AgScience
Limited

Haldon Solar Project
Ecological Impact Assessment

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Executive Summary

Lodestone Energy Limited proposes a Solar Farm development in part of a 320 ha site on flat fluvioglacial outwash site on Haldon Station, adjacent to Lake Benmore. The site has been used for pastoral grazing for over 150 years.

Ecological values were assessed in spring October – November 2024. Ground cover and vegetation species composition was quantitatively measured in fifty one 100 m^2 plots. Thirty seven were in or directly adjacent to the site and fourteen plots were in, or adjacent to, an exclosure plot 1.8 km from the site which was ungrazed for ~45 years. In each plot there were eight 1m^2 quadrats, each subdivided into nine 33 x 33 cm grid squares for measuring cover.

The vegetation on the site is introduced low-fertility grassland with a low density of an introduced shrub. This association has completely replaced the former indigenous vegetation, fescue tussock grassland community, and no longer comprises indigenous vegetation.

Bare soil and stones averaged 36% of the site ground cover. Introduced species comprised 42% cover with two dominant species, the mat weed *Hieracium pilosella*, 17% cover, and Chewing's fescue tussock, 5% cover. Other introduced grasses and herbs comprised 21% cover. Indigenous plant cover was less than 0.1%, lichens and moss averaged 21% cover.

The introduced shrub, sweet briar was the only woody canopy cover species on the site. It was present at very low densities but increased in adjacent micro-sites with higher soil moisture and fertility. Only one woody indigenous shrub, matagouri, was observed adjacent to the site. The only trees adjacent to the site were introduced conifers, poplars and willows. No rare or acutely threatened indigenous plant species were observed, though four species were classified in a lower threat class as 'At Risk – Declining'.

Birds and animals were observed in 3-5 minute early morning and late evening counts at 10 survey stations along a set 6.2 km route in the center of the site. All fauna were also recorded when seen throughout the day. Pitfall traps and sand strips in the survey stations assessed fauna active at night.

Sixteen bird species were observed during the survey. Eight of these were introduced with skylarks the most frequently occurring species. Only one wide ranging native species, the Black Fronted Tern, seen flying over the area, is classified as at risk Nationally Endangered. No native species were observed nesting, or with young, in the site. No herpetofauna, lizards, geckos or skinks were observed during the survey, or were captured in pitfall monitoring, or recorded on sand strips.

Invertebrates were not formally assessed as known locally threatened species were not observed and as invertebrate habitat will not be appreciably altered by development, excepting small areas for infrastructure and access (road & tracks 5.5 ha; cable trenching 5.3 ha; sub- and inverter stations 2.3 ha). Populations are not considered to be a risk from disturbance during solar installation or operation.

Indigenous plants and fauna populations are not considered likely to be adversely affected by solar development.

Solar array coverage is 40% of the site area with a large area, 844 ha. of directly adjoining similar outwash on Haldon station which will not be affected. There are extensive protected basin floor conservation areas in the Pukaki and adjoining Ecological Districts totaling 37,500 ha in the Pukaki and adjoining Ecological Districts. This provides adequate protection for all the indigenous species present on the site, as well as for all known high threat ranked indigenous species.

The Ecological Impact Assessment of solar development is that it will have a **Very Low** effect on ecological values**.**

1. Introduction

Solar Development Site

The proposed solar development site of 320 ha is on fluvioglacial outwash on Haldon Station adjacent to the confluence of the Tekapo and Pukaki Rivers and Lake Benmore (Latitude -44.353^0 Longitude 170.235^0 altitude 373 m; Figure 1).

The site was inspected on the 10th October 2024 to develop an ecological impact assessment survey, accompanied by representatives from Ngai Tahu.

Figure 1. Proposed solar site (grey fill) and adjacent similar fluvial and outwash surfaces on Haldon Station (white outline) and adjacent properties.

The site was mapped by high resolution drone imaging on the 21st October and this was used to identify vegetation and spatial distributions patterns (Figure 2). The fluvioglacial outwash terrace has uniform topography where former outwash stream channels result in small variations in soil depth phases which influence vegetation patterns.

Figure 2. The fluvioglacial outwash surface (slope 2.2 ^{0} E-W, 2.1^{0} N-S) with former braided stream channels (darker areas) having deeper soils and greater soil moisture holding capacity.

Proposed Solar Farm

The proposed solar development will consist of arrays of photovoltaic panels and underground cabling connecting to a substation which in turn connects to the National Grid transmission line (Figure 3a). The development area will be fenced with rabbit fencing and grazing of the development area by stock will cease. Solar arrays will have a maximum ground cover of approximately 40 % when panels are horizontal[1]. Solar array coverage is not continuous with a 16 ha clear central strip and smaller areas between arrays occurring throughout the site (Figure 3a, b).

[1] Lodestone Energy Limited supplied information

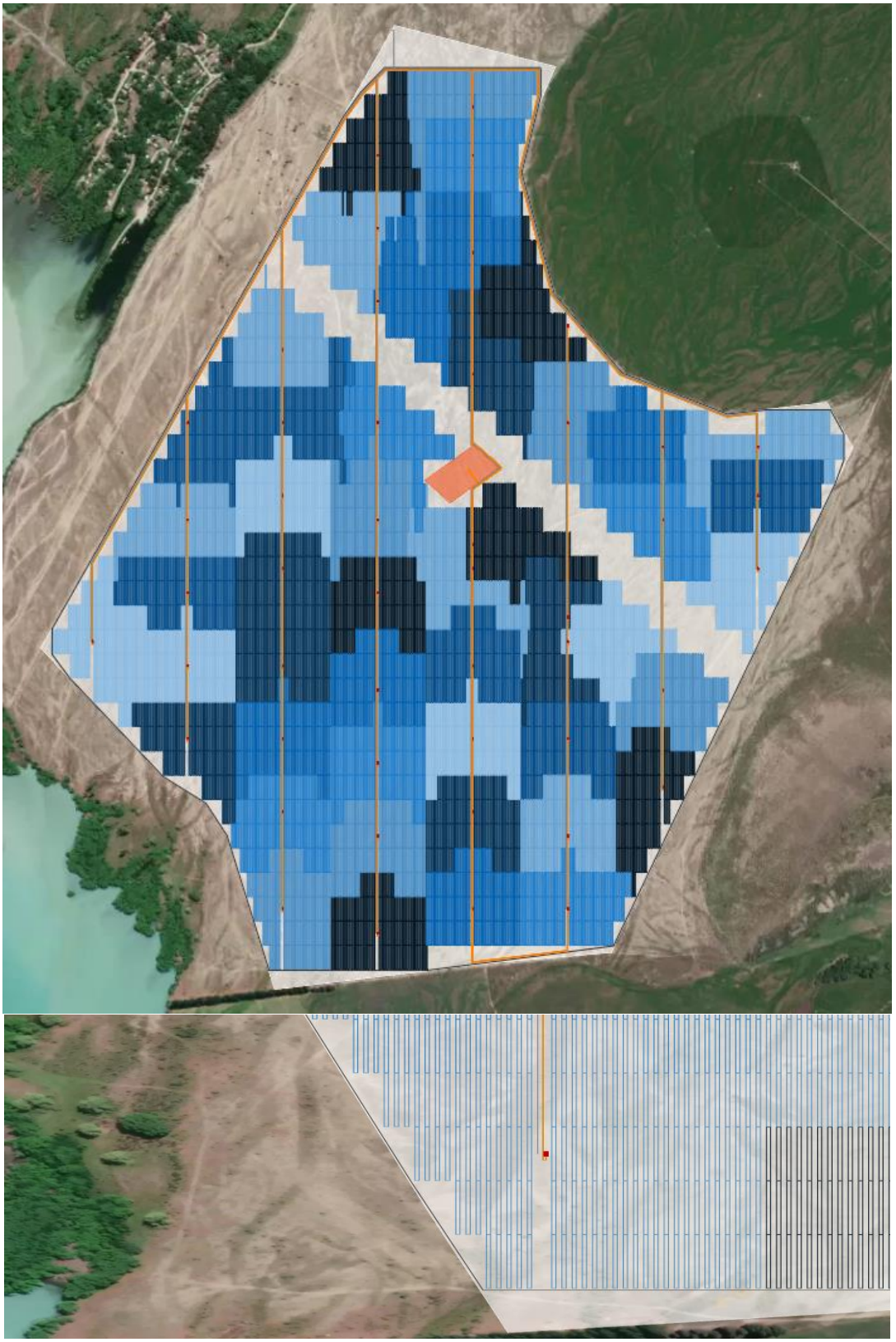

Figure 3a Upper: Solar arrays (blue- dark blue); voltage transmission trenches , tracks and substation (orange) Central strip: National Grid Transmission Line.
3b Lower: Expanded Solar array grid panels southern section.

Installation of photovoltaic solar panels will involve insertion of steel piles for support frames and panel centers will be elevated 1.5 m above the ground surface (Figure 4). Panels will be located in linear arrays with a

maximum ground coverage of 40% when panels are horizontal and less when inter array areas are included.

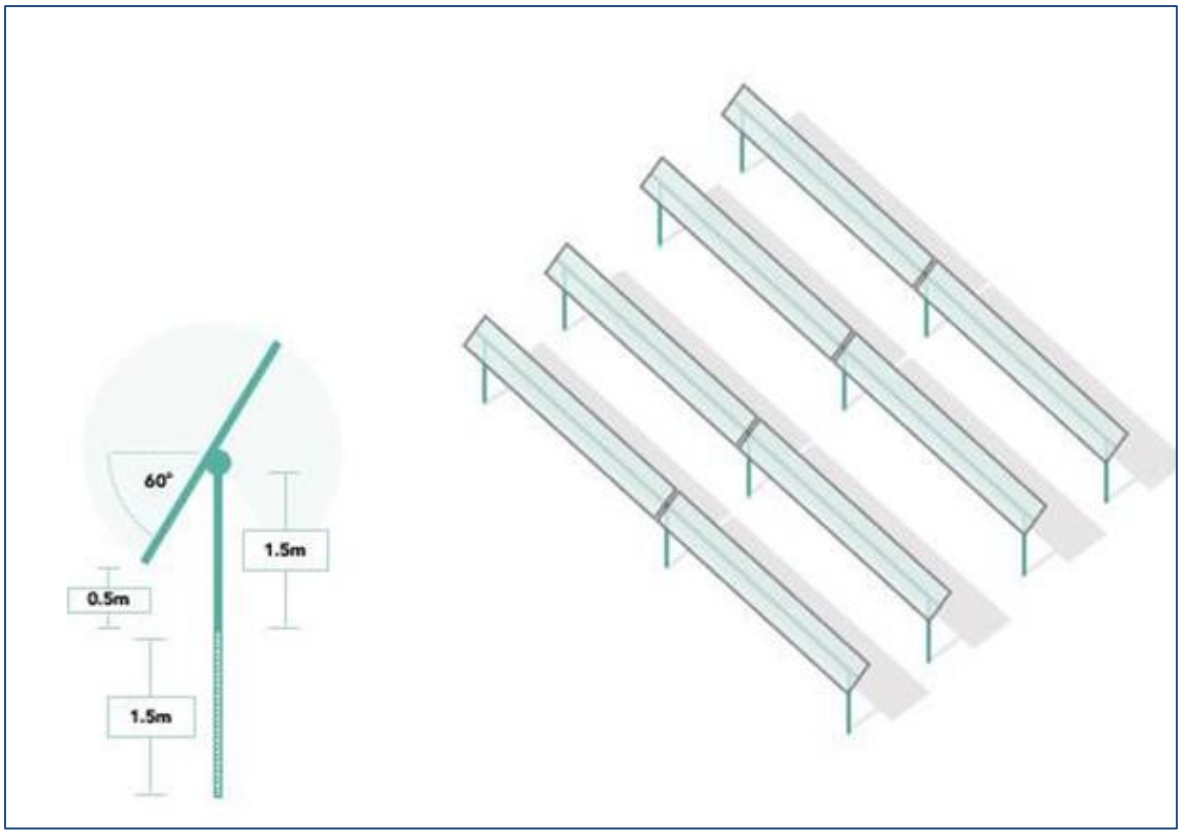

Figure 4. Solar panel dimensions and array configuration.

Electricity will be conducted from the arrays by underground cables to a substation which will link into the National Grid (Figure 3a). Maintenance access tracks and roads will follow the same route as the cabling, plus additional access road construction to the substation totaling 13.5 km. The total area of the site is 320 ha with trenching, tracking and infrastructure totaling approximately 13.2 ha (Table 1).

Table 1: Solar Farm Infrastructure and Disturbance Area

Item	Length (m)	Width (m)	Number	Area (m^2)	Area (ha)
Substation access road	1,500	5	1	7,500	0.75
Internal roads	11,970	4	1	47,880	4.79
AC MV cable	14,178	0.5	1	7,089	0.71
DC LV homerun cable	37,100	1.25	1	46,375	4.64
Inverter station	6	2.5	48	720	0.07
Pile (array posts)			65,840	0.003394	0.02
Laydown area				10,000	1.00
Substation footprint	153.3	78.7	1	12,064.71	1.21
Total area disturbed					**13.19**

2. Ecological Assessment

2.1 Vegetation

The site was initially inspected by walking and driving to determine the range of vegetation associations present, and was surveyed on the 16-18th, 21-23rd October, 4-5th, and on the 18-20th November 2024.

Vegetation assessment plots were located using a stratified random design. Four transect lines (T3-T6) running South East to North West were randomly positioned from north to south to cover the site area. Six 10 x 10 m plots per transect were offset by a random distance every 300 m along each transect line (Figure 5)

The immediately adjacent vegetation, that will not be affected by solar development, was also assessed. Transect one (T1) assessed grazed dryland outwash vegetation north of the site, where management will not be altered, and a second transect (T2) assessed the effect of irrigation and fertiliser development in an adjacent center pivot. Two further transects (T8-1, T8-2) assessed the effect of long-term exclusion from grazing in an exclosure 1.8 km east of the site on the same outwash surface and vegetation community (Figure 5).

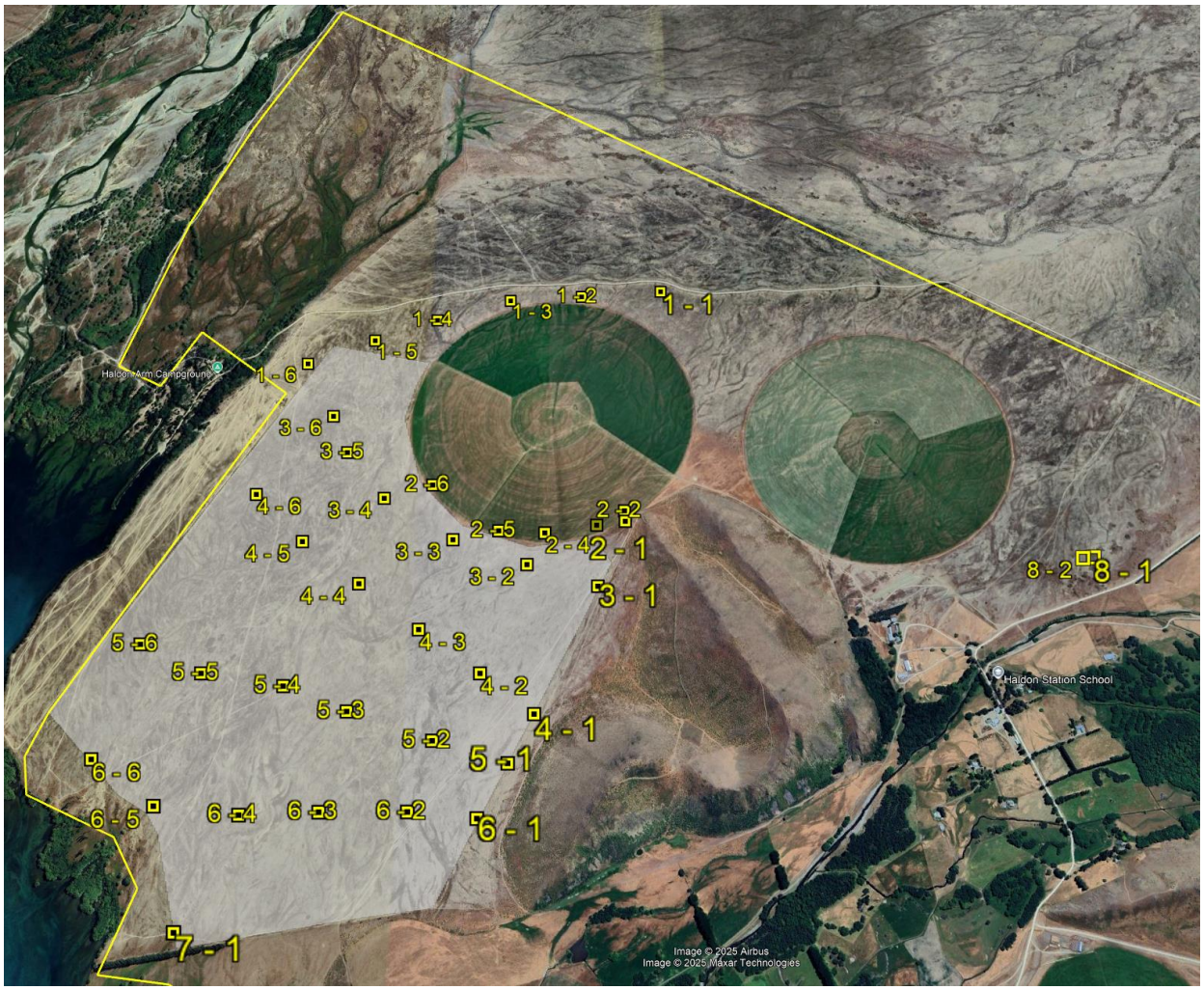

Figure 5. Solar site (grey fill), vegetation transects and plots and the area of adjacent similar outwash

on Haldon Station (yellow boundary).

In each plot eight 1 m^2 quadrats were randomly located for detailed species assessment. All species present in the whole plot were recorded and shrub density and height were measured. The large plot size and quadrat replication assesses the variation due to shallow and deep soil phases associated with former stream channels. Species in the surrounding vegetation were also examined and any additional species were recorded (Figures 6 - 7).

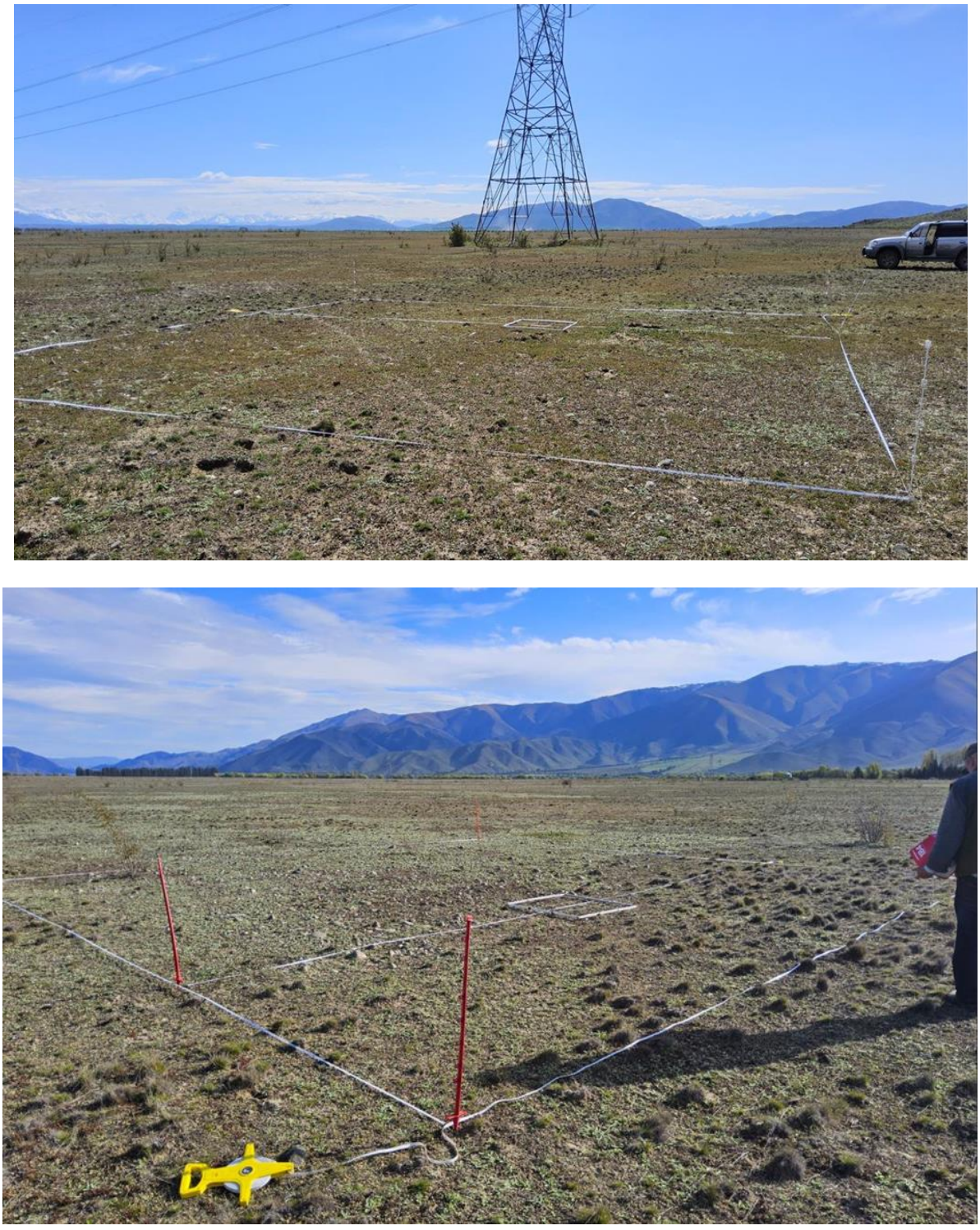

Figure 6. Vegetation assessment plots in typical vegetation representative of the main association across the entire site. The lower plot shows the effect of soil phases on vegetarian patterns.

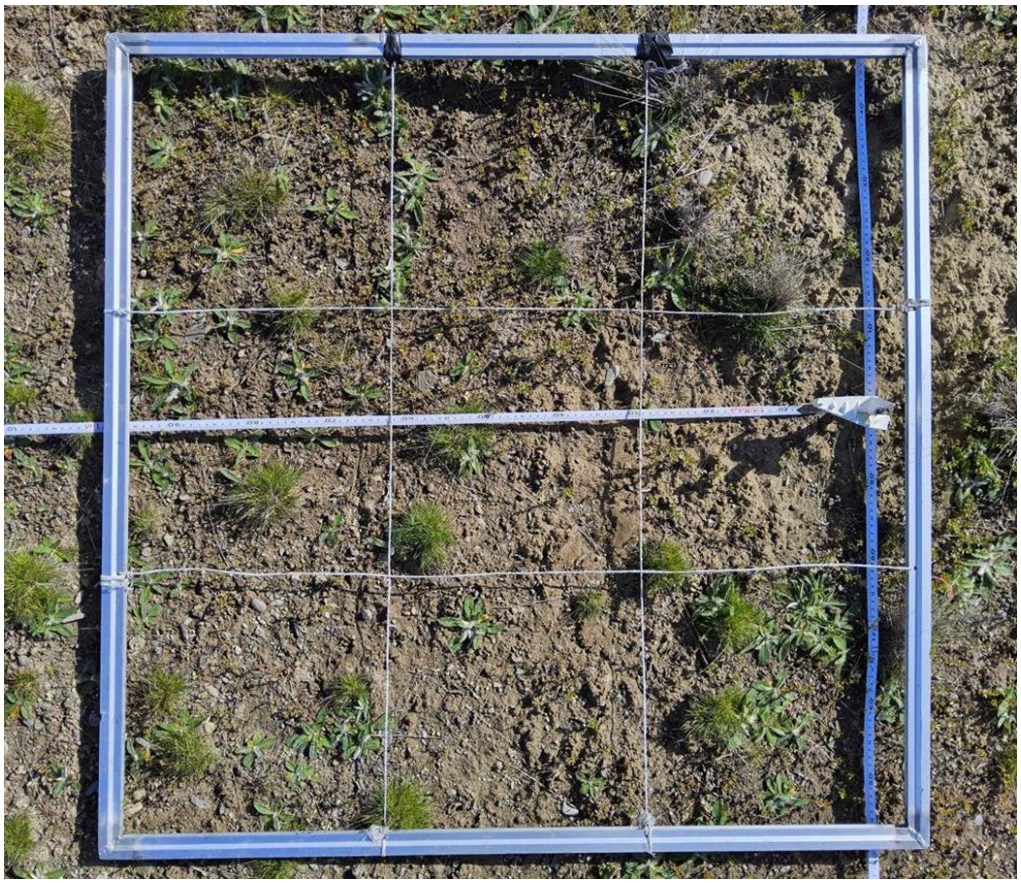

Figure 7. Vegetation assessment quadrat with typical ground cover, bare soil & stones, Chewing's fescue (green tufts) and Hieracium (light green rosettes);
Typical stature of the dominant dryland shrub, sweet briar rose and introduced grasses and herbs.

In addition to the solar site transects, we measured a large rabbit proof fenced exclosure (196 x 35 m)

established *ca.* 1980, 1.8 km east of the solar site, on the same outwash surface and with the same vegetation (Figure 8). Seven 35 m transects were located inside the exclosure, spaced 5 m apart, and were directly paired with a grazed transect, offset 20 m from the exclosure. Eight 1 m^2 quadrats were located at 5 m intervals along each transect. This allowed assessment of the long-term effect of rabbit and stock grazing, with obvious visual differences in species composition and Chewing's fescue tussocks and grasses when ungrazed (Figure 8).

Figure 8. Haldon long-term vegetation exclosure 1980 – 2024, showing soil phase and grazing contrasts.

Two distinct, but minor, dryland vegetation communities occurred adjacent to the site (T2-1, T7-1). These

had higher soil moisture supply. One, directly adjoining the pivot near a gate where stock concentrated, also had higher fertility resulting from dung and urine deposition (T2-1, Figure 9a). The other representing the greatest development in small seepage depression channels, occurred near the southern end of the site near Lake Benmore. T7-1, Figure 9b). Neither is a natural inland wetland due to dominance of non-hydrophilic species.

Figure 9. Upper: High moisture and fertility vegetation association immediately downwind of the pivot with possible spray drift, vegetation plot and species quadrat assessment (Transect 2 plot 1), Lower: Former stream channel with high moisture availability adjacent to Lake Benmore showing the growth response and measurement of sweet briar (Transect 7 plot 1).

2.2 Fauna

Birds (avifauna), lizard and skinks (herpetofauna) and insects (invertebrates) were assessed in survey stations along a specific route along two transects (Figure 10). In addition all fauna was recorded during the vegetation

surveys or when driving or walking thorough the solar site.

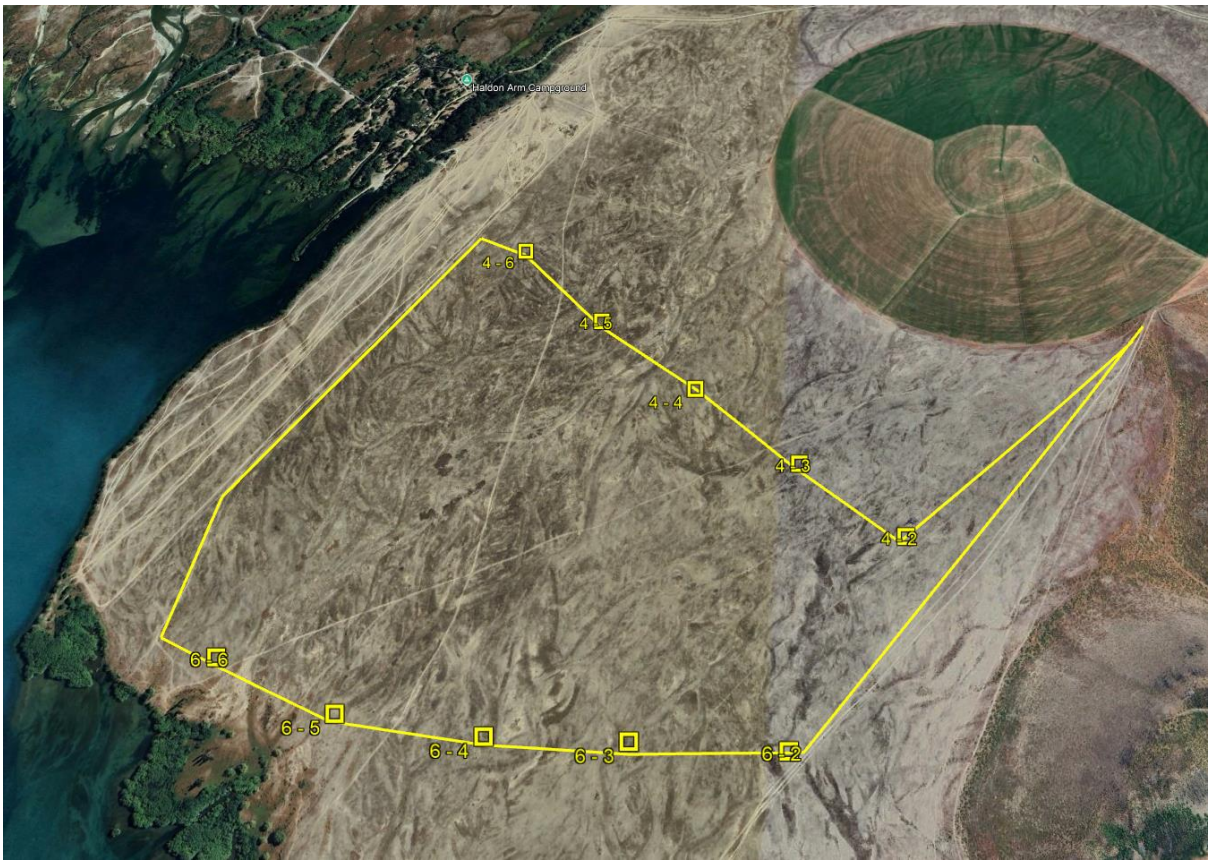

Figure 10. Site fauna assessment route and survey stations.

Herpetofauna were assessed by visual observation after searching and by using ten shaded pit-fall container assessments (cover Height 14-16.5 cm, container Height x Width x Depth 12.5 x 8.5 x 10.5 cm), with moistened sponge bases, baited with pears and/or peaches and water (Figure 11).

Ten 100 x 20 cm sand strips were installed next to the pitfall traps and examined for animal tracks.

These were installed on the 21st October and monitored until the 20th November, with bait replacement. As skinks were only to be observed, and not handled, no formal requirement for their assessment was required, as discussed with the Department of Conservation.

Figure 11. Covered and opened pitfall trap with darkling beetle, fruit bait, water and sponge,

Avivauna and animals were observed in 3-5 minute early morning and late evening counts at the 10 survey stations using paired observers with binoculars along a set 6.2 m route in the center and the southern end of the site and listening to calls (T3, T6; Figure 10). Birds and other fauna were also noted throughout the day during vegetation assessments and when driving through the site.

Figure 10. Fauna observation at site Transect 6 plot 6.

3. Ecological Context.

The site is in the Pukaki Ecological District which is the dry outwash plains between Lakes Tekapo and Benmore[2] . The site geology is greywacke fluvioglacial outwash deposits. The climate is semi-arid with cold winters, warm summers and 350 mm of annual rainfall. The site's Mackenzie soils have a variable depth of topsoil over gravels and are but drought prone in summer.

The site vegetation at human occupation was probably a mixture of dryland scrub and snow tussock (*Chionochloa rigida*) grassland. Only isolated remnants of this low dryland community or individual tussocks now remain in the Mackenzie Basin, and only a few remnants remain, on Omahau Station, though in higher rainfall on deeper soils, and on the Grampians station, on low outwash fan in the Hakataramea valley where its remoteness has resulted in its survival (Figure 11).

Figure 11. Lowland snow tussock grassland on fan outwash, Grampians Station.

This community may have intergraded into a short tussock (Festuca novae-zelandiae) grassland community with associated blue tussock (*Poa colensoi*), native grasses and prostrate herbs such as *Coprosma petriei* as well as scrub principally matagouri (*Discaria toumatou*) and coprosmas (e.g. Coprosma propinqua). Following early European pastoral burning and introduction of mammalian grazing and browsing this community was transformed into short tussock grassland.

[2] Espie et al. 1984. Mc Ewan 1987..

As this is so critical for evaluating the vegetation and its ecological significance at Haldon, following the next major ecological factor, Hieracium invasion, I present the long term scientific research which has quantitatively investigated vegetation change from the 1960's at adjacent basin floor sites on the same fluvioglacial outwash as at Haldon (Figure 12)[3].

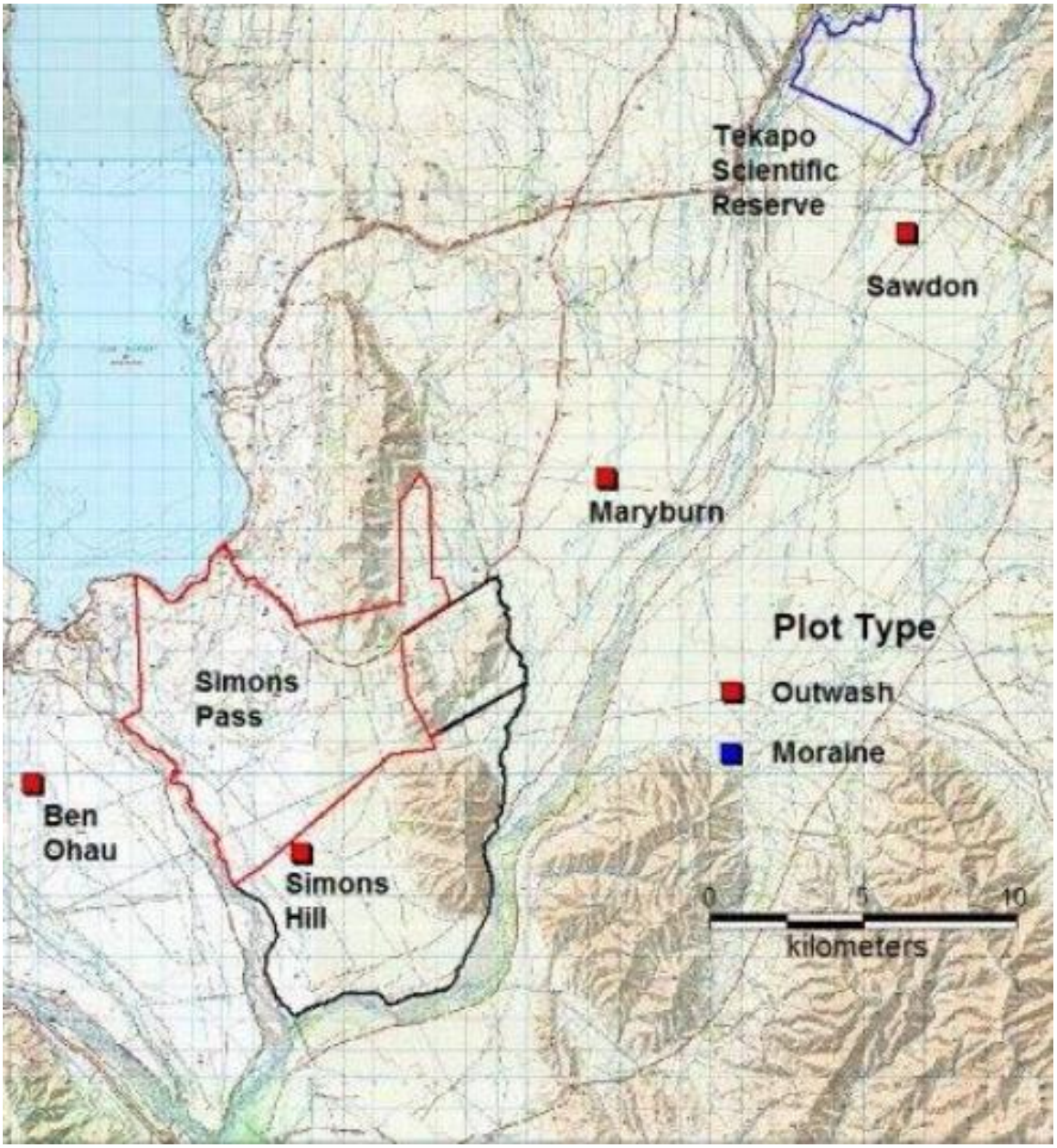

Figure 12. Long-term scientific research sites in the mid-Mackenzie basin.

At the closest sites to the solar site, Ben Ohau and Simons Hill Station, there was a huge decline in indigenous fescue tussock cover with Hieracium invasion accompanied by a large increase in bare ground and Hieracium cover (Figures 13 - 15).

[3] Connor 1964, Espie 2024.

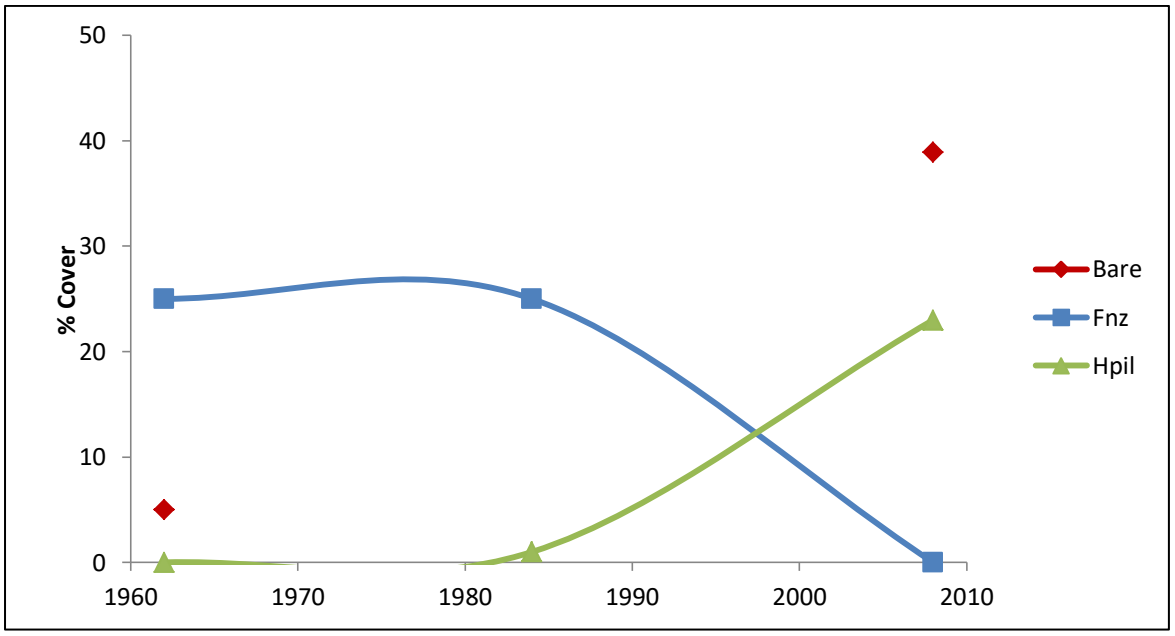

Figure 13. Long term change in ground cover 1962-2008, Simons Hill station, Pukaki outwash surface. Legend: Fnz: fescue tussock; Hpil: *Hieracium pilosella*; Bare: bare soil.

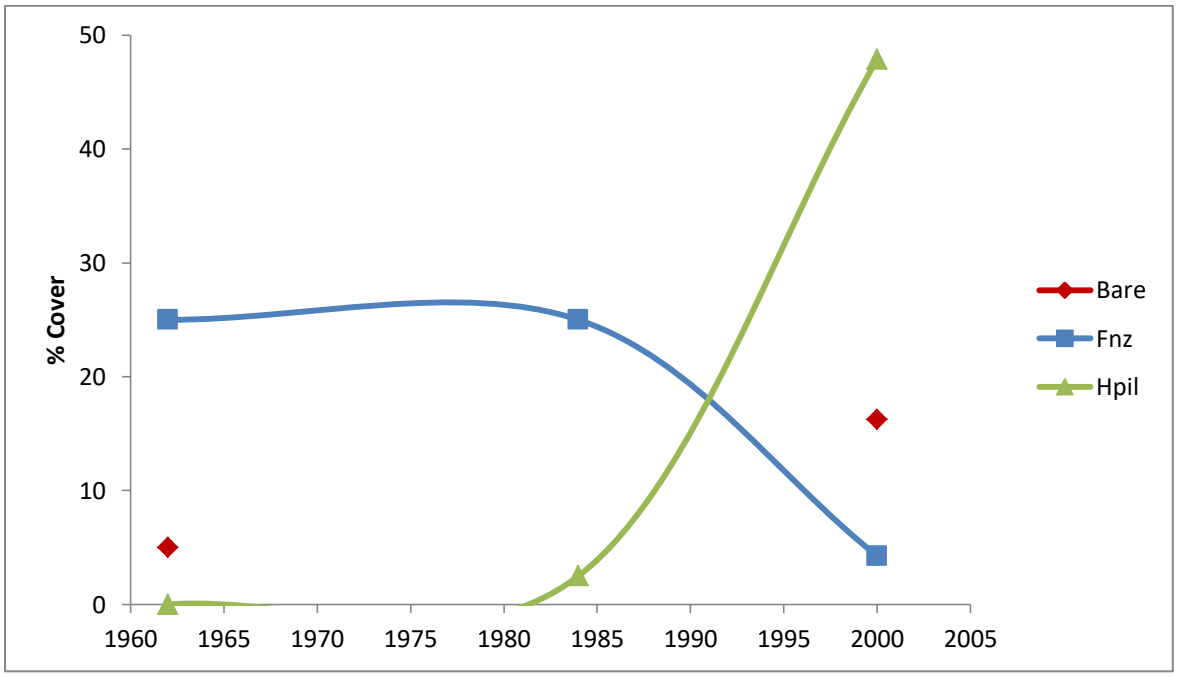

Figure 14. Long term changes in ground cover, Ben Ohau station, Pukaki outwash. Note the large increase in bare ground associated with Hieracium invasion.

Visually this is what happened at Simons Hill Station.

Figure 15. Simons Hill, Pukaki outwash in 1995 was fescue tussock grassland.
but by 2010 it had totally changed to Hieracium herb field and bare ground.

Species biodiversity, both indigenous and introduced, deceased over this period in each site (Figure 16).

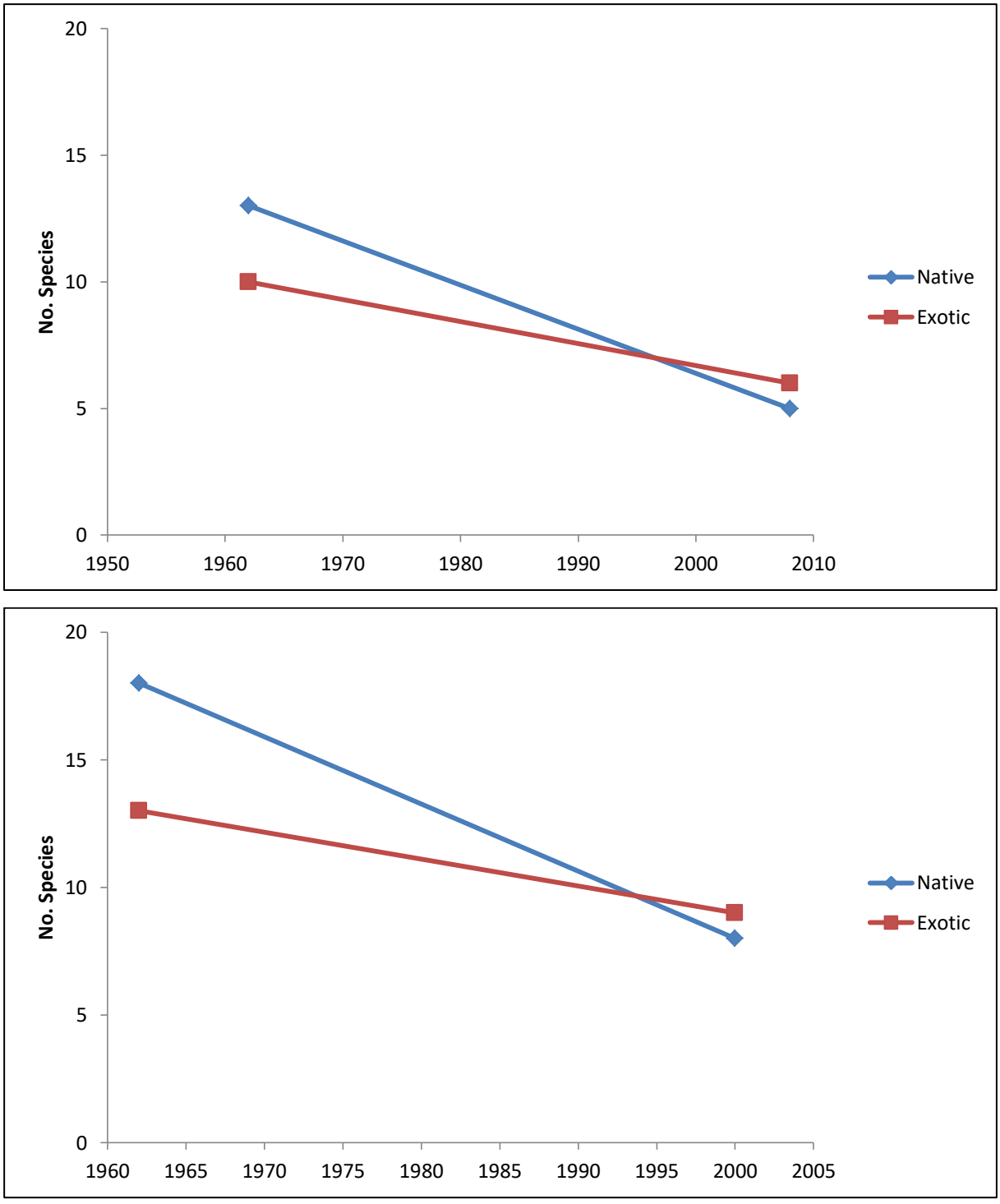

Figure 16. Long term change in species biodiversity, 1960 -2010.
Upper: Simons Pass Station, Lower: Ben Ohau Station, Pukaki outwash.

The effect of grazing was investigated using rabbit and stock proof exclosures (Nil grazing), stock proof exclosures (Rabbit without Stock grazing; +R-S) and grazing by both (+R+S)[4]. Grazing had little effect on the increase of Hieracium or the decline of fescue tussock (Figure 17) or the herb sheep's sorrel (Figure 18).

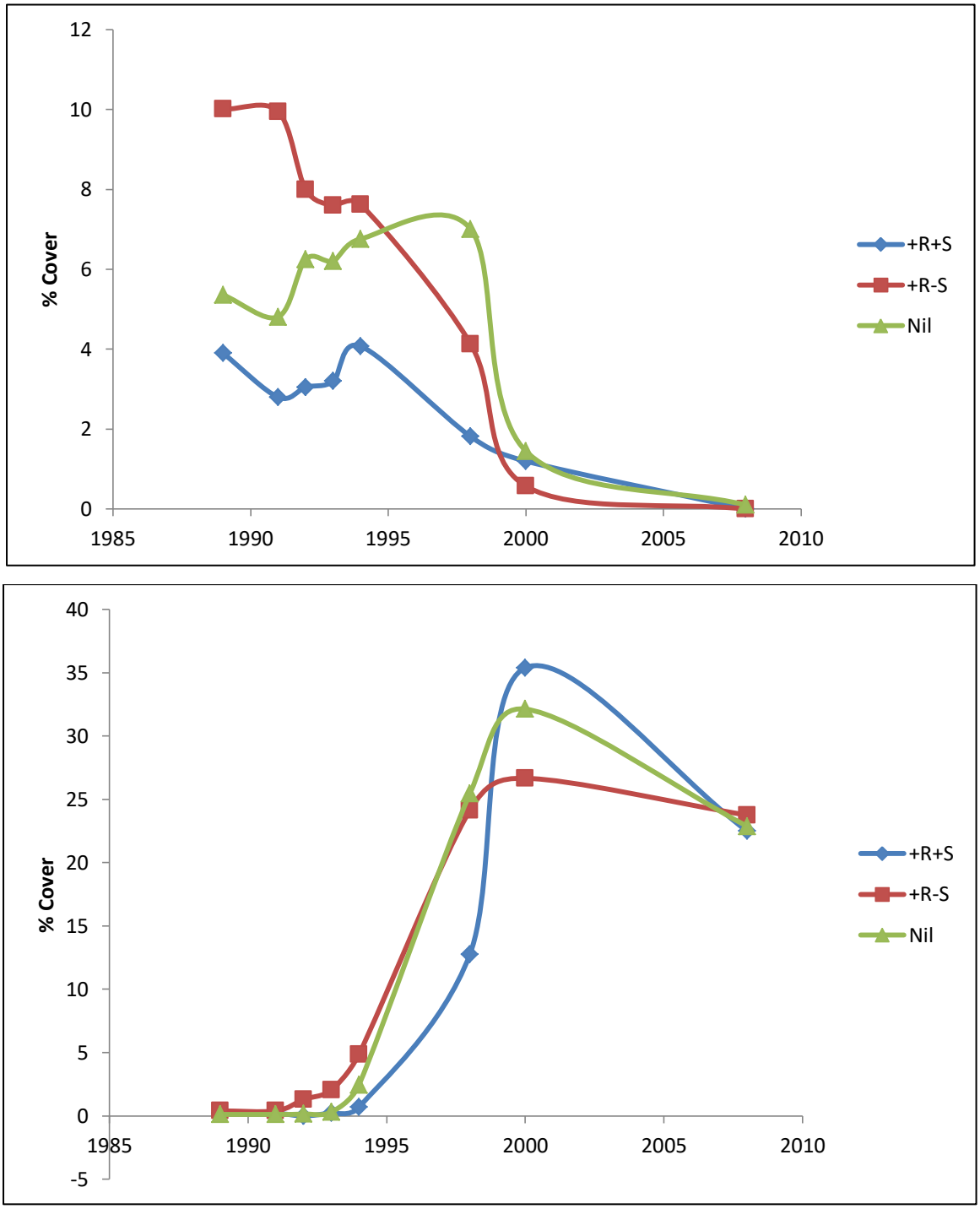

Figure 17. Change in fescue tussock (Upper) and Hieracium pilosella (Lower) 1990 -2008.

[4] Meurk et al 2002.

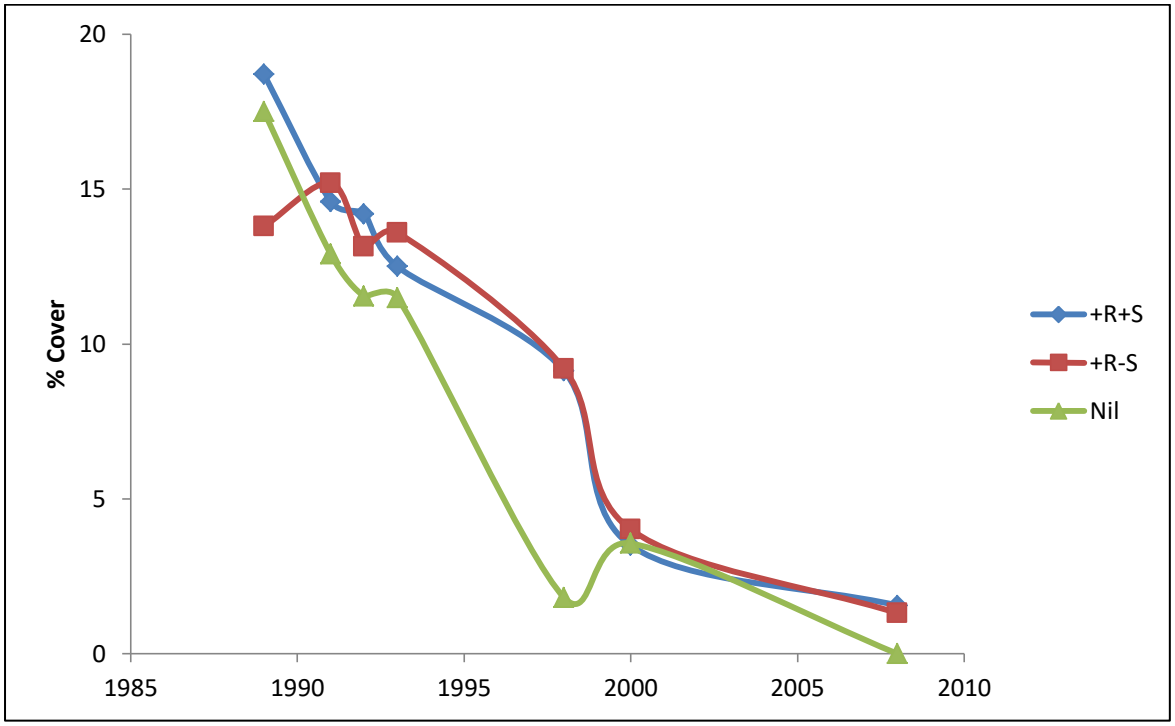

Figure 18. Change in a typical introduced herb, sheep's sorrel, Simons Hill, Pukaki outwash 1990 -2008.

A parallel decline in biodiversity occurred on Pukaki fluvioglacial outwash at Ben Ohau Station (Figure 19).

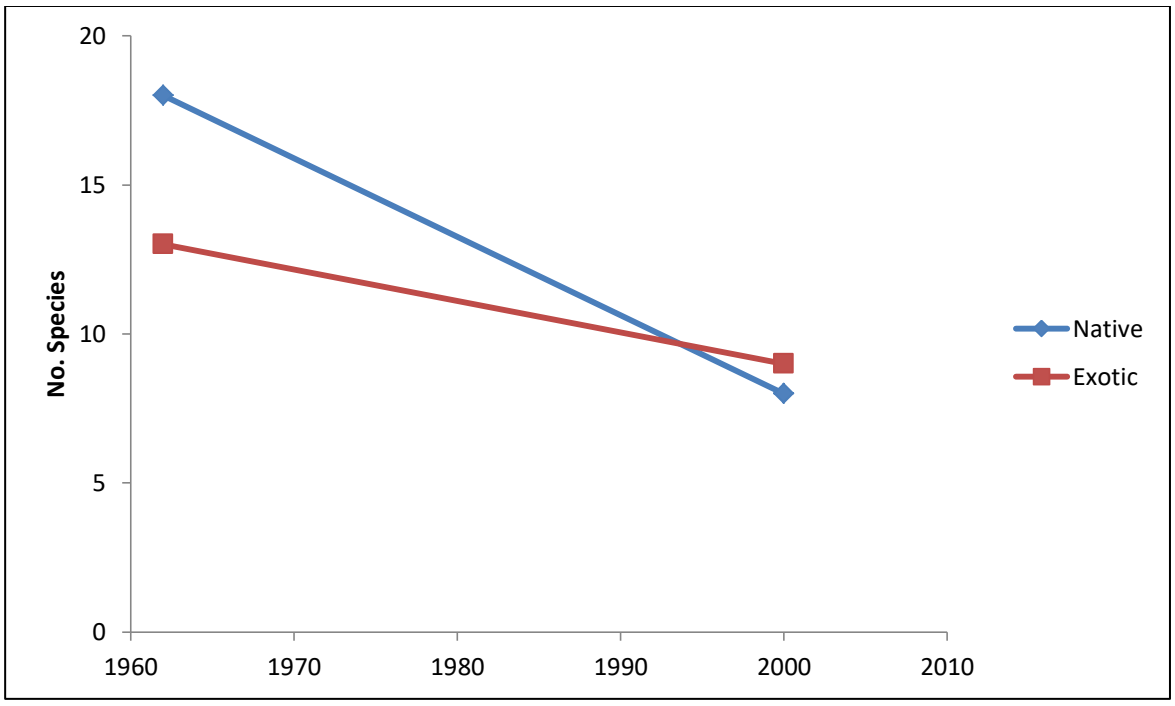

Figure 19. Long term changes in species biodiversity, Ben Ohau station, Pukaki outwash.

The same increase and eventual stabilisation in *Hieracium* cover also occurred on the Tekapo fluvioglacial outwash surface, with no evidence of return or recovery to initial levels, at Maryburn and Sawdon Stations (Figure 20).

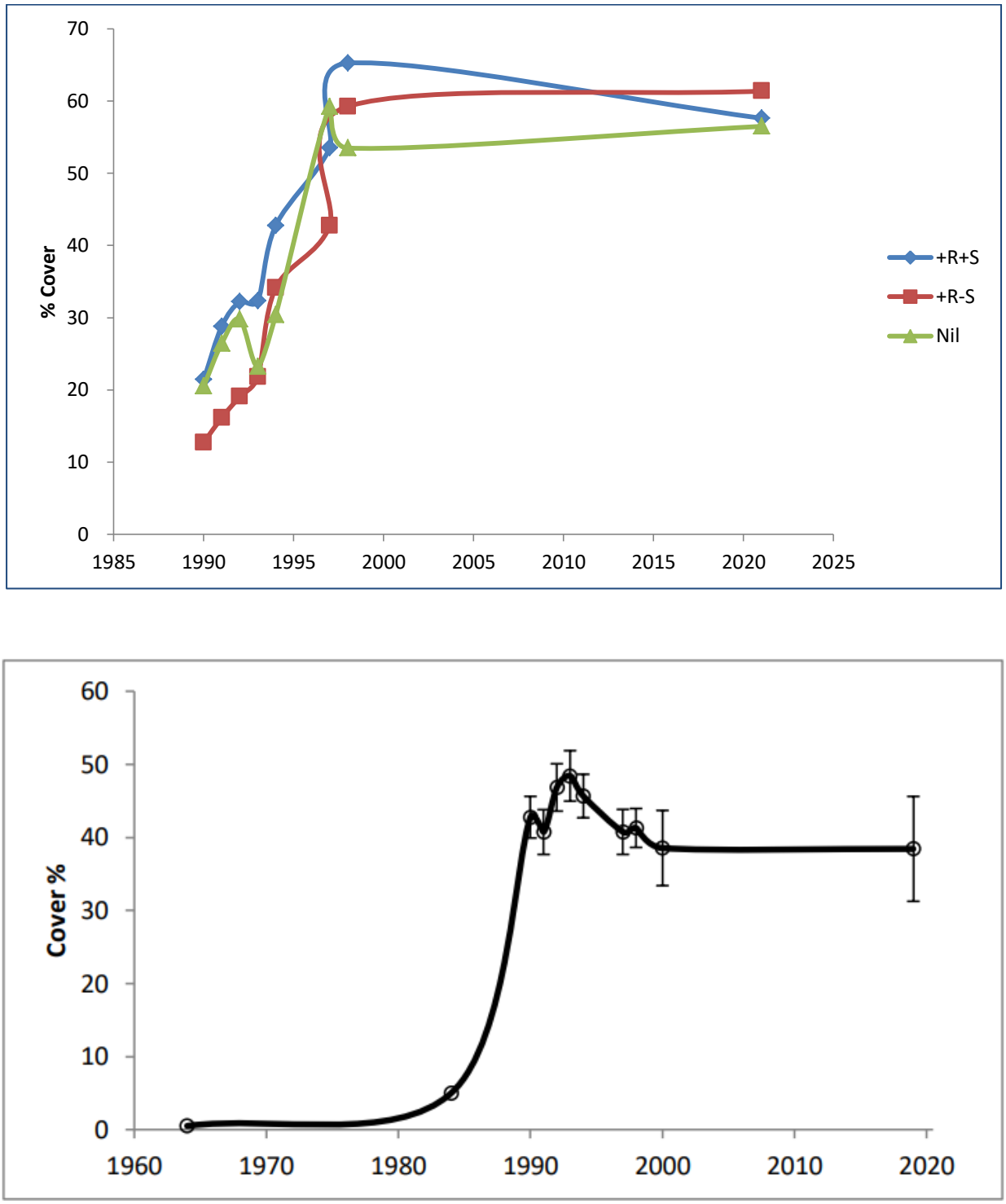

Figure 20. Changes in *Hieracium pilosella* cover on Tekapo outwash
Upper: Maryburn 1990 -2021; Lower Sawdon 1962-2019 ± Standard Error of the Mean.

At Maryburn there was over 50% decline in both indigenous and introduced species number over this period

(Figure 21), particularly with herbs (Table 2).

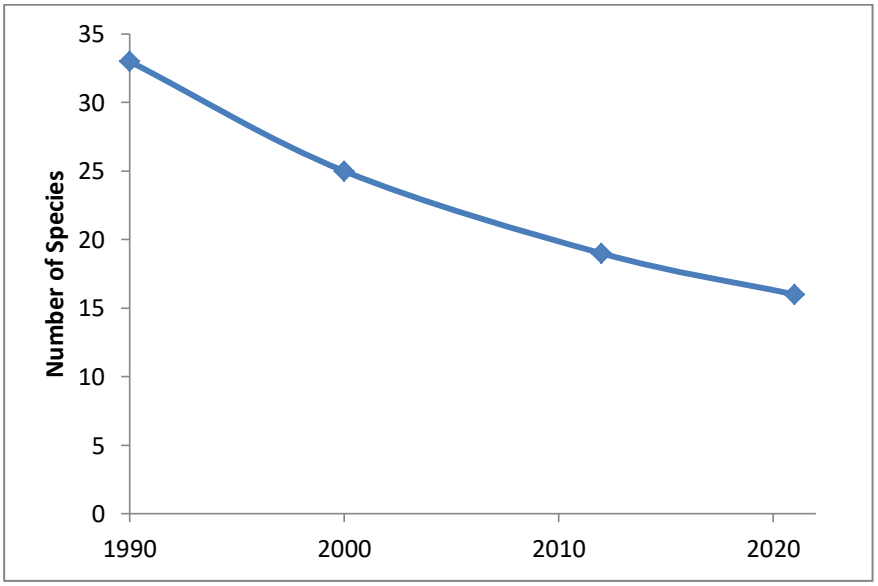

Figure 21. Change in indigenous species biodiversity 1990 -2021, Maryburn Station, Tekapo outwash.

Table 2. Change in species occurrence Maryburn Station 1990 -2021, Tekapo outwash.

Class	Number of Species				2021	
	1990	2000	2012	2021	% of 1990	% change
Introduced						
Grass	4	4	3	3	75	-25
Herb	13	9	6	5	38	-62
Total	**17**	**13**	**9**	**8**	47	-53
Indigenous						
Shrub	3	3	3	3	100	0
Tussock	2	2	2	2	100	0
Grass	4	6	5	3	75	-25
Herb	22	13	8	7	32	-68
Moss	2	1	1	1	50	-50
Total	**33**	**25**	**19**	**16**	48	-52
Total	**50**	**38**	**28**	**24**	48	-52

This evidence across different basin floor outwash sites and environments shows the decrease in fescue tussock and other species in the Pukaki Ecological District was directly correlated to the increase in Hieracium. This is consistent with what occurred elsewhere in Mackenzie basin floor outwash communities, in the western Omarama Ecological District, at Tara Hills Research Station (Figure 22).

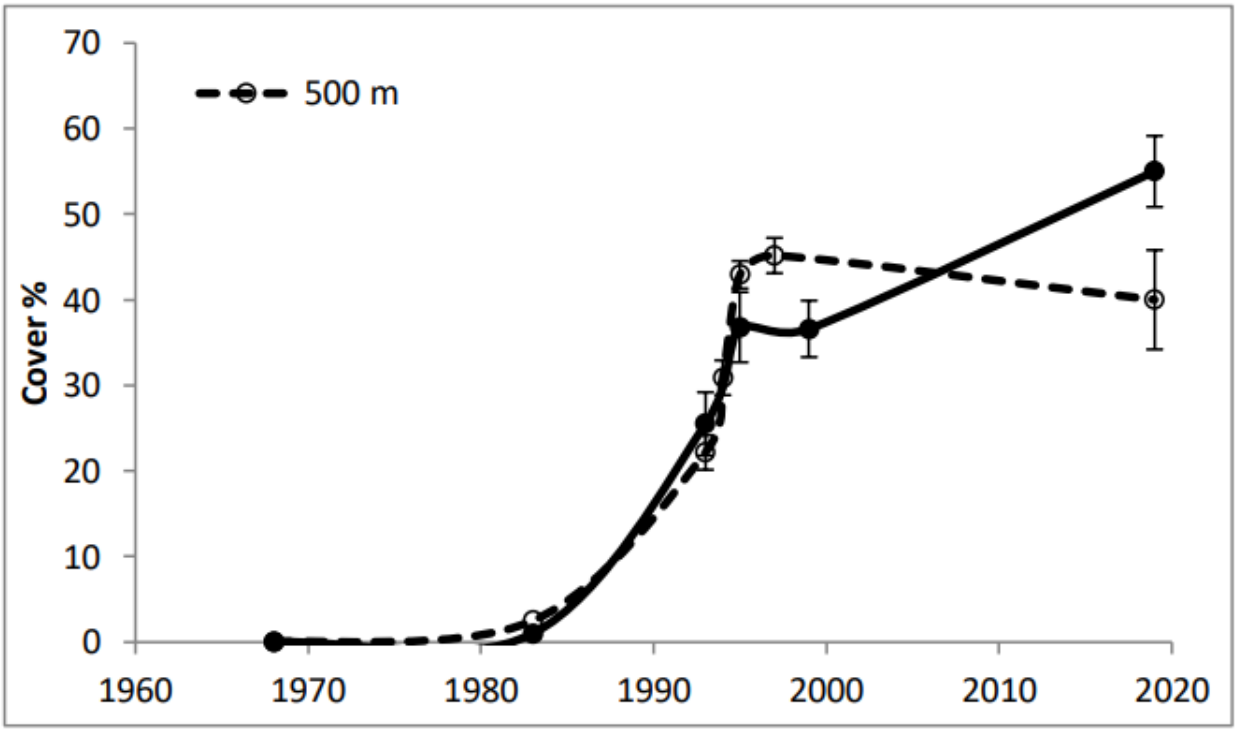

Figure 22. Changes in *Hieracium pilosella* cover on Ahuriri outwash 500 m (dotted line) and at 900 m solid line ± Standard Error of the Mean.

The fescue tussock and species biodiversity decline at Tara Hills and bare ground increased following Hieracium invasion[5] was shown to be due to competitive exclusion by Hieracium for soil moisture and nutrients. Injection of radioactive sulphur was used to determine the extent to which Hieracium competed for nutrients on the Ahuriri outwash plain[6]. In this semi-arid environment Hieracium patches exclude vegetation and, as other studies also show, this increases bare ground[7]. Hieracium extracted sulphur from up to 1 m from the center of patches, extracted soil moisture and increased the acidity of the soil. The superior water and nutrient uptake by Hieracium and its competitive ability is the reason that Hieracium is able to displace other plants and explains the decline in indigenous species biodiversity in fluvioglacial basin floor outwash ecosystems across the Mackenzie Basin and at Haldon.

[5] Espie 2001.
[6] Boswell & Espie 1998.
[7] McIntosh & Allan 1993 .

The site classified as a 'critically underprotected' land environment as a planning tool (Cieraad et al. 2015). This assessment rests on the criteria of less than 10% of a land environment's indigenous vegetation being protected. Fluvioglacial outwash is naturally uncommon in New Zealand, and this contributes to the site's assessment. The critical factor is that it is the indigenous vegetation communities and faunal populations that are the primary determinant of ecological or conservation value and though Haldon falls within this environmental class, these are primary critera on which ecological significance must be assessed.

The extent of locally adjacent protected conservation areas, totaling 18, 250 ha is shown in Figure 23 and are listed in Table 3, which with other similar basin floor areas total 37,500 ha.

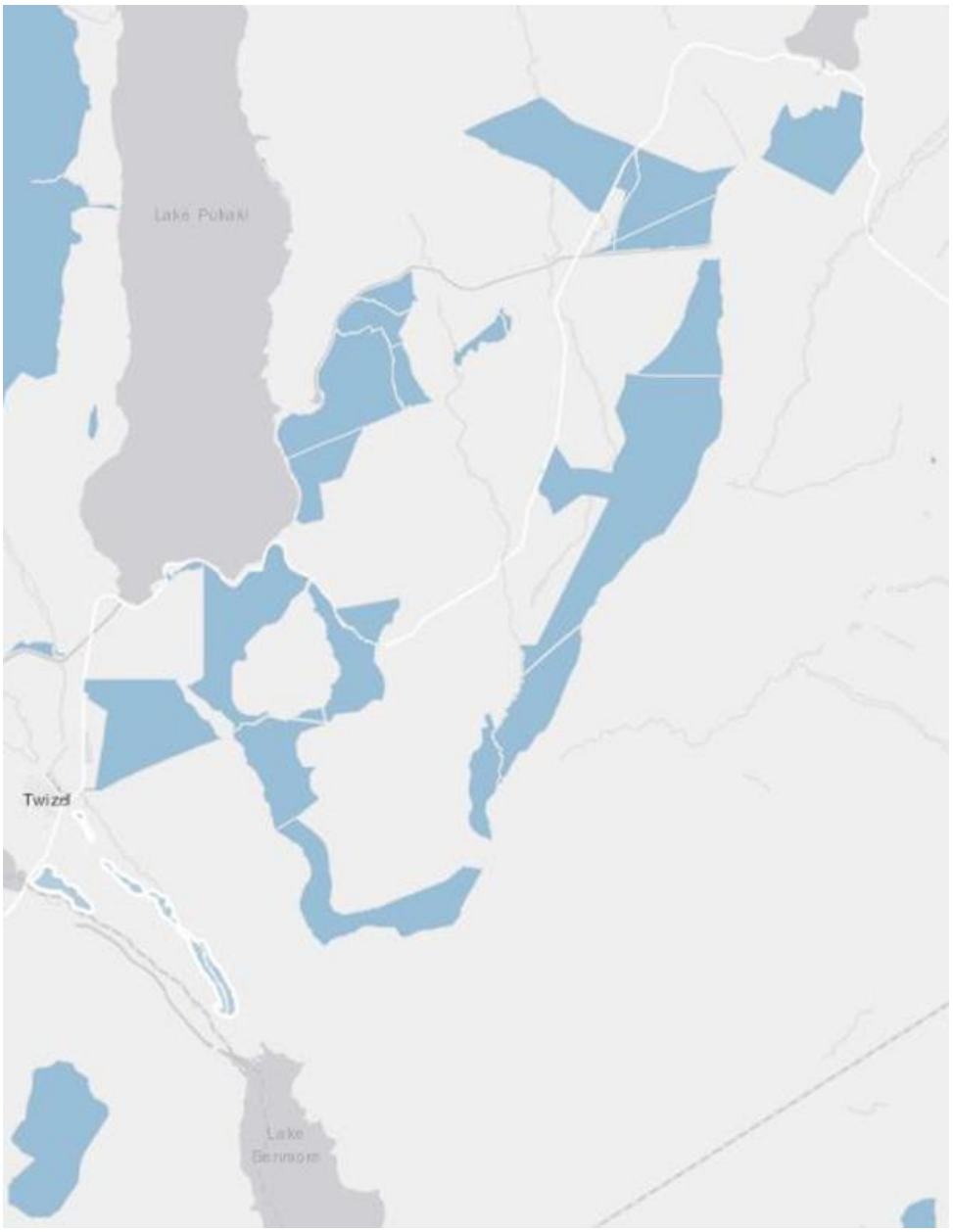

Figure 23. Conservation Areas (blue fill) in and adjacent to the Pukaki Ecological District and the Haldon solar site immediately north of Lake Benmore.

Table 3. Extent of Mackenzie Basin Floor Conservation Areas

Conservation Area	Area (ha)
Adjacent Basin Floor	
Lake Tekapo Scientific Reserve	1,009.6
Tekapo Triangle	444.3
Irishman Creek Conservation Area	2,607.1
Irishman Creek Scenic Reserve	1,354.0
Conservation Area A The Wolds	754.0
The Wolds Scientific Reserve	149.0
Maryburn	4,097.2
Pukaki River Tekapo River Confluence Dryland Recovery	1,183.0
Simons Hill Conservation Area	373.1
Simons Pass Conservation Area	3,131.4
Ben Ohau Conservation Area	1,362.1
Ohau Downs	1,792
	18,256.8
Additional Mackenzie Basin Floor	
Lower Ahuriri Riverbed Conservation Area True Left	59
Twin Peaks	136
Tasman Riverbed	4,100
NZ Defense Force Conservation Management	15,000
	19,295
Total	**37,551**

4. Ecological Survey Results

4.1 Vegetation

Ground cover in the solar site was 79% bare soil, stones and introduced plants, where two adventive species were dominant, and mouse-ear hawkweed (*Hieracium pilosella*) and Chewing's fescue (*Festuca rubra*). Indigenous vascular plant cover was 0.1%. This was repeated in adjacent dryland and exclosure sites, but not irrigated or moister sites (Tables 4, 5; Values <0.01 not shown..

Table 4. Average ground cover % in outwash vegetation communities (± Standard Error of the Mean).

Vegetation Class	Solar Site	Adjacent Dryland	Adjacent Irrigated	Adjacent Moist High Fertility	Adjacent Moist Low Fertility
No. Quadrats	192	48	40	8	8
Bare Soil	20.8 ± 3.1	32.7 ± 3.3	0.8 ± 0.6	2.9±0.01	0.1±0.01
Stones	15.2 ± 2.8	19.6 ± 6.2			
Rock	0.2 ± 0.1	0.7 ± 0.3			0.2
Dung	0.2 ± 0.1	1.2 ± 1.1	0.5 ± 0.2	2.0	4.5±0.1
Hieracium	16.5 ± 2.2	25.9 ± 4.9		5.4 ±0.02	
Fescue	4.6 ± 0.7	3.6 ± 1.0			
Sweet Briar				1.0 ±0.01	0.5
Other Exotic Plants	21.5 ± 6.7	6.7 ± 3.5	98.7 ±0.7	88.8± 0.02	94.7±0.2
Other Native Plants	0.1 ± 0.0	0.1 ± 0.0			
Cryptograms					
Moss	12.6 ± 3.0	2.5 ± 0.8			
Lichen	8.3 ± 1.2	8.0 ± 2.4			
Total	**100**	**100**	**100**	**100**	**100**

Table 5. Average ground cover % in outwash exclosure communities (SEM: Standard Error of the Mean).

Cover Class	Grazed Average	Grazed SEM	UnGrazed Average	UnGrazed SEM
Soil & Stones	69.7	1.3	23.7	0.5
Hieracium + Fescue	19.9	1.0	19.1	1.8
Σ Introduced	27.5	1.2	63.5	3.9
Σ Indigenous	0.1	0.0	0.1	0.0
`	2.7	0.3	12.8	2.5

The frequency of occurrence of species in each transect in the solar area is listed for introduced species in Table 6 and for indigenous species in Table 7. Note that in these tables the group averages are affected by the number of species present in a group.

Table 6. Frequency of occurrence of introduced plant species (%).

Species	Adjacent	Pivot	Solar Site				Moist		Solar
Transect	T1	T2	T3	T4	T5	T6	T7	T2-1	Ave.
Introduced									
Grass									
Agrostis capillaris	0	0	0	0	0	0	100	100	**0**
Aira caryophyllea	0	0	0	0	100	0	0	0	**25**
Anthoxantum odoratum	13	68	25	0	13	13	88	25	**13**
Bromus diandrus	13	0	0	0	0	0	0	0	**0**
Bromus tectorum	13	0	38	13	0	0	0	25	**13**
Dactylus glomerata	0	38	0	0	0	0	0	25	**0**
Festuca rubra	96	0	92	81	100	93	100	25	**91**
Lolium perenne	56	100	0	0	0	0	0	63	**0**
Poa pratensis	0	0	31	0	0	88	100	88	**30**
Vulpia bromoides	0	0	0	0	100	38	13	100	**34**
Average	**19**	**21**	**19**	**9**	**31**	**23**	**40**	**45**	**21**
Herb									
Aceana agnipila	13	0	13	13	0	50	0	25	**19**
Achillea millefolium	0	0	0	0	0	0	75	0	**0**
Arenaria serpyllifolia	0	0	0	0	38	0	0	0	**9**
Cerastium fontanum	25	13	31	25	56	13	0	25	**31**
Cuscuta epithymum	0	0	0	0	13	0	0	0	**3**
Echium vulgare	0	0	0	0	0	13	0	88	**3**
Erodium cicutarium	0	0	13	13	13	63	0	13	**25**
Erophilla verna	46	0	69	58	52	43	0	13	**55**
Hieracium pilosella	100	0	100	100	100	98	50	100	**99**
Hypericum perforatum	0	0	28	17	38	65	0	0	**37**
Hypochaeris radicata	0	13	0	0	0	0	50	0	**0**
Leucanthemum vulgare	0	0	0	0	0	0	50	0	**0**
Lotus pedunculatus	0	0	0	0	0	0	75	0	**0**
Myosotis discolour	78	0	73	60	73	58	0	25	**66**
Plantago lanceolata	0	13	0	0	0	0	63	0	**0**
Ranunculus repens	0	0	0	0	0	0	38	0	**0**
Rumex acetosella	75	0	71	77	71	75	50	25	**73**
Spergularia rubra	13	0	13	13	0	19	0	0	**11**
Taraxacum officinale	0	25	0	0	0	0	0	0	**0**
Trifolium arvensis	38	0	75	13	13	100	0	88	**50**
Trifolium pratense	0	0	0	0	0	0	0	25	**0**
Trifolium repens	0	100	0	0	0	0	100	100	**0**
Verbascum thapsus	0	0	0	0	0	0	0	13	**0**
Veronica verna	71	45	90	77	65	63	0	100	**74**
Average	**19**	**9**	**24**	**19**	**22**	**27**	**23**	**27**	**23**
Shrub									
Rosa rubiginosa	0	0	13	13	21	19	88	100	**16**
Tree									
Pinus contorta	0	0	0	0	0	0	13	0	**0**

Table7. Frequency of occurrence of native plant species, mosses and lichens (%).

Species	Adjacent	Pivot	Solar Site				Moist		Solar
Transect	T1	T2	T3	T4	T5	T6	T7	T2-1	Ave.
Grass									
Poa maniototo	0	0	31	50	88	50	0	0	**55**
	0	**0**	**31**	**50**	**88**	**50**	**0**	**0**	**55**
Herb									
Carex breviculmis	38	0	13	13	31	0	0	0	**14**
Carex coreacea	0	0	0	0	0	0	100	0	**0**
Luzula ulophylla	0	0	13	0	0	0	0	0	**3**
Meuhelbekia axillaris	0	0	0	0	100	13	0	0	**28**
Microtis uniflora	0	0	0	0	13	38	0	25	**13**
Thelymitra longifolia	0	0	13	13	13	13	0	0	**13**
Average	**5**	**0**	**5**	**4**	**22**	**10**	**14**	**4**	**11**
Lichen									
Xanthoparmelia semiviridis	100	0	85	100	100	100	0	100	**96**
Cladia spp.	13	0	16	13	21	38	0	0	**22**
Cladia aggregata	59	0	70	88	75	65	0	0	**74**
Cladonia spp.	0	0	13	0	0	0	0	0	**3**
Physcia spp.	52	0	38	43	60	80	0	50	**55**
Usnea spp.	0	0	0	0	38	0	0	0	**9**
Xanthoparmelia reptans	85	0	73	90	81	100	0	88	**86**
Xanthparmelia mougeotina	79	0	92	94	75	92	0	88	**88**
Average	**49**	**0**	**48**	**53**	**56**	**59**	**0**	**41**	**54**
Moss									
Tortula spp. mucronifolia?	0	0	0	0	88	0	0	0	**22**
Hypnum cupressiforme	13	0	13	19	25	44	0	0	**25**
Triquetrella papillata	0	0	0	0	50	0	0	0	**13**
Dicranoloma billardieri?	0	0	0	0	53	0	0	0	**13**
Hypnum spp.?	0	0	50	50	16	0	0	0	**29**
Polytrichum juniperinum	13	0	63	54	50	63	0	13	**57**
Average	**4**	**0**	**21**	**20**	**47**	**18**	**0**	**2**	**26**

Values <1% not shown.

Only four of the vascular native plants observed across the entire solar site are ranked in the low 'At Risk' category (Table 8) and, excluding *Poa maniototo*, all of these occur at very low frequency < 0.1 % occurrence or were absent in survey plots (Table 7).

Table 8. Threat ranking of native vascular species[8]

Name	Scientific Name	Threat Ranking
Grass		
Lindsay's Poa	*Poa lindsayi*	Not Threatened
Desert Poa	*Poa maniototo*	At Risk – Declining
Danthonia	*Rytdiosperma pumilum*	Not Threatened
Herb		
Grassland sedge	*Carex breviculmis*	Not Threatened
Cuttygrass	*Carex coriacea*	Not Threatened
Geranium	*Geranium brevicaule*	Not Threatened
Patotara	*Styphelia nesophila*	Not Threatened
Red woodrush	*Luzula rufa var albicomans*	Not Threatened
Creeping pohuehue	*Muehelbekia axillaris*	Not Threatened
Onion-leaved orchid	*Microtis uniflolia*	Not Threatened
Pohuehue	*Muehenbekia axilaris*	Not Threatened
Common scabweed	*Raoulia australis*	At Risk – Declining
Scabweed	*Raoulia beauverdii*	At Risk – Declining
Scabweed	*Raoulia hookeri var hookeri*	Not Threatened
Celadon mat daisy	*Raoulia parkii*	At Risk – Declining
Slender chickweed	*Stellaria gracilenta*	Not Threatened
White sun orchid	*Thelymitra longifolia*	Not Threatened

The threat rankings of non-vascular species are less well established, partly due to taxonomic and lower numbers of field identification surveys, but the most frequently occurring species on site, *Polytrichum juniperium* is globally widespread moss, *Cladia aggregata* is the most widely distributed lichen in New Zealand and *Xanthoparmelia semiviridis*, though also a widespread dryland lichen, is considered 'At Risk' [9] on the grounds of possible agricultural intensification.

[8] Rolfe et. al 2014, deLange et al. 2024.
[9] de Lange et al .2018

Sweet briar shrub density and growth were low in the solar and adjacent dryland outwash but strongly responded to moisture and soil fertility (Figure 9; Table 9).

Table 9. Sweet Briar density and height (cm).

Site	Fertility	Plots	Average No. ha $^{-1}$	Height cm Min	Mean	Max	Standard Error
Solar	Low	24	550	0	250	1,610	49
Adjacent	Low	6	64	0	46	172	26
Irrigated	High	5	0	0	0	0	
Moist	High	1	4,700	110	886	2,000	
Moist	Low	1	1,400	250	916	2,500	
Total		**37**	**1,383**	**0**	**218**	**2,500**	**274**

The exclosure grazing contrast showed that protection from rabbit and stock grazing had a large effect in reducing the area of bare soil and increased cover of other plants, mainly introduced herbs (Table 10).

Table 10. Ground cover (%) in the ungrazed exclosure (T8-1) and grazed grassland (T8-2) n = 35 quadrats per treatment ± Standard Error of the Mean.

Cover Class	Grazed Average	Grazed SEM	Un Grazed Average	Un Grazed SEM
Bare Soil	57	1.9	21	0.6
Stones	12	2.0	2	0.7
Rock	0.6	0.1	0.1	0.1
Dung	0.1	0.1	0.0	0.0
Hieracium	14	1.6	11	1.3
Fescue	6	0.5	8	2.3
Other Plants	8	1.7	44	8.2
Moss	1	0.3	10	3.6
Lichen	2	0.3	3	1.3

4.2 Fauna

Avifauna

Of the 16 bird species observed in, or adjacent to, the solar site, eight were introduced, and skylarks were the most frequently observed bird (Table 11). Birds were most frequently seen flying over the site with only the spur winged plover and pied stilt observed breeding, with chicks though on the center pivot. Skylarks, chaffinches, starlings, blackbirds, and paradise ducks were observed on the ground in the solar site and and variable oystercatchers on the center pivot.

Only one native species, the black fronted tern, is classified as Nationally Endangered. It was only observed at one location near the edge of the solar area near Haldon Arm camp ground. This species breeds in open shingle in braided river beds, feeds on aquatic insects or small fish in river channels and on terrestrial invertebrates, earthworms, grass grub larvae and skinks. It is a wide-ranging species found elsewhere in the Mackenzie Ecological Region, in coastal regions and as far as the North Island.

The key threats to the survival of the black fronted tern are riverbed habitat disturbance during breeding, weed invasion into riverbed habitat, and predation[10]. It is therefore highly probable that solar site is not used for breeding, as we did not observe this, and may be used primarily for terrestrial foraging. Therefore the proposed development will probably not adversely impact the black fronted tern breeding population given the extent of similar, or better local riverine habitat on Haldon and locally.

Table 11. Bird observed in or closely adjacent to the Solar Site and indigenous species threat ranking[11].

Name	Scientific name	Threat Status
Introduced		
Australian magpie	*Gymnorhina tibicen*	-
Canada goose	*Branta canadensis*	-
Chaffinch	*Fringilla coelebs*	-
Common starling	*Sturnus vulgaris*	-
Eurasian blackbird	*Turdus merula*	-
Eurasian skylark	*Alauda arvensis*	-
House sparrow	*Passer domesticus*	-
Mallard duck	*Anas platyrhynchos*	-
Indigenous		
Black fronted tern	*Chlidonias albostriatus*	Nationally Endangered
Paradise duck	*Tadorna variegata*	Not Threatened
Pied stilt	*Himantopus himantopus leucocephalus*	Not Threatened
Southern black-backed gull	*Larus dominicanus*	Not Threatened
Spur-winged plover	*Vanellus miles v. novaehollandiae*	Not Threatened
Swamp harrier	*Circus approximans*	Not Threatened
Variable oystercatcher	*Haematopus unicolor*	Not Threatened
White faced heron	*Egretta novaehollandiae*	Not Threatened

It is not known if solar arrays affect foraging on invertebrate or skink species, but they may have little effect, or if they do, the solar site only comprises a small part of the extensive local habitat.

[10] Wildlife Management Limited, Tarapirohe/ Balck Fronted Tern, www.wmil;.co.nz/project/tarapirohe-black-fronted-tern/
[11] Robertson et al 2021.

Herpetofauna

No lizards, geckos or skinks were observed, caught in pitfall traps, or their tracks recorded on sand strips. Weather conditions were favorable for basking and activity during the survey period. This absence indicates their absence or an extremely low population density. If present the species most likely to occur are the common skink (*Oligosoma polychroma*) or McCann's skink (*Oligosoma maccanni*). Both are common and widespread in other parts of the Pukaki Ecological District and Makenzie basin.

Invertebrates

Invertebrates were not formally surveyed as their habitat will remain under and between solar panels and the site has no known unique habitat features and therefore, excluding the limited infrastructure disturbance, their habitat will remain intact. The most commonly observed invertebrates in daylight were a common native grasshopper (*Sigaus australis* var. "semi-arid"), introduced honey (*Apis mellifera*) and bumble bees (*Bombus* spp. probably *terresteris*) an unidentified white moth or a white cabbage butterfly (*Pieris rapae*), and the nocturnal darkling beetles (Tenebrionidae) caught and released in pitfall traps. No rare grasshoppers, specifically *Sigaus minutus* or *Brachaspis robusta*, were seen after careful searching.

I assisted Dr Graeme White in his entomological surveys of moths (Lepidoptera) and grasshoppers (Orthoptera suborder Caelifera, Acrididea) in the Mackenzie basin and specifically on Haldon Station, during 1993-1994. I provided vegetation habitat surveys for him and participated in his invertebrate studies. This involved assessments of the threatened grasshopper *Sigaus minutus* and *Brachaspis robusta* populations. which was extremely useful in searching for the presence of these species on the site.

Animals

Rabbits were the most frequently observed animals, occurring thoroughout the site. The only other animal seen was a dead ferret (*Mustela furo*),, consistent with sand strip tracks. A dead chaffinch was found, suggesting that possibly that feral cats (*Felis catus***)** or stoats (*Mustela ermine*) may also be present.

5. Ecological Evaluation

Vegetation

The solar site is located within the Pukaki Ecological District which specifically represents basin floor environments and ecosystems in the Mackenzie Ecological Region[12]. It contains semi-arid dryland vegetation on fluvioglacial outwash in one of the driest parts of the Mackenzie basin[13]. Following the effects of Polynesian and European activity, primarily burning and introduction of grazing animals, the vegetation would have been short tussock grassland dominated by fescue tussock (*Festuca novae-zelandiae*) and associated grasses and herbs[14] as may be inferred from the occurrence of fescue tussock in the Haldon Exclosure. As Allan Innes, a former runholder at Haldon noted from family history, the subsequent invasion of rabbits from the 1880's had a severe and lasting impact on dryland vegetation productivity and species composition[15] at Haldon.

The introduction of sown pasture grasses, browntop, sweet vernal and Chewing's fescue and herbs commenced in 1859 at Haldon[16] and established a mixed dryland grassland community. The colonization of the invasive mat weed mouse-eared hawkweed (*Hieracium pilosella* syn. *Pilosella officinarum*) in the 1950's -70's[17] was the next species introduction that had a major effect on grassland species composition and cover. By competition for moisture and nutrients, as previously shown, in this dry, semi-arid fluvioglacial outwash environment this resulted in substantial reduction, or complete elimination, of fescue tussock and many associated indigenous species[18]. Indigenous vascular plants not only comprise 0.1% of vegetation cover on the site. I note that this effect is mitigated to some extent in higher rainfall zones and fescue tussock may persist in deeper soils with greater moisture holding capacity.[19]

This competition has resulted in non-vascular indigenous species, mosses and lichens increasing in cover on the site as they have low requirements for soil moisture., The two dominant species that contribute the majority of non-vascular cover, juniper haircap moss (*Polytrichum juniperinum*) the lichen (*Xanthoparmelia semiviridis*), are both now widespread throughout the Pukaki and similar Ecological Districts in the Mackenzie Ecological Region, but are not dominant in the understory of the original indigenous snow

[12]

[13] Leathwick et al. 2002. Land Environments of New Zealand, K4 The climate is cool, with high solar radiation, high vapour pressure deficits and low annual water deficits.

[14] Connor 1964, Espie 2001.

[15] Innes 2015.

[16] Douglas 1973; Innes 2015. Allan Innes., the former owner of Haldon records in his diary the over sowing of Chewing's fescue on the Haldon flats in the 1940 's to counter vegetation depletion by rabbits, soil loss by wind erosion and to improve pasturage.

[17] Allan Innes, personal communication. The Innes family previously farmed Haldon and still farm the adjacent Black Forest Station.

[18] Espie 2001, Boswell & Espie 1998.

[19] Walker et al. 2016..

tussock grassland or in less modified fescue tussock grassland .

A single remaining indigenous fescue tussock in the ungrazed exclosure unequivocally indicates that this species was once present and it is reasonable to infer was the dominant native tussock on the fluvioglacial outwash plain, consistent with other sites and runholder observations[20]. If fescue tussock grassland was the principal post-Polynesian / early European grassland community on the Haldon outwash flats and on the solar site it has now been completely transformed into introduced vegetation. It is now an introduced Chewing's fescue / Hieracium community with scattered introduced sweet briar shrubs, consistent with other research studies, and is no longer indigenous vegetation.

The Haldon survey data shows the consistency of the fluvioglacial outwash vegetation in the solar site with adjacent grassland and in the exclosure site. The dominant ground cover was consistently bare soil, stones, Hieracium, and Chewing's fescue, grasses browntop and sweet vernal and the secondary herbs introduced species such as sheep's sorrel (*Rumex acetosella*), forget-me-not (*Myosotis discolour*), hare's foot trefoil (*Trifolium arvense*) and spring speedwell (*Veronica verna*). This similarity allows valid comparison and extrapolation to the solar site.

The Haldon exclosure shows no recovery of fescue tussock grassland with the elimination of rabbit and stock grazing after ~44 years. This shows that removal from grazing does not promote indigenous community recovery and indicates that competition from exotic species for soil moisture and nutrients, coupled with tolerance of burning, rabbit and stock grazing, is the principal ecological driver responsible for the almost total transformation of the former fescue tussock grassland into the current exotic mat herb field – grassland.

This is consistent with evidence from other dryland tussock grassland transformations in the Mackenzie basin[21]. It also shows that unless these factors are changed, as happened, for example, with the introduction of irrigation and fertiliser in the center pivot plots, vegetation on the solar site will change, nor not naturally revert back to the original indigenous community. It is notable that the most abundant indigenous lichen *Xanthoparmelia semiviridis* is very unusual in that its thallus has no rooting rhizoids in contact with the soil and that other lichens and mosses only have very shallow soil depth contact. This is not recovery.

[20] Duncan Urquhart, personal communication. Duncan recalled to me as a boy in the 1930's his knees would get wet from the tussock seed heads on Grays Hill flat, an adjacent fluvioglacial outwash surface.
[21] Treskonova 1991; Boswell & Espie 1998, Espie 2001, Day & Buckley 2011

Significant Natural Area Assessment

Nothing in the National Policy Statement for Indigenous Biodiversity 2023 (NPSIB) applies to '*the development operation, maintenance or upgrade of renewable electricity generation assets and activities and electricity transmission network assets and activities*'[22]. The proposed solar development is for the development of renewable electricity generation assets therefore, assessment of the solar site against the criteria for identifying areas that qualify as significant natural areas (SNAs) in the NPSIB has not been undertaken. However, it is noted that in relation to the significance criteria that relies on the presence of threatened or at-risk species the NPSIB states:

> *If an area would qualify as an SNA solely on the grounds that it contains one or more indigenous flora species that are Threatened or At Risk (declining), and those species are widespread in at least three other regions, the area does not qualify as an SNA unless:*
> *(a) the species is rare within the region or ecological district where the area is located; or the protection of the species at that location is important for the persistence of the species as a whole*.

As the solar site vegetation is now no longer a natural indigenous community, evaluation of ecological significance rests on the vegetation community, the assembly of component species, rather than on the criteria of individual species, as used in the inclusion of threatened species in significance assessments[23]. None of the four plant species classed as 'At Risk – Declining' at Haldon are unique to the solar site, all occur locally outside the solar area, and elsewhere throughout the Pukaki, Tekapo and Omarama Ecological districts[24]. They are also present in extensive conservation areas. The solar site therefore does not qualify as a SNA.

Fauna

This also applies to the non-vascular indigenous mosses and lichens present on the site.

Indigenous fauna are not classified as at risk, with the exception of the Nationally Endangered Black fronted tern. This was only seen at the edge of the solar site near Lake Benmore. It is probable that the tern was using the adjacent riparian areas for foraging as well as the solar site. Its preferred breeding ground is open braided river habitat and no nesting birds were seen despite careful observation during the breeding season. The only breeding birds observed with young were pied stilts and spur winged plovers on the center pivot.

[22] Ministry for the Environment 2023. National Policy Statement on Indigenous Biodiversity Section 1.3.
[23] Clarkson et al. 2014, Ministry for the Environment 2022a, 2022b. There is no national standard methodology for survey and delineation of significant indigenous dryland terrestrial ecosystems, but there is for Natural Inland Wetlands and exotic pasture exclusion. The primary determinant of a wetland is the dominance and prevalence of wetland species cover. This must exceed > 50% in a binary classification. I have followed this methodology in differentiation of indigenous and introduced vegetation and seepage communities. They were not Natural Inland Wetlands.
[24] Dexter 2019. This shows the flora and fauna present on the solar site are all present in the immediately adjacent Simons Pass station and subsequently in the expanded Conservation Area.

Nor were any indigenous herpetofauna observed or recorded, suggesting their absence or very low populations. They also are recorded in adjacent conservation areas (Figure 23).

The Haldon invertebrate fauna was not unusual. The grasshopper and moth fauna was consistent with other Mackenzie basin sites. Dr White's study showed that oversown and top dressed sites, and better dryland sites had higher moth numbers, averaging 70% more of plant feeding moths, than depleted sites[25]. Faunal diversity was related to vegetation diversity and site degradation. Four key agents were associated with the reduction: the adventive forbs Hieracium species, sorrel (*Rumex acetosella)*, clovers and rabbits (*Oryctolagus cuniculus*). This parallels the major decline in abundance of many common species in montane fescue tussock grasslands in Cass, WaimakaririValley, Canterbury. With the invasion if the adventive grass browntop between 1961 - 1989, there was a major decline in indigenous herbs with an 88% decline in abundance of herb-feeding moths and a 74% decline in grass-feeding moths.

With a similar, almost total replacement of indigenous herbs and grasses at the Haldon solar site, plus the presence of all four of the key reducing agents, a similar magnitude of decline in the moth fauna almost certainly occurred, leaving a highly depleted fauna of lesser ecological diversity and value. This may also apply to the abundance of other invertebrates.

Threatened Environment

The solar site occurs on basin floor outwash system in a semi-arid environment which is of limited extent in New Zealand and therefore is considered a threatened environment[26]. Crucially it is the management of indigenous comminutes, the actual plant and fauna species that are present, and the extent of their protection, that is the critical determinate for conservation, not simply invoking significance from a generalized climatic or geomorphological proxy index.

A key consideration in evaluating conservation significance and priority for protection in land environments is the extent and adequacy of existing protection in these "threatened" environments. In this regard, of particular note is the adjacent 4,097 ha Maryburn conservation area, which contains the exactly the same dryland fluvioglacial outwash communities and species, in the same semi-arid environment, as in the solar area. This also applies to the 3,131 ha Simons Pass conservation area directly to the north of the solar site.

The directly adjacent Pukaki/Tekapo River Confluence conservation area contains braided rivers. These are the primary breeding and foraging habitat for the Black Fronted Tern. It also includes similar dryland outwash surface vegetation and threatened species. Similar basin floor fluvioglacial outwash ecosystems, with similar

[25] White and Sedicole 2009.
[26] Walker et. al. 2015.

species and habitat, are also present in the wider Mackenzie Basin, in adjacent Omarama Ecological District, notably in the 1,763 ha Ohau Downs conservation area, though in areas of slightly higher rainfall.

The implication is that overall ecological value of the Haldon solar site vegetation is low, and the indigenous ecological values, including all threatened plant and fauna species, are also locally and regionally present in the wider Pukaki and adjoining Ecological Districts. It is reasonable to conclude that indigenous ecological values in this landform and environment are adequately represented and protected.

Mackenzie District Plan Revision

Although the actual ecological value of the Haldon solar site vegetation is low, it should be noted that under the current proposed revision of the Mackenzie District Plan, the site would trigger the significance criteria under Section 19 (Ecosystems and Indigenous Biodiversity) of the Plan.

Section 19 was inserted into the Mackenzie District Plan by Plan Change 18 (PC18), which is concerned with:

> *(a) Protecting areas of significant indigenous vegetation and significant habitats of indigenous fauna: and*
>
> *(b) maintaining and enhancing "indigenous biodiversity.*[27]

in the Mackenzie District, which comprises 60.5% rural or 34.9% Conservation land[28].

The decisions version of PC18 included definitions of "improved pasture" and "indigenous vegetation as follows:

> *Improved Pasture: means an area of land where exotic pasture species have been deliberately sown or maintained for the purpose of pasture production, and species composition and growth has been modified and is being managed for livestock grazing.*
>
> *Indigenous Vegetation: means a plant community in which species indigenous to that part of New Zealand are important in terms of coverage, structure and/or species diversity. For these purposes coverage by indigenous species or number of indigenous species shall exceed 30% of the total area or total number of species present, where structural dominance is not attained. Where structural dominance occurs (that is indigenous species are in the tallest stratum and are visually conspicuous) coverage by indigenous species shall exceed 20% of the total area.*

[27] JJM Hassan Environment Court at Christchurch. RF&B & EDS v MDC- PC18 Interim Decision No. [2025] NZ EnvC125. Paragraph [4].
[28] NZ EnvC125 paragraph [6].

Applying these definitions, the Haldon solar site is improved pasture, not indigenous vegetation.

The issues in PC18 "are *primarily about the clearance of indigenous vegetation in the ordinary operations of dryland farming*." that occur in pasture maintenance through oversowing and top dressing, boom spray clearance and fencing[29].

The Mackenzie Region is considered to contain 36 "Nationally threatened" and 55 "At Risk" plant species. Some of these species and significant habitats of indigenous fauna are intermingled and dispersed across farmed dryland pasture on the Tekapo outwash.[30]

That intermingling is the basis for the proposed deletion of the definition of "improved pasture" and redefinition of 'indigenous vegetation" as:

> *Indigenous vegetation: means a community of vascular plants, mosses and/or lichens that includes species native to the ecological district. The community may include exotic species*.[31]

This definition, if regulatory, would change the basis for community classification. Under these changes, the occurrence of even a single indigenous lichen or moss may be taken as the determinant for classification as a plant community. This definition is so broad that Haldon's irrigated pivot pasture would be classified as indigenous vegetation, as it includes indigenous lichens and mosses that occur in the Pukaki Ecological District. This classification, which attributes naturalness to the presence of the presence of individual species conflicts with standard ecological definition of a plant community based on evaluation of all species as: *a collection or association of plant species within a designated geographical unit*. It also directly conflicts with New Zealand National Protocols for differentiating between indigenous and exotic vegetation based on rigorous and clearly defined multi species quantitative cover and frequency criteria for defining introduced pasture and delineation from inland wetland vegetation[32].

The proposed changes also result in the site vegetation triggering criterion 4 of the Canterbury Regional Policy criteria[33] for significant indigenous vegetation: *indigenous vegetation or habitat of indigenous fauna that supports an indigenous species that is threatened, at risk, or uncommon, nationally or within the relevant ecological district*, significant simply due to the presence of one or more At-Risk species. This assessment is problematic because meeting only one of ten criteria automatically assigns indigenous

[29] NZ EnvC125 paragraph [7].
[30] NZ EnvC125 paragraph [11].
[31] NZ EnvC125 paragraph [12].
[32] Wikipedia Plant Community (https://en.wikipedia.org/wiki/Plant_community); Clarkson 2014.
[33] Canterbury Regional Policy Statement Appendix 3. Criteria for determining significant indigenous vegetation and significant habitat of indigenous species.

significance, irrespective of any weighting or consideration of the other criteria. Therefore, this elevates species presence, not the attributes of the community, as determinative for assigning vegetation significance. It also does not include the broader ecological context within which the At-Risk species exists, specifically occurrence in protected areas as a factor to be included in evaluation.

Even with these caveats the indigenous species and habitat present will be maintained on the solar site due to the areas between solar arrays and possible enhancement through rabbit control.

Many of the 'At Risk' designations are provisional, not based on quantitative ecological field data but represent the best available current expert opinion, which is subject to revision.

Furthermore it is necessary for conservation management to consider whether the 'At-Risk' species has obligate or facultative interactions with the surrounding vegetation community and fauna. The 'At Risk' species now present would not have been present under the former pre-Polynesian vegetation and have expanded from their marginal dryland habitats on to the modified outwash successional vegetation. The decline in indigenous scab weeds (*Raoulia* spp.) is due to the decline in grazing pressure from rabbit herbivory and competion from introduced species. Solar arrays will not alter this. Conversely the occurrence of *Poa maniotito* and lichens are attributable to survival or expansion in the modified open secondary succession dryland vegetation with greater light availability, and this is not likely to be significantly altered by solar development. These species occur throughout the basin floor communities in the Mackenzie Ecological Region. Consequently, this needs consideration in weighing the significance attributed to the 'At Risk' species.

A further concern is that the rationale for proposed definition does not adequately take into consideration the adequacy of protection in Conservation land after 40 years of survey, identification and securing legal protection. This applies to all the threatened species, habitats of landforms of concern presented to the court.

I note that the Environment Court PC18 decision[34] is currently in High Court challenge, as well as uncertainty generated by the recent government decision halting Local council regulation pending revision of the Resource Management Act.

It should therefore be noted that the proposed change to the definition of indigenous vegetation are not final and may be returned for reconsideration, given the inconsistency with established practice, including:

(a) invalidity against standard ecological definition of a plant community, and national standards

(b) impracticality as it is so broad that it will result in gross misclassification, and

(c) unworkability in practical land or regulatory management.

[34] JJM Hassan Environment Court at Christchurch. RF&B & EDS v MDC- PC18 Interim Decision No. [2025] NZ EnvC125.

The potential effect for the Solar Farm, if the provisional definition remains un-amended, is that all the surveyed vegetation associations, including the pivot pastures, would be classified as indigenous vegetation. They would be subject to indigenous vegetation clearance rules.

Impact of Solar Installation

Solar arrays are not expected to significantly change the site vegetation. The vegetation is floristically and structurally the same extensive community as in the directly adjacent areas surrounding the site, which will not be altered by solar development (Figure 1). In addition, there are the areas which will not be altered occurring throughout the solar site (Figure 3). These areas are extensive: the area of outwash and riverine vegetation north and east of the solar site on Haldon Station, which will not be altered by solar development, totals around 541 ha. This, in combination with directly adjoining outwash in neighboring properties, provides extensive local habitat for invertebrates, fauna and indigenous plant species which will not be affected by development of the solar site. This is further supported by the large area of adjacent basin floor dryland conservation areas, 18,200 ha and 19,300 ha of additional Mackenzie Ecological Region basin floor conservation areas (Figure 23, Table 3). These facts are critical for assessment of ecological impacts.

The installation of the solar panels will cause temporary disturbance to birds during establishment, but this could be mitigated by scheduling construction outside the breeding season. The availability of large adjacent areas not currently under construction, or after completed on the site would provide alternative breeding and feeding sites.

The subsequent effect of solar arrays on avian breeding or habitat use is not known in New Zealand, but the most threatened species, the black fronted tern, does not breed in this habitat and may only use it for foraging. It is possible that some minor behavioral adjustment will occur with some species that currently use the solar and pivot sites. The large area of adjacent similar vegetation and habitat means that solar development is not likely to present significant risk to these species.

The disturbance to vegetation during solar array piling to 1.5 m depth and subsequent construction would also be temporary and would have a minor effect on plant and invertebrate populations. Once installed the array 1.5 m height and spacing provides for a large extent of open space between and under the arrays (Figures 1, 3) and once installed, operation is not expected to adversely impact plant and invertebrate populations.

The disturbance by cable trenching will result in temporary disturbance, but removed soil will be backfilled and

the introduced resident vegetation will recover, as Hieracium spatially expands by stoloniferous growth and the introduced grasses quickly recolonise following disturbance, as has been observed at Haldon after previous building and tracking disturbance in this environment. The rabbit fencing and control within the solar site will provide positive benefits for grazing sensitive species, as shown by the exclosure vegetation,

A limited amount of vegetation clearance will occur with the construction of the substation and access roads (~13 ha). This is a small part of the total site area and as the vegetation is so highly modified this will have minimal effect on indigenous species. In this semi-arid dryland environment the invasion of other weed species, beyond what are already present, if introduced, is unlikely to be significant, with the exception of scotch broom or fat hen (*Chenopodium album*). This can be addressed by cleaning and checking equipment when it is brought on site and by removing the low number of adjacent resident plants to eliminate possible seed sources.

The long term effects of solar panels in the Mackenzie Ecological Region are unknown as no solar farms have been built. Overseas studies show that the main environmental effects from solar arrays are reduced incident radiation, reduced wind ground speed, reduced vapour pressure deficits and increased soil moisture.[35]

The effects of shading, although in a wetter fescue tussock grasslands environment on the west of Lake Tekapo[36], have been extensively studied. The imposition of artificial shade, though at a lower height of 1.5 m, in a wet summer in 2008/09 significantly increased foliage and soil water content[37] and in a follow-up study in 2015, significantly increased total species richness, native forb richness and cover. Cover of the exotic grass sweet vernal and the native forb New Zealand harebell (*Wahlenbergia albomarginata*) significantly increased, while the cover of bare ground, lichens, and wire moss (*Polytrichum juniperinum*) significantly decreased. There was no change in mouse-ear Hieracium cover. A glasshouse study also suggests that indigenous plants are more competitive with *Hieracium pilosella* under low shade compared to full light[38].

The effect of shading on sweet briar is not known, but as transects T2-1 and T7-1 show, it responds to increased moisture. If the solar arrays increase soil moisture then briar could be expected to increase in density and growth. This could be limited by farm management control. Continued sheep grazing could also be considered as possible control strategy as briar densities were significantly higher and shrubs were taller in ungrazed sites in a similar adjacent dryland environment near Lake Benmore[39].

How solar arrays affect Mackenzie birds is unknown and some species may continue foraging and using the

[35] Wu et al 2022, Choi et al 2023.
[36] Norton et al 2006.
[37] Payne and Norton 2011
[38] Moen & Meurk 2001.
[39] Sage et al 2009.

habitat above, between and under the solar arrays. If some species are affected, then the extent of the solar area is relatively small in relation to similar adjacent outwash areas on Haldon, and very small in relation to the wider Ecological District. The same argument applies to herpetofauna.

The proposed rabbit fencing will also promote recovery of indigenous species reduced by historical browsing and grazing. This could result in an increase in indigenous biodiversity in the solar site.

Overall the construction and operation of the solar arrays is assessed to have **very low** to **low effect** on indigenous ecological values.

The grassland in the solar site is classified under the Mackenzie District Plan vegetation definitions as '***improved pasture***': *an area of land where exotic pasture species have been deliberately sown or maintained for the purpose of pasture production, and species composition and growth has been modified and is being managed for livestock grazing*[40]. This conflicts with the recent revision of the Mackenzie District Plan which altered the definition of '***indigenous vegetation'*** from assessment based on quantitative attributes to: *a community of vascular plants, mosses and/or lichens that includes species native to the ecological district*. Here the occurrence of even a single indigenous lichen or moss may be taken as the determinant for classification as a plant community. This definition is so broad that Haldon's irrigated pivot pasture would be classified as indigenous vegetation, as it includes indigenous lichens and mosses that occur in the Pukaki Ecological District. This classification, which attributes naturalness to the presence of the presence of individual species conflicts with standard ecological definition of a plant community based on evaluation of all species as: *a collection or association of plant species within a designated geographical unit*. It also directly conflicts with New Zealand National Protocols for differentiating between indigenous and exotic vegetation based on rigorous and clearly defined multi species quantitative cover and frequency criteria for defining introduced pasture and delineation from inland wetland vegetation[41].

The site vegetation does not meet the Canterbury Regional Policy criteria[42] for significant indigenous vegetation, as it is not indigenous vegetation (previous section). Though, using the same individual species criterion (criterion 4: *indigenous vegetation or habitat of indigenous fauna that supports an indigenous species that is threatened, at risk, or uncommon, nationally or within the relevant ecological district*) it would be regarded as significant simply due to the presence of one or more At-Risk species. The CRC assessment is also problematic because meeting only one of ten criteria automatically assigns indigenous significance, irrespective of any weighting or consideration of the other criteria. Therefore this again elevates species presence, not the attributes of the community, as determinative for assigning vegetation significance. It also does not include the broader ecological context within which the At-Risk species exists, specifically occurrence in protected areas as a factor to be included in evaluation.

Many of the 'At Risk' designations are not based on quantitative ecological field data but represent the best available current expert opinion which is subject to revision. Furthermore it is necessary for conservation management to consider whether the 'At-Risk' species has obligate or facultative interactions with the surrounding vegetation community and fauna. The 'At Risk' species now present would not have been present under the former pre-Polynesian vegetation and have expanded from their marginal dryland habitats on to the modified outwash successional vegetation. The decline in indigenous scab weeds (*Raoulia* spp.) is due to the decline in grazing pressure from rabbit herbivory and completion from introduced species. Solar

[40] Mackenzie District Plan, Section 3
[41] Wikipedia Plant Community (https://en.wikipedia.org/wiki/Plant_community); Clarkson 2014.
[42] Canterbury Regional Policy Statement Appendix 3. Criteria for determining significant indigenous vegetation and significant habitat of indigenous species

arrays will not alter this. Conversely the occurrence of *Poa maniotito* and lichens are attributable to survival or expansion in the modified open secondary succession dryland vegetation with greater light availability, and this is not likely to be significantly altered by solar development. These species occur throughout the basin floor communities in the Mackenzie Ecological Region. Consequently this needs consideration in weighing the significance attributed to the 'At Risk' species.

Environmental Assessment Impact of Solar Development.

The Environmental Institute of Australia and New Zealand's ecological impact assessment guidelines requires determination of the ecological effects of development against three primary attributes:

- the value of ecosystems and species present,
- the magnitude of impact and,
- assessment of the overall effect[43].

The value of**,** vegetation and habitat for terrestrial ecosystems[44], and their importance in relation the Haldon solar development, are:

Representativeness : **Very Low**. The species assemblages are not representative of typical or expected indigenous vegetation,

Rarity/ distinctiveness: **Low** The site does not meet any of the criteria of rare or distinctive vegetation, habitats, features, or locally uncommon species but has *Threatened* or *At Risk* species.

Diversity and Pattern: **Very Low**. Negligible indigenous biodiversity, abundance or biogeographical complexity or temporal habitat availability and utilization.

Ecological Context: **Very low.** Extremely modified, low RMA 'intrinsic value', integrity, function or spatial contribution to, or limitation of, ecological networks or habitat.

Assessing ecological value for **species**[45] ranges from **negligible** for the majority of the species, to **high** for the four plant species listed as *At Risk, Declining*.

The area's **ecological value** [46] is **Negligible** due to the **Very Low** rating of three of the four vegetation and species attributes; and that the community is not important at the ecological district level. Alternatively, if more weight is placed on the threat ranking of the four *At Risk, Declining* species as **High**, this moves the overall assessment to **Moderate**.

[43] Roper Lindsay et al. 2018
[44] Roper Lindsay et al. 2018, Table 1.
[45] Roper Lindsay et al. 2018, Table 2
[46] Roper Lindsay et al. 2018, Table 3

The magnitude of the **overall impact**[47] of solar development is **negligible** as it will result in a very slight change from the existing baseline vegetation condition and have a negligible or very low effect on known populations.

The combined **overall assessment** of the effect[48] of solar development is with **negligible** magnitude and an ecological value of either **negligible** or **high,** resulting in an overall **Very Low** classification**.**

6. Conclusions

The solar site vegetation is no longer an indigenous community due to past historical management and the superior competitive ability of introduced species. Indigenous vegetation ecological values are now minimal, even though a very low frequency of grazing resilient dryland indigenous vascular species remain, and all these are present in directly adjoining areas on Haldon and in extensive similar protected conservation areas in the Pukaki Ecological District and in the wider Mackenzie region. The lichens and mosses present are also widespread and extensively protected. Similarly there is an absence, or a very low frequency of indigenous herpetofauna on the site and indigenous invertebrates will remain resident. It is unknown what the effect on avian fauna will be, but given the extensive area of similar local and adjacent habitat that will not be modified it is probable that these effect will be minor.

The overall assessment of effect of solar development is that it will have a **Very Low** effect on ecological values**.**

The establishment of a solar farm will not result in loss of indigenous ecological values on Haldon Station or in the Pukaki Ecological District.

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[47] Roper Lindsay et al. 2018, Table 4
[48] Roper Lindsay et al. 2018, Table 5

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