

# **Crown Pastoral Land Tenure Review**

**Lease name : ROBROSA**

**Lease number : PO 252**

## **Conservation Resources Report - Part 1**

As part of the process of Tenure Review, advice on significant inherent values within the pastoral lease is provided by Department of Conservation officials in the form of a Conservation Resources Report. This report is the result of outdoor survey and inspection. It is a key piece of information for the development of a preliminary consultation document.

Note: Plans which form part of the Conservation Resources Report are published separately.

These documents are all released under the Official information Act 1982.

**August**

**06**

**DOC CONSERVATION RESOURCES  
REPORT ON TENURE REVIEW OF  
ROBROSA PASTORAL LEASE  
(P252)**

**UNDER PART 2  
CROWN PASTORAL LAND ACT**



TABLE OF CONTENTS

**PART 1: INTRODUCTION..... 3**

**PART 2: INHERENT VALUES: DESCRIPTION OF CONSERVATION RESOURCES AND ASSESSMENT OF SIGNIFICANCE ..... 5**

2.1 LANDSCAPE ..... 5

2.2 LANDFORMS, GEOLOGY AND SOILS ..... 13

2.3 NEW ZEALAND’S BIODIVERSITY PROTECTION NEEDS ..... 15

2.4 CLIMATE..... 17

2.5 VEGETATION..... 17

2.5.1 Problem Plants.....24

2.6 FAUNA ..... 25

2.6.1 Invertebrates ..... 25

2.6.2 Herpetofauna ..... 30

2.6.3 Avifauna ..... 31

2.6.4 Aquatic Fauna..... 32

2.6.5 Problem Animals ..... 33

2.7 HISTORIC ..... 33

2.7.1 Maori Cultural Values ..... 33

2.7.2 Pakeha Heritage Values ..... 33

2.8 PUBLIC RECREATION ..... 44

2.8.1 Physical Characteristics ..... 44

2.8.2 Access..... 45

2.8.4 Activities ..... 47

**PART 3: OTHER RELEVANT MATTERS & PLANS ..... 51**

3.1 CONSULTATION ..... 51

3.2 REGIONAL POLICY STATEMENTS & PLANS ..... 52

3.3 DISTRICT PLANS ..... 53

3.4 CONSERVATION MANAGEMENT STRATEGIES & PLANS ..... 53

3.5 NEW ZEALAND BIODIVERSITY STRATEGY ..... 54

**PART 4: ATTACHMENTS ..... 55**

4.1 ADDITIONAL INFORMATION..... 55

4.1.1 References ..... 55

4.1.3 Appendices ..... 58

4.1.3 Photographs.....

4.2 ILLUSTRATIVE MAPS .....

**PART 5: PROPOSED RECOMMENDATIONS REPORT: TENURE REVIEW OF ROBROSA PASTORAL LEASE (P252) HELD BY LITTLE BO PEEP SHEEP COMPANY LTD. UNDER PART 2 CROWN PASTORAL LAND ACT.....**

## PART 1: INTRODUCTION

The lessees of Robrosa Pastoral Lease have applied to the Commissioner of Crown Lands for a review of the property's pastoral lease tenure. Robrosa Station is leased by Little Bo Peep Sheep Company Ltd.

The 3735 ha property is located on the Pisa/Criffel Range, approximately three kilometres north of Cardrona Township, in Central Otago. It is a comparatively narrow property varying from less than two kilometres in the middle of the Lease to about five kilometres at its widest point. The property is bound by the Cardrona River to the west, extending eastwards up the Criffel Range scarp and across to the summit of the Pisa Range. The two ranges are separated by the Luggate Creek catchment, which includes the Cliff Burn, Princess Burn and head of the Luggate Creek itself. Streams draining the Criffel faces into the Cardrona River include Welshes Creek and Deep Creek.

Cardrona Valley Road provides formed legal road access to the front country at the western end of the property. The old homestead is situated on the Lease, off SH89, 18 km from Wanaka.

A short section of the Waiorau Snow Farm Road adjoins the property along its southeastern boundary, thereby providing formed legal road access to a point at about 1500 m asl.

Altitude ranges between 455 m on the Cardrona Valley floor to 1956 m on the crest of the Pisa Range, falling just short of the summit of Mt Pisa, the highest point on the range at 1964 m.

The Lease is made up of developed river flats; moderately steep faces which have been oversown and top-dressed (OSTD) up to about 1000 m, with tors prevalent along the upper Criffel scarp; a broad undulating summit plateau along the Pisa Range, and steep rocky country and tarns at high attitude within the Cliff Burn.

The Lease lies within the Central Otago Ecological Region and Pisa Ecological District. A Protected Natural Areas Programme (PNAP) survey which included this ecological district has been carried out (Ward *et al.* 1994). One area recommended for protection is located partially on the Lease. RAP A3: Pisa Tops is a montane to high alpine area of cushionfields, short and tall tussocklands (see Appendix 1 for details).

No parts of the Lease are currently subject to protection for conservation purposes.

Adjoining the property to the south and southwest is Pisa Conservation Area (Otago Conservation Management Strategy Inventory Number F40104). Mid Run/Lake McKay Special Lease, which has provisions for wander-at-will public foot access, is located to the north of the Lease, within the Princess Burn. There is a s.58 Land Act (1948) marginal strip present along the Cardrona River.

The tenure review inspection of Robrosa Pastoral Lease was undertaken on 23-26<sup>th</sup>

January 2006 by a range of specialists. 83 ha of adjoining freehold land (Sec 26 Blk VII Cardrona Survey District, SO1176) were included in the tenure review inspection, but no significant inherent values were identified on this land.

**PART 2: INHERENT VALUES: DESCRIPTION OF CONSERVATION RESOURCES AND ASSESSMENT OF SIGNIFICANCE****2.1 LANDSCAPE****Landscape Context**

The property extends from the Cardrona valley floor up the northwest faces of the Pisa/Criffel Range, and up onto the extensive summit plateau to the eastern edge of Pisa escarpment. The Criffel face forms part of the greater Pisa Range fault block mountain range that separates the Cardrona Valley from the Upper Clutha Valley. The Pisa Range is the highest and most western of the fault block schist mountain ranges of Central Otago. The ranges west of the Cardrona Valley have a distinctly different geology with glacial features such as steep-sided mountain slopes and sharp ridges akin to the western mountains of Otago.

The Pisa/Criffel Range features steep slopes and a broad, undulating summit plateau. The summit plateau is up to eight kilometres wide.

The elevational range extends from approximately 450 m to 1956 m at the highest point. There is a corresponding broad range of vegetation types from highly modified pasture on the Cardrona Valley floor to fescue tussockland, giving way to a band of snow tussock. Cushionfield and blue tussock cover much of the broad summit plateau.

Public conservation land adjoins Robrosa to the south and east. The Waiorau Snow Farm adjoins to the south from the Roaring Meg and on the Cardrona faces. Large scale earthworks on the Waiorau Snow Farm has had a major impact on the natural character on the summit plateau and visual effects are apparent over a wide area including views from Robrosa Pastoral Lease. The natural landform tussock and cushionfield vegetation patterns are disrupted by often-massive cuts and fill, and replaced by bare earth or sparse exotic pasture grasses. This has the effect of detracting from landscape values on the summit plateau in this part of the range and impacting on key characteristics of naturalness, and remoteness of the upland plateau as a whole.

**Methods**

The Lease has been divided into defined landscape units (LUs). These units reflect areas of similar landscape character. Landscape character is the quality that makes an area different from another and can be defined as follows:

*Landscape character results from a particular combination of characteristics formed by the interaction of natural processes and cultural (human) activities.'*

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For each unit a landscape character description is provided, along with a description of the key visual and scenic attributes present. An evaluation summary is presented, using a range of criteria to assess each unit and assist with determining each unit's high inherent values. The criteria include:

1. Intactness: Refers to the condition of the natural vegetation, patterns and processes and the degree of modification present.
2. Legibility: Refers to its expressiveness - how obviously the landscape demonstrates the formative processes leading to it.
3. Aesthetic Factors: Include criteria such as *distinctiveness* - the quality that makes a particular landscape visually striking. Frequently this occurs when contrasting natural elements combine to form a distinctive and memorable visual pattern. A further criterion assessed under aesthetic factors is *coherence*. This is based on characteristics including intactness, unity, continuity, and compatibility. Intrusions, alterations, disruptions tend to detract from coherence.
4. Historic Factors: Refers to historically valued attributes in the context of a high country landscape.
5. Visibility: Refers to the visibility from public places such as highways, waterways or local vantage points.
6. Significance: Refers to the significance of the characteristics and features, or combination of characteristics and features within individual units, whether they are locally, regionally or nationally significant, and whether they are representative of landscapes that characterise New Zealand.
7. Vulnerability: This is a measure of each landscape unit's susceptibility to further ecological deterioration, which would impact on landscape values.

## Landscape Description

For this assessment, the Lease is divided into three landscape units, the first of which has been further divided into three sub-units (refer Map 4.2.2 and Appendix 2 for photos). These include:

- Criffel Faces (LU1)
  - (a) Lower Criffel Faces and River Flats
  - (b) Mid Criffel Faces
  - (c) Upper Criffel Faces
- Luggate Creek (LU2)
- Upper Cliff Burn (LU3)

## **Criffel Faces - Landscape Unit 1 (LU1)**

### **Character Description**

This unit extends from the valley floor to the skyline of the Criffel Range.

#### *(a) Lower Criffel faces and river flats*

The lower flanks of the range consist of dry rocky slopes with shallow dissected gullies and fan formations at the toe of the slope. Recent spraying of the lower slopes to control briar has also killed grey shrubland. Modified grey shrubland is a feature of the lower slopes of the Pisa/Criffel Range. Vegetation now is mainly scattered short tussock, pasture grasses and weeds e.g. thistle and flannel weed. Patches of unsprayed shrubland remain at the upper level of the scrub belt.

The river flats are pasture with willow associated with the Cardrona River. Some old pine tree shelter belts occur on the toe of the slope near the farm buildings and yards.

#### *(b) Mid Criffel faces*

The dominant vegetation above the shrubland/scrub belt is short tussock (hard and silver tussock) and predominantly pasture. Short tussock is quite continuous across open undulating slopes with some rock outcrops. This short tussock belt is quite distinctive and extends to approximately 1200 m.

#### *(c) Upper Criffel Faces*

The upper Criffel faces feature steeper slopes and bluffs and more deeply dissected gullies with scattered and often very large rock outcrops and tors. Scattered snow tussock, speargrass and short tussock (including blue tussock) and herbfield form the main vegetation patterns. Snow tussock is very sparse and displaced by blue tussock and spaniard. Some exposed surfaces are devoid of vegetation reflecting the fragility of this alpine zone.

Above the steep bluffs and slopes there is a transition from the steep upper scarp to the summit plateau. The topography assumes a more undulating profile with rounded and smooth landforms and gentle basins. Vegetation is predominantly short tussock. The upper slopes appear as a reasonably natural landscape despite the loss of tall tussock. It is visually contiguous with the adjoining summit plateau. The lack of hawkweed on this property is notable considering its presence elsewhere on the range.

Cultural patterns on the upper slopes are few, limited to boundary fences and access tracks (as well as the less obvious modification to the vegetation patterns).

### **Visual & Scenic Values**

The Criffel faces, viewed as a whole from the base to the top of the range, form the eastern mountain range to the Cardrona Valley. Seen from Cardrona Valley Road they are rocky tussock slopes typical of block mountain ranges and that contribute to the distinctiveness of the Central Otago landscape. Apart from the upper scarp face, there are no individually distinctive features. The short tussock belt (predominantly silver/hard tussock) is notable for its apparent health and continuity combined with large rock outcrops. Viewed at close range, this zone has a high degree of coherence and

distinctiveness. The tawny tussock colours and the landforms smooth flowing lines and rock outcrops forming a memorable and aesthetically coherent landscape. The views up the Cardrona valley, and across the valley to the ranges beyond, also contribute to the visual values of this part of the range.

The upper slopes are also visually striking with smooth undulating slopes punctuated with large rock outcrops and some steep slopes on the upper edge of the range face. Views out are also impressive from the zone.

**Table 1: Evaluation Summary for Criffel Faces – LU1**

<b>Criteria</b>	<b>Value</b>	<b>Comment</b>
Intactness	Ranges from mod. high to low	Upper slopes intact apart from loss of tall tussock. Mid slopes modified short tussock. Lower slopes highly modified.
Legibility	High	High legibility at all levels due to low vegetation.
Aesthetic Factors	Medium	Overall medium. Upper slopes and the short tussock belt are visually distinctive and aesthetically coherent.
Historic Factors	Low	Some early gold-mining activity on lower slopes.
Visibility	Medium to high	Highly visible from Cardrona Valley Road and Cardrona Skifield.
Significance	Medium	Local significance.
Vulnerability	Medium	Open tussock landscape are vulnerable to change and alteration by human activities.

## **Luggate Creek Landscape Unit 2 (LU2)**

### **Character Description**

This is the largest landscape unit. It includes the summit plateau section of the Lease from the western (Criffel) edge of the range, but excludes the highest part of the summit plateau, the upper Cliff Burn.

The unit forms a relatively narrow segment of the extensive summit plateau and consists of tributaries of Luggate Creek including the Princess Burn and lower sections of the Cliff Burn. As a whole, the summit plateau includes landform patterns dominated by smooth rounded ridges, undulating landform and scattered tors and incised streams. The plateau surface is west tilting.

Vegetation is dominated by short tussockland and cushionfield although localised variations occurs in relation to altitude and aspect. North of Dome Rocks, tall tussock is a significant component in association with short tussock herbfield. Elsewhere tall

tussock is almost entirely absent from the ridges and reduced to scattered remnants within gullies.

In-faulted valleys are a feature of Luggate Creek. The edges of the valleys have been eroded back by past glacial processes. Small areas of alluvial surfaces occur within the Princess Burn and Luggate Creek.

Key characteristics of the landscape are the openness and expansiveness of the plateau. Views across the expansive plateau to the upper Clutha, Wanaka, Hawea, Mount Aspiring and the main divide are exceptional and outstanding.

Remains of gold workings occur within the Princess Burn, including a disused water race and tailings, but the workings are minor compared with other sites on the summit plateau. Cultural features are otherwise few, limited to boundary fences and access tracks. There are no internal fences within the unit, which has been extensively grazed as one block.

Recent earthworks to form a reservoir and track at the western edge of the unit have disrupted the naturalness in this part of the Lease.

Overall this unit appears as primarily a natural landscape. Despite modification to the tall tussock, native species are visually dominant, and natural patterns and processes are intact.

#### **Visual & Scenic Values**

Visually the landscape appears as a highly distinctive and coherent landscape especially seen in context of the wider summit plateau (and excluding the earthworks on the Waiorau Snow Farm). An important aspect of the property's visual values is that it is part of the broader summit plateau landscape, which has outstanding visual values. This area should not be seen in isolation of the greater summit plateau.

The visual values are derived from the following factors:

- The openness and expansiveness of the plateau
- The character and nature of the rolling, undulating landform
- the high degree of legibility i.e. the effects of glaciation and extreme climatic factors that have shaped the appearance of the land, the intricate vegetation patterns, (tussock herbfield on undulating slopes and seepages and wetland within gullies and the valley floor), and the spectacular views across the upland plateau to surrounding inland lake basins and mountains

**Table 2: Evaluation Summary: Luggate Creek LU2**

Criteria	Value	Comment
Intactness	Medium	Vegetation is primarily natural. Native species are visually dominant, but tall tussock severely diminished.
Legibility	High	Formative processes very legible.
Aesthetic Factors	High	Visually distinctive and coherent. Uninterrupted smooth flowing landform patterns.
Historic Factors	Medium	Some early goldmining but secondary within Lease boundary.
Visibility	Low	Visible from Snow Farm and from main flight path into Queenstown.
Significance	High	Regionally significant.
Vulnerability	High	Highly vulnerable to landscape degradation due to fragility of alpine environment and openness of landscape.

**Upper Cliff Burn - Landscape Unit 3 (LU3)**

**Character description**

The upper Cliff Burn is a highly distinctive unit including the head of the Cliff Burn and Dome Rock up to the eastern boundary of Robrosa and edge of the steep eastern fault-scarp face of the Pisa Range. The upper Cliff Burn forms a glacial cirque containing steep cliffs. It is without the steep headwall normally characteristic of cirques (Ward *et al.* 1994). Derivative slopes are particularly well developed on the south-facing slope of the cirque wall with steep slopes, bluffs and buttresses. Within the cirque are glacial features such as ‘tarns, ice-worn rock outcrops and moraine deposits, modified by solifluction since deglaciation<sup>1</sup>. There is a dramatic contrast between the steep derivative slopes and the smooth summit ridge.

The ridge surrounding the cirque basin has a smooth gently rounded profile and exposed lunar-like appearance. The most exposed sites on the summit ridge have lag gravels and stone pavements. Soil hummocks cover a large proportion of the area on ridges and gentle slopes. Other periglacial features are well developed, especially solifluction lobes on shady slopes.

Vegetation is dominated by high alpine cushionfields. Species diversity varies with the degree of exposure.

Other characteristics of the upper Cliff Burn include remoteness, wilderness, expansiveness, and openness. 4WD tracks and boundary fences are the only signs of human activity.

**Visual & Scenic Values**

The visual and scenic values of this unit are very high. The Cliff Burn cirque is a distinctive and dominant feature visible over a wide area on the summit plateau. Viewed at close range the individual features (derivative slopes, tarns, lag gravels) are very

impressive. Seen in context of the smooth rounded profile of the summit, and broad sweeping undulating plateau, with diverse high alpine vegetation patterns including cushionfield, snowbank communities and short and tall tussockland, the combination is outstanding.

The views north to the inland lake basins, north and west to Mount Aspiring and the main divide and east through Sally's Pinch to The St Bathans Range are breathtaking and spectacular.

**Table 3: Evaluation Summary – Upper Cliff Burn LU3**

<b>Criteria</b>	<b>Value</b>	<b>Comment</b>
Intactness	High	All patterns and processes intact.
Legibility	High	Highly expressive of formative processes i.e. glacial, periglacial and climatic.
Aesthetic Factors	High	Visually very distinctive and visually coherent.
Historic Factors	Low	Associated with early recreational activity and pastoralism.
Visibility	Low	Visible from Snow Farm and from overhead flight path.
Significance	High	Outstanding landscape of national significance.
Vulnerability	High	Highly vulnerable to degradation from any form of modification.

### **Significance of Landscape Values**

The following areas are identified on the Lease as having significant inherent landscape values (refer Map 4.2.2):

- The whole summit plateau including the upper Cliff Burn and Luggate Creek landscape units down to ~1600 m asl
- Luggate Creek Plateau and upper Cardrona/Criffel face
- The Cardrona/Criffel face short tussock belt

#### **Summit plateau including the upper Cliff Burn and Luggate Creek landscape units down to ~1600 m asl.**

This distinctive area forms part of the greater Summit Ridge and upper basins of the Pisa Range. It is one of the best examples of high alpine, schist block mountain range landscapes of Central Otago and near the eastern edge of glacial activity in Otago. The Cliff Burn cirque is visually very impressive with its steep derivative slopes, tarns, ice-worn rock outcrops and moraine deposits. The cirque is a distinctive feature of the summit plateau and visible over a wide area. The contrasting, smooth and rounded summit ridge with lag gravels, stone pavements, and soil hummocks are also a distinctive feature and are very expressive of the extreme exposure experienced in this landscape.

The whole of this unit is highly legible in terms of the glacial and subsequent weathering processes. Excellent examples of well developed periglacial features are present.

The vegetation patterns are diverse including cushionfield, snowbank communities and short and tall tussockland. The characteristics are likely to be little changed from pre-human times and therefore highly representative of an indigenous New Zealand landscape.

Viewed in the context of the wider plateau landscape, this landscape is outstanding, with the expansive and sweeping views to the main divide including Aoraki/Mt Cook on a good day, the inland lake basins of Hawea and Wanaka, south to the Remarkables and Hector Mountains and north and east to St Bathans Range.

### **Luggate Creek Summit Plateau and Upper Pisa/Criffel Face**

The Luggate Creek area is the western and lower portion of the expansive Pisa summit plateau. It forms a significant upland landscape with most natural patterns, processes and elements intact.

The open, smooth, undulating surface of the plateau and the infaulted valleys with their eroded rounded edges and alluvial surfaces are distinctive and memorable features, as well an integral part of the summit landscape. There is a very high degree of legibility in terms of formative processes. The vegetation cover is primarily natural. Indigenous species are visually dominant across the whole area. The rolling/undulating slopes are primarily tussock/herbfield with seepages and wetlands within gullies. The continuity of the vegetation cover and relative intactness gives a high degree of coherence to the landscape. Visually the higher plateau surface on the eastern side of the Pisa summit plateau is contiguous with, and complements the western (Luggate Creek) area. It reads as one unit and as part of the whole summit plateau landscape.

The spectacular and expansive views across the summit plateau to the surrounding ranges, mountains and basins are also a special feature of this area.

The upper scarp face and transition to the summit of smooth rounded undulating surfaces is also an essential and natural extension of the upper summit plateau landscape. The steep slopes and extensive rock outcrops and bluffs combined with comparatively intact tussockland and herbfield are a continuation of the Criffel Range upper scarp, which is a feature of this range. The bluffs and rock outcrops and steep eroded slopes are visually impressive and provide a striking contrast to the smooth undulating slopes immediately above it and on the summit plateau itself.

### **Criffel Face Short Tussock Belt**

The Criffel face short tussock belt, extending from approximately 1100 m to 1300 m is a significant feature on the Criffel Range. It provides a good example of short tussock in relatively good condition and with a high degree of continuity. Areas of silver and hard tussock in good condition are relatively rare in the high country. The combination of the tussock and the large rock outcrops present is a distinctive Otago landscape and

contributes to the character and identity of the range. The depleted condition of tussock on the lower slopes of the range makes the short tussock belt in this zone all the more significant.

The intactness of the dominant tussock forms an aesthetically coherent landscape. The distinctive tawny/straw colours and texture of the tussock cover is striking against the contrasting rock outcrops and as a foreground to the impressive views up the Cardrona Valley to Lake Wanaka.

The short tussock belt also represents a good example of where landscape values and productive values co-exist in what appears to be a sustainable way.

## 2.2 LANDFORMS, GEOLOGY AND SOILS

### (a) Landforms

The Pisa Range is the highest of the parallel fault-block mountains that characterise the Central Otago region, and the Lease extends to almost the summit of Mt Pisa, the highest part of this range. Unlike most other Otago block mountains, the Pisas present distinct fault escarpments on both sides, with an eight kilometre wide, sloping summit plateau between them. The western scarp crosses the Lease at about 1400 m.

The Luggate Creek catchment drains the plateau. The headwater sub-catchments are located on the property, and are shallow and intricate. The plateau landscape is characterized by gentle, rounded forms, and lies between 1700 and 1964 m.

On the Robrosa side of the range, slopes are generally much gentler than the eastern slopes. However there is a series of spectacular cirque basins present in the headwaters of the Cliff Burn. These basins contain a series of small lakes. This is an unusual previously glaciated valley, in that it lacks a steep wall at its head. Instead, the western side only has been gouged out by ice action, resulting in cliffs 180 m high (Mason 1988).

The most exposed sites on the summit ridge have lag gravels and stone pavements. Soil hummocks cover a large proportion of the area on ridges and gentle slopes. Other periglacial landforms are well developed, especially solifluction lobes on shady slopes. Some associated snowbanks are still active.

The alluvial sands and gravels which overlay schist, just west of the Princess Burn, have previously been worked for gold.

Random clusters of shaft and pedestal tors dot the summit crest e.g. Dome Rocks, providing stark contrast to their gentle surroundings. Bands of schistose rocky tors also occur along the fault escarpment lower down the property, at about 1400 m.

A narrow alluvial flood plain occupies the Cardrona Valley.

## (b) Geology

Robrosa Pastoral Lease lies on the eastern side of the Cardrona valley extending onto the summit of the Pisa Range massif, which is the highest of the westward tilted fault-block ranges characteristic of Central Otago. The Central Otago region is subject to ongoing continental shortening, which has formed folds over reversed faults from a peneplain surface cut into schist (Jackson *et al.* 1996). Ranges were formed by folding and uplift that occurred during the Kaikoura Orogeny, late Miocene to Pliocene (5 - 2million years ago) in Central Otago, in response to tectonic events on the Australian - Pacific plate boundary to the west. The asymmetric basins and ranges of Central Otago were formed by a compression east of the Alpine Fault, and are bound by major fault systems (Turnbull 2000). The relatively flat summits of these ranges are derived from the Otago peneplain, part of the Waipounamu Erosion surface WES (LeMasurier and Landis 1996).

Basement rock is Haast schist (Rakaia terrane, TZ IV - strongly foliated and segregated schist) (Turnbull 2000). This schist is commonly exposed in tors, or abrupt blocks or tower-like outcrops of platy laminated rock, and occurs on the Lease towards the summit ridges. Tors are usually blocks of rock between joints where softer material has been removed by erosion. Lines of tors probably result where joints intersect with lineations such as fold hinges in schistosity, or less frequently, with more resistant rocks (Forsyth 2001).

On the Cardrona Valley floor, fluvio-glacial or fluvial gravels are present in a faulted syncline (Turnbull 2000). The gravel is gold bearing and is of early Quaternary age, thought to have been deposited by a proto-Clutha that drained south through the Cardrona Valley into the Kawarau River. There is a thin gold-bearing alluvial mantle in the headwaters of Luggate Creek.

The western face of the Pisa Range overlooking the Cardrona River is characterised by ripply slump topography with dissected ridge and gully landform. Landslides dominate the landscape of many Otago ranges and are more common and extensive in schist (Forsyth 2001). Large landslides may have been active for thousands of years and many are still active. Slowly creeping landslides (up to 300 m thick) are often present on steeper flanks of these ranges and deeply incised gorges (McSaveney *et al.* 1991).

The summit plateau is relatively flat. The underlying schist is incised by Luggate Creek. There are remnant glacial features present (McCraw 1959). The peat swamps of poorly drained areas within the Cliff Burn headwaters are examples of landforms formed under peri-glacial conditions.

## c) Soils

Upland hygrous yellow-brown earths dominate the property. Stony Obelisk soils derived from schist solifluction detritus and schist occur near the main rolling summit ridge and exhibit solifluction stripes, ridges and hummocks. Carrick and Carrick Hill soils are the most widespread, present on the rolling to moderately steep slopes to 2000 m. A hummocky surface is common. Dunstan Steepland soils are found on the steeper slopes between 500 and 2000 m asl. Yellow Grey Earths are common at mid altitude (Soil Bureau 1968), and on sunny aspects above 1000 m. Soils include Arrow Steepland,

Blackstone and Blackstone Hill series. Small deposits of organic soils occur on easy rolling or flat and hilly topography between 650-1200 m. Kaherekoau Upland Swamp soils occur in upland valley floors and swamps, and support sedges and short tussocks.

Recent soils occur in the valley floors, and on fans and terraces. Soils occurring on the lowest terraces and fans include Gladbrook soils which are deep and well-structured; and Tarras soils which are poor, droughty and gravelly. Tarras stony sand soils of the Cardrona River flood plains are subject to periodic flooding.

A Soil Site (no. 317) is present at RAP A3: Pisa Tops, characterised by a gently-tilted summit plateau with cirque basins, steep cliffs, small talus cones, tarns, moraine and solifluction deposits, stone pavements and soil hummocks, and deeply incised valleys. Soils present include the upland yellow-brown earths Carrick, Dunstan and Obelisk series. The vegetation comprises cushionfield, short tussockland, snow tussockland, fellfield and herbfield (Arand *et al.* 1991 See Appendix 3).

### Significance of Geology, Landforms and Soils

The Soil Site located on the property along the Pisa Range tops, is of national importance, comprising a large highly natural area encompassing a moderate range of soil-vegetation associations (Arand *et al.* 1991).

The Pisa Range is the highest of the fault block mountains characteristic of Central Otago region, and one of the most distinctive landform and ecological systems of New Zealand (Ward *et al.* 1994).

## 2.3 NEW ZEALAND'S BIODIVERSITY PROTECTION NEEDS

There are two databases that have been used to assess biodiversity protection (Walker *et al.* 2005):

- The environmental distinctiveness of an area can be assessed through the Land Environments of New Zealand (LENZ). This is a classification of New Zealand lands using a comprehensive set of climate, landform and soil variables chosen for their roles in driving geographic variation in biological patterns (Leathwick *et al.* 2003). LENZ is a useful tool for measuring conservation initiatives against the New Zealand Biodiversity Strategy (see Section 3.6). It is presented at four levels of detail containing twenty, 100, 200 or 500 environments nationally. The most detailed is called LENZ Level IV.
- The area of unprotected indigenous cover in threatened land environments has been identified in the national land cover database (LCDB).

From the above databases, spatial data depicting indigenous vegetation cover and legal protection were overlaid on LENZ Level IV environments to identify biodiversity that is most vulnerable (i.e. most likely to be lost). This provides a measure for: a) percentages legally protected and b) percentages of remaining indigenous vegetation cover.

Based on these two criteria, five categories of threatened environments have been used to identify environments containing indigenous biodiversity at most risk of loss. They are classified as follows:

- Acutely threatened:* <10% indigenous vegetation cover remaining
- Chronically threatened:* 10-20% indigenous vegetation cover remaining
- At risk:* 20-30% indigenous vegetation cover remaining
- Critically underprotected:* >30% indigenous vegetation cover remaining and <10% protected
- Underprotected:* >30% indigenous vegetation cover remaining and 10-20% protected
- No threat:* >30% indigenous vegetation cover remaining and >20% protected.

At the level IV (500 environments nationally) the areas investigated at the Lease fall predominantly within Environments Q1.1a, Q3.3a, Q2.2a, Q1.1c and Q1.2a, with smaller contributions of N4.1d, K3.3b and K3.3a. See Appendix 4 for descriptions of these LENZ units and Appendix 5 for their distribution on the property). The extent of Level IV environments as Crown land managed mainly for conservation purposes is shown in Table 4 below.

**Table 4: Land Environments of New Zealand Units on Robrosa Pastoral Lease.**

Threat Category	LENZ Level IV Environments on the Lease	Area of LENZ unit on Robrosa Pastoral Lease (ha)	Percent protected nationally for conservation purposes	% of Indigenous vegetation cover remaining	Change in Indigenous Vegetation Cover between 1997 and 2002
Acutely Threatened	K3.3a	20.25	5.24	8.35	No Change
	K3.3b	38.07	4.58	7.3	No Change
Chronically Threatened	N4.1d	73.84	3.04	18.59	No Change
Critically Under-protected	Q2.2a	429.15	3.91	39.92	Decrease
Under-protected	Q1.1c	372.52	17.86	91.23	No Change
No Threat	Q1.1a	2016.51	24.81	98.37	No Change
	Q1.2a	290.33	37.2	98.99	No Change
	Q3.3a	479.55	25.6	96.91	No Change

### Significance of Land Environments of New Zealand

The Lease has five Level IV land environments that are significant because, on a national level the indigenous vegetation has largely been removed, and/or little of the environment is represented in lands protected primarily for conservation purposes:

- 1.56% of property has two “Acutely Threatened” Level IV LENZ units (i.e. K3.3a and K3.3b) that has <10% of its land area still in indigenous cover.

- 1.97% of property has one “Chronically Threatened” Level IV LENZ unit (N4.1d) that has 10-20% indigenous vegetation cover remaining.
- 11.49% of property has one “Critically Under-protected” Level IV LENZ unit (Q2.2a) that nationally has >30% of its land area still in indigenous cover and less than 10% of the unit is protected.
- 9.97% of property has one “Under-protected” Level IV LENZ unit (Q1.1c) that nationally has >30% indigenous vegetation cover remaining and 10-20% of the unit protected.

However, the botanical survey confirmed that indigenous cover has been largely removed from these land environments on the Lease.

## 2.4 CLIMATE

The climate of the Pisa ED is generally typical of Central Otago, having a dry subcontinental climate with the lowest annual rainfall and greatest seasonal temperature range in New Zealand. The climate is controlled by the inland location and the rain shadow effect of the enclosing mountains, particularly the Southern Alps to the north and west. Winds are predominantly westerly, mainly blowing from the south-south-west during winter, and the west or north-west for the rest of the year.

Annual rainfall ranges from 600 mm at the Cardrona River to 1500 mm at the crest of the property. Snow lies above 1000 m for much of the winter, persisting well into the summer months at high altitude.

## 2.5 VEGETATION

### Introduction

As the highest of the Otago block mountains, the Pisa Range attracted the attention of early botanical explorers who discovered and described many endemic species (e.g. Petrie 1886), giving rise to several type localities. The first comprehensive assessment of botanical significance arose through the Protected Natural Areas Survey Programme which surveyed the Lindis, Pisa and Dunstan Ecological Districts during the summer of 1984/85. The resulting report (Ward *et al.* 1994) identified 16 Recommended Areas for Protection (RAPs) for the Pisa Ecological District of which part of one (RAP A3 Pisa Tops) lies within Robrosa Pastoral Lease.

Other field botanists have also surveyed the range and compiled lists of vascular plants e.g. Druce *et al.* (1993). Their emphasis is likely to have been on the less modified and more accessible higher altitude parts of the range. Researchers, particularly from Otago University, have also utilised the range for study sites e.g. Mark & Bliss (1970).

The present vegetation on the Lease is thought to be very different from that in the past. The likely nature and extent of the pre-human vegetation has been assessed as part of a wider study of the woody vegetation of Central Otago (Walker *et al.* 2003). This suggests that at lowest altitudes (450 – 730 m) a kanuka-kowhai-Hall's totara forest would have occurred. At higher elevations (up to 1040 m) a beech-Hall's totara-snow totara forest

probably prevailed below a snow totara-mountain toatoa shrubland rising up to 1340 m. At the higher reaches of the Pisa Range, an alpine tussock-shrubland is predicted, with the models predicting dominance by mat-forming and other low-statured woody plants.

Some important relictual forest and shrubland is known from other parts of the Pisa Range. The montane zone on the north-eastern faces has several patches of Hall's totara-mountain toatoa-bog pine shrubland, some of which is protected within the Locharburn Scenic Reserve. The northern and southern ends of the range have important gully systems with silver beech forest remnants and associated species.

## Survey Method

The botanical survey was undertaken from 23 – 26 January 2006 by two botanists, each spending approximately 34 hours on the property. Survey of the freehold land, Criffel faces and Princess Burn catchments were carried out by vehicle and on foot. Survey of the entire Cliff Burn catchment within the Lease was carried out on foot as was a survey from the lower Cliff Burn west to the Lease boundary at Waiorau. Descriptions were made of the composition of major plant communities and notes taken on the impact of pastoral farming on those communities. Threatened plants were searched for in potentially suitable habitats. Digital photographs were taken of particular species, communities and landscapes to aid interpretation. Specimens were collected of uncertain taxa for later identification.

## Vegetation Description

The Lease has been broken up into units and sub-units to assist the description of vegetation on the property. These units are based primarily on topography:

- Pisa Tops
  - (i) *Cliff Burn*
  - (ii) *Headwaters of Welshes Creek, Deep Creek, Luggate Creek & Princess Burn*
- Criffel Faces

### Pisa Tops

#### (i) *Cliff Burn*

The Cliff Burn is a major deep glacial-derived valley arising from the crest of the Pisa Range and flowing north-west into Luggate Creek. It has an altitudinal range from c. 1900 m down to c. 1400 m at the Lease boundary. The head basin is unusual, lacking the steep headwall characteristic of cirques. The complexity of landform within the cirque basin is responsible for high species and community richness.

At highest altitude on the very exposed edge of the summit plateau are *Dracophyllum muscoides* dominated cushionfields. Along with the locally abundant alpine rush *Marsippospermum gracile*, other species normally present include *Anisotome imbricata*,

*Phyllachne rubra*, *Hectorella caespitosa*, *Celmisia viscosa*, *Abrotanella inconspicua*, *Kelleria croizatii*, and *Carex pterocarpa*. More local species include *Schizeilema exiguum*, *Anisotome lanuginosa* and *Poa pygmaea*.

South-facing derivative slopes provide a range of habitats. Exposed ledges are mostly the domain of yellow clumps of *Aciphylla simplex* and alpine rush, while sheltered overhangs and cavities have *Myosotis* aff. *pulvinaris*, *Leptinella pectinata*, *Ourisia glandulosa*, *Chionohebe thomsonii*, *Pachycladon novae-zelandiae* and *Poa novae-zelandiae*. Damp gravely ledges at the foot of bluffs often support *Ranunculus pachyrrhizus*.

Fine talus slopes have sparse vegetation which includes the local *Epilobium purpuratum*, *Hebe petriei*, *Colobanthus buchananii* and *Raoulia youngii*. Stony alluvial terraces alongside the infant Cliff Burn stream have a small population of the threatened forget-me-not *Myosotis pygmaea* var. *minutiflora*. It occurs with the local buttercup *Ranunculus maculatus* along with *Raoulia subulata*, *Neopaxia sessiliflorum* and *Leptinella pectinata*.

Small areas of snowbank vegetation are present and variously contain many of the species mentioned above. Dominant species in this community though are alpine rush, *Ranunculus pachyrrhizus*, *Ourisia glandulosa*, *Argyrotegium mackayi* and *Psychrophila obtusa*.

Three alpine tarns are present; two large tarns in the valley floor (1620 m and 1720 m) and one small tarn high under Dome Rock at c. 1840 m. The valley floor tarns have wet alluvial fans at their heads, and margins of herb seepage wetlands. This vegetation community is similar to that of surrounding bogs and seeps and is dominated by *Carex lachenalii*, *C. pyrenaica* var. *cephalotes*, *C. gaudichaudiana*, *Abrotanella caespitosa*, *Kelleria paludosa*, *Psychrophila obtusa*, *Phyllachne colensoi* and *Neopaxia sessiliflora*. Of note is the presence of the uncommon *Plantago obconica*. Small pools on hummocky moraine between the two largest tarns have the tiny herbs *Glossostigma cleistanthum* and *Crassula sinclairii*. A steep rocky gorge between the two lakes is lined with abundant *Dolichoglottis lyallii*. The bottom tarn has extensive beds of the aquatic herb *Myriophyllum propinquum*.

Downstream of the lower-most tarn the valley is less tightly confined and the flanking slopes are studded with many rock outcrops and talus. Slim snow tussock is scattered over the hillslopes but the groundcover is dominated by blue tussock and alpine fescue tussock along with cushions of *Dracophyllum muscoides*, *Abrotanella inconspicua*, *Raoulia grandiflora* and *Celmisia viscosa*. *Dracophyllum muscoides* is especially prevalent on well-drained stony hummocks and spur crests in association with *Hebe buchananii* and *Chionohebe densifolia*. Similar short tussock grasslands with a predominantly native inter-tussock ground cover extend down the Cliff Burn to the Lease boundary.

There are many valley side and toe-slope herb seep wetlands. Common species in this community include *Carex berggrenii*, *Plantago triandra*, *Euchiton lateralis* and *Coprosma atropurpurea*. At c. 1500 m patches of sweet vernal are apparent on preferred damp toeslope sites on sunny faces. This in stark contrast with the upper valley which is notable for the almost complete absence of introduced species except for sheep's sorrel at very low density.

(ii) *Headwaters of Welshes Creek, Deep Creek, Luggate Creek & Princess Burn*

This block is characterised by smooth undulating ridges (with many schist tors) and quite gentle valleys that flow into various Clutha River tributaries. The elevated plateau has extensive cushionfield vegetation and short tussockland with repeating vegetation patterns across surprisingly gentle topography.

On the most exposed, highest altitude sites are sparsely vegetated lag gravel fields and cushionfields similar to that described above for the Cliff Burn. Cushionfields dominated by *Dracophyllum muscoides*, *Chionohebe densifolia* and *Celmisia sessiliflora* also extend down the exposed crests of the many secondary ridges and spurs. Fields of *Celmisia viscosa* are common on more sheltered slopes below the crests. Slim snow tussock occurs as scattered plants or small groups on all aspects but is particularly evident on shady aspects.

The dominant cover over most of this block is short tussockland dominated by alpine fescue and blue tussock. Together with a myriad of other grasses, sub-shrubs and herbs, it provides a consistently dense ground cover with little bare ground. Common associated species include golden speargrass (which can be locally abundant), *Pimelea* aff. *sericeovillosa*, *Raoulia subsericea*, *Rytidosperma maculatum*, *Leucopogon fraseri*, *Chionohebe densifolia*, *Epilobium alsinoides*, *Carex wakatipu* and *Celmisia sessiliflorum*. Apart from sheep's sorrel and tussock hawkweed, both at very low density, and localised pockets of pasture grasses, few exotic plants are present.

Occasional large groups of spur-top tors have distinctive plant communities around their shady bases which include species largely restricted to this habitat. Distinctive species include *Galium propinquum*, *Geum leiospermum*, *Leptinella squalida* subsp. *mediana*, *Ranunculus multiscapus*, *Schizaelema haastii* var. *cyanopetalum*, *Uncinia drucei* and *Carex colensoi*. One tor has the threatened cress *Cardamine* "Pisa Range".

Small hillside seeps and valley floor wetlands are found throughout the block. These areas of high plant diversity have communities that reflect subtle differences in micro-topography, hydrology and fertility. Comb sedge is the most widespread and common species but other ubiquitous species include *Plantago triandra*, *Carex gaudichaudiana*, *Euchiton lateralis*, *Coprosma atropurpurea*, *Psychrophila obtusa*, *Phyllachne colensoi*, *Gentianella amabilis* and *Abrotanella caespitosa*. More localised species occurring at only one or few wetlands include *Centrolepis pallida*, bladderwort (*Utricularia dichotoma*), *Plantago obconica* and *Ranunculus maculatus*.

### Criffel Faces

This block is the western face of the Criffel Range, falling c. 1000 m from the edge of the summit plateau to the Cardrona Valley. The slopes are moderately steep and comprised of slumps into which streams are shallowly incised.

At the edge of the summit plateau the vegetation has much in common with that described below for the headwaters of Welshes Creek and Luggate Creek. Short tussocklands predominate on slopes while cushionfield communities dominated by *Dracophyllum muscoides* occur on exposed spur crests. Herbfield seeps occupy shallow gully heads. Patches of golden speargrass and occasional shrubs of cottonwood (*Ozothamnus*

*vauvilliersii*) are clustered around particularly large groups of rock tors that line the upper edge of the face. These tors are sites of high diversity and harbour species such as *Celmisia brevifolia*, *C. laricifolia*, *C. ramulosa*, *Schizaelema haastii* var. *cyanopetalum*, *Brachyglottis haastii*, *B. bellidioides*, *Colobanthus buechananii*, *Koeleria cheesemanii* and *Cystopteris tasmanica*.

With decreasing altitude there is a gradual deterioration in indigenous cover with increasing sweet vernal and mouse-ear hawkweed, although indigenous species continue to dominate to low altitude. Indigenous shrubs and sweet briar become more common and eventually coalesce into substantial shrublands below c. 900 m. The shrubland shows evidence of having been recently sprayed with herbicide with differential impacts apparent on the constituent shrub species. Porcupine shrub (*Melicactus alpinus*), mingimingi (*Coprosma propinqua*) and shrubby pohuehue (*Muehlenbeckia complexa*) appear little affected. Matagouri (*Discaria toumatou*), *Olearia odorata*, sweet briar (*Rosa rubiginosa*) and *Olearia lineata* appear dead or nearly so.

Two areas of shrubland above the herbicide-affected zone are notable for their relative complexity and intactness. The first area is a slump with large blocks of exposed rock at c. 1000 m. Shrubs present include matagouri, mingimingi, *Coprosma rugosa*, *Olearia odorata*, *O. lineata*, porcupine shrub, desert broom (*Carmichaelia petriei*) and sweet briar. Bush lawyer (*Rubus schmidelioides*) is a common liane. The second area is a rocky gully at c. 1100 m with the only recorded population of the native broom *Corallospartium crassicaule* var. *racemosum* on the Pisa Range, *Olearia odorata*, *Coprosma tayloriae*, and riparian herb communities with species uncommon on the Lease e.g. *Lagenifera cuneata* and *Rumex flexuosus*. Other areas of shrubland are expected at similar altitude in other, unvisited gullies.

The vegetation of the lowest parts of the property in the Cardrona valley floor is dominated by exotic grasses and exotic riparian treeland.

## Significance of Vegetation Values

Much of Robrosa Pastoral Lease has been identified as having significant vegetation values (refer Map 4.2.3).

Robrosa Pastoral Lease falls within the Pisa Ecological District (ED). It contains representation of the plants and plant communities in the montane, sub-alpine, low alpine and high alpine bioclimatic zones of the Meg Land System. The Pisa ED along with the neighbouring Lindis and Dunstan EDs were surveyed as part of the Protected Natural Areas Programme (PNAP) during the summer of 1984/85. The resulting report (Ward *et al.* 1994) identified 16 Recommended Areas for Protection (RAPs) in the Pisa Ecological District of which part of one lies within the Lease.

RAP A3 Pisa Tops is a large area (8560 ha) encompassing about half of the gently west-tilted plateau of the Pisa Range and a smaller segment of the steep eastern fault-scarp face. Most of the Lease above 1500 m falls within the RAP and contributes just under 25% of the total area of the RAP. The RAP is regarded as of outstanding representative significance by Ward *et al.* (1994), lying within one of the most distinctive land form and ecological systems of New Zealand. This more recent evaluation of the inherent values confirms and endorses the RAP description.

At least 292 native vascular species (see Appendix 6) are present representing approximately 67% of the vascular plant diversity recorded for the much larger (61 500 ha) and ecologically diverse Pisa Range (Druce *et al.* 1993).

Of the native vascular plant species present, at least 16 species are listed as threatened and a further two as Data Deficient in the most recent threat classification system (Hitchmough 2002 as amended by de Lange 2004). A list of these species with their threat of extinction status and distribution within the Lease is provided below in Table 5 and Appendix 7.

**Table 5: Threatened and data deficient plant species found on Robrosa Pastoral Lease**

Threat Division	Threat Category	Species	Location on lease		
Acutely threatened	Nationally Endangered	<i>Cardamine</i> "Pisa Range"	Rock outcrops in low-alpine zone		
	Nationally Vulnerable	<i>Myosotis pygmaea</i> var. <i>minutiflora</i>	Streamside gravel in upper Cliff Burn		
Chronically Threatened	Gradual Decline	<i>Acaena buchananii</i>	Short tussockland on Criffel faces		
		<i>Leptinella serrulata</i>	Short tussockland on Criffel faces		
At Risk	Sparse	<i>Olearia lineata</i>	Shrublands on Criffel faces		
		<i>Epilobium purpuratum</i>	Wet talus slopes in the Cliff Burn cirque		
		<i>Euchiton paludosus</i>	Alpine seep in Luggate Creek		
		<i>Plantago obconica</i>	Alpine seeps		
		<i>Ranunculus maculatus</i>	Alpine seeps		
		<i>Carex berggrenii</i>	Alpine seeps in Cliff Burn		
	Range Restricted	<i>Acaena tesca</i>	Tor bases in alpine zone		
		<i>Raoulia hectorii</i> var. <i>mollis</i>	Alpine fellfield		
		<i>Elymus falcis</i>	Throughout		
		<i>Festuca matthewsii</i> subsp. <i>pisamontis</i>	Short tussockland in alpine zone		
		<i>Poa pygmaea</i>	High altitude cushionfield and fellfield		
		<i>Carex pterocarpa</i>	High altitude cushionfield and fellfield		
		Data Deficient		<i>Corallospartium crassicaule</i> var. <i>racemosum</i>	Rocky gully on Criffel faces
				<i>Vittadinia australis</i>	Dry short tussockland on Criffel faces

Of highest significance is the presence of the Nationally Endangered cress *Cardamine* "Pisa Range", which occupies rocky ledges on summit tors in the alpine zone.

Also of highest significance is the occurrence of a population of a small forget-me-not *Myosotis pygmaea* var. *minutiflora* (ranking of Nationally Vulnerable) in the Cliff Burn. This is the first record for the Pisa Range and adds to the list of nine modern Otago populations and 16 modern South Island populations (Rogers *et al.* 2002). Its habitat on streamside gravels in the Cliff Burn is somewhat atypical although it has previously been recorded from the margins of lakes and tarns, including an alpine tarn, where it is thought it may not behave as a strict spring annual. Monitoring of some North Island populations suggest losses from expansion of exotic plants. The almost complete absence of exotic plants from the Cliff Burn suggests it may provide secure habitat for the species.

Species listed in the category Gradual Decline fall within the division 'Chronically Threatened'. Species in this division face extinction but are buffered slightly by either a large total population size, or a slow decline rate. Species listed as Sparse and Range Restricted fall under the division "At Risk". Although they are not currently in decline, their population characteristics mean a new threat could rapidly deplete their populations. Sparse taxa have very small, widely scattered populations. Species listed as Data Deficient have insufficient information on which to make an assessment as to their appropriate category.

Several other species, although not ranked as nationally threatened, are notable in a regional and local context and include *Pimelea* aff. *sericeovillosa*, *Crassula sinclairii*, *Myosotis* "Pisa", *Myosotis pulvinaris*, *Rumex flexuosus*, *Schizaelema haastii* var. *cyanopetalum*, and *Centrolepis pallida*.

High alpine and low alpine communities (cushionfield on patterned ground, alpine tors, alpine fescue tussocklands, snow banks and herb seepages) are significant as distinctive communities, and for their contribution to contiguous larger areas of these communities. In comparison with the rest of the property these communities have been least affected by recent pastoral farming activities. Extensive areas of short tussockland, between the alpine cushionfield and upper limit of the tall woody shrublands on the Criffel faces, are dominated by *Festuca mathewsii* and/or *Poa colensoi*. Cushion-forming plants are still important but their contribution to the community varies across landforms. These short tussock grasslands appear to have been derived from snow tussock grassland within the period of European settlement (Mark 1965). Compared to induced short tussocklands elsewhere in Otago, these have been remarkably little-affected by exotic grasses and weeds. They are a highly distinctive community largely restricted to the Otago block mountains.

The shrublands of the Criffel faces have been severely compromised through the widespread death and defoliation of key constituent species, apparently from the application of herbicide. Although this community lacks the structural dominants of the earlier predicted forest (Walker *et al.* 2003) it retains species thought to reflect the understorey composition of such a forest.

Two small areas in particular, on the basis of their relative complexity and intactness, stand out as having suffered less from recent disturbance. The first is a blocky slump at c. 1000 m dominated by *Olearia-Coprosma* shrubland and the second is a rocky gully at c. 1100 m with native broom-*Olearia-Coprosma* shrubland with associated riparian herbs. The importance of woody vegetation, and the desirability of protecting shrublands across a full range of Central Otago environments, has been given prominence by Walker *et al.* (2003). The recovery of shrublands in the absence of grazing and fire has been demonstrated at several sites in Central Otago and is a desirable biodiversity outcome. Numerous small seepages and bogs occur within an alpine setting of high natural character. As areas of high species richness, they make a disproportionately high contribution to the biodiversity of the property. Wetlands nationally have undergone a 90% reduction and remaining examples are a priority for protection. Five threatened species in Table 5 and three regionally uncommon species (*Crassula sinclairii*, *Centrolepis pallida* and *Rumex flexuosus* (native dock)) are found predominantly in wetland habitats.

The Pisa Range has been the focus of some botanical and ecological research by the University of Otago. Mark & Bliss (1970) in their major work on the high-alpine vegetation of Central Otago sampled vegetation on the Pisa Range in or near the Lease. At least two of the alpine plant species assessed for details of floral initiation in another research project (Mark 1970) came from the Pisa Range. More recently two long-term vegetation/environment monitoring sites in the Pisa Range adjoining the Lease have been established as part of the Global Observation Research Initiative in Alpine Environments (GLORIA). This is a study of climate change-initiated impacts on mountains and the associated responses in the distribution of alpine plant species (Alan Mark *pers. comm.*).

The presence of a large number of species with very limited geographical distribution has given rise to many type localities in and around Robrosa on the Pisa tops. These include type localities for *Chionobebe myosotoides*, *Myosotis cheesemani*, *Poa pygmaea*, *Carex berggrenii*, *Carex kirkii* var. *kirkii*, *Carex pterocarpa*, *Chionobebe thomsonii* var. *glabra* and *Leptinella goyenii*.

### 2.5.1 Problem Plants

At least 62 exotic species of plants (see Appendix 6 for full list) are present on the Lease but relatively few are of conservation concern. Many are plants of agricultural importance or are common pastoral weeds. The vast majority are present only at the lower elevations of the Lease.

Ryecorn (*Secale cereale*) is present by self-seeding in at least one site along the central access track through the Criffel faces. It was noted as common around the ski field buildings and roads within the adjoining Waiorau property. This exotic grass is virtually unknown in the high country and consequently its impacts are also unknown. Surveillance of disturbed sites within Robrosa should be carried out to determine any further spread and impacts of this plant.

At least two hawkweeds (*Hieracium pilosella*, and *H. lepidulum*) are widespread but seldom common except in low altitude communities. The prevalence of mouse-ear hawkweed is concomitant with the loss of taller indigenous cover through grazing. Maintenance and/or restoration of a dense tall tussock cover may reduce the impact and further spread of mouse-ear hawkweed, however, the impact and continued spread of tussock

hawkweed may be more intractable. Tussock hawkweed presents particular risks to rare species on rock bluff sites (Wardle 1999) which may necessitate site-specific control measures.

## 2.6 FAUNA

### 2.6.1 Invertebrates

#### Introduction

As with many of the Central Otago mountains, the subalpine and alpine zones are considered to have a very rich fauna by New Zealand standards, usually associated with less modified vegetation. While the Pisa Range is considered to be part of the alpine core of Central Otago, with a characteristic Central Otago fauna, it also has extra diversity because of distributional overlaps with species characteristic of the wetter mountains of north-west Otago (Ward *et al.* 1994). It forms the eastern limit for a number of species including the yellow tortricid moth *Ascerodes prochlora*.

The Pisa Range has its own endemic black butterfly, *Percnodaimon* sp. which is locally distributed across the tops (B. Patrick *pers. comm.*). Although there are no known endemic moths, there are many moth species that have distributions shared between the Pisa Range and one or two of the adjacent ranges (B. Patrick *pers. comm.*)

Pisa Range is the Type locality for two species of stoneflies: *Zelandobius inversus* and *Z. mariae*, and was the only known site for these two species at the time of description (McLellan 1993).

#### Method

The property was visited over the period 23-26<sup>th</sup> January 2006. During the survey the days were hot, but with some strong, cool winds at higher altitudes. Night temperatures declined with altitude. The season and weather conditions were favourable for a good representation of species to be present.

The usual limitations on invertebrate sampling over a very restricted time-frame and at a single time of year apply. Many species, insects in particular, have a very short and specific season of activity. While this activity tends to be concentrated in late spring to mid summer, for some species they can be at completely different times of year, including winter. For example, Central Otago has a significant fauna of winter-active insects, especially moths. Weather conditions during the survey period can also hugely influence what is active and accessible. Limited time-frames mean that sampling is fragmentary, only more accessible sites are surveyed in any detail and only the more accessible species are likely to be detected. Many potential specimens are left due to a lack of up-to-date taxonomy, identification keys or specialists willing/able to identify specimens. Therefore, surveys of this nature can seldom reveal more than a few percent of the total invertebrate diversity of a property.

Invertebrate values were assessed primarily on the basis of habitats present. Many parts of the property were not covered in detail, but much of it was viewed from vantage

points. Potentially significant areas which were not inspected for invertebrate values included some of the steep creeks falling westward from the Criffel Range, especially those south from the farm access track. These were likely to have included residual grey scrub vegetation with potential invertebrate values.

Time on the ground was split between walking through habitats to assess potential and searching, sweep-netting, rolling rocks and some vegetation beating.

Timer-operated UV light traps set out on two nights (23/1, 24/1) at altitudes of 1350 m, 1460 m and 1680 m (three trap-nights) failed to catch anything, despite daytime surveys in the area clearly indicating that moths and other species normally attracted to such traps were plentiful. There was no significant moonlight for the traps to compete with. It can only be assumed that insect activity on these nights was affected by wind or colder temperatures. In practice it has been noticed that a 'critical mass' of activity seems to be required to achieve a catch in these traps. During the day of 25/1 two noctuid moths (*Aletia cuneata*) were captured. They were still cold and torpid on grass in the shade of a tor, suggesting that the night may have been quite cold.

A UV wet trap operated on the night of 23/1 in a more sheltered locality at 1400m brought in a moderately extensive catch of species.

Other members of the survey team found and provided specimens in the course of their work.

### **Habitats and Invertebrate Fauna Description**

Invertebrate species recorded and identified from the property are listed in Appendix 8.

The invertebrate composition is described for the following collection areas:

- Pisa Tops
- Criffel Summit
- Upper Criffel Faces (900-1300m)
- Lower Criffel Faces and River Flats

#### **Pisa Tops**

This area includes the Pisa summit plateau, and the headwaters of Cliff Burn, Princess Burn and Luggate Creek. A mosaic of habitats is present that includes alpine cushionfields associated with periglacial landforms at altitude, short and tall tussocklands, occasional woody vegetation in lower, more sheltered sites, small lakes, extensive fens, headwater streams with riparian fens, cliffs, tors and fellfield.

Species found here include the speargrass weevil *Lyperobius hudsoni*, the grasshopper *Sigaus obelisci* (this is one of relatively few areas in which this species and *S. australis* overlap), the cicada *Maoricicada nigra frigida*, the flightless chafer *Prodontria capito* and the moths *Hierodoris gerontion*, *Gelophaula palliata* and *Notoreas galaxias*.

The small headwater streams have the appearance of having considerable stability, without rapid fluctuations in water level, presumably in part a result of the extensive headwater and riparian wetlands. This stability is implied in features such as widespread occurrence of organic fines, and the presence of species requiring stable water flow. Fully functional invertebrate communities are indicated by a range of species at many trophic levels, from herbivores and litter feeders to predators and specialised parasites.

### Criffel Range summit

This area extends from the 1300 m contour up to the Deep Creek/Luggate Creek watershed divide. Vegetation cover in this area, especially west of the Criffel Range, is generally more modified, with greater loss of woody species and presence of introduced pasture species. Nonetheless, significant parts conform broadly to the likely pre-human vegetation and the area has characteristic landforms of the range, with a mosaic of habitats including headwater and streamside wetland sequences, narrow, deeply cut gullies and a range of rocky habitats.

The invertebrate fauna features a mix of Central Otago or southern South Island endemics, along with a range of more widely distributed species. Species of note include two large carabid beetles; an undescribed montane-alpine grassmoth *Orocrambus* n. sp. with very localised occurrences in Central Otago and the MacKenzie Basin; and *Scoparia* n. sp., a species with local occurrences in alpine Central Otago. Both of these moth occurrences represent new distribution records for these species. The population of the 'range restricted' grasshopper *Sigaus obelisci* extends into this area also. The large idiopid trapdoor spider *Misgolas* sp. was also found.

The wetland influence shows in the presence of species such as moth *Orocrambus scoparioides*. The streams have a good diversity of fauna, based on observations of aquatic nymphs *in situ* and the catch of caddis (not identified) in the UV wet trap. Streamside habitats host the alpine crambid moths *Scoparia scripta* and *S. trapezophora*.

### Upper Criffel Faces

This area extends from c. 900 – 1300 m asl on the upper Criffel scarp. Compared with areas at higher altitude, this area has been more heavily modified. It continues to hold invertebrate values with the most significant confined to small patches of residual grey scrub. The grey scrub remnants are usually riparian, or in association with rocklands or tors. Much of this woody vegetation includes a component of *Olearia odorata* which hosts a range of insect species, including rare species and Otago endemics. Two such species, *Statbmopoda* sp. "*Olearia*" and *Maoritenes* sp. "*Olearia*", were taken from *O. odorata* in this area.

### Lower Criffel Faces and River Flats

The habitats of the Cardrona Valley and lower slopes of the Criffel Range have been heavily modified, and are of limited significance for invertebrates. The area, until recently, held some of the more extensive grey scrub communities on the property. These have since been sprayed, killing off key woody species and greatly reducing invertebrate conservation values.

## Significance of Invertebrate Fauna

### (i) Species of Conservation Interest

Three species are listed as threatened on the most recent classification system (Hitchmough 2002, amended in 2004 by a team of entomologists) (see Table 6).

**Table 6: Threatened invertebrate species found on Robrosa Pastoral Lease**

Threat Division	Threat Category	Invertebrate Species	Location/ comments
Acutely Threatened	Nationally Endangered	<i>Maoritenes</i> sp. "Olearia" moth	<i>Olearia odorata</i> shrublands of upper scarp of Criffel Range.
Chronically Threatened	Gradual Decline	<i>Stathmopoda</i> sp. "Olearia" moth	<i>Olearia odorata</i> shrublands of upper scarp of Criffel Range.
At Risk	Range Restricted	<i>Sigaus obelisci</i> grasshopper	Predominantly in plateau area between Pisa Range summit and Deep Creek/Luggate creek watershed, but also extending down to Criffel summit.

While the list of collected and identified species from this survey is not large it includes a very high proportion of species which are endemic to Western and/or Central Otago or to a wider area within central-southern South Island. Other species are notable for being a new distributional record, and so represent extensions to their known range. Table 7 provides a summary of all these notable species.

### (ii) Habitats

Much of the Lease has been identified as having significant habitats for invertebrate fauna (refer Map 4.2.4).

#### 'Plateau' area, from the Pisa Range to the Deep Creek/Luggate Creek watershed divide

The upper plateau, from the Pisa Range summit ridge to the Deep Creek/Luggate Creek divide, is considered to have outstanding invertebrate conservation value on the basis of the distinctiveness and high diversity of high altitude habitats, including extensive wetland sequences. These habitats are probably the most diverse on the range, are in good condition and their fully functional invertebrate communities strongly reflect a Western-Central Otago influence with wider links both north and south. There are many species endemic to the Pisa uplands, to Western and/or Central Otago generally or to a wider area of central-southern New Zealand. The habitat here supports a strong population of the threatened *Sigaus obelisci* grasshopper, and is one of relatively few areas in which this species and *S. australis* overlap.

**Table 7: Notable Species present on Robrosa Pastoral Lease**

Invertebrate Species	Location	Comments
<i>Antipodalycaena</i> n. sp. boulder copper butterfly	Throughout, but especially numerous in high alpine wetlands, including near Cliff Burn tarns	Local species of Central Otago. Larvae on <i>Muehlenbeckia axillaris</i> .
<i>Asaphodes declarata</i> moth	Pisa Range plateau	Locally common species of greater Wakatipu Basin
<i>Asaphodes dionysias</i> moth	Wetlands in high altitude parts of Pisa Range	Local alpine species of Central Otago.
<i>Gelophanla palliata</i> moth	Wetlands in high altitude parts of Pisa Range	Local alpine species of Central Otago
<i>Hieridoris gerontion</i> moth	Wetlands in high altitude parts of Pisa Range	Local alpine species of Central Otago
<i>Lyperobius hudsoni</i> speargrass weevil	High altitude Pisa plateau	Confined to ranges around Wakatipu Basin. Associated with small speargrass of high altitude cushionfields.
<i>Maoricicada nigra frigida</i> cicada	High altitude parts of Pisa Range	Local species; common and widespread in alpine Central Otago.
<i>Maoritenes</i> sp. "Olearia" moth	<i>Olearia odorata</i> shrubs of Criffel Range upper scarp	Otago/Southland endemic. New distribution record of rare species.
<i>Mecadema</i> sp. carabid beetle	High altitude parts of Pisa Range	Endemic to Western Otago and surrounds.
<i>Misgolas</i> sp. idiopid trapdoor spider	Criffel Range Summit	Likely limited distribution within or centred on Central Otago.
<i>Notoreas galaxias</i> moth	High altitude plateau of Pisa Range	Central Otago endemic; alpine diurnal species; larvae on <i>Kelleria</i>
<i>Orocrambus</i> n. sp. montane-alpine grassmoth	Criffel Range Summit	Very localised occurrences in Central Otago and Mackenzie Basin. New distribution record.
<i>Orocrambus scoparioides</i> grassmoth	Upland wetland areas of Criffel Summit	Local Central Otago species. Common.
<i>Orocrambus thymiastes</i> grassmoth	Alpine Pisa plateau area	New northern distribution record for rare grassmoth, usually associated with Southland wetlands
<i>Prodontria capito</i> Alpine flightless chafer beetle.	Alpine Pisa plateau area	Central Otago endemic.
<i>Sigauss obelisci</i> grasshopper	Alpine Pisa plateau area	Central Otago endemic. One of few areas in which this species and <i>S. australis</i> overlap
<i>Scoparia n.sp.</i> moth	Criffel Range Summit	Local occurrences in alpine Central Otago. New distribution record.
<i>Scoparia scripta</i> moth	Wetlands of Criffel Range summit	Localised in distribution.
<i>Stathmopoda</i> sp. "Olearia" moth	<i>Olearia odorata</i> shrubs of Criffel Range upper scarp	Otago/Mackenzie Basin endemic. New distribution record of rare species.

The plateau area is especially rich in small riparian cushionfield fens (*sensu* Johnson & Gerbeaux 2004) which occur along the streams in almost every headwater valley. The wetlands continue some distance downstream, often associated with side-streams and seepages. These wetlands have particularly high plant species richness, and make a disproportionately high contribution to the biodiversity of the property. Likewise, they provide important habitat for a diverse invertebrate fauna, representative of the Pisa Range. Some wetland species are endemic (e.g. the Central Otago endemic moth *Asaphodes dionysias*) or locally uncommon (e.g. *Orocrambus thymiastes* grassmoth which is more normally associated with Southland wetlands).

**Criffel Range summit (from the 1300 m contour to the Deep Creek/Luggate Creek divide)**

This area has very high invertebrate conservation values resulting from the quality and representativeness of habitats present. A diverse and functional invertebrate community is present, which reflects its Western-Central Otago location. The habitat here supports a

strong population of the threatened *Sigaus obelisci* grasshopper. The presence of moths *Oreocrambus* n. sp. and *Scoparia* n. sp. represent new distribution records.

Despite a degree of habitat modification, invertebrate communities are diverse and functional at all trophic levels.

### **Criffel Range upper scarp (900-1300 m)**

Remnant grey scrub patches present on the upper slopes of the Criffel Range provide important habitat for the threatened *Olearia* moths *Stathmopoda* sp. "*Olearia*" (Gradual Decline) and *Maoritenes* sp. "*Olearia*" (Nationally Endangered) where they host on *Olearia odorata* tree daisy. These are new distribution records for these species which are rare and localised in southern South Island.

## **2.6.2 Herpetofauna**

### **Introduction**

Whittaker (1987) suggested that the lower reaches of Luggate Creek may represent suitable habitat for Otago (*Oligosoma otagense*) and Grand (*Oligosoma grande*) skinks, but habitat modification and the presence of introduced mammalian predators may mean that this scenario has not eventuated. The nearest known population of these rare species is at Lake Hawea and Glenfoyle pastoral leases some 35 km away.

Roys Peak Gecko (*Hoplodactylus* sp. "Roys Peak") was originally found on Mount Roy near Lake Wanaka, and has been found at other sites in Otago. The top of the Pisa Range is within its altitudinal range.

### **Methods**

The property was searched for lizards on the 25<sup>th</sup> and 26<sup>th</sup> January 2006 by two people. The weather was clear and warm with light to moderate winds, good for detecting lizards. The survey was carried out by four wheel drive vehicle and on foot where habitat areas away from the farm tracks were inspected.

### **Habitats**

Robrosa is a relatively small narrow property that has a mixture of habitat areas suitable for lizards. The variety of vegetation cover and rocky outcrops found on the lower slopes in the Cardrona Valley provide particularly good habitat for skinks. At about 1200 m, rock tors are encountered and continue spasmodically up to the top of the Pisa Range. These eroding rocks tend to be thick blocks which are not favoured by lizards.

Vegetation on and around the rock tors varies with altitude. Habitat particularly suited to lizards is located at mid altitude where porcupine shrub (*Meliccytus alpinus*), native broom (*Carmichaelia petriet*), *Coprosma* species, golden speargrass (*Aciphylla aurea*), matagouri (*Discaria toumatou*), snowberry (*Gaultheria depressa*) and tree daisy (*Olearia odorata*) are present.

On the higher slopes above 1500 m, vegetation cover is sparser, with few plants present that would be conducive to good lizard habitat around the rocky areas. The lack of loose rocks in the large headwater basin near Dome Rock would act as a deterrent to geckos establishing at this site.

### Description of Lizard Fauna

Two species of lizard were identified on the Lease. McCann's skink (*Oligosoma maccanni*) was seen in abundance in open vegetation and rock habitat areas below 1500 m. Cromwell gecko (*Hoplodactylus* "Cromwell") was seen at a few selected loose rock habitat sites between 1200 m and 1600 m.

The best site seen on the property was in the headwaters of Deep Creek (at E2200168 N5588774), and comprised a jumbled rockfall area of approximately 10 ha. A good variety of large and small loose rocks were on site, as well as a large source of fractured bedrock. Good populations of Cromwell gecko and McCann's skink were found at this site.

### Significance of Herpetofauna

No threatened lizard species were recorded. A rockfall area in the headwaters of Deep Creek however provides significant habitat for Cromwell gecko and McCann's skink.

#### 2.6.3 Avifauna

Birds seen or heard during the tenure review inspection of the Lease are listed in Table 8 below.

**Table 8: Birds recorded during survey of the Lease**

Common Name (* denotes native species)	Scientific Name	Comments
Australasian harrier *	<i>Circus approximans</i>	Two harriers seen in Luggate Creek area and lower slopes of property.
Falcon *	<i>Falco novaeseelandiae</i>	One falcon seen in headwaters of a tributary to Luggate Creek (GR E2200498 N5587532).
New Zealand pipit *	<i>Anthus novaeseelandiae novaeseelandiae</i>	Four birds seen
Paradise shelduck	<i>Tadorna variegata</i>	Cliff Burn
Redpoll*	<i>Carduelis flammea</i>	Criffel Faces
Southern black-backed gull *	<i>Larus dominicanus</i>	12 birds seen high up on property near Sally's Pinch and tarns in Cliff Burn. These birds breed up on the open tops of Pisa Range in late Spring and Summer.
South Island Pied Oystercatcher *	<i>Haematopus finschi</i>	10 birds seen in upper Cliff Burn basin. They breed on open tops of Pisa Range.
Skylark	<i>Alauda arvensis</i>	10 birds seen all over the property

## Significance of Avifauna

New Zealand falcon is the only bird species recorded on the Lease that is listed as being under threat (Hitchmough 2002). It has a threat ranking of "Gradual Decline".

The top basin and headwaters of the Cliff Burn catchment, including the two tarns, is an important area of habitat and breeding grounds for the black backed gull and South Island pied oystercatcher.

### 2.6.4 Aquatic Fauna

#### Introduction

No freshwater fish records for streams on the Lease were found on the New Zealand Freshwater Fish Database (NZFFD). However, the database has records for six fish species elsewhere in the Cardrona Valley catchment. Native species recorded include common river galaxiid (*Galaxias vulgaris*), koaro (*Galaxias brevipinnis*), and long finned eel (*Anguilla dieffenbachia*). Introduced species recorded include brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and brook char (*Salvelinus fontinalis*).

#### Methods

The streams within the Lease flow into either the Cardrona River or Luggate Creek. The streams were sampled on 27<sup>th</sup> January 2006. Ten sites were sampled using a backpack electric fishing machine using a standardized method (Allibone 1999). Transport to the sites was by a R22 helicopter.

Of the ten sites, four were on the lower slopes at about 1200 m asl, four in the middle of the property at about 1500 m and two on the upper section of the property at around 1800 m.

The feeder tributaries to Luggate Creek, such as the Cliff Burn are small, with some being wetland areas rather than lotic waters. The streambeds of the creeks consist of mainly coarse gravels with only small areas of sand and bedrock substrate.

The sites selected to be fished contained riffle/run habitat, with only two sites containing pool habitat. Stream width, depth, substrate and riparian composition were visually estimated using the Freshwater Fish Database Form format.

In-stream invertebrates found during electric fishing surveys were noted.

#### Aquatic Fauna Description

No fish species were found during the electric fishing survey. This suggests that a gorge or series of waterfalls outside the Lease boundary is preventing the upstream movement of introduced sports fish which are found further downstream in Luggate Creek.

Invertebrate abundance ranged from poor in the sub-alpine sites to very abundant in the mid-range sites. Species composition is dominated by the mayflies, *Deletidium* and *Nesameletus* and the stonefly *Zealandperla*.

## Significance of Aquatic Fauna

No rare indigenous aquatic fauna were identified. However, the upper part of Luggate Creek and tributaries has the potential to provide excellent fish habitat and may provide suitable translocation sites for threatened non-migratory galaxiids.

### 2.6.5 Problem Animals

Rabbits are common, especially at the low to mid altitude parts of the property. Goats, deer, chamois, cats, possums, ferrets, stoats and hares may also be present.

## 2.7 HISTORIC

### 2.7.1 Maori Cultural Values

The first settlers in the region were the Maori as they travelled through Central Otago en-route to the West Coast on pounamu expeditions, as well as in search of seasonal food resources. There are no records of Maori archaeological sites on the Lease.

### 2.7.2 Pakeha Heritage Values

The history of the Lease is one of pastoralism and gold mining. Historic records describing the history of people who occupied or traveled through the land which encompasses the Robrosa Pastoral Lease are concerned with the history of ownership of the run and gold mining.

#### *Pastoral History*

The origin of the Robrosa Pastoral Lease lies in the break up of two large 19<sup>th</sup> century pastoral runs in the early 20<sup>th</sup> century. Both the Cardrona Run 340 and Mt. Pisa, being a conglomerate of Runs 245 and 245a-d, were early runs in Otago being first surveyed in the late 1850s. Survey maps from 1876 and 1883 of the pastoral licences in the Cardrona Valley and Mt Pisa Range and the *Otago Runs Register* show that the Lease was created in 1921 from the subdivision of the large 19<sup>th</sup> century pastoral licences of Mt. Pisa and the southern Cardrona lease Run 340. The Robrosa Pastoral Lease as seen today comprises a northern portion of the previous Run 340 and the western section of the former Mt. Pisa Run 245b. The first lessee of Robrosa in the *Otago Runs Register* is William Walter Robertson, a miner, who took up the run in 1925. It is unclear from historic records who had possession of the run from 1921 through 1924.

The history of the Mt Pisa run is particularly interesting. Prior to its break up and auction by the Government in 1921, there was a previous attempt by the Otago Land Board in 1882 to subdivide the station through the auctioning off of the separate smaller runs that were part of the station. However, the lessees outbid all bidders and held onto Mt. Pisa as one unit (Parcell 1976:280-282). Other than this written history of Robrosa, few details

on the pastoral history specific to the property appear to be available. Local knowledge has it that a parallel set of fences used to run up through part of the Lease, over the Pisa Range and down towards the Clutha. This parallel fence line was used during mustering on the Mt. Pisa run. Sheep were flocked into the 'channel' for ease of movement of the mob over the range from Cardrona (Pittaway *pers. comm.*). This is probably the reason for the location of the Pisa Hut on the 1921 survey map of Robrosa which shows the hut on the Cliff Burn not far from the Pisa summit. Another oral tradition has that a baby which died near Sally's Pinch when its parents were crossing the range into the Cardrona, is buried near Dome Rock (Mitchell *pers. comm.*).

### ***Gold Mining History***

Gold mining occurred where a line of gold bearing quartz gravel deposits, which stretch from the Criffel up to Mt Pisa and beyond as far as Mt Buster near Naseby, is present on the property. Following a c. 5 km stretch of this deposit across the western slopes of the Pisa Range beginning to the east of the Criffel workings to where the mining is present on Robrosa, gold miners prospected and worked two large claims (McKay 1894:C-4, 17). This area or line of mining was called the 'Fat Boys' workings named after the geographical feature Fat Boys (or Fatboy) Rock on a nearby ridge. Intensive gold mining along the quartz gravels occurred at two specific places (northern and southern ends) where the nature of the geology made working these difficult deposits worthwhile. Today, these mined areas can be seen as well defined white 'gashes' in the landscape.

No specific mention of gold mining during the 19<sup>th</sup> century on the Lease (i.e. the southern workings of Fat Boys) can be found in historic records regarding gold mining at Fat Boys (i.e. Wardens reports found in the *Appendix to the Journal of the House of Representatives* from 1863 to 1907 and McKay's (1894) geological surveying report on gold mining in Otago). Searches of 19<sup>th</sup> century mining survey maps at Land Information New Zealand revealed no record of such sites, even though early survey plans were made of mining claims at certain points along the line of the Fat Boys workings. Although a detailed description of mining at the northern claim at Fat Boys was provided by McKay (1894:17), and the AJHR between 1888 and 1894 notes mining at Fat Boys, mining at the southern area of Fat Boys on Robrosa is not referred to or detailed. This is unusual considering the size of the diggings on Robrosa and the investment of labour in the building of water races related to the gold mining (see below and Appendix 9). However, what these records do show is that the gold mining on Robrosa was part of the Fat Boys gold fields. McKay (1894:17) notes in his report that he only visited and concentrated his survey on the northern end of the Fat Boys where Nauman and Party were mining. But he also states that the line of the quartz gravels could be seen heading south by the "line of prospecting-holes made in white gravel for a considerable distance" and that the miner Halliday, based at Criffels, had confirmed the southern extent of the 'gravels'.

The Fat Boys goldfields were worked only during the summer and spring months of the year when flowing water was available for sluicing. This lack of water during the autumn and winter was due to the high altitude of the gold-mining which, being over 1350 m. meant the water races would freeze. Any pay-dirt extracted from the mining which could not be processed for gold before water ran short was encased in turfs over the autumn/winter to prevent it freezing hard in preparation for the spring thaw processing.

An approximate time period for mining on the Lease can be gained from the little information available. In 1888, the AJHR (Sec C-5, pp. 39) first records a rush of miners