Soils.

ORTHIC PUMICE SOILS

KEY TO SUBGROUPS OF PUMICE SOILS

MP PERCH-GLEY PUMICE SOILS

Perch-gley Pumice Soils occur in periodically saturated sites (unless artificially drained) in which wetness is indicated by grey colours along with brownish or reddish mottles. The wetness is caused by perching of water on a slowly permeable subsurface layer, although a groundwater-table may also be present.

MPU Perch-gley Pumice Soils with a duric horizon within 90 cm of the mineral soil surface.

Duric Perch-gley Pumice Soils

MPT Other soils.

Typic Perch-gley Pumice Soils

MI IMPEDED PUMICE SOILS

Impeded Pumice Soils have a horizon that severely restricts the movement of water and usually the penetration of roots. The restrictive horizon is commonly a layer of welded pumice.

MIMW Impeded Pumice Soils that have *both*

1. a compact welded layer of flow tephra (ignimbrite) that has brittle failure and no roots with an upper boundary within 90 cm of the mineral soil surface, *and*

2. a mottled profile form.

Mottled-welded Impeded Pumice Soils

MIW Other soils that have a compact welded layer of flow tephra (ignimbrite) that has brittle failure and no roots with an upper boundary within 90 cm of the mineral soil surface.

Welded Impeded Pumice Soils

MIM Others soils with a mottled profile form.

Mottled Impeded Pumice Soils

MIT Other soils.

Typic Impeded Pumice Soils

MO ORTHIC PUMICE SOILS

Orthic Pumice Soils are well drained to imperfectly drained, are deep rooting and do not severely restrict water movement.

MOM Orthic Pumice Soils that have a mottled profile form.

Mottled Orthic Pumice Soils

MOZ Other soils that have a B horizon, or subhorizon of the B, that is thicker than 20 cm and has hue 7.5YR or more.

Podzolic Orthic Pumice Soils

MOL Other soils that have a layer within the thickness of vitric soil material, that meets the requirements of an allophanic soil material (except for bulk density).

Allophanic Orthic Pumice Soils

MOBL Other soils with a layer of vitric soil material with a base at less than 60 cm from the mineral soil surface and within the B horizon, that overlies a layer which fails to meet the requirements of a vitric soil material but meets the requirements of allophanic soil material (except bulk density).

Buried-allophanic Orthic Pumice Soils

MOI Other soils with a Bw that is 30 cm or less thick and has hue 10YR or yellower and chroma 4 or more.

Immature Orthic Pumice Soils

MOT Other soils.

Typic Orthic Pumice Soils

RAW SOILS

CONCEPT OF THE ORDER

Raw Soils lack distinct topsoil development or are fluid at a shallow depth. They occur in environments where the development of topsoils is prevented by rockiness, by active erosion, or deposition. They include beach sands, alpine rock areas and active screes, lagoons and tidal estuaries.

CORRELATION

Raw Soils correspond in part with very weakly developed recent soils of the NZ Genetic Soil Classification, and in part with materials that were often not considered to be soil. They are either Entisols or are unclassified in Soil Taxonomy.

OCCURRENCE

Raw Soils occur scattered throughout New Zealand, particularly in association with high mountains, braided rivers, beaches and tidal mudflats.

ACCESSORY PROPERTIES OF THE ORDER

1. *No B horizons*. Pedogenetic horizons are lacking apart from a rudimentary topsoil.

2. *Fresh or weakly weathered*. Coarse fragments and sand particles are generally without coatings, although clasts in some screes may have weathering rinds.

3. *Inherited mineralogy*. The soil mineralogy is very similar to that of the parent material and a range of mineralogy classes is possible.

4. *In soils with a fluid subsurface layer, a continuously high water-table is present*. The deposition of fresh sediment may occur.

5. *Non-fluid soils occur in environments with active erosion or deposition*.

6. *Low fertility*. Nitrogen in particular, is deficient.

7. *Erosive*. Most materials are unaggregated and likely to be highly erosive.

8. *Sparse vegetation*. Vegetation is either absent, sparse or patchy, often consisting of ephemeral herbaceous plants, mosses or lichens. Mangroves occur mainly on Raw Soils.

SUMMARY OF RAW SOILS HIERARCHY

Group		Subgroup	Example of series
WG	Gley Raw Soils	Fluid-sulphidic	pt. Takahiwai
		Sulphidic	-
		Fluid-saline	-
		Saline	pt. Takahiwai
		Fluid	pt. Paratai
		Sandy	-
		Typic	-
WH	Hydrothermal Raw Soils	Active	-
WX	Rocky Raw Soils	-	pt. Alpine
WS	Sandy Raw Soils	-	pt. Riverton
WF	Fluvial Raw Soils	-	pt. Selwyn
WT	Tephric Raw Soils	-	pt. Ngauruhoe
WO	Orthic Raw Soils	-	pt. Alpine

KEY TO GROUPS OF RAW SOILS

WG Raw Soils that at 30 cm or less from the mineral soil surface have *either*

1. the upper boundary of a reductimorphic horizon, *or*
2. sufficient active ferrous iron to give a positive reaction to α,α'-dipyridyl at some time in the year, *or*
3. are saturated for 30 or more consecutive days in most years.

GLEY RAW SOILS

WH Other Raw Soils that have mean annual soil temperature at 30 cm depth of at least 2.5°C more than the mean annual air temperature.

HYDROTHERMAL RAW SOILS

WX Other Raw Soils with a lithic or paralithic contact within 30 cm of the soil surface.

ROCKY RAW SOILS

WS Other Raw Soils that have sand or loamy sand texture and that have less than 35% gravel (by volume) in all horizons, from the soil surface to 60 cm depth or more.

SANDY RAW SOILS

WF Other Raw Soils that have fluvial features and are not buried by more than 30 cm of non-fluvial soil material.

FLUVIAL RAW SOILS

WT Other Raw Soils in tephric soil material from the soil surface to 30 cm depth or more.

TEPHRIC RAW SOILS

WO Other Raw Soils.

ORTHIC RAW SOILS

KEY TO SUBGROUPS OF RAW SOILS

WG GLEY RAW SOILS

Gley Raw Soils occur in sites that are periodically or permanently flooded. Wetness is expressed in the soil by grey colours with brownish or reddish mottles, by water saturation or is indicated by a chemical test for the presence of reduced iron.

WGFU Soils that have *both*

1. moderately fluid or very fluid fluidity class at a depth of 30 cm or less, *and*
2. pH more than 4.0 and pH in boiling hydrogen peroxide less than 3.0, in some horizon at less than 90 cm from the mineral soil surface.

Fluid-sulphidic Gley Raw Soils

WGU Other soils that have pH more than 4.0 and pH in boiling hydrogen peroxide less than 3.0, in some horizon at less than 90 cm from the mineral soil surface.

Sulphidic Gley Raw Soils

WGFQ Other soils that within 30 cm of the mineral soil surface have *both*

1. moderately fluid or very fluid fluidity class, *and*
2. electrical conductivity of 0.8 mS/cm.

Fluid-saline Gley Raw Soils

WGQ Other soils that within 30 cm of the mineral soil surface have electrical conductivity of 0.8 mS/cm or more.

Saline Gley Raw Soils

WGF Other soils that within 30 cm of the mineral soil surface have moderately fluid or very fluid fluidity class.

Fluid Gley Raw Soils

WGS Other soils that have sand or loamy sand texture and that have less than 35% gravel (by volume) in all horizons, from the soil surface to 60 cm depth or more.

Sandy Gley Raw Soils

WGT Other soils.

Typic Gley Raw Soils

WH HYDROTHERMAL RAW SOILS

Hydrothermal Raw Soils occur in active hydrothermal areas affected by hot water.

WHA (only one subgroup recognised).

Active Hydrothermal Raw Soils

WX ROCKY RAW SOILS

Rocky Raw Soils occur on rock outcrops subject to erosion. The soil volume available to roots is severely restricted.

No subgroups have been defined.

WS SANDY RAW SOILS

Sandy Raw Soils occur in areas of active sand erosion, transportation and deposition, most commonly as dune sands.

No subgroups have been defined.

WF FLUVIAL RAW SOILS

Fluvial Raw Soils occur in sediments deposited by flowing water. They occur on land surfaces on which there is a high risk of flooding.

No subgroups have been defined.

WT TEPHRIC RAW SOILS

Tephric Raw Soils occur in unconsolidated sediments of volcanic origin including ash, cinders, lapilli, pumice and other pyroclastic material.

No subgroups have been defined.

WO ORTHIC RAW SOILS

Orthic Raw Soils occur in land that is being eroded, on rock outcrops or land that has received sediment emplaced primarily by slope processes.

No subgroups have been defined.

RECENT SOILS

CONCEPT OF THE ORDER

Recent Soils show only incipient marks of soil-forming processes because of youthfulness, truncation of an older solum or, less commonly, because the soil material is resistant to alteration. Soil formation has been sufficient to develop a distinct topsoil, or as in the case of fine-textured wetland soils, to have ripened sufficiently that fluid layers are not close to the surface. A continuous cover of vascular plants is normally well established. The concept of the order relates predominantly to weak soil development rather than to the length of time of soil formation.

CORRELATION

The order correlates with the recent soils, but not the gleyed-recent soils, of the NZ Genetic Soil Classification, and includes Entisols and some Inceptisols and Andisols of Soil Taxonomy.

OCCURRENCE

Recent soils occur throughout New Zealand in young landscapes, including alluvial floodplains, unstable steep slopes and slopes mantled by young volcanic ash.

ACCESSORY PROPERTIES OF THE ORDER

1. *Weak soil development*. Soil development is mostly confined to topsoils, with B horizon colours and/or pedality occurring in some soils.

2. *Base saturations are generally high*. Base saturations are usually high except in very humid areas.

3. *Gravel or rock is not strongly altered*. The alteration status of gravel or rock usually ranges from fresh to moderately weathered.

4. *Illitic mineralogy*. The soil mineralogy reflects the mineralogy of the parent material. Most Recent Soils have an Illitic mineralogy class except for those formed in tephra which are usually Glassy.

5. *Deep rooting*. Although textures vary, potential rooting depths are mostly large. Subsurface horizons are usually apedal or weakly pedal and penetration may be limited in some soils.

6. *Good drainage*. Poorly drained or very poorly drained soils are not included.

7. *Low P retention*. P retentions are likely to be either low or very low unless the soils occur in mafic materials.

8. *High fertility*. Natural fertility is generally high.

9. *Subject to erosion or sedimentation*. The soils are susceptible to erosion and/or sedimentation.

SUMMARY OF RECENT SOILS HIERARCHY

Group		Subgroup	Example of series
RH	Hydrothermal	Inactive	-
RX	Rocky	Peaty-acidic	pt. Titiraurangi
		Acidic	-
		Typic	pt. Cadzow
RS	Sandy	Mottled	Waiowhiro
		Acidic	Poison Bay
		Tephric	Hangatahua
		Typic	pt. Selwyn
RF	Fluvial	Mottled-acidic	Waiwhetu
		Mottled-saline	pt. Motukarara
		Saline	-
		Mottled-weathered	Eweburn
		Mottled	Hari Hari
		Acidic-weathered	pt. Manawatu
		Weathered	Waimakariri
		Acidic	pt. Seaforth
		Typic	pt. Selwyn

RT	Tephric	Mottled	-
		Buried-pumice	Matahina
		Buried-allophanic	-
		Typic	Ngauruhoe
RO	Orthic	Mottled-pallic	-
		Mottled	-
		Acidic-weathered	-
		Weathered	-
		Acidic	-
		Typic	Barhill

KEY TO GROUPS OF RECENT SOILS

RH Recent soils that have *either*

1. mean annual soil temperature at 30 cm from the mineral soil surface of at least 2.5°C more than the mean annual air temperature, *or*
2. pH of 4.8 or less in some part of a subsurface horizon at less than 60 cm from the mineral soil surface.

HYDROTHERMAL RECENT SOILS

RX Other Recent Soils that have a lithic or paralithic contact either directly beneath the A horizon or have a weathered-B or unconsolidated C horizon that is less than 10 cm thick.

ROCKY RECENT SOILS

RS Other Recent Soils that are have sand or loamy sand texture and have less than 35% (by volume) gravel, in all horizons between the base of the A horizon and 60 cm from the mineral soil surface. Lamellae of sandy loam (of insufficient thickness to meet the requirements of an argillic horizon) may be present.

SANDY RECENT SOILS

RF Other Recent Soils that have fluvial features and are not buried by more than 30 cm of non-fluvial soil material.

FLUVIAL RECENT SOILS

RT Other Recent Soils in tephric soil material from the mineral soil surface to 30 cm depth or more.

TEPHRIC RECENT SOILS

RO Other Recent Soils

ORTHIC RECENT SOILS

KEY TO SUBGROUPS OF RECENT SOILS

RH HYDROTHERMAL RECENT SOILS

Hydrothermal Recent Soils occur adjacent to active hydrothermal areas or areas that were formerly active. The soils indicate active or former hydrothermal activity by either elevated soil temperatures or extreme acidity, respectively.

RHI (only one subgroup recognised).

Inactive Hydrothermal Recent Soils

RX ROCKY RECENT SOILS

Rocky Recent Soils have rock at shallow depths, severely restricting the soil volume available to roots.

RXOA Rocky Recent Soils that have a peaty topsoil and a pH less than 5.5 in some part below 20 cm from the mineral soil surface.

Peaty-acidic Rocky Recent Soils

RXA Other soils that have pH less than 5.5 in some part below 20 cm from the mineral soil surface.

Acidic Rocky Recent Soils

RXT Other soils.

Typic Rocky Recent Soils

RS SANDY RECENT SOILS

Sandy Recent Soils occur in sand deposits which are dominantly aeolian, and sometimes alluvial in origin. Subsurface horizons are sandy.

RSM Sandy Recent Soils that have a mottled profile form.

Mottled Sandy Recent Soils

RSA Other soils that have pH less than 5.5 in some part between 20 and 60 cm from the mineral soil surface.

Acidic Sandy Recent Soils

RSK Other soils in tephric soil material from the mineral soil surface to 30 cm depth or more

Tephric Sandy Recent Soils

RST Other soils.

Typic Sandy Recent Soils

RF FLUVIAL RECENT SOILS

Fluvial Recent Soils occur in sediments deposited by flowing water. Many occur on land surfaces that are susceptible to flooding.

RFMA Fluvial Recent Soils that have *both*

1. a mottled profile form, *and*
2. pH less than 5.5 in some part between the base of the A horizon and within 60 cm of the mineral soil surface.

Mottled-acidic Fluvial Recent Soils

RFMQ Other soils that have *both*

1. a mottled profile form, *and*
2. have electrical conductivity of 0.8 mS/cm or more within 60 cm of the mineral soil surface at some time of the year.

Mottled-saline Fluvial Recent Soils

RFQ Other soils that have electrical conductivity of 0.8 mS/cm or more within 60 cm of the mineral soil surface at some time of the year.

Saline Fluvial Recent Soils

RFMW Other soils that have *both*

1. a mottled profile form, *and*
2. a weathered-B horizon with its lower boundary at 30 cm or more from the mineral soil surface..

Mottled-weathered Fluvial Recent Soils

RFM Other soils that have a mottled profile form.

Mottled Fluvial Recent Soils

RFAW Other soils that have *both*

1. a weathered-B horizon with its lower boundary at 30 cm or more from the mineral soil surface, *and*
2. pH less than 5.5 in some part of the subsurface horizons within 60 cm of the mineral soil surface.

Acidic-weathered Fluvial Recent Soils

RFW Other soils that have a weathered-B horizon with its lower boundary at 30 cm or more from the mineral soil surface.

Weathered Fluvial Recent Soils

RFA Other soils that have pH less than 5.5 in some part of subsurface horizons within 60 cm of the mineral soil surface.

Acidic Fluvial Recent Soils

RFT Other soils.

Typic Fluvial Recent Soils

RT TEPHRIC RECENT SOILS

Tephric Recent Soils occur in unconsolidated sediments of volcanic origin including ash, cinders, lapilli, pumice, and other pyroclastics.

RTM Tephric Recent Soils that have a mottled profile form.

Mottled Tephric Recent Soils

RTBP Other soils that have a buried soil, with its upper surface within 60 cm or less from the mineral soil surface that has a B horizon that meets the requirements of vitric soil material.

Buried-pumice Tephric Recent Soils

RTBL Other soils that have a buried soil within 60 cm or less from the mineral soil surface to the upper surface of the buried soil, and have a B horizon that meets the requirements of allophanic soil material, but not necessarily the requirements for bulk density.

Buried-allophanic Tephric Recent Soils

RTT Other soils.

Typic Tephric Recent Soils

RO ORTHIC RECENT SOILS

Orthic Recent Soils occur on land that is being eroded or has received sediment that has been deposited mainly as a result of slope processes.

ROMP Other soils that have *both*

1. a mottled profile form, *and*
2. meets part 2(b) of the requirements for Pallic Soils.

Mottled-pallic Orthic Recent Soils

ROM Orthic Recent Soils that have a mottled profile form.

Mottled Orthic Recent Soils

ROAW Other soils that have *both*

1. a weathered-B horizon with its lower boundary at 30 cm or more from the mineral soil surface, *and*
2. pH less than 5.5 in some part of the subsurface horizons within 60 cm of the mineral soil surface.

Acidic-weathered Orthic Recent Soils

ROW Other soils that have a weathered-B horizon with its lower boundary at 30 cm or more from the mineral soil surface.

Weathered Orthic Recent Soils

ROA Other soils that have pH less than 5.5 in some part between the base of the A horizon and within 60 cm of the mineral soil surface.

Acidic Orthic Recent Soils

ROT Other soils.

Typic Orthic Recent Soils

SEMIARID SOILS

CONCEPT OF THE ORDER

Semiarid Soils are high base status soils in which a soil water deficit prevails over most of the growing season. Wetting fronts in the natural state fail to penetrate deeper than the base of the solum, with consequent accumulation of pedogenic lime and soluble salts.

CORRELATION

The order comprises brown-grey earths, associated steepland soils and intergrades between brown-grey earths and yellow-grey earths and recent soils of the NZ Genetic Soil Classification. The order corresponds with the Aridisols of Soil Taxonomy.

OCCURRENCE

Semiarid Soils occur in the inland basins of Otago and southern Canterbury, where precipitation is less than about 500 mm per year.

ACCESSORY FEATURES OF THE ORDER

1. *Low secondary oxides*. Secondary iron and aluminium oxide levels are very low. P retention levels are also very low (usually less than 15%).

2. *High base status*. Base saturation values in subsoils are high and rise to 100% at the base of the solum.

3. *Parent materials*. The soils occur in materials from non-calcareous quartzo-feldspathic schist and indurated sandstone (greywacke).

4. *Illitic clay mineralogy*. Mica/illite clay minerals predominate with trace primary chlorite and kaolinite. Semiarid Soils almost always have an Illitic mineralogy class unless they have a clay content of less than 10% and fall into the Mixed class.

5. *Permeability*. Saturated hydraulic conductivity is slow in soils with argillic or cutanic horizons, and in some other silty or fine sandy soils. Infiltration may be reduced by traffic or treading when soils are saturated by irrigation water.

6. *Drainage*. No poorly or very poorly drained soils are included.

7. *Available water capacity*. Available water capacity is limited in most subsoils.

8. *Low biological activity*. In the natural state, biological activity is limited by droughtiness.

9. *High slaking and dispersion potential*. Soil materials are strongly dispersive and will readily slake.

10. *Erosive*. The soils are susceptible to wind and fluvial erosion.

11. *Weakly buffered*. The soils are weakly buffered because of low CEC and anion adsorption capacity. They are consequently very sensitive to management, showing rapid changes in response to fertilisation, irrigation and cultivation.

12. *Soluble salts*. Soluble salts are present in many soils and land management must consider the risk of salinisation.

13. *High sodium*. Many soils, particularly those with argillic horizons have high percentage sodium saturation of the exchange complex.

14. *Climate*. Precipitation ranges from about 350 to 500 mm per year, with zero water surplus and a spring soil moisture deficit.

SUMMARY OF SEMIARID SOILS HIERARCHY

Group		Subgroup	Example of series
SA	Aged-argillic	Mottled	-
		Weathered	Clyde
		Alkaline	pt. Drybread
		Thick	Clyde
		Typic	Lowburn
SZ	Solonetzic	Saline	pt. Chapman
		Typic	Manorburn

SJ	Argillic	Mottled	pt. Waenga
		Saline	pt. Ranfurly
		Alkaline	Blackmans
		Laminar	Manuherikia
		Typic	pt. Ranfurly
SI	Immature	Mottled	pt. Linnburn
		Saline	pt. Frazer
		Alkaline	pt. Linnburn
		Typic	-

KEY TO GROUPS OF SEMIARID SOILS

SA Semiarid Soils that have an argillic horizon in which the matrix has, in part, 7.5YR or redder hues or 10YR hue with chroma 6 or more

AGED-ARGILLIC SEMIARID SOILS

SZ Other Semiarid Soils that have an argillic horizon that has prismatic or blocky peds with more than 10% coatings of colour value 4 or less, and pH of 8.6 or more in some part.

SOLONETZIC SEMIARID SOILS

SJ Other Semiarid Soils that have an argillic horizon, or a cutanic horizon that meets the requirements of a slowly permeable layer.

ARGILLIC SEMIARID SOILS

SI Other Semiarid Soils.

IMMATURE SEMIARID SOILS

KEY TO SUBGROUPS OF SEMIARID SOILS

SA AGED-ARGILLIC SEMIARID SOILS

Aged-Argillic Semiarid Soils occur mainly on fans, terraces or hill slopes that have been relatively stable since mid to early Pleistocene. The argillic horizons are redder in colour than those in younger soils, and are usually slowly permeable.

SAM Aged-Argillic Semiarid Soils that have mottled soil profile form

Mottled Aged-argillic Semiarid Soils

SAW Other soils in which the majority of the gravel is weathered to the extent that clasts may easily be broken by hammer or spade.

Weathered Aged-argillic Semiarid Soils

SAK Other soils that have pH of 8.6 or more in some part within 60 cm of the mineral soil surface.

Alkaline Aged-argillic Semiarid Soils

SAH Other soils with an argillic horizon 30 cm or more thick.

Thick Aged-argillic Semiarid Soils

SAT Other soils.

Typic Aged-argillic Semiarid Soils

SZ SOLONETZIC SEMIARID SOILS

Solonetzic Semiarid Soils have a higher proportion of exchangeable sodium than other Semiarid Soils. This tends to promote the dispersion of clay and organic matter and very slow permeability through the clay enriched B horizons.

SZQ Solonetzic Semiarid Soils that have electrical conductivity of 0.8 mS/cm or more within 60 cm of the mineral soil surface at some time of the year.

Saline Solonetzic Semiarid Soils

SZT Other soils.

Typic Solonetzic Semiarid Soils

SJ ARGILLIC SEMIARID SOILS

Argillic Semiarid Soils occur on land surfaces of early Holocene or late Pleistocene age. The argillic horizon is brown, dark brown or olive brown in colour and usually slowly permeable.

SJM Argillic Semiarid Soils that have a mottled profile form.

Mottled Argillic Semiarid Soils

SJQ Other soils that have electrical conductivity of 0.8 mS/cm or more within 60 cm of the mineral soil surface at some time of the year.

Saline Argillic Semiarid Soils

SJK Other soils that have pH of 8.6 or more in some part within 60 cm of the mineral soil surface.

Alkaline Argillic Semiarid Soils

SJL Other soils that have an argillic horizon that is predominantly in the form of lamellae.

Laminar Argillic Semiarid Soils

SJT Other soils.

Typic Argillic Semiarid Soils

SI IMMATURE SEMIARID SOILS

Immature Semiarid Soils occur on Holocene land surfaces and do not have argillic horizons but usually have accumulations of calcium carbonate.

SIM Immature Semiarid Soils that have a mottled profile form.

Mottled Immature Semiarid Soils

SIQ Soils that have a horizon with electrical conductivity of 0.8 mS/cm or more within 60 cm of the mineral soil surface at some time of the year.

Saline Immature Semiarid Soils

SIK Other soils that have pH of 8.6 or more in some part within 60 cm of the mineral soil surface.

Alkaline Immature Semiarid Soils

SIT Other soils.

Typic Immature Semiarid Soils

ULTIC SOILS

CONCEPT OF THE ORDER

Ultic soils are acid soils with clayey and/or organic illuvial features in subsoil horizons. They are developed in clayey weathering products of siliceous sediments or acid igneous rocks and usually contain mixtures of clay minerals including kaolinite, halloysite, aluminium-interlayered vermiculite and smectite. A few are developed in the weathering products of limestones and greensands. They have low potassium, magnesium and phosphorus reserves and small concentrations of weatherable minerals. E horizons or other features such as skeletans in the upper parts of the Bt horizon are indicative of clay destruction/removal processes. Argillic horizons are usually present.

CORRELATION

The order comprises most northern yellow-brown earths, podzolised northern yellow-brown earths, many central yellow-brown earths (particularly those described as derived from pre-weathered parent materials) and some northern podzols and yellow-brown sands of the NZ Genetic Soil Classification. Most Ultic Soils are Ultisols in Soil Taxonomy.

OCCURRENCE

Ultic Soils are most common in the northern North Island, and the Wellington, Marlborough and Nelson regions.

ACCESSORY PROPERTIES OF THE ORDER

1. *Acidity*. KCl-extractable aluminium levels of more than 1 cmol(+)/kg are usual in B horizons, and indicate toxic aluminium which may inhibit root function and may contribute to shallow rooting habits in aluminium-sensitive plants.
2. *Clayey subsoils*. CEC values are medium to high. Ultic Soils cover a wide range of mineralogy classes, Kandic and Smectitic being the most common.

3. *Low Kc and Mgr*. Low concentrations of reserve magnesium and potassium resulting from strong weathering.

4. *Strongly weathered with low nutrient reserves*. Low levels of 0.5M H_2SO_4-extractable phosphorus (usually less than 3 mg/100 g) and total phosphorus (usually less than 20 mg/100 g) are characteristic. The former reflects low solubility and/or a low level of inorganic phosphorus reserves. Phosphorus supply from inorganic sources under zero phosphorus input grassland farming is negligible after about 2 years. Strong weathering is indicated by low ratio of 0.5M H_2SO_4-extractable phosphorus to inorganic phosphorus, usually 0.25 or less.

5. *Slow permeability*. A slowly permeable layer occurs in clayey profiles. The majority of soils are imperfectly to poorly drained, few are well-drained. Soil water movement is mainly along planar voids.

6. *Susceptibility to livestock treading damage*. Clayey or low strength silty surface horizons are susceptible to treading damage or compaction during wet periods.

7. *Dispersible surface horizons*. Surface horizons, especially silty ones, are dispersible according to the test of McQueen (1981), and are prone to erosion where the surface cover has been removed. Although P retention is usually moderate or high in B horizons, it may be low in A and E horizons consistent with low contents of secondary iron oxides.

SUMMARY OF ULTIC SOILS HIERARCHY

Group		Subgroup	Example of series
UD	Densipan	Perch-gleyed	Wharekohe
		Mottled	Hukerenui
UE	Albic	Perch-gleyed	Waikare, Okaka
		Mottled	Rangiora
		Yellow	Riponui
UP	Perch-gley	Sandy	pt. Tangitiki
		Typic	Omu
US	Sandy	Albic	Tangitiki
		Mottled	pt. Tangitiki
		Typic	pt. Red Hill

UY	Yellow	Magnesic	-
		Mottled-podzolic	Tennyson
		Mottled	Puhoi
		Podzolic	Opouri
		Buried-granular	Kairui
		Typic	Warkworth

KEY TO GROUPS OF ULTIC SOILS

UD Ultic Soils that have a densipan (Ed horizon)

DENSIPAN ULTIC SOILS

UE Other Ultic Soils that have an Eg or Er horizon overlying a firm, clayey B horizon that has prismatic peds with humus and/or clay coatings in some part.

ALBIC ULTIC SOILS

UP Other Ultic Soils that have a gley profile form.

PERCH-GLEY ULTIC SOILS

US Other Ultic soils with more than 60% sand in the B horizon.

SANDY ULTIC SOILS

UY Other Ultic Soils.

YELLOW ULTIC SOILS

KEY TO SUBGROUPS OF ULTIC SOILS

UD DENSIPAN ULTIC SOILS

Densipan Ultic Soils have a high density but uncemented pan at shallow depth which severely limits root penetration and water movement. Surface soil horizons are seasonally wet and the soil is very susceptible to livestock treading damage.

UDP Soils that have a reductimorphic horizon below the densipan.

Perch-gleyed Densipan Ultic Soils

UDM Other soils that have a redox-mottled horizon immediately underlying the densipan.

Mottled Densipan Ultic Soils

UE ALBIC ULTIC SOILS

Albic Ultic Soils have an E horizon immediately beneath the topsoil. The surface soil horizons are seasonally wet and the soil is very susceptible to damage from livestock treading.

UEP Soils that have a reductimorphic horizon below the E horizon.

Perch-gleyed Albic Ultic Soils

UEM Other soils that have a redox-mottled horizon below the E horizon.

Mottled Albic Ultic Soils

UEY Other soils.

Yellow Albic Ultic Soils

UP PERCH-GLEY ULTIC SOILS

Perch-gley Ultic Soils have seasonal wetness close to the soil surface, indicated by grey colours in horizons immediately beneath the topsoil. The topsoil is clayey and strongly buffered. The wetness is caused by perching on a clayey slowly permeable layer, although a groundwater-table may also occur.

UPS Soils that have more than 60% sand in the B horizon.

Sandy Perch-gley Ultic Soils

UPT Other soils that have a reductimorphic horizon with an upper boundary within either 15 cm of the base of the A horizon, or 30 cm of the mineral soil surface.

Typic Perch-gley Ultic Soils

US SANDY ULTIC SOILS

Sandy Ultic Soils occur in weathered aeolian sands. They are relatively weakly buffered, with lower CEC and available water than is typical of Ultic Soils.

USE Soils that have an Ea or Er horizon.

Albic Sandy Ultic Soils

USM Other soils that have a mottled profile form.

Mottled Sandy Ultic Soils

UST Other soils.

Typic Sandy Ultic Soils

UY YELLOW ULTIC SOILS

Yellow Ultic Soils are clayey and lack densipans or thick E horizons. They are moderately well or imperfectly drained. Few are well drained.

UYG Soils that have *either*

1. 5% (by volume) or more gravel that consists mainly of ultramafic rocks, *or*
2. have an exchangeable calcium/magnesium ratio of 0.2 or less and exchangeable magnesium of 1.5 cmol/kg or more in some part of the B horizon to 60 cm from the mineral soil surface.

Magnesic Yellow Ultic Soils

UYMZ Other soils that have *both*

1. pH of 4.8 or less in the E horizon (if present) or upper subhorizon of the B, and 10% or more humus coatings or coatings of colour value 4 or less on peds in some part of the B horizon, *and*
2. a mottled profile form.

Mottled-podzolic Yellow Ultic Soils

UYM Other soils that have a mottled profile form.

Mottled Yellow Ultic Soils

UYZ Other soils that have pH of 4.8 or less in the E horizon (if present) or upper subhorizon of the B, and 10% or more humus coatings or coatings of colour value 4 or less on peds in some part of the B horizon.

Podzolic Yellow Ultic Soils

UYBG Other soils that have *both*

1. silt loam or silty clay texture dominant from the soil surface to a depth of 60 cm, *and*
2. is underlain by a texture contrast to clay horizons that have colour values of 4 or less

Buried-granular Yellow Ultic Soils

UYT Other soils.

Typic Yellow Ultic Soils

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APPENDIX

The system for designating the soils consists of letters only. This method has been adopted to make for easier insertion of new subgroups, and to make the codes easier to remember.

The following is a list of the use which has been made of each code letter of the soil classification, the level at which it has been used, and the meanings.

Code	Order	Group	Subgroup
A	Anthropic	Acid, Aged-argillic	Acidic, Aged, Artifact, Active
B	Brown		Brown, Buried
C			Calcareous, Concretionary, Cemented, Compacted
D		Densipan	Pedal
E	Melanic	Melanic, Albic	Melanic, Earthy, Albic
F		Firm, Fibric, Fill, Fluvial	Fluid, Firm
G	Gley	Gley, Groundwater-gley	Gley, Gleyed, Magnesic, Granular
H		Humic, Hydrothermal	Thick, Humose
I		Immature, Impeded	Immature, Inactive, Ironstone
J		Argillic	Argillic
K			Alkaline, Tephric

L	Allophanic	Allophanic, Laminar, Litter	Allophanic, Laminar
M	Pumice	Mesic, Mafic, Mixed	Mottled, Mellow, Mafic
N	Granular	Nodular	Nodular, Sodic,Granular
O	Organic	Orthic	Peaty, Orthic
P	Pallic	Perch-gley	Pallic, Placic, Pumice, Perch-gleyed
Q			Saline, Ortstein
R	Recent	Recent, Refuse, Rendzic	
S	Semiarid	Sandy	Sphagnic, Sandy, Stony
T		Truncated, Tephric	Typic, Tailings
U	Ultic	Sulphuric, Duric	Sulphidic, Humus-pan, Duric
V		Vertic	Vitric, Vertic
W	Raw		Weathered, Welded, Wet
X	Oxidic	Oxidic, Pan, Rocky, Fragic	Pan, Fragic, Rocky, Oxidic
Y		Yellow	Yellow, Ultic
Z	Podzol	Solonetzic	Podzol, Podzolic, Silt-mantled