

## **Crown Pastoral Land Tenure Review**

**Lease name:**

**MT CECIL - Pt 078**

**MT STUDHOLME - Pt 079**

**KAIWARUA - Pt 114**

**Public Submissions  
- Part 1**

These submissions were received as a result of the public advertising of the Preliminary Proposal for Tenure Review.

**May**

**06**

17 original 16/01/2006

Submission # 1

10 Smacks Close  
Papanui  
Christchurch 5

Opus International  
Re : Mt Cecil, Studholme, Kaiwarua, leases

12 January 2006  
Dear Sir,

I realise that it is easier to follow an existing fence line and therefore save on the cost of erecting another but when the result is the loss of land for future generations I would prefer to spend the extra money now.

A natural boundary for these properties is obviously the top of The Hunters Hills and the fence line and boundary should run from s-d-u along the hill-tops, than down through the valley and across several streams.

It is stated that protection for the Otaio river will enhance the water quality and the area has high landscape values, which is true, so the entire valley and headwaters should be included in Crown ownership.

Yes, the land could be farmed but from a visual point of view, and the fact that it is the headwaters of the Otaio river , with high recreational value it would be more desirable to have the boundary along the hill-top following the existing track.

Regards

*Geoff Clark*

**MARK BELTON & ASSOCIATES LTD**

New Zealand Forestry Investment &amp; Douglas-fir Forestry

13 January 2006

Mike Todd  
Opus International Consultants Ltd  
PO Box 1482  
CHRISTCHURCH

Dear Mr Todd

**Submission: Tenure Review- Mt Cecil, Mt Studholme & Kaiwarua Pastoral Leases**

In relation to the **Land to be restored or retained in full Crown ownership and control** as **Conservation Area** (under section 35(2)(a)(i) Crown Pastoral Land Act 1998).

Issues of concern; Does the Department of Conservation have the resources to deal with the:

1. Management of weed species in the absence of grazing: Broom, Gorse and Wilding Trees?
2. Management of noxious pests: Wallabies, Possum, Goats, Hares?

**Question 1**

**Has pest management under Conservation management been realistically costed?**

**Question 2**

**What is the NPV of future pest management?**

Areas proposed for conservation below about 800m, and below exposed ridges, may present good growing conditions for Douglas-fir, a globally important commercial timber species. These areas may also contain good growing sites for exotic or indigenous forests for carbon capture and storage under the New Zealand governments Permanent Forest Sink Initiative.

These alternative forest based land uses have commercial value and create land expectation value (LEV's) for these lands of circa \$500-\$1000 per hectare in today's markets.

**Question 3**

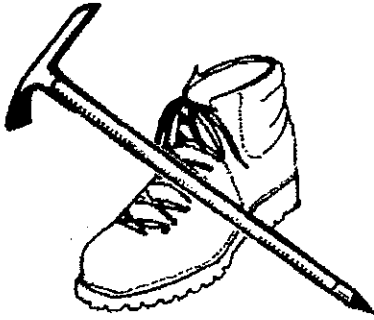
**Does the ascribed conservation value of this land equal these forestry landuse land values?**

Yours faithfully

Mark Belton

Received 13/2/06

Submission #3.



# Christchurch Tramping Club Inc.

FORMED 1932

*Affiliated to: FEDERATED MOUNTAIN CLUBS OF N.Z. INC.*

PLEASE ADDRESS ALL CORRESPONDENCE TO THE HON. SECRETARY P O BOX 527, CHRISTCHURCH

Email SECRETARY@CTC.ORG.NZ

WEB WWW.CTC.ORG.NZ

Opus International Consultants  
PO Box 1482  
Christchurch  
Attention: Mike Todd

9 February 2006

Dear Sirs

## **Preliminary Proposal: Mt Cecil, Mt Studholme and Kaiwarua Pastoral Leases**

Thank you for supply of the preliminary proposal documents.

This is not an area where our club tramps regularly but the information included in the documents suggests that we should pay it some attention in the future.

We note that the proposal summary states:

“Existing 4WD tracks on the property are proposed to be used for public and management access. This network is extensive and combined will provide comprehensive access to all areas of the proposed conservation and a number of round trip options for recreational users.”

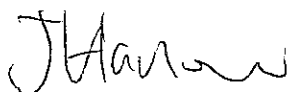
We agree with this statement. We have checked cadastral plans and note also that there is a marginal strip on the true left of the North Branch of the Waihao River. This adds to recreational options by linking the river between points c and h with the farm track network.

We support this proposal because of its comprehensive access provisions.

We note that this is in stark contrast which the minimal and sometimes inaccessible access proposed in some other reviews.

It seems necessary that objective and robust minimum access criteria need to be developed as a baseline for all reviews. Obviously this is not a matter that can be addressed within the context a single review such as this.

Yours sincerely

A handwritten signature in cursive script, appearing to read 'J Harlow', written in black ink.

Jenny Harlow  
Secretary  
Christchurch Tramping Club

cc: Richard Wesley, FMC  
Peninsula Tramping Club  
Royal Forest & Bird Protection Society  
Department of Conservation

Submission #4.

**A. & J. Evans**

**34 John Street, Temuka**

**Phone & Fax 03 6157 420**

Date: 4/3/06

To: Mr Mike Todd

Senior Property Consultant

OPUS

PO Box 1482

CHRISTCHURCH

Dear Sir:

I agree with the preliminary

proposal for future review of

Mr Cecil, Mr Steadholm and

Mr and Mrs Storey/Leese.

Thank you for the opportunity

to comment.

A J Evans

John

Submission #5.

Mt Cecil Studholme &amp; Kaiwarua PP6 Mar06



## New Zealand Deerstalkers' Association Incorporated

Level 1 45 – 51 Rugby Street P O Box 6514 Wellington  
 Phone: 04 801 7367 Fax: 04 801 7368  
 Email: [deerstalkers.org.nz](mailto:deerstalkers.org.nz)  
 Website: <http://www.deerstalkers.org.nz>

5 March 2006

Commissioner of Crown Lands  
 C/o Mike Todd, Opus International Consultants Ltd  
 Box 1482, Christchurch  
 Fax 03 365 7858  
[mike.todd@opus.co.nz](mailto:mike.todd@opus.co.nz)

### Submission: Mt Cecil, Mt Studholme & Kaiwarua Tenure Review: Preliminary Proposal

This submission is made on behalf of the New Zealand Deerstalkers' Association Incorporated (NZDA). NZDA is the national body of recreational deerstalkers and other big game hunters. We have 57 branches and a number of hunting clubs throughout New Zealand. We have 7200 members, and have been actively advocating for deerstalking and recreational hunting, and running deerstalker training courses, trips, conferences etc since 1937. NZDA also maintains the ethical side of hunting by maintaining ethics for hunting, including fair chase, and strongly encouraging harvesting of animals taken.

#### 1 Summary:

NZDA is not familiar with these 3 leases. However the proposed split will give 4,789 Ha to the Public Conservation Estate, more than half of the combined leases. This is a good deal for more public recreation land in an area that has few extensive such areas. We therefore support it.

NZDA is concerned that the CRR Report states the legal road that forms the boundary between Mt Cecil, and Noondale Forest, to the surrendered land, is blocked by deer fences and forestry operations. LINZ and the District Council should ensure the legal road is un-obstructed.

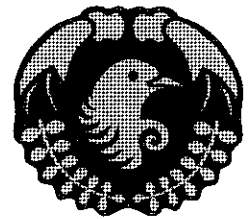
NZDA appreciates the significant number of farm tracks that are available for walking access from the west. This will allow round trips to from the surrendered land, and is appreciated. It is certainly much better walking access than that offered at Glenrock and Redcliffe, up the Rakaia.

Re recreational hunting opportunities, the main one is wallaby shooting. The hut of the Waimate Shooters Club on Kaiwarua Lease highlights this hunting opportunity. The area is also in the range of Red and Fallow deer, so will have deerstalking opportunities, as the tussocklands recover.

Yours truly

Dr Hugh Barr  
 National Advocate

Submission #6



**FOREST  
& BIRD**

Royal Forest and Bird  
Protection Society  
of New Zealand Inc

Royal Forest and Bird Protection Society  
PO Box 2516  
Christchurch Mail Centre  
Ph 03 3666 317  
Fax 03 365 0788  
[e.sage@forestandbird.org.nz](mailto:e.sage@forestandbird.org.nz)

6 March 2006

Mike Todd  
Opus Consultants  
PO Box 1482  
Christchurch

Dear Mike Todd

**SUBMISSION ON PRELIMINARY TENURE REVIEW PROPOSAL FOR MT  
STUDHOLME, MT CECIL, AND KAIWARUA PASTORAL LEASES**

**1. INTRODUCTION**

The Royal Forest and Bird Protection Society (Forest and Bird) is New Zealand's oldest and most active voluntary conservation organisation. Formed in 1923 the Society has around 38,000 members in 56 branches around New Zealand. This submission is on behalf of the Society's Central Office and Canterbury/West Coast regional office.

*The Society's constitution requires it to:*

*"Take all reasonable steps within the power of the Society for the preservation and protection of indigenous flora and fauna and natural features of New Zealand for the benefit of the public including future generations."*

*"Protection of natural heritage includes indigenous forests, mountains, lakes, tussocklands, wetlands, coastline, marine areas, offshore islands and the plants and wildlife found in those areas."*

The property was inspected in February 2006.

**2. PRELIMINARY PROPOSAL**

Forest and Bird understands the preliminary proposal (PP) to involve:

1. Restoration to or retention in full Crown ownership and control as conservation area of 4,789 ha (approx) edged in pink on the plans in Appendix 2. This comprises all of Mt Studholme pastoral lease (1,886 ha), and the easterly parts of Mt Cecil and Kaiwarua leases. This is subject easements in favour of Vodaphone, NZ, Telecom NZ, NZ Broadcasting Corporation and Television NZ.
2. Freehold disposal of 3,345 ha. to Kaiwarua Station Ltd. (Edged in green on the plans). This includes 1,219 ha. from Mt Cecil and 2,112 ha from Kaiwarua pastoral lease.



3. Public foot, horse and mountainbike access, and a management purposes (including vehicles) access easements "a-n", "c-d-e-f" "d-i", "e-g" and "h-i-j"
4. New fencing R-S, T-U and V-W.
5. Easement for Fish and Game management access to North Branch Waihao River.

### 3. GENERAL SUBMISSIONS

The restoration of 4,789 ha. to full Crown ownership and protection as conservation land is supported.

The access easements over the farm tracks are supported. Given the size of the property it is essential that all the easements are established. If the lessee has concerns about public mountainbike (MTB) access affecting driving of stock on the farm track this can be resolved by signage on the access route (e.g. on the Hunters Hills ridge access for MTBers to slow down) for the short time that the stock movement is occurring. Forest and Bird strongly opposes the withdrawal of any of the access easements.

Apart from the above elements, the Kaiwarua and Mt Cecil PPs are two of the worst Forest and Bird has made a submission on for the following reasons:

- The Summary of the PP (which is the basis for public submissions) is extremely misleading in its statements that the proposed freehold areas "*have been heavily modified by pastoral activity including burning, oversowing, and topdressing over many years. They are heavily tracked and in the main are intensively farmed (by high country standards). They have few inherent values remaining and it is considered that this land is suitable for continued pastoral production on an ecologically sustainable basis.*" This is incorrect for quite large areas (e.g. A, B, C on Maps 1 and 2 attached) where inherent values and naturalness are high.
- Extensive areas of healthy snow tussock *Chionochloa rigida* grasslands and dense shrublands are proposed for freeholding. The high significant inherent values of the grasslands and low altitude gully shrublands are understated.
- The Conservation Resources Reports (CRR) are inadequate and appears to be based on a very limited survey of the properties. They fail to describe the shrubland communities (especially on the western parts of Kaiwarua) or invertebrate fauna in any detail and severely understates their significance. The reports prepared in 1998 and the recommendations should have been reviewed in the light of subsequent research and Government August 2003 High Country Objectives and the need to implement the NZ Biodiversity Strategy.
- *Chionochloa rigida* snow tussock grasslands contribute to soil conservation and water yield. Their likely degradation through farm development following freeholding is contrary to the CPLA and will not promote ecologically sustainable management.
- LINZ and the CCL have allowed the lessee to burn *C. rigida* and the western facing gully draining to the Waihao River (Area B) on Map 1 attached **after** the Conservation Resources Report (CRR) was completed describing the area's values and identifying it as deserving protection.
- LINZ and CCL have also allowed the lessee to bulldoze a track along the ridge from near the Mt Cecil boundary to Mt Blyth and burn part of the Otaio

catchment above the wallaby hunters' hut, again after the CRR was completed. Subsequently the Director –General of Conservation delegate advised that “*these 2 consents have impacted on the SIV of the catchment*” and recommended that the area not become public conservation land.<sup>1</sup> By granting such consents during tenure review LINZ and the CCL have undermined the integrity of the review process. This encourages lessees to destroy or compromise identified significant inherent values (SIVs) in order to freehold such areas. This is opposed.

### Mapping

It would be helpful if unformed legal roads and marginal strips were marked on the PP maps as occurs with other proposals. Forest and Bird understood that LINZ had instructed contractors that this was to occur.

## SPECIFIC SUBMISSIONS

### 1. *Chionochloa rigida* grasslands are significant

Indigenous temperate grasslands are “the world’s most beleaguered biome”<sup>2</sup> with very low levels of protection. Less than 5 % were under any kind of protective status in the mid 1990s. This is one of lowest levels of protection of any of world’s recognised 15 major biomes. New Zealand’s indigenous grasslands are similarly much depleted and poorly protected. Less than 44% of the 82, 432 squ. km of indigenous grasslands assumed to have been present at the time of European settlement in New Zealand in 1840 remain, albeit in a modified or degraded state. Of this only 12 % (10,127 squ. km) or 28% of the remaining indigenous grassland has been protected as conservation land.<sup>3</sup> Less than 10 % of the original (1840) extent of tall tussock grasslands (including *Chionochloa rigida* grasslands) remain.

The Ministry for the Environment's comprehensive report, *The State of the New Zealand Environment* published in 1997 noted:

*“...very little unmodified tussock land exists, as virtually all of it has been burnt many times and most of it grazed as well....”*

*“The reduction in tussock area has been accompanied by a much greater decline in tussock biomass. The attempt to create short tussock pasture for sheep has led to short tussock replacing tall tussock in many areas, followed by a decline in short tussock growth and abundance due to soil degradation, over-sowing with other grasses, and the invasion of stress- resistant herbs, scabweed, and hawkweed.”*

*“Although no native plants are known to have become extinct in the South Island tussock lands, many of the herbs, flowers, and fine grasses normally associated with tall tussock have been displaced by short tussock and hawkweeds (Treskanova, 1991). Some species*

<sup>1</sup> Letter Mike Clare to Mike Todd 6 May 2003.

<sup>2</sup> Mark, A and McLennan B (2005) “The conservation status of New Zealand’s indigenous grasslands,” in *NZ Journal of Botany* 2005 Vol. 43:245-270 . Biome is a major regional ecological community characterised by principal plant species.

<sup>3</sup> Mark, A and McLennan B (2005)

are on the brink of extinction and some are confined to very restricted locations (Working Party on Sustainable Land Management, 1994).

*"A number of tussock-dwelling animals have disappeared, such as the weka, several reptiles and several invertebrates. The spread of the exotic grass, browntop, in the area near Cass has reduced the amount of tussock and herb cover and caused a dramatic fall in the populations of many native moths. (White, 1991). Although no moth species has yet disappeared, extinctions seem inevitable if the exotic grasses continue to spread at the tussock's expense."*<sup>4</sup>

Narrow leaved snow tussock including *Chionochloa rigida* was once widespread east of the Southern Alps. It is now restricted to less accessible mid altitude areas, with exotic grasses and intensive farming having replaced it elsewhere.

Given the extensive depletion of snow tussock grasslands and their under-representation in protected areas, the west draining catchments at the northern end of Kaiwarua (Areas A and B), and Areas C, D and E on Mt Cecil (See Maps 1 and 2 attached) have high SIVs. They deserve protection because of their health, extent, and naturalness. If left ungrazed and unburnt, those areas which have been burnt will recover. Freeholding them would cause continued biodiversity loss and exacerbate their continued decline.

## **2. Several western valleys draining to North Branch Waihao River have SIVs deserving protection (Areas A, B, C, and D)**

The CPLA requires that significant inherent values be protected. Significant inherent value is defined in relation to land that deserves the protection of management under the Reserves Act or the Conservation Act. The purpose of the Reserves Act includes ensuring as far as possible the preservation of representative samples of all classes of natural ecosystems and landscape which in aggregate originally gave New Zealand its own recognisable character.

Areas A and B in the catchments of tributaries flowing south west and west respectively from the crest of the Hunters Hills to the North Branch of the Waihao River at the northern end of the Kaiwarua pastoral lease and Areas C and D on Mt Cecil contribute to that distinctive character. They have SIVs deserving protection. (Areas A and B see Map 1 and Areas C and D on Map 2).

### **2.1 These SIVs include:**

- A high degree of naturalness and intactness (apart from the spur track to Mt Blyth.). The discussion of proposed designations in the Drafting Instructions for the Draft Preliminary Proposal<sup>5</sup> contradicts the claims made in the summary of the PP about development and modification. e.g. " *The properties have very little development or improvements. They have always been run in conjunction with adjoining freehold and run comparatively little stock.*

.....

<sup>4</sup> Ministry for the Environment (1997) "The State of the New Zealand's Environment" at pp 8.71-8.72.

<sup>5</sup> Drafting Instructions Draft Preliminary Proposal; Submission Phase 3 Standard 8 – Undated.

*“The low management input, lack of development and grazing patterns of all three properties has resulted in the preservation of a diverse range of significant inherent values, mainly in the form of vegetation cover and bird and invertebrate habitat especially at high altitude and on the darker, wetter catchments in the east.”*

- Extensive healthy and good quality narrow leaved snow tussock grassland which is uncommon in the area.
- As Appendix 3 Photo 1 shows, indigenous vegetation cover dominates Areas A and B with little evidence of exotic pasture grasses. The tussock grasslands and dense matagouri, *Coprosma propinqua*, and *Melictyus* shrublands on the lower slopes, and gullies contribute to and help sustain the natural landscape and the integrity of the high country landscape.
- Their intactness and natural contribute to the landscape, scenic, aesthetic and recreational values of the area.
- Much of the land in these north tributary catchments is above 600 m. asl. extending to more than 800 metres. As the Kaiwarua CRR notes, above 800 metres snow tussock cover is between 80-100% of vegetation cover and at lower altitudes between 60-90% of cover with a range of indigenous inter-tussock species.<sup>6</sup> As the Mt Cecil CRR notes, narrow leaved snow tussock is the dominant cover above 700 m, and above 500 m on some south and east faces. Given the dominance of indigenous communities and very limited extent of pasture grasses, freeholding conflicts with s24(b).
- DoC has determined that Area B meets the Protected Natural Area Programme criteria for protection as a priority natural area<sup>7</sup>. It was recommended for protection by the department<sup>8</sup> because it is the best representation of snow tussock cover extending from the Waihao River at 500 m asl to the crest of the Hunters Hills at 800 m. asl.
- The snow tussock grasslands are representative of the former vegetation in the Hunters Ecological District (ED) of the Pareora Ecological Region. This comprised extensive tussocklands with some forest remnants.<sup>9</sup>
- The snow tussock grasslands (and potentially also the lower altitude shrublands) are a “rich faunal environment”<sup>10</sup> for invertebrates with several hundred invertebrates species present, including a rich moth fauna. The PP fails to recognise adequately these habitat values adequately. The retention of such a rich fauna depends completely on the retention of healthy indigenous

<sup>6</sup> DoC (20 July 1998) “Conservation Resources of Kaiwarua Pastoral Lease, Canterbury” at para 2.4.

<sup>7</sup> DoC, (1999) “Kaiwarua Revised Conservation Resource Report Recommendations (Kaiwarua Pastoral Lease – Recommendations and Justifications)” Attached to letter from Mike Clare to Ray Ward Smith Knight Frank, 10 August 1999 at para 4.2.1.3, p 4.

<sup>8</sup> Department of Conservation (5 March 1999) Kaiwarua Recommendations Map.

<sup>9</sup> NZ Lands and Survey (1981) Ecological Regions and Districts of New Zealand Map, NZMS 242 Sheet 4.

<sup>10</sup> Department of Conservation (20 July 1998) Conservation resources of Kaiwarua pastoral lease.

vegetation cover. The ground dwelling invertebrates rely on dense tussock cover to provide the more humid conditions they prefer.

Part of Area B has been burnt recently. As noted above, the fact that this was allowed during tenure review and after the CRR was prepared undermines the integrity of the process and highlights LINZ and the CCL's failure to protect the public and Crown interest. If ungrazed and not burnt again the area can recover. It would be unfair to allow the lessee to benefit from this deliberate effort to degrade identified SIVs. It would send the wrong message to other lessees.

As the photos in Appendix 3 demonstrate, Areas A, B, C and D are outside those parts of the western hill country which have been significantly modified by burning, and oversowing and top-dressing.

## 2.2 Gully and lower slope shrublands Areas A, B and D

- These shrublands are part of altitudinal sequence and provide an important indigenous vegetation linkage between the more alpine vegetation and snow tussock grasslands of the proposed conservation area and the developed farmland and forestry on the western part of the broad Waihao Valley. Protection of Areas A, B and D would protect a full and continuous altitudinal sequence from the eastern faces of the Hunter Hills around Mt Blyth and down the western flanks to the valley floor. Such a sequence was originally proposed in the Conservation Resources Report.
- Scientists have only recently begun to understand and emphasise the importance of shrubland remnants. These areas could qualify as a RAP if a Protected Natural Area survey had been conducted.
- The shrublands in Areas A and B are dense and have a high potential for further regeneration. Those in Area D are less dense but also have this potential.
- New information on the significance of low altitude shrublands as invertebrate habitat has become available since the CRRs were completed in 1998. The first published invertebrate survey focusing on low altitude shrubland (450 m asl) communities in New Zealand occurred in 2001. It found 280 species of invertebrates associated with just two shrub species, *Olearia bullata*, and *Coprosma propinqua*. Approximately 90% of the identified species were endemic, emphasising the importance of such remnant habitats for the protection of New Zealand's indigenous biodiversity.<sup>11</sup> This level of endemism is one of the highest in the world for a discrete area. If similar survey work was done in the Kaiwarua and Mt Cecil shrublands results may be similar. The Kaiwarua CRR indicates that the tussockland area is a "rich faunal environment" with no analysis of the shrubland communities..
- The riparian shrublands and dense shrub cover on slopes close to the North Branch of the Waihao River contribute to its high natural character. (See Appendix 3 Photo 1). The PP fails to buffer the river by protecting any areas

<sup>11</sup> Derraik, J et al (2001) "Invertebrate survey of a modified native shrubland, Brookdale Covenant, Rock and Pillar Range, Otago in *NZ Journal of Ecology* , 2001 Vol 28 at p 273.

adjacent to it. The intensive development on some freehold land on the true right/south bank of the river highlights the loss of indigenous biodiversity, landscape and natural character which is likely to follow freeholding.

### 2.3 Other reasons for protection

The Kaiwarua CRR fails to include any assessment of the western gully and Waihao River shrublands in terms of their botanical or entomological significance. Failure to assess does not mean the values don't exist.

The Kaiwarua and Mt Cecil PP does not implement the principles of good reserve design. Walker<sup>12</sup> et al. recommend that reserve design should envisage and allow for the expansion and eventual restoration of sequences of native woody vegetation from the valley floors to the range tops and existing remnants should be viewed as foci and seed sources. The PPs do not do this. Walker et al<sup>13</sup> indicate that limited experience with removal of herbivores from Central Otago woody remnants suggests that there is considerable potential for regeneration of certain woody species, and that this may have long been underestimated.

Nor does the PP recognise the need to design reserves around seriously neglected invertebrate communities. As Derraik et al<sup>14</sup> note, reserves are "often based on the distribution of charismatic large vertebrates or on botanical surveys" rather than on the presence of invertebrates. Not correcting this fails to implement the NZ Biodiversity Strategy

Freeholding Areas A, B, C and D is inconsistent with Government's August 2003 High Country Objective (g) - *Ensure that conservation outcomes for the high country are consistent with the New Zealand Biodiversity Strategy.*<sup>15</sup> (NZBS).

The NZ Biodiversity Strategy has a goal to halt the decline of our indigenous biodiversity. It requires LINZ and DoC to:

*"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 ecosystems in production...."*

Narrow leaved snow tussock and lowland shrublands are depleted and scarce habitats with SIVs deserving protection. A full range of invertebrate habitat also needs protecting to implement the Biodiversity Strategy.

Areas A and B appear to have been lightly grazed historically and used only in periods of drought. Kaiwarua Station already owns a sizeable area of freehold land. Generous freeholding is proposed elsewhere on Kaiwarua and Mt Cecil. There is no evidence in the consultation notes or other reports that Areas A, B, C or D are required for the economic

<sup>12</sup> S. Walker, W.G. Lee & G.M. Rogers 2002: *Woody Biomes of Central Otago, NZ: Their Present, Past Distribution and Future Restoration*: Landcare Research Contract Report. LL1020/084

<sup>13</sup> S. Walker, W.G. Lee & G.M. Rogers 2002: *Woody Biomes of Central Otago, NZ: Their Present, Past Distribution and Future Restoration*: Landcare Research contract Report. LL1020/084

<sup>14</sup> Derraik, J et al (2001).

<sup>15</sup> Cabinet Paper POL Min (03) 19/7

viability of the property (even if this was a reason for freeholding under the CPLA, which it isn't). Given this and the presence of SIVs, freeholding cannot be justified because it would result in SIVs being destroyed or degraded.

The 1,553 ha. of Kaiwarua initially suggested for freeholding<sup>16</sup> has been increased to 1,233 ha in the preliminary proposal at the expense of proposed conservation land with no apparent justification. This is opposed, as is the similar reduction in new conservation land on Mt Cecil.

Decision sought

Restore to Crown ownership and protection as conservation land Areas A, B, C, and D on Maps 1 and 2 attached.

If there is any doubt about the need for protection undertake a thorough invertebrate survey and assessment of the shrublands in Areas A and B and D.

**3. Area F (Otaio tributaries), Kaiwarua**

Area F (Otaio tributaries) includes the head of several tributaries draining east to the Otaio from the crest of the Hunter Hills, south of new fence point "S" and north of Trig 866m above the wallaby hunters' hut. This area was identified in 1998 as having values deserving protection and recommended for protection by DoC.<sup>17</sup>

Forest and Bird strongly opposes the lessee being rewarded for having subsequently deliberately damaged SIVs by burning and tracking, by being able to freehold this area. There is the potential for recovery of tussock grasslands and the shrublands in the gully bottoms appear to have survived somewhat better than the upper slope grasslands.

Decision sought

Protect Area F as conservation land (preferably) or retain as Crown pastoral lease land. If this cannot be achieved because of DoC's change of view in its 6 May 2003 letter<sup>18</sup> then the LINZ and the Crown's poor handling of the discretionary consent situation should strengthen the case for the protection of Areas A-E

**4. Areas C, D and E, Mt Cecil**

Area C (see Map 2) in the northern part of Mt Cecil includes the upper parts of several small tributary catchments draining west from the crest of the Hunter Hills, south of Trig Point 863 and north of proposed access easement "h-i". The catchments drain to the North Branch of the Waihao River.

Area D includes the south facing slopes of the gully south of proposed access easement "h-i". It was identified by DoC as having values deserving protection.<sup>19</sup> No information or substantive reasons are provided (in the Consultation Meeting notes) or elsewhere as to

<sup>16</sup> Report/Submission for Draft Preliminary Proposal and Drafting Instructions for Kaiwarua Pastoral Lease (undated) at p 13. File No. Pt 114

<sup>17</sup> Department of Conservation (5 March 1999) Kaiwarua Recommendations Map

<sup>18</sup> Letter from Mike Clare to Mike Todd.

<sup>19</sup> Department of Conservation (5 November 1998) Mount Cecil Values Map.

why it is not part of the proposed conservation area. Its protection would contribute to good reserve design by providing a full altitudinal sequence from the crest of the range to the Waihao.

Area E includes the upper parts of several small tributary catchments draining east from the crest of the Hunter Hills, south of Trig Point 863 and north of proposed access easement "h-i". It was identified by DoC as having values deserving protection.<sup>20</sup> No information or substantive reasons are provided (in the Consultation Meeting notes or elsewhere) as to why it is not part of the proposed conservation area.

Snow tussock grassland in good condition dominates Areas C, D and E and they have the SIVs described above in sections 1 and 2. They contribute to the integrity of the high country landscape and are highly natural. Slopes are steep and unsuitable for continued pastoral development because of risk of soil erosion and the landscape scarring which further tracking would cause.

#### Decision sought

Restore to Crown ownership and protection as conservation land Areas C, D and E. See Map 2 attached.

### **5. Freeholding not ecologically sustainable**

Freeholding Areas A, B, C and D in the western valleys draining to the North Branch of the Waihao River and Area E (Otaio) (see Maps 1 and 2) does not promote ecologically sustainable management and is contrary to s24 CPLA for the following reasons:

1. The current lessee has recently burnt extensive areas of *Chionochloa rigida*/ snow tussock grasslands. Such burning will lead to the gradual degradation and loss of these grasslands.
2. It does not recognise the crucial role of snow tussocks and associated indigenous vegetation in soil conservation and the impacts of burning on soils described in Appendix 1 attached. Vegetation reduces the erosive force of wind, rain or running water by binding the soil with its roots and reinforcing the resistance of soil to movement.
3. Less than 10 % of New Zealand's tall tussock grasslands remain. Tall tussock grasslands have declined significantly in extent and vigour as a result of the combined effects of burning and grazing as MfE's comprehensive 1997 state of the environment report<sup>21</sup> noted. That decline will continue with preliminary proposals such as Kaiwarua and Mt Cecil because they fail to acknowledge the conclusions of existing research that continued burning and grazing is ecologically unsustainable. The impacts of burning and the reasons why it is unsustainable are described in Appendix 1.

<sup>20</sup> Department of Conservation (5 November 1998) Mount Cecil Values Map.

<sup>21</sup> Ministry for the Environment, (1997) "The State of New Zealand's Environment" chapter 8.



4. The CRRs note that the Waimate District Plan only controls indigenous vegetation clearance above 900m asl. As much of the land proposed for freeholding is at lower altitude neither the Plan nor the Resource Management Act can promote sustainable management by controlling the clearance or degradation of existing indigenous cover here. Protection as conservation land is the only mechanism to do this.
5. Some 1, 233 ha. of the proposed freehold is on Mt Cecil lease. An estimated 503 ha. of this is Class VII land. As the Draft Preliminary proposal<sup>22</sup> notes Class VII land "*is defined as land that is not usually well suited to grazing due to the requirement for special soil conservation practices.*" The land is not suitable for forestry because of its high altitude and because wilding spread would cause severe problems for adjacent conservation land. The Kaiwarua CRR notes the existing forestry plantings in the area are likely to cause a "wilding explosion". Forestry related tracking, given the steepness of the country, is also likely to cause significant soil erosion and damage landscape SIVs. Forestry is not a sustainable because of this and its impacts on water yield.
6. The value and role of snow tussock grasslands in providing the ecosystem service of catching and holding water, as described in Appendix 2 attached, are not recognised or safeguarded. Local weather patterns and easterly drift mean that the tops of the Hunter Hills are often in cloud and fog. Research has established that tussocks are much more effective than exotic pasture at catching fog droplets, for example.
7. Freeholding will encourage farm development, land use intensification and the degradation and conversion and of tussock grasslands to exotic pasture and/or forestry, significantly reducing destroying their water holding capacity. These adverse impacts are nowhere analysed in the file information provided under the Official Information Act.
8. With climate change and increasing drought in the eastern South Island, water is an increasingly valuable resource – its use heavily contested by down country farmers, hydro generators, and recreational and environmental interests. These snow tussock grasslands have a much higher economic value if they are maintained in Crown ownership for biodiversity and water harvesting reasons . The Dunedin City Council recognised the importance of tall tussock grasslands for water yield and made a significant contribution to the cost of purchasing part of Otago's Te Papanui Tussockland Park to protect tall tussocklands (and remove grazing) because of their importance as a catchment area for Dunedin's water supply. It is appropriate for LINZ and DoC to recognise their value more intelligently in tenure review to help promote ecologically sustainable management.

Loss of snow tussock cover through any form of land development is essentially irreversible. Implementing the CPLA and promoting ecologically sustainable

<sup>22</sup> Drafting Instructions Draft Preliminary Proposal; Submission Phase 3 Standard 8 – Mt Cecil.

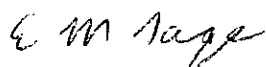
management requires DoC, LINZ and their contractors to promote the retention and protection of snow tussock grasslands because of their SIVs in terms of biodiversity and landscape and recreational values, and their significant contribution to water yield.

Decision sought

Amend the preliminary proposal to restore to Crown ownership and protect as conservation land Areas A, B, C, D and E described above and identified on Maps 1 and 2 instead of freeholding them.

Retain Area F as Crown land.

Yours sincerely



Eugenie Sage  
South Island Field Co-ordinator

**Attachments**

- Appendix 1 The impacts of burning
- Appendix 2 The value of tussock grasslands for water yield
- Appendix 3 Photo supplement Kaiwarua/Mt Cecil
  
- Map 1 Kaiwarua Detail Sheet – Amended Designations sought by Forest and Bird
- Map 2 Mt Cecil Detail Sheet – Amended Designations sought by Forest and Bird

## APPENDIX 1 THE IMPACTS OF BURNING

### 1. IMPACTS OF BURNING ON TALL TUSSOCK GRASSLANDS

Scientists largely agree that burning and grazing of unimproved tall tussock grasslands depletes both the soil and vegetation resource. *"The physiological changes in snow tussocks following burning persist for many seasons. During the first two years after burning, the growth of surviving tussocks exceeds that in unburnt plants, but rates then decline for several seasons to well below those of normal (i.e. unburnt) tussocks. Snow tussock grasslands may be weakened, and subsequent soil loss and weed invasion may then occur through wind and water action if the areas are reburnt or grazed before the snow tussock has a chance to recover."*<sup>1</sup>

The former Government's working group on sustainable land management in the high country (Martin Report, 1993) concluded that the combined effects of burning and grazing were unsustainable on 80 % of the unimproved high country.

McIntosh (1997)<sup>2</sup> has concluded that continued grazing and burning of tussock grasslands without nutrient inputs is unsustainable. He measured a net decline of nutrients in biomass and soils under grazing, or grazing with burning by measuring or estimating biomass changes, nutrient cycling, temporal soil trends, and comparing soils and biomass in differently managed areas of grazed, unfertilised tussock grasslands. He concluded that the measured nutrient losses were greater than could be accounted for by the direct effects of grazing and that there was no evidence that such losses are significantly mitigated by the addition of nutrients by weathering or other natural processes.

While some farmers believe that snow tussocks recover quickly after a burn and return to their original condition within 10 years this is not supported by scientific evidence. Research suggests that tussock plants are adversely affected for up to 15 -20 years after a burn. Post burn grazing reduces the number of tussock plants and their tillers and greatly slows any recovery.

Regrowth occurs very quickly after a fire which gives the impression that tussocks recover quickly. After a spring burn, snow tussocks show immediate enhanced leaf elongation, tillering and flowering compared to unburnt tussocks. This effect lasts for up to two years and creates the impression of enhanced tussock vigour following burning. However this is not the case. Total tiller productivity has been shown to be severely reduced in the first year after a fire and only returns to pre-burn productivity in the second and third years after the fire (depending on species and elevation). This recovery in tiller production is based entirely on the production of many new tillers, since all of the older ones flower as a result of the fire and then die in the second summer after the fire. Although leaf and tiller production in burnt plants were similar to unburnt plants three years after the fire, leaf growth subsequently declined and remained below that of

<sup>1</sup> Clearwater, S (1999) "Upland Lane Use and Water Yield", University of Otago Ecology Research Group, Issues Paper No. 1 at p7.

<sup>2</sup> McIntosh, P (May 1997) "Nutrient Changes in Tussock Grasslands, South Island, New Zealand" in *Ambio* Vol.26 No 3 May 1997 at pp147 -151, Royal Swedish Academy of Sciences.

unburnt plants for 14 years. Basher, et al (1990) reports that even after 15 years, total plant biomass is still only 65 % of the unburnt tussock biomass.

After fire, narrow leaved snow tussock (*Chionochloa rigida*) demonstrate a change in the internal concentrations of nitrogen and other minerals. These nutrients are transferred from the roots to the recovering leaf tissue, a process which continues for at least two years after the fire. Research has identified higher concentrations of minerals in the leaves of *C. rigida* which are recovering from a burn than in unburnt tussocks. Nutrient concentrations in the root tissues remain significantly depressed for 13 years, suggesting that leaf growth continues to be at the expense of below ground nutrient reserves. This suggests that a rapid depletion of nutrients after fire for tussocks growing in low fertility soils could limit the amount of nutrient uptake from soils for at least 13 years. These changes in nutrient concentration parallel the period of enhanced growth in the two years after the fire, and the subsequent depression in both growth and flowering and strongly suggest that the time taken for tussocks to recover after fire is closely related to the time required to restore equilibrium between nutrient supply and nutrient demand.

Accurate assessments of tussock recovery after fire require an assessment of nutrient status in the soil and root systems. Because of the growth spurt in the immediate post burn period, photographs and visual examination of leaf regrowth and insufficient to assess the health of individual plants.

In low fertility soils already low nutrient status is aggravated by the loss of nutrients to plant uptake after burning and possible loss by leaching in the period before plant cover is re-established.

Fire when combined with mammalian grazing has resulted in prolonged reductions in tussock biomass, vigour and stability as well as in the control and yield of water.<sup>3</sup> Where there is less plant cover, evaporative losses from the soil will also be greater<sup>4</sup> and there is increased potential for weed spread.

## 2. IMPACTS OF BURNING ON SOILS

The costs of soil degradation for future generations and in reducing life supporting capacity are high. Soil is a finite resource and is created on a geological, not a human time scale. The effects of soil degradation are likely to be permanent and irreversible given limited human knowledge and understanding of soil micro-organisms activity, nutrient cycles and soil structure.

The soil resource needs to be maintained because it is the medium for supplying water and nutrients for plant growth. Soil fertility depends on adequate levels of organic matter, a diverse population of soil micro-organisms and efficient nutrient cycling. (Basher, 1990). Burning adversely affects all of these, especially when combined with grazing.

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<sup>3</sup> Mark. AF (1994) "Effects of Burning and Grazing on Sustainable Utilisation of Upland Snow Tussock (*Chionochloa* spp.) Rangelands for Pastoralism in South Island, New Zealand" in *Aust. J. Bot.*, 1994 42 at pp149-161.

<sup>4</sup> Clearwater, S (1999)

There is an increasing amount of research information which confirms that burning vegetation has adverse effects on nutrient cycling regimes, soil structure, water holding capacity of the soil and soil micro-organisms (e.g. Basher et al, Oct. 1990).

**The adverse effects of burning include:**

- loss of plant vigour and a decline in the extent of vegetation cover which increases the potential for soil loss through wind and sheet erosion.
- part of the litter layer and soil organic matter are destroyed. Fire removes most of the above ground herbage and litter. A decline in soil organic matter contributes to soil degradation and a gradual fertility loss.
- when soil temperatures exceed 60-100 degrees some of the nutrients in vegetation litter such as nitrogen and organic sulphur and phosphorus are lost from the soil because they are released as smoke.<sup>5</sup>
- carbon, nitrogen and sulphur which would become part of soil nutrient cycles are volatilised and lost from plants when burns reach temperatures of 200-300 degrees C.<sup>6</sup>
- increased soil temperatures and changes in soil micro-climate from burning will increase microbial activity and mineralisation of organic matter.<sup>7</sup>
- changed "food supply" (e.g. plant litter) for soil micro-organisms which affects nutrient cycles. Micro-organisms are important in changing plant residues and nutrients in soils. Unless vegetation rapidly regenerates after a fire and the same quality and quantity of residue inputs are resumed, the microbial biomass and soil organic matter would gradually decline, reducing an important reservoir of plant nutrients.
- increased potential for loss of organic matter and plant nutrients by volatilisation, leaching and erosion.<sup>8</sup>
- overseas research has shown that the physical properties of soil change after burning so that soil particles are more likely to repel water. This could lead to an increased overland flow and run-off, contributing to erosion and reducing the water holding capacity of soils and their ability to slow stormwater run-off after rain storms.
- contributes to soil acidification.

Burning on lands where nutrients are not replaced by fertiliser or inputs from the atmosphere and weathering "*will inevitably degrade the soils, although the time scale will be long.*" "*... soil degradation will limit plant growth and make land use unsustainable.*"<sup>9</sup>

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<sup>5</sup> Basher L.R et al (October 1990) "The Effects of Burning on Soil Properties and Vegetation – A review of the scientific evidence relating the sustainability of ecosystems and land use in the eastern South Island hill and high country," DSIR Land Resources Technical Record 18, DSIR Land Resources.

<sup>6</sup> Basher (1990).

<sup>7</sup> Basher (1990).

<sup>8</sup> Basher (1990).

<sup>9</sup> Basher (1990).

Post burn oversowing and topdressing would however result in the expansion of pasture grasses and the degradation of tussock grassland to a brown top and short tussock grassland.

### **3. IMPACTS OF GRAZING AFTER BURNING**

Grazing of tussocks following burning has a detrimental effect on their recovery, subsequent vigour and survival. The tussocks are at their most vulnerable in the year following burning as they are dependent upon the survival of their newly produced tiller and leaves which eventually mature to form a canopy. Young tillers are highly palatable and stock tend to graze them exclusively. It is not known how long these young tillers take to flower and reproduce but it is likely to be more than 10 years.<sup>10</sup> The young shoots are also nutrient rich and early grazing further reduces available nutrients in individual plants.

Burning creates opportunities for new tussocks to replace those killed through burning, or old age, however sheep preferentially graze these new plants and so suppress tussock regeneration.

McKendry and O'Connor<sup>11</sup> in their review of the ecology of tussock grasslands noted that post burn recovery of snow tussocks was fastest if grazing did not follow the fire.

These factors led the Mountain Lands Institute to recommend a minimum of one year's post burn spell from grazing. Dr Bill Lee and others have concluded that recovery of snow tussock after burning takes at least 20 years and grazing, particularly in the first few seasons after burning, reduces the number and size of tillers and tussocks in the grassland and greatly slows the rate of tussock recovery.

H. Gitay et al. (1992) recommended that if the criterion is the retention of narrow leaved tussock grassland, then burning intervals should be at least 15 years and the grassland should not be subjected to grazing for two or three years following burning.

### **4. CONTRIBUTION OF BURNING AND VEGETATION DEGRADATION TO SOIL EROSION**

In parts of Kaiwarua, the combined effects of grazing animals and recent burning are depleting the vegetation cover, increasing the risk of human induced erosion from wind and water.

There is a considerable body of evidence which establishes that where soils have been denuded of vegetation cover, the combined effects of frost and wind cause surface erosion (O'Connor and Harris, 1991). This has played a key role in the desertification of around 200,000 ha of former tussock land which is now bare or covered in hawkweed (Belton, 1991 in MfE, 1997 at 8.55).

<sup>10</sup> Dr Bill Lees, pers. comm.

<sup>11</sup> McKendry, P.J and O'Connor, K.F (October 1990), "The Ecology of Tussock Grasslands for Production and Protection - Burning Management Workshop October 1990", A report for the Department of Conservation.

The main factors which determine whether erosion is likely to occur as a result of human activity include: soil type, slope, the length of time soil is bare of vegetation cover, the method of vegetation clearance, soil disturbance, the size of the area affected, the prevailing climate (wind and rainfall direction) and the time of the year.

Areas most at risk from induced erosion:

- have a high natural susceptibility to erosion because of their physical characteristics e.g. slopes composed of loess or soft sedimentary rocks.
- are already degraded due to induced erosion or other soil processes.
- are subject to high impact activities eg activities which remove vegetation cover, including forest clearance, burning, overgrazing by stock and/ or pests; or activities that disturb the soil, including earthworks and cultivation. (CRC, May 1995)

The dry high country is a key area identified by Environment Canterbury<sup>12</sup> and Council initiated research<sup>13</sup> as being at risk of induced soil erosion because of its biophysical characteristics and the history of land management.

#### **"High country**

*"Areas that are "most at risk" from induced erosion occur within the "undeveloped", semi-arid tussock grassland. In these areas the introduction of grazing animal, both domestic and feral) and some burning practices have significantly depleted the vegetation cover, increasing the risk of induced erosion. Annual rainfall plays a significant role in determining the resilience of vegetation to disturbance and must be a key factor in management decisions.*

*"Areas with depleted or no vegetation cover ( e.g. where hieracium is the dominant vegetation, or where cultivation has been carried out) are susceptible to frost heave, water and wind erosion."*

#### **"Intermontane basins**

*"As with the high country zone the areas that are "most at risk" from induced erosion are found in undeveloped areas. In these areas the grassland has lost its vigour and is more easily affected by grazing animals (both domestic and feral) drought, hieracium and burning. The physical nature of the zone means that it is highly suited to rabbits."<sup>14</sup>*

<sup>12</sup> CRC, (May 1995) "Soils and Land Use Issues & Options – A Discussion Document as part of the Natural Resources Regional Plan, Report 95(4).

<sup>13</sup> Hunter G., Guest P., and Metherell A (eds) (December 1997) "Science Workshop on Soil Trends in the High Country – Discussion notes from a workshop convened by Canterbury Regional Council, Landcare Research and AgResearch" 23-24 April 1997.

<sup>14</sup> CRC, (May 1995) "Soils and Land Use Issues & Options – A Discussion Document as part of the Natural Resources Regional Plan," Report 95(4).

Nutrient depletion in soils in drier areas of the high country is a particular risk as noted in a 1997 Science Workshop on Soil Trends<sup>15</sup> :

*"The area at greatest risk of nutrient depletion from grazing and burning is the dry zone (Pallic, Recent and Semi-arid soils). In this zone, levels of S (sulphur) and N (nitrogen) are of greatest concern."*<sup>16</sup>

*"Losses of up to 2 to 4 cm of soil from bare, exposed sites in the dry high country over the last 40 years exceed natural rates of soil development and are unsustainable."*

*"At typical eroded sites in dry areas, losses of nutrients through erosion will exceed losses from other processes including grazing, implicating erosion as a significant agent of nutrient loss."*

*"Finely textured soils at exposed sites under a depleted vegetation cover are at high risk from surface soil erosion."*

*"Factors contributing to increased risk of soil erosion are decreasing vegetative cover/increasing bare ground, a high proportion of erodible fine material at the soil surface, incidence of frost lift, and the exposure to wind and high intensity rain."*

*"Careful management to maintain an intact vegetative cover is critical to minimising soil erosion."<sup>17</sup> (my emphasis).*

*"Burning releases nutrients bound in living plants, especially N and S to the atmosphere. Burning may change species composition and expose soils to erosion. Repeated burning at frequent intervals without nutrient replacement and without restoration of vegetative cover is likely to be unsustainable."*

*"The area most "at risk" from the adverse effects of grazing and burning is the dry high country. Direct and indirect animal impacts on vegetation, through nutrient depletion, will have more severe impacts on the structure of dry soils due to their lower SOM (soil organic matter) levels."*

.....  
*"Although the magnitude of impacts from current grazing and burning regimes are poorly known, a conservative approach should be taken. In particular, dry areas are at greatest risk of adverse impacts. The Semi-arid and Pallic and associated Recent soils in dry areas have lower total C (carbon), N (nitrogen) and S (sulphur) and lower levels of SOM than moister soils. It is also more difficult to establish many plant species in dry, depleted environments."<sup>18</sup>*

<sup>15</sup> Hunter G., Guest P., and Metherell A (eds) (December 1997) "Science Workshop on Soil Trends in the High Country – Discussion notes from a workshop convened by Canterbury Regional Council, Landcare Research and AgResearch," 23-24 April 1997.

<sup>16</sup> Hunter G et al (1997) at p 7.

<sup>17</sup> Hunter G et al (1997) at p 7.

<sup>18</sup> Hunter G et al (1997) at pp8-9.



In undeveloped areas where plant biomass has declined, unless a vegetation cover is maintained that is adequate to prevent wind erosion, land degradation will continue. Burning and grazing are significant risk factors.

Removing or reducing vegetation cover by clearing shrublands, burning, over-grazing by stock, wallabies or rabbits, especially in drought conditions, or replacing deep rooted vegetation with shallow rooting vegetation is one of the most common precursors to induced erosion (CRC, May 1995).

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## APPENDIX 2 THE VALUE OF TUSSOCK GRASSLANDS FOR WATER YIELD

Research over 30 years has established the value of upland snow tussock grassland and its condition, for optimising the yield of high quality water and regulating its discharge to groundwater, rivers and streams.

Upland areas such as the crest of the Hunter Hills are important for water production as the amounts of rainfall, fog and snow are greater than in lowland areas. Evaporation rates are also lower due to lower temperatures so less of the available water is lost back to the atmosphere.

Snow tussocks are very efficient at catching and straining water from precipitation. Their long and narrow leaves give each plant a high surface area. The long fine foliage of ungrazed snow tussocks have a much greater surface area than pasture or short tussock to catch moving fog for example. Some studies have shown that fog makes "substantial contributions" to water yield, especially to groundwater.<sup>19</sup>

The condition of the snow tussock grassland contributes to water yield. Research<sup>20</sup> has established that ungrazed or lightly grazed snow tussock grassland has a higher water yield than severely grazed snow tussock, recently burned tussocks, short blue tussock, and bare soil. In one study, the water yield from snow tussock grassland was considerably higher. Up to 86% of measured precipitation was yielded as water from snow tussock grassland compared with 40% from bare soil. The studies also found that water yield from burned and severely grazed tussocks increased over several years as the tussocks recovered.<sup>21</sup>

Tussock grassland can influence snow accumulation and melt which contributes to water yield. Tussocks intercept snow, preventing it being lost to the atmosphere. Snow accumulates in a half cone shape on the downwind side on individual tussock plants. These tussock "vegetation traps" are the "most important part of the upland landscape for the storage of winter snow."<sup>22</sup> Snow also melts more slowly in snow tussock grassland than pasture because tussocks act as a buffer from wind and sunlight. This slows melting and run-off into rivers. In one study, 20 cm tall tussocks stored three times as much water as snow, than 10 cm tall tussocks.<sup>23</sup>

Snow tussocks also contribute to water yield because their leaf structure means they have relatively low water loss (transpiration) compared to most other plants in New Zealand. Their stomatal pores (where moisture loss occurs) are in grooves on the concave side of their rolled leaves and are less exposed to the surrounding air. When atmospheric

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<sup>19</sup> In Graham and Mark (1999) in Clearwater, S (1999).

<sup>20</sup> Clearwater, S (1999).

<sup>21</sup> Rowley (1970) Mark and Rowley (1976) and Holdsworth and Mark (1990) in Clearwater S (1999).

<sup>22</sup> Clearwater, S (1999).

<sup>23</sup> Twaddle D in Clearwater, S (1999).

conditions become drier, tussock leaves roll up more tightly. This further reduces water loss from the stomata.<sup>24</sup>

Conversion to pasture affects water yield through evapotranspiration. While there is little difference between annual evapotranspiration in pasture and snow tussocks, pasture extracts more water from the soil in summer than snow tussocks do. There are longer periods when the flow of water is low from pasture, compared to that from snow tussock grassland.

Research has also shown that conversion of snow tussock grassland to forestry can alter water chemistry, flow rates, sedimentation, and the amount of water yielded from a catchment. Five years after planting afforestation had a "sustained influence on low flows" in one study. In a paired catchment study, water yield from the forested catchment was 31 % less than from the control catchment in snow tussock grassland, nine years after planting.<sup>25</sup> This is thought to be due to the interception loss from the pines being much greater than from snow tussock.

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<sup>24</sup> Clearwater, S (1999) "Upland Lane Use and Water Yield", University of Otago Ecology Research Group, Issues Paper No. 1.

<sup>25</sup> Fahey and Watson (1991) and Fahey and Jackson (1997) in Clearwater S, (1999)