Distributional analysis of rare plant species associated with Caltha Herblands on the Bogong High Plains, Victoria

Bianca Berto

A report prepared for the Research Centre for Applied Alpine Ecology

La Trobe University

May 2018

SUMMARY

A survey of 92 *Caltha intraloba* Herblands on the Bogong High Plains, Victoria was conducted in 2018 to record the presence and abundance of 12 rare and/or endangered plant species, and the severity of deer impacts in these herblands. Using three major geographical areas (further divided into nine sub-areas), this report compares the historical distributions of the 12 target species with the current distribution. The frequency of occurrence, average abundance, degree of restriction to the Caltha Herbland habitat, and degree of restriction to sub-areas or major areas is discussed for each species. The minimum population size was estimated for each species alongside comments on the accuracy of these estimates. A ranking system was developed to determine which of the targeted species were most rare and/or threatened on the Bogong High Plains. Using the rank value of each species, rare (targeted) plant species richness within herblands, and the data on deer impacts, this report identifies herblands, sub-areas, and major areas to be prioritized for conservation action. Suggestions are made about the method of conservation action required (e.g. deer control, population monitoring), and a 4-year monitoring regime is proposed.

For most species, this survey has provided a foundation to better understand distributions, population sizes, and the restriction of these species to the Caltha Herbland habitat and/or particular areas. Clear trends in rare plant diversity and deer impact severity have been identified from the species through to landscape scale and hold significant value for future conservation efforts.

INTRODUCTION

Caltha intraloba Herbland Communities (hereafter known as Caltha Herblands) are a type of highly specialised open herbland, largely restricted to the sub-alpine and alpine areas of the Bogong High Plains, Victoria, Australia. This community type was listed under the *Flora and Fauna Guarantee Act 1988* in 1992. Caltha Herblands commonly occur in relatively small patches (rarely more than a few hundred m^2) on a stony substrate which remains largely unvegetated due to constant water flow from ground water and/ or snow melt (Harvey, 2003; Tolsma and Wahren, 2016; DELWP, n.d). The communities are known to support a suite of rare and endangered plant species (Harvey, 2003; DELWP, n.d.), and are threatened by feral deer and horses (Brown *et al*., 2016; Ingamells, 2017), as well as weeds, increased fire frequency, and climate change (Tolsma and Wahren, 2016). This survey was conducted to record the occurrence of the rare plant species associated with Caltha Herblands and evaluate these herblands for deer activity. This report examines the distribution of the targeted plant species, their estimated population sizes, and their degree of rarity and restriction to Caltha Herblands. Each herbland surveyed has been evaluated based on rare plant diversity, the value of the particular species it supports, and the severity of deer impacts. In doing so, 17 herblands have been identified for conservation priority and recommendations have been made regarding action towards conserving these herblands.

MATERIALS AND METHODS

Study Area

This survey was conducted across the Bogong High Plains in the Alpine National Park, Victoria. A total of 92 discrete Caltha Herblands were surveyed across three major study areas, which were further separated into nine sub-areas for distribution analysis purposes (Figure 1, Table 1).

Target Species and their Distribution

The species list for survey was generated using the Flora Information System. A list of plants recorded in key areas of importance (e.g. Cope Creek, Mt Nelse Snowpatch) was produced. Species of interest were selected from this master list based on their association with Caltha Herblands, their classification as Critically Endangered in Victoria based on the IUCN Red List criteria or their listing under the EPBC act. Many of these species are also listed under the Flora and Fauna Guarantee Act or the DEPI advisory list of Rare and Threatened plants. (Table 2).

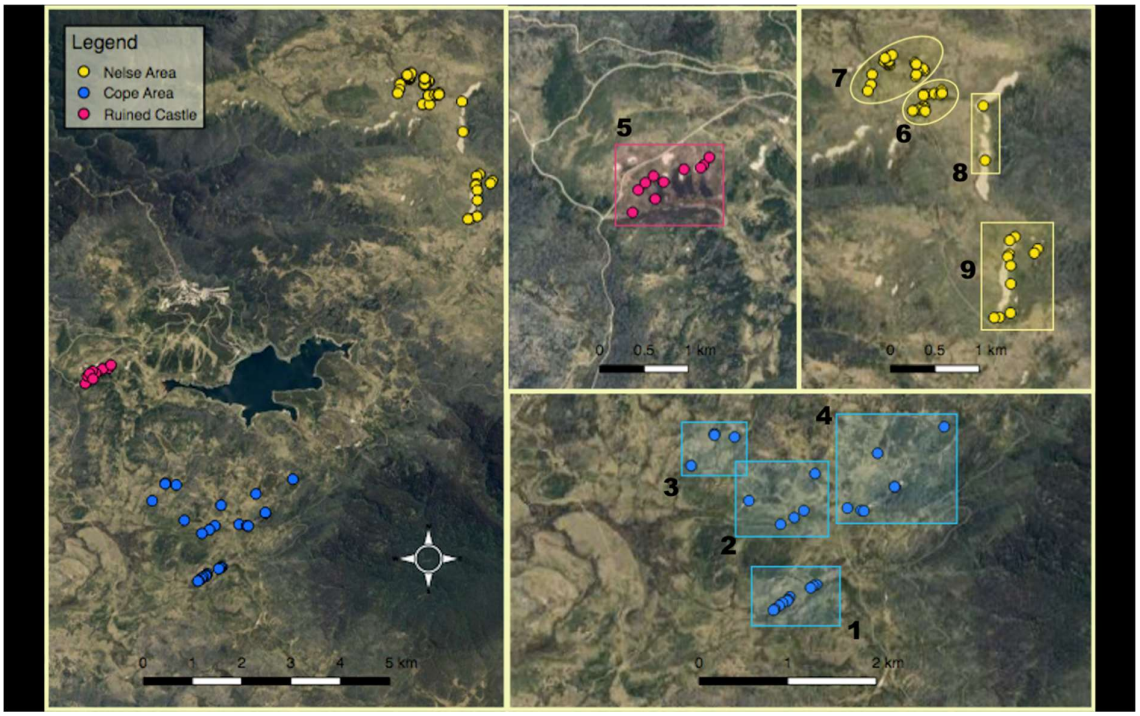

Figure 1. Map of the three major study areas and the nine sub-areas with the locations of each Caltha Herbland plotted. Each sub-area is outlined and given a number (see Table 1). Map created using QGIS.

Table 1. Summary of the three major study areas and their respective sub-areas. The number of each sub-area links to the numbered areas in Figure 1.

Area	**Sub-Area**
Cope	1. Cope Creek 2. ITEX Waterways 3. Long SSE Creek 4. Cope Hut
Ruined Castle	5. Ruined Castle
Nelse	6. Warby Corner 7. Whiterocks 8. Nelse North 9. Mt. Nelse Snowpatch

Table 2. A list of the targeted species for this survey and their respective EPBC, FFG and DEPI listing(s). Information extracted from DEPI (2014).

Species	*EPBC*	*FFG*	*DEPI*
Abrotanella nivigena			Vulnerable
Argyrotegium nitidulum	Vulnerable		Rare
Celmisia sercophylla		Listed	Vulnerable
Deyeuxia affinis		Listed	Endangered
Diplaspis nivis			Rare
Juncus antarcticus		Listed	Vulnerable
Oreomyrrhis pulvinifica			Endangered
Pappochroma paludicola			
Parantennaria uniceps			Vulnerable
Plantago glacialis			Vulnerable
Rytidosperma australe			Endangered
Utricularia monanthos		Listed	Vulnerable

Historical records for each species were extracted from the Victorian Biodiversity Atlas (VBA) and filtered to ensure these records were accurate and relevant. Records were deleted if:

1. They were not within the Bogong High Plains, or;
2. They had an ambiguous site description (e.g. Centre about X km [DIRECTION] of [Location]) and could not be accompanied by accurate GPS coordinates. GPS coordinates were decided to be accurate for all records after 2000 as it is likely that the coordinates were actually extracted from a GPS rather than generated from an approximate placement of a point on a digital map,
3. If their survey method was anything BUT "Species List for a Defined Area",
4. If they lacked a meaningful site name containing a meaningful landmark (e.g. Mt. Nelse, Mt. Jim, Cope Hut).

Species were identified as per their descriptions on the Flora of Victoria website and Costin *et al*. (1979). Most identifications were made in the field, with few instances where specimens were collected to confirm identification at a later time.

Locating Caltha Herblands

Tolsma and Wahren (2016) identified and mapped the distribution of Caltha Herblands across the Bogong High Plains, identifying 98 Caltha Herbland patches. The locations of these herblands formed the basis for the three major surey areas: Cope, Nelse, and Ruined Castle. Additional herblands were located by searching along streams, bogs, headwaters, and snowpatches within the major study areas, especially where historical records for targeted species existed. These vegetation types and landscape features were identified using the Bogong High Plains Vegetation Map & Guide to Alpine Flora (McDougall, 1986). Several herblands were also found incidentally in the field and were included in the survey.

Survey Methods

For each Caltha Herbland, a site description was made and included an estimate of size, aspect, slope, identification of dominant plant species, presence of gravels, pavements, silts and flowing water, and a description of the surrounding vegetation type. To avoid over- or under-sampling particular sites, a guideline of 15 minutes for the first 100 m^2 and 6 – 10 minutes per 100 m^2 thereafter was followed. All target species were searched for within each Caltha Herbland and where present, were given an abundance score ranging between 1 to 4 (Table 3).

For clonal species (e.g. *Plantago glacialis, Oreomyrrhis pulvinifica, Parantennaria uniceps, Abrotanella nivigena, Celmisia sericophylla*), this estimation of abundance counted each ramet as an individual and did not distinguish what were true genetic individuals. For such clonal species, the estimates of abundance are likely to overestimate the true population sizes.

Table 3. The abundance scoring system used to estimate the population sizes of targeted species.

Abundance score	Translation
1	1s of individuals
2	10s of individuals
3	100s of individuals
4	1000s of individuals

When a target species was located, additional notes regarding habitat and growth preference were made (e.g. found growing within Sphagnum beds, only found at fringes, etc.), and specimens were collected for herbarium records if the species had an abundance score of 2 or more.

Within each herbland, an assessment of deer impacts was made. Impacts were given a score of 0, 1, 2, or 3 which corresponded to absent, light, moderate or heavy (Table 4). Note that in several cases recording an intermediate score was accepted (e.g. 1.5 = low to moderate impact).

Table 4. Descriptions and definitions of the terms used to assess the severity of deer impacts at each Caltha Herbland.

Deer Impact Score	Definition
Absent (score = 0)	No obvious signs of recent deer activity
Low (score = 1)	No more than a few hoof prints found in peat and/or sphagnum. Prints may be shallow or difficult to distinguish.
Moderate (score = 2)	Several clear hoof prints found in peat/sphagnum. Prints often deep and easy to distinguish. Pellet groups may be present.
Heavy (score = 3)	Tens of deep and easily distinguished hoof prints found in peat/sphagnum. Vegetation clearly damaged by activity, signs of herbivory (esp. on Caltha) may be present. Pellet groups commonly found.

Data Analysis

For each species the VBA historical records and the records obtained from this survey were mapped and compared using QGIS mapping software. Differences in the number of records, as well as declines or expansions in species distributions over time were considered.

For each species, a minimum population size estimate was made using abundance scores. To do this, all abundance scores were converted to their minimum value (e.g. 2 = 10, 3 = 100), and then added for each species. The total sum for each species was its minimum estimated population size. To add more detail to these estimates, the total number of Caltha Herblands each species occurred at was calculated to give some indication of sub-population sizes and frequency of occurrence.

The species data were converted to presence-absence data in order to identify which Caltha Herblands had the highest diversity of rare plants. The results were graphed as number of rare plant species (i.e. rare plant species diversity) against the number of herblands with that rare plant diversity.

Deer impacts were mapped to determine which areas and herblands were most severely impacted. The average percentage of herblands impacted and the average severity of impact were calculated for each sub-area and major area.

A ranking system was developed to determine which herblands were most valuable and most at risk. To do this, each plant species was given a score from 1 to 3 based on five criteria; minimum estimated population size, the number of herblands it occurred in, the number of major areas it occurred in, the number of sub-areas it occurred in, and how restricted the species was to the Caltha Herbland habitat (Table 5). These scores were added for each species and then converted to a rank score, with a higher score indicating that the species was rarer.

Table 5. The criteria and scoring system used to rank each species based on their rarity.

Ranking variable	Score		
	1	**2**	**3**
Population Size	> 5000	1000 - 5000	< 1000
Number of Herblands the species was recorded in	> 30	10 - 30	< 10
Number of major areas the species was recorded in	3	2	1
Number of sub-areas the species was recorded in	6 - 9	3 - 5	1 - 2
Restriction to the Caltha Herbland habitat	Not restricted to Caltha Herblands. Clearly occurring beyond herblands and sighted in other habitats.	Occurs outside of Caltha Herblands but usually nearby or at fringes. Possibly sighted in other habitats.	Only ever seen in Caltha Herblands. Does not occur beyond fringes of herblands.

Once each species had been ranked, each herbland was given a score based on the sum of the rank scores for each species recorded within it. The higher the score, the more valuable the herbland. High scores could be obtained where a herbland had high rare plant diversity, and where a herbland only had a few of the targeted species recorded, but these species had a high rank.

For deeper insight and evaluation, the herbland scores and their respective deer activity score were considered such that individual herblands could be isolated for conservation priority.

RESULTS

Individual Species

Abrotanella nivigena

The historical distribution was comprised of a total of 5 reliable records on the BHP. These records were all located in the Nelse Area, more specifically, within the Whiterocks sub-area and just outside (NNW, upslope) of the Warby Corner sub-area. This survey confirmed that the distribution of this species is highly restricted to the Caltha Herblands of Whiterocks Creek. The distribution of *A. nivigena* does not extend to the sites surveyed in the Warby Corner sub-area. The species was recorded in a total of 15 herblands, often with hundreds to thousands of individuals present where it did occur (Appendix I). The population size of this species is estimated to be ~3000 for the areas surveyed (Table 6). Since the species was restricted to Caltha Herblands in one localised area, this is likely to be a fairly accurate estimate for the species across the Bogong High Plains.

Argyrotegium nitidulum

The historical distribution was comprised of 17 reliable records, which were widely spread across the BHP and located within all major study areas. During this survey, the species was recorded in a total of 22 Caltha Herblands and was generally found in abundances of a few to tens of individuals (Appendix I). *A. nitidulum* was found in all major study areas, and six out of nine sub areas (Cope Creek, Cope Hut, Ruined Castle, Warby Corner, Nelse North and Nelse Snowpatch). The species is not restricted to Caltha Herblands and was often encountered in surrounding herbfields and grasslands. Little can be implied about distributional changes for this species. The population size of this species is estimated to be ~200 for the areas surveyed (Table 6). The species was not restricted to Caltha Herblands. Given this, the minimum population size estimate generated by this survey is a poor representation of the true population size of this species across the Bogong High Plains.

Celmisia sericophylla

The historical distribution was comprised of 31 reliable records which were located across all three major study areas, and the Cope Hut, Ruined Castle, Warby Corner, Nelse North and Nelse Snowpatch sub-areas. This survey found a very similar distribution, with the species being present in only one new sub-area (Whiterocks). *C. sericophylla* was recorded at a total of 30 Caltha Herblands where it commonly

occurred in abundances of hundreds, sometimes thousands of individuals (Appendix I). The species is found thriving on rocky substrate at the headwaters of Caltha Herblands. The population size of this species is estimated to be ~6000 for the areas surveyed (Table 6). The species was not restricted to Caltha Herblands and was common at the headwaters of drainage areas with a constant, flowing water supply. Given this, the population size estimate generated by this survey is a poor representation of the true population size of this species across the Bogong High Plains.

Deyeuxia affinis

The historical distribution included 9 reliable records, all within the Cope Area, specifically within the Cope Creek and Cope Hut sub-areas. This survey identified the presence of *D. affinis* at 14 herblands, all within the historical range. Within these herblands there were typically 10s (rarely 100s) of individuals (Appendix I). The population size of this species is estimated to be ~250 for the areas surveyed (Table 6). The species was restricted to Caltha Herblands in a very localised area, but also occurred in adjacent *Sphagnum* bog systems. Given this, the population size estimate is likely to be fairly accurate for the species across the Bogong High Plains.

Diplaspis nivis

Despite being a comparatively common species, only one reliable historical record for this species was available and was located within the Whiterocks sub-area. During this survey, the species was recorded in a total of 65 Caltha Herblands, where it was commonly in abundances of tens to hundreds (in several cases thousands) of individuals (Appendix I). The species was not restricted to Caltha Herblands, often occurring primarily within fringing *Sphagnum* moss beds and extending from here into bog systems. The minimum population size of this species is estimated to be ~9000 for the areas surveyed (Table 6). The species was not restricted to Caltha Herblands and was common through Sphagnum bog systems. Given this, the population size estimate generated by this survey is a poor representation of the true population size of this species across the Bogong High Plains.

Juncus antarcticus

There were a total of 13 reliable historical records for this species. These were located throughout the Cope and Nelse areas, and all of their respective sub-areas excluding ITEX and Nelse North. This survey detected the species in a total of 38 Caltha Herblands across all sub-areas of Cope and Nelse. The species was restricted to the Caltha Herblands (i.e. didn't extend beyond fringes), and was common in highly

exposed areas. At sites where it was recorded, its abundance was variable but typically there were tens to hundreds of individuals at a single Caltha Herbland (Appendix I). According to this survey, the distribution in these areas has remained stable. The population size of this species is estimated to be ~3500 for the areas surveyed (Table 6). Since the species was generally restricted to Caltha Herblands, this is likely to be a reasonably accurate estimate for the species across the Bogong High Plains.

Oreomyrrhis pulvinifica

A total of 5 reliable historical records, all located within the Nelse Snowpatch sub-area, were available for this species. This survey confirmed this restricted distribution, with the species occurring within just 4 Caltha Herblands. Two of these records were new findings, while the other two reconciled with the same Caltha Herbland as historically recorded. It is possible that the southern-most population has been lost, granted that the coordinates from historical records are accurate. Note that all populations found were located in Caltha Herblands within 100 m of one another. *O. pulvinifica* tended to occur on the fringes of Caltha Herblands, closer to their headwaters (Appendix I). It was found in abundances of hundreds to thousands of individuals (Appendix I). Plants were in flower and fruiting when the survey was conducted. The minimum population size of this species is estimated to be ~2000 for the areas surveyed (Table 6). Since the species was highly restricted to Caltha Herblands in an extremely localised area, this is likely to be an accurate estimate for the species across the Bogong High Plains.

Pappochroma paludicola

A total of 5 reliable historical records were available for this species; however, they were all on the fringes of the Rocky Valley Dam meaning they were not within the major study areas. Despite this, the species was relatively common in this survey, being recorded in a total of 56 Caltha Herblands. It was present in every herbland in the Cope area, and was found within all Nelse sub-areas except Nelse North (note it was also very uncommon at Nelse Snowpatch). The species was absent from Ruined Castle. Where the species was recorded, it was represented by tens and in a few cases hundreds of individuals (Appendix I). The species was not restricted to Caltha Herblands, commonly occurring in *Sphagnum* moss beds at the fringes of the herbland and extending into bog systems. The absence of the species at Ruined Castle may be due to the higher levels of human disturbance at this site, or simply because the site does not meet the species requirements. Little can be implied about distributional changes, however this survey provides a more detailed foundation for understanding the species on the Bogong High Plains. The population size of this species is estimated to be ~1500 for the areas surveyed (Table 6). The species was somewhat restricted to

Caltha Herblands, but also occurred in adjacent *Sphagnum* bog systems and grasslands. This estimate is therefore likely to be inaccurate for the species across the Bogong High Plains

Parantennaria uniceps

A total of 10 reliable historical records were available for this species, nine of which were located in the Cope Hut and just outside of the Cope Creek sub-areas and one in the Whiterocks sub-area. This survey confirmed the rarity and restricted distribution of this species, recording the species at a total of 6 Caltha Herblands. The species was recorded again at the Cope Hut sub-area, but was not recorded in the Cope Creek sub-area. Two sites where it occurs in the Cope-Creek sub-area, the New Species and Sister Species wetlands, were not surveyed to avoid interfering with other long-term ecological surveys being conducted at the time of this survey. An informal survey of these two sites confirmed the persistence of *P. uniceps* at New Species wetlands, with the population represented by hundreds of individuals. New records of the *P. uniceps* were made at the Long SSE Creek sub-area but the historical record at Whiterocks was not confirmed. The population sizes were highly variable, but were generally in the tens for smaller Caltha Herblands (< 250 m^2), and present in the thousands for especially large (> 500 m^2) herblands (Appendix I). According to this survey, the distribution of this species is remaining relatively stable, albeit restricted. The population size of this species is estimated to be ~2000 for the areas surveyed (Table 6). Since the species was highly restricted to Caltha Herblands in a localised area, this lower estimate is likely to be fairly accurate for the species across the Bogong High Plains

Plantago glacialis

A total of 6 reliable historical records were available for this species. These were located in the Nelse Snowpatch, Warby Corner, and Cope Creek sub-areas. This survey recorded the species in a total of 4 Caltha Herblands, confirming the rarity and restricted distribution of the species. Records were present for the New Species Wetland, but due to other ecological research only an informal survey was conducted here. This informal survey suggests that the New Species Wetland population is very restricted and contains only a few individuals. All individuals are currently under threat by deer trampling. All formal records from this survey were located within Caltha Herblands at the Nelse Snowpatch. The population sizes were variable, but generally only comprised of a few to tens of individuals (Appendix I). Note that accurate estimates were difficult due to the clonal nature of the species. *P. glacialis* tended to occur on largely bare areas of peat on the fringes of Caltha Herblands and is heavily restricted to these sites. The largest distributional change may be that the population within the Warby Corner sub-area may have

become extinct. The minimum population size of this species is estimated to be ~100 for the areas surveyed (Table 6). Since the species was highly restricted to Caltha Herblands in an extremely localised area, this is likely to be an accurate lower estimate for the species across the Bogong High Plains.

Rytidosperma australe

Only two reliable historical records were available within the study areas, both within the Cope Creek sub-area. Once again, these could not be confirmed as both records were from New Species Wetlands. This survey provided a new record for the species at a single Caltha Herbland within the Cope Creek sub-area. This population was represented by hundreds to thousands of individuals (Appendix I). Both the historical records and this survey emphasise the rarity of the species on the Bogong High Plains. Very little can be concluded about distributional changes over time. The minimum population size of this species is estimated to be ~100 for the areas surveyed (Table 6). Since the species was highly restricted to Caltha Herblands in an extremely localised area, this is likely to be a very accurate lower estimate for the species across the Bogong High Plains.

Utricularia monanthos

Six reliable historical records were available for the species, all from the Cope Hut and Cope Creek sub-areas. The species was recorded in 3 Caltha Herblands, and 3 more populations were informally confirmed*. Those formally surveyed were located within the Cope Hut sub-area, and new population was found in the Warby Corner sub-area. In herblands where the species was found, there were tens to hundreds of individuals (Appendix I). Overall the distribution of this species appears to be remaining stable, and a population far beyond the historically known range has been newly found. The minimum population size of this species is estimated to be ~300 for the areas surveyed (Table 6). Since the species was highly restricted to Caltha Herblands in an extremely localised area, this is likely to be a very accurate lower estimate for the species across the Bogong High Plains.

Table 6. The minimum estimated population size for each species as well as their frequency of occurrence (number of herblands the species occurred in), and extent of their distribution (number of sub-areas and major areas the species occurs in).

Species	Minimum population size estimate	Number of herblands	Number of sub-areas	Number of major areas
Abrotanella nivigena	2940	15	1	1
Argyrotegium nitidulum	175	22	7	3
Celmisia sericophylla	5790	30	6	3
Deyeuxia affinis	221	14	2	1
Diplaspis nivis	8903	65	8	3
Juncus antarcticus	3512	38	8	2
Oreomyrrhis pulvinifica	2200	4	1	1
Pappochroma paludicola	1514	56	8	2
Parantennaria uniceps	2040	6	2	1
Plantago glacialis	131	4	1	1
Rytidosperma australe	100	1	1	1
Utricularia monanthos	310	4	3	2

Rare Plant Diversity

The diversity of the listed rare plant species was similar overall to that from previous records for the Cope and Nelse Areas. The Ruined Castle area had higher diversity overall than what could be seen from historical records but was still species-poor (for rare species) compared to the Cope and Nelse Areas. All sub-areas had higher diversity of the targeted plants than could be observed in the historical records. This probably reflects the fact that this study targeted particular habitats and species rather than suggesting that rare-species diversity has increased in these places. The sub-areas with the highest rare plant diversity (i.e.

5 or more of the target species) were found at Cope Creek, Cope Hut, Warby Corner, Whiterocks, and Mt. Nelse (Appendix II). Only 11 herblands supported 5 or more of the targeted species.

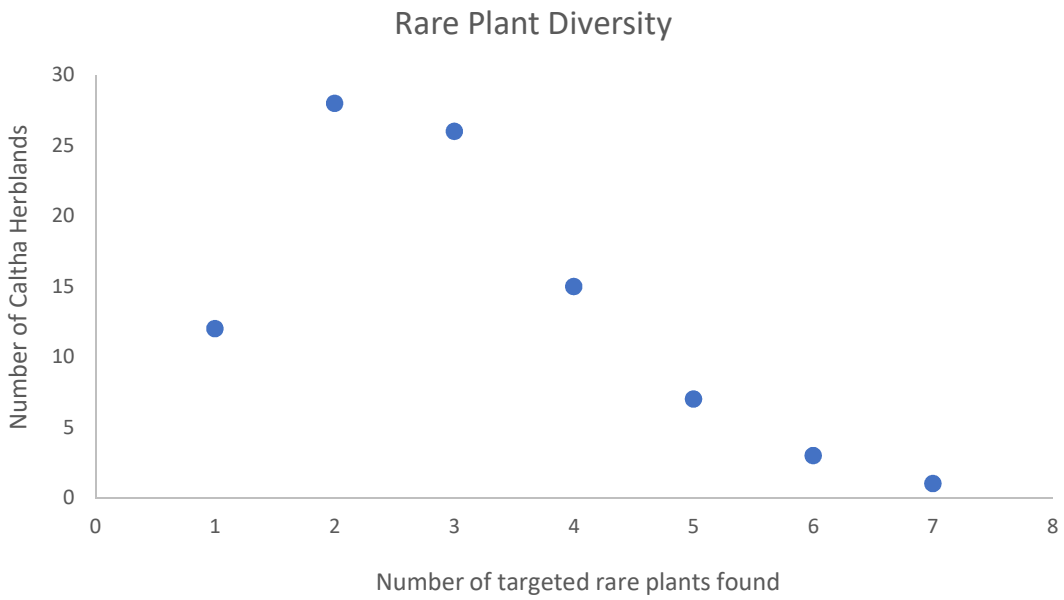

Figure 2. The number of Caltha Herblands at which x number of targeted rare plant species were recorded.

Herbarium specimens

A total of 58 specimens of the targeted species were collected (Appendix III) and have been submitted to the La Trobe University Herbarium.

Deer Impacts

Deer impacts were seen at 60 of the 92 Caltha Herblands surveyed (65%; Appendix I). The Nelse Area was most heavily impacted by deer, both in proportion and severity (Table 7). The Cope Area had a much smaller proportion of impacted herblands; however, where present impacts were still of moderate severity. The Ruined Castle Herblands were relatively unaffected by deer, with activity being rare and of low intensity.

Table 7. Percent deer impacted herblands and the average impact severity of those affected within each major area and sub-area.

Area	Sub-area	Number of herblands surveyed	Percent of herblands impacted by deer	Percent of herblands impacted and average impact score for the Area
Cope	Cope Creek	10	20%	36%, 1.8
	ITEX Waterways	4	50%	
	Long SSE Creek	5	20%	
	Cope Hut	6	67%	
Ruined Castle	Ruined Castle	10	10%	10%, 1.0
Nelse	Warby Corner	8	63%	88%, 1.9
	Whiterocks	35	94%	
	Nelse North	2	100%	
	Mt. Nelse Snowpatch	12	83%	

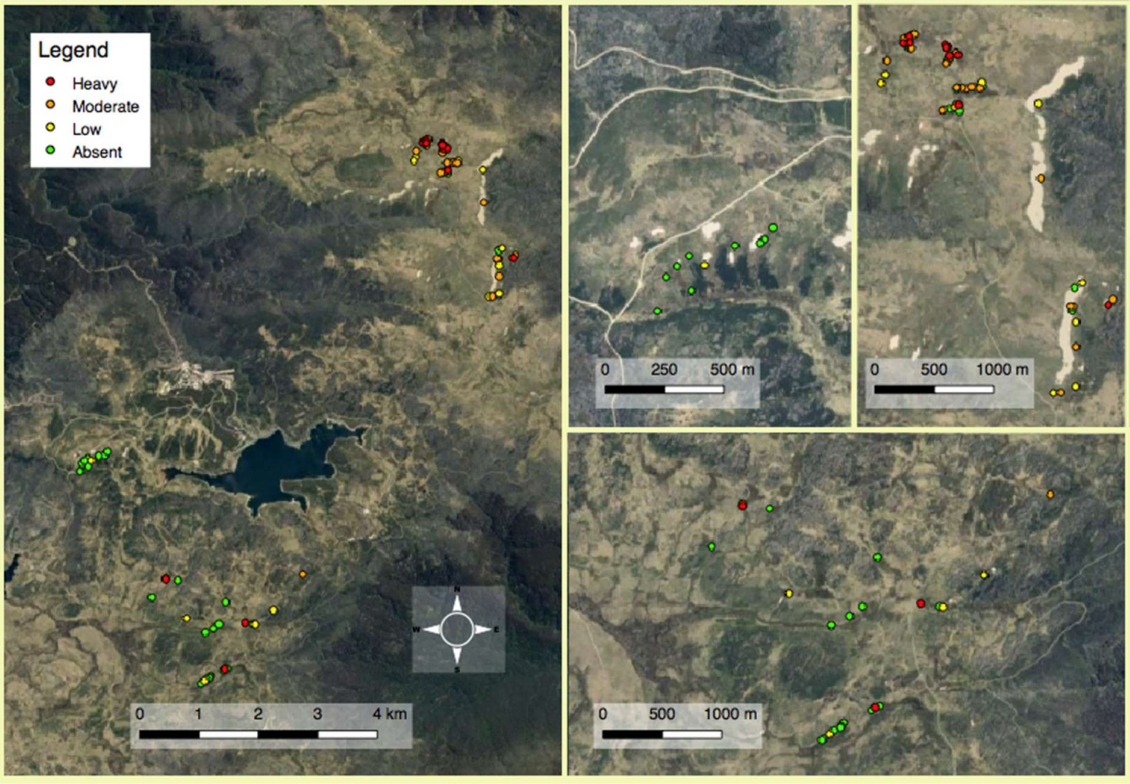

Figure 3. Map displaying the deer impact severity for each Caltha Herbland surveyed. Impacts were scored as 'absent' (green), 'low' (yellow), 'moderate' (orange), or 'heavy' (red).

CONSERVATION IMPLICATIONS

A total of 17 sites were identified for conservation priority (Figure 4). These sites hold high value due to having either high diversity of the targeted plant species, and/or support one or more of the rarest and most vulnerable of the targeted species (Appendix II). Of these high-value herblands, nine were impacted by deer and these impacts were moderate on average (average score = 1.8). The Cope Hut, Mt. Nelse Snowpatch and Cope Creek sub-areas contain the majority (13 of 17) of these high-value herblands.

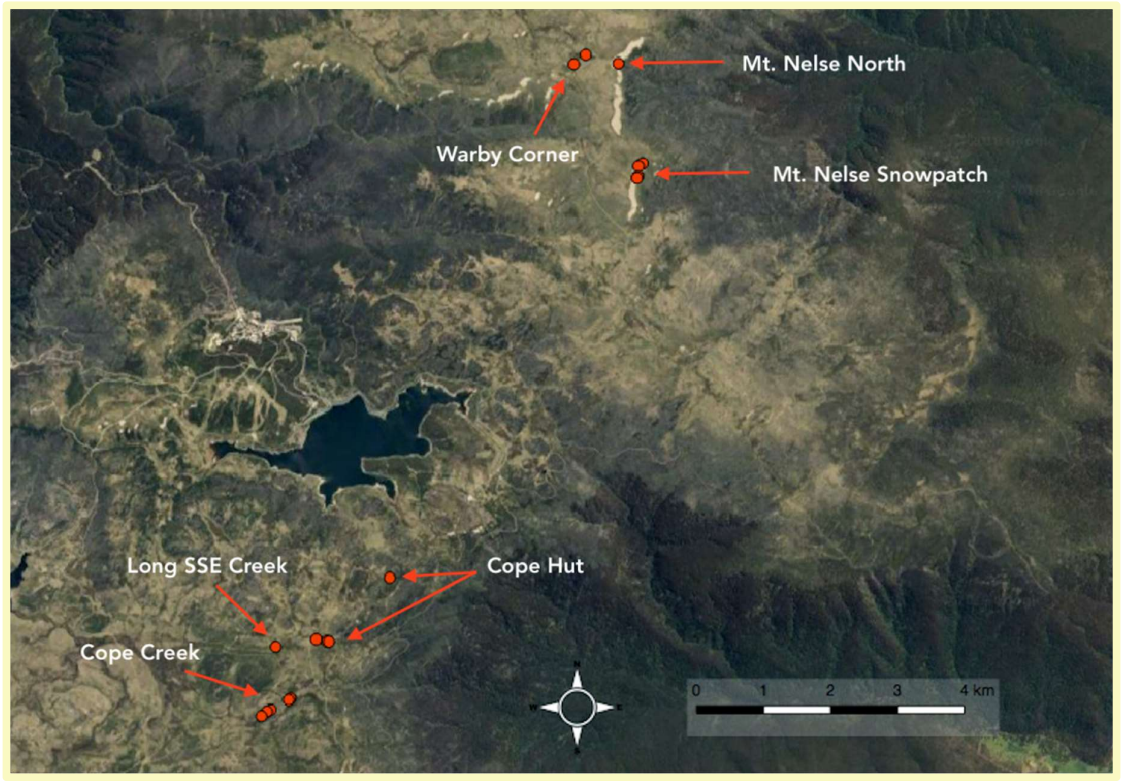

Figure 4. The 17 sites recommended for conservation priority and the sub-areas they occur in.

Different approaches need to be taken for the management of different areas and sites. For instance, some sites are heavily impacted by deer and this needs to be controlled urgently, while other sites remain unaffected however support populations of especially rare species. Outlined below are sub-area and/or herbland specific recommendations for conservation action.

Cope Creek

Only 1 of the 5 prioritized herblands were impacted by deer. There was relatively high diversity at most of these herblands (3 to 5 targeted species), and where diversity was low, the plants that are present are of high value (e.g. one herbland supports the *R. australe* population). It is recommended that the persistence of these plants is monitored every 2 years and that any signs of deer activity are recorded. Appropriate measures to control or exclude deer should be taken where necessary. If populations remain stable and deer impacts are absent for 6 years, monitoring may be reduced to every 3 years (depending on status of deer and other threats on the BHP at the time).

Cope Hut

This sub-area encompasses the top 2 high diversity and value herblands. In addition, 3 out of the 4 prioritized herblands are impacted by deer with these impacts being moderate on average. Annual monitoring of these herblands is recommended and deer control/exclusion is urgent. If populations remain stable and/or increase and deer are successfully controlled/excluded for 5 years, monitoring can be reduced to every 2 years.

Long SSE

The one site prioritized for conservation in this sub-area is not impacted by deer, however plant diversity is reasonable (4 targeted species), and the herbland supports a newly recorded *P. uniceps* population. Monitoring both the persistence of these plant populations and keeping watch for deer activity every 2 years is recommended. If populations remain stable and deer impacts are absent for 6 years, monitoring may be reduced to every 3 years (depending on status of deer and other threats on the BHP at the time).

Mt. Nelse Snowpatch

A total of 4 herblands were identifies for conservation priority in this sub area due to their high rare plant diversity and extremely valuable plants (in particular *P. glacialis* and *O. pulvinifica*). Of the 4 herblands, 2 were impacted by deer and impacts were light to moderate. Monitoring these herblands every 2 years for their rare plants and severity of deer impacts is recommended. If populations remain stable and deer impacts are absent for 6 years, monitoring may be reduced to every 3 years (depending on status of deer and other threats on the BHP at the time). If deer impacts become moderate to heavy and/or rare plant populations are in decline, deer control/exclusion should be introduced, and the impacts of hares/rabbits should be considered as there was a lot of activity noticed. In this case, increase the monitoring to annual surveys to ensure adequate and timely feedback.

Warby Corner

Two herblands have been prioritized for conservation efforts in this sub-area. Deer impacts were moderate to high and rare plant diversity was high. The newly discovered *U. monanthos* population was recorded at one of these herblands, and it was noted that evidence of previous rehabilitation of this herbland was present. Monitoring these plants every 2 years and exclusion/control of deer is urgent. Note that the Warby Corner sub-area requires urgent deer control as a whole. If populations remain stable and/or

increase and deer are successfully controlled/excluded for 6 years, monitoring may be reduced to every 3 years (depending on status of deer and other threats on the BHP at the time).

All herblands (non-prioritized)

It is recommended that all herblands are surveyed as part of a 4-year cycle for their rare plants and deer activity. A suggested monitoring regime is outlined below (Table 8).

Table 8. Suggested 4-year monitoring regime for both non-prioritized and prioritized herblands.

Year	Herblands to survey
1	Cope Hut, Warby Corner prioritized herblands (total = 6)
	Whiterocks non-prioritized herblands (total = 34)
2	Nelse North, Mt. Nelse, Cope Hut, Cope Creek, and Long SSE Creek prioritized herblands (total = 15)
	Nelse North and Mt. Nelse non-prioritized herblands (total = 9)
3	Cope Hut, Warby Corner prioritized herblands (total = 6)
	Warby Corner and Ruined Castle non-prioritized herblands (total = 17)
4	Nelse North, Mt. Nelse, Cope Hut, Cope Creek, and Long SSE Creek prioritized herblands (total = 15)
	Cope Hut, Cope Creek, Long SSE Creek and ITEX Waterways non-prioritized sites (total = 15)

ACKNOWLEDGEMENTS

I would like to thank the La Trobe University Research Centre for Applied Alpine Ecology and the Murray Darling Freshwater Research Centre for funding this survey. I would also like to thank Zac Walker, Warwick Papst, David Cameron, and Dr. John Morgan for their inputs and suggestions on structuring this survey and report.

REFERENCES

Brown, D., Thomas, E., Herbert, K., & Primrose, K. (2016). Evaluating the effects of feral deer management on endangered alpine peatlands: The Alpine National Park deer control trial, 4. *Plant Protection Quarterly. 31*(2), 63 - 66. Parks Victoria.

Department of Environment, Land, Water and Planning. (n.d). *Flora and Fauna Guarantee Act 1988 – Threatened List: Characteristics of Threatened Communities.* Retrieved from https://www.environment.vic.gov.au/__data/assets/pdf_file/0018/50418/Flora-and-Fauna Guarantee-Characteristics-of-Threatened-Communities-.pdf

Department of Environment and Primary Industries. (2014). *Advisory list of rare or threatened plants in Victoria*. Retrieved from https://www.environment.vic.gov.au/__data/assets/pdf_file/0021/50448/Advisory-List-of-Rare-or-Threatened-Plants-in-Victoria-2014.pdf

Harvey, A. J. (2003). Snow patch vegetation of Mount Hotham, Victoria. School of Ecology and Environment, Deakin University. Retrieved from http://www.mthotham.com.au/all-about hotham/why-hotham/corporate/publications/images/HothamsnowpatchThesis.pdf

Ingamells, P. (2017). What's the plan? *Park Watch*. *271*, 14 – 15.

Tolsma, A. D. and Wahren, C-H. (2016). Mapping and Monitoring *Caltha intraloba* Herbland Community. Unpub. Client Report for DELWP.