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Updating information on monitoring condition of frost flat heathlands, a critically threatened rare ecosystem in the Waikato region

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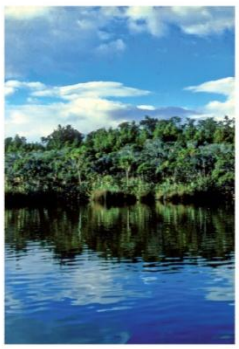

Updating Information on Monitoring Condition of Frost Flat Heathlands, a Critically Threatened Rare Ecosystem in the Waikato Region

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Manaaki Whenua

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Executive Summary

Frost flats are one of the signature ecosystems of the Volcanic Plateau. They were created after vast quantities of pumice were deposited during the titanic eruptions that shaped the plateau. The pumice was washed from the surrounding hills and filled basins and valleys to form plains. These sites are at relatively high elevation (400-800 m a.s.l.) so are focal points for cold-air ponding and they suffer from year-round frosts. The pumice is naturally infertile, and the vegetation is typically dominated by monoao (*Dracophyllum subulatum*) (Smale 1990). Frost flats are home to several threatened and rare plant and insect species and are Critically Endangered historically rare ecosystems (Holdaway 2010) in the Waikato Region. However, they are threatened by a variety of factors, especially weed invasion. Waikato Regional Council is monitoring these ecologically valuable areas in order to manage and protect them effectively, and to meet obligations under the RMA 1991 to maintain and enhance biodiversity. The remaining frost flats (frost flat heathlands) at west Taupo have been identified as Significant Natural Areas (SNA) based on the Waikato Regional Council Policy Statement (Appendix 3).

A network of permanent plots was initiated in January–May 2013 and January 2014 for the Waikato Regional Council to establish a baseline for monitoring change in the condition – 'ecological integrity' – of the remaining substantial frost flat heathlands. The project objectives were (1) to establish a baseline for monitoring the condition – 'ecological integrity' – of significant frost flat heathlands remaining in the Waikato Region, and (2) to validate ecological information for Significant Natural Areas (SNA) inventory by ground truthing.

The results show that: Only three of the 12 diagnostic frost flat species – monoao (*Dracophyllum subulatum*), danthonia (*Rytidosperma gracile*) and *Cladonia confusa* – were present in more than half of all plots, and one of them – woolly moss (*Racomitrium lanuginosum*) – was absent altogether. Forest precursors were present in nearly half of all plots but only three species – lancewood (*Pseudopanax crassifolius*), mountain toatoa (*Phyllocladus alpinus*) and mānuka (*Leptospermum scoparium*) – were at all widespread. Nine invasive weed species were recorded in plots, but only five of them – Yorkshire fog (*Holcus lanatus*), heather (*Calluna vulgaris*), broom (*Cytisus scoparius*), sweet vernal (*Anthoxanthum odoratum*), and browntop (*Agrostis capillaris*) – were at all widespread.

Invasive weed frequencies were high in the Kuratau, Taparoa and Pokaiora Clearings, but weeds were absent from plots on the Whenuakura Plain. Adventive species contribute most of the vegetative cover in the Kuratau Clearing and a significant amount of it in the Taparoa Clearing. Whenuakura Plain has high ecological integrity, Pokaiora and Taparoa Clearings moderate integrity and Kuratau Clearing low integrity.

Conservation management priorities have been established. Three of the four remaining substantial frost flat sites in the Waikato Region have moderate to high ecological integrity and are considered worthy of management input in terms of periodic weed control.

The following are key recommendations:

- Information from temperature loggers should be analysed when available in March 2015 and related to vegetation pattern across the frost flat spectrum.
- Soil fertility analyses across both regions would also help elucidate the reasons behind differences in vegetation pattern between them.
- Vegetation history of the sites from charcoal and pollen analysis would enable the fire frequency needed to maintain open communities to be ascertained.
- The matrix surrounding remaining frost flat heathlands should be defined and its impact on them assessed.
- The most obvious immediate management priority is the control of woody weeds, particularly of heather at Whenuakura. The recent introduction of biological control for heather elsewhere on the Volcanic Plateau may largely eliminate it from Kuratau – where it is now beyond feasible chemical or manual control – in the foreseeable future.
- Plots should be remeasured on a 5-yearly basis, next in summer of 2018.

Key words:

Frost flat heathlands; Uncommon Ecosystems, Significant Natural Areas (SNA); Monitoring, Waikato Region, New Zealand.

1 Introduction

A network of permanent plots was established by Landcare Research in January–May 2013 for the Waikato Regional Council to establish a baseline for monitoring changes in the condition – 'ecological integrity' – of frost flat heathlands remaining in the Waikato Region. These remaining frost flat heathlands have been identified as Significant Natural Areas (SNA) based on the Waikato Regional Council Policy Statement, RPS 5: "It is indigenous vegetation or habitat that is, and prior to human settlement was, nationally uncommon such as geothermal, Chenier plain, or karst ecosystems".

2 Background

'Frost flat' heathlands comprise short sclerophyllous shrublands dominated by the ericaceous shrub monoao 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 maintains the treeless community. 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 shrubland and replacing it with shorter shrubland and grassland (Fig. 1). The taller shrub component – bog pine (*Halocarpus bidwillii*) and mountain toatoa – 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. At west Taupo, the Taparoa Clearing and Whenuakura Plain are both likely to have been part of Maori travel routes (A.E. Beveridge, pers. com.) and therefore subject to regular burning in pre-European times. The Pokaiora and Kuratau Clearings lie at the western edge of formerly extensive secondary communities that surrounded Lake Taupo and resulted from a long history of pre-European burning (Nicholls 1986).

Figure 1: Monoao scrub on frost flat heathland on the Whenuakura Plain, Pureora Forest Park. Short conifer (mountain toatoa) forest in the background. At 790 m asl, this is highest-elevation frost flat on the Volcanic Plateau. May 2013.

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 the surrounding matrix on survival prospects is unknown, but likely to be significant.

Until extensive land development after the Second World War, West Taupo was an important centre of frost flat heathland which now survives at only a handful of sites. A network of permanent plots across them will enable us to monitor changes in condition over time, and also to assess the influence of the surrounding matrix on their prospects for survival.

3 Objectives

The objectives of this study were (1) to establish a baseline for monitoring the condition – 'ecological integrity' – of significant frost flat heathlands remaining in the Waikato Region, and (2) to validate ecological information for Significant Natural Areas (SNA) inventory by ground truthing.

4 Methods

4.1 Permanent plots

Fifteen permanently marked 2 × 2-m permanent plots adapted from Hurst and Allen (2007) were placed at locations pre-selected by stratified random sampling defined by GIS polygons manually 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).

Within plots, the following raw data 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.

One larger intact site with apparently good prospects for survival was sampled (Fig. 2): Whenuakura Plain, Pureora Forest Park: 72 ha.

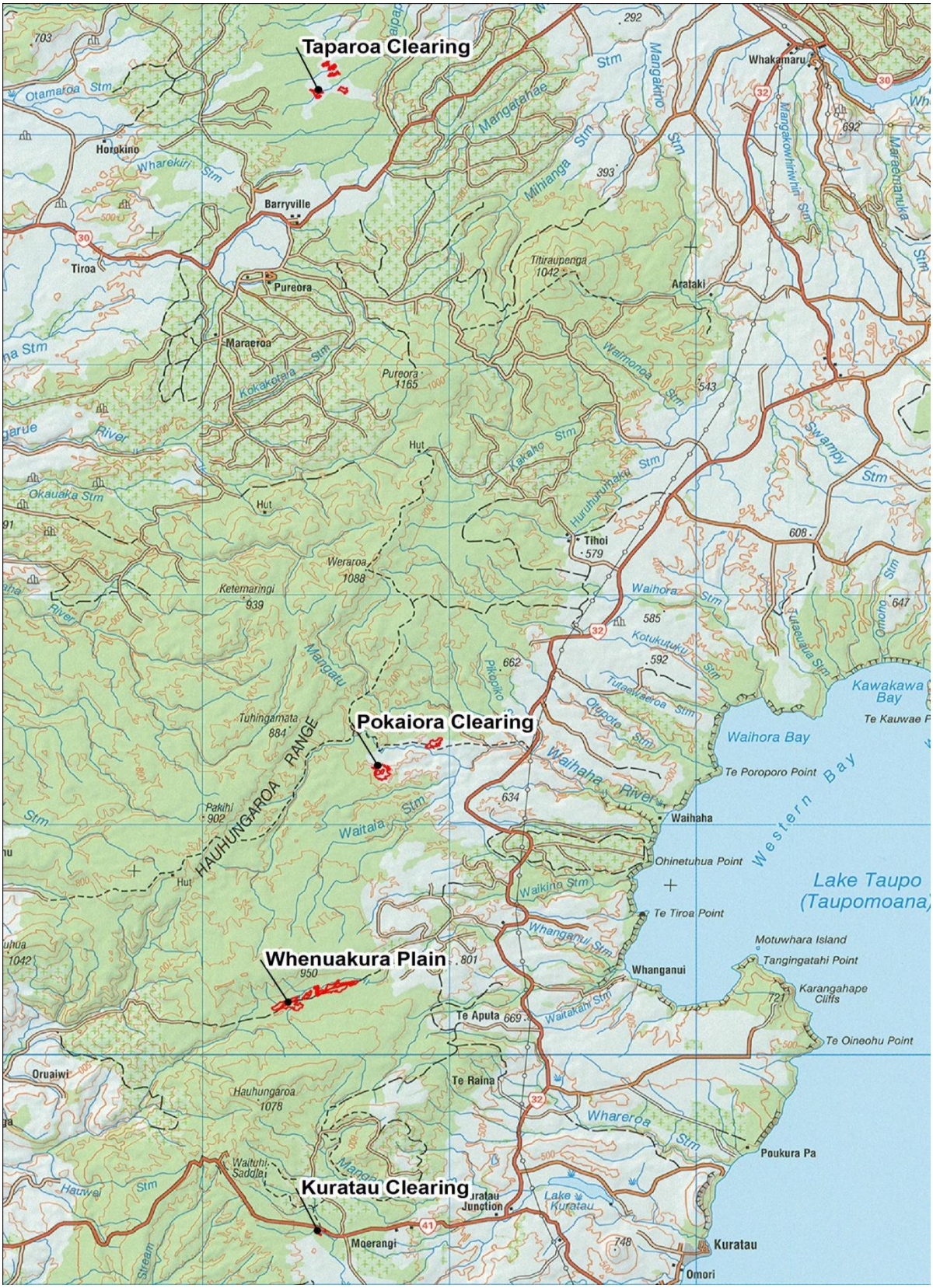

Figure 2: Map showing extant frost flat heathlands in the Waikato Region.

Three smaller sites with apparently poorer prospects for survival were sampled:

- Pokaiora Clearing, Waihaha Ecological Area, Pureora Forest Park: 38 ha.
- Taparoa Clearing, Waipapa Ecological Area, Pureora Forest Park (Figs. 3, 4): 23 ha (Leathwick 1987).
- Kuratau Clearing, Waituhi-Kuratau Scenic Reserve: 0.8ha.

Appendix 4 describes data collection and further information as metadata.

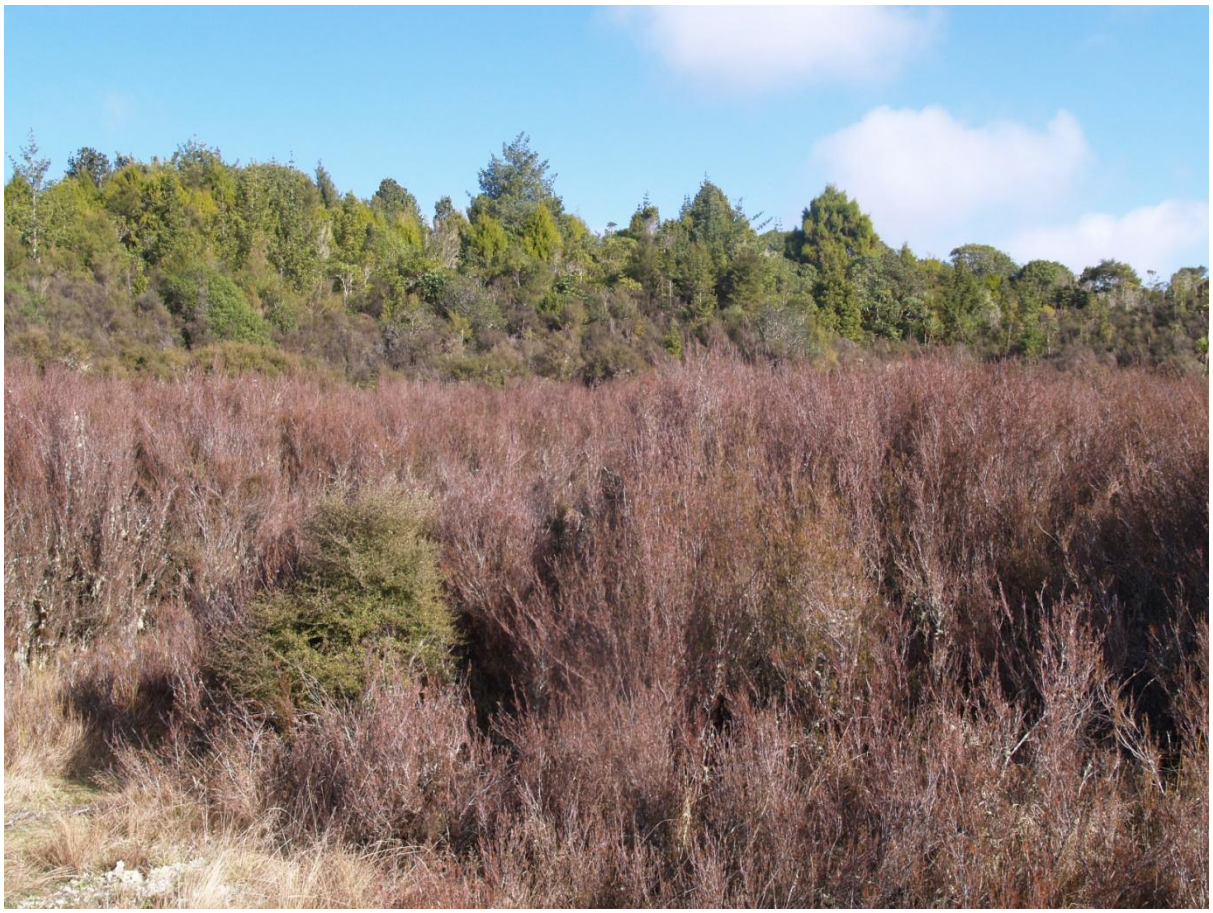

Figure 3: Monoao scrub in frost flat heathland in Taparoa Clearing, Waipapa Ecological Area, Pureora Forest Park. Manuka scrub and conifer forest on the hillslope behind. March 2013.

Figure 4: Understory of monoao scrub with coral lichen and *Uncinia* species in frost flat heathland in Taparoa Clearing, Waipapa Ecological Area, Pureora Forest Park. March 2013.

4.2 Data analysis

Levels of ecological integrity were calculated and averaged for four indicators (measures of ecological integrity) for each site from the raw data:

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

Overall ecological integrity was derived by averaging mean frequencies of the four individual indicators. Mean frequencies of each of the above measures below 20% were ranked very low, 20–50% low, 50–70% moderate, and above 70% high.

5 Results

5.1 Diagnostic frost flat species

Of the 12 diagnostic frost flat species originally listed for frost flat heathland (Smale 1990), only six – monoao, danthonia, coral lichen, *Cladonia confusa*, catsear, and *Leucopogon fraseri* – were widespread (i.e., occurring in at least 15% of all plots), and only three of them – monoao, danthonia and *Cladonia confusa* – occurred consistently, i.e., in at least half of all plots (Table 1). A total of 97 species (including prominent lichens) was recorded across all plots, including 17 adventives (Appendix 2). No threatened species were recorded.

Table 1 Mean frequency (% of plots in which recorded) of 12 diagnostic frost flat species at four frost flat sites in Waikato Region. * denotes adventive. Common and scientific names of plants are given in Appendix 1

Site	*Dracophyllum subulatum*	*Rytidosperma gracile*	*Cladonia confusa*	*Cladia retipora*	**Hypochoeris radicata*	*Leucopogon fraseri*	*Celmisia gracilenta*	*Poa cita*	*Cladonia capietallata*	*Pimelea prostrata*	*Deyeuxia avenoides*	*Racomitrium lanuginousm*
Pokaiora Clearing	100	80	33	47	33	60	33	7	7	20	7	0
Whenuakura Plain	100	47	40	67	7	7	7	7	7	0	7	0
Taparoa Clearing	100	100	47	20	87	33	13	33	13	7	0	0
Kuratau Clearing	87	40	80	60	27	0	0	0	7	0	7	0
All sites	97	67	50	48	38	25	13	12	8	7	5	0

5.2 Forest precursor species

Eleven potential tree and shrub precursor species of forest were recorded in plots (Fig. 5), of which only three – lancewood, mountain toatoa and manuka – were widespread (Table 2). No species occurred consistently. The remaining species were pokaka, broadleaf, manuka, poataniwha, tanekaha, Hall's totara, totara, matai, and lancewood.

Table2 Mean frequency (%) of the five more widespread and any forest precursor species at four frost flat sites in the Waikato Region.

Site/Species	*Lancewood*	*Mountain toatoa*	*Manuka*	*Tanekaha*	*Matai*	*Any species*
Pokaiora Clearing	13	0	13	20	0	40
Whenuakura Plain	13	53	0	0	13	53
Taparoa Clearing	40	7	13	7	7	53
Kuratau Clearing	0	7	40	0	0	40
All sites	17	17	16	7	5	47

Figure 5: Matai seedling (lower right) – a precursor of tall forest – developing under monoao scrub in frost flat heathland, Taparoa Clearing, Waipapa Ecological Area, Pureora Forest Park. March 2013.

5.3 Invasive weeds

Ten invasive weed species were encountered in plots, of which species, Yorkshire fog, heather, broom, sweet vernal and browntop, were widespread (Table 3). No invasive weed species was recorded in plots on the Whenuakura Plain. The remaining species were Chewing's fescue, lotus, mouse-ear hawkweed, and white clover.

Table 3 Mean frequency (%) of the six most widespread and any invasive weed at four frost flat sites in the Waikato Region

Site/Species	*Yorkshire fog*	*Heather*	*Broom*	*Sweet vernal*	*Browntop*	*Blackberry*	*Any species*
Pokaiora Clearing	53	0	0	33	7	0	73
Whenuakura Plain	0	0	0	0	0	0	0
Taparoa Clearing	53	0	0	33	27	33	87
Kuratau Clearing	0	100	93	7	33	0	100
All sites	27	25	23	18	17	8	65

5.4 Adventive dominance

Adventive species contributed minimally to vegetative cover except in the Kuratau and Taparoa Clearings (Table 4).

Table 4 Mean adventive dominance at four frost flat sites in the Waikato Region

Site	*Adventive/Indigenous cover ratio*
Pokaiora Clearing	0.09
Whenuakura Plain	0
Taparoa Clearing	0.11
Kuratau Clearing	5.83
All sites	1.51

5.5 Ecological integrity

Whenuakura Plain has high ecological integrity, Pokaiora and Taparoa Clearings moderate integrity, and Kuratau Clearing low integrity (Table 5).

Table 5 Ecological integrity of four frost flat sites in the Waikato Region

Site/Measure	*Mean frequency of any diagnostic frost flat species*	*Mean frequency of any native forest precursor*	*Mean frequency of any invasive weed*	*Adventive dominance*	*Overall*
Pokaiora Clearing	High	Low	High	Very low	Moderate
Whenuakura Plain	High	Moderate	Absent	Very low	High
Taparoa Clearing	High	Low	High	Low	Moderate
Kuratau Clearing	High	Low	High	Very high	Low

6 Discussion and conclusions

The list of 12 diagnostic frost flat species ('key' species: Smale 1990) was derived from Rangitaiki Conservation Area on the southern Kaingaroa Plateau, and later reduced to eight after much wider sampling in the region (Smale and Fitzgerald 2012). Frost flat heathland at these locations is characterised by open short shrubland; denser, taller scrub on more fertile (Yeates et al. 2004) and probably moister sites is much more local. In contrast, the west Taupo frost flats sampled here are characterised by tall, dense scrub except for Kuratau Clearing, which supports open, shorter communities. The consistent (i.e., present in at least half of all plots) occurrence of only three diagnostic species – monoao, danthonia and *Cladonia confusa* –highlights the fundamentally different nature of frost flat heathland between these regions.

Forest precursor species are far more widespread in west Taupo heathlands (mean frequency of any species 47%) than on the Kaingaroa Plateau (kanuka, the only native precursor, 5%). A much wider range of species, 11 *vs* 2, is also present (Fig. 6). Thus, succession to native forest is likely in the foreseeable future on much of the west Taupo frost flat heathland.

Figure 6: Totara seedling – a precursor of tall forest – developing under monoao scrub in frost flat heathland, Taparoa Clearing, Waipapa Ecological Area, Pureora Forest Park. March 2013.

Invasive weed species are more widespread in west Taupo heathlands (mean frequency of any species 65%) than on the Kaingaroa Plateau (42%). A wider range of species, 9 *vs* 4, is also present. The high weediness of Kuratau and Taparoa Clearings reflects their smaller size and proximity to roads and in the case of Kuratau, to pasture as well. Kuratau is also the closest site to the extensive heather population in and around Tongariro National Park. Pokaiora Clearing and Whenuakura Plain are larger and more remote.

Notably and in stark contrast to Kaingaroa, lodgepole pine – one of the most threatening weeds of this ecosystem – is absent from the west Taupo frost flat heathlands. Heather is now ubiquitous at Kuratau, spreading on road verges at Whenuakura (Fig. 7) and occasional at Pokaiora. Broom is nearly ubiquitous at Kuratau and present at Taparoa. Overall adventive dominance at west Taupo (mean 1.51) is higher than that on the Kaingaroa Plateau (0.06).

Figure 7: The invasive weed heather spreading on a foot track on the Whenuakura Plain, Pureora Forest Park. January 2013.

Both heather and broom are ruinous weeds in frost flat heathland. Heather is an ecological analogue of monoao and can almost completely oust it, as has already happened at Kuratau (Fig. 8). The recent introduction of biological control for heather elsewhere on the Volcanic Plateau may largely eliminate heather from Kuratau – where it is now beyond chemical or manual control – in the foreseeable future (Fig. 9).

As a nitrogen fixer, broom alters the key attribute of heathland ecosystems – low soil chemical fertility – 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.). Survival of frost flat heathland in the Waikato region depends on control of both heather and broom.

Figure 8: Frost flat heathland north of SH 41 in the Kuratau Clearing, Waituhi-Kuratau Scenic Reserve, greatly modified by weed – heather and broom – invasion. January 2014.

The low frequency of many diagnostic frost flat species and high frequency of forest precursor species highlight the fundamentally different nature of frost flat heathland at west Taupo (Waikato Region) and on the Kaingaroa Plateau (Bay of Plenty Region). Both regions have a long fire history, and other factors are likely to be responsible for the differences between them. The frost regime in the Taparoa Clearing is significantly milder than at Rangaitiki Conservation Area (Smale 1990). Information from the temperature loggers installed during this study across most of the frost flat spectrum in both regions will help clarify the contribution to differing vegetation pattern of this important limiting aspect of local climate. Soil fertility (not yet tested) may also be a contributing factor.

Figure 9: Frost flat heathland south of SH 41 in the Kuratau Clearing, Waituhi-Kuratau Scenic Reserve, greatly modified by weed – heather and broom – invasion. January 2014.

7 Recommendations

The following recommendations are proposed as a result of this work:

- Control of woody weeds, particularly of heather at Whenuakura is the most obvious immediate management priority. The recent introduction of biological control for heather elsewhere on the Volcanic Plateau may largely eliminate it from Kuratau – where it is now beyond practicable chemical or manual control – in the foreseeable future.
- 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. This requires a parallel suite of monitoring plots in the two very substantial frost flats remaining in the Hawke's Bay Region: the upper Waipunga and Kokomoka valleys and the upper Ripia Valley. Funding is being sought from Envirolink to establish these. Explanatory variables such as soil fertility, fire history, and temperature regimes from a subset of plots would greatly assist interpretation of the classification.

- Information from temperature loggers should be analysed when available and related to vegetation pattern across the frost flat spectrum.
- Soil fertility analyses across both regions should be carried out to elucidate the reasons behind differences in vegetation pattern between them.
- Vegetation history of the sites from charcoal and pollen analysis would enable the fire frequency needed to maintain open communities to be ascertained.
- Plots should be remeasured on a 5-yearly basis, next in summer 2018.

8 Acknowledgements

We would like to thank the Waikato Regional Council for funding this project, Dr Yanbin Deng (Waikato Regional Council) for facilitating and managing the contract and providing useful comments, David Smith (Department of Conservation, Te Kuiti) for arranging permits, Thomas Hepi (Murupara) and Campbell Brown (Whenuakura) for access, and Scott Bartlam (Landcare Research, Hamilton), Christopher Floyd (Ohaupo) and Thomas Emmitt (Department of Conservation, Te Kuiti) for field assistance. Dr Ines Schoenberger, Dr Peter Heenan, Dr Robin Smissen and Ms Kerry Ford (Landcare Research, Lincoln) identified plant taxa, and Dr Sarah Richardson (Landcare Research, Lincoln) provided helpful comments.

9 References

Holdaway RJ, Wiser SK, Williams PA 2012. Status assessment of New Zealand's naturally uncommon ecosystems. Biological Conservation DOI: 10.1111/j.1523-1739.2012.01868.x

Hurst JM, Allen RB 2007. The RECCE method for describing New Zealand vegetation. Version 4, Lincoln, Manaaki Whenua – Landcare Research.

Leathwick, JR 1987. Waipapa Ecological Area: a study of vegetation pattern in a scientific reserve. FRI Bulletin no. 130. Forest Research Institute, Rotorua.

Lee WG, McGlone MS, Wright E (comps) 2005. Biodiversity inventory and monitoring: a review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Contract Report LC0405/122. Lincoln, Landcare Research. 216 p.

Ministry for the Environment/Department of Conservation 2007. Protecting our places. Wellington, MfE/DOC.

Nicholls, JL 1986. A descriptive overview of the central North Island volcanic upland *In* Veale, B, Innes, JG: *Ecological research in the central North Island Volcanic Plateau region*. Proceedings of a New Zealand Forest Service workshop, Forest Research Institute, Rotorua.

Smale MC 1990. Ecology of *Dracophyllum subulatum*-dominant heathland on frost flats at Rangitaiki and Pureora, central North Island, New Zealand. New Zealand Journal of Botany 28: 225–248.

Smale, MC, Fitzgerald, NB 2012: Monitoring condition of frost flat heathlands, a rare ecosystem in the Bay of Plenty Region. Landcare Research Contract Report LCR996 to Bay of Plenty Regional Council.

Yeates GW, Schipper LA, Smale MC 2004. Site condition, fertility gradients and soil biological activity in a New Zealand frost-flat heathland. Pedobiologia 48: 129–137.

Appendix 1 – Common and scientific names of plants used in text

Common name	*Scientific name*	*Origin*[1]
blackberry	*Rubus fruticosus* agg.	Adventive
bog pine	*Halocarpus bidwillii*	Native
broadleaf	*Griselinia littoralis*	Native
broom	*Cytisus scoparius*	Adventive
catsear	*Hypochoeris radicata*	Adventive
Chewing's fescue	*Festuca rubra*	Adventive
	Celmisia gracilenta	Native
coral lichen	*Cladia retipora*	Native
	Cladonia capitellata	Native
danthonia	*Rytidosperma gracile*	Native
flax/harakeke	*Phormium tenax*	Native
Hall's totara	*Podocarpus cunninghamii*	Native
heather	*Calluna vulgaris*	Adventive
kānuka	*Kunzea ericoides*	Native
lancewood	*Pseudopanax crassifolius*	Native
lodgepole pine	*Pinus contorta*	Adventive
lotus	*Lotus pedunculatus*	Adventive
manuka	*Leptospermum scoparium*	Native
matai	*Prumnopitys taxifolia*	Native
monoao	*Dracophyllum subulatum*	Native
mountain oat grass	*Deyeuxia avenoides*	Native
mountain toatoa	*Phyllocladus alpinus*	Native
mouse-ear hawkweed	*Pilosella officinarum*	Adventive
native daphne	*Pimelea prostrata*	Native
patotara	*Leucopogon fraseri*	Native
pokaka	*Elaeocarpus hookerianus*	Native
poataniwha	*Melicope simplex*	Native
reindeer lichen	*Cladonia confusa*	Native
silver tussock	*Poa cita*	Native
sweet vernal	*Anthoxanthum odoratum*	Adventive
tanekaha	*Phyllocladus trichomanoides*	Native
totara	*Podocarpus totara*	Native

[1] Glossary of Origin is described in appendix 3

white clover	*Trifolium repens*	Adventive
woolly moss	*Racomitrium lanuginosum*	Native
Yorkshire fog	*Holcus lanatus*	Adventive

Appendix 2 – Flora of frost flat heathland in the Waikato Region (including species not present in plots)

Scientific name	*Common name*	*Origin*	*Kuratau*	*Pokaiora*	*Whenuakura*	*Taparoa*
Acaena agnipila	sheep's bur	Adventive				Y
Agrostis capillaris	browntop	Adventive	Y	Y		Y
Androstoma empetrifolia	bog mingimingi	Endemic			Y	Y
Anthoxanthum odoratum	sweet vernal	Adventive		Y		Y
Aporostylis bifolia	odd-leaved orchid	Native	Y			
Aristotelia fruticosa	mountain wineberry	Endemic		Y	Y	Y
Blechnum penna-marina		Native		Y	Y	Y
Campylopus sp.		Native			Y	
Carex dipsacea		Endemic				Y
Celmisia gracilenta		Endemic		Y	Y	Y

Centella uniflora		Endemic		Y		Y
Chionochloa rubra	red tussock	Endemic			Y	
Cladia aggregata		Native			Y	
Cladia retipora	coral lichen	Native	Y		Y	Y
Cladonia capitellata		Native	Y	Y	Y	Y
Cladonia confusa	reindeer lichen	Native	Y	Y	Y	Y
Clematis quadribracteolata		Endemic		Y		Y
Conyza sp.	fleabane	Adventive				Y
Coprosma ×cunninghamii		Endemic				Y
Coprosma cheesemanii		Endemic			Y	
Coprosma dumosa		Endemic			Y	Y
Coprosma propinqua	mingimingi	Endemic		Y	Y	Y
Crepis capillaris	smooth hawksbeard	Adventive		Y		Y

Cytisus scoparius	broom	Adventive	Y			
Deyeuxia avenoides	mountain oat grass	Endemic	Y	Y	Y	
Dichondra brevifolia		Endemic			Y	
Dicranoloma robustum	golden shaggy moss	Native	Y		Y	Y
Dracophyllum subulatum	monoao	Endemic	Y	Y	Y	Y
Elaeocarpus hookerianus	pokaka	Endemic		Y		
Festuca rubra	Chewing's fescue	Adventive		Y		
Geranium microphyllum	small-leaved cranesbill	Endemic		Y		Y
Gleichenia dicarpa	tangle fern	Native			Y	Y
Gnaphalium sp.	cudweed	Endemic		Y		
Gonocarpus aggregatus		Endemic		Y	Y	Y
Gonocarpus micranthus		Native		Y		Y
Griselinia	broadleaf	Endemic			Y	

littoralis						
Halocarpus bidwillii	bog pine	Endemic	Y		Y	
Helichrysum filicaule	creeping everlasting daisy	Endemic				Y
Hierochloe redolens	karetu	Native			Y	Y
Histiopteris incisa	water fern	Native			Y	
Holcus lanatus	Yorkshire fog	Adventive		Y		Y
Hydrocotyle moschata		Endemic				Y
Hydrocotyle novae-zeelandiae var. montana		Endemic				Y
Hymenophyllum sanguinolentum		Endemic			Y	Y
Hypericum perforatum	Saint John's wort	Adventive		Y		
Hypnum cupressiforme		Native				Y
Hypochaeris radicata	catsear	Adventive	Y	Y		Y
Lepidosperma	square sedge	Endemic			Y	Y

australe						
Leptecophylla juniperina	prickly heath	Endemic			Y	
Leptospermum scoparium	mānuka	Endemic	Y	Y		Y
Leptostigma setulosa	scrub nertera	Endemic	Y	Y		
Leucopogon fraseri	patotara	Endemic		Y	Y	Y
Lobelia angulata	panakeake	Endemic	Y		Y	Y
Lotus pedunculatus	lotus	Adventive	Y			Y
Luzula decipiens		Endemic			Y	
Luzula picta var. pallida		Endemic			Y	Y
Luzula sp.	woodrush	Native		Y		
Lycopodium fastigiatum	alpine clubmoss	Native		Y	Y	Y
Melicope simplex	poataniwha	Endemic				Y
Microlaena stipoides	meadow rice grass	Native				Y

Muehlenbeckia axillaris		Native			Y	
Myrsine divaricata	weeping mapou	Endemic		Y	Y	
Notogrammitis angustifolia subsp. nothofageti		Native				Y
Olearia virgata		Endemic		Y	Y	
Oreomyrrhis ramosa		Endemic		Y	Y	Y
Phyllocladus alpinus	mountain toatoa	Endemic			Y	
Phyllocladus trichomanoides	tanekaha	Endemic		Y		Y
Pilosella officinarum	mouse-ear hawkweed	Adventive	Y	Y		
Pimelea prostrata	New Zealand daphne	Endemic	Y	Y		Y
Pittosporum tenuifolium	kohuhu	Endemic				Y
Pittosporum turneri		Endemic			Y	
Poa cita	silver tussock	Endemic		Y		Y

Podocarpus cunninghamii	thin-barked totara	Endemic			Y	
Podocarpus totara	Totara	Endemic				Y
Polytrichum juniperinum		Native	Y	Y	Y	Y
Prumnopitys taxifolia	matai	Endemic			Y	Y
Prunella vulgaris	selfheal	Adventive		Y		
Pseudopanax arboreus	fivefinger	Endemic				Y
Pseudopanax crassifolius	lancewood	Endemic		Y	Y	Y
Pterostylis sp.	greenhood	Native			Y	
Raukaua anomalus		Endemic			Y	Y
Rubus fruticosus	blackberry	Adventive				Y
Rumex acetosella	sheep's sorrel	Adventive		Y		
Rytidosperma gracile	danthonia	Native		Y	Y	Y
Senecio jacobaea	ragwort	Adventive		Y		

Simpliglottis cornuta	bird orchid	Native			Y	
Thelymitra longifolia		Native	Y			
Thuidium furfurosum		Native				Y
Trifolium repens	white clover	Adventive		Y		
Trifolium sp.	clover	Adventive		Y		
Uncinia angustifolia		Endemic				Y
Uncinia rubra	red hook sedge	Endemic		Y	Y	Y
Uncinia rupestris		Endemic			Y	
Uncinia sp.	hook grass	Native		Y		
Veronica corriganii		Endemic			Y	
Veronica stricta	koromiko	Endemic			Y	Y
Viola cunninghamii	mountain violet	Native				Y

Appendix 3 – Glossary of scientific terms

Adventive	Accidentally or deliberately introduced from elsewhere into New Zealand
Endemic	Native to New Zealand and nowhere else
Native	Native to New Zealand and other countries as well

Appendix 4 – Metadata

1 Identification Information

Data Set Name:

Waikato Frost Flat Heathland Monitoring Sites – GIS Layer

Data Set Abstract:

This GIS data shows the locations of the 4 remaining frost flat heathland sites (Whenuakura Plain, Pokaiora Clearing and Taparoa Clearing all in Pureora Forest Park, Kuratau Clearing in Waituhi-Kuratau Scenic Reserve) in the Waikato Region. Waikato Regional Council monitors the ecological integrity of the sites from 15 permanent plots. These remaining frost flat heathlands have been identified as Significant Natural Areas (SNA) based on the Waikato Regional Council Policy Statements (RPS 5).

Content of Data Set:

The 4 sites are shown as vector polygons. The attributes are described below:

ID = Unique numeric identifier

OBJECTID = Numeric identifier

Block = Site name

VegClass = (not populated)

VegDesc = (not populated)

SHAPE_Leng = (not populated)

SHAPE_Area = Area of the site in square meters

GIS Features:

WaikatoFrostFlats_20140616

WRC File Location:

S:\GISWork\RIG\BIODIVERSITY\Significant_Natural_Areas\External_Data\Landcare\Waikato FrostFlats June 2014\As Supplied\WaikatoFrostFlats_20140616

Key Words:

Frost flats, heathland, Pureora Forest Park

Resource:

Land, GIS.

Data Set Ids:

This is not WRC corporate data and should only be used with approval from Yanbin Deng – Ecologist.

EWDOCS# 3086807.

Metadata Date:

9 October 2014

2 Contact Details

Contact Organisation:

Waikato Regional Council

Contact Position:

GIS & Data Management Team Leader

Programme:

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Supplier:

Mark Smale

Landcare Research New Zealand Ltd

Private Bag 3127,

Hamilton 3240

3 Spatial Information

Geographic Extent:

Pureora Forest Park

West 175.552790 East 175.648866

North -38.429730 South -38.891493

Projection and Co-ordinates:

NZGD 2000: New Zealand Transverse Mercator

WKID: 2193 Authority: EPSG

North: 5743222.7283

East: 1829743.1237

South: 5692126.6819

West: 1822825.4896

Positional Accuracy:

20 m

4 Data Acquisition History

Period and Frequency of Record:

January 2013 - January 2104. Five-yearly in future.

Data Acquisition Method(s):

Field teams of two people from Landcare Research.

5 Data Quality Information:

Data Quality:

Vegetation extent was derived from WRAPS 2007 aerial imagery with some ground truthing during monitoring plot establishment. Accuracy unknown where boundary delineation is unclear.

Attribute Accuracy:

Where populated attribute accuracy is good.

Completeness:

The data is complete for the purpose of locating the frost flat heathland monitoring sites.The data only names the sites, and has the area. There is no information within the GIS layer regarding species.

Logical Consistency:

The data is logically consistent.

6 Distribution Information

Data Form:

Hard copies (pdf) of raw data, electronic copies of data and GIS maps

Digital Format:

ESRI shapefile

WRC file location:
S:\GISWork\RIG\BIODIVERSITY\Significant_Natural_Areas\External_Data\Landcare\Waikato FrostFlats June 2014\As Supplied\WaikatoFrostFlats_20140616

Applications:

Smale MC; Fitzgerald NB 2014. Updating Information on Monitoring Condition of Frost Flat Heathlands, a Critically Threatened Rare Ecosystem in the Waikato Region.

Data Set Availability:

This is not WRC corporate data and should only be used with approval from Yanbin Deng – Ecologist.

Acknowledgement:

All printed maps or other outputs should attribute the data to Waikato Regional Council:

> © Waikato Regional Council 2014. Waikato frost flat heathland monitoring sites data.

7 Status Information

Data Status:

Permanent plots established and initial measurements collected. Five-yearly frequency intended.

8 Further Metadata Information

Related Information:

Holdaway RJ, Wiser SK, Williams PA 2012. Status assessment of New Zealand's naturally uncommon ecosystems. Biological Conservation DOI: 10.1111/j.1523-1739.2012.01868.x

Hurst JM, Allen RB 2007. The RECCE method for describing New Zealand vegetation. Version 4, Lincoln, Manaaki Whenua – Landcare Research.

Leathwick, JR 1987. Waipapa Ecological Area: a study of vegetation pattern in a scientific reserve. FRI Bulletin no. 130. Rotorua, Forest Research Institute.

Lee WG, McGlone MS, Wright E (comps) 2005. Biodiversity inventory and monitoring: a review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Contract Report LC0405/122. Lincoln, Landcare Research. 216 p.

Ministry for the Environment/Department of Conservation 2007. Protecting our places. Wellington, MfE/DOC.

Nicholls, JL 1986. A descriptive overview of the central North Island volcanic upland In: Veale B, Innes JG eds Ecological research in the central North Island Volcanic Plateau region: Proceedings of a New Zealand Forest Service workshop. Rotorua, Forest Research Institute.

Smale MC 1990. Ecology of *Dracophyllum subulatum*-dominant heathland on frost flats at Rangitaiki and Pureora, central North Island, New Zealand. New Zealand Journal of Botany 28: 225–248.

Smale MC, Fitzgerald NB 2012. Monitoring condition of frost flat heathlands, a rare ecosystem in the Bay of Plenty Region. Landcare Research Contract Report LCR996 to Bay of Plenty Regional Council.

Yeates GW, Schipper LA, Smale MC 2004. Site condition, fertility gradients and soil biological activity in a New Zealand frost-flat heathland. Pedobiologia 48: 129–137.

General Notes:

None.

Document Links:

EWDOCS_n2976104_v7_Monitoring_condition_of_frost_flat_heathlands__a_Critically_Threatened_Rare_Ecosystem_in_the.docx

WWW Links:

Waikato Regional Council Technical Report 2013/56: Monitoring condition of frost

flat heathlands, a critically threatened rare ecosystem in the Waikato region

http://www.waikatoregion.govt.nz/PageFiles/28548/TR201356.pdf

Need More Help?

Email the GIS & Data Management Team Leader – inforeq@waikatoregion.govt.nz