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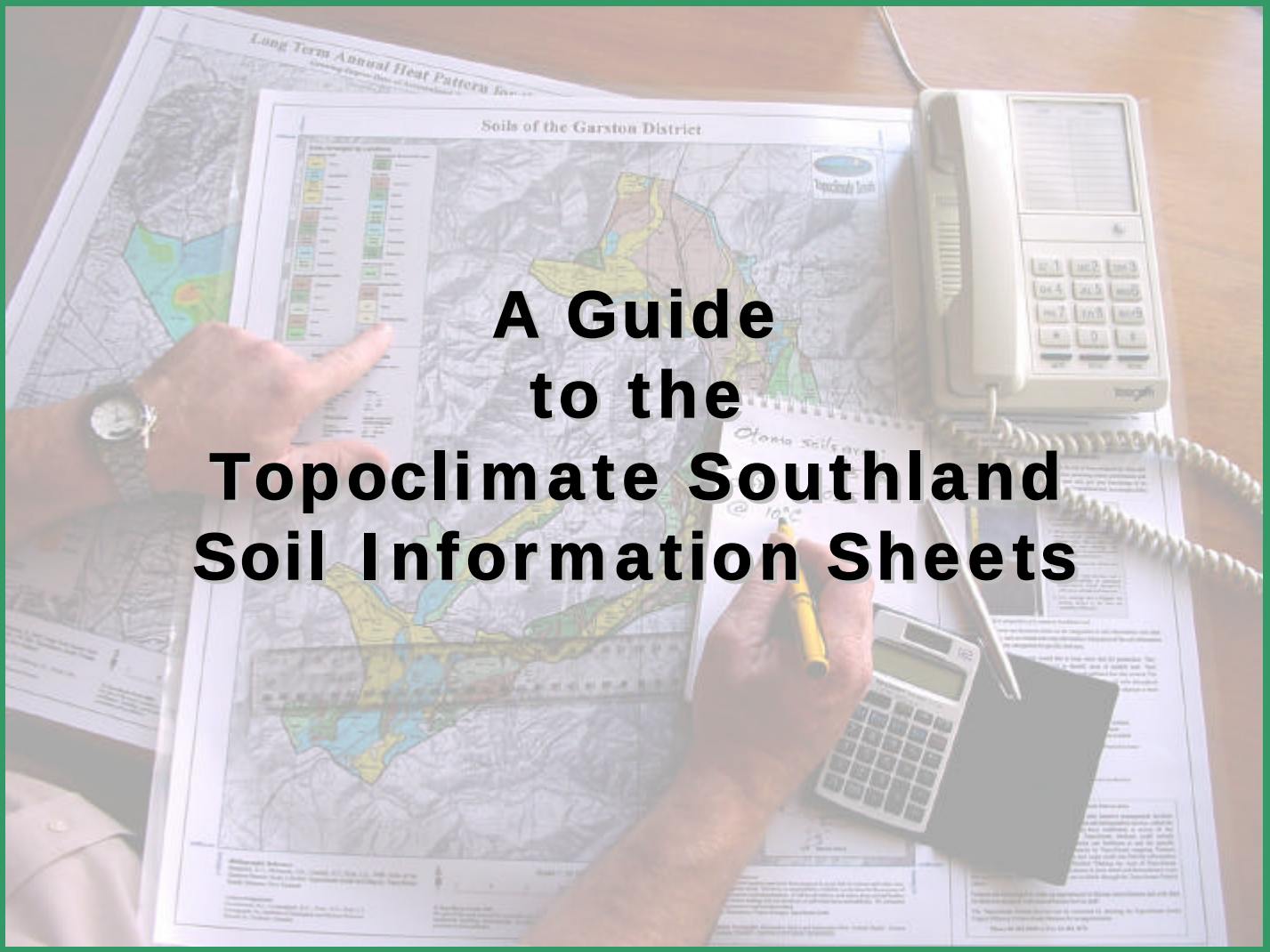

A Guide to the Topoclimate Southland Soil Information Sheets

Crops for Southland
Invercargill

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Introduction

Crops for Southland has produced a Soil Information Sheet for each of the 175 soil types that were mapped by Topoclimate South in the 1:50,000 soil survey of Southland's soil resources. The aim of the Soil Information Sheet is to summarise the soil survey's technical data and present it in a user-friendly form. The information sheets are designed to inform Southland people about the properties and sustainable diversification potential of the soils in their region.

A companion series, *Topoclimate Southland Soil Technical Data Sheets*, offers much more detailed descriptions of the soil profiles, along with typical values for the physical and chemical properties of every horizon. These are intended for users with a more advanced level of knowledge and understanding of soil science.

It is important to understand that the soil sheets describe the **typical average properties** of a soil type. These average values are essentially a summary of a number of separate soil profiles that were described for each soil type during the Topoclimate soil survey. Crops for Southland can provide the detailed data from a specific soil profile if you need it.

The soil fact sheets also provide sustainability and landuse versatility interpretations for each soil type. Again, it is important to recognise that these are typical average ratings of an undisturbed soil and it is assumed there has been minimal management intervention to overcome the major soil limitations. A landuser can assume a higher versatility rating where significant efforts have been made to overcoming a limitation to the versatility of the soil. A common example of this is where landusers have significantly improved the aeration and reduced waterlogging by installing mole and tile drainage networks.

This Guide attempts to explain the key concepts and terms used in the Soil Information Sheets and to assign values, or ranges of values, to the ratings given for each soil property. The glossary at the end defines all the technical terms used in the Information Sheets.

Topoclimate Soil Survey and maps

The Topoclimate Survey of Southland and South Otago was carried out over three years, between 1998 and 2001. It covered approximately 825,000 hectares of the intensively farmed land of the region. The more extensively farmed hill country, major forestry areas, and conservation lands were excluded from the survey. The results of the survey were published as a series of 36 district maps at a scale of 1:50,000. This scale is capable of identifying significant soil variations at the farm level, which is sufficient for most land users. It is more detailed than any previous surveys of Southland, although some intensive surveys have been carried out previously on small portions of the region.

Soil information collected

The soil survey teams studied variation in soil properties across the land. Observations were recorded at each point and similar points were grouped in a soil map unit. The density of these observations is illustrated in Figure 1.

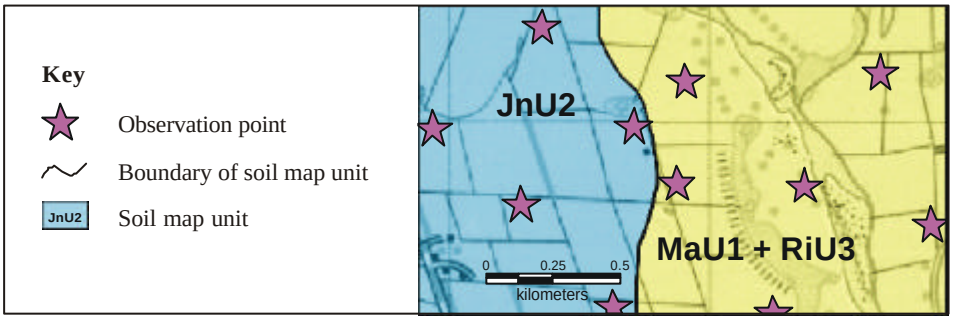


Figure 1: Density of observation points for soil maps

Soils on some landforms, such as river flats, are variable and occur in complex patterns. When this occurs, soils are grouped together, e.g., MaU1 + RiU3. The dominant soil is listed first, with additional soil(s) following if they occur in at least 15% of the soil map unit.

Soils in map units may need to be further separated depending on the proposed intensity of land use. A Global Positioning System (GPS) was used to accurately record the position of every observation point, so they can be easily revisited for more detailed mapping.

For each soil identified on the soil map, soil pits were dug and the profiles described and photographed. Each soil was also sampled for laboratory analysis, to measure physical and chemical properties.

The main soil physical properties measured were: texture, structure, stoniness, wetness, depth to parent material, potential rooting depth.

The main soil chemical properties measured were: pH, phosphate retention, organic matter, base saturation, cation exchange capacity.

Information on additional soil properties is also available. A comprehensive database of each soil and its properties has been compiled for use by landowners and managers. This database can be accessed through Crops for Southland.

Interpreting soil symbols

The abbreviated soil symbols used on Topoclimate soil maps have three components. The first two letters (e.g., Wq) represent the soil name and can be identified by reference to the legend of soils arranged by landform on the map sheet. The capital letter in the middle (U, R, H or S) denotes the slope or topography of the land and the number at the end (3, 2 or 1) denotes the depth of the soil profile. In some cases there is an additional suffix that denotes an associate or "variant".

For example: WqU1 = Waikoikoi, undulating, deep
Wq = Waikoikoi
U = undulating
1 = deep

Symbol	Slope phase	Slope
U	Undulating	0 – 7°
R	Rolling	8 – 15°
H	Hilly	16 – 25°
S	Steep	26°+

Symbol	Depth phase	Depth of soil to bedrock/gravel
3	Shallow	0 – 45 cm
2	Moderately deep	45 – 90 cm
1	Deep	90+ cm

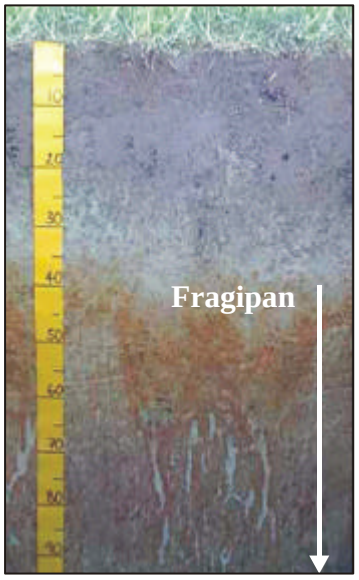
Associates

vc = clayey variant	vl = loamy variant
vf = floodplain variant	vm = mineral subsoil variant
vg = gravelly subsoil variant	vo = peaty subsoil variant
vh = humose subsoil variant	vr = recent variant
vi = imperfectly drained variant	vw = raw variant
vj = argillic variant	U = undifferentiated

Using the soil information

The Topoclimate survey studied the soil to a depth of one metre, as soil properties to this depth have significant influence on most land uses. Soil information to this depth can be used to assess a soil's suitability for specific land uses.

Knowledge of soil properties can reduce or avoid the risk to farm productivity from soil-related problems such as waterlogging, compaction, declining animal performance and poor crop yields. There is no such thing as a poor soil, just poor knowledge of its capabilities. Key properties have been identified for each Southland soil, an example of this is shown in Figure 2.



Key soil properties

- Moderately acid pH and medium natural fertility.
- The key property is the presence of a dense subsoil fragipan, which impedes roots. This perches water and causes poor drainage. The fragipan limits the potential rooting depth to between 40 and 60cm.
- The fragipan means the soil has slow permeability
- The soil has weak structure, and a high vulnerability to structural degradation from intensive cultivation and high stocking rates.
- Poor drainage and a fragipan are limiting factors to the land use versatility of this soil.

Figure 2: Key properties of a common Southland soil

The success of land use decisions relies on the integration of soil information with other knowledge bases, such as climate and crop information. Integration of the soil information means it can be easily interpreted for specific land uses.

For example, a flower company would like to lease more land for production. They contact Crops for Southland to identify areas of suitable land. Their requirements are that the soil is stone-free, well drained and has a low clay content. Crops for Southland's soil database can be searched to identify and map the location of the soils that match these specifications. The flower grower is most interested in the suitability of soils adjacent to their production base, as shown in Figure 3.

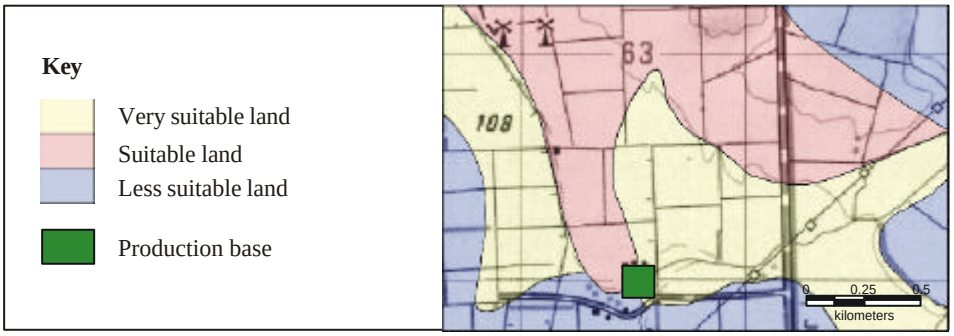


Figure 3: Interpreting the suitability of soils for flower production

Soil Information Sheets

The subject matter of each section or heading in the Soil Information Sheets is explained below.

Soil name

The Topoclimate Survey identified 175 unique soil types in the intensively farmed areas of Southland and South Otago. Soil types were mapped across the region according to differences in their New Zealand Soil Classification (NZSC). The NZSC provided a consistent method by which to define and map the location of different soil types. It also ensured that soil types were distinguished only where the differences in their properties were such that there would be a significant difference in some aspect of land management.

Generally a new soil name was assigned where a different NZSC was identified. The Topoclimate Survey endeavoured to rationalise the soil names used in Southland so that each soil name would identify a different soil type. Where possible soil names were based on those previously identified in earlier surveys. In a number of cases this was not possible for three main reasons:

- The same soil name may have been used in a number of previous soil surveys to identify different soil types.
- Different soil names may have been used in a number of previous soil surveys to identify the same soil type.
- A soil type may not have been identified by previous surveys.

Soil profile photo

Photographs have been selected to illustrate a typical profile for the soil in question. Because soils vary so much, the photograph will not be a perfect match to every example of the soil but gives a general indication of what the soil looks like. In particular, do not place too much reliance on the colour reproduction in illustrations because this may reflect variations in printing more than intrinsic colour properties of the soil.

Overview

The overview is a very brief introduction to each soil type. The geographical distribution and approximate total area of land in the region covered by the soil is given and the nature of the parent material and the typical landform on which the soil occurs are described. Some key soil properties that are discussed in later sections may also be described. A brief mention is made of the current and potential landuses of the soil and there is a very generalised statement about the climate of the areas in which it is found.

Parent material

The parent material describes the geological origin of the sediments or rocks from which the soil has formed. When describing soils, ‘parent material’ refers only to that which occurs within one metre of the soil surface. The great majority of soils in the intensively farmed areas of Southland have developed in secondary sediments rather than as the result of direct weathering of rock beneath them. These secondary sediments are:

- *Loess* describes deposits of windblown silts or sands. Although loess is being deposited continually, the extensive deposits in Southland occurred mostly during the ice ages, when glaciers were producing large quantities of ground up rock dust.
- *Alluvium* describes material that has been deposited by water action and is found adjacent to rivers and streams. Alluvial deposits are described as 'fine' where they are dominated by particles less than 2mm in diameter, and 'gravelly' when particles are greater than 2mm.
- *Colluvium* describes material that has been deposited by mass movements down slopes. Colluvial deposits may also be described as fine or gravelly.

Landform

The landform describes the surface where a soil type is located in the landscape. The predominant landforms that occur in the Southland region are shown in Fig. 4.

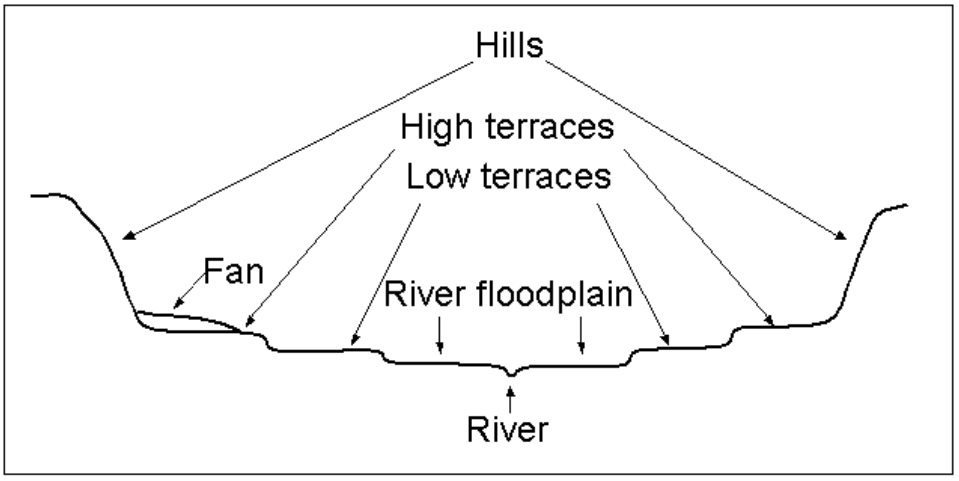


Figure 4: Profile of typical landforms of the Southland region

- *Floodplains* of the present rivers and streams.
- *Terraces* of various ages formed when old river floodplains were left high and dry during periods of land uplift (or falling sea level). Each major Southland river has an associated sequence of terraces, and these are described as High, Intermediate, or Low according to their position in that sequence.
- *Fans* are formed along the margins of hills and mountain ranges by the streams that drain their slopes. A fan commonly occurs where there is a marked decrease in gradient, for example where a stream in a hill gully meets the gentler floodplain or terrace of a river. Fan gravels are generally angular in shape, while those of terraces are rounded.
- *Downlands* are gently to strongly rolling land with a deep mantling of loess. The downland may be underlain by terrace gravels or bedrock, but the loess is the dominant parent material in defining the shape of the land.
- *Hilly and steeplands* are those areas where the landform is predominantly defined by the underlying bedrock.

Physical properties

The key physical properties of the soil that have a bearing on land use or constitute a significant limitation to land use are described here. These may include:

- Potential rooting depth and the nature of any barrier to root penetration that may be present and other physical properties that may restrict the growth of plant roots.
- Aeration (based on drainage class).
- Plant-available water-holding capacity.
- Permeability and bulk density.
- Texture differences down the profile.
- Topsoil clay content
- Presence and abundance of gravel
- Notes on any significant differences in the physical properties of other *phases* of this soil type.

Fertility properties

The key chemical properties of the soil that have a bearing on land use and fertiliser requirements are described here. These may include:

- Topsoil organic matter levels.
- Levels of plant-available nutrients in the topsoil and subsoil.
- Soil P-retention levels (ability to lock up phosphorus)
- Soil pH (acidity) levels.
- Nutrient reserves in the subsoil.
- Any significant trace element deficiencies if known.
- A broad indication of likely fertiliser responses.

Associated and similar soils

This section highlights other soils that are typically *associated*, either in a complex or on similar landforms, with the soil in question. For each soil identified, its main distinguishing properties and the typical landform on which it occurs are described.

Soils that have *similar* properties to the soil in question, but occur in other locations in Southland, are also listed and their main distinguishing properties described.

Sustainable management indicators

Sustainable management indicators are a system of rating soils according to their relative vulnerability to, or the level of risk of, environmental impacts that may adversely affect sustainable landuse. The vulnerability rating is intended to highlight to land users the relative resilience of their soil, and the importance of appropriate management techniques to minimise the risk to productivity and environmental sustainability. They are based on the combined effect of various inherent soil characteristics that directly influence the productivity, land management, or environmental sustainability aspects of landuse.

Emphasis is placed on using inherent physical characteristics that are difficult for people to change. Soil, land or climate characteristics that change in response to management are not used. Using inherent physical characteristics provides a rating that represents the likely average soil vulnerability over the year, when compared to other soils in Southland and elsewhere in New Zealand. The vulnerability rating will vary throughout the year, due to the

influence of additional factors such as soil moisture content. For example, as soils dry out in summer, the severity of their structural compaction vulnerability will diminish.

Methods for assessing the likely dynamic vulnerability of the soil over time, and at the level of paddock scale assessments, have been developed by research agencies such as Landcare Research and AgResearch. For further information please contact Environment Southland.

Soil vulnerability for each sustainable management factor is rated on a 7-point scale, with a blank indicating no data available:

nil	minimal	slight	moderate	severe	very severe	Extreme

Not all the points on the scale are used in Southland. For example, no soil in the Topoclimate survey area achieved a rating of 'extreme' for any of the vulnerability factors, and in the waterlogging assessments it was not possible to separate a 'minimal' rating between 'nil' and 'slight'. Where vulnerability ratings of moderate to very severe are indicated, advice may be sought from Environment Southland or a farm management consultant.

Structural compaction

The nature of topsoil structure has marked effects on a number of important physical properties such as water retention, crusting, aeration and transmission of water and air. Soil structure is significantly influenced by the duration, type and magnitude of management operations.

Structural stability is the ability of soil to maintain its porosity, or spaces in which to store water and air, when subjected to different management. The assessment of structural stability provides an estimate of the inherent resistance of topsoil structure to deterioration as a consequence of both intensive cultivation and compaction through intensive stocking or machinery use. The compaction vulnerability rating compares the vulnerability of different soil types to structural degradation. Vulnerability to structural degradation is strongly influenced by the land management techniques applied by individual land users.

Nutrient leaching

Nutrient leaching vulnerability is the potential for excess nutrients to leach beyond the root zone and contaminate groundwater. The nutrient leaching vulnerability rating assesses only the inherent soil properties of the root zone and allows comparison of the relative vulnerability to leaching of different soils. For this purpose, it is assumed that the soils occur within the same climatic zone and are under the same management.

The potential for nutrients to leach to groundwater depends on many factors beyond the scope of this assessment, including the composition of the soil and leachates above the water table, the depth to the water table, and environmental factors affecting the potential for natural treatment by soil organisms. There are also land management factors such as the vulnerability associated with the specific materials that people apply to the land, the rate of fertiliser application, stocking rates, and the degree to which the soil root zone has been modified (e.g., by artificial drainage networks).

Topsoil erodibility by water

Soil erosion is a form of soil degradation, causes pollution of water in streams and results in crop production losses. Only limited data on rates of soil loss from erosion are available in New Zealand. Soil erosion is usually assessed subjectively from past erosion features, soil

dispersibility, climate and topography. Clay provides the "glue" that holds soil together, so the lower the clay content in the topsoil, the more susceptible to erosion it is likely to be.

The vulnerability rating indicates the inherent erodibility of a particular soil, in a lowland mixed cropping or pastoral farming system. The rating is used to show the relative differences in erodibility between Southland soils where the other factors that affect erosion are the same for each soil. The actual risk will depend on the nature and interaction of factors such as rainfall intensity, slope, vegetation cover, and conservation management techniques. Generally risk increases where rainfall intensity and slope increase, and vegetation cover decreases.

Organic matter loss

Vulnerability to soil organic matter loss is defined as the inherent vulnerability to soil organic matter loss over time. Organic matter loss depends heavily on management. Organic matter loss when pasture is converted to cropping is due mainly to reduction in plant material inputs (mostly from root growth and litter) and partly to cultivation disturbance of soil structure. It is important to recognise that any soil will lose soil organic matter initially following such conversion, and differences between soils will become apparent only after many years or decades as some soils stabilise at new levels of soil organic matter that are lower than others.

The assessment of vulnerability to soil organic matter loss is a comparative estimate of the long-term relative difference in organic matter loss between soils subjected to the same changes in management (i.e., plant material inputs and cultivation techniques).

Waterlogging

Vulnerability to waterlogging is defined as the risk of a soil having a high water table that may cause the root zone to be saturated for sustained periods. Vulnerability to waterlogging includes soils with water tables caused by either groundwater or by perching of water on a slowly permeable horizon. Sustained waterlogging means that, during the year, there will be a risk that air supply to the root zone will cease for sustained periods. This may adversely affect plant growth, or excess wetness may increase the risk of runoff and structural compaction by heavy stocking or vehicle traffic.

General landuse versatility ratings

Landuse versatility ratings classify land according to its ability to support sustainable production and management of a specified range of crops within a landuse class such as non-arable horticulture, arable, intensive pasture, or forestry. The overall aim is to rate the quality of a soil for a particular landuse relative the other soils in Southland. The versatility rating for each landuse is determined by the land qualities that impose the most significant limitation for that landuse. The versatility rating identifies the most limiting land quality by establishing a comparative weighting of individual qualities based on their relevance and significance to achieving optimum conditions for that landuse.

The degree of limitation is evaluated in the context of the current regional land quality status at the time of the survey, and not according to pre-European conditions. It is also recognised that there is considerable variation in the degree to which on-farm management intervention has overcome landuse limitations. Therefore the limitation imposed by a land quality is defined as that which would occur with minimal management intervention by a landowner, but within the current regional interventions (e.g., regional drainage and flood protection networks). Where the landowner is confident that their management intervention (such as mole and tile drainage) has significantly improved the main limiting land quality, they may consider interpreting their land as having a versatility class higher than that indicated.

The classification rates the versatility of land on a 4-point scale according to the degree of versatility for each of four landuse types (see below), with a blank indicating that no data are available. The classification also identifies the two main land qualities primarily responsible for the versatility rating.

Landuse versatility ratings			
Unsuitable	Limited	Moderate	High

Non-arable horticulture

This landuse applies to perennial crop production based on high capital and energy inputs, highly mechanised methods and fertiliser inputs sufficient to meet crop nutrient requirements. The classification assumes that inter-row areas are grassed or in fallow and regular tillage is not required, other than during land preparation. It is also assumed that suitable shelter is provided. The classification generally assumes that adequate irrigation is available if required. However, allowance is made for soil water deficits in non-irrigated conditions to cover situations where soil water deficits are expected to be relatively low and where irrigation is not considered economic.

Non-arable crops are those harvested for fruit, nut, leaf or flower components and include:

- Orchard – growing trees for fruit and/or nut production (e.g., stone fruit, pip fruit).
- Berry fruit – growing shrubby plants, mainly cane plants for soft fruit production (e.g. raspberry, black currant). Strawberry production is therefore excluded.
- Vineyard – growing vines for fruit crops (e.g. kiwifruit), leaf and flower crops (e.g. hops). The system does not consider grape production as grapes have a number of unusual, crop-specific requirements.
- Cut flowers – growing crops such as paeonies, hydrangeas and other plants for cut flower production.

Arable

Arable landuse is defined as non-irrigated crop production that involves tillage, based on high capital and energy inputs with highly mechanised methods and fertiliser inputs sufficient to meet crop nutrient requirements. The classification is applicable to field crop and market garden land uses and includes crops harvested for grain, vegetable, tuber, fruit or flower components. Crops that are naturally adapted to wetland conditions are excluded. The classification is restricted to crop production involving conventional tillage. Production involving conservation tillage is excluded, as soil performance using conservation tillage may differ from conventional methods.

Intensive pasture

Pastoral landuse is defined as non-irrigated ryegrass/clover grassland that is used for semi-intensive to intensive grazing. It is assumed that fertiliser inputs are adequate to overcome known soil nutrient limitations. Grazing strategy and type of livestock will significantly affect whether optimal landuse is achieved. Landuse versatility for annual fodder crops (e.g., kale, swedes) should be evaluated as arable landuse.

Forestry

Forestry landuse is defined as commercial growing of trees for wood production. It is assumed that fertiliser practice is adequate to overcome known soil nutrient limitations.

Further information

If you need assistance with interpreting the Topoclimate Soil Maps and Soil Information Sheets, or wish to obtain further copies, please contact:

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Crops for Southland
143 Spey Street
PO Box 1306
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Phone: 03 211 1413
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Email: info@cropssouthland.co.nz
Website: www.cropssouthland.co.nz

For advice on environmental and landuse sustainability issues, please contact:

Land Sustainability Officer
Environment Southland
Cnr North Road & Price Street
Private Bag 90116
INVERCARGILL

Phone: 03 215 6197 or call free for Southland area 0800 768 845
Fax: 03 2125 8081
Email: service@envirosouth.govt.nz
Website: www.envirosouth.govt.nz

Glossary

Aeration Presence of air-filled space in the soil profile. Inadequate aeration has adverse effects on root function and can result in suppression of yield and crop failure. Aeration limitation is defined as the proportion of the year in which anaerobic conditions may prevail in the soil.

See also: **Profile drainage**; **Anaerobic**

Alluvium Material that has been deposited by water action. Alluvial deposits are described as *fine* where they are dominated by particles less than 2mm in diameter, and *gravelly* when particles are greater than 2mm.

Anaerobic Absence of air. The condition that pertains when the soil is waterlogged.

See also: **Aeration**; **Waterlogging**

Argillic Soils with a subsurface horizon into which clay has moved. It has at least 5% more clay than the horizons above.

Associates *See* **Variants**

Associated soils Soils that occur as a complex with the predominant soil in a defined *polygon*, or occur on landforms that are associated with the described soil.

Base saturation A general measure of soil fertility and leaching. Base saturation (BS) is calculated as the sum of the exchangeable cations of calcium, magnesium, potassium and sodium, expressed as a percentage of the total number of sites available for *cation exchange* (CEC). A low to very low BS indicates strong leaching. The BS of a soil can be raised by adding lime, or by adding fertilisers containing cations in a readily available form.

Bulk density The mass of oven-dry soil contained in a sample of known volume. Soils with low bulk density generally have fewer problems of root penetration and water permeability than soils with high bulk density.

Cation exchange capacity (CEC) The total number of sites in a soil available for cation exchange; a measure of the ability of the soil to retain added nutrients such as calcium, magnesium and potassium. Nearly all the cation exchange sites are on the surfaces of *clay* particles or *organic matter*. Consequently, soils with large amounts of clay or organic matter usually have a higher CEC than soils with low amounts of clay or organic matter.

Clay The finest of the three texture classes of soil, the others being *sand* and *silt*; soil material consisting of particles <0.002mm in diameter; clay is responsible for the swelling and shrinking properties of soil and the stickiness or slipperiness of moist soil, different clay minerals having different characteristics in this regard; plant nutrient elements (cations) attach themselves to the clay particles in the soil. Organic matter works with clay particles to hold and supply nutrients to plants.

Colluvium Material that has been deposited by mass movements down slopes. Colluvial deposits may be described as *fine* or *gravelly*.

Deep Soil that is 90 cm or more deep to gravel or bedrock is described as deep; one of the three *depth phases* used in the description of soils in the Topoclimate survey.

Depth (phase) Soils in the Topoclimate survey are assigned to one of three depth phases according to their depth above gravel or bedrock that could not be penetrated by a soil auger:
1 (Deep) = 90 cm +
2 (Moderately deep) = 45–90 cm
3 (Shallow) = 0–45 cm

Downland Gently to strongly rolling land that has a deep mantling of loess. The downland may be underlain by terrace gravels or bedrock, but the loess is the dominant parent material in defining the shape of the land.

Drainage *See* **Profile drainage**

Fans Soil-forming material deposited along the margins of hills and mountain ranges by the streams that drain their slopes. A fan commonly occurs where there is a marked decrease in gradient, for example where a stream in a hill gully meets the gentler floodplain or terrace of a river. Fan gravels are generally angular in shape, while those of terraces are rounded.

Floodplain Nearly flat land on either side of a river that was formed by periodic flooding and deposition of sediments from the river and which, in the absence of flood protection works, may still be subject to flooding.

Fragipan A natural sub-surface horizon with high bulk density, and sufficiently compacted to provide a barrier to root penetration. Fragipans are slowly or very slowly permeable to water. The presence of a fragipan frequently gives rise to impeded drainage and *perched water tables.*

Gleying, Gley A term used to describe the predominance of grey colours in a soil *horizon*. Grey colours indicate sustained periods of anaerobic conditions due to poor *profile drainage*.

Gravel Particles of >2mm diameter; may be rounded, as in terrace soils or others based on alluvial sediments, or angular, as in fan soils or soils derived from *colluvium*. Where the term *gravel* is used on its own, it is used to describe a layer that contains at least 35% gravel. There are also 5 classes of gravelliness that may be described: very slightly (1-5%); slightly (5–15%); moderately (15–35%); very (35–70%); and extremely (>70%). Two important thresholds of gravelliness, 35% and 70%, are often used in versatility evaluation to indicate significant changes in the quality of the rooting zone and water holding capacity.

Greywacke A dark grey sandstone flecked with dark angular fragments of finer rock, formed by the hardening of deposits in ancient ocean basins; the major rock type of central New Zealand.

Hilly Land with a slope of 16–25°, where the landform is predominantly determined by the underlying rock; one of the four *slope phases* used in the description of soils in the Topoclimate survey.

Horizon *See* **Soil horizon**

Landform The surface where a soil type is located in the landscape. The predominant landforms that occur in the Southland region are: *floodplains, terraces, fans, downlands, hilly and steep lands.*

Land characteristics	Individual attributes of the soil, land, or climate that, on their own, do not directly determine landuse versatility.
Land qualities	Attributes of land that directly influence its landuse versatility, and are derived from land characteristics. Land qualities may comprise single land characteristics (e.g., topsoil stoniness), or be a function of several land characteristics (e.g., topsoil structural vulnerability is a function of the characteristics *organic matter*, *P-retention*, *clay* content and *profile drainage*).
Landuse versatility	Each soil in the Topoclimate survey is classified according to its estimated ability to support sustainable production and management of a range of crops within each of four landuse classes. Where limitations are identified, management practices that might help to improve soil versatility are suggested.
Loess	Deposits of windblown silts or sands originating mostly from the ice ages, when glaciers were producing large quantities of ground up rock dust.
Loamy silt	One of the most common soil texture classes in Southland; composed of at least 40% silt (0.002–0.06mm particle size range) and less than 18% clay (<0.002mm particle size range).
Metamorphic (rock)	Rock whose nature has been transformed by natural geological processes, usually heat and pressure, from a pre-existing form.
Micro-nutrients	Chemical elements needed in only very small (micro) amounts for the growth of plants, e.g., boron, molybdenum.
Moderately deep	Soil that is 45–90 cm deep to gravel or bedrock; one of the three *depth phases* used in the description of soils in the Topoclimate survey. In soils with gravelly layers, the soil is described as moderately deep if there is a horizon with greater than 35% gravels between 45 and 90cm depth.
Mottles, Mottled, Mottling	Spots or blotches of colour different from the predominant soil colour. Often mottles are rusty red in colour, indicating the presence of iron oxides. Mottles indicate that there are periods of restricted *profile drainage*. The severity of the restriction to profile drainage is indicated by the abundance and depth at which mottles and *gleying* occurs.
New Zealand Soil Classification (NZSC)	The system of soil classification adopted in New Zealand in 1992, and used for the Topoclimate Survey, based on a four-level hierarchical structure. The level of detail about the properties of a soil type increases with each level down the hierarchy.
Nutrient leaching	The process whereby excess nutrients not held by the clay and organic matter complex of the soil leach beyond the root zone and contaminate groundwater.
Nutrient reserves	Reserves of sulphur, phosphorus and potassium held in 'reserve' – mainly in the subsoil – and able to be released for use by plants. This nutrient 'pool' is less dependent on management and more on soil type. The rating of nutrient reserves provides a qualitative estimate of a soil's potential to release or immobilise nutrients.

Organic matter The organic as distinct from mineral component of the soil, including plant and animal residues at various stages of decomposition and the cells and tissues of soil organisms; the lifeblood of productive soil, it plays a crucial role in improving soil structure, storing and recycling nutrients and modifying soil pH. Vulnerability to organic matter loss is one of the important indicators of sustainable management.

Parent material The geological origin of the sediments or rocks from which the soil has formed. Most Southland soils are formed in secondary sediments rather than by direct weathering of rock.

Ped A unit of soil structure; an aggregate of soil particles formed by natural processes, so distinct from a clod, which is formed artificially by humans.

Perched water table A zone in the soil where, due to an impermeable layer such as a fragipan, water is unable to percolate downwards and the water table is said to be 'perched' above the impermeable layer of soil.

Permeability A measure of the rate at which water can flow through the soil. The permeability of the soil is an important characteristic to many landuse issues such waterlogging risk, nutrient leaching vulnerability, and suitability for irrigation. A soil type's overall permeability is usually based on the horizon with the slowest permeability class, and the depth at which this layer occurs. Permeability classes and their equivalent flow rates (mm/hour) used in the Topoclimate survey are:
Slow = <4
Moderate = 4–72
High = 72–>288

pH A measure of the acidity or alkalinity of a soil. The pH controls the availability of plant nutrients, particularly the availability of trace elements, and aluminium toxicity. It also affects the biological activity of the soil and hence the release of nutrients from organic matter. The optimum pH level for most plants is about 6.0.

Phase(s) Differences in either soil depth (*see also* **Depth**) or slope angle (*see also* **Slope**) for a given soil type that are insufficient to justify separation into a new soil type. Phases are distinguished by symbols on the soil maps. If there is a significant difference in soil properties, it is recognised in the general landuse versatility ratings.

Phosphate retention, P-retention A measure of the ability of the soil to remove phosphorus from solution, holding onto it firmly, tending to make it unavailable to plants. In acid soils the phosphorus is retained by reactive aluminium and iron minerals. High P-retention values indicate that plants will give a lower response to the same amount of phosphate fertiliser than on a soil with low P-retention.

Plant readily-available water (PRAW); Plant available water-holding capacity The amount of water held in a soil that can be easily absorbed by plant roots. PRAW is used as a basis to determine soil qualities such as the potential for droughtiness, leaching vulnerability, and irrigation potential.

Plant-available nutrients Nutrients in the soil that are immediately and readily available for plants to take up and use as required. The pool of plant-available nutrients is dynamic and depends on transformation rates from less readily available forms, and on gains and losses through fertiliser input, animal transfer, plant uptake and leaching loss pathways. Soil nutrient 'fertility' is transient and strongly depends on management.

Potential rooting depth (PRD) The effective depth of soil that can be exploited by the rooting systems of most common crops, and which can provide a medium for root development, water and nutrient uptake. The ability of crop root systems to exploit the PRD depends on crop type and development stage. PRD is defined as the depth to a soil horizon with an inherent characteristic that is a significant physical impediment to root extension, and that cannot be easily improved by management intervention.

Polygon A soil mapping unit; a defined area of soil type distinguished on the soil maps by a black line border, coloured fill and identified by soil symbols.

P-retention *See* **Phosphate retention**.

Profile drainage Profile drainage provides an indication of how long a soil, or part of a soil, is saturated with water, and how quickly it can rid itself of excess water. Profile drainage is used to identify soil qualities such as aeration and waterlogging limitations. For example, in well drained soils the water is removed readily; in poorly drained soils the root zone is waterlogged for long periods unless artificially drained, and the roots of ordinary crop plants cannot get sufficient free oxygen.

Raw soils Soils lacking distinct topsoil development or which are fluid at a shallow depth; they occur where development of topsoil is prevented by rockiness, active erosion or deposition (e.g., beach sands, active screes, lagoons and tidal estuaries).

Rolling One of the four slope phases to which all soils in the Topoclimate survey were assigned (*see* **Slope phase**); land with a slope of 8–15°.

Root penetrability The ease with which plant roots can grow and utilize the soil within the *potential rooting depth*. Root penetrability is determined by the soil density, root growth becoming more limited as density increases.

Rooting depth *See* **Potential rooting depth**

Sand The coarsest of the three soil textural classes (*sand*, *silt* and *clay*); a soil particle between 0.06 and 2.0mm in diameter.

Schist A *metamorphic rock* that has developed distinctive layering and can be split into slabs or flakes. Mica appears as characteristic shiny flecks in the rock.

Secondary sediments Sediments, forming the parent material of most of Southland's intensively farmed soils, that originated elsewhere and have been transported and deposited in their current location. They include *loess*, *alluvium* and *colluvium*.

Shallow Soil that is 0–45cm deep to gravel or bedrock is described as shallow; one of the three *depth phases* used in the description of soils in the Topoclimate survey. In soils with gravelly layers, the soil is described as shallow if there is a horizon with greater than 35% gravel within 45cm depth.

Short-term waterlogging The risk of short periods (up to one week) of anaerobic conditions in the soil after heavy rain, which can have marked effects on plant growth and yield. (See also **Waterlogging**)

Silt The intermediate soil textural class between sand and clay; a soil particle between 0.002 and 0.06mm in diameter.

Silt loam One of the most common soil texture classes in Southland; composed of at least 40% silt (0.002–0.06mm particle size range) and 18–35% clay (<0.002mm particle size range). In the Topoclimate survey soils are described as *light* silt loam when they have a clay content between 18 and 25%, and *heavy* silt loam when clay content is 25–35%.

Silty clay One of the most common soil texture classes in Southland; composed of at least 30% silt (0.002–0.06mm particle size range) and 35–60% clay (<0.002mm particle size range).

Slope (phase) Soils in the Topoclimate survey are assigned to one of four Slope phases according to the slope angle of the landscape on which they are located:
U = Undulating (0–7°)
R = Rolling (8–15°)
H = Hilly (16–25°)
S = Steep (25°+)

Soil complex A soil *polygon* on the soil map that includes more than one soil type within its boundaries. The dominant soil is listed first, with additional soil(s) following if they occur in at least 15% of the soil map unit.

Soil horizon A distinct layer in a soil profile, with different physical, chemical and biological properties from adjacent layers.

Soil profile A vertical section of a soil showing all its horizons; can be seen in stream banks, roadside cuttings or by digging a pit. In the Topoclimate survey the soils were classified by describing the unique characteristics of their soil profiles to 90cm depth.

Soil structure The way in which soil particles are aggregated into soil *peds*. Structure is described by ped size (fine, medium, or coarse), shape, and how strongly they are formed (weakly, moderately or strongly). The presence of peds is important because spaces are left between and within them. These spaces are necessary for root growth and the movement of water and air within the soil. Unless a soil is well structured, crop yields will be low and erosion may occur. The structure of many soils may be damaged by too much cropping, or by the movement of machinery (such as tractors) over the soil when it is too wet. Intense treading by animals, especially cattle, when the soil is too wet will also damage soil structure.

Soil texture

Soil texture is very important in determining soil qualities such as water-holding capacity, ease of cultivation, root penetrability, and vulnerability to structural degradation.

Soil texture is used to describe the particle distribution of those particles in a mass of soil that are less than 2mm in diameter. Particles coarser than 2mm are described as gravel and are not regarded as a textural component. Soil texture is usually described as a class determined from a standard texture triangle based on the relative proportions of sand, silt and clay. The most common soil textures for Southland soils are silt loam or silty clay.

Steep

One of the four slope phases to which all soils in the Topoclimate survey were assigned (*see* **Slope phase**); land with a slope of 25°+.

Stoniness

Stoniness is evaluated in terms of its negative affects on management. Stoniness affects cultivation (particularly rotary hoeing), germination, harvesting, drainage, mowing, fencing and trellising. Stoniness also has negative effects on water retention, rooting depth and soil water deficit and positive effects on soil temperature and drainage properties. These effects are accounted for in other land qualities.

Topsoil stone content is a cost to implement 'wear and tear' and very stony topsoils can have marked negative effects on plant growth. Negative impacts of topsoil stoniness may be reduced by stone removal.

Stoniness in the 0–45cm depth zone is seen as a management limitation for installation of infrastructure such as fencing, trellising, wind protection, and drainage. It may also be seen as a limitation for ease of planting shrubs and trees.

Structural compaction, Structural stability

Soils vary in their structural stability, or the ability to retain their arrangement of solid and void space when exposed to different stresses. Natural soil structure can be damaged or destroyed if the soil is compacted by vehicular traffic, treading by livestock, or excessive cultivation. Soils vary in their vulnerability to structural compaction, and vulnerable soils are more so when wet or low in organic matter. The assessment of structural compaction vulnerability estimates the inherent resistance of topsoil structure to deterioration as a consequence of both intensive cultivation and compaction through intensive stocking or machinery use.

Sustainable management indicators

A system of rating soils according to their relative vulnerability to, or the level of risk of, environmental impacts that may adversely affect sustainable landuse.

Terrace

Old river floodplain left high and dry following periods of land uplift (or falling sea level). Each major Southland river has an associated sequence of terraces, and these are described as High, Intermediate, or Low according to their position in that sequence.

Topsoil erodibility by water

The extent to which the topsoil is inherently susceptible to erosion by water, as distinct from wind erosion. Erodibility is likely to be greater the lower the clay and organic matter content of the topsoil.

Trace elements Chemical elements needed in only very small (trace) amounts for the growth of plants (e.g., boron, molybdenum) or animal health (e.g., copper, zinc). cf. **Micro-nutrients**.

Undifferentiated soils Soil mapping units in which a number of soils occur in a highly variable complex – that is, not in a regular pattern of association that can be distinguished on the soil map; depicted by a U prefix in the Topoclimate soil symbols.

Undulating One of the four slope phases to which all soils in the Topoclimate survey were assigned (*see* **Slope phase**); land with a slope of 0–7°.

Variant(s) Soil variants are described where there is a difference in a single soil property that is insufficient to justify separation into a new soil, but where all other soil properties remain the same as the 'parent' soil. The soil is recorded as a variant because it does not occupy a significant area in its own right (usually less than 200 ha) or occurs in a complex that cannot be separated from the main soil type at the scale of mapping used. Variants are distinguished in soil symbols by lower case suffix 'v' and another letter to indicate the nature of the variant (e.g., 'vi' = imperfectly drained variant)

Water-holding capacity *See* **Plant readily-available water**.

Waterlogging Periods of anaerobic conditions in the soil after heavy rain or flooding, which can have marked effects on plant growth and yield. Topoclimate defines two types: *short-term waterlogging*, where aneorobic conditions may occur after heavy rainfall for periods of up to one week; and *waterlogging* where there are sustained aneorobic conditions for periods of greater than one week due to a high groundwater table or perched water table.