Otago Regional Council

Companion Booklet

growOTAGO® Products

The climate and soil information mapped by growOTAGO® can be obtained in three forms:

1. **High quality maps** that display all mapped parameters on a regional and local scale (1:50000). A core set of maps can be viewed at each of the Otago Regional Council offices in Dunedin, Alexandra and Queenstown. All maps produced for growOTAGO® are available as Adobe pdf documents or can be printed as hard copy large format maps. Contact info@orc.govt.nz for more information on how to obtain hardcopy maps.

2. **Climate and Soil Maps CD-ROM** containing software to view the climate maps and soil maps produced by growOTAGO®. The software allows seamless viewing across Otago of all the mapped parameters on a PC. The software includes an index map of Otago, a list of all the available types of maps (including topographic maps and aerial photographs) and legend explaining each specific climate and soil map. The software also provides tools to map sites of interest by the user.

3. **Web site http://www.otago.orc.govt.nz.** This web site links to a site that allows for interactive viewing of the climate layers and soil maps produced by growOTAGO®.

This companion booklet contains the installation guide for the CD-ROM software and a general overview of the parameters mapped by growOTAGO®. It does not provide an exhaustive description of how each climate variable or soil parameter was derived. Full descriptions of the methods used in mapping the climate and soil information over the course of the growOTAGO® project can be found in the References listed towards the end of the booklet.

growOTAGO® mapped climate and soils information is further supported by Otago Regional Council publications such as *The Climate of Otago* and the monthly *Southern Climate and Pasture Outlook*. Otago Regional Council weekly and monthly rainfall reports also provide up to date information on rainfall. Contact info@orc.govt.nz for more information.

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What is growOTAGO®?

The growOTAGO® project was undertaken by the Otago Regional Council to comprehensively map climate and soils across the Otago region. It provides information for improving existing land uses, developing new high value, land-based activities and fostering regional economic development, through the optimum use of Otago's varied climate and soils.

growOTAGO® utilised scientific skills from several New Zealand research organizations. Existing climate and soil data, satellite observations, temporary climate station measurements and additional soil measurements were merged through innovative approaches using the latest computer mapping techniques.

Measurements, data analysis and collation, and creation of the final maps were managed by the National Institute of Water and Atmospheric Research (NIWA). Partners in the project included AgResearch, Manaaki Whenua Landcare Research, EcoBureau, and the University of Otago.

Many Otago farmers also made important contributions. They shared their knowledge about local conditions, advised on suitable sites for extra climate stations, allowed scientists to install climate stations on their land (in some cases purchasing stations themselves) and provided feedback on the initial draft maps.

Otago Regional Council Staff were involved throughout in planning for the project, organising local liaison and providing advice based on their own local knowledge.

This partnership between the Council, residents and scientists has produced a unique resource. It will help farmers, horticulturalists, foresters and tourism operators confidently take new opportunities to utilise niche climates and soils.

A regional study such as this cannot tease out very detailed microclimate and soil variations within individual farms. Localised measurements and specialist advice will still be desirable, before final decisions are made about changes to land use and management.

This booklet contains information about the growOTAGO® climate and soil maps. It includes an index map, a list of all the available types of maps and guidance on how to interpret them.

Otago's climate

New Zealand's weather is dominated by the prevailing westerly airflow and generally eastward progression of weather systems that occur at mid-latitudes of the oceanic southern hemisphere. It is also significantly affected by the barrier to these weather systems presented by the Southern Alps and other ranges. In the west of Otago, the Southern Alps rise to 3026m (Mt Aspiring) and are a major factor in the region's climate. The most remarkable demonstration of this is the contrast between the mean annual rainfall at Milford Sound (6813mm) and that at Alexandra (358mm). Enough precipitation spills over the divide, however, to provide considerable inputs of snow melt and rain water to the headwaters of Otago catchments.

There is a marked difference in the climate of inland and coastal areas of Otago, particularly with respect to air temperature. The sea has a moderating effect on the temperature, leading to less extreme temperatures at coastal locations compared with inland locations. This is clearly shown by the average number of air frosts per year, which is between 30 and 50 in coastal regions and between 50 and 100 in inland locations.

Over much of Otago the wind is strongly channelled by hills and valleys. The degree of channelling increases as a valley becomes deeper in relation to its width. Föhn winds are important for Otago. These arise from the effect of the Southern Alps on the moist marine winds arriving from the west to northwest direction across the Tasman Sea. The air's high water vapour content is converted to heavy rainfall in the mountains, resulting in a downstream flow of warm dry winds east of the main ranges. Sometimes these winds can be very strong and blustery. Their dryness increases the evaporation of water from soils, rivers and lakes, and can be an important contributor to drought conditions.

Climate parameters mapped by growOTAGO®

Climate classification of New Zealand (mapped at 1:1500000 Scale)

This map represents areas of similar climates found around New Zealand. These were identified using various combinations of parameters such as elevation, annual rainfall, annual air temperature, and daily solar radiation determine each class. Areas of similar climates were identified using a statistical clustering analysis.

The model identified 16 general climate classes based on whether the value of the input parameters was low, moderate or high. Classes 1 to 6 are located principally in the

Table 1: General description of the climate classes for New Zealand (referred to as Table 3.2 on printed NZ Climate Classification map)

Class	Elevation	Rainfall	Temperature	Solar radiation
1	low	moderate	warm	high
2	low	moderate	warm	moderate
3	moderate	moderate	moderate	high
4	high	high	moderate	high
5	low	moderate	moderate	moderate
6	moderate	moderate	warm	high
7	moderate	low	moderate	high
8	moderate	moderate	moderate	moderate
9	moderate	high	moderate	moderate
10	moderate	high	moderate	high
11	low	low	moderate	low
12	moderate	low	moderate	low
13	moderate	low	moderate	moderate
14	high	low	cool	low
15	high	high	cool	moderate
16	high	high	cool	low

North Island; classes 7 to 10 are located principally in the southern half of the North Island and the northern half of the South Island, and classes 11 to 16 are located principally in the South Island.

Regional maps (mapped at 1:500000 Scale)

These maps include regional summaries of Air temperature anomalies along with percentage of normal precipitation during an El Niño and La Niña year. These variables have been mapped for all seasons. Snow water equivalent has also been estimated. This is the amount of water expected if all the snow melts. It is an important parameter to map for river flow estimations and irrigation requirements. Snow water equivalent is related to the depth of snow (snow depth multiplied by snow density equals snow water equivalent) so these maps are also useful for ski field operators and snow hazard analysts.

Table 2: Regional maps of climate information

Climate parameter	Period	Percentile	Scale
Maximum snow water equivalent	Ann	20th, 50th, 80th	1:500,000
Date of the maximum snow water equivalent	Ann	20th, 50th, 80th	1:500,000
Percent of normal precipitation during an El Niño	Sum, Aut, Win, Spr	50th	1:500,000
Percent of normal precipitation during a La Niña	Sum, Aut, Win, Spr	50th	1:500,000
Air temperature anomaly during an El Niño	Sum, Aut, Win, Spr	50th	1:500,000
Air temperature anomaly during a La Niña	Sum, Aut, Win, Spr	50th	1:500,000

*see Table 3 for abbreviation description.

Climate maps (mapped at 1:50000 Scale)

Eleven climate parameters have been mapped for the entire Otago region at a scale of 1:50,000 or 1:500,000. The climate parameters are listed (with the scale in parentheses):

- Total rainfall (1:50,000)
- Number of days of rain (1:50,000)
- Air temperature (1:50,000)
- Growing degree days (base 5°C and 10°C) (1:50,000)
- Frost incidence and number of frosts in the spring months (1:50,000)
- Potential evapotranspiration (1:50,000)
- Wind speed (1:50,000)
- Solar radiation (1:50,000)
- Cool season chilling (1:50,000)
- Soil temperature at 10cm (1:50,000).

Most of the parameters have been mapped for each season as well as for the whole year. (Note that the seasons for the growOTAGO® climate maps are different from the standard climate seasons - summer is January to March; autumn is April to June; winter is July to September; and spring is October to December.)

There are also maps of 2-monthly periods (September to October, November to December, January to February, and March to April) for total rainfall and potential evapotranspiration.

The median value is mapped for every parameter except wind speed, where the average value is mapped, based on climate data from the period 1970-2001. The **median** is the middle value when all the values over the period are ranked from lowest to highest. Thus, the median represents the value which is equalled or exceeded 50% of the time (or one-year-in-two, on average). For example, a median annual rainfall of 1000 mm means that 50% of the time you will get this much or more rainfall in a year and 50% of the time you'll get less than 1000 mm.

For some parameters, the 20th and 80th percentiles are also mapped. The 20th percentile is the value that is equalled or exceeded four-years-in-five, on average, while the 80th percentile is the value that is equalled or exceeded one-year-in-five, on average. Using annual rainfall as an example once again, the 20th percentile may only be 800 mm while the 80th percentile may be 1200 mm. This means that one-year-in-five, on average, the annual rainfall is less than 800 mm and one-year-in-five, on average, the annual rainfall is 1200 mm or more. Thus, the 20th and 80th percentile maps can be used to assess the variability of the climate parameter, while the median shows the 'normal' values.

Table 3 lists the climate parameters mapped for Otago at 1:50,000 scale. Maps have been produced for each of the NZMS260 Topographic map sheets shown in Figure 1.

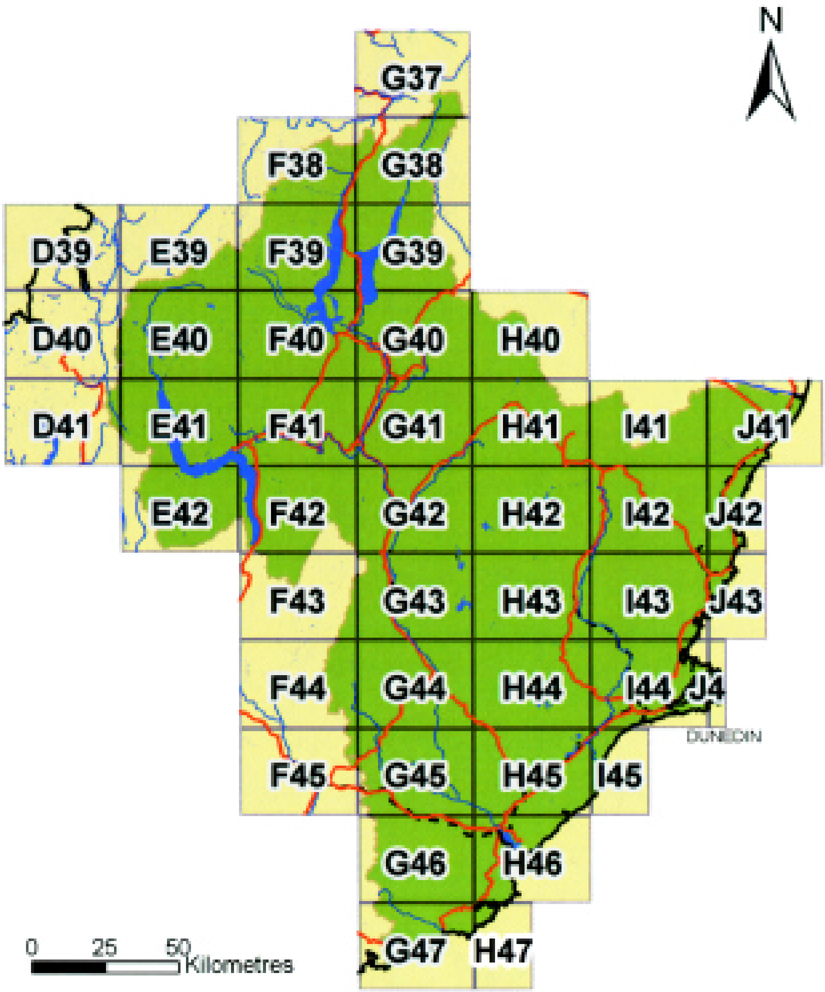

Figure 1. NZMS260 1:50,000 map sheets covering the Otago Region (see Overview map on CDROM).

Table 3: Mapped climate parameters

Climate parameter	Period	Percentile	Scale
Rainfall total	Ann, Sum, Aut, Win, Spr, SO, ND, JF, MA	20th, 50th, 80th	1:50,000
Number of days of rain (rainfall > 1 mm)	Ann, Sum, Aut, Win, Spr	50th	1:50,000
Maximum 24-hour rainfall total	Sum, Aut, Win, Spr	80th	1:50,000
Air temperature	Ann, Sum, Aut, Win, Spr	50th	1:50,000
Number of days with air temperature > 25 °C	Ann	50th	1:50,000
Growing degree days (base 10 °C)	Ann	20th, 50th	1:50,000
Growing degree days (base 5 °C)	Ann	50th	1:50,000
Frost-free period		50th	1:50,000
Number of frosts in September, October, and November		50th	1:50,000
First frost date		20th	1:50,000
Last frost date		80th	1:50,000
Potential evapotranspiration	SO, ND, JF, MA	50th	1:50,000
Wind speed	Ann	Average	1:50,000
Maximum wind speed	Ann	Average	1:50,000
Solar radiation	Ann, Sum, Aut, Win, Spr	50th	1:50,000
Autumn and winter chilling		20th, 50th	1:50,000
10cm soil temperature	Ann, Sum, Aut, Win, Spr	50th	1:50,000

Ann = Annual (January – December), Sum = Summer (January – March), Aut = Autumn (April – June), Win = Winter (July – September), Spr = Spring (October – December), SO = September – October, ND = November – December, JF = January – February, MA = March – April.
The 20th percentile is the value equalled or exceeded in four-out-of-five years, on average. The 50th percentile is the middle value (also called the median value). The 80th percentile is the value equalled or exceeded in one-out-of-five years, on average.
Wind speed was modelled using a special computer model, the output of which was the average, not the median.
Air temperature measurements 1.3m above the ground were used to derive temperature-related parameters such as growing degree days and winter chilling. Frost parameters refer to air frosts (temperature at 1.3m above the ground is less than 0°C).

General description of the climate variables

The following sections describe what has been mapped for each climate parameter and provide a definition of the parameter in cases of derived variables.

Rainfall and rain days

The median, 20th percentile, and 80th percentile total rainfall is mapped for the year, each season and for the 2-month periods September to October, November to December, January to February, and March to April. The median number of days of rain (a day of rain is counted if the 24-hour rainfall total exceeds 1 mm) is mapped for the year and each season. Lastly, the 80th percentile maximum 24-hour rainfall total is mapped for each season. These maps show the maximum 24-hour rainfall total in any season that is equalled or exceeded only 20% (or one-year-in-five, on average) of the time.

Air temperature

The median seasonal and annual air temperature is mapped for all of Otago. This is the air temperature measured in a standard Stevenson screen at 1.3 m above the ground. The median annual number of days with air temperature greater than 25 °C is also mapped.

Growing degree days

Growing degree days are calculated by subtracting a base temperature from the average daily temperature. Base temperatures of 5 °C (useful for pasture and field crops, e.g. peas) and 10 °C (useful for sub-tropical crops, e.g. grapes) have been mapped. If the average temperature is below the base temperature, the growing degree day value for that day is zero. Daily growing degree day values are added together for the whole year, providing an indication of the energy available for plant growth. The median annual growing degree days have been mapped for both base temperatures, and the 20th percentile annual growing degree days (i.e. the growing degree days in a cold year) have been mapped for the 10 °C base temperature.

Frost

There are two measures of frost: a ground frost and an air (or screen) frost. All the frost maps for growOTAGO® are air frost maps. An air frost occurs when the minimum air temperature measured 1.3 m above the ground falls below 0 °C. The frost parameters that have been mapped are the median length of the frost-free period (i.e. the number of days between the last frost in spring and the first frost in the following autumn), the median number of frosts in each of September, October, and November, the 20th percentile date of the first frost of the year and the 80th percentile date of the last frost of the year.

Potential evapotranspiration

Evapotranspiration is the transfer of water to the atmosphere by evaporation and plant transpiration. Potential evapotranspiration occurs when evapotranspiration is at its maximum, in conditions of unlimited moisture supply. This parameter is calculated using the Priestley-Taylor (1972) method, which calculates the energy available for evapotranspiration from the incoming solar radiation, the albedo (or reflectivity) of a grass surface, the air temperature and the vapour pressure of the air. It also allows for aerodynamic (i.e. wind) effects on evapotranspiration. The median potential evapotranspiration for the 2-month periods September to October, November to December, January to February and March to April is mapped.

Wind speed

The average annual wind speed and the average annual maximum wind speed (i.e. the average of all the annual maximums) have been mapped for all of Otago. These wind speeds are 10-minute averages. Higher speeds occur over smooth surfaces and lower speeds near buildings or trees. Seasonal estimates of the average wind speed and the average maximum wind speed can be made by multiplying the mapped values with the in Table 4.

Note: These multipliers only give estimates of the seasonal wind speeds.

Table 4: Seasonal wind speed multipliers

	Summer	Autumn	Winter	Spring
Average wind speed	1.2	0.9	0.8	1.2
Average maximum wind speed	0.8	0.7	0.8	1.0

Solar radiation

Solar radiation (measured in $MJ/m^2/day$) is the amount of energy received at the ground both directly from the sun and indirectly after it is scattered by clouds and particles in the air. The median annual and seasonal solar radiation has been mapped.

Cool season chilling

Chilling totals are calculated from hourly air temperatures measured 1.3 m above the ground. If the average temperature for any hour is between 0 °C and 7 °C then one hour of chilling is counted. The chilling hours are then accumulated over the 6-month period, April to September, to give a chilling total. The median cool season chilling is mapped and the chilling in a warm year (i.e. the 20^{th} percentile) is also mapped.

Soil temperature

The median temperature of the soil at a depth of 10 cm is mapped for the year and for each season.

Climate map accuracy

The information used in preparing the climate maps includes long-term climate observations in the region, the year's special observations at selected extra sites installed for growOTAGO® and very detailed terrain data.

The models used to map climate variables allow for the calculation of the standard error of the interpolated parameter to be made at the input data locations (i.e. the permanent and temporary climate station locations). This is achieved by a method of omitting each station in turn and re-interpolating the surface. These standard error values were then mapped so that estimates of the standard error could be made for all of Otago. Table 5 shows the ranges of standard errors for each mapped parameter for lowland and upland areas. Standard errors were also calculated from the models used to map solar radiation, wind speed and frost. No estimate of the standard error has been made for snow water equivalent.

Quality checking the climate data

The first step was to carefully quality control the climate observations (both short-term growOTAGO® measurements and long-term climate observations), and correct or discard faulty data. This analysis involves comparing climate elements (such as rainfall) at the short-term growOTAGO® sites with the values from the same season (or year) from neighbouring growOTAGO® sites and from permanent observing sites.

Estimation of long-term values at the temporary climate station locations

Each temporary growOTAGO® climate station (approximately 100 locations had full stations measuring rainfall, air temperature, relative humidity, solar radiation, wind speed, temperature in the grass and soil temperature at 10cm, and around 100 additional locations had temperature-only stations) was operated for a period of a little over one year.

The data from these short-term stations were used to adjust estimates of the long-term climate values at the temporary growOTAGO® sites made from data from the surrounding long-term permanent climate station sites. This lets us adjust for the fact that (for example) the growOTAGO® summer may have been drier than the long-term average. A full description of the methodology used for estimating the long-term values at the temporary growOTAGO® sites is in Sansom and Tait (2003)(p36).

Table 5: Typical standard errors for each climate map

Climate parameter	Lowland areas	Upland areas
Annual rainfall total	30 – 40 mm	70 – 90 mm
Seasonal rainfall total	10 – 20 mm	40 – 50 mm
2-monthly rainfall total	7 – 15 mm	30 – 40 mm
Annual number of rain days	4 – 6 days	8 – 10 days
Seasonal number of rain days	1.5 – 2.5 days	5 – 6 days
Seasonal 24-hour maximum rainfall total	2 – 5 mm	5 – 15 mm
Annual air temperature	0.3 – 0.5 °C	0.3 – 0.5 °C
Seasonal air temperature	0.3 – 0.5 °C	0.3 – 0.5 °C
Annual number of days with temperature > 25 °C	1.5 – 3.5 days	0.5 – 1.0 days
Annual growing degree days (base 10°C)	35 – 45 GDDs	10 – 20 GDDs
Annual growing degree days (base 5°C)	60 – 70 GDDs	30 – 40 GDDs
Frost-free period	26 – 28 days	26 – 28 days
Number of frosts in September, October, and November	0.6 – 0.8	0.6 – 0.8
First and last frost date	10 – 20 days	10 – 20 days
2-monthly potential evapotranspiration	7 – 9 mm	6 – 8 mm
Annual wind speed	4 – 5 km/hr	7 – 8 km/hr
Annual maximum wind speed	15 – 18 km/hr	30 – 35 km/hr
Annual solar radiation	0.6 – 1.0 MJ/m^2/day	0.6 – 1.0 MJ/m^2/day
Seasonal solar radiation	0.6 – 1.0 MJ/m^2/day	0.6 – 1.0 MJ/m^2/day
Cool season chilling	65 – 80 hours	90 – 110 hours
Annual soil temperature	0.4 – 0.6 °C	0.4 – 0.6 °C
Seasonal soil temperature	0.4 – 0.6 °C	0.4 – 0.6 °C

Soil parameters mapped by growOTAGO®

General description of the regional single attribute maps (mapped at 1:500000 Scale)

Drainage

Profile drainage indicates how long a soil profile is saturated with water and consequently unable to supply plant roots with sufficient free oxygen, and how quickly it can rid itself of excess water. For example, in well-drained soils the water is removed readily, while in poorly drained soils the root zone is waterlogged for long periods unless artificially drained. The five drainage classes depicted are described in the following table.

Table 6: Description of profile drainage classes

Map colour	Drainage Class	Estimated duration of limited
Light yellow	Well drained	Adequate aeration all year
Yellow	Moderately well drained	Adequate aeration all year except winter at depths usually below 0.6 m and generally below 0.9 m
Green	Imperfectly drained	Aeration limitations in upper 0.3 to 0.6 m for <6 months during winter, part spring and part autumn
Light blue	Poorly drained	Potentially anaerobic for 6-10 months in most of the upper 0.3 to 0.6 m layer
Dark blue	Very poorly drained	Anaerobic throughout for most of the year

Profile readily available water (PRAW)

Profile readily available water or PRAW is the amount of water held in a soil that can be easily extracted by plant roots, within the potential rooting depth. PRAW is measured as the water that can be extracted between field capacity (-10kPa) and permanent wilting point (-1500kPa) to 0.4 m depth, and between -10kPa and -100kPa at 0.4 to 0.9 m depth. For the Otago soils PRAW is assessed, where available, on laboratory-measured volumetric water content, but is predominantly estimated by using pedotransfer functions of Giltrap developed from the National Soils Database. (*Giltrap D.J. 2002 Pedo-transfer functions for moisture porosity and bulk density. Unpublished Landcare research report*)

Table 7: Description of profile readily available water classes

Map colour	Class	PRAW (mm)
Green	Very high	> 150
Light green	High	100 – 150
Yellow	Moderately high	75 – 100
Light yellow	Moderate	50 – 75
Orange	Low	25 – 50
Red	Very low	< 25

Fertility - natural soil fertility

Soil fertility refers to the ability of a soil to supply a balance of nutrients to plants. Such relationships are traditionally approximated as soil nutrient 'fertility' analysis of the labile pool of soil nutrients, e.g. MAF 'quick tests'. Such soil nutrient 'fertility' is transient, strongly management-dependent and unsuitable for a regional representation of natural soil fertility. Combinations of minimum soil pH (0.2–0.6m), cation exchange capacity (0–0.6m) and phosphate retention (0–0.2 m) have been used to provide a general measure of natural soil fertility as they represent the non-labile nutrient 'pools' that are considered to be less dependent on management, more dependent on soil type and better represent the long term fertility.

Derivation of the soil maps (1:50000)

The aim of the growOTAGO® soil maps is to provide a 1:50,000 soil map coverage for the region. These soil maps are a compilation of a large number of published soil maps together with additional soil surveys undertaken during 2001–2003. During the compilation a number of previous soil series have been merged to provide a uniform coverage of soil series. Some simplification and loss of detail were necessary where very detailed soil maps were available. A regionally correlated and rationalised soil legend is provided for the lowlands (Carrick *et al.*, 2003), while the existing soil set nomenclature (New Zealand Soil Bureau, 1968) has been used for the uplands. Soil series distinguish soil properties that have a major influence on land management or land use.

The 1:50,000 soil maps may be used to help determine whether more detailed mapping is required to assist in decision-making. The terrain of the Otago region ranges from rugged, steep mountain lands and high upland plateaus where existing detail on soils is poor, to gently undulating lowland valley floors and down lands where detail is better but patchy. To accommodate this wide range of terrain and the patchy distribution in the amount of existing detailed soil mapping, two different approaches to presenting the 1:50,000 soil coverage have been adopted.

Soil coverage of the Lowlands

DSIR Soil Bureau, latterly DSIR Land Resources, had mapped much of the flat to easy rolling land on the valley floors, in the inland Central Otago basins and the North Otago downlands prior to 1992 at scales ranging from 1:7,960 to 1:126,720 (see Appendix). The areas where detailed soil mapping was available were field checked, the soils were correlated across the entire Otago region, inclusive of the growOTAGO® funded work, and the mapping units rationalised for presentation at the 1:50,000 map scale. Correlation was necessary because previous soil surveys had been carried out by a number of pedologists with different objectives over a wide time frame in which there has been significant advances in our understanding of soils, their properties and behaviour.

Lowland areas lacking detailed soil mapping have been surveyed at 1:50,000 scale as part of the growOTAGO® project during 2001-2003. Extensive use was made of aerial photographs to identify and map landforms. Soil landscape models derived from the earlier work were extended and field observations, including some more detailed 1:25,000 scale mapping funded by the Dunedin Rural Development Inc., were utilised.

Soil types were mapped according to differences in their New Zealand Soil Classification (NZSC, Hewitt 1998). In the lowland areas a new name was assigned where a different NZSC class was identified. Where possible, soil names were based on those previously identified in earlier surveys. Soil names were changed or new soil names were assigned where:

- the same soil name may have been used in different soil surveys to identify different soil types
- different soil names may have been used to identify the same soil type
- a soil type may not have been previously identified.

Lowland soil series are depicted by codes unique to the growOTAGO® soil maps and begin with letters.

Soil coverage of the Uplands

Where detailed soil mapping in the uplands existed, these areas were simplified to 1:50,000 scale, e.g. Otago Peninsula (Leslie, 1976), Waipori Farm Settlement (Hewitt, 1982). Soil series recognised in areas of detailed uplands soil mapping have been included in the regional lowland soils legend (Carrick *et al.*, 2003), and are depicted by codes beginning with letters. To further assist in distinguishing these areas on the soil maps they are also depicted by the lowland colour shades.

For the balance of the upland hill and mountain lands, the New Zealand Land Resource Inventory (NZLRI), (National Water and Soil Conservation Organisation 1975-79) interpretation of the 4-mile soil set coverage has been used. The NZLRI soil boundaries provide a 1:63,360 scale interpretations of soils and landforms. This coverage has been overlain on a 1:50,000 scale digital terrain model allowing the texture, aspect and grain of the hill and mountain lands to be readily visualised through the soil layer.

The upland soils are depicted by codes beginning with numbers, which are the same as those used for the soil sets of the General Survey of the soils of South Island, New Zealand (New Zealand Soil Bureau 1968).

Understanding the 1:50,000 soil maps

Soil classification and soil map colours

Both the upland and lowland soils are depicted on the soil maps using standard sets of colours. Soils have been coloured according to their classification at the Order and Group levels of the NZSC (Hewitt, 1998). To distinguish the detailed upland (an extensive region of relatively high land, usually distant from the coast) and lowland (low-lying land, often near the coast, usually <450 m asl) surveys from the more generalised uplands survey, different colour shades have been used.

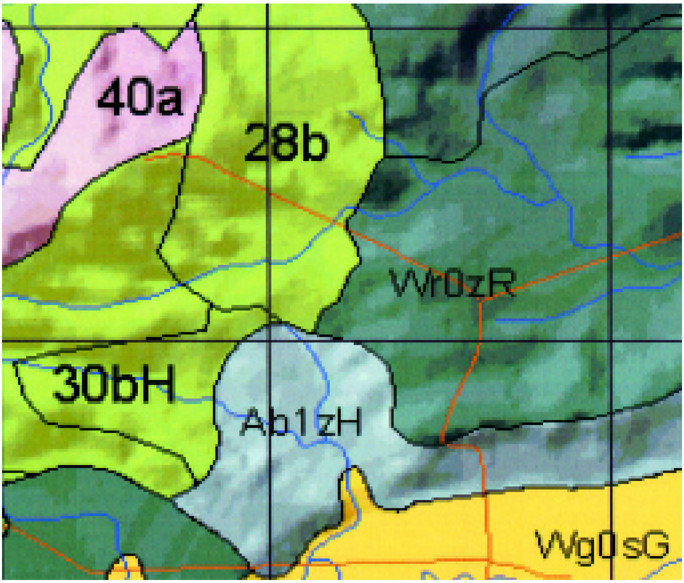

Figure 2. Part of soil map I42, Waikouaiti showing the upland soils coded by numbers (28b Warepa soils, 30bH Abbotsford Hill soils, and 40a Taratu soils), and the lowland soil series coded by letters (Wr0sG Warepa deep silt loam rolling, Ab1zH Abbotsford moderately deep silt loam hilly, and Wg0sG Wingatui deep sandy loam gently undulating).

Table 8: Explanation of the growOTAGO® soil map colouring scheme

Map colour	Soil order and explanation of the key concepts of the order
Orange	Anthropic soils – soils disturbed/created by man e.g. as a result of mining activity.
Brown	Brown soils – have yellowish brown subsoils, stable well structured topsoils, are well to imperfectly drained, with low to moderate fertility and are generally drought free.
Grey	Melanic soils – have high fertility, dark, well structured topsoils, and are associated with lime-rich rocks or dark (basic) volcanic rocks.
Blue	Gley soils – are saturated by water for prolonged periods and have pale greyish subsoils, originally wetlands.
Dark Blue	Organic soils – formed from partly decomposed plant materials (peat), are strongly acidic and have high water tables.
Green	Pallic soils – have pale coloured high bulk density subsoils, weak structure, are slowly permeable and have limited rooting depths. They are dry in summer and wet in winter.
Yellow	Recent soils – formed in young sediments. Have a distinct topsoil, but weakly developed subsoils, with moderate to high fertility and are well to imperfectly drained. They have widely variable rooting depths and water storage capacities.
Pink	Semiarid soils – are dry for most of growing season, with moderate to high natural fertility, and are well to imperfectly drained. They are fragile with weak soil structure, and very low organic matter.
Light Pink	Allophanic soils – dominated by allophanic minerals that maintain a porous, low bulk density structure with weak strength. They have stable topsoil structure and high phosphate retention.
Light Yellow	Raw soils – are very young soils lacking distinct topsoil, on active sites of deposition or erosion.
Purple	Podzol soils – they occur in high rainfall areas, are strongly acid and strongly leached, with very low fertility. Drainage is variable from well to poorly drained.

Lowland soil legend

Interpreting lowland soil symbols

On the growOTAGO® soil maps the abbreviated soil symbols used for the lowland and upland areas with existing detailed mapping have four components. The first two letters (e.g. **Gd**) represent the soil name and can be identified by reference to the lowland soil legend, arranged by landform, parent materials, age and soil depth on the left hand side of the map sheet. The following number (**0, 1, 2, 3,** or **4**) denotes the depth of the soil profile. The following lower-case letter or combination of letters separated by a back slash represent the fine earth texture of the soil in stratigraphic sequence down the profile. The following upper-case letter (**G, H, R, S,** or **U**) denotes the slope or topography of the land. In some cases there is an additional ^ and upper-case letter or combination of letters that denote extra information defined as a phase or 'variant'.

For example: **Gd0zU^M** = Gladbrook deep silt loam, undulating, mottled phase.

Soil Depth

On fans, terraces and floodplains soil depth has been used to group soil series. Deep soils are those with >45 cm of fine alluvium (<2 mm diameter) or loess above gravel or bedrock. Shallow soils are those with <45 cm of fine alluvium or loess above gravel or bedrock.

Soil texture

Soil texture is a function of the relative proportions of particles of different size ranges (sand, silt or clay) present in the fine earth fraction (<2 mm) of the soil. Particles coarser than 2 mm are classed as *gravel*. Soil texture is usually described as a class determined from a standard texture triangle. The most common soil texture in Otago soils is silt loam. A silt loam contains greater than 40% silt and 18-35% clay.

Slope

Soils in the growOTAGO® survey are assigned to one of five slope phases according to the slope angle of the landscape on which they are located:

- G = Gently undulating (0–3°)
- U = Undulating (4–7°)
- R = Rolling (8–15°)
- H = Hilly (16–25°)
- S = Steep (>25°).

Soil phase

Soil phases represent minor variations in the soil type. While these variations are expressed on the soil map, they are not considered to have a significant difference in overall soil properties sufficient to justify a new soil series. The soil is recorded as a phase/variant because either:

- it does not occupy a significant area in its own right (usually less than 200 hectares) or
- the soil properties that vary are not those used in the soil classification.

Upland soils

The upland soils are depicted by codes beginning with numbers, which are the same as those used for the soil sets of the General Survey of the soils of South Island, New Zealand (New Zealand Soil Bureau 1968), e.g. 41b, Silver Peaks Steepland soils. Further information on the parent materials, native vegetation, topography rainfall and a representative profile etc is contained in Soil Bureau Bulletin 27 (New Zealand Soil Bureau 1968).

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Appendix

A catalogue of existing soil mapping and map scales, used to compile each map sheet of the Topographic 260 series and used for the growOTAGO® soil maps.

Topomap 260 series

Sheet	Sheet name	Data sources	Original mapping scale
D40	Milford	Lowlands: NZ Soil Bureau 1968	1:253 440
		Uplands: NZ Soil Bureau 1968	1:253 440
D41	Eglington	Lowlands: NZ Soil Bureau 1968	1:253 440
		Uplands: NZ Soil Bureau 1968	1:253 440
E39	Aspiring	Lowlands: NZ Soil Bureau 1968	1:253 440
		Uplands: NZ Soil Bureau 1968	1:253 440
E40	Earnslaw	Lowlands: Lynn & Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
E41	Queenstown	Lowlands: Lynn & Carrick 2003a	1:50 000
		McIntosh et al 1996	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
E42	Walter Peak	Lowlands: NZ Soil Bureau 1968	1:253 440
		Uplands: NZ Soil Bureau 1968	1:253 440
F38	Wilkin	Lowlands: Lynn & Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
F39	Matukituki	Lowlands: Lynn & Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440

F40	Wanaka	Lowlands: Leamy et al 1967	1:31 680
		Lynn & Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
F41	Arrowtown	Lowlands: McCraw 1957	1:7 920
		Leamy et al 1967	1:31 680
		Beecroft 1985	1:15 000
		McIntosh et al 1996	1:50 000
		Lynn & Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
F42	Kingston	Lowlands: Beecroft 1985	1:15 000
		McIntosh et al 1996	1:50 000
		Lynn & Carrick 2003b	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
F43	Garvie	Lowlands: Lynn & Carrick 2003b	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
F44	Waikaia	Lowlands: Bruce et al 2001	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
F45	Gore	Lowlands: Bruce et al 2001	1:50 000
		NZ Soil Bureau 1968	1:253 440
G37	Landsborough	Lowlands: NZ Soil Bureau 1968	1:253 440
		Uplands: NZ Soil Bureau 1968	1:253 440
G38	Haast Pass	Lowlands: Lynn & Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
G39	Lake Hawea	Uplands: NZ Soil Bureau 1968	1:253 440
G40	Lindis	Lowlands: Leamy et al 1967	1:31 680
		Uplands: NZ Soil Bureau 1968	1:253 440

G41	Cromwell	Lowlands: Leamy et al 1967	1:31 680
		Beecroft 1985	1:15 000
		Orbell 1974	1:31 680
		Lynn 2002	1:50 000
		McCraw 1966a	1:31 680
		Uplands: NZ Soil Bureau 1968	1:253 440
G42	Alexandra	Lowlands: Beecroft 1985	1:15 000
		Orbell 1974	1:31 680
		McCraw 1964	1:15 840
		McCraw 1966a	1:31 680
		Leamy & Wilde 1971a	1: 63 360
		Uplands: NZ Soil Bureau 1968	1:253 440
G43	Roxburgh	Lowlands: Leamy & Wilde 1971a	1:63 360
		Hewitt 1983	1:25 000
		McCraw 1956	1:15 840
		Uplands: NZ Soil Bureau 1968	1:253 440
G44	Beaumont	Lowlands: Hewitt 1983	1:25 000
		Carrick 2002b	1:50 000
		Eyre et al. 1998	1:50 000
		Taylor et al. 1999	1:50 000
		Bruce et al. 2001	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
G45	Tapanui	Lowlands: Carrick 2002b	1:50 000
		Carrick 2003b	1:50 000
		Eyre et al. 2001	1:50 000
		Galloway et al. 2000	1:50 000
		Taylor et al. 1999	1:50 000
		Bruce et al. 2001	1:50 000
		Alexandra et al 2001	1:50 000
		Uplands: Kennedy 1983	1:100 000
		NZ Soil Bureau 1968	1:253 440

G46	Clinton	Lowlands: Galloway	1: 50 000
		Carrick 2003b	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
G47	Tautuku	Uplands: NZ Soil Bureau 1968	1:253 440
H39	Omarama	Uplands: NZ Soil Bureau 1968	1:253 440
H40	Otemetata	Lowlands: Lynn 2002	1:50 000
		McIntosh et al 1985	1:25 000
		Uplands: NZ Soil Bureau 1968	1:253 440
H41	Ranfurly	Lowlands: Orbell 1974	1:31 680
		McCraw 1966a	1:31 680
		Raeside et al 1966	1:31 680
		Lynn 2002	1:50 000
		Carrick 2003a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
H42	Waipiata	Lowlands: McCraw 1966a	1:31 680
		Raeside et al 1966	1:31 680
		Lynn and Carrick 2002	1:25 000
		Uplands: NZ Soil Bureau 1968	1:253 440
H43	Middlemarch	Lowlands: Lynn and Carrick 2002	1: 25 000
		Raeside 1962	1: 63 360
		Uplands: NZ Soil Bureau 1968	1:253 440
H44	Lawrence	Lowlands: Carrick 2002b	1:50 000
		Carrick et al 2002	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
		Hewitt 1981	1:50 000
		Ragg et al 1973	1:63 360
		Kennedy 1983	1:100 000

H45	Milton	Lowlands: Carrick et al 2002	1:25 000
		Carrick 2002b	1:50 000
		Carrick 2003b	1:50 000
		Uplands: Kennedy 1983	1:100 000
		Wright et al 1952	1:63 360
		Kennedy 1983	1:100 000
		NZ Soil Bureau 1968	1:253 440
H46	Balclutha	Lowlands: Carrick 2003b	1:50 000
		Cutler et al 1952	1:63 360
		Kennedy 1983	1:100 000
		Uplands: NZ Soil Bureau 1968	1:253 440
		Kennedy 1983	1:100 000
		Wright et al 1952	1: 63 360
H47	Hinahina	Uplands: NZ Soil Bureau 1968	1:253 440
I41	Danseys Pass	Lowlands: Kear et al 1967	1:126 720
		Carrick 2003a	1:50 000
		Webb 2002	1:50 000
		Wilson 1979	1:20 000
		Uplands: NZ Soil Bureau 1968	1:253 440
I42	Dunback	Lowlands: Carrick 2002a	1:50 000
		Carrick 2003a	1:50 000
		Webb 2002	1:50 000
		Lynn & Carrick 2002	1:25 000
		Uplands: NZ Soil Bureau 1968	1:253 440
I43	Waikouaiti	Lowlands: Carrick 2002a	1:50 000
		Lynn & Carrick 2002	1:25 000
		Campbell 1971	1:63 360
		Uplands: NZ Soil Bureau 1968	1:253 440

I/J44	Dunedin	Lowlands: Campbell 1971	1:63 360
		Beecroft et al 1992	1:10 000
		Carrick et al 2002	1:25 000
		Uplands: Tomlinson et al 1978	1:31 680
		Leslie & Kennedy 1977	1:15 840
		Campbell 1971	1:63 360
		McIntosh 1985	1:10 000
		Wright et al 1952	1:63 360
		Ragg et al 1978	1:63 360
		NZ Soil Bureau 1968	1:253 440
I45	Taieri Mouth	Lowlands: Carrick et al 2002	1:25 000
		Wright et al 1952	1:63 360
		Kennedy 1983	1:100 000
J141	Oamaru	Lowlands: Kear et al 1967	1:126 720
		Wilson et al 1979	1:20 000
		Webb 2002	1:50 000
J42	Hampden	Lowlands: Kear et al 1967	1:126 720
		Webb 2002	1:50 000
		Carrick 2002a	1:50 000
		Uplands: NZ Soil Bureau 1968	1:253 440
J43	Palmerston	Lowlands: Carrick 2002a	1:50 000
		Camphill 1971	1:50 000
		Uplands: Kear et al 1967	1:126 720
		NZ Soil Bureau 1968	1:253 440

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8.1. The User acknowledges that the software belongs to ORC and agrees to observe absolute confidentiality with respect to all aspects of the software.

8.2. The User acknowledges that in the course of its relationship with ORC it may have access to, or otherwise come into possession of information in respect of the organisation, business and finances of ORC and its dealings, transactions and affairs, all of which information is or may be confidential information.

8.3. The User will not, except as is necessary or required to fulfill its duties under this agreement, without the written consent of ORC, use or attempt to use, for its own purpose or for any purpose other than that of ORC or divulge or disclose to any person, any confidential information of ORC. The User will also use its best endeavours to prevent the unauthorised publication or disclosure of any confidential information relating to ORC.

9. Warranty

9.1. ORC warrants that for a period of 30 days from the date of receipt, the software, unless modified by the User, will perform substantially the functions specified.

9.2. If the User gives written notice to ORC during the warranty period that the software does not substantially perform the functions described in the software operating specifications and user manuals, ORC will, at its sole discretion, either: use its best endeavours to attempt to make the software operate as warranted by providing a correction; or replace the software; or allow the User to return the software and terminate this agreement in exchange for a full refund of any licence fees paid.

10. Consumer Guarantees Act

The Consumer Guarantees Act 1993 applies to the terms of this licence unless the User has held itself out as acquiring the software for the purpose of a business in terms of section 43(2) of the Consumer Guarantees Act 1993, in which case the User and ORC agree the terms of the Consumer Guarantees Act 1993 do not apply to this licence agreement.

11. Limitation of Liability

11.1. Except as expressly provided to the contrary in this agreement, all terms, conditions, warranties, undertakings, inducements or representations whether express, implied, statutory or otherwise relating in any way to the software program or to this agreement are excluded.

11.2. Where any Act of Parliament implies in this agreement any term, condition or warranty, and that Act avoids or prohibits provisions in a contract excluding or modifying the application of or exercise of, or liability under such term, condition or warranty, such term, condition or warranty shall be deemed to be included in this agreement.

11.3. Subject to clause 9, ORC does not warrant that the functions contained in the software will meet the User's requirements or that the operation of the software will be uninterrupted or error free.

11.4. In no circumstances shall ORC be under any liability to the User, or any other person whatsoever, for any indirect or consequential damage arising out of or in connection with any use or inability of using the software.

11.5. Without limiting clauses 11.1 – 11.2, ORC's liability in damages for losses (whether direct or indirect) arising out of any failure or alleged failure of the software or in accordance with any warranty or representation made by ORC will be limited to the value of the consideration (if any) paid by the User to ORC for the grant of this licence.

12. Entire Agreement

12.1. This Agreement constitutes the entire Agreement between the parties in relation to the subject matter of this Agreement. Any prior arrangement, agreements, representations or undertakings are expressly superseded and extinguished.

12.2. This Agreement may only be amended in writing signed by the parties.

12.3. In the event of any inconsistency between the provisions of this Agreement and any other document, including, without limitation, any terms and conditions contained on invoices, statements or shipping documents, the provisions of this Agreement shall prevail.

13. Assignment

13.1. This agreement may not be assigned, sub-licensed or otherwise transferred by the User without the consent of ORC.

14. Resolving Disputes

14.1. Any dispute, controversy or claim arising out of or concerning this agreement shall be referred to a single arbitrator agreed upon by both parties, or failing such agreement, to an arbitrator nominated by the President of the Canterbury District Law Society. The arbitrator shall resolve the dispute in accordance with the provisions of the Arbitration Act 1996.

14.2. The parties agree that any decision made by the arbitrator shall be binding on the parties and that the parties waive their respective rights to pursue the matter in any court or tribunal except for the purpose of enforcing the decision of the arbitrator.

14.3. The parties agree that all costs and expenses of arbitration shall be borne in accordance with the decision of the arbitrator.

15. Miscellaneous Provisions

15.1. The terms of this agreement will be governed by the laws of New Zealand and the User agrees to submit to the jurisdiction of the New Zealand courts to consider and determine any claim, dispute or issue arising out of or relating to this agreement.

15.2. If any provision of this agreement shall be deemed to be invalid, illegal or unenforceable the validity, legality and enforceability of the remaining portions of this agreement shall not be affected or impaired.

15.3. ORC will not be deemed to have waived any rights under this Agreement unless the waiver is express, in writing and signed on behalf of that party by an authorised signatory of ORC. Any such waiver will not constitute a waiver of any subsequent or continuing right or of any other provision in this Agreement. A failure to exercise or delay in exercising any right under this Agreement will not operate as a waiver of this right.

15.4. The User acknowledges that it has read this agreement, understands it and agrees to be bound by its terms and conditions.