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Conservation significance of upper Ripia frost flat heathland, a Critically Threatened Ecosystem in Hawke's Bay

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Conservation significance of upper Ripia frost flat heathland, a Critically Threatened Ecosystem in Hawke's Bay

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Summary

Project and Client

- Frost flat heathland is a Critically Endangered Historically Rare Ecosystem restricted to the Hawke's Bay, Bay of Plenty, and Waikato Regions of New Zealand. Hawke's Bay Regional Council contracted Landcare Research to assess the condition – 'ecological integrity' – of the substantial frost flat heathland in the upper Ripia valley, Hawke's Bay.

Objectives

- Determine and map the extent of frost flat heathland in the upper Ripia valley
- Assess vegetation and physical parameters at random locations to quantify the occurrence of diagnostic species of this ecosystem, forest precursor species, invasive weeds, and adventive dominance
- Determine the ecological integrity and conservation value of the site

Methods

- Frost flat extent was mapped from aerial imagery and field visits
- Quantitative cover estimates of all vascular species and prominent bryophytes and lichens were recorded in 15 randomly located plots. Physical parameters such as slope, altitude and aspect, height of the tallest individual of tallest monoao (*Dracophyllum subulatum*), the dominant or other vascular species if higher, and human and introduced mammal impacts in the plots were also recorded.
- Four measures of ecological integrity – presence of each of 12 diagnostic frost flat species, presence of forest precursor species, invasive weed frequency, and adventive dominance (adventive/indigenous vegetative cover ratio) – were calculated for each site.

Results

- All 12 diagnostic frost flat species are present at upper Ripia, eight of them in more than half of plots.
- No potential forest precursor species were present in plots.
- Four invasive weed species were recorded in plots, none of them consistently present. Only three – Chewing's fescue (*Festuca rubra*), Yorkshire fog (*Holcus lanatus*), mouse-ear hawkweed (*Pilosella officianarum*) – are at all widespread.
- Four other threatening weeds, lodgepole pine (*Pinus contorta*), broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), and heather (*Calluna vulgaris*), not recorded in plots, are locally present.
- Ripia frost flat has high ecological integrity.

Conclusions

- Succession to native forest is unlikely in the foreseeable future on almost all of Ripia.
- The occurrence of common spaniard (*Aciphylla squarrosa*) is now a rare feature of this ecosystem and of particular interest.
- Although native dominance is high, this could be threatened in future by nascent populations of invasive woody weeds.
- Ripia has higher ecological integrity than most other remaining frost flat heathland sites and is worthy of management input in terms of periodic weed control.
- With its high ecological integrity, rarity of threatening weeds, lack of human imprint and excellent buffering, the upper Ripia valley is an outstanding natural area and has excellent long-term prospects for survival. Along with nearby Rangitaiki Conservation Area, it is one of the two best examples of this ecosystem remaining in New Zealand.

Recommendations

- The most obvious immediate management priority is the control of woody weeds, particularly lodgepole pine at the northern end, and very local broom, gorse and heather.
- A robust, comprehensive classification of vegetation types for this rare ecosystem has not been produced and is needed for decisions on resource allocations for future management.
- Plots should be remeasured on a 5-yearly basis, next in the summer of 2023.

1 Introduction

Frost flat heathland is a Critically Endangered Historically Rare Ecosystem restricted to the Hawke's Bay, Bay of Plenty, and Waikato Regions of New Zealand. A network of permanent plots was established by Landcare Research in February 2018 for Hawke's Bay Regional Council to allow assessment of condition – 'ecological integrity' – of the frost flat heathland in the upper Ripia valley in Hawke's Bay Region, and to establish a baseline for monitoring changes in the future.

2 Background

'Frost flat' heathlands comprise short sclerophyllous shrublands dominated by the ericaceous shrub monoao (*Dracophyllum subulatum*) on mostly well drained but universally infertile volcanic soils. They were characteristic of shallow basins on the North Island Volcanic Plateau mantled by deep deposits of infertile rhyolitic tephra (Smale 1990). Despite their occurrence well below regional treeline under climates that are generally amenable for plant growth, the most ecologically stressed sites are subject to a year-round frost regime resulting from cold air ponding; this apparently maintains the treeless community (Bishop 2005). The potential additional role of soil infertility in excluding native forest from frost flats remains unexplored.

A long history of human burning has undoubtedly played a major role (as elsewhere) in reducing taller woody vegetation and replacing it by shorter woody vegetation and grassland (Fig. 1). The taller shrub component – bog pine (*Halocarpus bidwillii*) and mountain toatoa (*Phyllocladus alpinus*) – of frost flat heathland is likely to have been severely reduced by burning and now survives only as scattered remnants, mostly on sites like dongas (deep, steep-sided, dry erosion gullies) that are protected from fire. The floristic affinities of frost flat heathland with the largely fire-induced short tussock grasslands of the eastern South Island (Smale 1990) emphasise the role fire may have played in helping form and maintain these communities. The Kaingaroa Plateau has a long history of Maori fire (Nicholls 1978), and a mosaic of heathland communities of various ages resulting from fires at different times is present at some frost flats like Rangitaiki Conservation Area (Smale 1990).

The long-term persistence of non-forest communities on well-drained sites under reasonable rainfall is unusual in New Zealand, and frost flats provide habitat for a suite of species that would otherwise be absent from these landscapes. As a historically rare ecosystem, frost flat heathland falls within National Priority 3 ('To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types') of the National Biodiversity Strategy (MfE/DOC 2007) and is now a Critically Endangered ecosystem (Holdaway et al. 2012).

The pre-European extent of frost flat heathland is estimated to have been several tens of thousands of hectares (Smale 1990), but has been reduced by an order of magnitude since c. 1930 by land development for agriculture and forestry to a few thousand hectares. The few intact remaining frost flats are highly fragmented and susceptible to a range of threats

such as weed invasion – especially broom and heather – and nutrient enrichment through topdressing drift. The influence of surrounding land use on survival prospects is unknown, but likely to be significant.

Until extensive land development after the Second World War, the Kaingaroa Plateau was the centre of frost flat heathland which now survives at only a handful of sites. A network of permanent plots has been established across them (Smale & Fitzgerald 2012), enabling us to monitor changes in condition over time and also to assess the influence of the surrounding land use matrix on their prospects for survival.

The largest area of remaining frost flat heathland is within the Rangitaiki Conservation Area, Bay of Plenty. Two substantial areas of frost flat heathland survive in Hawke's Bay: the upper Waipunga valley (Crown land) was assessed in 2015 (Smale & Fitzgerald 2015), and the upper Ripia valley (freehold: Lochinver Station), the subject of this study. Aerial photographs indicate that another substantial area of frost flat may occur on Maori land in the Tunamaro Stream valley (Wharetoto 3 Block) approximately 3-km southwest of upper Ripia.

3 Objectives

- Determine and map the extent of frost flat heathland in the upper Ripia valley.
- Assess vegetation and physical parameters at random locations to quantify the occurrence of diagnostic species of this ecosystem, forest precursor species, invasive weeds, and adventive dominance.
- Determine the ecological integrity and conservation value of the site.

4 Methods

4.1 Mapping

Frost flat heathland extent was mapped using 0.5-m orthophotography (Waikato 0.5 m Rural Aerial Photos (2012/2013)), ground-truthed during field visits in February 2018.

4.2 Vegetation assessment plots

Vegetation was assessed at fifteen 2 × 2-m plots using protocol adapted from Hurst and Allen (2007). The sample locations were pre-selected by stratified random sampling within the GIS polygons derived from aerial photographs. The 2 × 2-m plot size for frost flat heathland was arrived at after deriving the species/area curve at Rangitaiki Conservation Area before beginning the major sampling exercise there in 1988 (Smale 1990). Plot corner markers were left in place to allow future remeasurement and monitoring.

Within plots, the following were recorded:

- All vascular species present, including invasive weeds, as well as prominent bryophytes and lichens, and quantitative cover estimates of each
- Physical parameters such as slope, altitude and aspect
- Height of the tallest individual of the dominant vascular species (usually monoao)
- Human impact (e.g. off-road vehicle tracking)
- Introduced mammal impact, including the presence of faecal pellets and trampling and presence and degree of browsing by species.

4.3 Data analysis

Levels of ecological integrity were calculated and averaged for 4 indicators (measures of ecological integrity) and compared to previous sampling of other sites:

- Mean frequency (percentage of plots where present) of each of 12 diagnostic frost flat species (Smale 1990), a measure of 'species occupancy' (Lee et al. 2005).
- Mean frequency (percentage of plots where present) of forest precursor species.
- Mean frequency (percentage of plots where present) of invasive weeds, e.g. Yorkshire fog.
- Adventive/indigenous cover ratio, i.e. total indigenous and total adventive cover summed over all tiers, the inverse of 'indigenous dominance' (Lee et al. 2005).

Mean frequencies of each of the above measures below 20% were ranked very low, 20–<50% low, 50–<70% moderate, and >70% high. Overall ecological integrity was subjectively assessed on the basis of the four individual indicators.

5 Results

5.1 Frost flat heathland mapping

We identified and delineated three prominent types of vegetation at Ripia (Figure 1) – monoao-dominant heathland (502.6 ha; Fig. 2), degraded frost flat vegetation (47.2 ha), and wetlands (4.3 ha). The upper Ripia appears to be the third most extensive frost flat heathland remaining in the Central North Island (Manaaki Whenua-Landcare Research unpublished data), after Rangitaiki/Okoeke (2470 ha) and Waipunga (665 ha).

Degraded frost flat occurs at the north of the valley. Although now fenced from stock, the frost flat appears to have been previously grazed and wildling lodgepole pines are common (Fig. 3).

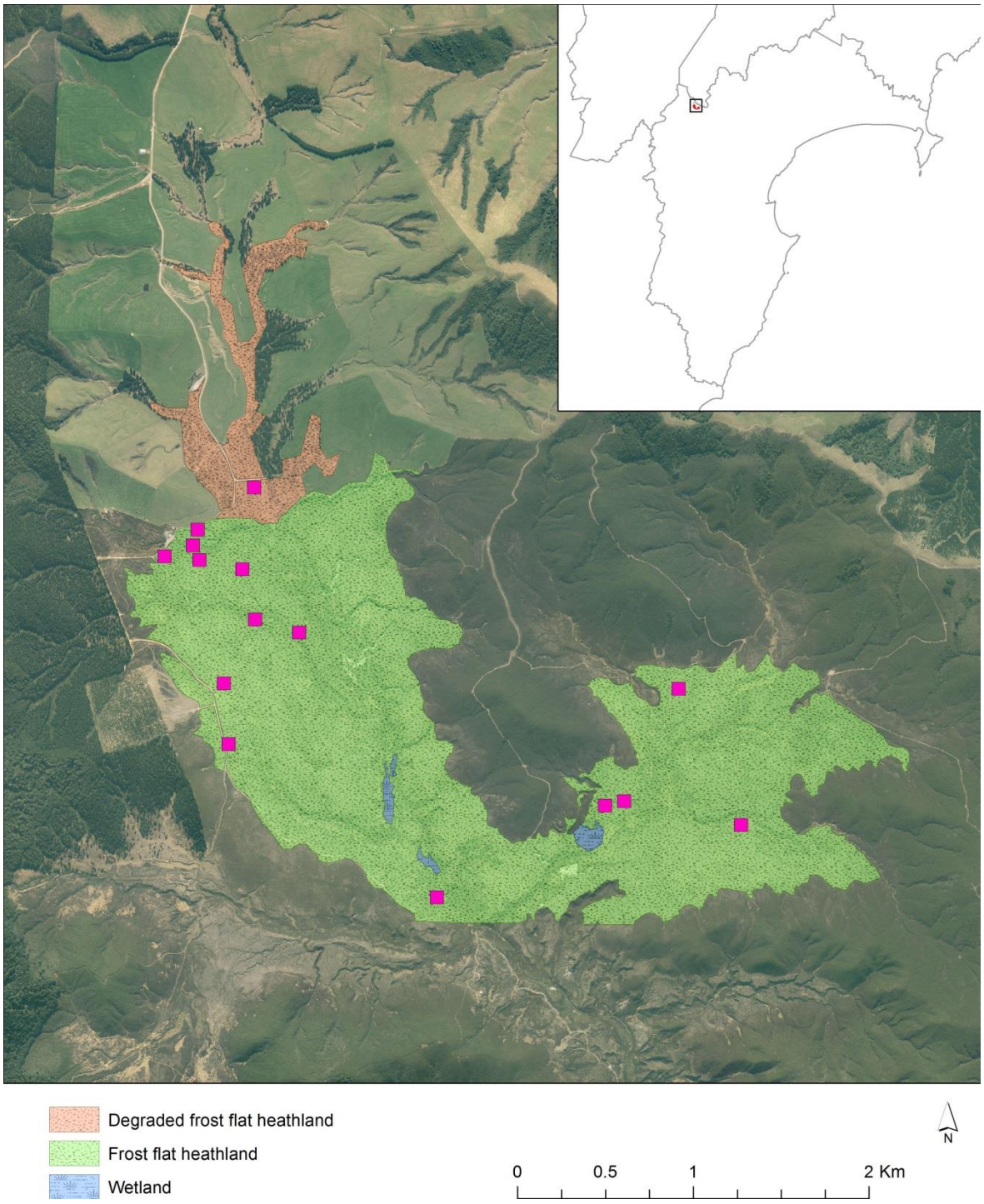

Figure 1 Dominant vegetation types in the upper Ripia valley. The location of the frost flat in the Hawke's Bay Region is inset. Pink squares indicate the location of vegetation assessment plots established in February 2018. Waikato 0.5m Rural Aerial Photos (2012/2013), CC BY 3.0 NZ.

Figure 2 View north over monoao-dominant frost flat heathland, upper Ripia, February 2018.

Figure 3 Grazed pasture on former frost flat (foreground) with degraded frost flat heathland being invaded by lodgepole pine in the distance, Lochinver Station, upper Ripia, February 2018.

Within the monoao-dominant heathland are several streams, dongas, and other topographic features where patches of other vegetation types, such as taller scrub occur (Fig. 4).

Wetlands (characterised by poor drainage) are distinct from frost flats where the primary abiotic drivers are frost and low fertility. However, within the study area we found three noteworthy areas of wetland vegetation that appear to be in good condition, with few adventive plants and no evidence of artificial influence on hydrology or nutrient status.

Figure 4 A large donga in frost flat heathland provides cold air drainage and creates micro climatic conditions where more frost-sensitive species such as manuka (*Leptospermum scoparium*) can grow. Upper Ripia, February 2018.

5.2 Diagnostic frost flat species

All 12 diagnostic frost flat species (Smale 1990) are present at Ripia, eight of them consistently, i.e. in at least half the plots (Table 1).

Table 1 Mean frequency (% of plots in which recorded) of 12 diagnostic frost flat species at Ripia in Hawke's Bay Region. * denotes adventive. Common and scientific names of plants are given in Appendix 1

Species	Mean frequency (%)	Growth form
Celmisia gracilenta	33	Forb
Cladia retipora	87	Lichen
Cladonia capitellata	27	Lichen
Cladonia confusa	80	Lichen
Deyeuxia avenoides	60	Grass
Dracophyllum subulatum	100	Shrub
**Hypochaeris radicata*	53	Forb
Leucopogon fraseri	13	Subshrub
Pimelea prostrata	20	Subshrub
Poa cita	73	Grass
Racomitrium lanuginosum	67	Moss
Rytidosperma gracile	80	Grass

5.3 Forest precursor species

No potential tree or shrub precursor species of forest was recorded in plots at upper Ripia.

5.4 Invasive weeds

Four invasive weed species were encountered in plots; none of them consistently present (Table 2). One or more of these invasive species were found in 47% of the plots, or, inversely, 53% of plots did not have any species considered to be invasive.

Table 2 Mean frequency (% of plots in which recorded) of each of the four invasive species found in random plots, and the proportion of plots in which any one or more invasive weed was present at Ripia in Hawke's Bay Region

Species	Mean frequency (%)
Yorkshire fog	20
Chewing's fescue	27
Sweet vernal	7
Mouse-ear hawkweed	27

5.5 Adventive dominance

Adventive species contributed minimally to vegetative cover, with mean adventive dominance of 0.13. Only two of the 15 plots were dominated by adventives.

5.6 Ecological integrity

Based on the four individual indicators (Table 3), we assess the Ripia as having high ecological integrity.

Table 3 Ecological integrity of Ripia frost flat in Hawke's Bay Region

Indicator	Rank
Mean frequency of any diagnostic frost flat species	High
Mean frequency of any native forest precursor	Very low
Mean frequency of any invasive weed	Low
Adventive dominance	Very low

6 Discussion and conclusions

Frost flat heathland at upper Ripia is characterised by open short shrubland. Denser, taller – and probably moister – scrub on more fertile sites (Yeates et al. 2004), as at nearby Rangitaiki Conservation Area, is much more local. The list of 12 diagnostic frost flat species ('key' species in Smale 1990) was derived from nearby Rangitaiki Conservation Area on the southern Kaingaroa Plateau, and it was suggested that it be reduced to eight after much wider sampling in the region (Smale & Fitzgerald 2012). Those species are the eight widespread species at Ripia. The four less widespread species – a lichen (*Cladonia capitellata*), herb (*Celmisia gracilenta*), and two subshrubs (*Leucopogon fraseri*, *Pimelea prostrata*) – are characteristic of young heathland (as in the younger communities at Rangitaiki), not older floristically poorer communities such as those at Ripia.

Lochinver Station shares a similar history – early extensive pastoralism and abandonment – with the Rangitaiki Conservation Area. Widespread tracts of secondary forest on surrounding ranges and the virtual absence of bog pine also suggest – as with Rangitaiki – a long fire history. As Maori land, it was part of a late 19th-century pastoral lease to runholders Lane and Carswell, then abandoned sometime after the First World War. In 1958 it was sold to Auckland roading and quarrying magnate Sir William Stevenson and intensively developed from 1963 onward (Newton 1969). Lying at the southern end of the station beyond a low range of forest-covered hills, the upper Ripia frost flat heathland itself may never have been grazed to any significant extent. Apart from the road on the western side of the valley and a few minor tracks elsewhere, there is no evidence of human activity within most of the heathland. Neither is there any evidence of recent fire, unlike Rangitaiki Conservation Area, which has extensive tracts of young heathland resulting from fires mostly associated with adjacent land development since 1964 (Smale 1990).

Frost flat heathland at upper Ripia is much more similar to other sites on the eastern Volcanic Plateau (Smale & Fitzgerald 2012, 2015) than to those at west Taupo (Smale & Fitzgerald 2014). Along with the oldest (c. 1900) community at Rangitaiki, it is the only site where no forest precursor species were encountered in plots. Like the other eastern sites and unlike the western ones, upper Ripia is likely to remain as open shrubland for the foreseeable future.

Of particular interest is the widespread occurrence of common spaniard (*Aciphylla squarrosa;* Figs 4 & 5), known elsewhere in frost flat heathland only from Taho in Whirinaki Forest Park (where it is now very rare). It is susceptible to grazing by hares and rabbits and is likely to have been more widepread in frost flat heathland in the past.

Several species not recorded in plots but occasional in frost flat heathland elsewhere were observed in the upper Ripia frost flat: *Veronica parviflora* (formerly *Hebe parviflora*), red tussock, and a single plant each of *Pittosporum divaricatum* and bog pine.

Apart from two adventive grasses (Chewing's fescue and Yorkshire fog) and mouse-ear hawkweed, four threatening weeds are locally present at Ripia: lodgepole pine at the far northern end; locally present broom; and very local gorse and heather (only on tracks). Lodgepole pine and broom are both ruinous weeds in frost flat heathland. Lodgepole pine rapidly forms a dense canopy that overtops and eliminates all native frost flat vegetation. Furthermore, it exploits much greater volumes of regolith, thereby elevating soil fertility to the point where invasive adventive grasses can become dominant (authors, pers. obs.). As a nitrogen fixer, broom alters low soil chemical fertility (e.g. Broadbent et al. 2017), one of the key attribute of heathland ecosystems, and therefore enables species of moderately fertile sites to replace heathland vegetation. A small area of monoao-dominant frost flat heathland at Mihi first visited in 1966 had been completely ousted by broom when revisited 22 years later (MCS, pers. obs.). Heather is an ecological analogue of monoao and can almost completely oust it, as has already happened at Kuratau (west Taupo). The survival of frost flat heathland at Ripia depends on control of lodgepole pine, broom, gorse, and heather.

Ripia has higher ecological integrity than most other remaining frost flat heathland sites in the Bay of Plenty and Waikato Regions. With its high ecological integrity, rarity of threatening weeds, lack of human imprint, and excellent buffering by native forest and pine plantation, the frost flat heathland of the upper Ripia valley is an outstanding natural area and has very good prospects for long-term survival. Along with nearby Rangitaiki Conservation Area, it is one of the two best examples of this ecosystem remaining in New Zealand.

Figure 5 Common Spaniard (arrows indicate some examples in the foreground) growing in degraded frost flat heathland, upper Ripia, February 2018.

Figure 6 Common spaniard (*Aciphylla squarrosa*) growing in frost flat heathland at upper Ripia, February 2018.

7 Recommendations

- The most obvious immediate management priority is the control of woody weeds, particularly lodgepole pine at the northern end, and very local broom, gorse and heather.
- A robust, comprehensive classification of vegetation types for this rare ecosystem has not been produced and is needed for decisions on resource allocations for future management.
- Plots should be remeasured on a 5-yearly basis, next in the summer of 2023.

8 Acknowledgements

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Appendix 1 – Flora recorded in frost flat heathland at Ripia (including species not present in plots)

Scientific name	Common name	Biostatus	Growth form
Acaena microphylla		Endemic	Forb
Aciphylla squarrosa	common spaniard	Endemic	Forb
Anthoxanthum odoratum	sweet vernal	Adventive	Grass
Blechnum penna-marina	little hard fern	Native	Fern
Calluna vulgaris	heather	Adventive	Shrub
Carex punicea	red hook-sedge	Endemic	Sedge
Celmisia gracilenta		Endemic	Forb
Chionochloa rubra	Red tussock	Endemic	Grass
Cladia retipora	coral lichen	Native	Lichen
Cladonia capitellata		Native	Lichen
Cladonia confusa	reindeer lichen	Native	Lichen
Cladonia coccifera		Native	Lichen
Coprosma propinqua	mingimingi	Endemic	Shrub
Cytisus scoparius	broom	Adventive	Shrub
Dactylis glomerata	cocksfoot	Adventive	Grass
Deyeuxia avenoides	mountain oat grass	Endemic	Grass
Dicranoloma billardierei	shaggy moss	Native	Moss
Dracophyllum subulatum	monoao	Endemic	Shrub
Festuca rubra	Chewing's fescue	Adventive	Grass
Gentianella grisebachii		Endemic	Forb
Galium perpusillum		Endemic	Forb
Geranium brevicaule		Endemic	Forb
Geranium potentilloides	small-leaved cranesbill	Native	Forb
Gleichenia dicarpa	tangle fern	Native	Fern
Halocarpus bidwillii	bog pine	Endemic	Shrub
Helichrysum filicaule		Endemic	Subshrub
Holcus lanatus	Yorkshire fog	Adventive	Grass
Hydrocotyle novaeseelandiae var. montana		Endemic	Forb
Hypnum cupressiforme		Native	Moss
Hypochaeris radicata	catsear	Adventive	Forb
Leucopogon fraseri	patotara	Endemic	Subshrub
Lycopodium fastigiatum	alpine clubmoss	Native	Clubmoss
Microseris scapigera		Native	Forb
Muehlenbeckia axillaris		Native	Subshrub

Mycelis muralis	wall lettuce	Adventive	Forb
Pilosella officinarum	mouse-ear hawkweed	Adventive	Forb
Pimelea prostrata	New Zealand daphne	Endemic	Subshrub
Pinus contorta	lodgepole pine	Adventive	Tree
Pittosporum divaricatum		Endemic	Shrub
Poa cita	silver tussock	Endemic	Grass
Polytrichum juniperinum		Native	Moss
Rytidosperma gracile	danthonia	Native	Grass
Stackhousia minima		Endemic	Subshrub
Ulex europaeus	gorse	Adventive	Shrub
Veronica parviflora		Endemic	Shrub
Wahlenbergia albomarginata	harebell	Endemic	Forb

Appendix 2 – Glossary of scientific terms

Adventive	Accidentally or deliberately introduced from elsewhere into New Zealand
Endemic	Native to New Zealand and nowhere else
Forb	Herbaceous flowering plant that is not a grass, sedge or rush
Invasive	Adventive species with a tendency to spread to a damaging degree
Native	Native to New Zealand and other countries as well