

**South Island Pastoral Lease Land Tenure Review:
An Interim Vegetation Cover Map**

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Summary

Project and Client

This report accompanies a map of the vegetative cover of the South Island high country, prepared in November/December 2003 by Landcare Research, Palmerston North. The map is based on existing digital databases and is intended for use as background information to the land tenure review of pastoral leases, by Land Information New Zealand.

Objectives

- Prepare a broad-scale vegetation cover map of the South Island high country using the best available existing map data (including LCDB1, NZLRI and the Vegetation Cover Map of New Zealand), as an interim map pending completion of the Land Cover Database version 2 in 2004.
- Generate from the map summary tables of vegetation cover with the high country and within the total pastoral lease lands by altitude zone, by historic production lease groupings, and LENZ environments.

Emphasis in this report and map is on provision of information about vegetation cover, rather than analysis or interpretation of such information for tenure review.

Statement of limitation

This map has been prepared from sources first compiled as early as the 1950s. There have been many areas of vegetation change that are not shown on this map. This map is an interim solution pending completion of Land Cover Database 2 proposed for 2004.

Methods

The vegetation map was prepared from five sets of spatial data relating to the vegetative cover of the South Island: Land Cover Database 1; the New Zealand Land Resource Inventory; InfoMap 260; the Vegetative Cover map of New Zealand; and Forest Service Mapping Series 6 – Forest Class Maps.

As it was recognised that none of these datasets alone are suitable for the detailed description of the vegetative cover the aim for this interim map was to combine the strengths of each of them.

The datasets were combined in a rule-based process of evidential reasoning to derive a best approximation of vegetative cover. The map was compiled for the area of the South Island high country defined by the a generalised high country boundary.

Area tables were calculated for areas within the RFT boundary and for areas within the pastoral leases. Within the pastoral lease lands, areas were calculated for three altitude zones (<900 m; 900 to 1200 m; and >1200 m); a grouping of high country properties based on broad regional and rainfall zones; and Level 1 Land Environments of New Zealand categories.

Results

Vegetation and non-vegetated areas were classified into twenty classes. Map data show that

tall tussock and short tussock and associated grasslands comprise 31% and 34.9% of the total area of pastoral lease lands respectively. Unvegetated land, comprising alpine rock and scree, covered 10% of the area.

We note that because only the dominant vegetation cover (i.e., that covering the greatest area) in each area was recorded, minor vegetation components are under-represented in the area tables and on the map. The age of the input data layers is a further limitation of the map, with areas of vegetation change in the intervening years.

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1. Introduction

This report documents a study of vegetative cover in pastoral lease lands in the high country of the South Island, New Zealand. The 'pastoral high country' is land characterised by large properties situated at high altitudes with extensive grazing, and which are subjected to severe weather hazards. The term 'high country' defies classification by simple numerical characteristics such as minimum altitude, property size or flock proportions. The high country regional boundary has been traditionally drawn to include all runs (properties) with broadly similar climate, topography and stock policy to the New Zealand Meat and Wool Boards' Economic Services 33 sample runs of their Class 1 and 2s (Ward 1960). Temperature and soil moisture are major limitations to production within the pastoral high country. Growing seasons are short; frost frequency is high in all seasons, and temperature constraints increase significantly with altitude. Currently we are using a Rural Futures Trust (RFT) boundary clipped to the Main Divide to encompass such land and set the context of the study. The boundaries of the 304 leases were supplied to Landcare Research by the Department of Conservation on 23/11/03.

2. Vegetative cover information sources

Five data sets containing vegetation/land cover information were used for this study. All have national coverage but none are ideally suited to the detailed description of current vegetative cover. We have used the five data sets in combination using a rule-based process of evidential reasoning to derive our best approximation of vegetative cover for the study area.

2.1 The New Zealand Land Cover Database (LCDB)

The LCDB (MfE 2000) is a national database of land cover derived from visual interpretation of mainly SPOT 2 and SPOT 3 satellite imagery recorded during the New Zealand summer of 1996/97. To date this survey has achieved national coverage in its first edition (LCDB1). A second edition is currently in preparation, and future editions are planned at 5-year intervals. A minimum map unit size of 1 Ha is claimed, with a mapping accuracy of 92%. The survey maps to a classification of 16 classes (10 vegetative and 6 non-vegetative).

The advantages of the vegetation cover information in the LCDB are:

- Spatial resolution
- Currency.

The main disadvantages are:

- Poor thematic resolution
- Sometimes questionable accuracy.

Being geographically comprehensive, relatively current of good spatial resolution, but lacking thematic detail, the LCDB contributed most of the primary vegetative cover boundaries and provided default classifications in the areas where vegetative cover could not be determined using other databases.

2.2 The New Zealand Land Resource Inventory (NZLRI)

The New Zealand Land Resource Inventory (NWASCO, 1975–79) contains an inventory of 5 physical factors controlling land use—rock type, soil, slope, erosion type and severity, and vegetation cover. The associated Land Use Capability classification is an assessment of the land's capacity for sustained productive use, taking into account physical limitations, soil conservation needs and management requirements.

Vegetation cover is recorded within largely physiographic land units as an inventory of vegetation components recorded in descending order of prominence. The minimum map unit (mmu) size is nominally 40–60 ha. Mapping for the bulk of the South Island dates from the mid, to late 1970s. The catchments of the Awatere, Wairau and Clarence rivers were remapped in the period 1989–92 to a higher spatial resolution (mmu 10 Ha) and in greater thematic detail.

The advantages of the vegetation cover information in the NZLRI are:

Thematic resolution. The NZLRI recognises about 50 vegetation cover classes and has the capacity to record up to 5 classes per map unit

The NZLRI was validated by field verification.

The main disadvantages are:

It is seldom possible to resolve detailed boundaries between vegetation classes due to the primarily physiographic definition of the polygon and to the inventory style of the vegetation recording

With most mapping dating from the 1970s, the currency of the vegetation record is questionable in areas of change.

Being geographically comprehensive and with good thematic resolution, the NZLRI was used to provide evidence for the classification of the vegetative cover in polygons delineated by LCDB.

2.3 Infomap 260 (1:50 000 scale) digital topographic database (Topo50)

The Topo50 (LINZ 1985–2002) represents all features recorded on the 1:50 000 scale topographic maps published by New Zealand's national mapping agency, Land Information New Zealand (LINZ). These data are derived photogrammetrically from stereo aerial photographs supplemented with historic records, field verification and, in recent years, from satellite imagery.

Positional accuracy of features in the Topo50 can be expected to equate to, or surpass, those of the other databases used, except where geographic separation has been cartographically imposed to improve legibility of adjacent features such as roads, railways and coastlines.

The Topo50 has national coverage of over 150 thematic layers, 11 of which were used in this classification. The selected themes are primarily hydrological (rivers, lakes, ponds, swamps, etc.), and those of the 'barren environments' (scree, shingle, sand, rock, snow/ice, etc.), but include intensive land uses not always well delineated by other layers, notably orchards and vineyards.

he main advantages of Topo50 are:
Excellent positional accuracy
Delineation of features not well described by other databases.

The Topo50 database was used to tighten the definition of vegetative cover classes in areas of weakness in other databases, notably water bodies, bare ground and horticultural land.

2.4 Vegetative Cover Map of New Zealand (VCM)

The VCM (Newsome 1987) is a vegetation map compiled between 1981 and 1986 for publication at a scale of 1:1 000 000. It compiled its information from a variety of sources including the NZLRI, vegetation maps, forestry plans, and extensive field verification both from the ground and the air.

Vegetative cover is recorded from a classification of 49 communities with elaboration from a further 9 vegetation elements. The minimum map unit size is approximately 500 ha. Mapping for the bulk of the South Island dates from 1983–85.

The advantages of the vegetation cover information in the NZLRI are:
Good thematic resolution
The VCM is validated by field verification.

The main disadvantages are:
Poor spatial resolution
With mapping dating from the mid-1980s, the currency of the vegetation record is questionable in areas of change.

Being geographically comprehensive, with good thematic resolution but poor spatial resolution, the VCM was mainly used to reinforce or qualify other sources of evidence for the classification of the vegetative cover in polygons delineated by LCDB.

2.5 Forest Service Mapping Series 6 – Forest Class Maps (FSMS6)

The FSMS6 maps (NZFS 1970–79) were compiled during the 1970s for publication at a scale of 1:250 000. Their information is based on a variety of sources including most prominently the National Forest Survey of New Zealand (Masters et al 1957) and the ecological surveys that followed. This database describes only indigenous forest (a term that includes all woody communities above 6 m in height).

Forests are described from a classification of 18 associations. The minimum map unit (mmu) size is not documented but is probably about 20 ha.

The advantages of the vegetation cover information in the FSMS6 are:
Good thematic resolution for indigenous forest
Reasonable spatial resolution.

The main disadvantages are:
Poor temporal resolution – source data may be as old as 50 years
Poor locational precision.

The FSMS6 was mainly used to reinforce or qualify other sources of evidence for the classification of indigenous forest.

3. Vegetative cover mapping

3.1 Approach

All the databases described in the previous section contain boundaries and descriptions relating to vegetation. However, each database has its own strengths and weaknesses in regard to compiling a map of contemporary vegetative cover.

We sought therefore to combine the strengths of each database while attempting to subdue their weaknesses, as follows:

- LCDB: we relied on its relative currency and its boundary resolution for broad vegetative structural groups (forest, scrub, pasture, tussock, etc.)
- NZLRI: we relied on its ability to identify the vegetative cover class within the vegetative group delineated by the LCDB and sometimes to alter the LCDB group where indicated by the weight of evidence.
- VCM: we relied on its ability to support or clarify the vegetative cover class evidence presented by the NZLRI/LCDB.
- Topo50: we relied on its spatial precision and ability to delineate particular features not always well distinguished by other databases (e.g., bare ground).
- FSMS6: we relied on its ability to support or clarify the vegetative cover class evidence for indigenous forests and scrub presented by the NZLRI/VCM/LCDB.

3.2 The database integration process

Because of the complexity of the classification process and the potential volume of data represented by the combined LCDB, NZLRI, VCM, Topo50 and FSMS6 databases, integration was a stepwise process as outlined below and illustrated in Figure 1.

- First, we reclassified the basic LCDB classes to as close an approximation of our desired vegetative cover classes as was possible. Though we intended to improve on this layer, we needed to have it as a contingency in case other databases were unable to elucidate the vegetative cover. Conceptually, this is the lowermost layer in Figure 1.
- Secondly, subdivisional classification was both practical and desirable in four LCDB vegetative structural groups: Primarily Pasture, Tussock, Scrub and, Indigenous Forest. These were classified individually first. This involved extracting these groups from the LCDB and then intersecting each with the NZLRI, FSMS6 and VCM. The classification of each group began with the hypothesis that the vegetative group description was true and thence sought to infer the nature of the component vegetative cover class from the evidence contained in the NZLRI, FSMS6 and VCM. Rules were defined to guide the decision-making process. Orthophotographs (2.5m pixel size, panchromatic) downloaded from the LINZ website were occasionally used to help determine appropriate rules for particular situations. In most cases this resulted in a reasonable inference of vegetative

cover class within the hypothesised group. In some cases the evidence prompted a shift to another group (pasture to tussock for example), and in other cases reconciliation between conflicting layers of evidence was difficult. In the latter instance we either inferred a probable vegetative cover class from associated vegetations or allowed the polygon to default to the original LCDB vegetative cover group. Conceptually, this process contributes the Tussockland, Pastureland, Scrub, and Forest layers in Figure 1.

- Third, refinements were possible in the delineation of wetlands, horticulture and unvegetated areas through the inclusion of selected layers from the Topo50 database. Conceptually, this process contributes the uppermost five layers in Figure 1.
- Finally, the 10 intermediate layers produced in the preceding steps were combined in strict order so that each successive layer contributed degrees of refinement to the layers below, (the lowermost layer being the basic LCDB). The end product of this step is our comprehensive, improved vegetative cover layer for the study area.

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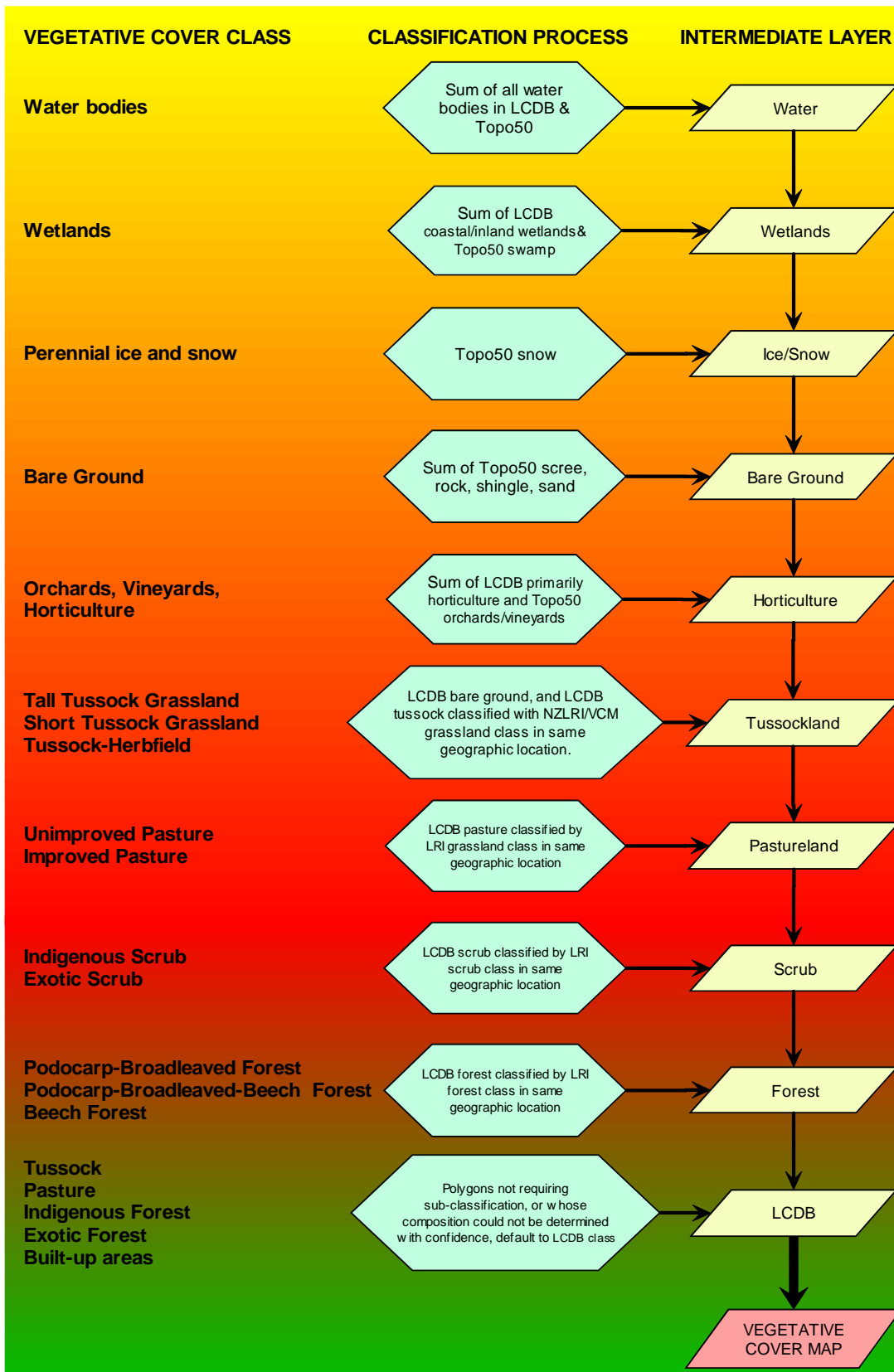


Figure 1. Conceptual flow diagram of the database integration process. Background colour indicates the respective influence of descriptors from the LCDB (green), NZLRI/FSMS6/VCM (red) and Topo50 (yellow) on the vegetative cover classification

4. The Vegetative cover classification

The vegetative cover class definitions generally align with conventions established by the Vegetative Cover Map of New Zealand (Newsome 1987) and New Zealand Land Resource Inventory (NWASCO 1975–79).

Horticulture

Admixtures of pastureland with fruit orchards, perennial vine fruit, berry fruit process vegetable cropping or market gardening.

Improved Pasture

Exotic sward grasses of good pastoral quality indicative of relatively high levels of soil fertility and grazing management, typically cultivated and sown.

Unimproved Pasture

Exotic sward grasses of poor pastoral quality indicative of relatively low levels of soil fertility and grazing management, often including browntop and sweet vernal grassland with a range of other species.

Pasture (undefined)

Exotic sward grasses whose nature could not be deduced from the databases available.

Short Tussock and Modified Short Tussock Grassland

Lowland to alpine short tussock grassland usually dominated by indigenous species of *Festuca*, *Poa* or *Rhynchospora*, but also including oversown and top-dressed tussocklands and tussock grassland modified by fire, grazing, weed and pest invasion.

Tall Tussock Grassland

Montane and alpine tall tussock grassland dominated by species of *Chionochloa* (snow tussock). Most of this grassland is composed of snow tussocks, but minor areas of red tussock (*Ch. Rubra*) occurring in damp areas, are mapped in this class also.

Tussock-Herbfield

More-or-less sparse, montane-alpine, herbaceous communities, usually with a tussock component, but dominated by rosette and mat plants and often conspicuous bare ground. At high elevations this class includes the indigenous alpine herbfields and at lower elevations the heavily degraded short tussocklands invaded by *Hieracium*, catsear and thyme.

Tussock Grassland (undefined)

Tussock grassland whose nature could not be deduced from the databases available.

Note: Within the area of grasslands, there are many areas of mixed grasslands or gradations between the classes which we have not depicted on the map. These complexes include for example, mixes of tall and short tussock grassland, especially in the mid-altitude zone (900–1200 m) and a range of degrees of grassland development and depletion (and hence composition), especially in the montane zone (<900 m).

Indigenous Scrub

Vegetation communities dominated by indigenous shrubs or fern.

Exotic Scrub

Vegetation communities dominated by exotic shrubs.

Podocarp-Broadleaved Forest

Evergreen forest with a canopy dominated by indigenous mixed broadleaved and podocarp trees and an emergent storey dominated by podocarp trees.

Podocarp-Broadleaved-Beech Forest

Evergreen forest with a canopy dominated by indigenous mixed broadleaved, southern beech and podocarp trees and an emergent storey dominated by podocarp trees.

Beech Forest

Evergreen forest with a canopy dominated by indigenous southern beech (*Nothofagus*) trees.

Indigenous Forest (undefined)

Indigenous forest whose nature could not be deduced from the databases available.

Exotic Forest

Forest plantations dominated by exotic conifers or broadleaved trees.

Wetlands

Communities dominated by herbaceous species occurring in freshwater habitats where the water is above, at, or near the substrate surface for most of the year.

Bare Ground

Areas of little or no vegetation where the surface comprises bare rock, shingle, scree/talus, or sand. Mines and dumps were included in this class.

Perennial Ice and Snow

Areas of permanent ice and snow occurring at altitudes above the late summer snow line.

Water Bodies

Lakes, Ponds, Tarns, and Rivers.

Built-up Area

Areas within the perimeter of towns or mappable conclaves of buildings

Note about vegetation change: It is certain that there has been vegetation change since the source maps were compiled. Such changes include the development of pastures for agriculture from vegetation previously recorded as tussock grasslands, increases of weedy and/or woody species in grassland, loss (or possibly gain) of physiognomic dominants (e.g., tussocks, shrubs), and depletion of biomass.

5. Analysis of vegetative cover

The Vegetative Cover Class layer is georegistered to the New Zealand Map Grid, the same coordinate system as its parent data layers and the same coordinate system as the GIS layers being generated during the process of the South Island Pastoral Tenure Review.

We intersected this new layer with five other layers for the purpose of analysis:

- An outline of all high country land
- The outline of all South Island Pastoral lease lands
- A delineation of broad altitudinal zones (<900 m, 900–1200 m, >1200 m)
- The Tussock Grasslands and Mountain Lands Institute classification of property classes from the High Country Production Survey
- Summary environments, taken from Land Environments of New Zealand (LENZ), Level 2

Vegetative cover within pastoral high country and pastoral lease lands

The distribution of the vegetative cover classes within the high country boundary and the 304-property pastoral lease area shows the vegetation dominated by tussock grasslands and associated modified tussock grassland. This analysis appears in Table 1.

Table 1: Area and percentages of each vegetative cover class for the pastoral lease lands and the high country land area.

Vegetative Cover Class	Pastoral lease (ha)	%	High country	%	Existing Conservation estate	%
Horticulture	3	<0.1	2 816	<0.1	33	0.0
Improved Pasture	20 970	1.0	520 821	7.8	5 409	0.3
Unimproved Pasture	104 327	4.7	552 980	2.4	18 278	1.1
Pasture (undefined)	83	<0.1	1 888	<0.1	294	0.0
Short Tussock Grassland	746 091	34.9	1 682 350	25.1	128 092	7.5
Tall Tussock Grassland	682 660	31.0	1 372 574	20.5	389 732	22.7
Tussock-Herbfield	121 454	5.5	320 776	4.8	131 623	7.7
Tussock Grassland (undefined)	1 610	<0.1	13 767	0.2	3 939	0.2
Indigenous Scrub	194 386	8.8	609 712	9.1	175 275	10.2
Exotic Scrub	9 236	0.4	48 470	0.7	5 789	0.3
Podocarp-Broadleaved Forest	2 468	0.1	12 252	0.2	6 676	0.4
Podocarp-Broadleaved-Beech Forest	118	<0.1	3 157	0.1	2 432	0.1
Beech Forest	75 189	3.4	523 933	7.8	417 202	24.4
Indigenous Forest (undefined)	905	<0.1	3 557	0.1	1 051	0.1
Exotic Forest	3 293	0.2	92 390	1.4	3 386	0.2
Wetlands	12 369	0.6	29 461	0.4	3 866	0.2
Bare Ground	221 121	10.0	683 691	10.2	349 774	20.4
Perennial ice and snow	2 273	0.1	60 708	0.9	58 473	3.4
Water bodies	3 348	0.2	158 287	2.4	11 679	0.7
Built up areas	16	<0.1	4 206	0.1	149	0.0
TOTAL	2 201 920		6 697 796		1 713 152	100.0

Vegetative cover within altitudinal zones

Lowland, montane, subalpine and alpine are terms widely used in reference to altitude. As well as delineating zones of distribution of indigenous vegetation (Table 2), these zones also reflect options and levels of production for economic and use. For example, 900 m is widely accepted as an indicative upper limit for pasture improvement and production forestry.

Although a fixed set of altitude limits tends to be applied throughout the high country, altitude zones decline from north to south. For example, the upper subalpine limit, in humid, beech-forested areas is about 1500 m in the Wairau Valley Marlborough, 1350 m in the Harper Valley, mid Canterbury, and 1150 m in the lower Dart Valley, Otago. Such trends suggest that use of a single, altitude-based set of elevation/temperature zones oversimplifies relationships and is likely to misrepresent conditions in much of the high country.

Table 2: Conventional descriptive parameters of altitudinal zones. Modified from Hunter (1992) after Wardle (1991).

Zone	Altitudinal limit, central South Island	Mean warmest month temp	Indigenous vegetation
Lowland (warm temperate)	<400 m	>14° C.	Luxuriant, diverse forest
Montane (cool temperate)	400–900 m (upper limit from 800-1000m south – north)	11–14° C.	Less luxuriant and diverse forest. Main zone of short tussock and montane shrubs such as matagouri, coprosma
Subalpine	900–1200 m (upper limit from 950 – 1350m south-north)	<11° C (100 m higher where beech forms timberline)	Upper limit of forest trees. Silver and mountain beech, subalpine scrub species, tall and some short tussock grasslands.
Alpine (incl. pen-alpine)	>1200 (> 1100–1350)		Tall tussock grassland, alpine herbfield, subalpine scrub (lower levels). Bare rock and scree, grading to ice/snow/rock.

However, the widespread use of altitude zones defined by 900 m (montane), between 900 and 1200 m (subalpine) and above 1200 m (alpine) captures much of the general pattern of plant communities. Against this background, we have used these altitude/climatic zones in this report as a pragmatic and ‘familiar’ first-approximation of the influence of altitude-related temperatures of the distribution of vegetation.

In so far as these zones are a significant input to land assessment for the tenure review process, we strongly recommend that any follow-up approach be based on the known critical temperature limits. These may be derived from either the published LENZ environments or from the climate surfaces (particularly ‘mean warmest month’) that underpin them (Leathwick et al. 2003a). The distribution of vegetative cover classes within these generalised altitudinal zones are shown in Table 3.

Table 3: Vegetative cover for pastoral lease lands by altitudinal zone.

Vegetative Cover Class	Pastoral lease (ha)	<900 m lowland/montane	900–1200 m subalpine	>1200 m alpine
Horticulture	3	3	0	0
Improved Pasture	20 970	20 637	200	133
Unimproved Pasture	104 327	102 210	1 862	255
Pasture (undefined)	83	83	0	0
Short Tussock Grassland	746 091	547 217	142 836	56 038
Tall Tussock Grassland	682 660	119 390	273 527	289 743
Tussock-Herbfield	121 454	28 150	6 336	86 968
Tussock Grassland (undefined)	1610	811	79	720
Indigenous Scrub	194 386	126 620	47 240	20 526
Exotic Scrub	9 236	8 569	633	34
Podocarp-Broadleaved Forest	2 468	2 315	109	44
Podocarp-Broadleaved-Beech Forest	118	104	8	6
Beech Forest	75 189	40 109	26 826	8 254
Indigenous Forest (undefined)	905	774	81	50
Exotic Forest	3 293	2 988	297	8
Wetlands	12 369	6 993	2 605	2 771
Bare Ground	221 121	17 380	26 562	177 179
Perennial ice and snow	2 273	0	13	2 260
Water bodies	3 348	2 735	389	224
Built up areas	16	4	0	12
TOTAL	2 201 920	1 027 092	529 603	645 225

Vegetative cover within High Country Production Survey classes

Table 4 shows the distribution of vegetative cover classes for each of the former Tussock Grasslands and Mountain Lands Institute's (TGMLI), 'High Country Production Survey' classes, (Hughes 1973,; Kerr et al. 1979,; Kerr & Lefever 1984,; Kerr & Abrahamson 1988). Properties not included in the original TGMLI data have been assigned to their respective class using the original criteria. The 'Dry' class receives rainfalls of <500 mm/y, 'Moist' between 560–1000 mm/y, and 'Wet' >1000 mm/y. The provincial classes "Otago" etc indicate where most of the class is located. The allocation of properties to classes is given in Appendix 2.

Table 4: Area of each productivity group for the ‘high country production survey’ property classes.

Vegetative Cover Class	Cant Moist (ha)	Cant Wet (ha)	Marlb Moist (ha)	Otago Dry (ha)	Otago Moist (ha)	Otago Wet (ha)	Southl Moist (ha)
Horticulture	0	0	0	3	0	0	0
Improved Pasture	5 637	1 502	1 158	1 170	4 847	2 034	4 584
Unimproved Pasture	9 209	5 911	6 458	15 417	31 589	19 940	15 219
Pasture (undefined)	13	13	1	17	0	33	6
Short Tussock Grassland	149 651	114 340	50 694	91 275	182 916	89 125	68 090
Tall Tussock Grassland	105 363	79 742	10 648	57 554	165 059	163 763	100 531
Tussock-Herbfield	17 554	23 255	2 418	14 328	28 615	31 247	4 037
Tussock Grassland (undefined)	216	811	150	14	14	405	0
Indigenous Scrub	22 810	64 389	30 560	7 171	22 123	38 332	8 969
Exotic Scrub	2 004	1 090	950	1 360	2 545	1 056	230
Podocarp-Broadleaved Forest	838	74	229	0	778	131	100
Podocarp-Broadleaved-Beech Forest	15	64	27	0	2	8	0
Beech Forest	4 971	32 734	5 672	5	1 818	20 283	9 637
Indigenous Forest (undefined)	63	150	42	0	7	587	37
Exotic Forest	915	938	211	259	696	55	220
Wetlands	902	3 809	20	1 209	2 343	1 161	2 920
Bare Ground	29 813	96 554	28 779	733	10 287	53 385	1 521
Perennial ice and snow	0	999	0	0	0	1 274	0
Water bodies	874	901	76	181	183	909	96
Built up areas	0	0	0	2	12	2	0
TOTAL	350 848	427 276	138 093	190 698	453 834	423 730	216 197

Vegetative cover within land environments

Land Environments of New Zealand (LENZ) (Leathwick et al. 2003a) is an environmental classification developed as a tool for biodiversity research and management. LENZ identifies climatic and landform factors that influence plant growth and the distribution of species, and groups together sites that have similar environmental conditions. It has the ability to predict the potential character of sites where natural ecosystems have been modified, or replaced by introduced plants and animals.

The environmental layers used to create LENZ include: mean annual temperature, mean minimum temperature of the coldest month, mean annual solar radiation, winter solar radiation, October vapour pressure deficit, annual water deficit and monthly water balance ratio, slope, soil drainage, soil fertility, soil age, and chemical limitations to plant growth. The soil factors have been derived mainly from the NZLRI soil layers.

Land environments are defined as a four-level hierarchy. At the highest level, 20 Level 1 environments are defined for New Zealand. Of 100 Level 11 land environments mapped nationally, 52 are mapped in the pastoral leases. Analysis of vegetation cover by land environment should be based on a clear set of questions, and determination of the levels of complexity required, both of which lie outside the scope of this report. In Table 5 we provide an ‘entry level’ summary of the distribution of vegetation cover by Level 1 environments for the pastoral lease lands.

Table 5: Distribution of vegetation cover by Level 1 land environments for the pastoral lease lands.

Vegetative Cover Class	Central Dry Lowlands	Central Dry Foothills	Central Hill country	Central Well-drained Recent	Central Upland Recent Soils	Southern Lowlands	Western South Island Recent	Eastern South Island Plains	Western South Island Foothills	Central Mountains	Southeastern Hillcountry and Mountains	Southern Alps	Ultramafic Soils	Permanent Snow and Ice	Unclassified
	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
Horticulture	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Improved Pasture	544	3 344	3	177	2 739	3 148	301	6 829	46	539	3 182	28	0	0	91
Unimproved Pasture	1 964	12 720	2	793	7 293	1 908	2 561	39 671	53	4 334	32 429	18	0	0	579
Pasture (undefined)	0	2	0	0	2	1	3	6	0	0	5	0	0	0	64
Short Tussock Grassland	5 521	186 176	48	4 281	26 279	1 047	2 369	10 8335	2 323	67 759	335 328	4 487	0	0	2 139
Tall Tussock Grassland	19	30 580	0	114	2 980	335	195	3 780	118	115 162	482 742	44 653	0	1 702	281
Tussock-Herbfield	76	6 721	0	882	817	170	6	16 462	0	28 319	40 970	26 829	0	101	103
Tussock Grassland (undefined)	9	93	0	5	135	0	5	15	0	518	77	67	0	107	578
Indigenous Scrub	2 607	61 383	6	784	6 217	239	318	10 881	156	48 472	53 668	8 897	16	81	662
Exotic Scrub	84	1 965	17	161	1 126	117	75	2 708	0	167	2 378	0	1	0	435
Podocarp-Broadleaved Forest	8	303	0	0	1	0	20	22	297	152	1 610	43	0	0	13
Podocarp-Broadleaved-Beech Forest	4	78	0	0	1	0	1	0	0	20	2	1	0	0	10
Beech Forest	66	14 015	0	1	518	45	122	289	655	36 198	21 611	1 512	0	0	157
Indigenous Forest (undefined)	1	126	0	2	51	11	23	30	4	112	384	70	0	0	92
Exotic Forest	29	1 182	0	15	358	21	0	1 100	0	251	265	0	27	0	45
Wetlands	7	2 372	0	191	2 981	503	110	725	183	224	4 738	4	0	0	332
Bare Ground	392	10 861	0	410	3 669	157	311	647	26	141 534	27 542	29 975	0	2 692	2 904
Perennial ice and snow	0	0	0	0	0	0	0	0	0	85	10	1 247	0	932	0
Water bodies	4	269	0	6	152	7	62	142	11	37	104	11	0	8	2 535
Built up areas	0	0	0	0	2	0	0	2	0	0	11	0	0	0	1

Vegetative cover within indicative freehold and conservation split for the pastoral lease lands

An indicative freehold and conservation estate split for all pastoral lease lands by land use potential grouping is summarised in Table 6. In Table 7 this data is placed alongside areas for the existing conservation estate, and freehold and other land for the whole high country.

Table 6: Indicative freehold and conservation estate split for the pastoral lease lands by vegetation cover class.

Vegetative Cover Class	Total area of	Indicative	Indicative		
	lease lands (ha)	Freehold (ha)	%	Conservation (ha)	%
Horticulture	3	2	67	1	33
Improved Pasture	20 970	19 136	91	1 834	9
Unimproved Pasture	104 327	84 744	81	19 583	19
Pasture (undefined)	83	57	69	26	31
Short Tussock Grassland	746 091	475 670	64	270 421	36
Tall Tussock Grassland	682 660	163 014	24	519 646	76
Tussock-Herbfield	121 454	28 969	24	92 485	76
Tussock Grassland (undefined)	1 610	412	26	1 198	74
Indigenous Scrub	194 386	85 450	44	108 936	56
Exotic Scrub	9 236	6191	67	3 045	33
Podocarp-Broadleaved Forest	2 468	692	28	1 776	72
Podocarp-Broadleaved- Beech Forest	118	39	33	79	67
Beech Forest	75 189	18 419	24	56 770	76
Indigenous Forest (undefined)	905	309	34	596	66
Exotic Forest	3 293	2 829	86	464	14
Wetlands	12 369	3 536	29	8 833	71
Bare Ground	221 121	32 426	15	188 695	85
Perennial ice and snow	2 273	49	2	2 224	98
Water bodies	3 348	2 158	64	1 190	36
Built-up areas	16	15	94	1	6
Totals	2 201 920	924 117	42	1 277 803	58

Table 7: Summary results of the indicative freehold and conservation land split within the high country, combined with data for whole high country

Vegetation cover	Total 'High Country'	Freehold			Conservation		
	Hectares	Existing freehold ¹ (excluding Pastoral lease)	Indicative Freehold	Total	Existing ² Conservation	Indicative Conservation	Total
Horticulture	2 816	2 780	2	2 782	33	1	34
Improved Pasture	520 821	494 442	19 136	513 578	5 409	1 834	7 243
Unimproved Pasture	552 980	430 376	84 744	515 120	18 278	19 583	37 861
Pasture (undefined)	1 888	1 511	57	1 568	294	26	320
Short Tussock Grassland	1 682 350	808 167	475 670	1 283 837	128 092	270 421	398 513
Tall Tussock Grassland	1 372 574	300 181	163 014	463 195	389 732	519 646	909 378
Tussock-Herbfield	320 776	67 698	28 969	96 667	131 623	92 485	224 108
Tussock Grassland (undefined)	13 767	8 217	412	8 629	3 939	1 198	5 137
Indigenous Scrub	609 712	240 051	85 450	325 501	175 275	108 936	284 211
Exotic Scrub	48 470	33 445	6 191	39 636	5 789	3 045	8 834
Podocarp-Broadleaved Forest	12 252	3 108	692	3 800	6 676	1 776	8 452
Podocarp-Broadleaved-Beech Forest	3 157	606	39	645	2 432	79	2 511
Beech Forest	523 933	31 541	18 419	49 960	417 202	56 770	473 972
Indigenous Forest (undefined)	3 557	1 601	309	1 910	1 051	596	1 647
Exotic Forest	92 390	85 710	2 829	88 539	3 386	464	3 850
Wetlands	29 461	13 226	3 536	16 762	3 866	8 833	12 699
Bare Ground	683 691	112 796	32 426	145 222	349 774	188 695	538 469
Perennial ice and snow	60 708	(-38)	49	11	58 473	2 224	60 697

Water bodies	158 287	143 260	2 158	145 418	11 679	1 190	12 869
Built up areas	4 206	4 041	15	4 056	149	1	150
Totals	6 697 796	2 782 719	924 117	3 706 836	1 713 152	1 277 803	2 990 955

¹ includes 'other' crown land

² boundary of conservation estate as supplied by DOC, August 2002, within the 'high country' boundary
There are approximately 4000 ha unaccounted for in the totals.

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Land listed as indicative freehold tends to include a relatively high proportion of the following vegetation cover classes: improved pasture (91% of the total); unimproved and undefined pasture (81% and 69%); short tussock grassland and associated vegetation (64%); exotic scrub (67%); and exotic forest (86%). Most of these are relatively strongly cultural in value. However, many such areas will also contain natural values, some of which are expressed in the vegetation map but many of which are hidden by the generalities of the mapping (See 'limitations of the map').

Land listed as indicative conservation includes a relatively high proportion of the following classes: tall tussock grassland (76%); tussock herbfield (76%); indigenous scrub (56%); indigenous forest classes (66–76%); and wetlands (71%). It also includes most of the (alpine) bare ground and ice and snow.

6. Limitations of the map

The vegetation cover map presented in this report was compiled to provide interim information for the high country, using best-available spatial vegetation cover data pending completion of the Land Cover Database 2 (LCDB2

Each data source provided high country (and generally nation-wide) coverage, so the emphasis was on consistent information over large areas (i.e. small scale) rather than on finer levels of detail and/or accuracy for local areas (i.e. large scale). Data sources are dated and there has inevitably been vegetation cover change since they were compiled. Such changes include the development of pastures for agriculture from vegetation previously recorded as tussock grassland, increases of weedy and/or woody species in grassland, loss (or possibly gain) of physiognomic dominants (e.g., tussocks, shrubs), and depletion of biomass.

Vegetative cover is often a complex of many components, ranging from species mixes, to mixes of different plant communities (e.g., grassland and shrubland). In compiling this map, only the dominant classification was recognised within each area delineated on the map. This procedure, plus the scale limitations of broad-scale mapping, has resulted in the under representation of assemblages of plants that are either subdominant, occupy small areas, or are atypical of the wider general area.

No systematic checking has been undertaken to verify the processes used to combine the data input layers into the new map and field checking was confined to the initial checks used to compile the original layers.

The requirement for this map was to provide a small-scale overview of the vegetative cover of the high country to help plan tenure review at higher levels. Although the map scale can be enlarged to show vegetation at local areas, such as individual pastoral leases, it must be used with caution at such levels, and after verification. The map does not replace local area, detailed data on vegetation cover.

In assessing the composition, dynamics and eventually the 'values' of vegetation cover in the high country, it will be important to consider an environmental as well as a biological

context. LENZ and its underlying environmental data layers provide a key framework for this.

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8. Appendices

Appendix 1: Classification rules applied to vegetative cover groups

All rules maintained the assumption that the LCDB was accurate to the extent of delineating the broad vegetation structural groups. Even where LCDB polygons are contradicted by the NZLRI/VCM/FSMS6 description we did not change the structural class of the vegetation. Instead we either inferred the most likely vegetative cover class or allowed the polygon to default to one of the unspecified classes.

Pasture classification

The LCDB pasture area was intersected with the NZLRI and VCM layers and then:

- Areas of agreement (where the NZLRI vegetation record was dominated by pasture) were classified as 'improved' or 'unimproved' pasture as appropriate.
- Areas where the grassland element of the NZLRI/VCM record is described as tussock rather than pasture are classified as 'short' or 'tall' tussock grassland as appropriate.
- Areas where there is no grassland element recorded in the NZLRI/VCM are still assumed to be grassland. Where NZLRI vegetation is suggestive of marginal lands, but not high elevation (notably lowland scrub classes), these were classified as 'unimproved pasture'

Tussock classification

The LCDB tussock and bare ground area was intersected with the NZLRI and VCM layers and then:

- Areas mapped by NZLRI with >40% cover of herbfield classes (H4 or H7) were classified as 'tussock-herbfield'
- Areas in the NZLRI recorded as sparse vegetation dominated by low density herbfield (h4, h7), tussock (p4, p3, and some p2), or sub-alpine scrub (m5) were classified as 'tussock-herbfield'
- Areas of the Mackenzie basin where the VCM records semi-arid herbfield (and this mapping class is absent from the NZLRI) were classified as 'tussock-herbfield'
- Remaining areas where the NZLRI vegetation record was dominated by tussock were classified as 'short or 'tall' tussock as appropriate.
- Areas where the NZLRI vegetation record was dominated by pasture were classified as 'improved' or 'unimproved' pasture as appropriate
- Areas where there is no grassland element recorded in the NZLRI/VCM are still assumed to be grassland. Where NZLRI/VCM vegetation is suggestive of lowland vegetation (notably lowland scrub and forest classes), these were classified as 'unimproved pasture'. Where NZLRI/VCM vegetation is suggestive of montane vegetation (notably mid-altitude scrub and forest classes), these were classified as 'short tussock'. Where NZLRI/VCM vegetation is suggestive of upland vegetation (notably subalpine scrub and upland forest classes), these were classified as 'tall tussock'.

Scrub classification

The LCDB scrub area was intersected with the NZLRI, FSMS6 and VCM layers and then:

- Areas mapped by NZLRI as scrub were classified as ‘indigenous’ or ‘exotic’ scrub as appropriate.
- In the remaining areas we inferred the most likely scrub class from the vegetation record in the NZLRI/FSMS6/VCM.

Indigenous forest classification

The LCDB indigenous forest area was intersected with the NZLRI, FSMS6 and VCM layers and then:

- Areas mapped by NZLRI as forest were classified as ‘beech’, ‘podocarp-broadleaved’ or ‘podocarp-broadleaved-beech’ forest as appropriate.
- Remaining areas were classified from FSMS6/VCM vegetation records where possible. Failing this, beech forest was inferred from associated vegetation records or the vegetative cover class was allowed to default to ‘unspecified’ forest.

Vegetative cover class assignments made following the rules defined above could then be subsequently overwritten during the process of integrating the 10 intermediate spatial layers as shown in Figure 1.

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Appendix 2: TGMLI 'High Country Production Survey' groupings of properties

Canterbury Moist (CM)

Airies
Asheridge
Barrosa
Bauchops Hill
Ben McLeod
Ben More
Ben Ohau
Bendrose
Blue Mountain
Brooksdale
Bush Spurs
Caberfeidh
Castle Hill
Chetwynd
Clayton
Clent Hills
Cloudy Peaks
Cora Lynn
Curraghmore
Dry Creek
Glenariffe
Glenrock
Glenrock
Hakatere
Holbrook
Hunter Hills
Inverary
Invercroy
Irishman Creek
Kaiwarua
Kirkliston
Lochaber
Manahune
Maryburn
Mt Alford
Mt Cecil
Mt Dalgety
Mt Hay
Mt Hutt
Mt Nimrod
Mt Olympus
Mt Oxford
Mt Peel
Mt Pember
Mt Studholme
Omahau Hill
Orchard Estate
Peak Hill

Rata Peaks
Redcliffe
Rollesby
Sawdon
Shenley
Silver Hill
Simons Hill
Simons Pass
Snowdale
Stew Point
Stoneleigh
Tenahaun
The Gorge
The Grampians
The Wolds
Three Springs
Waikari Hills
Wairua Downs
Waitangi
West Hills
Winterslow
Woodbank
Woodstock

Canterbury Wet (CW)

Braemar
Double Hill
Erewhon
Eskhead
Ferintosh
Glen Lyon
Glenfalloch
Glenhope
Glenmore Station
Glentanner
Glenthorne
Glynn Wye Station
Godley Peaks
Island Hills
Lake Taylor
Lilybank Station
Manuka Point
Mesopotamia
Mt Algidus
Mt Arrowsmith
Mt Cook
Mt Gerald
Mt Oakden
Mt Potts

Mt White
Pukaki Downs
Rhoboro Downs
Richmond
St James
The Lakes
The Poplars
Upper Lake Heron

Marlborough Moist (MM)

Awapiri Station
Blairich
Camden
Clarence Reserve
Cloudy Range
Compensation Run
Hossack
Leatham Run
Middle Hill Station
Middlehurst
Muller Station
Muzzle Station
Raglan Run
Rainbow Station
Ramshead Run
The Jordan
Upcot Station

Otago Dry (OD)

Aviemore Station
Black Forest
Bog Roy
Cloudy Peak
Cluden Station
Galloway Station
Grays Hills
Hawksburn Station
Leaning Rock
Little Valley
Matangi
Moutere Station
Mt Campbell
Mt Difficulty
Omarama Station
Otematata Station
Riverside
Rugged Ridges
Stony Creek
Streamlands

Te Akatarawa

Otago Moist (OM)

Ahuriri Downs
Balmoral
Bargour
Beaumont Station
Bellamore
Ben Dhu
Ben Ledi
Ben Nevis
Berwen
Birdwood
Braeside
Branch Creek
Breast Hill
Burgan Run
Caithness
Cambrian
Cambrian Hills
Carrick Station
Carrickmore
Castle Dent
Clover Flats
Courthill
Craigroy
Dalrachney Station
Deep Creek
Dome Hills 1 - 2
Dunstan Burn
Dunstan Downs
Dunstan Peaks
Eastburn_Waitiri
Emerald Hills
Eweburn
Forest Range
Glencoe
Glencoe - Po144
Glenfoyle
Gorge Farm
Grafton Hills
Grange Hill
Happy Valley
Home Hills
Islay Downs
Kawarau
Killermont
Kinross
Kyeburn
Lauder Station
Lindis Group

Little Mt Ida
Long Gully
Longlands Station
Longslip Station
Lowburn Valley
Matakanui Station
Michael Peak
Morven Hills
Mt Alexander
Mt Dasher
Mt Grand
Mt Pisa I
Mt Soho Station
Mt St Bathans
Mt Stalker
Obelisk
Obelisk Creek
Omahau Downs
Otamatapaio
Patearoa Syndicate
Pisgah Downs
Quailburn
Ribbonwood
Riverslea
Robrosa
Rostriever
Sandy Point
Shag Valley Station
Shingley Creek
Shortlands Station
Silverbirch
Stonehurst
Styx Run
Sunny Peaks
Sunset Farm
The Beeches I
The Dasher
The Homestead
The Larches
The Wandle
Twin Peaks
Twinburn
Two Mile
Waipiata Syndicate

Otago Wet (OW)
Alpha Burn
Ben Avon
Ben Lomond
Birchwood
Cattle Flat

Cecil Peak Station
Coronet Peak
Dingleburn Station
Earnslaw
Glen Dene
Glendhu Station
Halfway Bay
Hunter Valley Station
Huxley Gorge
Lake Hawea
Loch Linnhe
Matukituki
Minaret Station
Motatapu Station
Mount Creighton
Mt Albert Station
Mt Aspiring Station
Mt Burke
Mt Nicholas Station
Rees Valley
Rees Valley Station
Remarkables
Temple Peak
The Branches
Walter Peak Station
West Wanaka
Wyuna

Southland Moist (SM)

Allandale
Ardross Station
Argyle Station
Beaumont
Cattle Flat & Henroost
Coal Creek Station
Crown Rock
Fiery Creek
Gem Lake
Glen Nevis
Glenaray Station
Glenfellen
Glenlapa
Gorge Creek
Greenvale
Henroost
Hukarere
Kelvin Grove
Kingston Station
Lorne Peak
Mataura Valley
Moa Hills

Mt Benger
Mt Hope
Mt Prospect
Nokomai Station
The Forks
The Herrons
The Jollies
The Knobbies
Waterloo Station
Whitecomb
Whitecoomb

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