

Crown Pastoral Land Tenure Review

Lease name : GLENMORE

Lease number : PT 001

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.

December 06

GLENMORE PASTORAL LEASE



CONSERVATION RESOURCES REPORT

DEPARTMENT OF CONSERVATION

NOVEMBER 2006

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PART 1 INTRODUCTION

Glenmore Pastoral Lease is an 18,823 ha property located northwest of Lake Tekapo in the northern part of the Mackenzie Basin, South Canterbury. It straddles Joseph Ridge and the eastern Gammack Range between the Cass River and Fork Stream, and the moraines and outwash flats on the south side of the lower Cass River between Mt Joseph and Lake Tekapo. The part of the property north of Mt Joseph, comprising most of the property, is steep and mountainous. The major summits are mostly higher than 2000 m and rise along the range to over 2600 m at Mt Lucia on the Liebig Range at the northern end of the property. The lower-altitude country south and east of Mt Joseph is dominated by the spectacular and well-known Glenmore Tarns moraine.

Access to the property is via Godley Peaks Road, from State Highway 8 near the town of Lake Tekapo. Public access is also available from the Cass River valley.

The northern part of the property lies in the Godley Ecological District, within Tasman Ecological Region. The south-eastern part lies in Tekapo Ecological District, within Mackenzie Ecological Region. The Mackenzie Ecological Region has been surveyed and lower-altitude parts of the property surrounding Glenmore Tarns recommended for protection as part of the Protected Natural Areas Programme. The Tasman Ecological Region has not been surveyed.

The property adjoins Godley Peaks Pastoral Lease and Godley Peaks Conservation Area (Conservation Land Unit I36009) across the Cass River to the northeast, Cass River Delta Conservation Area (I37005), Lake Tekapo and a block of privately-owned land to the east, Lake Alexandrina Scenic Reserve (I37060) and privately-owned land to the south, Braemar Pastoral Lease to the southwest, Braemar Conservation Area (I37059) to the west and the Liebig Range/Upper Jollie/Cass Conservation Area (I36002) to the north. A substantial part of the Glenmore Tarns moraine on the property is protected as a QEII Open Space Covenant.

The tenure review inspection of the property was undertaken during October and December 2005 by a range of specialists. These specialists' reports (listed below) form the basis of this Conservation Resources Report.

- 1 Glenmore Pastoral Lease Landscape Assessment, Alan Petrie, October 2005, 9p + photos + map.
- 2 Glenmore Station Botanical Values, Nicholas Head, December 2005, 28p + maps.
- 3 Assessment of the Fauna Values (birds and lizards) of Glenmore Pastoral Lease, Jane Sedgeley and Colin O'Donnell, February 2006, 34p + photos + maps.
- 4 Glenmore Pastoral Lease, A Report on the Aquatic Fauna Surveys, Scott Bowie, February 2005, 29p + maps.
- 5 Glenmore Pastoral Lease Tenure Review Assessment of Entomological Values, Rowan Emberson and Pauline Syrett, January 2006, 16p + photos + maps.

Insert topo/cadastral map here

Insert Glenmore Tarns map here

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

2.1 LANDSCAPE

2.1.1 Landscape Context

The 1993 Canterbury Regional Landscape Study (Boffa Miskell and Lucas Associates) identified the mountains that border the Mackenzie Basin as a regionally-outstanding natural feature and landscape. The front ranges on Glenmore Pastoral Lease help augment the recognizable character of the Mackenzie Basin by visually and physically defining the edges of the basin. Special traits of the basin include its sheer scale, sense of spaciousness and the dominance of natural patterns and processes over human intervention. A distinctive natural feature of the Mackenzie Basin is the imprint of glacial action, which is clearly apparent in the landforms of the property.

2.1.2 Landscape Description

For the purposes of this landscape assessment Glenmore Pastoral Lease is divided into six landscape units, principally based on water catchment areas and landform changes. The criteria used to assess and evaluate the landscape values of each unit are based on the following attributes:

- 1 Naturalness: an expression of the indigenous content of the vegetative cover and the extent of human intervention.
- 2 Legibility: an expression of the clarity of the formative processes and how striking these processes are.
- 3 Aesthetic value: the memorability and naturalness of the area, including factors which can make a landscape vivid, such as simplicity in landform, muted colours and fine-textured ground cover.
- 4 Visual values: a sub-set of landscape values which relate to the visibility of a particular landscape or natural feature as seen from public vantage points.

Unit 1, Eastern Downs

This landscape unit includes all the rolling down lands that overlook Lake Tekapo and the unit also includes the margins of Lake Alexandrina to the south. The main access to the property (Godley Peaks Road) traverses this landscape unit. Several gravel vehicle tracks are present and a small cluster of well-maintained fishermen's huts are present at the northern end of Lake Alexandrina.

The downs within this unit have been widely subdivided into paddocks and sown in pasture. The paddocks surrounding the homestead are sheltered by plantings of pines. A ribbon of willow trees follows the watercourse that flows into the northern end of Lake Alexandrina. The terraces

are clad in modified short tussockland with a high component of introduced grasses. The Cass River delta is predominantly stonefield with a wide scattering of matagouri and cushions of grey moss.

Landscape Values

The inherent landscape values within this unit have been modified by extensive conversion to pasture. Cultural elements and patterns in the form of paddocks, shelter plantings, deer enclosures, access tracking and farm buildings dominate the landscape. The water bodies adjacent to this unit, (Lake Alexandrina and Lake Tekapo) become a significant natural element and focal point, particularly within a high country landscape that conveys semi-arid qualities. The contrast in colour between the water and the surrounding tawny grasslands is a vivid and memorable feature.

Potential Vulnerability to Change

Land uses and activities that have the potential to adversely affect this unit are:

- 1 Geometric blocks of trees, especially single-species plantations.
- 2 Encroachment of structures along the presently uncluttered and open margins of Lake Tekapo.
- 3 Unsympathetically-sited gravel borrow-pits on the Cass River delta.
- 4 Further spread of crack willow around the margins of Lake Alexandrina.

Unit 2, Glenmore Tarns Moraine

This unit incorporates the wide band of hummocky moraine that extends across the property in a northeast-southwest direction and continues south beyond the property boundary. A distinctive feature is the limited altitudinal variation. The unit features a repetitive pattern of low narrow ridges separated by concave gullies frequently containing circular hollows or kettle-holes formed by the melting of blocks of ice during the last glacial retreat. A mantle of glacial till and fine gravel is draped over the subdued topography, reinforcing the distinctive curvilinear form of the moraine. Surface rocks are very localized and mostly confined to the kettle-holes. Permanent and ephemeral tarns occupy the concave gullies and kettle-holes.

In the southern part of the unit the ground cover is typically sparse, with depleted short tussockland in the concave gullies and on the darker sides of the low ridges. Sunnier aspects frequently have bare ground, mats of low vegetation and tufts of fescue tussock. The northern part is more modified, with extensive areas of grassland. Access tracks lead onto the hummocky moraine from the north and south. There are few structures other than fences, including deer fences at the eastern side of the moraine. The spread of wilding pines has been controlled.

Landscape Values

This unit contains high inherent landscape values principally due to the distinctive hummocky terrain. The repetitive nature and consistency of these glacial deposits is an outstanding natural feature. The legibility of the formative processes is accentuated by the low stature of the vegetative cover. The clusters of tarns are a special feature within a semi-arid landscape. The absence of structures helps to reinforce the backcountry qualities of the unit. This unit should not be seen as a separate entity but as an integral component of the broader hummocky moraine that stretches onto adjoining properties. The legibility and naturalness of the landscape is less distinctive towards the north.

Potential Vulnerability to Change

Land uses and activities that have the potential to adversely affect this unit are:

- 1 Tree planting.
- 2 Damage to the fragile margins of kettle-holes by four-wheel-drive vehicles.
- 3 Earth disturbance that would allow the establishment of opportunist naturalized species.
- 4 Spread of wilding pines.
- 5 Introduction of structures.
- 6 Unsympathetically-sited fences that could lead to the fragmentation of the coherent qualities of the hummocky moraine.

Unit 3, Joseph Valley

This unit comprises the main valley of Joseph Stream, between the Glenmore Tarns moraine (Unit 2) and the southeast slopes of Mt Joseph (Unit 4). The southern part of this unit, on the ridge separating Joseph Stream from Fork Stream, is characterized by hummocky terrain with a cluster of kettle-holes and dry boulder fields. The mid reaches of Joseph Stream are contained within a low entrenched valley. The valley floor increasingly widens downstream towards the Cass Valley, with the stream channel meandering across the full width of the valley floor. A feature is the abandoned stretches of channel that have become ribbon wetlands.

The upper section of the catchment is primarily clad in depleted short tussockland with introduced grasses. Tall tussockland is present on the lower slopes. Drier slopes and ridges support mats of mouse-ear hawkweed, open gravelfield, scattered fescue tussock and thickets of matagouri. The matagouri is more abundant along the darker toe slopes. Where the valley begins to widen near the Cass River the original ground cover has been extensively changed to improved pasture and subdivided into paddocks with pine-tree shelter belts. Sheds, stockyards and a musterers' hut are located in the lower valley.

Landscape Values

The upper (southern) section of this unit has high inherent landscape values owing to the presence of hummocky terrain and tall tussockland. These natural features form a segment of a landscape continuum that extends onto the adjoining mountain country (Unit 4). The balance of the unit possesses only moderate landscape values due to modification of the original ground cover. The visual enclosure of the unit contrasts with the openness of the surrounding topography.

Potential Vulnerability to Change

Land uses and activities that have the potential to adversely affect this unit are:

- 1 Further loss of riparian vegetation along the margins of Joseph Stream.
- 2 Further depletion of tall tussock cover.

Unit 4, Mt Joseph

This unit comprises the southeast-facing slopes of Mt Joseph, overlooking the lower-altitude parts of the property. The upper (northwest) limit of the unit is the back wall of the cirque below the summit of Mt Joseph (1682 m); the lower (southeast) limit is the toe slopes at approximately 900 m adjoining Joseph Valley (Unit 3). The unit incorporates an assemblage of natural landforms and features that are associated with a glaciated high country landscape. These include a cirque with a tarn, tilted benches that stretch across the upper slopes, a wide band of hummocky lateral moraine and steeper lower slopes. Deep V-shaped gullies dissect the slopes.

Tall tussockland extends down to approximately 1000 m altitude on the darker southwest slopes, grading below this to short tussockland and grassland. In the sunnier northeast corner, modified grasslands are dominant. The lower gullies support shrubland and scrub. A rough vehicle track traverses the slopes.

Landscape Values

The unit contains high inherent landscape values attributable to the wide assemblage of natural features. A special feature is the legible imprint of the glacial processes, especially the ice-scoured cirque that forms the distinctive front edge to Joseph Ridge. Other notable natural features include the tilting benches, hummocky moraine and the unvarying sward of tall tussock cover on the mid and upper side slopes. At the southwest corner of the unit a special characteristic is the altitudinal sequence of snow tussock that descends to near Fork Stream. The only detectable human element is the vehicle track.

Potential Vulnerability to Change

Land uses and activities that have the potential to adversely affect this unit are:

- 1 Fences that lead to artificial fragmentation of the existing coherent tussock cover.
- 2 Earth disturbances that would allow opportunist naturalized species to establish.
- 3 Introduction of structures in such a highly visible natural landscape.
- 4 Spread of wilding pines.

Unit 5, Cass Valley

This substantial unit encompasses a large block of mountainous country extending from Mt Joseph in the south to the northern property boundary on the Liebig Range in the upper Cass Valley. The unit also incorporates the alluvial terrace that borders the braided Cass River. It spans a wide altitudinal range from 800 m on the lower river terraces to over 2600 m at Mt Lucia.

The peaks of this mountainous country feature sharp ridges, cut-off spurs, small hanging valleys and jagged rock formations. The upper slopes feature bare rock and patches of stable scree. The mid slopes exhibit an alternating pattern of long scree faces, eroding chutes and tall tussockland. The lower slopes have stable and active alluvial cones that frequently fan out over the Cass River flats. A notable feature of the unit is the waterfalls that plunge from a number of small hanging valleys.

Vegetation on upper slopes is dominated by rockland, scree and cushionfield. Tall tussockland and shrubland are present below approximately 1000 m. South of Waterfall Hut the lower slopes have been over-sown and top-dressed. The greening of these slopes extends into the lower Joseph Stream catchment. Blocks of pines and other trees have been established around the three huts that are sited at regular intervals up the Cass Valley. There has been an attempt to control the spread of these exotic trees across adjoining slopes.

Landscape Values

This unit contains high inherent landscape values principally due to the overall sense of naturalness and intactness. Nature dominates the landscape. The legibility of the various landforms and natural features that have been forged by both glacial processes and subsequent natural erosion are conspicuous in various forms such as the classic U-shaped hanging valleys and waterfalls. Other features include extensive scree faces that often extend from the upper slopes down to the floor of the valley. The steep slopes create an overall sense of enclosure that contrasts markedly with the spaciousness of the Mackenzie Basin. The inherent landscape values are reduced downstream (east) of Waterfall Hut where pasture is dominant.

Potential Vulnerability to Change

Land uses and activities that have the potential to adversely affect this unit are:

- 1 Uncontrolled four-wheel-drive vehicle use on the river terraces.
- 2 Further spread of exotic trees from the plantings around the huts.
- 3 Introduction of structures that would be detrimental to the existing backcountry and semi-wilderness qualities.

Unit 6, Fork Valley

This unit comprises the entire west-facing side slopes of Joseph Ridge, extending from the southwest corner of the property to the Gammack Range at the head of Fork Stream. It includes the valley floor and the alluvial terraces alongside Fork Stream. The unit ranges in altitude from approximately 1000 m in Fork Stream to over 2300 m at the northern end of Joseph Ridge. The natural features and landforms within this unit are similar to those in Unit 5, with the mountain peaks and slopes featuring jagged exposed rock, stable scree, deep gravel chutes and intermittent patches of tussockland. There is a change in topography adjacent to the alluvial terrace where the landform becomes more curvilinear in appearance due to the deeper deposits of colluvium. A series of V-shaped gullies cut through the lower slopes.

The unit possesses an intact sequence of tall tussockland from the crest of Joseph Ridge down to the edge of the alluvial terrace. A large proportion of the terrace is covered in short tussockland with introduced grasses. Small depressions contain patches of red tussock. Grey mats of mouse-ear hawkweed are common on the dry stony ridge that separates Fork Stream from Joseph Stream.

Landscape Values

The inherent landscape values within this unit are similar to those of Unit 5. A primary difference is the presence of the alluvial terrace that conveys a strong sense of coherence owing to the fine texture and near monochromatic tonal range of the grasslands. The colour range within these grasslands contrasts markedly with the coarse texture and variations in the surface on the adjoining slopes.

Potential Vulnerability to Change

Land uses and activities that have the potential to adversely affect this unit are:

- 1 Fences that lead to artificial fragmentation of the existing coherent tussock cover across the alluvial terrace.
- 2 Introduction of structures on the highly visible terrace.
- 3 Spread of wilding pines.

2.1.3 Visual Values

A large proportion of Glenmore Pastoral Lease is visible from many public vantage points around Lake Tekapo and across the Mackenzie Basin. These uninterrupted views are principally due to the extent of the water mass between the viewer and the property and the absence of intervening landforms in the Mackenzie Basin. The following views are particularly important:

- 1 Views from State Highway 8 (Tekapo-Twizel Road): From near Tekapo Aerodrome (viewing distance approximately 9 km) Mt Joseph and the southwest slopes of Joseph Ridge

are highly conspicuous, forming the edge to the outwash plains and the abutting mountains. The Tekapo-Twizel Road is a key tourist route between Christchurch and Aoraki/Mt Cook and the southern lakes.

- 2 Views from Lilybank Road: From the opposite side of Lake Tekapo adjacent to Boundary Stream (viewing distance approximately 7 km) the margins of the lake, the downs and the southeast and east slopes of Joseph Ridge are all highly visible.
- 3 Views from Godley Peaks Road: From this road the views of Glenmore Pastoral Lease tend to be more specific and concentrated on individual elements (e.g. Lake Murray), rather than the panoramic views from more distant locations.

Aesthetically, the wide assemblage of landforms that step down from the mountains towards Lake Tekapo are of visual interest and complement similar glacial landforms that are conspicuous on the other properties that border the lake.

Significance of Landscape Values

The Glenmore Tarns moraine (Unit 2) is a highly significant landscape due to the repetitive nature of the glacial landforms, notably the low ridges and mounds separated by concave hollows. A striking feature of the moraine is the contrast between the semi-arid country and the permanent tarns.

The margins of Lake Tekapo (Unit 1) convey a natural character that is open and uncluttered with few structures on the first prominent ridge above the edge of the lake. The original ground cover has been extensively converted to improved pasture, but the lake margins remain significant as an integral component of the wider Lake Tekapo landscape.

A large proportion of Glenmore Pastoral Lease (Units 5 and 6, and parts of Unit 4) makes a positive contribution towards the regionally-outstanding Mackenzie Basin landscape. These outstanding qualities are portrayed in many forms of media, including pictorial calendars, artwork and tourist promotions. Collectively, Glenmore Pastoral Lease is classic Canterbury high country in which the legibility of natural processes and the imprint of glacial activity are conspicuous.

Insert Landscape map here

2.2 GEOLOGY, LANDFORMS AND SOILS

2.2.1 Geology

The basement rocks of all the northern mountainous part of Glenmore Pastoral Lease, on Joseph Ridge and the Gammack Range, are weakly-indurated greywacke and argillite of the Torlesse Group. Lower-altitude parts of the property east of Mt Joseph comprise glacial till and outwash gravels of the Balmoral, Mt John and Tekapo formations (Otira Glaciation) and more recent alluvial deposits (river gravels) along Joseph Stream and on the Cass River delta. The large Glenmore Tarns moraine is part of the Mt John Formation. The older Balmoral Formation lateral moraine is present on the southern slopes of Mt Joseph, and the most recent moraines of the Tekapo Formation occupy the area between Glenmore Tarns and Lake Tekapo (Gair, 1967). The glacial tills of the area are composed predominantly of greywacke, with minor schist and argillite and their fine-grained derivatives (Suggate, 1978).

2.2.2 Landforms

The northern mountainous parts of Glenmore Pastoral Lease are dominated by the steep glaciated mountains of Joseph Ridge, the Gammack Range and the eastern Liebig Range. The main summits are higher than 2000 m and reach a maximum height within the property at Mt Lucia (2617 m) at the northern boundary of the property on the Liebig Range. High summits on the Gammack Range are over 2400 m altitude in the vicinity of Mt Jukes, over 2300 m in the vicinity of Mt William Grant and over 2400 m altitude at Hells Gates near the northern end of Joseph Ridge. The main summits decrease in height south along Joseph Ridge to approximately 1600 m at Mt Joseph. The main valley floors of the Cass River and Fork Stream lie between 800 and 1200 m altitude.

The range summits comprise steep rocky peaks and gentler intervening ridges and basins dominated by shattered rock bluffs, boulderfields, scree, rock pavement and small areas of snowfield in the vicinity of Mt Lucia and Mt Jukes. Evidence of recent glaciation is present throughout, with ice-scoured peaks, cirques in valley heads, U-shaped upper side valleys, hanging valleys with waterfalls and the broad U-shaped Cass and Fork valleys.

The southern and eastern lower-altitude parts of the property are dominated by material deposited following successive advances and retreats of large glaciers which flowed from the Godley and Cass valleys. A prominent lateral moraine covers the lower eastern slopes of Mt Joseph and an extensive ablation moraine forms the Glenmore Tarns terrace. Between these two landforms, Joseph Stream flows down the valley of an ice margin melt-water stream. Hummocky country between the Glenmore Tarns moraine and Lake Tekapo is more recent moraine of the Tekapo Formation. River flats in the vicinity of the homestead and the lower Cass River are recent landforms resulting from deposition of gravels by the Cass River.

The landforms of the Glenmore Tarns area have been described in greater detail by Johnson (1994), drawing on interpretations by Trevor Chinn. Five landform units are described by Johnson. Landform Unit 1, covering the western area (including Sunday Tarn, Cluster and Boundary tarns) has terminal moraines deposited by the retreat of the main glacier back towards the Cass River, parallel southwest-trending ridges created by a short advance of ice over the earlier moraine, and the knob and kettle topography formed during melting of the deposited ice. Unit 2, covering the country between Glenmore and Grebe tarns, has similar topography to Unit 1

but with the addition of an old south-trending outwash channel (kame). Unit 3 covers the main southeast-trending outwash channel between the terminal moraines and including the group of seepage and outlet stream-drained tarns between Glenmore Tarns and Hartley Tarn. Unit 4, covering the northern area around Stony and Tui tarns is formed from extensive deposition of outwash gravels which engulfed isolated blocks of ice. Unit 5, covering the northeast area, contains the surfaces of deltas deposited by outwash streams flowing into a lake having a level higher than the present Lake Alexandrina (Johnson, 1994).

The Glenmore Tarns moraine probably represents the best assemblage of kettle lakes in the country (Ward, 1986). Johnson (1994) concluded that, compared with kettle-hole areas in ten other parts of inland eastern South Island, the Glenmore Tarn moraines have the greatest diversity and concentration of kettle-hole and associated wetland types.

Four geopreservation sites, all listed as 'extremely well defined landforms of scientific and educational value', have been identified on the property:

- 1 Glenmore Station Kame (Site 30587): A very large example of kame (a glacial deposit of alluvium formed by meltwater streams), on the Glenmore Tarns moraine (Landform Unit 2). Listed as the best example of kame in New Zealand.
- 2 Joseph Stream Meander (Site 30645): A random-walk meander in Joseph Valley.
- 3 Lake Alexandrina Moraine (Site 30675): A small lake on ablation moraine, northwest of Lake Alexandrina.
- 4 Mt Joseph Cirque (Site 30781): A well-defined cirque on the upper southeast flank of Mt Joseph.

The property is drained by the Cass River and its tributaries (Ailsa Stream, Tin Hut Stream and a number of un-named streams) in the north and east, Fork Stream and its tributaries in the west, and Joseph Stream and small tributaries of Lake Alexandrina and Lake Tekapo in the south. Cass River, Joseph Stream and Lake Alexandrina drain into Lake Tekapo. Fork Stream drains into the Tekapo River. All eventually flow into the Waitaki River.

2.2.3 Soils

Higher-altitude parts of Glenmore Pastoral Lease support bare rock and weakly-developed alpine and Kaikoura steepland soils. Puketeraki soils, Cass hill soils and Tekapo soils are present on the summit and flanks of Mt Joseph. The moraine country supports Tekapo hill soils and Cass hill soils. Recent alluvial surfaces support Tasman sandy loams and Dobson shallow soils.

Significance of Geology, Landforms and Soils

The geology and landforms of Glenmore Pastoral Lease are part of a much more extensive area of glaciated high mountain country of the eastern Southern Alps and the associated extensive glacial and fluvio-glacial deposits of the intermontane Mackenzie Basin. The mountainous country within the property is unmodified and spectacular, though similar to that present in the surrounding Gammack, Liebig and Hall ranges. The moraines and other landforms of glacial

origin in the eastern part of the property are especially significant. The Glenmore Tarns moraine is regarded as the best assemblage of kettle lakes, with the greatest diversity and concentration of kettle hole and associated wetland types in the country. Four geopreservation sites classified as ‘extremely well defined landforms of scientific and educational value’ are present in the Glenmore Tarns moraine-Mt Joseph area.

2.3 CLIMATE

Glenmore Pastoral lease lies in the rain shadow of the main divide of the Southern Alps. Winds are predominantly from the northwest and are most frequent in spring and autumn. Summers are warm and dry; winters are cold with frequent snow and severe frosts. Snow can fall throughout the year and can lie for several months at higher-altitudes. Annual precipitation is 600 mm at Lake Tekapo and probably over 5000 mm in the north of the property (McEwen, 1987). Mountainous parts of the property have cold temperatures, with high annual and moderate winter solar radiation. Rainfall deficits are only slight. Lower-altitude eastern parts of the property have a cool climate with high annual solar radiation and low annual average water deficits (Leathwick *et al.*, 2003).

2.4 LAND ENVIRONMENTS OF NEW ZEALAND (LENZ)

LENZ is, as described by Leathwick *et al.* (2003): “a classification of New Zealand’s landscapes using a comprehensive set of climate, landform and soil variables chosen for their role in driving geographic variation in biological patterns.” The classification units of LENZ, termed environments by Leathwick *et al.* (2003), aim to: “identify areas of land having similar environmental conditions regardless of where they occur in New Zealand.” The consequences of this are that “LENZ provides a framework that allows prediction of a range of biological and environmental attributes. These include the character of natural ecosystems, the vulnerability of environments to human activity, and the potential spread or productivity of new organisms (Leathwick *et al.* 2003).” Leathwick *et al.* (2003) present the LENZ information at four levels of detail, with level I containing 20 environments, level II containing 100 environments, level III containing 200 environments and level IV containing 500 environments. These LENZ classes are presented nationally to assist use at a range of scales; however, this data should be interpreted with caution, as the predicted extent and suggested vegetation types for each Land Environment (Leathwick *et al.*, 2003) have been extrapolated from limited field data.

In an analysis of the LENZ level IV data, with consideration of the remaining indigenous vegetation cover and the legal protection of these environments, Walker *et al.* (2005) proposed a threat classification for the remaining indigenous biodiversity in New Zealand’s environments based on the two components of vulnerability (likelihood of loss): poor legal protection and risk of loss. This threat classification (Table One) has become the recognised benchmark for the promotion of threatened LENZ conservation.

Table One LENZ threat categories and definitions (Walker *et al.* 2005)

Category	Criterion
Acutely Threatened	<10% indigenous cover remaining
Chronically Threatened	10-20% indigenous cover remaining
At Risk	20-30% indigenous cover remaining
Critically Underprotected	>30% indigenous cover remaining <10% legally protected
Underprotected	>30% indigenous cover remaining 10-20% legally protected
No Threat Category	>30% indigenous cover remaining >20% legally protected

A large part of the moraine country is “chronically threatened”. Chronically threatened land environments are those in which less than 20% of the original indigenous vegetation remains. The remaining low-altitude country is “at risk”. At risk land environments are those in which between 20% and 30% of the original indigenous vegetation remains. Lower slopes of Mt Joseph and areas along Joseph Stream and the old outwash channels are “critically under-protected”. Critically under-protected land environments are those in which more than 30% of the original indigenous vegetation remains and less than 10% is legally protected. Collectively these areas cover almost one third (approximately 30%) of the property. Beyond the lower slopes of Mt Joseph to the north the classification is “No Threat Category”. (See LENZ Threat Category Map).

Significance of Land Environments

All lower-altitude parts of Glenmore Pastoral Lease (below 900 m) and the lower slopes of Mt Joseph (below c.1100 m) are classified as “chronically threatened”, “at risk” or “critically under-protected” land environments. This area covers almost one third (approximately 30%) of the property and includes all the area between the lower slopes of Mt Joseph and the shores of Lake Tekapo.

Insert LENZ map here

2.5 VEGETATION

2.5.1 Ecological Context

The northern part of Glenmore Pastoral Lease, covering the higher mountainous country, lies in the Godley Ecological District, within Tasman Ecological Region. The southeast part, covering the recently-deposited landforms of glacial and fluvial origin, lies in Tekapo Ecological District, within Mackenzie Ecological Region. The Mackenzie Ecological Region has been surveyed as part of the Protected Natural Areas Programme. The following areas were recommended for protection on or adjacent to Glenmore Pastoral Lease (Espie *et al*, 1984). The approximate size of each area within the property is indicated.

- 1 Tekapo 18 Lake Alexandrina and Lake McGregor: A breeding and feeding area for waterfowl and waders.
- 2 Tekapo 19 Lake Murray (6 ha): A large tarn which provides good feeding and breeding habitat for black stilt, other waders and waterfowl.
- 3 Tekapo 20 Mailbox Exclosure: Black stilt breeding site.
- 4 Tekapo 21 Glenmore Tarns (930 ha): The most outstanding area of kettles in the South Island.
- 5 Tekapo 22 Joseph Swamp (160 ha): A large partly-developed swamp.
- 6 Tekapo 23 Lower Cass River: A breeding and feeding area for many wading birds and terns.
- 7 Tekapo 26 Lake Tekapo: A large deep glacial lake with a steep shoreline, mudflats and breeding and feeding habitat for populations of waders and waterfowl.

A significant proportion of the Godley Ecological District lies above the natural timberline, and originally supported (and still supports) extensive areas of rockland, boulderfield (talus), stonefield/gravelfield (scree), tall tussockland and cushionfield. In the montane zone, scattered low-stature forest dominated by mountain toatoa and mountain totara is likely to have been present at stable sites (Wilson, 1978). Small areas of silver beech forest may have been present in the southeast of the ecological district (McEwen, 1987). Elsewhere, dense mountain toatoa-inaka scrub, tall tussockland, herbfield and stonefield (scree and rock pavement) are likely to have been dominant. At lower-altitudes, on the beds of the Cass River and Fork Stream, stonefield, mossfield, cushionfield and areas of short tussockland were probably present.

The original vegetation of Tekapo Ecological District was strongly influenced by recent glaciation, a harsh intermontane basin climate and infrequent natural fires. It appears unlikely that forest was present except perhaps for areas of low-stature mountain toatoa-bog pine forest on moraines and mountain totara forest on lower range slopes (McGlone, 2001). The ecological district was probably dominated by short tussockland, red tussockland, tall tussockland, mountain toatoa-bog pine scrub and matagouri-*Coprosma* scrub (Espie *et al*, 1984). Areas of wetland vegetation were probably relatively common along Fork and Joseph streams, the Cass River and on lake and kettle margins.

2.5.2 Vegetation and Flora

Present-day vegetation over much of the property is indicative and/or representative of the indigenous vegetation that occurred prior to human arrival. This is especially so for the alpine and sub-alpine vegetation of mainly narrow-leaved snow-tussock, slim snow-tussock and sub-

alpine shrubland, which are the major plant communities above 1000 m on the property. Extensive scree and rock is a feature of the upper valleys and at higher altitudes. Very little original forest remains; it was probably removed long ago by either natural processes or early Polynesian fires (Rogers *et al*, 2005). However, small pockets and scattered individuals of mountain toatoa, mountain ribbonwood and mountain totara remain as relics of the original forest cover. Extensive areas of small-leaved shrubland, short tussockland and wetland (swamps, bogs, tarns, kettle-holes and sedgeland) are present at lower altitudes.

Most of the property has experienced varying degrees of modification and depletion associated with burning and grazing over the past 150 years. These impacts have been especially pronounced at lower altitudes (below 1100 m) and on sunny aspects, but have also occurred at relatively high altitudes in places. The presence of wild animals, such as Himalayan thar, has contributed to this modification. Modified areas are characterised by a high proportion of fescue tussock or unpalatable native herbs, such as false speargrass at higher altitudes, and exotic species at lower altitudes, particularly mouse-ear hawkweed. Nevertheless many induced plant communities retain high naturalness and/or native species richness. Much of the gentle terrain on the lower altitude front country, such as the terraces and fans, has been developed through cultivation and/or over-sowing and top-dressing, and is dominated by exotic pasture species. The vegetation of Glenmore Pastoral Lease is described below for the four main parts of the property:

Northern Mountains and Valleys

This area covers the predominantly steep mountainous terrain of the Gammack Range and Joseph Ridge between Fork Stream and the Cass River, north of the Mt Joseph area. It has steep mountain slopes, extensive rock and scree, cirque basins, numerous large colluvial slopes and alluvial fans and river terraces.

Scree covers extensive areas in the Fork Stream and Cass River valleys and their tributaries, and is the dominant feature in the headwaters of the catchments. These stonefields/gravelfields are generally unstable, typically 'flowing' to the valley floor, and appearing relatively barren of plant life. However, specialised scree plants are found throughout, especially where the scree is less mobile and contains more fine material. Commonly observed plants on scree included *Epilobium pycnostachyum*, bristle tussock, *Koeleria cheesemanii*, *Myosotis traversii* var. *cantabrica*, *Cardamine* 'scree' (*Cardamine* aff. *Bilobata*), *Hebe buchananii*, *Pimelea traversii*, *Stellaria gracilentia* and *Uncinia divaricata*. A few plants of *Ranunculus haastii* were seen on scree at higher altitudes (above 1600 m).

Herbfield occurs on damper sites and depressions on the upper slopes, usually between 1600 m and 1900 m. It forms distinctive mat and cushion vegetation assemblages of comb sedge, *Carpha alpina*, *Celmisia haastii*, *C. sessiliflora*, *Gentiana* spp., *Marsippospermum gracile*, *Raoulia grandiflora*, *Phyllachne rubra*, *Donatia novae-zelandiae*, *Anisotome imbricata* var. *prostrata*, *Ranunculus gracilipes*, *Leptinella pectinata* ssp. *villosa*, *Luzula pumila* and yellow caltha. Native species diversity is high at these sites and few exotic species are present, although sheep's sorrel and king devil hawkweed are present in very low abundance. Herbfield is a distinctive component of the tall tussockland community, especially at its upper altitudinal limit. Curly snow tussock and snow-patch grass also occur throughout this zone.

Tall tussocklands form extensive cover on the mountain slopes in the Fork and Cass valleys. At the valley heads, in the highest rainfall areas, midribbed snow-tussock is the dominant tall tussock species, occurring on stable slopes up to approximately 1900 m altitude. It also extends to the

valley floors in the upper tributary valleys, where it mixes with slim snow-tussock. With decreasing rainfall down-valley, midribbed snow-tussock is replaced by slim snow-tussock as the dominant tall tussock community above 1300 m altitude. Slim snow-tussockland is the most extensive tall tussock community on the property. Narrow-leaved snow-tussock occupies lower mountain slopes usually below 1300 m altitude, although slim snow-tussock is also present in a transitional zone between 1200 m and 1400 m altitude.

Slim snow-tussock cover typically varies between 40% and 60% depending on local site conditions and aspect. It can be quite sparse in places, often occurring with large areas of broken and bare ground. Generally the densest cover occurs on the shady aspects. False speargrass is a major component of these grasslands, often up to 30% cover and occasionally over 70% cover. Native species commonly present include *Aciphylla monroi*, *Anaphalioides bellidioides*, *Anisotome aromatica*, *A. flexuosa*, *Blechnum penna-marina*, *Brachyglottis bellidioides*, *B. haastii*, *Brachyscome longiscapa*, *B. sinclairii*, blue tussock, *Celmisia angustifolia*, dainty daisy, *Colobanthus acicularis*, *Craspedia lanata*, dwarf inaka, *Kelleria dieffenbachii*, patotara, mountain heath, *Luzula rufa* var. *rufa*, *Lycopodium fastigiatum*, *Pimelea oreophila*, *Raoulia subsericea* and harebell. Exotic species include mouse-ear hawkweed, sheep's sorrel and catsear, though these species are not abundant. The presence of exotic species increases with decreasing altitude, especially below 1400 m where they become common.

Narrow-leaved snow-tussock first appears at around 1400 m as scattered individuals in slim snow-tussockland. The abundance of narrow-leaved snow-tussock gradually increases with decreasing altitude, becoming dominant below 1300 m. However, narrow-leaved snow-tussock has suffered a greater degree of modification and much of the narrow-leaved snow-tussock zone is quite depleted. This is especially so for the faces below 1200 m in the Cass Valley, where narrow-leaved snow-tussock has largely been replaced by fescue tussock communities, with the exception of sparse and scattered individuals. Consequently few intact narrow-leaved snow-tussock communities remain in the Cass Valley, and those that do rarely exceed 30% cover. In Fork Stream, narrow-leaved snow-tussock cover is more extensive and more intact altitudinal sequences remain. Fescue tussock and mouse-ear hawkweed are locally abundant within the narrow-leaved snow-tussockland, as are the exotic grasses browntop and sweet vernal. Other common native species present are similar to those found within the slim snow-tussock grasslands, but include a greater range of dryland herbaceous native inter-tussock species and sub-shrubs, such as dainty daisy, *Scleranthus uniflorus*, *Thelymitra longifolia*, onion-leaved orchid, mat *Coprosma* species (*C. petriei* and *C. atropurpurea*), creeping pohuehue, *Rytidosperma buchananii*, *Carex breviculmis* and grassland buttercup. Shrubs are commonly scattered through this zone, especially inaka, mountain heath, matagouri and bush snowberry.

Fescue tussocklands are common on the lower mountain slopes, alluvial fans and terraces of the Fork and Cass valleys. Fescue tussocklands on mountain slopes are mostly induced and have replaced previous tall tussockland and woody cover. However, many have good (up to 30%) tussock cover, and a high diversity of native inter-tussock species, typically including bidibid, *Helichrysum filicaule*, *Anisotome aromatica*, blue tussock, *Brachyscome sinclairii*, *B. longiscapa*, *Brachyglottis bellidioides*, *Carex breviculmis*, mat *Coprosma* species, patotara, dainty daisy, grassland buttercup, *Deyeuxia avenoides*, blue wheatgrass, *Geranium sessiliflorum*, *Luzula rufa* var. *albicomans*, *L. rufa* var. *rufa*, woolly head, onion-leaved orchid, *Stellaria gracilenta*, *Thelymitra longifolia* and harebell. Numerous native shrubs are also typically scattered throughout, such as matagouri, tauhinu, *Hebe buchananii* and porcupine shrub. Exotic species are also common, especially mouse-ear hawkweed which forms up to 30% cover in places and is often the dominant inter-tussock species.

In the upper valleys sub-alpine shrub species are a conspicuous component of fescue tussockland, including dwarf inaka, inaka, mountain heath, snowberry and *Pentachondra pumila*, as well as scattered narrow-leaved snow-tussock. The best and most natural short tussock communities are found on the recent alluvial terraces and fans. Tussock cover on these surfaces is typically sparse (rarely above 30%), and occurs with a distinctive assortment of species, such as blue tussock, *Colobanthus buehnerii*, *Poa lindsayi*, scabweed, *Raoulia apicinigra*, *R. hookerii*, *Scleranthus uniflorus*, creeping pohuehue, *Coprosma petriei* and *Pimelea traversii*. Woolly moss is often common in these plant communities. In the lower Cass Valley, fescue tussockland has been over-sown and top-dressed and frequently has a dense sward of exotic grasses and herbs, such as sweet vernal, browntop, white clover, suckling clover and abundant mouse-ear hawkweed, intermixed with the typical native inter-tussock species mentioned above.

Silver tussock and alpine fescue tussock are also present, but mainly as small isolated populations. Silver tussock is usually found along river and stream margins at the base of colluvial slopes, whereas small patches of alpine fescue tussock occur at higher altitudes on recent alluvial surfaces.

Small-leaved shrubland and sub-alpine shrubland are the most common woody plant communities of the Fork and Cass valleys, but remnant trees and distinctive shrubland on bluffs, scree and talus are also features of the area. Often the various shrublands grade together forming a mosaic of shrubland types associated with the varied landforms on which they occur.

The most extensive woody plant communities are the small-leaved shrublands that occur at lower altitudes (below 1200 m). These are associated with stream margins, unstable terrace risers, colluvial fans and bluffs. They can form relatively extensive areas, typically occurring as patches or corridors of woody vegetation between tussocklands and often grading into sub-alpine shrubland at higher altitudes. Common species include matagouri, mountain wineberry, *Olearia odorata*, *Coprosma propinqua*, native broom, *Clematis marata*, porcupine shrub and tauhinu. Mountain ribbonwood is often a component of these shrublands and can be the dominant species. Mountain toatoa and a few specimens of mountain totara are also occasionally present as old relic trees. In the upper Fork and Cass valleys, yellow tree-daisy, *Olearia cymbifolia*, *Hebe odora* and *H. subalpina* are more common, including some very large specimens of the former species. In the lower valleys *Coprosma intertexta* is present. Prickly shield fern, *Blechnum penna-marina*, thousand-leaved fern, golden speargrass and *Aciphylla scott-thomsonii* are common in these shrublands. Broad-leaved snow-tussock is present at damper sites.

Inaka scrub is the dominant sub-alpine shrub species on mid to upper slopes between 1100 m and 1400 m altitude, where it can cover relatively extensive areas. It tends to be more prominent on southern aspects and in the upper Cass Valley and its tributaries (above Waterfall Hut). Typically these shrublands are patchy and can be sparse in cover. They usually occur in combination with slim snow-tussock and narrow-leaved snow-tussock, false speargrass, bare stony ground and an assortment of other sub-alpine shrubs, such as yellow tree daisy, *Myrsine nummularia* and *Olearia cymbifolia*.

Snow totara shrubland occupies talus and coarse colluvium, typically in the mid-slope zone, but can extend to the valley floor in places in the upper valleys. Snow totara can form quite extensive, albeit localised, patches of up to 80% cover at these sites. Other common species include matagouri, porcupine shrub, *Coprosma cheesemanii*, *C. ciliata*, dwarf inaka and golden speargrass. At some sites, remnant trees of mountain toatoa and mountain ribbonwood are present.

The numerous rocky bluffs support interesting assortments of shrub species associated with dry rocky habitats, such as *Hebe tetrasticha*, *H. epacridea*, *H. haastii*, *H. pimeleoides* ssp. *pimeleoides*, *Helichrysum intermedium*, *Exocarpus bidwillii*, bush snowberry and white fuzzweed. Numerous common native herbs and grasses are also present. In a few places in the lower Cass Valley, small patches of manuka remain around bluffs where they have escaped burning.

Mt Joseph

This area covers Mt Joseph, a dome-shaped mountain at the southern end of Joseph Ridge, the valley sides of the lower Fork and Cass valleys and Joseph Valley. Slim snow-tussockland and narrow-leaved snow-tussockland are the dominant plant communities on Mt Joseph, including relatively intact altitudinal sequences on the southwest (Fork Valley) slopes. Red tussockland, fescue tussockland, shrubland and wetland are also present, although much of the lower country in the Cass and Joseph valleys is modified and/or developed and dominated by exotic species.

Slim snow-tussockland is the most extensive plant community on Mt Joseph, dominating the vegetation from around 1200 m altitude to the summit (with the exception of fellfield on the very summit). On the upper summit slopes on gentle undulating country tussock cover is typically clumpy, often in 'wind-sculpted' strips, with numerous patches of bare and stony ground. Inter-tussock species diversity tends to be low at these sites, but typically includes false speargrass, *Anisotome imbricata* var. *prostrata*, blue tussock, *Aciphylla monroi*, *Anisotome flexuosa*, *Lycopodium fastigiatum* and *Raoulia subsericea*. Rocky and bare areas support dwarf inaka, bristle tussock, blue tussock, *Leptinella atrata*, *Poa lindsayi*, *Phyllachne rubra*, *Pimelea pulvinaris*, *Raoulia hookerii*, *R. grandiflora* and *R. petriensis*. The latter species is only on the summit fellfield.

On the steeper slopes below the summit, slim snow-tussock cover is more consistent (up to 60% cover) and there is much less bare ground, although scree is prevalent at higher altitudes in the Cass Valley. There is a higher diversity of inter-tussock species, including (in addition to those listed above) golden speargrass, *Brachysome sinclairii*, *Brachyglottis bellidioides*, *B. haastii*, *Celmisia angustifolia*, dainty daisy, *Craspedia lanata*, snowberry, *Luzula rufa* var. *rufa*, patotara, *Pimelea oreophila* and harebell, with patches of alpine fescue tussock in places. As in the upper valleys, tussock cover decreases on the sunny slopes and with decreasing altitude, and the diversity and abundance of exotic species increases, especially mouse-ear hawkweed, king devil hawkweed and catsear.

Narrow-leaved snow-tussock is present below approximately 1300 m and becomes the dominant snow tussock species at lower altitudes. However, as in the upper valleys, narrow-leaved snow-tussock cover also becomes increasingly patchy with decreasing altitude. This is especially so below 1200 m on northeast faces in the Cass valley and above Joseph Swamp, where tussock cover is reduced to scattered clumps and largely replaced by fescue tussock and exotic pasture species. There is an old record of the rare herb *Plantago obconica* from this area, but it could not be found. Exotic species, such as mouse-ear hawkweed, sweet vernal, browntop and white clover often form the dominant cover in these areas, especially the former species, which provides up to 40% cover in places. *Celmisia angustifolia* and matagouri (many recently burnt) are also abundant. Conversely, on the southwest faces in the Fork Valley narrow-leaved snow-tussock remains widespread on the lower slopes (up to 60% cover) and forms good altitudinal sequences with slim snow-tussock. Narrow-leaved snow-tussock also extends onto the gentle moraine surfaces on the slopes at the head of Joseph Stream, although tussock cover tends to be patchy

and sparse on lower slopes. Coral broom and *Carmichaelia vexillata* occur sporadically in this area.

Red tussock is present on the poorly drained river terraces in the Fork and Cass valleys. In the Fork Valley, red tussock occurs in a complex pattern with narrow-leaved snow-tussock (and hybrids) and fescue tussock. These communities intermix across the poorly-drained river terraces, the adjoining moraine and in wetter gullies on the southwest slopes of Mt Joseph to about 1400 m altitude. The best red tussock sites have a canopy cover of about 70%, but cover is typically patchy. Numerous herbaceous native species of both damp and dry grasslands are associated with these sites, such as *Raoulia subsericea*, *Carpha alpina*, bog rush, rautahi, *Carex flaviformis*, blue tussock, fescue tussock and *Oreomyrrhis ramosa*. Coral broom and *Aciphylla subflabellata* are occasionally present here. On moraines, red tussock is present along the margins of drainage channels and around several kettle-holes. Red tussock also occurs sporadically on drier moraine surfaces with narrow-leaved snow-tussock and fescue tussock, but tends to be sparse, as tall tussock cover generally is on these dry sites. Exotic weed species, notably mouse-ear hawkweed, Yorkshire fog and browntop, are an obvious component of the red tussocklands especially on the flat river terrace site. Cattle damage and evidence of previous fires are obvious. Red tussock on the southwest slopes of Mt Joseph hybridises with both narrow-leaved snow-tussock and slim snow-tussock in the adjoining drier grasslands. These sites are relatively intact, with fewer weeds present than the lower altitude red tussocklands. They commonly occur with bog rush, sphagnum moss, wire moss and various native herbs such as *Ranunculus gracilipes* and native violet.

Red tussockland in the Cass Valley is confined to the poorly-drained terrace and meandering stream between the Cass River and the northeast slopes of Mt Joseph. It presently occupies approximately 30 ha, although dead stumps indicate it was much larger. The core of the area retains good red tussock cover (up to 80% in places), but generally the tussock cover is open and patchy, becoming increasingly so around the edge where it is replaced by fescue tussock and exotic grasses and herbs. The inter-tussock flora is highly modified and dominated by exotic grasses and herbs, such as white clover, browntop, Yorkshire fog, *Poa pratensis* and sweet vernal. The exotic oval sedge and soft rush are also common. Associated native plant species tend to be confined to the bases of the tussocks and margins of watercourses, and include *Blechnum penna-marina*, *Cardamine debilis*, dainty daisy, *Gonocarpus micranthus*, *Hydrocotyle hydrophila*, *Lagenifera petiolata*, *Leptinella pusilla*, *Potentilla anserinoides*, *Ranunculus glabrifolius*, *Rumex flexuosus* and the liverwort *Marchantia berteriana*. Patches of bog rush, rautahi, *Carex diandra*, *C. kaloides*, *C. gaudichaudiana*, sphagnum moss and a few plants of *Olearia bullata* are present throughout. Occasional ponds are present, but they are very pugged by cattle and dominated by exotic species, such as marsh fox tail, jointed rush, oval sedge and water forget-me-not. Native turf species are still present, including *Crassula sinclairii*, *Euchiton traversii*, *Neopaxia lineariifolia* and *Myriophyllum aquaticum*.

Fescue tussocklands are the dominant plant community on the lower north and east faces and fans on Mt Joseph adjacent to the Cass River and Joseph Stream below 1100 m. They have been greatly modified by burning, over-sowing and top-dressing. Tussock cover is typically very sparse (less than 15%) and dominated by exotic herbs and grasses, such as mouse-ear hawkweed, sheep's sorrel, haresfoot trefoil, white clover, suckling clover, downy brome, browntop and sweet vernal, although numerous common native herbs are also present. Bare ground and low-stature matagouri are also prominent in places. More natural and better condition fescue tussocklands occur on the moraine and lower slopes of Mt Joseph at the head of Joseph Stream, where they occur in combination with red tussock and narrow-leaved snow-tussock communities. These short tussocklands contain good examples of the native plant communities that occupy dry

surfaces and add to the overall diversity of this ecologically interesting area. Fescue tussock cover is typically patchy but is often up to 30%, and includes a high diversity of inter tussock species compared to exotic species, although mouse-ear hawkweed can be locally abundant in places. Common native species include *Anisotome flexuosa*, blue tussock, *Brachyglottis bellidioides*, *Carex breviculmis*, *Carmichaelia vexillata*, patotara, *Coprosma petriei*, *C. atropurpurea*, *Luzula rufa*, onion-leaved orchid, *Pimelea oreophila*, and *Thelymitra longifolia*.

Wetlands (bogs, flushes, tarns and kettle-holes) are found throughout the Mt Joseph Area. However, Joseph Swamp, which occupied much of the valley floor of Joseph Stream and was identified for protection by Espie *et al* (1984), has been drained and developed. Only very minor areas of wetland vegetation remain, such as the odd patch of bog rush adjoining streams or drains. On the top of Mt Joseph is a series of string bogs and flushes which provide a rather striking pattern of open water and 'peaty' islands. The vegetation is dominated by wire moss, herbaceous turf species, rushes and sedges, including comb sedge, *Abrotanella caespitosa*, *Caltha novae-zelandiae*, *Celmisia alpina*, *Neopaxia lineariifolia*, *Gentiana* sp., sundew, bog rush, *Carex gaudichaudiana*, *Juncus antarcticus*, *Kelleria dieffenbachii*, *Ranunculus gracilipes* and *Rostkovia magellanica*. A few plants of red tussock also occur near the margins. Directly below the summit of Mt Joseph are numerous flushes with vegetation similar to that described above, and an alpine tarn which is characterised by bare rocky margins and a lack of associated wetland species.

Several ephemeral kettle-holes occur on the moraine on the lower southwest flank of Mt Joseph. These kettle-holes support a diverse and unique turf flora associated with fluctuating water levels and remain largely intact and weed free. They are part of a much larger and diverse collection of kettle-holes associated with the Glenmore moraines, which are discussed in more detail below. However, the rare species *Iphigenia novae-zelandiae* and *Oreomyrrhis colensoi* var. *delicatula* were found in the kettle-holes in this area.

Shrublands have been reduced to refuges in inaccessible areas where they have escaped fire. A few good areas of shrubland remain along stream gorges, where they form narrow strips. These are similar to those found in the Cass and Fork valleys and are dominated by relatively large specimens of mountain ribbonwood, *Olearia odorata*, mountain wineberry, matagouri, *Hebe rakaiensis*, *Coprosma propinqua*, *Clematis marata* and golden speargrass. Much of the woody cover has been recently burnt. A variation on the shrubland type described above occurs in the head of Joseph Stream where dry shrubland species, such as *Carmichaelia petriei*, porcupine shrub and *Coprosma intertexta*, occur with the species described above.

Glenmore Tarns Moraine

This area covers the predominantly glacial topography formed by the deposition of rock debris from the Tekapo and Cass glaciers. It has a large collection of tarns and kettle-holes, which support an exceptionally diverse collection of plant communities and species (Johnson, 1994). It is a nationally-significant landform complex and was identified for protection by the Protected Natural Areas Programme survey of the Mackenzie Ecological Region by Espie *et al* (1984). In recognition of the values present in this area, a QEII covenant has been placed over a large part of the moraine. The covenant does not cover the northern part of the moraine system, which includes the Stony and Tui tarns.

Plant communities and species assemblages associated with the wetland complex are extensive and have been described in reports by Johnson (1986; 1991; and 1994). For the tarns and kettle-holes, species typically occur in distinctive 'turf' zones that vary in composition, depending

largely on the hydrological conditions of each system, such as water fluctuation and the extent of inundation. This in turn is influenced by a multitude of local site factors, such as profile, shape and slope of the local catchment, moraine debris particle size, degree of loess mantling and alluvial siltation, surface moraine deposition (stone and boulder strips), predominant wave action and size of the fetch, and whether the kettle is landlocked or drained by an outlet channel. Consequently, species composition can vary markedly between what would appear to be very similar systems, often in very close proximity to each other. The turf vegetation commonly includes the following species (to name a few): *Agrostis muscosa*, *Carex berggrenii*, *Crassula sinclairii*, *Galium* aff. *perpusillum*, *Glossostigma elatinoides*, *Deschampsia chapmanii*, *Isolepis aucklandica*, *Epilobium angustum*, *Euchiton mackayii*, *E. traversii*, *Hypsela rivalis*, *Hydrocotyle hydrophila*, *H. microphylla*, *H. sulcata*, *Juncus pusillus*, *Leptinella maniototo*, *Neopaxia australasica*, *Parahebe canescens*, *Plantago triandra*, wire moss, *Pratia perpusilla*, *Schoenus concinnus* and *Stackhousia minima*. *Isolepis basilaris* was found throughout the tarn complex.

Highlighting further the variation in tarn/kettle-hole habitat and species present is the limited distribution of some rare species found during the survey. For example *Cardamine* ‘tarn’ was found only in Stony and Tui tarns, in the northern part of the moraine system. These relatively large tarns are distinctive for their rocky shores and deeply-cracked mud margins that form polygonal shapes. *Cardamine* ‘tarn’ is confined to a narrow zone between the rocky shore and the muddy margin. *Myosotis pygmaea* var. *minutiflora* and *Luzula celata* were found only in the Boundary Tarn complex, where they occur in turf associated with shallow relatively-dry (rarely filled with water) kettle-holes at the lower end of the moraine. *Oreomyrhiis colensoi* var. *delicatula* was found only in the Cluster Tarns complex at the western end, distinctive for their coarse rocky debris. And, in the central Glenmore Tarn complex which includes tarns that retain permanent water, sedgeland and bogs have their own distinctive assemblage of wetland species, such as sedge and rush species, red tussock, bog rush and sphagnum moss. The sparse *Aciphylla subflabellata* and uncommonly seen *Carex decurtata* occur here. Furthermore, at the southeast end of the moraine system above the Lake Alexandrina huts, is a large tarn dominated by raupo, adding further variation to the tarn complex. Consequently the full range wetland diversity is not fully replicated in any one part of the system, but is spread over the entire moraine.

The majority of the tarns remain quite intact, with few weed species present. This is especially so for those which are more regularly inundated with water. Regular inundation appears to limit the establishment of many of the exotic species that occur around the drier margins, such as mouse-ear hawkweed, sheep’s sorrel, browntop, sweet vernal and white clover. Conversely, the drier kettle-holes appear more susceptible to weed invasion, especially where disturbance such as vehicle tracks, stock trampling and rabbit digging disrupts intact turfs. Moisture tolerant exotic species such as marsh foxtail, soft rush, and floating sweet grass are also present, but generally in low numbers and were not particularly widespread. White clover is common in some tarns and kettle-holes in the eastern part of the moraine system.

Fescue tussockland is the major plant community on the dry moraine surfaces (interfluves, hummocks and slopes). Generally these tussocklands are depleted, with sparse cover (c.15%, and less in places) and a high proportion bare ground, but the majority remain quite natural with high native species diversity. Species composition can change dramatically over relatively short distances due to the environmental subtleties associated with the highly varied moraine topography. At the best sites, tussock cover can be up to 30% (rarely greater), but these are confined to what are possibly the more fertile sheltered sites. Sparsest tussock cover is on the exposed northern slopes and summits of moraine hummocks, where stunted matagouri and numerous other shrubs and sub-shrubs are common. At these sites miniature dryland shrublands contain *Carmichaelia vexillata*, *Coprosma atropurpurea*, *C. petriei*, *C. perpusilla*, *Hebe*

pimeleoides ssp. *pimeleoides*, patotara, *Leucopogon nanum*, *Pimelea oreophila*, *P. pulvinaris* and porcupine shrub. Coral broom, *Coprosma petriei*, *C. intertexta* and *C. propinqua* are also present at some sites. Other commonly occurring native species include blue tussock, *Brachyglottis bellidioides*, *Carex breviculmis*, *Convolvulus verecundus*, *C. muellerii*, *C. resectans*, dainty daisy, *Colobanthus* sp., *Elymus solandri*, *Luzula ulophylla*, creeping pohuehue, *Geranium sessiliflorum*, orchids (*Microtis uniflora*, *Hymenochilus tristis* and/or *H. tanypoda* (no flowers seen), *Prasophyllum colensoi*, *Thelymitra longifolia*), scabweed, *Raoulia parkii*, *Raoulia monroi* (occasionally) *Rytidosperma pumila*, *Scleranthus uniflorus*, *Stellaria gracilentia*, *Vittadinia australis* (occasionally) and harebell.

Mouse-ear hawkweed is the most abundant exotic species, often with a cover between 30% and 40% and sometimes higher. Other exotic species present include king devil hawkweed, catsear, sheep's sorrel, browntop, sweet vernal and various annual species, such as mouse-ear chickweed, silvery hair grass and *Veronica verna*. With the exception of mouse-ear hawkweed, other exotic species tend to be sparse and not abundant. Toward the north, on the moraine surfaces that have more fine alluvium, the grasslands are more modified through over-sowing and top-dressing. Here the inter-tussock composition has less bare ground and a higher proportion and cover of exotic species, such as sweet vernal, browntop, haresfoot trefoil, downy brome and white clover. These areas are primarily confined to the lower northern end of the moraine around Tui and Stony tarns, although white clover occurs in local patches in the moraine system around Hartley and Grebe tarns from what appears to be recent over-sowing, but it is never abundant and possibly ephemeral.

Shrublands are fairly ubiquitous though scattered throughout the area. The most intact shrublands are usually associated with rocky areas and moraine walls. Species typically include matagouri, native brooms (*Carmichaelia australis* and *C. petriei*), *Coprosma dumosa*, *C. propinqua*, *C. intertexta*, porcupine shrub, matagouri, mountain wineberry, *Olearia odorata* and the climbers *Clematis marata* and scrub pohuehue. Composition varies depending on site conditions, with porcupine shrub, matagouri and native broom species dominating drier rocky sites, whereas *Coprosma dumosa* appears confined to boulderfield. The most extensive shrubland and scrub occurs on the slopes of the steeply-incised outwash stream channel flowing southeast from the wetlands west of Hartley Tarn. Species present here are relatively dense with tall matagouri, mountain wineberry, *Coprosma propinqua*, *C. intertexta*, *Olearia odorata*, *Clematis marata*, golden speargrass, *Aciphylla scott-thomsonii* and occasional broad-leaved snow-tussock.

Lower-altitude Front Country

This area includes the lower undulating country between the Cass River, Lake Tekapo and Lake Alexandrina, including large areas of alluvial outwash from the Cass River. The majority of this area is highly modified fescue tussockland and developed pasture, and includes large areas of cultivated and irrigated paddocks. The indigenous plant communities that remain in natural condition are described below.

Cass River outwash surfaces

This area lies south of the lower Cass River on either side of Godley Peaks Road. It comprises relatively recent stony alluvial deposits with a distinctive dendritic drainage pattern of rills. It supports an interesting assortment of native species specific to very dry alluvial surfaces. Stunted matagouri up to approximately 1 m tall is the dominant species. Numerous other dryland species are present, including patches of *Muehlenbeckia ephedroides*, creeping pohuehue, scabweed, *Raoulia apicinigra*, *R. monroi*, *R. tenuiculmis*, *Scleranthus uniflorus*, *Coprosma petriei*, woolly moss, *Poa lindsayi*, *P. maniototo*, porcupine shrub, *Geranium sessiliflorum*, *Helichrysum*

depressum, *Rytidosperma gracile*, *Stellaria gracilentia*, *Convolvulus verecundus*, *Elymus falcis*, *Epilobium* sp., white fuzzweed and lichen species. Silver tussock and fescue tussock are occasionally present in small patches on lobes of fine alluvium. This area is remarkably free of exotic species, and many of those that are present tend to be annuals, such as *Veronica verna*, silvery hair grass, *Poa annua*, downy brome, haresfoot trefoil, storksbill and vulpia hair grass. Mouse-ear hawkweed is occasionally present but was struggling. A few shrubs of sweet brier are present.

Lake Murray

Lake Murray is a kettle-hole that occurs in a shallow depression at the base of an old moraine between Lake Alexandrina and Lake Tekapo. It was identified for protection during the Protected Natural Areas Programme survey, primarily for its value to native water fowl. It is quite a shallow water system that dries out in summer leaving a deeply cracked and quaking muddy bottom, which is colonised by turf species. Species composition occurs in zones around the margins depending on subtle changes in water, slope and sediment. Common species include *Crassula sinclairii*, *Glossostigma elatinoides*, *Isolepis aucklandica*, *Lachnagrostis filiformis*, *Myriophyllum triandra* and *Neopaxia lineariifolia*. Exotic jointed rush, toad rush, *Ranunculus trichophyllus* and marsh foxtail are relatively common. The margins are quite damaged by stock trampling, but overall the tarn has high natural values. Many exotic species are associated with areas of high stock concentration. These species include Californian thistle, Scotch thistle, soft rush, *Poa pratensis*, woolly mullein and white clover. Small patches of matagouri, *Olearia odorata* and porcupine shrub occur in the adjoining depleted fescue tussocklands.

Lakeshore shrublands

Small areas of remnant shrubland occur on the terraces immediately beside Lake Tekapo south of Pierce Pond. These shrublands occur as strips of relatively large matagouri (up to 2.5 m tall), and include *Olearia odorata*, *Clematis marata*, scrub pohuehue and porcupine shrub. An interesting variation to these shrublands occurs on top of the lower terrace at the northern end on an exposed deflated (wind-scoured) surface of unconsolidated sandy soils, similar to a dune field. Here matagouri is stunted and occurs in combination with fescue tussock, blue tussock, large *Carmichaelia vexillata*, *Convolvulus verecundus*, *Coprosma petriei*, *Raoulia monroi*, *R. australis*, *Scleranthus uniflorus*, *Pimelea pulvinaris* and patotara.

Wetlands

Much of the lower country adjoining Lake Tekapo would have supported wetlands but most of this area has been drained and cultivated. A small area of wetland remains in approximately the middle of the developed paddock east of the airstrip, where it occurs around a stream and old cut-off meander channel which drains to Mailbox Inlet. Bog rush is the dominant species, in combination with fescue tussock, although the inter-tussock species are predominately exotic, such as sweet vernal, oval sedge, white clover and Yorkshire fog. Pukio, *Carex diandra*, *C. kaloides*, *Carex flaviformis*, *Hydrocotyle hydrophila* and *Ranunculus gracilipes* are present around the stream margins and ponds.

Notable Species Recorded

Notable plant species recorded from Glenmore Pastoral Lease are listed in Table Two below. Threat categories are those proposed by de Lange *et al* (2004).

Table Two Notable plant species, Glenmore Pastoral Lease.

Plant species	Threat status	Distribution on property
<i>Aciphylla subflabellata</i>	Sparse.	Mt Joseph red tussockland; moraine grassland.
<i>Cardamine</i> aff. <i>Bilobata</i> (<i>Cardamine</i> 'scree')	Data deficient.	Upper Cass Valley screes.
<i>Cardamine</i> 'tarn'	Nationally endangered.	Tui and Stony tarns.
<i>Carex berggrenii</i>	Sparse.	Tarns throughout.
<i>Carex kaloides</i>	Sparse.	Mt Joseph red tussockland;
<i>Carex muelleri</i>	Sparse.	Moraine grassland.
<i>Carmichaelia crassicaule</i> (<i>Coral Broom</i>)	Gradual decline.	Moraine grassland; Mt Joseph.
<i>Carmichaelia vexillata</i>	Serious decline.	Moraine grassland; lakeshore shrubland; Mt Joseph.
<i>Convolvulus verecundus</i>	Sparse.	Moraine grassland; Cass River outwash; lakeshore shrubland.
<i>Coprosma intertexta</i>	Sparse.	Fork and Cass valley shrubland; moraine shrubland.
<i>Elymus falcis</i>	Range restricted.	Cass River outwash.
<i>Hymenochilus tanypoda</i>	Sparse.	Moraine grassland.
<i>Hymenochilus tristis</i> and/or <i>H tanypoda</i> (no flowers seen)	Sparse.	Moraine grassland.
<i>Iphigenia novae-zelandiae</i>	Gradual decline.	Cluster Tarns and kettle holes on moraine, lower south west. flanks of Mt Joseph.
<i>Isolepis basilaris</i>	Serious decline.	Tarns throughout.
<i>Luzula celata</i>	Serious decline.	Boundary Tarns.
<i>Muehlenbeckia ephedroides</i>	Sparse.	Cass River outwash.
<i>Myosotis pygmaea</i> var. <i>minutiflora</i>	Nationally vulnerable.	Boundary Tarns.
<i>Oreomyrrhis colensoi</i> var. <i>delicatula</i>	Nationally endangered.	Cluster Tarns and kettle holes on moraine, lower south west. flanks of Mt Joseph.
<i>Raoulia monroi</i>	Gradual decline.	Moraine grassland; Cass River outwash; lakeshore shrubland.
<i>Raoulia petriensis</i>	Range restricted.	Mt Joseph summit.
<i>Vittadinia australis</i> (<i>White fuzzweed</i>)	Data deficient.	Cass Valley bluffs; moraine grassland; Cass River outwash.

Significance of Vegetation and Flora

Glenmore Pastoral Lease contains an excellent representation of the indigenous plant communities of the Godley and Tekapo ecological districts. This is especially so for the sub-alpine to alpine bioclimatic zones, where the plant communities (tall tussockland, alpine wetland, herbfield, bog, stonefield and shrubland) are predominantly original, with very few exotic species. High naturalness is also a feature of lower-altitude tarns, kettle-holes and the Cass River alluvial surfaces.

The mountainous country, including Mt Joseph represent a full and varied range of montane to alpine plant communities including excellent examples of vegetation sequences across rainfall and altitudinal gradients, such as the transition between mid-ribbed snow-tussock and slim snow-tussock with decreasing rainfall, and the transition between slim snow-tussock and narrow-leaved snow-tussock with decreasing altitude. Herbfield, alpine wetland, shrubland, fescue tussockland and stonefield (scree) communities add to the complexity of this botanically diverse area. The rounded summit of Mt Joseph supports a distinct assemblage of inter-tussock species and peat bog communities not replicated elsewhere on the property, and includes intact altitudinal sequences with slim snow-tussock, narrow-leaved snow-tussock and red tussock.

The Glenmore Tarns moraine contains outstanding examples of tarns and kettle-holes associated with the ablation moraine topography. These are complemented and buffered by extensive depleted fescue tussockland and shrubland on the surrounding dry moraine surfaces. The conservation values of the Glenmore Tarns moraine are well recognised. The Protected Natural Areas Programme survey of the Tekapo Ecological District recommended the majority of the Glenmore Tarns moraine for protection (RAP 21) for its tarn vegetation, the surrounding fescue tussocklands and for wildlife habitat. It was considered to be the most outstanding area of kettles in the South Island (Espie *et al*, 1984). Johnson (1986; 1991; 1992; and 1994) states that the kettle-hole wetlands support an extremely large flora of native plants, many of them restricted to turf shore habitats, and concluded that the Glenmore Tarns moraine is an excellent example of glacial ablation topography. Johnson recorded 146 native plant species in these wetland systems with over 50 species restricted to the turf zone of kettle-holes and tarns, including three nationally-rare species, *Crassula peduncularis*, *Iphigenia novae-zelandiae* and *Isolepis basilaris* (Johnson, 1994).

The lower altitude front country is especially notable as it contains, on the Cass River outwash, the only example in the ecological district of indigenous plant communities that occupy recent alluvial surfaces. The vegetation on this landform is probably the only natural and intact example remaining in the ecological region.

The Glenmore Tarns moraine and the lower altitude front country and to a lesser extent Mt Joseph, support some of the most threatened and under-represented indigenous plant communities in New Zealand. 22 plant species are listed as threatened or uncommon (de Lange *et al*, 2004) (Table 2). Nine of the 22 species, including the two nationally-endangered species and the one nationally-vulnerable species, are confined to tarn and kettle-hole margins on the Glenmore Tarns moraine. Of highest significance are *Cardamine* 'tarn' and *Oreomyrrhis colensoi* var. *delicatula*, which have a threat ranking of nationally-endangered and face a very high threat of extinction in the wild. *Cardamine* 'tarn' has only been recorded from a few locations in Canterbury, but has not been seen recently until now. *Oreomyrrhis colensoi* var. *delicatula* is known from only one other site in Canterbury outside of the Glenmore Tarns moraine. Also present is the nationally-vulnerable *Myosotis pygmaea* var. *minutiflora* and three species classified as serious decline and three species as gradual decline. Two species not ranked as threatened but are notable in a local context are manuka (uncommon in the ecological district) and *Rostkovia magellanica* (first time recorded in the ecological district).

Insert Botanical values map here

2.5.3 Problem Plants

Introduced plant species that may have an important effect on indigenous plant communities on the property, and that can be controlled or contained, are listed and discussed below. Other ubiquitous naturalised species for which containment or control are probably impractical, such as mouse-ear hawkweed and pasture grasses, are not discussed here but are listed in the vegetation descriptions. Large parts of the property are free of significant plant pests.

Wilding conifers

Several small mixed plantations of Douglas fir, larch, *Pinus ponderosa* and *P. nigra* occur around huts in the Fork and Cass valleys, and are spreading into tussockland and shrubland. However, the majority of the property remains remarkably free from wilding conifers.

Rowan

Rowan trees are present around the homestead. Rowan fruits are readily dispersed by birds.

Russell lupin

Russell lupins are present near the homestead and in Joseph Stream. This species poses a significant threat to open habitats, such as riverbeds, outwash gravels and lake margins.

Crack willow

Crack willows are widespread around Lake Alexandrina, in lower Fork Stream and the lower Cass River, threatening the integrity of the numerous tarns and wetlands on the property if not contained.

Wetland weeds

Water-tolerant species such as oval sedge, soft rush, jointed rush, marsh foxtail and floating sweet grass are a potential problem for the many tarns and wetlands on the property. They threaten the turf communities at the tarn and kettle-hole margins.

Gorse

Gorse occurs as occasional plants along access tracks in the Cass River catchment.

2.6 FAUNA

2.6.1 Bats

Bats have not been recorded from this area. Glenmore Pastoral Lease was not checked for the presence of bats during this survey because bats are generally associated with forest, and there are no large stands of indigenous forest on the property.

2.6.2 Birds

The Glenmore Tarns moraine and margins of the Cass River and Fork Stream have long been recognised for their outstanding value to birds. The region is particularly important for the threatened black stilt (threat status: nationally-critical). Prior research confirmed the importance of the Glenmore Tarns (Tui, Stony, Little Stony, Hartley, Glenmore, Grebe, Sunday, Cluster and Boundary tarns) and associated unnamed wetlands and ephemeral tarns, collectively with a range of other wetlands on the property, as breeding and feeding habitat for black stilt (Budgeon, 1977; Pierce, 1982).

Tarns on the Glenmore Tarns moraine have been listed as Sites of Special Wildlife Interest (SSWI) by Jarman (1987), including Tui Tarn (ranked moderate value to wildlife), Stony Tarn (outstanding), Hartley Tarn (high), Glenmore Tarns (outstanding), Grebe Tarn (outstanding), Sunday Tarn (moderate), Cluster Tarns (outstanding) and Boundary Tarns (potential). Lake Murray was also ranked as outstanding for wildlife. O'Donnell (2000) found wetlands on the Glenmore Tarns moraine were significant habitats for indigenous fauna in the context of Section 6 of the Resource Management Act (1991), being some of the best examples of these habitats in the region.

Collectively these tarns support breeding and feeding populations of 25 indigenous wetland bird species including Australasian crested grebe (nationally-endangered), Australasian bittern (nationally-endangered), black-fronted tern (nationally-endangered), grey duck (nationally-endangered), wrybill (nationally-vulnerable), banded dotterel (gradual decline), black-billed gull (serious decline) and black shag (sparse). The tarns provide a staging point for wrybill (nationally-vulnerable) and banded dotterel (gradual decline) prior to migration to their wintering sites, and foraging habitat for all riverbed birds when the Cass River is in flood. Glenmore Tarns provide breeding habitat for chestnut-breasted shelduck, a species presently colonising New Zealand. Marsh crake (sparse) have been recorded breeding in swamp vegetation on or adjacent to Mick's Lagoon (north of the property), Mailbox Inlet (Pierce Pond) and Lake Alexandrina. Joseph Valley Wetland, northwest of the Glenmore Tarns moraine was ranked outstanding for wildlife by Jarman (1987) because black stilt bred there until 1978 and Australasian pied stilt, and a range of waterfowl, waders and terns used the site for breeding and feeding.

The significance of the Cass River, along the eastern boundary of the property, for wildlife has long been recognised and was ranked outstanding by Jarman (1987). The Cass River is a SSWI. Pierce (1982; 1983) confirmed the importance of the area to black stilt and a wide range of braided river bird species. Braided rivers of the type found in Canterbury are nationally and internationally rare habitat types (O'Donnell and Moore, 1983). Braided rivers provide habitat for over 80 species of birds, many unique to New Zealand, and many of which have been recorded in the Cass River (O'Donnell and Moore, 1983; Pierce, 1983; Maloney *et al.*, 1997). Four endemic threatened species have evolved on braided rivers: wrybill, black stilt, black-billed

gull and black-fronted tern. Two further endemics, banded dotterel (gradual decline) and South Island pied oystercatcher use braided rivers as their major breeding habitats (O'Donnell and Moore, 1983). All of these species have significant populations in the Cass Valley. Caspian tern (nationally vulnerable) also breeds in the Cass Valley. Rare migrants appear on the river, including frequent white-winged black tern, and sporadically eastern curlew, bar-tailed godwit, turnstone, pectoral sandpiper, lesser knot, Japanese snipe and arctic tern (Maloney *et al.*, 1997; Ornithological Society of New Zealand Recording Scheme; R. Pierce, *pers. comm.*).

There are no large stands of indigenous forest on the property, but birds of open country and shrubland recorded from the Tekapo and Godley ecological districts include South Island tomtit, South Island fantail, grey warbler, shining cuckoo and silvereye (McEwen, 1987). Morepork and long-tailed cuckoo (gradual decline) have occasionally been recorded. Birds of open country and alpine areas include kea (nationally-endangered), New Zealand falcon (gradual decline) and New Zealand pipit. Rock wren (nationally-vulnerable) has also been recorded in the area (Bull *et al.*, 1985; McEwen 1987; Sedgely 2002a; R. Pierce, *pers. comm.*).

Lake Alexandrina adjacent to the pastoral lease is listed as a SSWI. The lake is one of the most important sites in New Zealand for Australasian crested grebe and other waterfowl.

Birds observed on Glenmore Pastoral Lease are described below for the main areas surveyed.

Upper Tin Hut Stream

Alpine areas on the property comprise extensive areas of rockland, stonefield/gravelfield (rock pavement and scree), herbfield, cushionfield and tall tussockland. In a typical alpine area surveyed in upper Tin Hut Stream, New Zealand pipits were common and a pair of southern black-backed gulls was present. The higher altitude parts of the property provide potential habitat for rock wren (nationally vulnerable).

Mt Joseph Basin

High altitude tussocklands and small high altitude bogs dominate the summit of Mt Joseph and the large basin to the south. Three New Zealand falcons were observed here. Banded dotterel, New Zealand pipit and introduced birds were present.

Cass Valley Shrubland

Indigenous shrubland dominates rocky-sided gullies and steeper slopes of the Cass Valley above the confluence of Joseph Stream. These shrublands provide feeding and breeding habitat for grey warbler, silvereye and South Island rifleman (gradual decline). Welcome swallows were observed foraging over shrubland near Memorial Hut. A pair of New Zealand falcon (gradual decline) were observed hunting over the shrublands upstream from Tin Hut, a single New Zealand falcon observed downstream from Tin Hut, and kea (nationally-endangered) were observed at higher altitudes. Lower in the valley (below Waterfall Hut) grey warbler, silvereye, Australasian harrier, New Zealand falcon and South Island rifleman were observed. Notable was the large numbers of black-fronted terns seen foraging over indigenous shrubland and tussockland on the lower slopes throughout the valley. Introduced birds were observed in shrubland throughout the valley.

Cass River Margins

The margins of the Cass River bordering the northeast boundary of the property were surveyed along three stretches: below the Cass River gorge to Lake Tekapo; between the gorge and the stock fence across the river (between Waterfall and Tin huts); and between the fence and Memorial Hut.

River edge habitat consists of bare shingle (gravelfield), herbfield, wetland turfs, small spring-fed channels (often with margins of *Schoenus* and *Carex*), matagouri shrubland and scattered red tussockland. 16 indigenous wetland bird species were observed in these habitats during the inspection, with an additional 11 species recorded in the past (in total 27 species). Four threatened species were present: wrybill (nationally-vulnerable), black stilt (nationally-critical), black-billed gull (serious decline) and black-fronted tern (nationally-endangered). Wrybill and black-fronted tern were present in high numbers (hundreds of individuals); higher numbers than on most rivers in New Zealand (O'Donnell and Moore, 1983; Maloney *et al.*, 1997; Keedwell, 2004; Keedwell, 2005). Wrybill were present up to a point just below Memorial Hut. Black-fronted terns foraged even further up valley. Black stilt and black-billed gull were confined to the lower river (below the fence). Two additional endemic species, banded dotterel (gradual decline) and South Island pied oystercatcher were present in high numbers and breeding along all sections surveyed. White-winged black tern, a rare migrant, was present near the delta. Black-fronted terns, in particular, foraged extensively along the spring-fed channels on the river flats within the property boundary. Black shag and grey duck were also observed.

Cass Valley Red Tussockland

This is a c.40 ha area of red tussock-dominated swamp on the floor of the Cass Valley, northwest of the airstrip. During the survey the area was relatively dry, except along the banks of three streams that flow through the red tussockland. Black-fronted tern and southern black-backed gull were foraging over the wetland during the survey. Black stilt have previously been recorded feeding here (Source: Black Stilt Database).

Lower Fork Valley

Hill slopes in lower Fork Stream are dominated by short tussockland and tall tussockland, with areas of shrubland, rockland and stonefield (scree). Fork Stream, on the property boundary, is a small braided river that is relatively weed free and provides good foraging and nesting habitat for wetland birds. Paradise shelduck, black-fronted tern, banded dotterel, South Island pied oystercatcher and southern black-backed gull were present on the riverbed and along the river margins. Shrublands here provide breeding and feeding habitat for silvereye and grey warbler. A New Zealand falcon was observed over grasslands near the hut.

Mt Joseph Shrubland

Matagouri-dominated shrubland is present in gullies and faces on the lower slopes of Mt Joseph, above lower Fork Stream and Joseph Stream. Some of these shrublands have been recently burnt. South Island tomtit, grey warbler and silvereye were present here during the survey. South Island tomtits are generally uncommon away from the forests of the Main Divide of the Southern Alps. This was the only area on the property where South Island tomtits were seen.

Joseph Valley Wetland

Joseph Stream is a small meandering stream that is surrounded by a remnant of a previously extensive wetland. Today, there are only small patches of emergent swamp vegetation, though these have some restoration potential. Black-fronted tern and black-billed gull were foraging over the wetland during the survey, and paradise shelduck and New Zealand pipit were present. Previously, the wetland provided feeding and breeding habitat for black stilt (Jarman, 1987). Paradise shelduck, South Island pied oystercatcher, spur-winged plover and Australasian pied stilt have bred (and may still breed) here.

Glenmore Tarns Moraine

The following tarns and wetlands on the Glenmore Tarns moraine were surveyed.

Tui Tarn and associated unnamed wetlands and ephemeral tarns

This is a large (c.5 ha) tarn, largely surrounded by developed grassland and ephemeral wetlands. A small area of emergent swamp vegetation at the northwest end and bare mud and very shallow water at the south end provide good foraging habitat for waders. Eight indigenous wetland species were present feeding at the tarn during the survey. Three other species have been recorded previously (in total 11 species, including five threatened species). Threatened species present during the survey were black stilt, black-fronted tern, black-billed gull and a small flock of six grey duck (nationally-endangered). Australasian crested grebes (nationally-endangered) also use this tarn (R. Pierce and R. Maloney, *pers. comm.*) but were not present during the survey. Most of the associated wetlands and wetland turfs were dry during the survey, but would clearly provide feeding and roosting habitat for birds at other times of the year.

Stony Tarn and associated unnamed wetlands and ephemeral tarns

Stony Tarn is a large (c.6 ha) tarn, largely surrounded by developed grassland and small ephemeral wetlands. Nine indigenous wetland species were present during the survey. Five other species have been recorded previously (in total 14 species, including six threatened species). Black swan and paradise shelduck were breeding on the tarn at the time of survey. Relatively large numbers of waterfowl (New Zealand scaup, New Zealand shoveler and grey duck) were roosting and feeding on the tarn. Black-fronted tern and black-billed gull were foraging over the open water. Australasian pied stilt and spur-winged plover were also present. Most of the associated wetlands and wetland turfs were dry during the survey, but would clearly provide feeding and roosting habitat for birds at other times of the year. Black stilts are regularly present on the tarn and breed there, Australasian crested grebe have bred on the tarn in the 1980s and in the last five years, and Australasian bittern (nationally-endangered) have been recorded in the past.

Little Stony Tarns

These two small tarns lie east of Stony Tarn. Three indigenous wetland species were present during the survey: paradise shelduck, spur-winged plover and Australasian pied stilt. Black stilts use these tarns occasionally, and have been previously recorded breeding on both tarns. The eastern-most tarn was dry during the survey.

Hartley Tarn

Hartley Tarn is a moderately large, deeply incised tarn with scattered crack willow, sedgeland and stony beaches along its shore. Ten indigenous wetland species were present during the inspection. Two other species have been recorded previously (in total 12 species, including five threatened species). One pair of Australasian crested grebe was foraging on the tarn during the

survey. Crack willow trees at the western end of the tarn provide important nesting sites for this threatened species (which has a national population of <400 individuals). Black-fronted tern and black-billed gull were foraging over the open water. Black swan, New Zealand scaup and paradise shelduck were breeding on the tarn. Grey duck were observed during the survey. Black stilts have been previously recorded.

Glenmore Tarns and associated unnamed wetlands and ephemeral tarns

Glenmore Tarns is a complex mosaic of c.12 small tarns spread over c.80 ha. Most are linked to one another by swamp vegetation, particularly sedgeland and wetland turf communities. Fifteen indigenous wetland bird species were present during the survey. Eight other species have been recorded previously (in total 23 species, including nine threatened species). One pair of Australasian crested grebe, one pair of black stilts, banded dotterel, black-fronted tern and black shag were feeding on the tarns during the survey. Black swan and paradise shelduck were breeding on the tarns. Grey duck and black-billed gull were observed during the survey. Australasian bittern and wrybill have been previously recorded at the tarns.

Grebe Tarn

This large (c.12 ha) tarn is surrounded by depleted short tussockland. Nine indigenous wetland species were present during the survey. Seven other species have been recorded previously (in total 16 species). Eight threatened species have been recorded feeding or breeding on this tarn: Australasian bittern, Australasian crested grebe, black stilt, black-fronted tern, black shag, banded dotterel, grey duck and wrybill. Black-fronted tern, black shag, banded dotterel and grey duck were present during the survey.

Sunday Tarn

This large (c.10 ha) tarn is surrounded by depleted short tussocklands, with some emergent swamp vegetation along its shore. No indigenous wetland species were present during the survey. However, ten species have been recorded previously, when water was present, including black stilt, Australasian bittern, black-fronted tern, Australasian crested grebe and grey duck.

Cluster Tarns

Cluster Tarns comprise c.10 small tarns and wetland turfs spread over c.40 ha. They are surrounded by depleted short tussockland. Five indigenous wetland species were present during the survey. Eleven other species have been recorded previously (in total 16 species). Black-fronted tern and banded dotterel were feeding on the tarns during the survey and paradise shelduck were breeding. Black stilts are present regularly and Australasian bittern, black-billed gull, grey duck and black shag have been previously recorded.

Boundary Tarns and associated unnamed wetlands and ephemeral tarns

Boundary Tarns comprises six small tarns and wetland turfs surrounded by depleted short tussockland. No indigenous wetland species were present during the survey because the tarns were dry. Four wetland species have been recorded previously, when water was present. Banded dotterel were present in the 1980s.

Collectively, Glenmore Moraine tarns and associated habitats provide an important post-breeding flocking point and pre-migration staging point for banded dotterel and wrybill. Most banded dotterels at inland sites migrate to Australia, so a large proportion of birds travelling this route will use basin tarns prior to migration (Pierce, 1999). The tarns also provide important foraging habitat when the Cass River is in flood (Pierce, 1986) and important moulting sites for paradise

shelduck. Several of the associated wetlands and wetland turfs were quite dry during the survey, but would clearly provide feeding and roosting habitat for birds at other times of the year.

Cass River Outwash Flats

The area of recent outwash gravels south of the Cass River is a mosaic of open stonefield/gravelfield, matagouri shrubland and short tussockland, with small spring-fed streams and seepages. Banded dotterels were common here, breeding on the open habitats. South Island pied oystercatcher, New Zealand pipit, black-fronted tern and Australasian pied stilt were present. A black stilt was observed foraging in a small stream.

Corner Pond is a small ephemeral wetland at the northeast edge of the outwash surface, adjacent to the Cass River delta. This area was dry at the time of the survey, but is an important feeding area for black stilt, banded dotterel and wrybill (R. Maloney, *pers. comm.*).

Clover Hill Ponds comprises three small tarns and an area of ephemeral wetland covering c.15 ha, at the southeast edge of the outwash surface. Wetland turfs are present on the tarn margins and the area is surrounded by short tussockland. During the survey the area was completely dry. Only paradise shelduck was present. However, when wet, these tarns provide important breeding and feeding habitat for black stilt. During times of midge emergence this wetland provides important foraging habitat for black-fronted terns (R. Maloney, *pers. comm.*).

Mailbox Inlet Tributaries

This is an area of degraded swamp covering c.40 ha, comprising a number of spring fed creeks east of the airstrip beside Godley Peaks Road. It has been modified by pasture development, though areas of sedgeland are still present. Ten black swans, spur-winged plover, c.200 Canada geese, New Zealand scaup and several pairs of breeding paradise shelduck were observed here during the survey. The creek forms the catchment of Mailbox Inlet, an important wetland bird habitat adjacent to the property. Surrounding areas, including irrigated pastures, are used extensively by South Island pied oystercatcher, banded dotterel, black-fronted tern, Australasian pied stilt and black stilt. Caspian terns forage here (R. Maloney, *pers. comm.*). The lack of trees, proximity to the river and the presence of wetland habitat and water make this area important for birds (R. Pierce, *pers. comm.*).

Lake Murray

This is a large tarn with wetland turf on the margins and surrounded by short tussockland. The water area of the tarn can cover c.8 ha, but more than 80% of the tarn was drying out during the survey. Much of the shore comprises mudflats, some of which provide feeding habitat for waders. No birds were present at the time of the survey, though 21 indigenous species are commonly reported from this tarn. The tarn provides important feeding habitat for black stilt when wet. Pied stilts and mixed pairs of black and Pied/hybrids nest here, and there is definite potential for black stilts to nest here as the population increases. One pair of Australasian crested grebe has bred here in the past. Other threatened species that have been recorded as using the lake for foraging include banded dotterel, black-fronted tern, Caspian tern, black-billed gull and grey duck. New Zealand scaup have been recorded here in the past.

Deer Paddocks adjacent to Lake Alexandrina Scenic Reserve

The deer paddocks contain numerous small ponds and small streams fringed with sedges, which are remnants of more extensive wetlands. These remnants still provide feeding habitat for black stilt. The property also directly borders the shore of Lake Alexandrina. The lake is one of the most important sites in New Zealand for Australasian crested grebe. It also provides feeding and breeding habitat for a wide range of waterfowl including Australian coot, New Zealand scaup, black shag and grey duck. These birds also utilise the adjacent paddocks on the pastoral lease. Black-fronted terns feed over the lake and its surrounds (R. Maloney, *pers.comm*).

Low-altitude Grassland

Exotic grassland and degraded short tussockland are present throughout lower altitude parts of the property. Australasian harrier and southern black-backed gull were commonly observed in these habitats. It has been previously recorded that banded dotterels feed and breed in these habitats, and South Island pied oystercatcher and black-fronted tern feed in these habitats during the breeding season (R. Maloney, *pers. comm.*). Introduced birds were common. Irrigated paddocks and crops provide some foraging habitat for black-fronted tern, black-billed gull, paradise shelduck, South Island pied oystercatcher and banded dotterel. Black stilt also feed in these habitats but none were seen here during this brief survey.

Species Recorded

46 bird species were recorded on Glenmore Pastoral Lease during this survey: 29 indigenous species and 17 naturalised species. 11 threatened bird species were recorded. Another seven indigenous species (including three threatened species) have been recorded previously on the property, but were not recorded during this survey (see Table Three).

The 17 naturalised bird species commonly recorded on Glenmore Pastoral Lease during the survey were Australian magpie, blackbird, Canada goose, California quail, chaffinch, chukor, dunnoek, goldfinch, greenfinch, grey duck/mallard hybrid, house sparrow, mallard, redpoll, skylark, song thrush, starling and yellowhammer.

Table Three Indigenous bird species recorded from Glenmore Pastoral Lease.

Key:

* Hitchmough and Bull, *in press*.

† Not seen during the 2005 inspection, but recorded previously by Jarman (1987), Pierce (1983), R. Pierce *pers. comm.*, Maloney *et al.* (1997), and R. Maloney, *pers. comm.*

Bird species	Threat status*	Distribution on property
Australasian bittern†	Nationally endangered.	Stony, Glenmore, Sunday, Cluster and Grebe tarns.
Australasian crested grebe	Nationally endangered.	Stony, Hartley, Glenmore, Sunday and Grebe tarns; Lake Murray and Tui Tarn.
Australasian harrier	Not threatened.	Throughout.
Australasian pied stilt	Not threatened.	Wetlands and tarns throughout.

banded dotterel	Gradual decline.	Cass River margins; Glenmore Tarns moraine; most other tarns; widespread across property.
black-billed gull	Serious decline.	Lower-altitude habitats throughout.
black-fronted tern	Nationally endangered.	Lower- to mid-altitude habitats throughout.
black shag	Sparse.	Cass River; Glenmore Tarns moraine.
black stilt	Nationally critical.	Cass River margins; Glenmore Tarns moraine; irrigated pasture.
black swan	Not threatened.	Glenmore Tarns moraine, Cass River and Mailbox Inlet.
Caspian tern†	Nationally vulnerable.	Cass River; Mailbox Inlet; Lake Murray.
chestnut-breasted shelduck†	Not threatened;	Glenmore Tarns moraine.
grey duck	coloniser.	
	Nationally endangered.	Glenmore Tarns moraine, Cass River and Lake Murray.
grey warbler	Not threatened.	Indigenous shrubland.
kea	Nationally endangered.	Mountain areas.
little shag	Not threatened.	Glenmore Tarns moraine and Lake Murray.
long-tailed cuckoo†	Gradual decline.	Pine trees (passage migrant).
morepork†	Not threatened.	Pine and willow trees throughout.
New Zealand falcon (eastern)	Gradual decline.	Mountain areas and lower Fork Valley.
New Zealand pipit	Not threatened.	Cass River margins; Glenmore Tarns moraine; mountain areas; tussocklands.
New Zealand scaup	Not threatened.	Glenmore Tarns moraine; Lake Murray; Mailbox Inlet.
New Zealand shoveler	Not threatened.	Glenmore Tarns moraine, Cass River and Lake Murray.
paradise shelduck	Not threatened.	Lower-altitude habitats throughout.
pukeko†	Not threatened.	Lake Alexandrina and adjacent streams.
shining cuckoo†	Not threatened.	Shrubland; pines (passage migrant)
silveryeye	Not threatened.	Indigenous shrublands.
southern black-backed gull	Not threatened.	Habitats throughout.
South Island fantail	Not threatened.	Shelter belts.
South Island pied oystercatcher	Not threatened.	Cass River margins; Glenmore Tarns, moraine; Lake Murray, mountain areas; tussocklands, Lower Fork valley.
South Island rifleman	Gradual decline.	Indigenous shrublands.
South Island tomtit	Not threatened.	Mt Joseph shrublands.
spur-winged plover	Not threatened.	Lower-altitude habitats throughout.
welcome swallow	Not threatened.	Lower-altitude habitats throughout.
white-faced heron	Not threatened.	Glenmore Tarns moraine, Cass River and Lake Murray.
white-winged black tern	Not threatened.	Margins of lower Cass River, Lake Murray and Glenmore Tarns.
wrybill	Nationally vulnerable.	Cass River margins; Glenmore Tarns moraine.

Significance of the Bird Fauna

Fifty-three bird species have been recorded on Glenmore Pastoral Lease, including 14 threatened bird species: Australasian crested grebe (nationally-endangered), Australasian bittern (nationally-endangered), banded dotterel (gradual decline), black-fronted tern (nationally-endangered), black stilt (nationally-critical), black shag (sparse), black-billed gull (serious decline), Caspian tern (nationally-vulnerable), grey duck (nationally-endangered), kea (nationally-endangered), long-tailed cuckoo (gradual decline), New Zealand falcon (gradual decline), South Island rifleman (gradual decline) and wrybill (nationally-vulnerable). The property has very high species richness compared with many other pastoral leases.

Collectively, wetland areas on the property are of national significance for black stilt and black-fronted tern. Both species feed over much of the property, and black stilts breed both on the property and on the adjacent Cass River. Black stilt is one of the rarest wetland bird species in New Zealand, numbering approximately 72 adults in the wild of which 14 were productive or breeding pairs in the 2005/2006 season. The entire breeding population occurs in the upper Waitaki Basin. The Department of Conservation's black stilt database has 10,120 records from Glenmore Pastoral Lease, 9,802 of which are sightings since 1990 and 7,865 are sightings since 2000 (R. Maloney *pers. comm.*; DOC black stilt database), indicating the importance of wetlands on the property to this species. There is an active black stilt recovery programme (Maloney and Murray, 2002), and conservation of wetlands in the region is essential to provide breeding habitat for the recovering population.

The tarns on the property provide an important post-breeding flocking point and pre-migration staging point for banded dotterel and wrybill. The tarns also provide important foraging habitat when the Cass River is in flood (Pierce, 1986), and important moulting sites for paradise shelduck. The Glenmore Tarns moraine supports some of the only chestnut-breasted shelduck breeding in New Zealand. The Cass River adjoining the property is ranked as outstanding value for wildlife, notably for black stilt and a wide range of braided river bird species. The Glenmore Tarns, Lake Murray and the Cass River are listed as Sites of Special Wildlife Interest.

Higher-altitude parts of the property provide extensive intact habitat for kea, New Zealand pipit, and New Zealand falcon and potential habitat for rock wren. This area buffers and complements a much more extensive area of largely-protected mountain habitat of the Southern Alps.

2.6.3 Lizards

Several threatened lizard species have been recorded in the vicinity of Glenmore Pastoral Lease. Jewelled gecko (threat status: gradual decline) has been reported from the nearby Tasman and Tekapo river margins (McEwen, 1987). Spotted skink (gradual decline) occurs at several sites around Lake Tekapo, including the adjacent Godley Peaks Pastoral Lease (Sedgeley, 2002a). Scree skink (gradual decline) and long-toed skink (sparse) have been recorded on the eastern side of Lake Tekapo (Sedgeley, 2002b). Common skink, McCann's skink and Southern Alps gecko have been recorded on the adjacent Godley Peaks Pastoral Lease (Sedgeley, 2002a; DOC Herpetofauna Database). The only lizard record listed in the Herpetofauna Database for Glenmore Pastoral Lease is McCann's skink from near Glenmore Tarns.

Lizards observed on Glenmore Pastoral Lease are described below for the main areas surveyed.

Cass Valley Shrubland and Tussockland

Indigenous shrubland, stonefield (including scree), rockland and tussockland dominate the steep slopes of the Cass Valley above the confluence of Joseph Stream. These communities provide a mosaic of suitable habitats for lizards. Common skink and Southern Alps gecko were common throughout this area.

Lower Fork Valley

Hill slopes in lower Fork Stream are dominated by short tussockland and tall tussockland, with areas of shrubland, rockland and stonefield (scree). These communities provide very good habitats for lizards. McCann's skink, common skink and Southern Alps gecko were abundant in this area. A large skink was seen in tall tussockland in lower Fork Stream. The colour and size of the skink, and the habitat in which it was observed, suggest it is likely to be a spotted skink (gradual decline) or scree skink (gradual decline).

Glenmore Tarns Moraine

This extensive area of rolling moraine is dominated by depleted short tussockland and a diverse mosaic of small tarns and wetlands. Small rock outcrops and patches of stonefield (talus) are scattered throughout. The deeply-incised old outwash stream valley that cuts southeast through the moraine contains small patches of scrub, shrubland, short tussockland and stonefield. These communities provide suitable habitats for lizards. McCann's skink and Southern Alps gecko were present on the moraine surface. Droppings from an unidentified lizard species were found under rocks in the incised valley.

Species Recorded

A total of 101 lizards of three species were recorded from 61 different locations on Glenmore Pastoral Lease: common skink (21 individuals), McCann's skink (28) and Southern Alps gecko (52). Extensive screes in the upper Cass and Fork valleys contain potential habitat for scree skink. A large unidentified skink observed in tussockland in the lower Fork Valley was most likely a spotted skink (gradual decline).

Significance of the Lizard Fauna

Extensive suitable lizard habitat is present on Glenmore Pastoral Lease, notably where rockland and stonefield (bluff, talus and scree) are associated with indigenous shrubland and tall tussockland. Large numbers of common lizard species were recorded at lower altitudes. Suitable habitat is present for threatened spotted skink (gradual decline), scree skink (gradual decline) and jewelled gecko (gradual decline).

Insert Bird and Lizard values map in here

2.6.4 Freshwater Fauna (fish and invertebrates)

Glenmore Pastoral Lease is in the Waitaki Catchment, on the western shore of Lake Tekapo. It lies between the Cass River and Fork Stream and includes parts of the Gammack Range, all the peaks of Joseph Ridge and Mt Joseph itself. The property is drained by Fork Stream to the west, Lake Alexandrina and Lake Tekapo to the southeast and the Cass River and its tributaries (Ailsa, Tin Hut and Joseph streams) to the east. The property also includes the nationally-outstanding Glenmore Tarns (Espie *et al.*, 1984), a series of permanent and ephemeral water bodies on the extensive ablation moraine west of Glenmore Homestead.

One of the distinguishing features of the Waitaki Catchment is the presence of hydroelectric dams. This has two major effects on fish communities. The first is that fish communities upstream from the dams are generally composed of only non-diadromous species (those species without a marine phase in their lifecycle), although some exceptions do occur (e.g. longfin eel may still be present and common bully and koaro have become non-diadromous substituting lakes for the sea). The second effect is that fish communities are separated into discrete populations preventing re-colonization of previously dewatered streams.

The New Zealand Freshwater Fish Database (NZFFD) has 887 records (at the 24th of January 2006) from the Waitaki River catchment. Species recorded from streams near the property are longfin eel, koaro, bignose galaxias, alpine galaxias, Canterbury galaxias, upland longjaw galaxias, upland bully, common bully, rainbow trout and brown trout. Of these, longfin eel, bignose galaxias and upland longjaw galaxias are listed as threatened species (all gradual decline) by Hitchmough and Bull (*in press*) and Hitchmough (2002).

Most of the Waitaki River, including all of the catchments on this pastoral lease, is recognised in the Waters of National Importance (WONI) documentation (DOC – Chadderton *et al.* 2004). This recognition comes in two forms: ‘Type I’ and ‘Type II’. Glenmore Pastoral Lease is split with the Cass River catchment, including part of the ‘Glenmore Tarns’ being ‘Type I’ and the remainder of the pastoral lease, mainly Fork Stream catchment being ‘Type II’. ‘Type I’ implies that the majority of the waterway is nationally significant. The significance is because it is in the top ten sites by Natural Heritage Value score in its biogeographical unit, and it also contains populations of threatened birds. ‘Type II’ implies that the waterway contains special features of national significance. Only sections of ‘Type II’ catchments are of national importance. This significance is because it contains populations of threatened bird and fish communities.

Glenmore Pastoral Lease comprises three main geographical areas of freshwater habitat, with distinct topographical or habitat characteristics. These areas are the Cass Valley above the confluence of Joseph Stream, Fork Valley and the Front Country covering the moraine tarns and developed country. Six freshwater habitats, classified by size and physical character, were observed on or adjacent to the property. These habitats and the fish species recorded are described below and listed in Table Four.

Braided Rivers

These rivers have wide flat beds, braided channels and mostly-permanent surface water flow. Two braided rivers, Cass River and Fork Stream, flow along the boundaries of the property. The beds and margins of these rivers are sparsely vegetated; with wide expanses of stonefield and gravelfield, areas of cushionfield and mossfield, and smaller areas of tussockland, grassland and shrubland. Access to these riverbeds by stock, wild animals and vehicles is unrestricted. The

river channels are generally between 10 and 20 m wide, although smaller braids may be less than 3 m wide. They are more than 200 mm deep with occasional pools up to 700 mm deep. Braided river substrates are generally comprised of boulders, cobbles and gravel with sand in some areas.

Nine sites of braided river habitat were electro-fished, five in the Cass River and four in Fork Stream. Koaro were found at all five sites in the Cass River (Cass River above Memorial Hut, Alisa Stream, Cass River above Tin Hut, Cass River near upper floodgate fence and Tin Hut Stream), upland longjaw galaxias at three sites (Cass River above Tin Hut, Cass River near floodgate fence and Tin Hut Stream) and alpine galaxias at two sites (Cass River above Memorial Hut and Tin Hut Stream). In Fork Stream, alpine galaxias were found at all four sites (Fork Stream topmost survey, above Fraser Stream, just below Fraser Stream and near Mt Joseph) and upland longjaw galaxias at one site (Fork Stream near Mt Joseph). No koaro were found during this survey of Fork Stream. Unidentified galaxiid juveniles were observed at two sites in the Cass River, and an adult rainbow trout observed in a large pool in the Cass River below Waterfall Hut. Additional species previously recorded from Cass River (in the NZFFD) are upland bully and brown trout; additional species previously recorded from Fork Stream are bignose galaxias, Canterbury galaxias, rainbow trout and brown trout.

Macro-invertebrates observed in braided rivers were *Zelandobius* sp., *Olinga feredayi*, *Pycnocentria* sp., *Pycnocentroides* sp., *Hydropsychidae* sp., *Deleatidium* spp. and sandfly larvae (*Austrosimulium* sp.).

Permanent Streams

Permanent streams have year-round surface water flows and are confined to a single channel, or have wider slightly-braided channels but are separated from braided rivers by high waterfalls. Eight permanent streams or sections of streams of this habitat type were observed on the property: Joseph Stream, two tributaries of Joseph Stream, the lower parts of waterfall stream, the lower parts of the stream near Waterfall Hut, the middle reaches of Tin Hut Stream, the middle reaches of the two streams with waterfalls near Memorial Hut, the middle reaches of Ailsa Stream and the water-race near Pierce Pond. These streams generally flow through open stonefield in their upper reaches, tussockland, shrubland and occasionally low-forest in their mid reaches and short tussockland or grassland in their lower reaches. The lower reaches of Joseph Stream flow through developed pasture. All, except minor gorged sections of the streams are accessible to stock and wild animals. The permanent streams are between one and four metres wide, and between 100 and 800 mm deep, with occasional deeper pools, though flows are likely to vary seasonally. Permanent stream substrates range from bedrock to mud and silt, though most substrates are gravels and cobbles.

Seven permanent stream sites were electro-fished, all in the Cass Valley. Koaro were observed at five sites (“Waterfall Hut Stream”, “Stream from fans above Waterfall Hut”, Joseph Stream (mid section), Joseph Stream (upper section) and “Water Race near Pierce Pond”), upland bully at two sites (Joseph Stream (mid section) and “Water Race near Pierce Pond”), upland longjaw galaxias at two sites (“Waterfall Hut Stream” and “Stream from fans above Waterfall Hut”), alpine galaxias at the same two sites, longfin eel at one site (Joseph Stream (mid section)) and an unidentified juvenile salmoniid at one site (Joseph Stream – lower section). In addition, koaro were collected by hand-net in a small tributary of Joseph Stream, and more than 50 spawning rainbow trout were observed in a tributary of Lake Alexandrina. Also, Canterbury galaxias have been recorded from the mouth of Joseph Stream (NZFFD).

Macro-invertebrates observed in permanent streams were *Archichauliodes diversus*, *Aoteapsyche* sp., *Nesameletus* sp., *Deleatidium* spp., *Coloburiscus humeralis*, *Olinga feredayi*, *Pycnocentria* sp., snails (*Potamopyrgus* sp.), flatworms (Platyhelminthes) and Amphipods.

Ephemeral Streams

These are streams that do not have year-round surface flows. Ephemeral streams are present throughout higher-altitude parts of the property. They mostly have steep gradients, though occasionally have long reaches with gentler gradients, and flow through a range of vegetation types. All are accessible to stock and wild animals, except where access is occasionally limited by topography or winter snow. Ephemeral streams are generally up to one metre wide, normally smaller, and less than 100 mm deep (though most were dry at the time of survey). Stream substrates are varied, with bedrock, boulders, cobbles, gravels and silt present.

No ephemeral streams were surveyed for fish or macro-invertebrates as they were all dry, with only sub-surface flows (if any).

Springs and Seepages

These are spring or seepage fed waterways with year-round flows. On the property, they are common at the toe of the slopes in the Cass and Fork valleys, notably above the small hut in Fork Stream. The wetland near the Cass delta has a spring stream association. Surrounding vegetation is frequently tussockland and occasionally shrubland, grassland, sedgeland and cushionfield. Springs and seepages appear accessible to stock and wild animals, and vehicles. They are generally up to two metres wide and occasionally wider than three metres. They are between 100 and 500 mm deep and occasionally over one metre deep. Substrates are generally cobbles or gravel, and occasionally boulders and mud.

Nine spring and seepage streams were electro-fished, seven in Fork Valley and two in Cass Valley. In Fork Valley, alpine galaxias were observed at two sites (“Spring Tributary of Upper Fork Stream” and “Large Spring Tributary of Fork Stream”), bignose galaxias at one site (“Springfed Stream on Large Flat”) and upland longjaw galaxias at one site (“Large Spring Tributary of Fork Stream”). No fish were recorded at four sites. In Cass Valley, koaro were observed at two sites (“Spring opposite Ryder Hut” and “Cass Delta Wetland Stream”), and common bully, upland bully and brown trout observed at one site (“Cass Delta Wetland Stream”). Additional records (in the NZFFD) are koaro, Canterbury galaxias and brown trout in the Fork Valley, and alpine galaxias, upland longjaw galaxias, Canterbury galaxias and rainbow trout in the Cass Valley. Koaro, upland bully, common bully and brown trout were observed in a spring associated with the Cass River delta wetland, and the NZFFD has records of Canterbury galaxias and upland longjaw galaxias from this site.

Macro-invertebrates observed in springs and seepages were caddisflies (*Beraeoptera roria*, *Pycnocentria* sp., *Pycnocentroides aeris*, *Hydrobiosis* sp., and *Hydropsychidae* sp.), *Deleatidium* spp., *Nesameletus* sp., *Coloburiscus humeralis*, sandfly larvae (*Austrosimulium* sp.) and flatworms (Platyhelminthes).

Tarns

Most tarns on Glenmore Pastoral Lease are on the low-altitude moraines, notably the Glenmore Tarns moraine. Glenmore Tarns is a collection of tarn groupings including Tui, Stony, Hartley, Glenmore, Grebe, Cluster, Sunday and Boundary tarns. Of these Tui, Stony, Hartley, Grebe and Sunday are individual tarns, whereas the others are groupings of tarns falling under the common name. Tarns are also present on Mt Joseph and in high-altitude basins. The moraine tarns are surrounded by depleted short tussockland and grassland, with minor areas of crack willow trees, sedgeland and reedland. Margins of the moraine tarns are highly variable, with areas of boulderfield, stonefield and mud, depending on topography, slope, substrate size and fluctuating water levels. High altitude tarns are within tall tussockland (such as on Mt Joseph) or boulderfield and stonefield. All tarns are accessible to stock and wild animals, and most low-altitude tarns are accessible to vehicles. The tarns vary in size from a few hectares to less than 100 m². The largest (Tui, Stony, Grebe and Sunday tarns) are longer than 200 metres and wider than 50 metres. The tarns are generally deeper than one metre, sometimes over four metres deep, with mostly muddy substrates. A number of tarns are ephemeral, with no water for a substantial part of the year.

Eight tarn habitats were surveyed using gee-minnow traps. These were in Tui, Stony, Hartley and five unnamed tarns. Koaro was the most common fish species caught (in five tarns). Common bullies were caught in two tarns and upland bully in one tarn. A single unidentified bully was caught in one tarn. Large salmoniids were seen in Hartley Tarn and juveniles of either galaxiids or bullies were seen in one other tarn. Koaro and common bully have been previously recorded in Hartley Tarn (NZFFD).

Macro-invertebrates observed in tarns were dragonfly (*Anisoptera* spp.), damselfly larvae (*Zygoptera* spp.), *Triplectides* sp., water-boatmen (*Sigara* sp.) backswimmers (*Anisops* sp.), *Rhantus* sp. and snails (*Potamopyrgus* sp. and *Lymnaea* sp.).

Wetlands

Six wetlands were identified during the survey although it is likely additional wetlands are present, as not all moraine tarns were visited. Wetlands are present on the summit of Mt Joseph, beside the Cass River above the confluence of Joseph Stream, along Joseph Stream (Joseph Valley Wetland), on the Cass River delta, west of the homestead, and around the tarns north of Glenmore Tarns. Joseph Valley Wetland has been drained and the Cass River delta wetland lies mainly on adjoining land, although it is grazed by Glenmore Station. The wetlands support red tussockland, sedgeland, grassland and scattered shrubland. All are accessible to stock and/or wild animals, and most are accessible to vehicles. The wetlands vary in size, from more than 50 hectares to about four hectares. Wetland substrates are muddy, with some small patches of gravel.

No wetlands were directly surveyed for fish or macro-invertebrates. However, koaro, upland bully, common bully and brown trout were observed in a spring associated with the Cass River delta wetland, and the NZFFD has records of Canterbury galaxias and upland longjaw galaxias from this site. Longfin eel, koaro, upland bully and an unidentified salmoniid juvenile were observed in the stream associated with Joseph Valley Wetland. Koaro, upland longjaw galaxias, upland bully, rainbow trout and brown trout have been recorded from the wetland beside the Cass River (NZFFD).

Species Recorded

Nine fish species were recorded during this survey of Glenmore Pastoral Lease: longfin eel, koaro, bignose galaxias, alpine galaxias, upland longjaw galaxias, upland bully, common bully, rainbow trout and brown trout. A diverse range of aquatic macro-invertebrates including insect larvae and worms were found.

Table Four Fish species recorded from Glenmore Pastoral Lease, December 2005.

Fish species	Threat status	Distribution on property
alpine galaxias	Not threatened	Braided rivers; many permanent streams; some springs and seepages.
bignose galaxias	Gradual decline	Fork Stream.
brown trout	Introduced	Rivers and streams with easy access to the rivers.
common bully	Not threatened	Some permanent streams; tarns; springs and seepages.
koaro	Not threatened	Braided rivers; many permanent streams; springs and seepages.
longfin eel	Gradual decline	Joseph Stream (middle reaches) but likely to be more widespread.
rainbow trout	Introduced	Rivers and streams near Lake Tekapo and Lake Alexandrina.
upland bully	Not threatened	Some permanent streams; tarns; springs and seepages.
upland longjaw galaxias	Gradual decline	Some permanent streams; springs and seepages.

Significance of the Freshwater Fauna

Three threatened fish species are present on Glenmore Pastoral Lease: longfin eel (gradual decline), bignose galaxias (gradual decline) and upland longjaw galaxias (gradual decline). The presence of longfin eels is significant, as this species requires access to the sea to breed. Longfin eels in the upper Waitaki Catchment River must be at least 50 years old, since access for eels up the Waitaki River has been restricted since the completion of the first dam in 1954. Although the population of longfin eels is declining, it remains an important component of the upper Waitaki River system.

The presence of bignose galaxias in Fork Stream is also significant. This newly-recorded population emphasises the importance of the Waitaki catchment for this threatened species. It also meets Objective 9.1 (Action 1.1) of the Non-migratory Galaxiid Recovery Plan (Identify a minimum of 30 key non-migratory galaxiid sites for each species by June 2005). The Fork Stream population of bignose galaxias appears to comprise large numbers of fish (c. 190 individuals caught at one site, compared with 20-50 recorded in other surveys). Co-occurring with bignose galaxias in Fork Stream, although not at the same sites, are upland longjaw galaxias. These are sites outside the previous known distribution of this species. This population of upland longjaw galaxias is very significant in respect to location as this is the only known occurrence of upland longjaw galaxias in tributaries below the glacial lakes. These are also the only occurrences of bignose galaxias and upland longjaw galaxias co-occurring in the same tributaries, given that bignose galaxias are not found above the glacial lakes.

Other significant aquatic fauna communities are those that have greater diversity, particularly of native species. Six sites have three or more species occurring in them. Glenmore Pastoral Lease contains diverse freshwater fauna communities, with important populations of threatened species.

Most of the Waitaki River, including all of the catchments on this pastoral lease, is recognised in the Waters of National Importance (WONI) documentation (DOC – Chadderton *et al.* 2004). This recognition comes in two forms: 'Type I' and 'Type II'. Glenmore Pastoral Lease is split with the Cass River catchment, including part of the 'Glenmore Tarns' being 'Type I' and the remainder of the pastoral lease, mainly Fork Stream catchment being 'Type II'. 'Type I' implies that the majority of the waterway is nationally significant. The significance is because it is in the top ten sites by Natural Heritage Value score in its biogeographical unit, and it also contains populations of threatened birds. 'Type II' implies that the waterway contains special features of national significance. Only sections of 'Type II' catchments are of national importance. This significance is because it contains populations of threatened bird and fish communities.

Insert Aquatic values map

2.6.5 Invertebrates

The invertebrate fauna of the tarns on Glenmore Pastoral Lease has been studied by Burns *et al* (1984) and an invertebrate assessment of the adjacent Godley Peaks Pastoral Lease was undertaken by Morris (2003). Burns *et al* (1984) identified rare crustaceans in the tarns on the Glenmore Moraines and their study increased the known distribution and habitat range for several species. The threatened alpine grasshopper, *Brachaspis* 'Hunter Hills' (range restricted), was found on scree and rockfield at the southern end of Haszard Ridge on Godley Peaks Pastoral Lease (Morris, 2003). The small grasshopper, *Sigauss minutus* (gradual decline), was collected from Godley Peaks at its highest recorded altitude (1180 m) (Morris, 2003). Specimens have also been collected from the Cass River flats by the Godley Peaks Road (S.J. Morris, *pers. comm.*). A comprehensive survey of the distribution of *S. minutus* in the Tekapo region was carried out by Davis (1989) during which nearly 500 specimens were positively identified, indicating that the preferred habitat of this small grasshopper is on younger river terraces with a high proportion of native plant cover, especially cushion and mat species.

Invertebrates of Glenmore Pastoral Lease are described below for the main parts of the property surveyed.

Northern Mountains

This area encompasses the northern part of the property, on the Gammack Range and Joseph Ridge between Fork Stream and the Cass River. The extensive screes are prime habitat for the black butterflies *Percnodaimon merula* and *Erebiola butleri*, scree weta, and alpine grasshoppers including *Brachaspis* 'Hunter Hills' and *Sigauss australis*. Caterpillars of the large noctuid moth, *Graphania nullifera*, mine the flower stalks of speargrass. The speargrass weevil, *Lyperobius spedenii*, is common between 1700 and 1900 m. Another large weevil, *Inophloeus* cf. *sulcifer*, was found under rocks between 1800 and 2000 m. At slightly lower altitude on Joseph Ridge, the barren tops provide habitat for the uncommon ground beetle, *Holcaspis falcis*, a locally endemic darkling beetle, *Mimopeus impressifrons*, and a second species of *Inophloeus*. Remnants of original shrubland are present, especially on islands in stable scree slopes above both rivers. These shrublands support a rich diversity of specialist insect herbivores, including the weevils *Hoherius meinertzhageni* and *Peristoreus durus* on mountain ribbonwood, *Peristoreus fusconotatus* and *P. leucomus* on *Olearia* shrubs and *Rhynobelus aenescens* and *Rhinorhynchus rufulus* on mountain toatoa and snow totara. An undescribed "Bembidion" species was collected in the Cass River bed at Tin Hut Stream. This has only been collected once before, ('Lake Tekapo' in 1976) and is considered acutely threatened because only two specimens have ever been collected despite extensive collecting effort.

Mt Joseph

This area covers the summit and slopes of Mt Joseph. Mt Joseph dominates the southern end of the property and the surrounding country. It is largely tussock covered with some remnant shrubland in the gullies and a high altitude turf wetland on its north-east flank. The tussock ringlet, boulder copper, common copper and common blue butterflies were frequently seen flying over the tussock slopes. Alpine grasshoppers were also common. Even though the area had been recently burned, the specialist mountain ribbonwood weevils were found in a deep gully on the south face. On a stable scree, remnant original vegetation yielded host-specific weevils on native broom (*Peristoreus sudus*) and on *Olearia odorata*. From a similar vegetated scree slope two additional host-specific weevils were collected. A litter-dwelling rove beetle, *Nototorchus*

ferrugineus, collected from under a rock at the foot of the slope has not previously been recorded south of Nelson. Although the wetland areas high up on Mt Joseph appear to be in good condition, none of the typical beetle fauna such as ground beetles, rove beetles, scavenging water beetles and marsh beetles were collected, probably because of the cold, wet conditions at the time of the survey.

Cass River Flats, Joseph Valley and Fork Stream Flats

This area covers the Joseph Valley Wetland and developed areas alongside the Cass River and Fork Stream, much of which has been cultivated. The orange-and-black longhorn beetle, *Gastrosarus nigricollis*, was collected in Cass Valley. Otherwise only widespread and common beetle species were collected from this area, such as introduced and native ladybirds, flower beetles and manuka beetles.

Glenmore Tarns Moraine

The Glenmore Tarns moraine covers an area stretching from the Cass River to the southern boundary of the property. This area contains a large number of diverse morainic tarns and kettle-holes. Three species of predaceous diving beetles were collected from the tarns. Water boatmen, backswimmers, red damselflies and giant dragonflies were seen at the tarns. Eight species of ground beetle were collected under rocks beside the tarns and one ground beetle and two species of scavenging water beetles were found on bare muddy surfaces around the tarns. Although the vegetation between the tarns is modified, the acutely threatened small grasshopper *Sigauss cf. minutus* 'orange' and the chronically threatened *Sigauss cf. minutus* 'blue' (gradual decline) were collected from the steeper stony ridges where mat and cushion plants are prevalent. The chronically threatened *Sigauss cf. minutus* 'green' (gradual decline) was collected from grassy areas. Very small patches of native shrubs were beaten for insects and the specialist weevil, *Peristoreus sudus*, was collected from native broom at two sites. Also collected was a longhorn beetle (*Stenellipsis linearis*) and a dark beetle, *Hypocryphalus* species.

In Table five, the ground beetle fauna around three tarns heavily used by cattle at the time of our visit is compared with the fauna of four tarns that were protected from cattle use. Only one or two ground beetle species occurred around each of the cattle-utilised tarns, while tarns without cattle supported between three and six species. Together, the four cattle-free tarns supported eight native and one exotic ground beetle species while the three cattle-utilised tarns supported only two species in total. The three ground beetle species collected from Glenmore tarn 2 were from pitfall traps (the only tarn where traps were placed), and were running on bare mud. There were no rocks to provide shelter for ground beetles around the edges of this tarn. Both *Bembidion rotundicolle* and *Euthenarus brevicollis* are tolerant of a wide range of habitat types, and while most of the other beetles are also generalists, *Scopodes* are usually associated with native vegetation and *B. anchonoderum* usually occurs beside streams and bodies of clean water. *Notogonum feredayi* is also associated with native habitats while *N. submetallicum*, often regarded as introduced from Australia, occupies a wider range of habitats.

Table Five Ground beetles collected from the perimeters of tarns containing water at the time of survey.

Ground beetles	Tarns heavily used by cattle			Tarns protected from cattle use			
	Tui Tarn	Stony Tarn	Unnamed tarn	Glenmore tarn 1	Glenmore tarn 2	Glenmore tarn 3	Cluster Tarns
<i>Anisodactylus binotatus</i> *				×		×	×
<i>Bembidion anchonoderum</i>						×	
<i>Bembidion rotundicolle</i>	×			×		×	×
<i>Euthenarus brevicollis</i>	×	×	×	×			×
<i>Mecyclothorax rotundicollis</i>					×		
<i>Notogonum feredayi</i>				×	×	×	
<i>Notogonum submetallicum</i>				×		×	×
<i>Scopodes edwardsi</i>					×		
<i>Scopodes versicolor</i>				×			
Number of species	2	1	1	6	3	5	4
Number of native species	2	1	1	5	3	4	3
Total number of species	2			9			
Total number of native species	2			8			

* A European species, first recorded in Christchurch in 1938.

Cass River Outwash

This area covers the outwash flats immediately south of the Cass River delta. The small, eastern South Island tiger beetle, *Cicindela dunedensis*, was very common here. The area provides highly suitable habitat for the threatened small grasshoppers *Sigauf cf. minutus* ‘blue’ and *Sigauf cf. minutus* ‘green’, which have been collected previously from the roadside here (S.J. Morris, pers. comm.). A large number of juveniles of *Sigauf cf. minutus* were present during our survey.

Developed areas between Lakes Tekapo and Alexandrina

This area includes rolling country and terraces between Glenmore Tarns moraine and Lake Tekapo. Although the terraces above Lake Tekapo retain some remnant shrubs, these are insufficient to provide good native beetle habitat.

Species Recorded

During this entomological assessment of Glenmore Pastoral Lease, 128 species of insects were collected or observed from 57 sites across the property. All were identified at least to sub-family

and nearly all to genus or species. There were 103 species of Coleoptera (beetles) from 27 different families. Eight of the beetles were naturalised species. Eleven notable insect species were identified: four threatened species (all undescribed), one range-restricted species, one very sparse species, one species outside its currently known distribution, three large flightless weevil species vulnerable to mammalian predation, and one local endemic species. The small grasshopper, *Sigaus minutus*, is currently being revised because it has been shown to consist of a number of distinct forms (S.J. Morris, *pers. comm.*). Three of these (referred to here as *S. cf. minutus* ‘orange’, ‘blue’ and ‘green’) were collected.

Table Six Significant species recorded from Glenmore Pastoral Lease and the adjacent Cass River bed, December 2005.

Invertebrate species	Significance	Distribution on property
<i>Bembidion</i> new species	Undescribed species of a well-known genus, collected only once before, ‘Lake Tekapo’ (Lindroth, 1976).	Cass Valley.
<i>Brachaspis</i> ‘Hunter Hills’	Range restricted.	Gammack Range; Cass Valley; Fork Valley.
<i>Inophloeus cf. sulcifer</i>	Large flightless weevil vulnerable to mammalian predation.	Gammack Range.
<i>Inophloeus</i> sp.	Large flightless weevil vulnerable to mammalian predation.	Joseph Ridge.
<i>Lyperobius spedenii</i>	Large flightless weevil vulnerable to mammalian predation.	Gammack Range.
<i>Mimopeus impressifrons</i>	Local endemic (Mackenzie Basin, Central Otago only).	Joseph Ridge.
<i>Nototorchus ferrugineus</i>	Widespread in the North Island, not previously known south of Nelson (McCull, 1982).	Lower Fork Valley.
<i>Rhichobelus aenescens</i>	Widespread but very sparse, previously known from only 15 specimens from 12 localities (Kuschel, 2003); (5 new specimens collected on property).	Cass Valley, lower slopes.
<i>Sigaus cf. minutus</i> ‘orange’	Previously collected from only 4 sites, very few specimens known (S.J. Morris <i>pers. comm.</i>).	Glenmore Tarns Moraine.
<i>Sigaus cf. minutus</i> ‘blue’	Gradual decline; reproducing population.	Glenmore Tarns Moraine.
<i>Sigaus cf. minutus</i> ‘green’	Gradual decline; reproducing population.	Glenmore Tarns Moraine.
<i>Sigaus cf. minutus</i>	Gradual decline; reproducing population; only juveniles collected.	Cass River delta.

Significance of the Invertebrate Fauna

Almost the entire Glenmore Pastoral Lease provides important invertebrate habitat and retains highly significant communities of indigenous invertebrates. It supports at least four threatened species (all undescribed), one range-restricted species, one very sparse species, one species outside its currently known distribution, three large, flightless weevil species vulnerable to mammalian predation, and one local endemic species. Large parts of the property are identified as having significant entomological values.

Insert Invertebrate values map

2.6.6 Problem Animals

Introduced animal species that may have an important effect on indigenous plant or animal communities on the property, and that can be controlled or contained, are listed and discussed below. Other ubiquitous naturalised species for which containment or control are probably impractical (such as rodents) are not discussed here.

Brush-tail possum

Possum sign was observed in rockland habitats throughout lower altitude parts of the property. Possums are browsers of palatable indigenous plants and predators of birds, lizards and invertebrates.

Rabbits and hares

Hares were observed throughout the property, and rabbits were observed at lower-altitudes.

Cats, mustelids and hedgehogs

Scats (droppings) of stoats, cats and hedgehogs were observed throughout the property. These animals are predators of indigenous fauna.

Himalayan thar, red deer and chamois

Thar were observed on higher-altitude parts of the property. No other large wild animals were seen on the property. However red deer and chamois are likely to be present.

2.7 HISTORIC

2.7.1 European Heritage Values

The area covered by Glenmore Pastoral Lease was first taken up for grazing by Joseph Beswick shortly after exploration of the area west of Lake Tekapo by E G Stericker and G W Hall in 1858. Financial difficulties prompted sale of the property in 1866 to John Hall, who ran the property in conjunction with his Balmoral Run, forming a property extending from the Cass River to the Tasman River. The lower-altitude part of present-day Glenmore was called the 'home run' or 'the Tekapo', and the whole Glenmore Run appears to have been known as Castle Station. John Hall sold Glenmore Run to Alfred Cox in 1869 and the property became known as Castle Hall. In 1873 Castle Hall was sold to John McGregor. In 1873 and 1874 new leases were taken out in the upper Cass Valley. In 1875 the runs of Mistake Station were adjusted and McGregor got all the runs on the western side of the river, making the Cass River the boundary of the property. At this time the property included Mt John. McGregor's loan company took over Glenmore Run in 1891 and ran it in conjunction with Balmoral (Pinney, 1971).

In June and July 1895, a succession of snow storms swept over the country causing severe damage and stock losses. Stock losses, reported in sworn evidence to the Land Board, were 40,000 sheep from a flock of 45,000 on Glenmore and Balmoral runs (Andersen, 1916). In 1910 the Glenmore Homestead was reported as deserted and in 1922 Mt John was divided from the property. Glenmore Station became Run 79 and was leased to Miss Roma Hope. In 1914 the property was transferred to Herbert Nalder and, at his death, it passed to his daughter, the wife of George Murray. In 1927 the run passed to Gerald Murray and it has remained in the Murray family since that time (Pinney, 1971).

There are four huts situated on the pastoral lease, three in the Cass River valley (Memorial Hut, Tin Hut and Waterfall Hut) and one in Fork Stream (Fork Stream Hut). An assessment of the huts has not been completed. Memorial Hut may have historic significance as may the other huts within the local context of pastoral activities.

Significance of Historic Resources

No significant historic resources are known from the property. An assessment of the huts on the property has yet to be completed.

2.8 PUBLIC RECREATION

2.8.1 Physical Characteristics

The property can be divided into three main recreation units:

Mountains

This recreation unit covers the higher mountains and valley-heads that dominate the northern part of the property. It comprises high rugged mountain summits and ridges, steep valley sides and the upper parts of the Cass and Fork valleys. The terrain in the southern part of this area in the

vicinity of Mt Joseph and the lower valleys is gentler, though still relatively mountainous. It is a highly natural recreation setting that is contiguous with extensive areas of high mountains and remote valleys that form the central Southern Alps. There are four huts within this unit, three in the Cass River valley and one in Fork Stream. A vehicle track exists in the Cass River. The setting for this unit is remote.

Front Country

This recreation unit covers Joseph Valley, Glenmore Tarns moraine and the lower Cass Valley. It covers the lower-altitude country of gentler relief. The influence of pastoral farming, including exotic trees, roads, fences and buildings, are evident. There are no recreational structures. The setting for this unit is predominantly cultural due to the influence of farming.

Lakeshore and Roadside

This recreation unit covers the country of relatively gentle relief alongside Godley Peaks Road and between the road and the shore of Lake Tekapo. It comprises rolling moraine hills and flat outwash surfaces that provide a scenic backdrop to people travelling on Godley Peaks Road and Lake Tekapo. The vegetation of this area is substantially modified. There are no recreational structures. The setting for this unit is predominantly cultural due to the influence of farming.

2.8.2 Legal Access

Roads

One legal formed road, Godley Peaks Road, crosses the low-altitude eastern part of the property. This provides access to the property and to Godley Peaks Station and the Godley Valley beyond.

Marginal Strips

Existing marginal strips are present along the shores of Lake Tekapo and Lake Alexandrina at the eastern and southern boundaries of the property. Marginal strips are also present along the Cass River, on the east and northeast property boundaries, and along Fork Stream on the west and southwest property boundaries.

Adjoining Public Conservation Land

Public access is legally available in the Godley Peaks Conservation Area across the Cass River northeast of the property, Lake Alexandrina Scenic Reserve to the south, Braemar Conservation Area to the west and from the Liebig Range/Upper Jollie/Cass Conservation Area north of the property.

2.8.3 Activities

Recreation activities undertaken in the mountainous parts of the property are ski-touring/ski-mountaineering, hunting, climbing and tramping. Entries in the book at Memorial Hut indicate that the upper Cass and Ailsa valleys are utilised by ski-touring parties. Hunters are seeking thar and chamois, and utilising all parts of the upper valley. Climbing parties are recorded ascending Mt Lucia and crossing Kehua Pass. A challenging alpine tramping route traverses the area,

crossing from the Godley Valley via Rankin Pass, through the upper Cass River, then into the Jollie Valley via Ailsa Stream and Jollie Saddle. The head of the Cass River as far as Memorial Hut, is readily accessible by four-wheel-drive vehicle, providing relatively easy access to the rugged Liebig Range. The Cass River is also suitable for horse-riding and mountain-biking.

Recreation activities undertaken on or suitable for lower-altitude parts of the property are scenery-viewing, bird-watching, walking, mountain-biking, horse-riding and (in places) four-wheel-drive use. The extent to which these activities occur on the property at present is unclear. However, the property forms a backdrop for these activities (and other activities such as boating, fishing and picnicking) that occur on adjoining areas, notably Lake Tekapo, Lake Alexandrina and along the Godley Peaks Road.

Significance of Recreation

Glenmore Pastoral Lease provides a regionally important setting for recreation. Mountainous backcountry parts of the property are an integral part of the mountain country east of Mount Cook/Aoraki National Park and provide very good opportunities for ski-mountaineering, climbing, hunting and alpine tramping. Lower-altitude parts of the property are clearly visible from Lake Tekapo, are relatively accessible, contain spectacular landforms and scenery, and provide potential opportunities for a range of recreational activities. The property offers good opportunities for the development of recreation facilities, such as walking tracks and picnic or camping areas associated with Lake Tekapo, Lake Alexandrina, Lake Murray, the Cass Valley, Fork Stream, Mt Joseph and the Glenmore Tarns moraine.

PART 3 OTHER RELEVANT MATTERS AND PLANS

3.1 CONSULTATION

Information-gathering meetings were held with representatives of non-governmental organisations (NGOs) at Christchurch on 5th September 2005 and at Geraldine on 6th September 2005. Comments made at those meetings are summarised below.

- Whole-property protection is the most appropriate outcome (no freeholding should be permitted), due to its proximity to Mount Cook National Park, its high landscape values, its proximity to Lake Tekapo, the very high natural values of Glenmore Tarns, and the lack of controls on subdivision.
- The Army Training Area should be protected, especially the area adjacent to Glenmore Tarns.
- All land north of the Army Training Area should become conservation land.
- The Cass River should be protected from stock trespass.
- Glenmore Tarns have especially important natural values, including black stilt habitat, and should be protected.
- The property is effectively an enclave within conservation land; the whole property should be protected.
- The protection of water quality on the property is an important consideration, as it provides catchment areas for Lake Alexandrina, Glenmore Tarns and Lake Tekapo.
- Joseph Stream has very important fishery values.
- Lake shores and the immediate catchments of the lakes should be protected; they are presently affected by top-dressing.
- Protection of landscape values around Lake Tekapo is especially important; further subdivision of lake shore property should be prevented.
- There are ongoing difficulties with four-wheel-drive access up the Cass River; the property has great potential for vehicle access.
- Vehicle access along the track up the Cass River should be protected by a legal easement.
- There are a number of huts on the property, some historic, which are well-maintained by the lessee; access is presently available for a fee and huts can be booked for recreational use.
- Huts in the Cass River appear to be on Crown Land, not pastoral lease; huts (including those on the property) should become public huts, available for public use.
- Access to Mailbox Inlet/Mailbox Lagoon should be provided by legal easement along the existing road.
- The hills east of Lake Alexandrina would provide a great route for a walking track.
- Legal foot access along the shore of Lake Tekapo should be provided.

3.2 DISTRICT PLANS

Glenmore Pastoral Lease lies within the Rural Zone of the Mackenzie District.

Sites of Natural Significance listed in the Mackenzie District Plan that lie on or adjacent to the property are:

- 56 Lake Tekapo (on the eastern boundary of the property)
- 58 Lake Alexandrina (on the southern boundary of the property)
- 59 Glenmore Tarns (covering the southern part of the Glenmore Tarns moraine and Tui and Stony tarns)
- 60 Lake Murray (on the property, beside Godley Peaks Road)
- 61 Mailbox Enclosure (on the eastern boundary of the property)
- 66 Cass River (on the northeast boundary of the property)

3.3 CONSERVATION MANAGEMENT STRATEGIES

Glenmore Pastoral Lease lies within the Waitaki Place Unit of the Canterbury Conservancy. Relevant priority objectives for this unit are listed in the CMS (Department of Conservation, 2000) as:

- To identify, maintain and seek to enhance the natural landscapes and natural landscape values of the Waitaki Unit.
- To identify the significant indigenous vegetation and threatened species of the Waitaki Unit.
- To use a range of effective methods to protect the indigenous biodiversity of the Waitaki Unit.
- To protect and enhance the viability of priority threatened species populations and their habitat(s) in the Waitaki Unit.
- To improve the range of viable riparian habitats for indigenous species in the Mackenzie Basin.
- To encourage landholders to cooperate in protecting braided river systems.
- To prevent the loss of natural and landscape values from wilding trees on land managed by the Department.
- To liaise with land managers and regulatory agencies to control and contain wilding trees.
- To reduce and maintain rabbit and thar densities to levels that ensure their adverse effects on natural values are minimised.
- To provide new recreational facilities and opportunities by the Department and other organisations and concessionaires where natural and historic values are not compromised.
- To liaise with adjacent landholders to resolve conflicts over access for recreation to land managed by the Department.
- To increase public awareness of the natural and historic values of the Waitaki.

3.4 NEW ZEALAND BIODIVERSITY STRATEGY

The New Zealand Government is a signatory to the Convention on Biological Diversity. In February 2000, Government released the New Zealand Biodiversity Strategy. This strategy is a blueprint for managing the country's diversity of species and habitats. It sets a number of goals to achieve this aim. Of particular relevance to tenure review is Goal 3, which states:

- Maintain and restore a full range of remaining natural habitats and ecosystems to a healthy functioning state, enhance critically scarce habitats, and sustain the more modified systems in production and urban environments, and do what is necessary to:
- Maintain and restore viable populations of all indigenous species across their natural range and maintain their genetic diversity.

PART 4 ATTACHMENTS

4.1 ADDITIONAL INFORMATION

4.1.1 Scientific Names of Species

Plant Species referred to in text

Species names follow those in the published volumes of New Zealand Flora and the name changes listed in A Checklist of Indigenous Vascular Plants of New Zealand, 10th Revision (*Unpublished Document*, S. Courtney, Department of Conservation, Nelson). Maori names are included for taonga species listed in Schedule 97 of the Ngai Tahu Claims Settlement Act 1998. Naturalised species are indicated by an asterisk (*).

<u>Common name</u>	<u>Scientific name</u>
alpine fescue tussock	<i>Festuca matthewsii</i>
bidibid	<i>Acaena caesiiglauca</i>
blue tussock	<i>Poa colensoi</i>
blue wheatgrass	<i>Elymus solandri</i>
bog pine	<i>Halocarpus bidwillii</i>
bog rush	<i>Schoenus pauciflorus</i>
bristle tussock	<i>Rytidosperma setifolium</i>
broad-leaved snow-tussock	<i>Chionochloa flavescens</i>
browntop*	<i>Agrostis capillaris</i>
bush snowberry	<i>Gaultheria antipoda</i>
Californian thistle*	<i>Cirsium arvense</i>
catsear*	<i>Hypochoeris radicata</i>
comb sedge	<i>Oreobolus pectinatus</i>
coral broom	<i>Carmichaelia crassicaule</i>
crack willow*	<i>Salix fragilis</i>
creeping pohuehue	<i>Muehlenbeckia axillaris</i>
curly snow tussock	<i>Chionochloa crassiuscula</i> ssp. <i>torta</i>
dainty daisy	<i>Celmisia gracilentia</i>
Douglas fir*	<i>Pseudotsuga menziesii</i>
downy brome*	<i>Bromus tectorum</i>
dwarf inaka	<i>Dracophyllum pronum</i>
false speargrass/taramea	<i>Celmisia lyallii</i>
fescue tussock	<i>Festuca novae-zelandiae</i>
floating sweet grass*	<i>Glyceria fluitans</i>
golden speargrass/taramea	<i>Aciphylla aurea</i>
grassland buttercup	<i>Ranunculus multiscapus</i>
harebell	<i>Wahlenbergia albomarginata</i>
inaka	<i>Dracophyllum uniflorum</i>
jointed rush*	<i>Juncus articulatus</i>
king devil hawkweed*	<i>Hieracium praealtum</i>

larch*	<i>Larix decidua</i>
manuka	<i>Leptospermum scoparium</i>
marsh foxtail*	<i>Alopecurus geniculatus</i>
matagouri	<i>Discaria toumatou</i>
midribbed snow-tussock	<i>Chionochloa pallens</i>
mountain heath	<i>Leucopogon suaveolens</i>
mountain ribbonwood/houhi	<i>Hoheria lyallii</i>
mountain toatoa	<i>Phyllocladus alpinus</i>
mountain totara	<i>Podocarpus hallii</i>
mountain wineberry	<i>Aristotelia fruticosa</i>
mouse-ear chickweed*	<i>Cerastium fontanum</i>
mouse-ear hawkweed*	<i>Hieracium pilosella</i>
narrow-leaved snow-tussock	<i>Chionochloa rigida</i>
native broom	<i>Carmichaelia australis</i>
native violet	<i>Viola cunninghamii</i>
onion-leaved orchid	<i>Prasophyllum colensoi</i>
oval sedge*	<i>Carex ovalis</i>
patotara	<i>Leucopogon fraseri</i>
porcupine shrub	<i>Melicytus alpinus</i>
prickly shield fern	<i>Polystichum vestitum</i>
pukio	<i>Carex secta</i>
raupo	<i>Typha orientalis</i>
rautahi	<i>Carex coriacea</i>
red tussock	<i>Chionochloa rubra</i>
rowan*	<i>Sorbus aucuparia</i>
Russell lupin*	<i>Lupinus polyphyllus</i>
scabweed	<i>Raoulia australis</i>
Scotch thistle*	<i>Cirsium vulgare</i>
scrub pohuehue	<i>Muehlenbeckia complexa</i>
sheep's sorrel*	<i>Rumex acetosella</i>
silver tussock/wi	<i>Poa cita</i>
silvery hair grass*	<i>Aira caryophyllea</i>
slim snow-tussock	<i>Chionochloa macra</i>
snowberry	<i>Gaultheria depressa</i>
snow-patch grass	<i>Chionochloa oreophila</i>
snow totara	<i>Podocarpus nivalis</i>
soft rush*	<i>Juncus effusus</i>
sphagnum moss	<i>Sphagnum sp.</i>
storksbill*	<i>Erodium cicutarium</i>
suckling clover*	<i>Trifolium dubium</i>
sundew	<i>Drosera arcturi</i>
sweet brier*	<i>Rosa rubiginosa</i>
sweet vernal*	<i>Anthoxanthum odoratum</i>
sycamore*	<i>Acer pseudoplatanus</i>
tauhinu	<i>Ozothamnus leptophyllus</i>
thousand-leaved fern	<i>Hypolepis millefolium</i>
toad rush*	<i>Juncus bufonius</i>
vulpia hair grass*	<i>Vulpia bromoides</i>
water forget-me-not*	<i>Myosotis laxa ssp. caespitosa</i>
white clover*	<i>Trifolium repens</i>
white fuzzweed	<i>Vittadinia australis</i>

willow*	<i>Salix</i> sp.
wire moss	.....	<i>Polytrichum juniperinum</i>
woolly head	.....	<i>Craspedia lanata</i>
woolly moss	.....	<i>Racomitrium pruinosum</i>
woolly mullein*	<i>Verbascum thapsus</i>
yellow caltha	.....	<i>Psychrophila novae-zelandiae</i>
yellow tree-daisy	.....	<i>Brachyglottis cassinioides</i>
Yorkshire fog*	<i>Holcus lanatus</i>

Animal Species referred to in text

Species names follow King (1990) for mammals, the June 2003 version of the New Zealand Recognized Bird Names list (compiled by C.J.R. Robertson and D.G. Medway for the Ornithological Society of New Zealand Inc.) for birds, Whitaker (1998) for lizards and McDowall (2000) for fish. Maori names are included for taonga species listed in Schedule 97 of the Ngai Tahu Claims Settlement Act 1998. Naturalised species are indicated by an asterisk (*).

<u>Common name</u>	<u>Scientific name</u>
alpine galaxias	<i>Galaxias paucispondylus</i>
arctic tern	<i>Sterna paradisaea</i>
Australasian bittern	<i>Botaurus poiciloptilis</i>
Australasian crested grebe/kamana	<i>Podiceps cristatus australis</i>
Australasian harrier/kahu	<i>Circus approximans</i>
Australasian pied stilt/poaka	<i>Himantopus himantopus leucocephalus</i>
Australian coot	<i>Fulica atra australis</i>
Australian magpie*	<i>Gymnorhina tibicen</i>
banded dotterel	<i>Charadrius bicinctus bicinctus</i>
bar-tailed godwit	<i>Limosa lapponica</i>
bat	.....see South Island long-tailed bat
bignose galaxias	<i>Galaxias macronasus</i>
black-billed gull	<i>Larus bulleri</i>
blackbird*	<i>Turdus merula</i>
black-fronted tern	<i>Sterna albobriata</i>
black shag/koau	<i>Phalacrocorax carbo novaehollandiae</i>
black stilt/kaki	<i>Himantopus novaeseelandiae</i>
black swan	<i>Cygnus atratus</i>
brown hare*	<i>Lepus europaeus occidentalis</i>
brown trout*	<i>Salmo trutta</i>
brushtail possum*	<i>Trichosurus vulpecula</i>
California quail*	<i>Callipepla californica brunnescens</i>
Canada goose*	<i>Branta Canadensis maxima</i>
Canterbury galaxias	<i>Galaxias vulgaris</i>
Caspian tern	<i>Sterna caspia</i>
cat*	.....see house cat
chaffinch*	<i>Fringilla coelebs</i>
chamois*	<i>Rupicapra rupicapra rupicapra</i>
chestnut-breasted shelduck	<i>Tadorna tadornoides</i>
chukor*	<i>Alectoris chukar</i>
common bully	<i>Gobiomorphus cotidianus</i>
common skink	<i>Oligosoma nigriplantare polychroma</i>
dunnock*	<i>Prunella modularis</i>
eastern curlew	<i>Numenius madagascariensis</i>
European hedgehog*	<i>Erinaceus europaeus occidentalis</i>
European rabbit*	<i>Oryctolagus cuniculus cuniculus</i>
feral cat* (house cat)	<i>Felis catus</i>
goldfinch*	<i>Carduelis carduelis</i>
greenfinch*	<i>Carduelis chloris</i>
grey duck/parera	<i>Anas superciliosa superciliosa</i>
grey warbler/riroriro	<i>Gerygone igata</i>
hare*	.....see brown hare

hedgehog*	.....	see European hedgehog
Himalayan thar*	<i>Hemitragus jemlahicus</i>
house cat*	<i>Felis catus</i>
house sparrow*	<i>Passer domesticus</i>
Japanese snipe	.....	<i>Gallinago hardwickii</i>
jewelled gecko	.....	<i>Naultinus gemmeus</i>
kea	.....	<i>Nestor notabilis</i>
koaro	.....	<i>Galaxias brevipinnis</i>
lesser knot	.....	<i>Calidris canutus</i>
little shag	.....	<i>Phalacrocorax melanoleucos brevirostris</i>
longfin eel/tuna	.....	<i>Anguilla dieffenbachii</i>
long-tailed cuckoo/koekoea	.....	<i>Eudynamys taitensis</i>
long-toed skink	.....	<i>Oligosoma longipes</i>
McCann's skink	.....	<i>Oligosoma maccanni</i>
mallard*	<i>Anas platyrhynchos platyrhynchos</i>
marsh crake	.....	<i>Porzana pusilla affinis</i>
morepork/ruru koukou	.....	<i>Ninox novaeseelandiae novaeseelandiae</i>
New Zealand falcon/karearea	.....	<i>Falco novaeseelandiae</i>
New Zealand pipit/pihoihoi	.....	<i>Anthus novaeseelandiae novaeseelandiae</i>
New Zealand scaup	.....	<i>Aythya novaeseelandiae</i>
New Zealand shoveler/kuruwhengu	.....	<i>Anas rhynchotis variegata</i>
paradise shelduck/putakitaki	.....	<i>Tadorna variegata</i>
pectoral sandpiper	.....	<i>Calidris melanotos</i>
possum*	.....	see brushtail possum
pukeko/pakura	.....	<i>Porphyrio porphyrio melanotos</i>
rabbit*	.....	see European rabbit
rainbow trout*	<i>Oncorhynchus mykiss</i>
red deer*	<i>Cervus elaphus scoticus</i>
redpoll*	<i>Carduelis flammea</i>
rock wren	.....	<i>Xenicus gilviventris</i>
scree skink	.....	<i>Oligosoma waimatense</i>
scree weta	.....	<i>Deinacrida connectens</i>
shining cuckoo/pipiwharau	.....	<i>Chrysococcyx lucidus lucidus</i>
silveryeye	.....	<i>Zosterops lateralis lateralis</i>
skylark*	<i>Alauda arvensis</i>
song thrush*	<i>Turdus philomelos</i>
Southern Alps gecko	.....	<i>Hoplodactylus</i> aff. <i>maculatus</i> "Southern Alps"
southern black-backed gull/karoro	.....	<i>Larus dominicanus dominicanus</i>
South Island fantail/piwakawaka	.....	<i>Rhipidura fuliginosa fuliginosa</i>
South Island long-tailed bat	.....	<i>Chalinolobus tuberculatus</i>
South Island pied oystercatcher	.....	<i>Haematopus ostralegus finschi</i>
South Island rifleman/titipounamu	.....	<i>Acanthisitta chloris chloris</i>
South Island tomtit/miromiro	.....	<i>Petroica macrocephala macrocephala</i>
spotted skink	.....	<i>Oligosoma lineocellatum</i>
spur-winged plover	.....	<i>Vanellus miles novaehollandiae</i>
starling*	<i>Sturnus vulgaris</i>
stoat*	<i>Mustela erminea</i>
thar*	.....	see Himalayan thar
tui	.....	<i>Prosthemadera novaeseelandiae</i>
	.....	<i>novaeseelandiae</i>
turnstone	.....	<i>Arenaria interpres</i>

upland bully	<i>Gobiomorphus breviceps</i>
welcome swallow	<i>Hirundo tahitica neoxena</i>
white-faced heron	<i>Ardea novaehollandiae novaehollandiae</i>
white-tailed deer*	<i>Odocoileus virginianus borealis</i>
white-winged black tern	<i>Chlidonias leucopterus</i>
wrybill	<i>Anarhynchus frontalis</i>
yellowhammer*	<i>Emberiza cintrenella</i>

4.1.2 References Cited

Andersen, J.C. 1916. *Jubilee History of South Canterbury*. Whitcombe & Tombs Ltd. 775p.

Boffa Miskell and Lucas Associates. 1993. *Canterbury Regional Landscape Study*, Volumes I & II.

Budgeon, L.A. 1977. Aspects of the biology of black stilts *Himantopus novaezealandiae* (Gould) in the upper Waitaki Basin. *Unpublished BSc (Hons) thesis*. University of Canterbury, Christchurch.

Bull, P.C.; Gaze, P.D.; Robertson, C.J.R. 1985. *The atlas of bird distribution in New Zealand*. OSNZ, Wellington.

Burns, C.W.; Butler, M.I.; Cuttance, P.M. 1984. Invertebrates, macroalgae, and chemical features in morainic ponds near Lakes Tekapo and Ohau, including new distribution records of Crustacea. *New Zealand Journal of Marine and Freshwater Research* 18: 197–210.

Davis, C.M. 1989. A survey of *Sigauss minutus*. *Unpublished Report No. 252*. Department of Lands and Survey, Christchurch. 20 p.

de Lange, P.J.; Norton, D.A.; Heenan, P.B.; Courtney, S.P.; Molloy, B.P.J.; Ogle, C.C.; Rance, B.D.; Johnson, P.N.; Hitchmough, R. 2004. Threatened and uncommon plants of New Zealand. *NZ Journal of Botany* 42: 45-76.

Department of Conservation, 1993. Himalayan thar control plan. *Canterbury Conservancy Conservation Management Series No. 3*. Department of Conservation, Christchurch. 68p.

Department of Conservation, 1994. Recreation Strategy for Canterbury Conservancy. *Canterbury Conservancy Conservation Management Planning Series No. 7*. Department of Conservation, Christchurch. 102p.

Department of Conservation, 2000. Canterbury Conservation Management Strategy, *Canterbury Conservation Management Planning Series No. 10*. Department of Conservation, Christchurch. 320p.

Espie, P.R.; Hunt, J.E.; Butts, C.A.; Cooper, P.J.; Harrington, W.M.A. 1984. *Mackenzie Ecological Region, New Zealand Protected Natural Areas Programme*. Department of Lands and Survey, Wellington.

Gair, H.S. 1967. Sheet 20 Mt Cook. *Geological Map of New Zealand 1:250,000*. Department of Scientific and Industrial Research, Wellington.

Hitchmough, R. (compiler) 2002. New Zealand threat classification system lists. *Threatened Species Occasional Publication 23*. Department of Conservation, Wellington.

Hitchmough, R.; Bull, L. in press. New Zealand threat classification system lists 2005. *Threatened Species Occasional Publication*. Department of Conservation, Wellington, New Zealand.

- Jarman, L. 1987.** Wildlife and sites of special wildlife interest in the upper Waitaki and adjacent areas. *NZ Wildlife Service Occasional Publication No. 9*. NZ Wildlife Service, Department of Internal Affairs, Wellington.
- Johnson, P.N. 1986.** Lake Tekapo wetlands: botanical report. *Unpublished report*. DSIR Botany Division. 7p.
- Johnson, P.N. 1991.** Tekapo kettleholes: botanical report. *Unpublished report*. DSIR Land Resources. 12p.
- Johnson, P.N. 1992.** Canterbury lakes and kettleholes, botanical report. *Unpublished report*. Landcare Research. 20p.
- Johnson, P.N. 1994.** Glenmore moraines, Tekapo botanical report. *Contract Report LC 9394/76*. Landcare Research, Dunedin.
- Keedwell, R.J. 2004.** Use of population viability analysis in conservation management in New Zealand. *Science for Conservation 243*, Department of Conservation, Wellington.
- Keedwell, R.J. 2005.** Breeding biology of black-fronted terns (*Sterna albostrata*) and the effects of predation. *Emu 105*: 39-47.
- Keedwell, R.J.; Sanders, M.D. 2002.** Nest monitoring and predator visitation at nest of banded dotterels. *Condor 104*: 899-902.
- King, C.M. (editor). 1990.** *The Handbook of New Zealand Mammals*. Oxford University Press, Auckland. 600p.
- Kuschel, G. 2003.** *Nemonychidae, Belidae, Brentidae (Insecta: Coleoptera: Curculionoidea)*. *Fauna of New Zealand 45*. Manaaki Whenua Press, Lincoln. 95p.
- Leathwick, J.; Wilson, G.; Rutledge, D.; Wardle, P.; Morgan, F.; Johnston, K.; McLeod, M.; Kirkpatrick, R. 2003.** *Land Environments of New Zealand*. David Bateman, Auckland. 184p.
- Lindroth, C.H. 1976.** Genus *Bembidion* Latreille (Coleoptera: Carabidae) in New Zealand: a revision. *New Zealand Journal of Zoology 3*: 161–198.
- McCull, H.P. 1982.** Osoriinae (Insecta: Coleoptera: Staphylinidae). *Fauna of New Zealand 2*: 89p.
- McDowall, R.M. 2000.** *The Reed Field Guide to New Zealand Freshwater Fish*. Reed Publishing (NZ) Ltd., Auckland.
- McEwen, W.M. (editor) 1987.** Ecological regions and districts of New Zealand, third revised edition (Sheet 4). *New Zealand Biological Resources Centre Publication No.5*. Department of Conservation, Wellington, 1987.
- McGlone, M.S. 2001.** The origin of the indigenous grasslands of south eastern South Island in relation to pre-human woody ecosystems. *NZ Journal of Ecology 25*: 1-15.

- Maloney, R.F.; Rebergen, A.L.; Nilsson, R.J.; Wells, N.J. 1997.** Bird density and diversity in braided river beds in the Upper Waitaki Basin, South Island, New Zealand. *Notornis* 44: 219-232.
- Maloney, R.F.; Murray, 2002.** *Kaki (Black Stilt) Recovery Plan 2001-2011*. Department of Conservation Biodiversity Recovery Unit, Wellington.
- Morris, S.J. 2003.** Godley Peaks Pastoral Lease Invertebrate Assessment. *Unpublished Report* 11p.
- O'Donnell, C.F.J. 2000.** The significance of river and open water habitats for indigenous birds in Canterbury, New Zealand. Environment Canterbury *Unpublished Report U00/37*. Environment Canterbury, Christchurch.
- O'Donnell, C.F.J.; Moore, S.M. 1983.** The wildlife and conservation of braided river systems in Canterbury. *Fauna Unit Survey Report No. 33*, New Zealand Wildlife Service, Christchurch.
- Pierce, R.J. 1982.** A comparative ecological study of pied and black stilts in South Canterbury. *Unpublished PhD thesis*, University of Otago, Dunedin.
- Pierce, R.J. 1983.** The charadriiformes of a high country river valley. *Notornis* 30: 169-185.
- Pierce, R.J. 1986.** Foraging responses of stilts (*Himantopus* spp.) to changes in behaviour and abundance of their riverbed prey. *NZ Journal of Marine and Freshwater Research* 20: 17-28.
- Pierce, R.J. 1999.** Regional patterns of migration in the banded dotterel *Charadrius bicinctus*. *Notornis* 46: 101-122.
- Pinney, R. 1971.** *Early South Canterbury Runs*. A.H. & A.W. Reed Ltd. 330p.
- Rogers, G.; Walker, S.; Lee, B. 2005.** The role of disturbance in dryland New Zealand: past and present. *Science for Conservation* 258. Department of Conservation, Wellington.
- Sagar, P.M.; Barker, R.J.; Geddes, D. 2002.** Survival of breeding Finsch's oystercatchers (*Haematopus finschi*) on farmland in Canterbury, New Zealand. *Notornis* 49: 233-240.
- Sedgeley, J. 2002a.** Assessment of the fauna values (birds and lizards) of Godley Peaks Pastoral Lease. *Unpublished Report*. Department of Conservation, Christchurch.
- Sedgeley, J. 2002b.** Assessment of the fauna values (birds and lizards) of Sawdon Pastoral Lease. *Unpublished Report*. Department of Conservation, Christchurch.
- Suggate, R.P. (Editor). 1978.** *The Geology of New Zealand, Volume II*. NZ Geological Survey. Department of Scientific and Industrial Research, Wellington.
- Ward, C.M. 1986.** Priority areas in the Mackenzie Ecological Region. *Unpublished Report for PASAC*, Department of Lands and Survey.
- Whitaker, T. 1998.** Mackenzie Basin lizards: a field key. *Unpublished Report*. Department of Conservation, Twizel. 12p.

Wilson, H.D. 1978. *Wild Plants of Mount Cook National Park.* Field Guide Publications, Christchurch. 294p.