Threatened plant monitoring

Case studies by the Department of Conservation

Proceedings of a workshop hosted by Southern Regional Office, Department of Conservation, Gisborne 14th September 2004

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Introduction

A threatened plant monitoring workshop involving the Department of Conservation's Technical Support Officers (Flora) was held in Gisborne on Tuesday 14th September 2004.

The objectives of that workshop were to:

- Present case studies of threatened plant monitoring from each conservancy
- Review gaps in the national threatened plant monitoring programme;
- Develop a standard approach to identifying priorities for threatened plant monitoring
- Increase awareness of monitoring techniques and standards being used nationwide
- Discuss how best to improve the Department's plant monitoring activities

The purpose of this report is to publish the case studies presented at that workshop. Workshop attendees were: John Barkla, Andrea Brandon, Paul Cashmore, Janeen Collings, Shannel Courtney, Lisa Forester, Nick Head, Cathy Jones, Dave Kelly, Illona Keenan; Phil Knightbridge; Graeme LaCock, Don McLean, Jo Meys, Brian Rance, John Sawyer, Nick Singers, Bec Stanley, Mike Thorsen, Andrew Townsend and Elaine Wright. Dave Kelly of the University of Canterbury attended to provide an external perspective on the Departments plant monitoring and to give a presentation on plant population monitoring.

The workshop was part of a national programme to review the Department of Conservation's biological monitoring run by Research, Development and Improvement (formerly SRO). For more information about that review see Lee et al 2005 and Wright et al. 2005.

References:

Lee, W.; McGlone, M.; Wright, E. 2005. Biodiversity Inventory and Monitoring: A review of national and international systems and a proposed framework for future biodiversity monitoring by DOC. Unpublished Landcare Research Contract Report LC0405/122, prepared for Department of Conservation.

Wright et al. 2005.

Threatened plant monitoring in New Zealand – a review

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INTRODUCTION

Threatened plant monitoring is the acquisition and analysis of quantitative data that document the condition of the population or plant community over time (Palmer 1987). It is undertaken to detect and document population recovery or decline. This paper provides a brief overview of the threatened vascular plant population monitoring carried out by Department of Conservation staff largely undertaken since 1990. The review is based on information collated in a national spreadsheet of the Departments threatened plant projects. The review documents the number and location of threatened plant monitoring projects throughout the country. It identifies where most of the effort is being directed and highlight the positive aspects of this national programme but also identifies gaps and shortfalls.

THE NATIONAL PROGRAMME

The Department of Conservation is currently undertaking over 350 threatened plant monitoring projects for xxx plant taxa. These projects are spread over the entire country although a third of projects (35%) are being undertaken by Nelson / Marlborough Conservancy (see Figure 1).

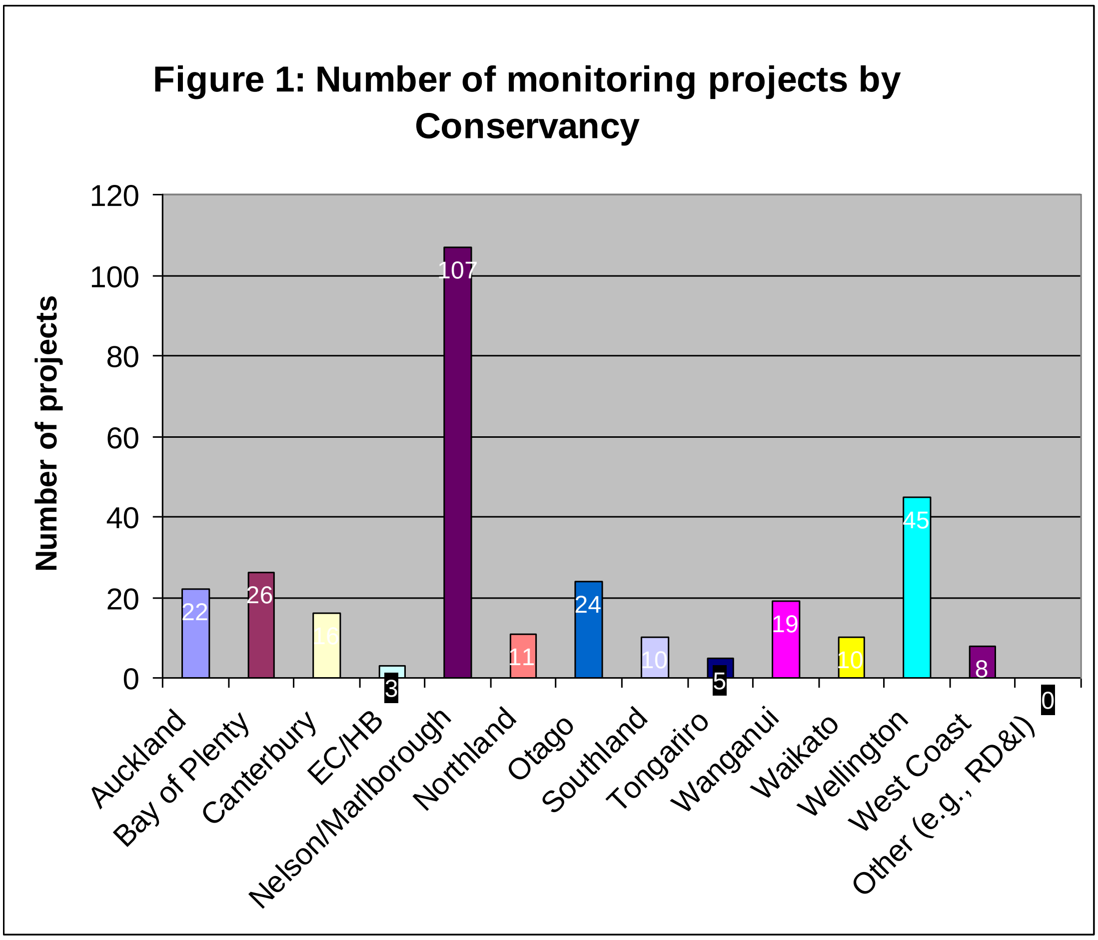


Figure 1: Number of monitoring projects by Conservancy

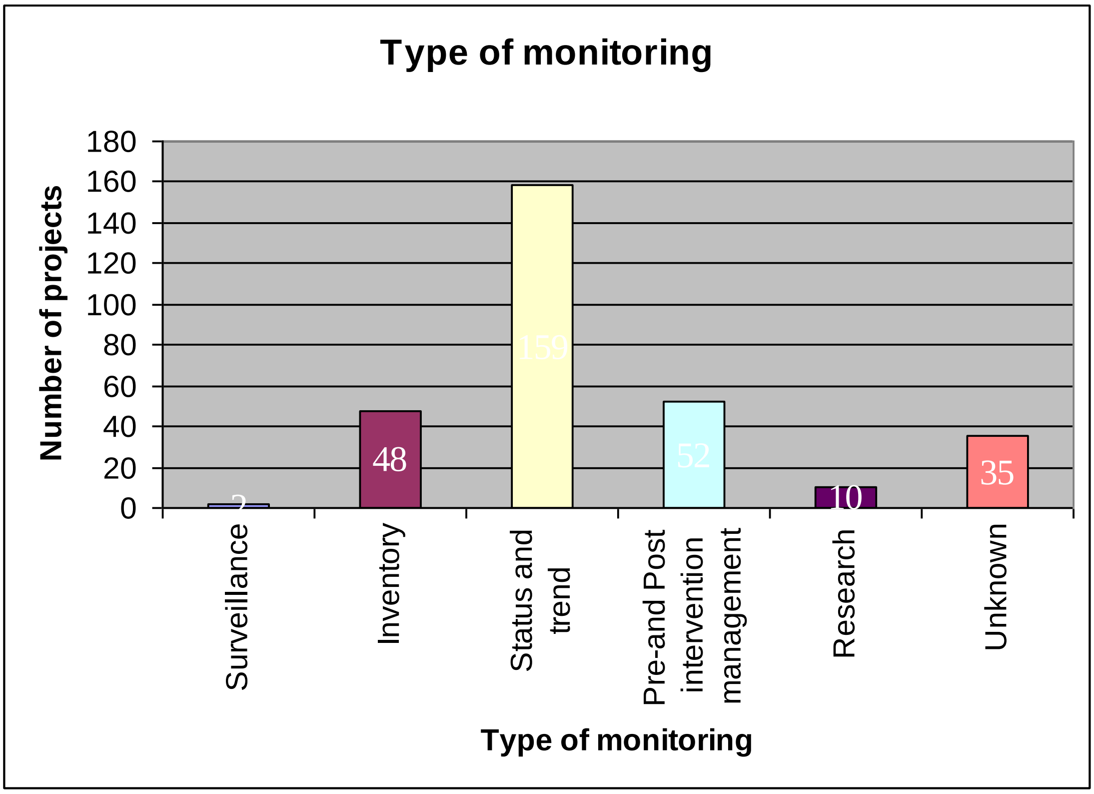
OBJECTIVES OF MONITORING

Threatened plant monitoring objectives may vary from project to project. The Department's projects were classified into one of four types of monitoring objective. Those categories were: (1) changes in ecological status and integrity; (2) effectiveness of management; (3) fundamental understanding and (4) unknown. In 40% of projects the objective is to gain a fundamental understanding of the species. This demonstrates the early stages of learning about the autecology of New Zealand's threatened plant species. In 30% of projects the objective was to determine changes in ecological status and integrity. For a small number of projects (10%) the objective was not yet recorded in the spreadsheet which was due to people either not knowing what the original project objective was, the project starting without a clear objective or the spreadsheet not being completed.

MAIN TYPES OF MONITORING

The main types of monitoring used for threatened plant populations are shown in Table 3. The majority of monitoring is status and trend (52%). A further 17% of project are monitoring the effects of pre and post intervention management.

Figure 2: Types of monitoring used for threatened plants



MONITORING TECHNIQUES USED

A wide range of techniques are already used by the Department of Conservation to monitor plant populations. Techniques include making a number count of individuals, visual assessments, mapping plant cover, measuring individual plant performance, transects and plots (Table 4). The most commonly used techniques are plant measurements (22%), number counts (21%), mapping (12%) and visual assessments (29%). Together these account for 84% of all projects. If improvements are to be made to the Department of Conservation’s plant population monitoring then this should be focussed on standardising those key techniques. There are no projects where line intercepts or point intercepts are used. No technique was recorded on the database for 37 projects and these have been excluded from the statistics.

VEGETATION PARAMETERS MEASURED

Vegetation characters used in monitoring projects by the Department of Conservation include the health of a plant, flowering and fruiting (phenology), cover, vigour, size of the population, height, diameter and volume (Table 4). The most commonly used vegetation character used in monitoring plant populations are plant ‘health’ (22%), size of population (22%), height or age class (15%) and phenology (9%). These characters are used in 68% of projects. If the Department of Conservation is to improve plant population monitoring then improvements, and perhaps standardisation, of techniques for recording these characters will be necessary.

Table 4: Techniques and vegetation parameters used in threatened plant population monitoring

Vegetation character or feature	Monitoring technique										
	Plant measurement	**Line intercepts**	**Sampling**	**Transects**	**Visual assessment (e.g. FBI)**	**Quadrats/plots**	**Number count**	**Photo-point**	**Point intercepts**	**Mapping extent**	**Total**
Volume	**9**										**9 (2%)**
Density	**3**			**2**		**28**					**33 (8%)**
Frequency				**1**		**1**					**2 (0%)**
Cover				**5**	**1**	**13**				**50**	**69 (16%)**
Basal Area/diametre	**12**										**12 (3%)**
Height/size classes/age cass	**63**										**63 (15%)**
Veg. structure				**1**				**1**			**2 (0%)**
Productivity/vigour	**4**							**1**			**5 (1%)**
Health					**87**			**9**			**96 (22%)**
Phenology	**2**				**37**						**39 (9%)**
Plant community composition	**1**			**1**				**8**			**10 (2%)**
Size of population	**1**			**1**	**2**	**1**	**89**				**94 (22%)**
Totals	**95 (22%)**	**0 (0%)**	**0 (0%)**	**11 (3%)**	**127 (29%)**	**43 (10%)**	**89 (21%)**	**19 (4%)**	**0 (0%)**	**50 (12%)**	**434**

WHAT IS BEING MONITORED?

Of the 350 threatened plant monitoring projects xxx are of single species (including multi-species mistletoe monitoring). In 3 cases an unspecified suite of threatened plant species are being monitored. In only two cases are projects devoted to monitoring threatened plant communities (wetland communities and coastal salt turflands, shrublands and dunelands).

WHAT IS MONITORED BY THREAT ASSESSMENT CATEGORIES

Table 5 shows the number of plant species being monitored by threat category (see de Lange et al. 2004, Molloy and Davis 1994). This shows that…

Using the more recent threat classification (de Lange et al 2004) only 27% of Nationally Critical determinate and indeterminate taxa are subject to monitoring. Only 12% of plant taxa included on this most recent national list of threatened and uncommon species are subject to monitoring.

Table 5: No of nationally threatened plant taxa that are subject to monitoring by the Department of Conservation

National Threat status Category	No of determinate taxa monitored (% of total)	No of taxa by category	No of indeterminate taxa monitored (% of total)	No of taxonomically indeterminate taxa by category	Total % of taxa monitored by category
Critical	17 (37%)	47	6 (16%)	38	27%
Endangered	23 (43%)	54	2 (14%)	14	37%
Vulnerable	7 (33%)	21	1 (50%)	2	35%
Serious decline	4 (15%)	26	1 (25%)	4	17%
Gradual decline	22 (31%)	70	0 (0%)	8	28%
Sparse	10 (8%)	126	1 (7%)	14	8%
Range restricted	7 (2%)	373	3 (4%)	75	2%
Data deficient	0 (0%)	45	2 (4%)	51	2%
Not Threatened	8	N/A	3	N/A	N/A
TOTAL	**98 (13%)**	**762**	**19 (9%)**	**206**	**12%**

DATA STORAGE METHODS

Data collected during plant monitoring projects is stored in a variety of places. Some of the main tools used for storage of data are: DME Excel spreadsheets (20%) and hard copy file notes (30%). In 43% of cases no data storage method location is listed which may indicate that the information is not known or has not yet been added to the spreadsheet. BIOWEB and conservancy databases account for 3% of data storage.

DATA ANALYSIS AND REPORT PRODUCTION

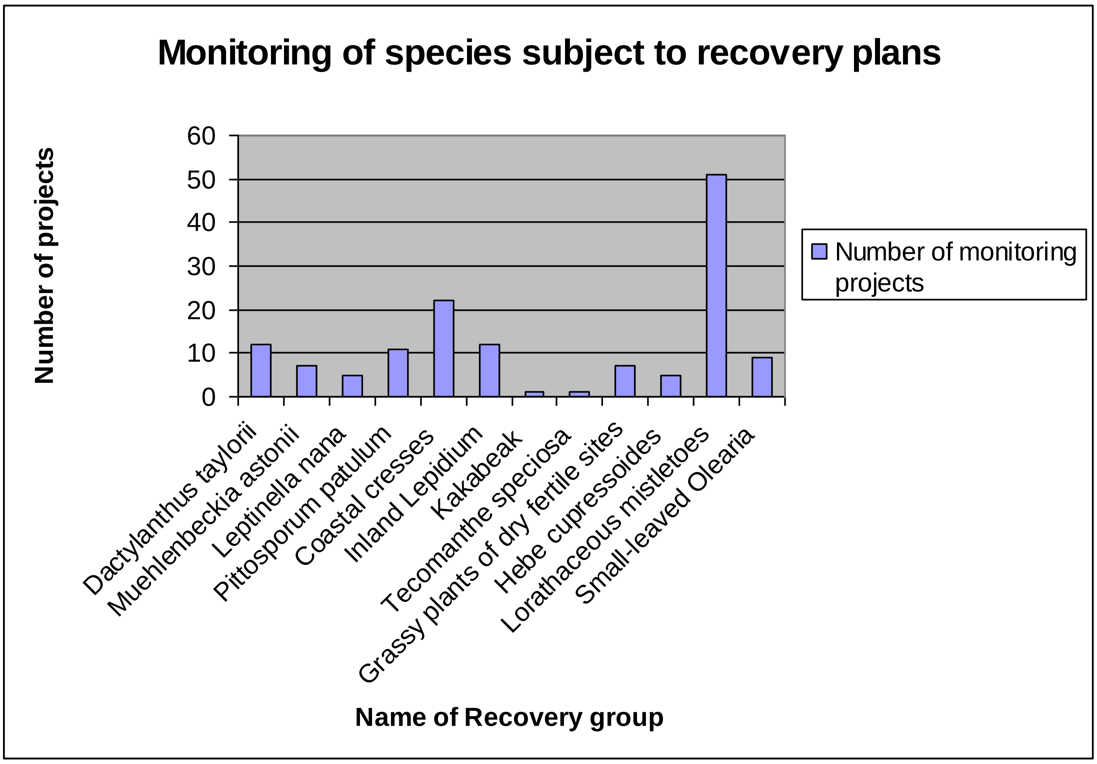
Reporting and analysis of data is a key part of any monitoring project. In many cases (60% of projects) it was unknown what reporting and analysis had been done. No reporting or analysis has been completed for 16% of projects. In many cases the reporting undertaken to date involves annual written reports produced internally for Departmental staff and remains unpublished. That means no data analysis has been completed as projects have more years to run.

TECHNIQUES USED EFFECTIVELY AND CONSISTENTLY

Nationwide there are 350 separate vascular plant monitoring projects for XXX plant taxa. The five loranthaceous mistletoe species are the most monitored of all native plants accounting for 51 (17%) of all monitoring undertaken (leafless mistletoes account for a further 7 projects).

The majority of species that are monitored are generally those for which a species recovery plan has been developed (e.g., *Dactylanthus taylori*, *Pittosporum patulum*, loranthaceous mistletoes). These account for 143 (47%) of all projects (Table 8). This demonstrates an important role for recovery groups in establishing monitoring for threatened plants and in many cases national standard protocols t be adhered to by staff.

Figure X: Monitoring of threatened plant species for which a recovery plan exists



GAPS AND SHORTFALLS IN THE MONITORING PROGRAMME

Many plant species are not yet being monitored in a consistent way nationwide. This leads to data capture that is not always comparable nationally. There are good reasons to improve national consistency in monitoring effort so as to improve our ability to assess species status and trends in condition on a national basis.

A second shortfall in the Departments programme is that many groups of species are not subject to monitoring. For some species, techniques have yet to be developed, adopted and approved. The greatest gap in the programme is the monitoring of acutely threatened species. Only 27% of Nationally Critical plant taxa are subject to monitoring. Only 12% of taxa listed on the published national threatened and uncommon species list are subject to monitoring. Only one threatened or uncommon cryptogam (*Fissidens berteroi*) is subject to monitoring and none of the 50 Nationally Critical fungi are being monitored. There are good reasons for this. In 1994 the Department published a priority setting system for species (see Molloy and Davis 1994). This ranked species according to their priority for conservation action. The Department then embarked on many species recovery and monitoring programmes for species ranked highly by this system. As more information came available the priority status of many of these species was downgraded. The Department had already committed to monitoring programmes. The response time to re-direct effort to new priority species is slow due to the legitimate reluctance to drop monitoring that has already been set up.

Current plant monitoring techniques have not been reviewed to determine if they are appropriate or effective for achieving the objectives.

The urgency of monitoring populations of many threatened or uncommon taxa must be determined (especially those for which a recovery plan has not been prepared). There are many plant species that may be high priorities including Nationally Critical taxa such as *Anzybas carsei*, *Brachyscome pinnata* and *Hebe breviracemosa*.

CONCLUSIONS

Some general conclusions can be drawn from this review. They are:

- The Department of Conservation has invested a huge amount of energy to determine the changing state of threatened plant populations in New Zealand.
- There is limited use of the full array of available monitoring techniques
- Monitoring standards have been developed for species subject to recovery plans indicating a valuable role of recovery groups for setting national standards.
- Priorities for threatened plant monitoring may need re-visiting and the speed at which the Department can respond to changes in threat status may also need reviewing.
- Many techniques currently used will not provide enough information to inform management or information needs for threat status classification. That means a limited knowledge base is being used for devising management.

References

de Lange, P.J. et al. 2004. Threatened and uncommon plants. *New Zealand Journal of Botany, 2004, Vol. 42: 45*

Palmer, M.E. 1987. A critical look at rare plant monitoring in the United States. *Biological Conservation 39*: 113-127

Gunnera hamiltonii monitoring at Three Sisters Dune and at Doughboy Bay, Stewart Island

B. D Rance, L. Sheldon-Sayer & E. Ganley

Introduction

Gunnera hamiltonii is a rhizomatous, rosette forming herb endemic to Southland. The leaves are glossy brown with pink to red petioles. Typical habitat is stable areas within a dune system, including dune fringe with low open vegetation and stable substrate areas. In favourable conditions it can form a dense mat, while it becomes sparse in thicker vegetation and other less favourable sites. The species is dioecious with only seven plants known, five female and two males. Each of the sites the plant varies from a few square metres to over 800 sq m of occupancy. At some sites the plant has become fragmented and so is best considered a clone. At original sites two plants have died, however material from these plants survives in the wild as transplants and are also known in cultivation.

G. hamiltonii is known from two plants (clones) on the mainland near Invercargill (both female) and 5 plants (clones) on Stewart Island (Doughboy Bay 3 clone, Masons Bay 1 clone and West Ruggedy Beach 1 clone). Several transplants have been established especially on Doughboy Bay. In the most recent threatened plant listing (de Lange et. al 2004) it was assigned the status of nationally critical.

Monitoring of *G. hamiltonii*

There are two major monitoring projects underway. These are:

a) Habitat occupancy and status at the Three Sisters dune
b) Establishment and growth of transplants at Doughboy Bay

A Habitat occupancy and status at the Three Sisters dune

Three Sisters dune is located near Omaui, south of Invercargill. This dune is a large sand blow dune system that extends to c. 100 m asl and 1 km inland. The dune system retains one of the largest populations of pingao on the Southland coast (excluding Fiordland) and also contains at least 10 other listed threatened and uncommon species including (*Ranunculus recens, Austrofestuca littoralis, Mazus arenarius, Gunnera arenaria, Libertia peregrinans, Myosotis pygmea* ssp. *pygmea, Epilobium chionanthum, Pimelea lyallii, Euphrasia repens, Agrostis ammobia*). The dune dynamics are changing as a consequence of dune stabilisation primarily by marram grass (*Ammophila arenaria*) and secondarily by other exotic grasses. The department has initiated a land protection proposal with the support of the Maori Trustee and local landowners. A weed control programme has also been initiated which aims to eradicate marram grass from the dune.

The *G. hamiltonii* Three Sisters plant is one of only two plants on the mainland, and is thought to be the type locality for the species. The *G. hamiltonii* is restricted to one small area and appears to have fluctuated in abundance and health since 1987 when it was rediscovered.

i) The purpose of monitoring

The primary purpose of the monitoring is to establish whether the plant is increasing/decreasing/stable in extent and density? Secondary questions that will be answered by the monitoring are:

a) Will the marram control programme have any impact upon the plant?
b) How does the plant interact with different substrates within its area of occupancy.

ii) Methodology

Monitoring was established on 1 March 2004. A 20 x 20m plot was established and permanently marked. This plot contains the extent of the main patch of the plant. The plot was divided into 400 1 x 1m sub-plots. In each sub-plot the percentage cover of *G. hamiltonii* was estimated. In addition 20 sub-plots were randomly selected for more detailed recording. In each of these sub-plots the percentage cover of each vascular plant species present and substrate was recorded. The substrate was assigned as sand, clay, gravel or rock.

iii) Results

A baseline of density and distribution has been established from which future changes in extent and density can be recorded. The extent and density of the plant has been illustrated (see Appendix 1). 164 sub-plots contained *G. hamiltonii* cover. Of these only 11 contained 20% or greater *G. hamiltonii* cover, including only two sub-plots containing greater than 40% cover (50% and 60% cover). No analysis of density or distribution compared with substrate has yet been undertaken. No trend information will be available until at least one remeasure has been undertaken.

iv) Discussion

- The methodology is relatively simple, however should allow objectives to be achieved.
- Only the corner pegs of the 20 x 20 m plot are permanently marked, therefore some inaccuracy is expected when the 1 x1 m grid is re-established during subsequent monitoring.
- The 20 sub-plots were not permanently marked. This will rectified at the next remeasure.
- There will be some level of observer variation in recording percentage cover.
- Establishment of the 20 x 20m plot took c. 5 hours?
- The first re-measurement is planned after two years and dependent upon that monitoring will be repeated at either 2 or 5 yearly intervals.
- During plot establishment *Ranunculus recens* and *Myosotis pygmea ssp. pygmea* were recorded at this site for the first time!
- This method could be applied to other *G. hamiltonii* sites or other mat forming plants.

B Establishment and growth of transplants at Doughboy Bay

Doughboy Bay is a dune system on the east coast of Stewart Island. The dune vegetation had become dominated by marram grass. The marram grass is now under a control programme. Doughboy is the only site with more than one plant of *G. hamiltonii* and has both sexes present (two female and 1 male plants). The male plant ("doughboy") was discovered in 1986, the original female plant ("doughgirl") was discovered in 1995 a second female plant was discovered in 1998. Soon after the discovery of "doughgirl" in February 1995 there was concern at the erosion to the sand dune and progressive loss of this plant. A number of transplants were undertaken to ensure that the genetic material was maintained in-situ. By early 2002 the original "doughgirl" plant was lost.

A number of transplants have been undertaken. These were by Rance in 1995 (both male and female plants), by Morecraft in 1996/97 (2 female plants), by Chadderton & Baxter in 1998 (2 female plants) and by Maria in 1998 (see Maria 1999). The growth of these transplants has been reported by the author (see Rance 1995, 1998, 1999, 2002a, 2002b & 2004).

i) The purpose of monitoring

To monitor the establishment and growth of transplants.

ii) Methodology

Initially a count of rosettes was undertaken, however soon the growth was such that it was too time consuming to count individual rosettes! Therefore size measurements have been relied on. The size measurements taken have been standardised, being two axis at right angles. The first axis is across the widest part of the plant. The second measurement is at right angles to the first measurement and across the widest point along that axis.

iii) Results

There have been six sets of transplants undertaken giving a total of 14 transplants. Of these two failed to establish (probably because to stock plant was taken from the beach below the source plant and had been exposed to salt water), one has been eroded away and 11 have survived. The surviving plants consist of one male plant, seven "doughgirl" plants and three mixed sex plants. The oldest transplants were established in October 1995 and to date 4 re-measurements have been made (see Appendix 2).

iv) Discussion

- The method does not record plant density.
- The methodology is very quick and simple, however should allow objectives to be achieved.
- No plants need to be permanently marked as long as the transplant can be found – all sites are recorded using a GPS (important at a site with reasonably frequent visitors).
- No formal analysis of data undertaken to date. Transplants show a high rate of establishment success, rapid growth and high density of cover

References:

Maria, L. (1999) Recovery Plan for the endangered species *Gunnera hamiltonii* Kirk. M Sc thesis, Environmental Science Department, University of Otago.

Rance, C. & Rance, B. D. (1996) *Gunnera hamiltonii*: new information on phenology and distribution. New Zealand Botanical Society Newsletter, No. 44, 8-9.

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Rance B. D. (February 2002) Report on a brief inspection of Doughboy Bay. Unpublished report, Department of Conservation, Invercargill.

Rance B. D. (December 2002) Report on a brief inspection of Doughboy Bay. Unpublished report, Department of Conservation, Invercargill.

Rance B. D. (2004) Report on a brief inspection of Doughboy Bay. Unpublished report, Department of Conservation, Invercargill.

Appendix 1 Density and distribution of *G. hamiltonii* with Three Sisters Dune plot

381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
380	379	378	377	376	375	374	373	372	371	370	369	368	367	366	365	364	363	362	361
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
340	339	338	337	336	335	334	333	332	331	330	329	328	327	326	325	324	323	322	321
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
300	299	298	297	296	295	294	293	292	291	290	289	288	287	286	285	284	283	282	281
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
260	259	258	257	256	255	254	253	252	251	250	249	248	247	246	245	244	243	242	241
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
220	219	218	217	216	215	214	213	212	211	210	209	208	207	206	205	204	203	202	201
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
180	179	178	177	176	175	174	173	172	171	170	169	168	167	166	165	164	163	162	161
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
140	139	138	137	136	135	134	133	132	131	130	129	128	127	126	125	124	123	122	121
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82	81
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

under 20% yellow, 21-40% blue, 41-60% pink

Appendix 2 Size data of Doughboy Bay transplants

Transplant name		June 1998	January 2002	September 2002	August 2004
Rance transplants	October 1995				
Male plant	35x15cm	195x123cm	550x460cm	620x450cm	880x720cm
Female plant	25x12cm	188x137cm	570x560cm	645x610cm	900x 880cm
Morecraft transplants	August 1997 *1				
Female t1	c.600x400m	109x75cm	250x2.4cm	260x280cm	1060x870cm#
Female t2	c.600x400m	Not recorded!	600x470cm	620x5.9cm#	Extinct
Chadderton					
Female t1		33x23cm	Not recorded	280x180cm	370x320cm
Female t2		4 separate rosettes, c. 4.9x10cm	Not recorded	560x330cm	730x425cm
Maria					
Mixed southern		300x450cm *2		650x520cm	950x640cm
Mixed middle		See above		440x280cm *3	575x70cm
Mixed northern		See above		600x450cm *4	110x58cm
Ganley					
Female south				35x25cm	120x95cm
Female middle				45x25cm	150x70cm
Female north				45x35cm	130x141

These plants were being eroded.

*1 Only the second set of Morecroft plants is recorded, the first set of two transplants was not successful and have not been included.

*2 The Maria transplants involved 18 pieces of *G. hamiltonii* (3 of each of 1 rosette, 10cm sq & 20cm sq of each sex), these were randomly sorted and spaced at 75cm apart along three transects spaced 1m apart. Therefore the initial transplant size was c. 3 x 4.5m. See Maria 1999.

*3 This plant was unhealthy and may have been affected by herbicide.

*4 This plant was healthy but largely underwater. The plant stayed underwater for several months.

Does *Hieracium pilosella* threaten *Acaena rorida* at Makirikiri Tarns near Ruahine Corner, central North Island?

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Introduction

Acaena rorida B. Macmillan (Rosaceae; Figure 1) was described in 1991 (Macmillan, 1991). It was first found by Tony Druce in 1973 at its only confirmed location, in the vicinity of the Makirikiri Tarns (Figure 2) on the Magaohane Plateau, central North Island. However, there are recent reports of a population in central Otago (J. Barkla pers. comm.), and another 1.5 hours walk north of Makirikiri Tarns (G. Rogers, pers. comm.). These records need to be confirmed.

Figure 1: *Acaena rorida*

The Makirikiri Tarns are part of the Aorangi-Awarua Kawenata, a Nga Whenua Rahui Conservation Deed between the Aorangi-Awarua Trust and the Department of Conservation. The threat status of *Acaena rorida* is currently "Nationally Critical" (Hitchmough, 2002; de Lange et al., 2004). This is the highest threat status. The qualifiers for this ranking are "Conservation dependent" and "One locality" (Hitchmough, 2002; de Lange et al., 2004).

Acaena rorida occupies several different habitats within its range. These include *Hieracium pilosella* beds (Figure 3), the bases of tussock and invasive grasses (Figure 3), turf communities in ravine beds, and the slopes of a small tomo. The most common habitat, tussock grassland, is also the habitat where most *Acaena rorida* occurs.

Figure 2: Makirikiri Tarns

Hieracium pilosella (hawkweed) also occurs in the Makirikiri Tarns, and is perceived to pose a threat to *Acaena rorida.* One of the objectives of the *Acaena rorida* recovery plan (Nicholls & Ravine, 2003) was to assess the competition between *A. rorida* and *Hieracium pilosella.* This report presents interim results for the first three years of this investigation, and recommendations for future monitoring.

Methods

Four study sites were chosen to determine whether *Hieracium pilosella* is threatening the survival of *Acaena rorida*, one from each of the habitats described above. The ravine and tomo were considered to be the sites least affected by invasive plant species. A point intercept method was used. At each site a 7.5 m or 10 m transect was laid out, depending on the site. Twenty-five one metre lines were measured perpendicularly from the transect line, at a spacing of 15 or 20 cm. All plants immediately below the tape at 2 cm intervals were recorded. The start and end point of each transect were permanently marked, but not the perpendicular lines. The transects were established in January 2002, and remeasured in December 2002 and January 2004. The ravine site was under approximately two metres of water in December 2002, so measurement of this site was carried out in early 2003.

The data allow analysis of trends in each species at each site over time, and a comparison between the two species at each site over time. Each 1 m line is treated as a sample unit. No attempt has been made to determine whether any significant trends in the *Acaena rorida* population can be attributed to any of the plant species present other than *Hieracium pilosella*.

The original intention was to undertake this monitoring until 2006 (6 years; Nicholls & Ravine, 2003).

Figure 3: The *Hieracium pilosella* beds (hawkweed site; near bags) and grass site (either side of tape). This is also the vicinity where the individual plant measurements were attempted.

Results

The frequency of occurrence of *Acaena rorida* remained relatively stable between years at the grass, hawkweed and ravine site, however it showed a steady decline at the tomo site (Figure 4). However, highest numbers were recorded at the tomo site in each year.

There was a significant drop in mean number of *Acaena rorida* plants between year 1 and 2 at the ravine site (one–way ANOVA, $F=9.63$, $P=0.0002$, $df=2$) and year 1 and 3 at the tomo site (one–way ANOVA, $F=14.45$, $P<0.0001$, $df=2$).

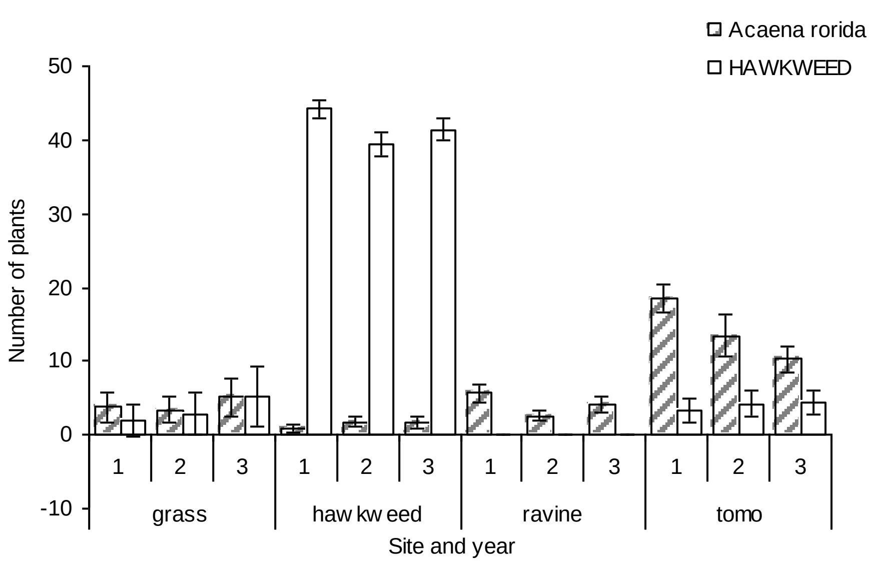

Figure 4. Mean number of plants per line ± standard error.

Hawkweed numbers remained relatively stable at each site between years (Figure 1) and there was no hawkweed at the ravine site. The only significant drop for hawkweed occurred between year 1 and 2 at the hawkweed site (one–way ANOVA, F=10.90, P,0.0001, df=2).

Non–parametric correlations between numbers of *Acaena rorida* and hawkweed plants produced variable results. For most sites in most years there was no significant correlation. At the hawkweed site in year 3 there is a negative correlation between numbers of *Acaena rorida* and hawkweed (Kendall's tau_b, Corr. Coeff.= -0.394, P=0.013, Spearman's rho Corr. Coeff.= -0.505, P=0.010), whilst at the grass site in year 3 there was a positive correlation between the two species (Kendall's tau_b, Corr. Coeff.= +0.362, P=0.023, Spearman's rho Corr. Coeff.= +0.463, P=0.020).

Therefore, with the current data we are unable to conclude that hawkweed is having a negative impact on *Acaena rorida*. Number of plants are variable from year to year, and variable along the one metre lines and this variability may be obscuring trends. However no overall trend is depicted in Figure 1.

Suggested improvements

The current monitoring has been designed to be done as quickly as possible, because of time constraints with flying to and from the site.

David Kelly (pers. comm.) has suggested that the data will be more robust if study sites were spread out instead of being confined to one replicate for each habitat type. The ravine and tomo are one-off sites that we cannot duplicate, however it will be possible to collect data from alternative or additional hawkweed and grass sites if time permits.

Other methods that failed

An attempt was also made to monitor individual plants from year to year in a hawkweed mat and at the base of tussocks. In 2002 a few plants were selected that appeared to be discrete entities, with no other plants in close proximity. These were permanently marked with an aluminium tag on a cable tie stuck into the ground. The direction and distance to each plant were also recorded from permanent pegs. The longest axis and the broadest point perpendicular to the long axis were measured. On small plants the number of shoots and the number of leaves on each shoot were determined. When we attempted to remeasure these individuals two problems manifested themselves: 1) several tags had been dislodged from the ground, either through frost action on the ground or rabbit or deer activity; and 2) it was virtually impossible to decide on where one plant ended and another started. This hadn't seemed to be a problem when the permanent plants were selected. This method has been abandoned.

Discussion

There have been some changes in the frequency of occurrence of *Acaena rorida* and *Hieracium pilosella* at each site, but we have not been able to show any definite correlation between *A. rorida* decline and a corresponding increase in *H. pilosella*. *Acaena rorida* appears to be stable at the grass, hawkweed and ravine site, but its frequency of occurrence has dropped from 18 to 10 (n = 50) at the tomo site. Nevertheless, the frequency of occurrence here is still roughly double that of any other site.

Conclusion

These results do not show that it is necessary to start treating *Hieracium pilosella* to save *Acaena rorida.* This may be because the limited sample sizes and short time frame for monitoring do not supply enough evidence to base a decision on. Therefore we recommend that annual monitoring continue until December 2006, as per the management plan (Nicholls & Ravine, 2003).

In future data collection in the hawkweed and grass habitats will include collection from alternative or additional sites, to make the data more statistically robust.

Acknowledgements

Thanks to all the people that have helped with field work over the years and to those that helped with the data analysis.

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Monitoring of red-bearded orchids (*Calochilus robertsonii*), Rotorua City 1985-2004

Paul Cashmore and George Pardy

What is being monitored?

The genus *Calochilus* (bearded orchids) comprises about 12 species, mostly Australian, but is also recorded from New Caledonia, New Guinea, and New Zealand. The three species that occur in New Zealand are shared with Australia: *C. herbaceus*, *C. paludosus*, and *C. robertsonii* Benth. (red bearded orchid). Although these three species are widespread in Australia, they are uncommon in New Zealand (Merrett *et. al.* 2001).

Red bearded orchid is the most abundant of the three species which occur in New Zealand. However it is uncommon and found at only a small number of sites and is currently ranked as "At Risk – Sparse" (de Lange *et. al.* 2004). It occurs mainly in the central North Island in open scrub and grassland, often on poor soils and geothermally influenced ground. The largest known population occurs in Rotorua City, where it occurs in open grassland, which is mown only in winter to allow flowering and seed production.

Figure 1: Red bearded orchid

Why monitor?

Monitoring, which began in 1985 has been undertaken for a variety of reasons as follows:

1. Species had a much higher threat ranking when management began in 1985.
2. It is the largest known population of this species in New Zealand
3. The site was under a high degree of threat at the time from clearance, mowing, horse trampling, collecting of plants, fertilising, oversowing with grasses and weed encroachment – mainly exotic grasses and blackberry.
4. To establish whether changes in management of the area (i.e. not mowing the plants when flowering and seeding) were successful in maintaining the population.

Original reasons for establishing the monitoring are not explicitly stated in the files but related to studying population changes following a change in management regime (mowing only during winter when the orchids are not flowering or seeding). However there is only one year of pre-management data although casual observations of a small neighbouring population which rapidly became extinct with no vegetation management had led to a need for urgent management action and subsequent monitoring to determine responses. Today, objectives relate more to following long term changes in the population over time as the management regime is constant.

Methods

An annual census of the red bearded orchid population is undertaken each year in late November – early December. The orchids occur within a reasonably defined area which is historically known (largely inside a circular training track) and therefore we are able to survey the entire population. The survey involves griding the area into belt transects. It is only in recent years since 2001 that these have been permanently marked which is difficult in mown grassland. This has enabled spatial changes in the orchid population in different belt transects to be studied. In total there are 7 belt transects.

Teams of volunteers and DoC staff walk each transect twice in opposite directions and place a self adhesive paper 'dot' beside each red bearded orchid plant (flowering and non-flowering) located. The entire known area is surveyed in this manner.

Figure 2: DoC staff and volunteers marking red bearded orchid plants on a belt transect.

The number of orchids counted is determined by calculating the number of self adhesive 'dots' per metre of backing tape (63) and measuring the length of backing tape used for the survey.

Results

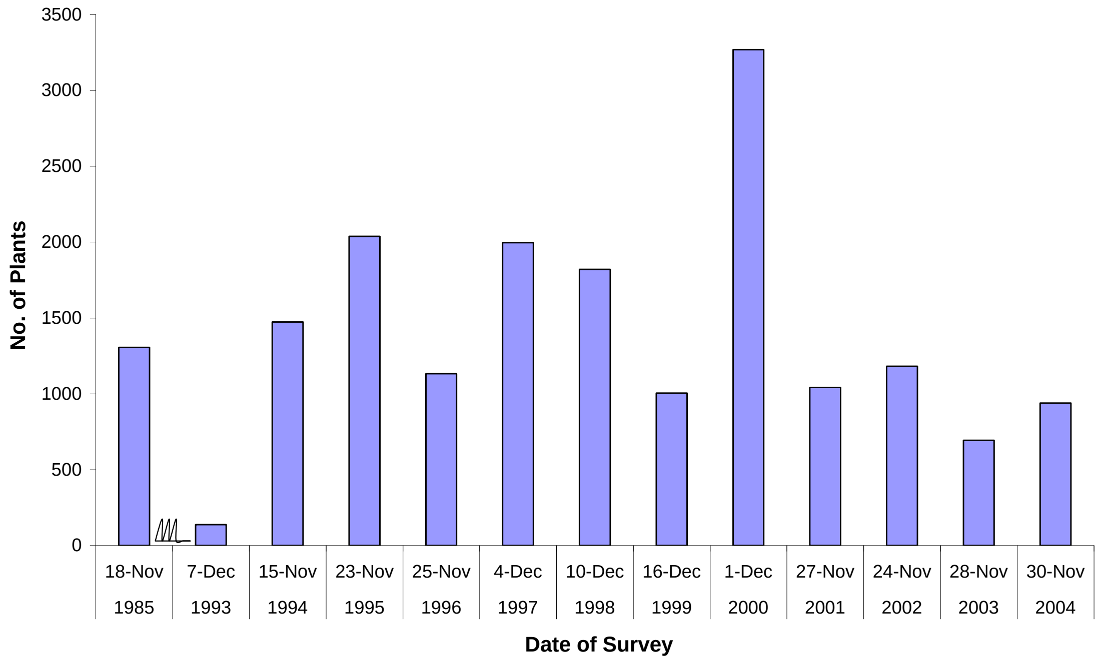

Figure 3: Total number of red bearded orchids counted, Rotorua City 1985-2004

A census has occurred annually since 1993 with a census also undertaken in 1985. Figure 3 shows that orchid numbers fluctuate greatly from year to year. Some of the extremes in earlier years were partly due to management regimes e.g. in 1993 could have been due to mowing being undertaken at the wrong time of the year and possibly failure to recognise some smaller non-flowering plants. In recent years with a more constant management regime fluctuations in population size are likely to be natural, rather than human-influenced. Overall in the past decade the population appears to have fluctuated between 1000-2000 plants, although in 2003 the population declined to 694. There was a big increase in numbers in 2000 to 3268.

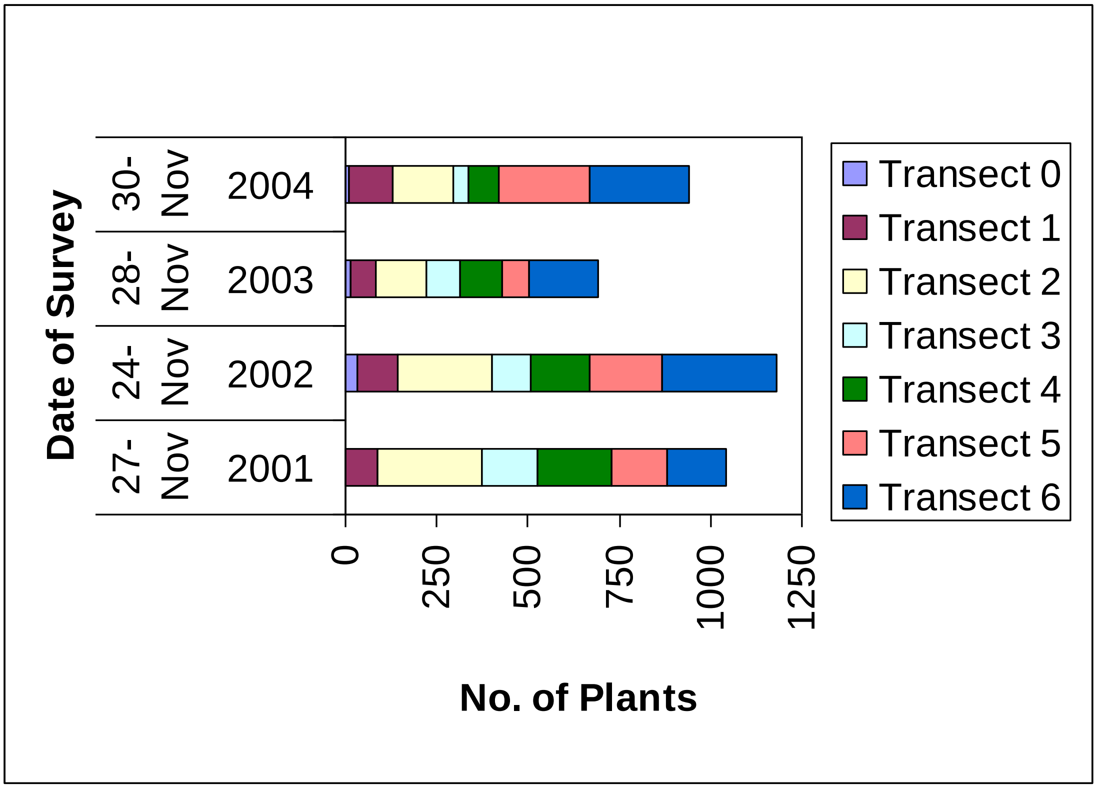

Figure 4: Number of red bearded orchid plants within each belt transect 2001-2004.

Figure 4 shows that since 2001 when transects were permanently marked (and most likely before this) the orchid population had large spatial fluctuations from year to year. There is no strong evidence of a south (transect 0 and 1) to north (transect 5 and 6) movement of plants (or vice versa) over this period of time. The only consistent trend shown is an ongoing decline in the number of plants in transects 2 and 3 in the middle of the survey area.

Issues with this monitoring technique

Overall it appears that this is a fairly robust technique. It is not sampling but a census therefore avoids the problems associated with sampling (Ian Westbrooke *pers. comm.*). There is some observer bias as volunteers are used plus a core of DoC staff so there are different observers and number of observers between years. However red bearded orchid plants are easy to identify and there are no other orchid species present at the site.

The timing is crucial as this ideally needs to be at peak flowering to maximise visibility. In 2000 when monitoring results were reviewed it was felt that some of the monitoring dates had been slightly late e.g. mid December. This could have contributed to undercounting as a higher proportion of plants would have finished flowering and started to die off and therefore may have been harder to see. Since 2000 we have narrowed the sampling period further to between 20th November - 4 December (maximum flowering period) to further minimise any timing bias.

There is consistent undercounting of the orchid population as the annual surveys would never find every plant. However we have reason to believe that this undercounting is <10% of the true population size. In 2000 Chris Ecroyd from Forest Research, who would be considered a very experienced observer "audited" our census and found 7% more plants immediately after the census which confirmed our initial estimates that the undercounting is not substantial. This was the year of the record 3000+ plants therefore the undercounting may have been higher than normal as well.

We consider that the survey have been carried out in a consistent manner since 1994 and do not believe that these issues are significant enough to account for the relatively large population fluctuations recorded and therefore believe the trends shown are largely real population trends.

Summary and Implications for Work Programme

Long term monitoring has shown that although the population fluctuates between years and spatially within the existing known area there is still a substantial red bearded orchid population present. However we are still unclear as to the exact reasons for the sometimes large annual fluctuations seen in this population. This would require much more detailed autecology studies.

The monitoring results show that the management regime implemented in the 1980's of winter mowing and no fertilizer or oversowing appears to have been successful in sustaining the orchid population at this site. Based on these results there is confidence that no new changes in the management regime are required at present.

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Acknowledgements

We would like to thank Chris Ecroyd (Forest Research, Rotorua) who initiated the monitoring and management regime. Chris has provided valuable advice on management and monitoring of the red bearded orchid population for many years and provided comments on a draft of this paper. Keith Owen (Department of Conservation, Rotorua) was involved in the earlier monitoring programme. We would also like to especially thank the many volunteers who have given up their time to assist with the monitoring over the years.

Leptinella featherstonii: monitoring a curious Chatham endemic

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Introduction

Leptinella featherstonii (Asteraceae), the Chatham Island button daisy, is a Chatham Island endemic. It has a conservation status of nationally vulnerable (de Lange et al 2004) and has the qualifiers of 'Conservation dependent' (meaning it is likely to move to a higher threat category if current management ceases) and 'Island endemic' which refers to taxa confined to a single archipelago beyond the three main islands of New Zealand (see Molloy *et* al 2002).

L. featherstonii is one of the most distinctive plants on the Chatham Islands and is the only button daisy with elevated woody stems (Walls *et al* 2003). It is a woody shrub that forms low, rounded bushes. Its blue-grey leaves are notched and spoon shaped. The small button-like cream flowers occur in spring and summer.

There are three distinct races of *L. featherstonii* corresponding to geological isolation episodes during the history of the Chatham Islands. There are two separate races on the Forty Fours and the Pyramid and a more widely distributed race on the main Chatham Island and other islands and islets around the archipelago (Walls 2004). Figure 1 shows the distribution of *L featherstonii* throughout the island group and the location of the Kaingaroa population that will be discussed in this paper.

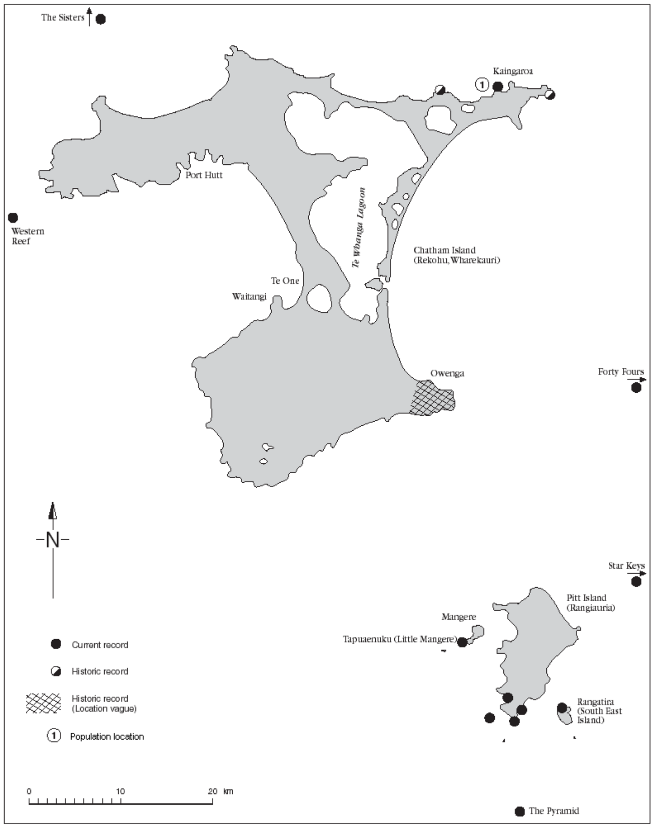

Figure 1 Distribution of *Leptinella featherstonii* on the Chatham Islands (after Walls 2004).

Figures 2 and 3 show the location of the monitored population at Rangikapua Point, Kaingaroa. This is the only site that *L. featherstonii* occurs on the main island in the Chatham archipelago. It grows in peat surrounding a single schist outcrop, and in association with *Disphyma papillatum, Carex trifida* and *Asplenium chathamense*. The button daisy usually grows in association with burrowing or nesting seabirds and the associated with high soil nutrients at these sites. There are a number of threats that could effect this population including: stochastic events e.g. severe storm damage, loss of habitat, weed invasion, browsing animals, loss of sea bird activity, decline in soil nutrients, disease and indiscriminate collection and visitation.

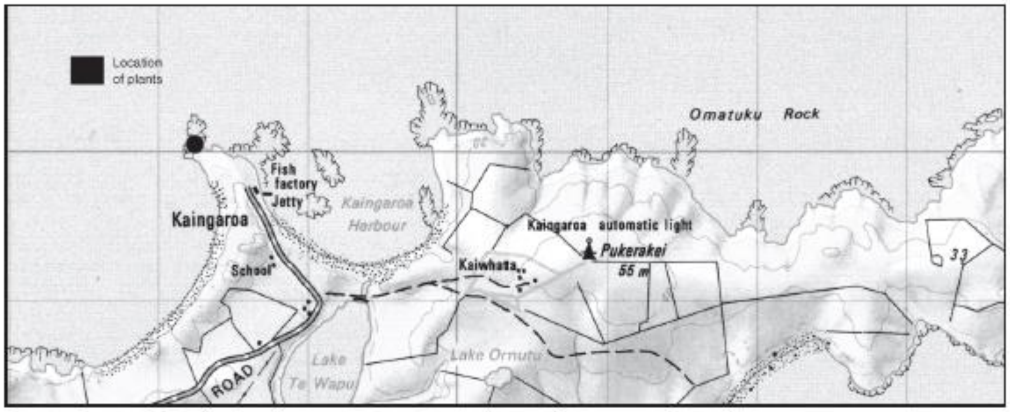

Figure 2 Map of the monitored Kaingaroa population of *Leptinella featherstonii* (Walls 2004)

Figure 3 Photo of location of Kaingaroa population looking west.

Objectives

The management objective for this site is to ensure the button daisy continues to exist at Kaingaroa, and to ensure that the population becomes (or remains) self-sustaining in the wild (Walls 2004). The monitoring objective is to identify changes in extent and abundance and to follow individuals and/or population, to establish trends, recruitment and threats.

Methods

The site, which measures approximately 10 metres by 12 metres, has been divided into 3 plots, two of which have been marked with pegs and permalate and are monitored regularly. The other plot has not been monitored. The site has been visited annually since 1989 and a more formal monitoring regime was put in place in 2001. Since then the plots have been monitored six times, three times in 2001 and annually since then. At each of the monitored plots every individual was recorded. The plants were identified using bearings and distances from marked plot centers. Information was collected for each individual, including size class, dimensions, health, phenology, threats, and habitat information. Information was collected as field notes by various staff with no standardized field form.

The size classes were divided into seedlings (both 'ephemeral'-cotyledon leaves only and larger seedlings), juveniles (any plant larger than a seedling with no evidence of reproduction) and adults (any plant with evidence of reproduction). In some years other size classes were recorded such as clusters and shoots. These terms were used when there was uncertainty if what was being measured was one plant or numerous plants. For example there were numerous of shoots in an area that might have been connected underneath, but there was no way of telling if they were, without destroying the plant. In 2003 there were so many shoots that they were not counted, rather an area covered was given so this number is an estimate based on cover value.

Active management also took place to counter-act some of the threats associated with the site. The plants have been fertilised whenever they were monitored. This was done to try and replicate the nutrient environment of seabirds which are no longer at the site. In 2001 rock wall shelters were constructed to protect plants and bare soil from easterly winds. Seeds collected from plants at the site were scattered on areas of bare ground in March 2001.

Results

Figure 4 shows the total number of plants by their size classes at the different monitoring dates. The adult plant numbers show an increase in population size from ten adults in 1999 to nineteen adults in 2004.

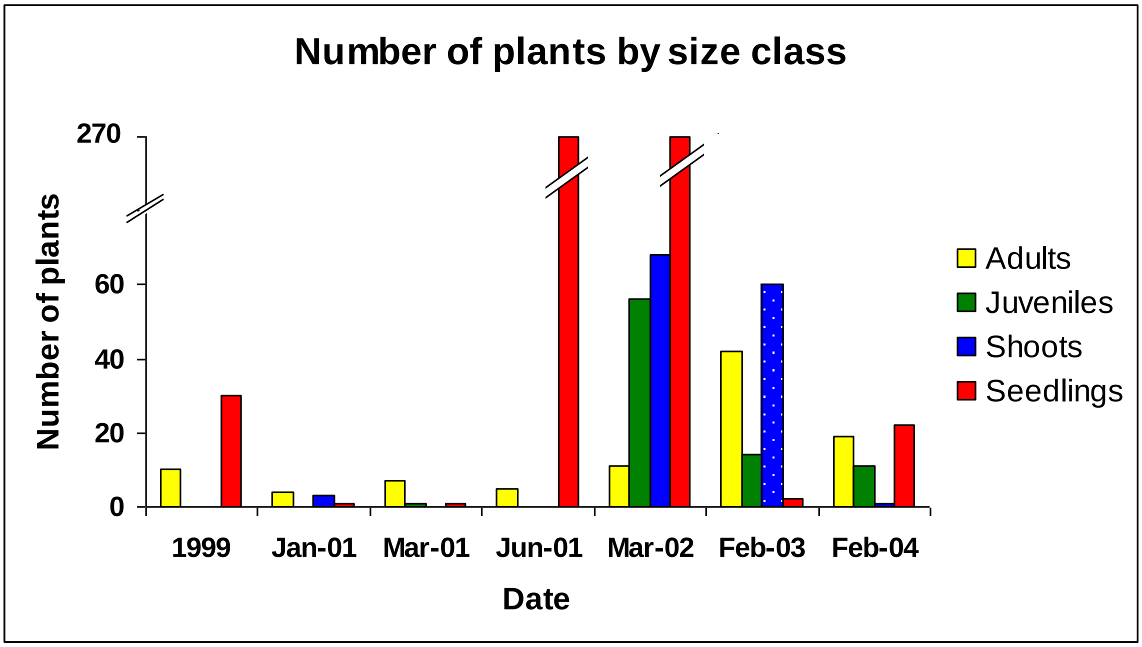

Figure 4 Bar graph showing numbers of plants by their size classes for each year monitored (1999 – 2004).

Discussion

Figure 4 could indicate that spreading the seeds around (as was done in March 2001) may have had an impact on the recruitment numbers at the site for the next year. However it could be a random event, such as successful seed set that produced larger numbers seedlings the following year.

Showing shoots here on the graph indicates the difficulties in trying to define what an individual plant is in particular years. Especially when there are a large number of shoots there is an inclination to give a cover value or estimate numbers. It also indicates the difficulties in comparing data when the methods change from year to year.

It is interesting to note that in 2001, the plot on the western side of the rock had no plants at all. This was the first time that had happened since 1989 (Baird, A. pers comm. 2004). This minor extinction event is an indication of how vulnerable the species is at this site, and the need for a monitoring regime to be able to take this into account for and hopefully try to work out ways to avoid it from happening again.

Problems and the impact monitoring has had on the work programme

It is not clear that monitoring individual plants of *L. featherstonii* is the most useful method. In addition the information recorded may not be the most appropriate for this population. The information has not been collected consistently, and that creates problems for data analysis between years. Some simple definitions and protocols could be created to solve these issues. One issue that monitoring protocols need to deal with is the changing nature of the plants' habit over time, making it impossible to differentiate individuals (the ground is covered with a mass of stems) which creates havoc when trying to count them and let the data remain comparable between years.

It has been suggested by the Chatham Island Plant Advisory Group that the distribution of plants should be mapped showing the plants spatial extent and continue to estimate numbers. Tracking the establishment of seedlings may also increase the knowledge about the factors that effect recruitment this knowledge might be transferable to establishing new population at other sites.

Conclusion

This is a very vulnerable population of a threatened plant, it is important to protect and enhance this last population on Chatham Island. Monitoring the population and applying constructive management techniques will enhance its chances of survival.

Acknowledgements

Hokotehi Moriori Trust and the Barker Brothers (owners until 2004) for access to the site. Bridget Gibb, Suzan Dopson and Amanda Baird.

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Monitoring *Cardamine* "Tarn": a battle with *Carex ovalis*

Cathy Jones & Jan Clayton-Greene

1. Abstract

Some background information is given for *Cardamine* (b) "Tarn". This is followed by a description of the method used by South Marlborough Area of the Department of Conservation to monitor the species at the Sedgemere ephemeral tarn, results of monitoring to date and a summary of past and proposed management. The conclusion contains notes on problems and advantages of the method and on the effort required.

2. Background

2.1 The species

Cardamine (b) "Tarn" is a small annual cress found in fertile ephemeral wetlands. It is classified as Nationally endangered (Hitchmough 2002). It is one of a suite of species and communities monitored every three years at the Sedgemere ephemeral tarn.

2.2 Macro-habitat

The tarn is on Molesworth Station and is one of several in this area recommended for protection in the Molesworth Protected Natural Areas Programme survey report (Courtney and Arand 1994). It is an area with a severe climate, experiencing extremes of hot and cold as well as drought. Molesworth has a history of burning, pre- and post-European settlement, followed by sheepfarming until 1940 when it was realised that overgrazing was resulting in serious damage. Since then the farm has been stocked with cattle.

2.3 Micro-habitat

The habitat of the *Cardamine* is a muddy patch in the centre of the tarn. It is the wettest area of the tarn and is totally inundated for much of the year. The tarn dries out once or several times each year depending on frequency and quantity of rainfall. The plant germinates first on the mud surface, then later in cracks as surface dries out. It is part of a natural community of small natives such as *Limosella lineata, Myriophyllum votschii, Agrostis muscosa, Lilaeopsis ruthiana*

2.4 Threats to the species

Cattle pugging, *Carex ovalis* and *Alopecurus geniculatus* invasion are thought to threaten the species. It is not known whether drought and hares also threaten the plant, or whether they might be useful in suppressing weedy competitors. The tarn was fenced to exclude cattle in 1996. Following this, because it was thought that competition with *Carex ovalis* was likely to become an issue, monitoring was set up for several threatened plants and vegetation communities in the ephemeral wetland including *Cardamine* "Tarn" and the mud patch on which it grows.

3. Monitoring

3.1 Objectives of monitoring

The objectives of the *Cardamine* section of the monitoring are to determine the degree of threat posed by *Carex ovalis* and introduced grasses, to check the continued presence of *Cardamine* "Tarn" and to determine population trends.

3.2 Monitoring method

Transects were set up across each of the two mud patches where *Cardamine* "Tarn" is known to occur. An 0.5m grid is used to gather data at points 4m apart along the transects. Data gathered at these points are:

- number of gridsquares containing the plant
- number of *Cardamine* "Tarn" plants in the four corner grid squares (totalled)

Notes are also gathered on where the transect intersects solid *Carex ovalis* around the mud patch and where the transect intersects isolated *Carex ovalis* plants and introduced grasses.

3.3 Results

As shown in the following tables and graphs more data is required to provide definite trends. This is particularly so because there were several drought seasons in a row between 1998 and 2003. It seems, however, that *Cardamine* numbers are decreasing, *Carex ovalis* is gradually taking over *Cardamine* habitat and introduced grasses are increasing on the second transect.

Table 1. Number of quadrat squares with *Cardamine* present

Quadrat No	1997	1998	2001	2004
6116	31	2	0	5
6117	29	5	1	3
6118	9	0	1	4
6119	22	1	2	5
6122	31	10	8	3
6123	34	27	10	13
Total	156	45	22	33

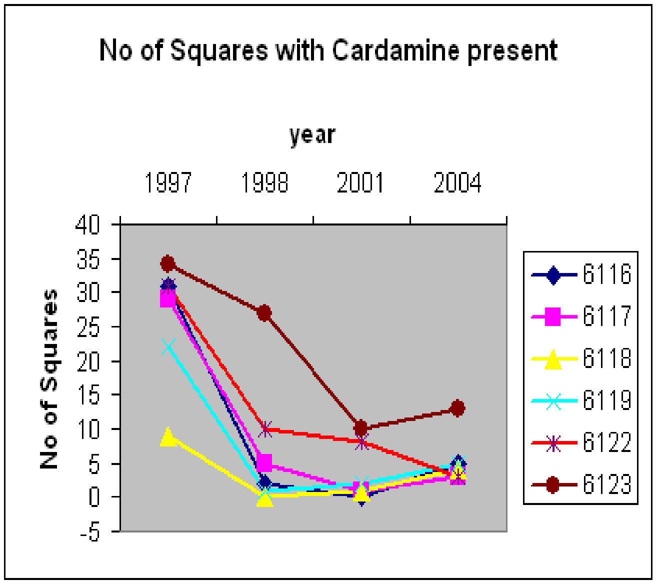


Table 2. Number of plants in four corner squares of quadrat (4 squares = c. 11% of each quadrat)

Quadrat No.	1997	1998	2001	2004
6116	2	1	0	7
6117	2	0	0	1
6118	0	0	0	1
6119	8	0	0	3
6122	10	1	0	20
6123	20	5	0	1
Total	42	7	0	33

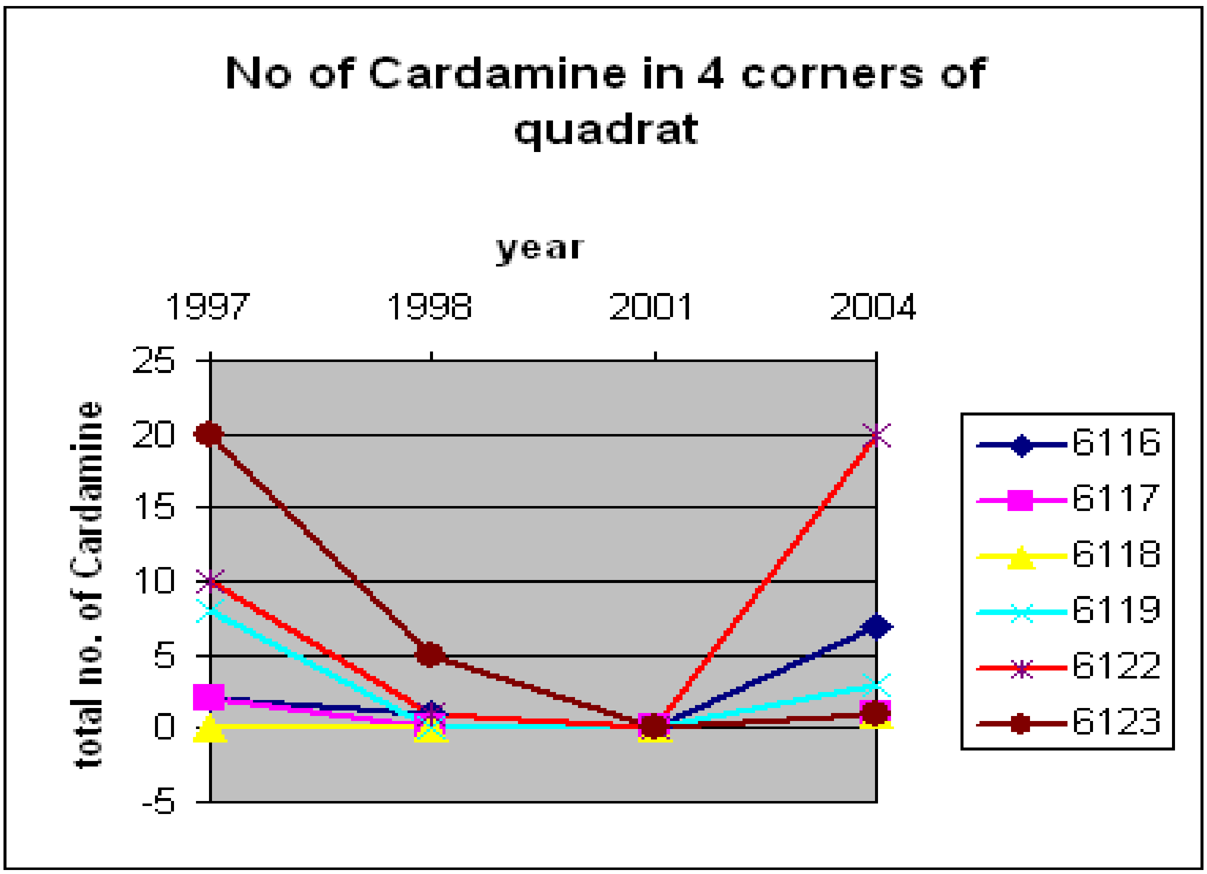


Table 3. Transect 3 *Carex ovalis* presence (in metres along 20 metre transect). Note the rest of the transect is available mud habitat.

Carex	1997	1998	2001	2004
Solid	1.86	1.83	2.8	3.35
Thick	0	0.25	0.29	0
Scattered	0.82	0.29	2.74	0
None	17.32	17.63	14.17	16.65

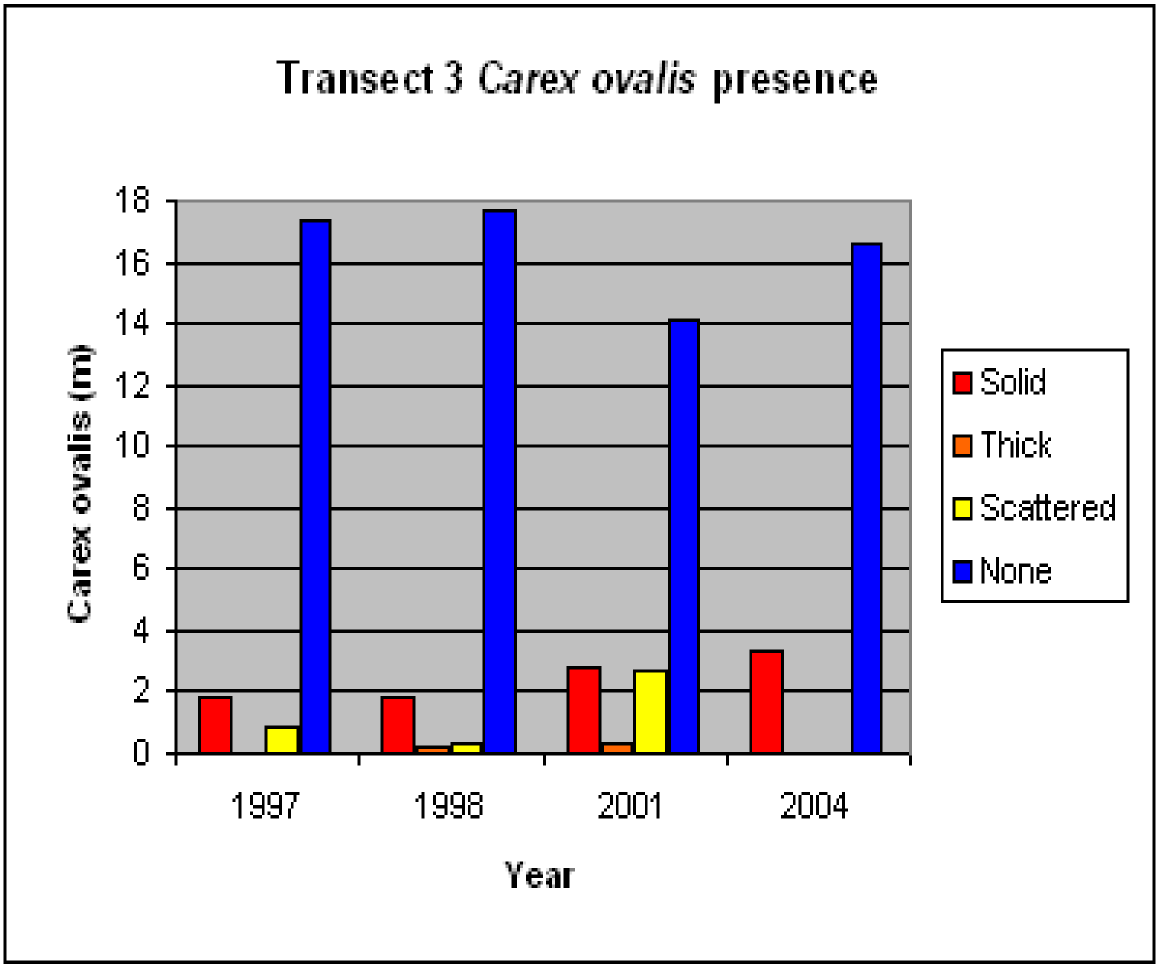
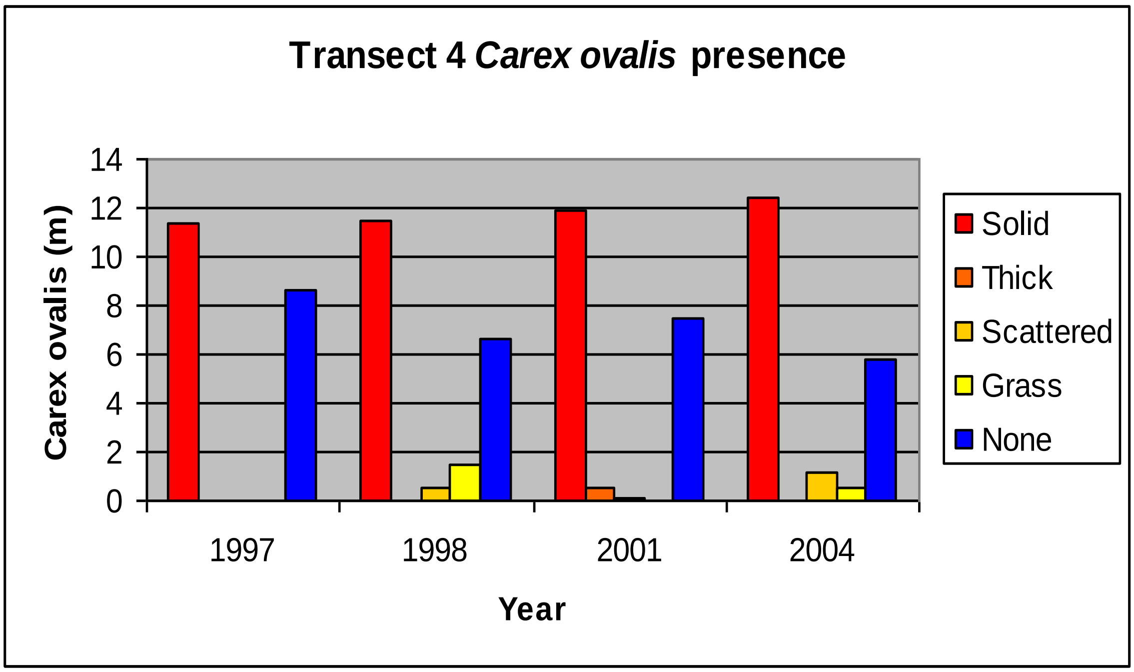


Table 4. Transect 4 *Carex ovalis* presence (in metres along 20 metre transect). Note the rest of the transect is available mud habitat.

Carex	1997	1998	2001	2004
Solid	11.39	11.43	11.85	12.45
Thick	0	0	0.57	0
Scattered	0	0.49	0.14	1.20
Grass	0	1.43	0	0.51
None	8.61	6.65	7.44	5.84



4. Management resulting from monitoring

4.1 Management actions to date

Because of the apparent increase in *Carex ovalis* control trials have been conducted in collaboration with Biodiversity Recovery Unit over the last 3 years. They included blanket spraying and more selective herbicide application with a weed wand. The weed wand seems to be a good option where *Carex ovalis* plants are scattered, while blanket spraying is satisfactory for areas of solid infestation. A disadvantage of using herbicide, particularly in areas which are blanket sprayed is the destruction of the native *Carex gaudichaudiana* which is hard to distinguish from the introduced species at several stages of its lifecycle.

4.2 Proposed management actions

It is proposed that staff commence careful *Carex ovalis* control over a large part of the tarn area in 2004-05, using both blanket spraying and weed wand. Monitoring will be continued, with results dictating whether there is a need to redesign the *Carex ovalis* control methods. It is important to ensure that monitoring separates the effects of *Carex ovalis* encroachment from *Alopecurus geniculatus* invasion. If results confirm that grass invasion is a problem *Alopecurus* control will also be considered.

5. Discussion

5.1 Problems faced during the monitoring

Data will need to be collected for several more years to validate results, particularly as the area is affected by drought years. Because of the unpredictability of water levels in different seasons and the distance from the office it is difficult to ensure that monitoring is carried out with the plant and its associates at a similar growth stage each time. There is also no un-managed scientific control population to compare this managed population with. Nor was any data collected prior to erection of the fence. A logistical problem is that frost heave sometimes pulls out the wire pins that mark grid positions.

5.2 What worked?

The method is simple and can easily be carried out by two people in a few hours. There is a low chance of error or variability in data collection methods as the parameters measured are clearly defined and not open to interpretation.

5.3 Impact on work programme

Monitoring the *Cardamine* takes at most half a day for two people every three years plus travel. It is combined with monitoring of other species and communities at this same site. The herbicide trials have taken about three extra days per year for two or three people (for the whole tarn area), allowing extra time to increase chances of patches of calm weather for spraying. The proposed *Carex ovalis* control programme is projected to fit into those same three days per year.

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Monitoring and habitat management to enhance a population of the nationally critically threatened swamp greenhood orchid (*Pterostylis micromega*) at Tangiwai Bog near Ohakune

Introduction

The swamp greenhood orchid is a small herbaceous plant growing to approximately 20cm high when in full flower. It is found in swamps and bogs from lowland areas to approximately 1200m a.s.l. in Tongariro National Park. In was once fairly widespread and locally common, occurring from northern Waikato, Bay of Plenty, to North–West Nelson. It has declined considerably as a result of land clearance and drainage for farmland. In addition, most wetlands in the Waikato and Bay of Plenty have been severely invaded by weeds, especially by grey willow (*Salix cinerea*) and more locally plants such as royal fern (*Osmunda regalis*). This is likely to have resulted in it completely disappearing from Waikato and the Bay of Plenty wetlands. Currently, only a few populations remain nearly always in more natural and unmodified wetlands. The Central North Island is the strong hold with 7 known sites with several sites around Waiouru and Rangataua being valuable habitat. However, it is very scarce elsewhere with single populations known in Taranaki, Wanganui, Waiarapa and Nelson.

Its optimal habitat appear to be moderately fertile swamps especially near small slow moving streams in wetlands that receive regular flooding and silt deposition. It rarely grows beneath standing water or in acidic peat bogs. Often it grows on slightly raised moss covered mounds just above the standing water level.

Tangiwai Bog Site History

The swamp green–hooded orchid has been known from Tangiwai Bog for nearly 60 years when Dan Hatch first collected it there in 1944 (AK 163349) and 1945 (AK163352). He also collected it at other wetlands near Waiouru around this time. Dan described (pers.com 2002) that "*Pterostylis micromega* was not uncommon in these wetlands and one would see it regularly when searching these areas at the right time of year". At that time this wetland and surrounding land (which was taller tussock land) was grazed by sheep and the tussockland and the wetland would have been regularly burnt, to encourage better grazing. Sheep are generalist grazers and would readily eat the soft leaves of *P. micromega*. However it is likely that they would have only eaten it on the edges of the wetland when it was dry, while the interior it would have been left untouched. At this time Dan Hatch described the wetland as being shorter sedges and rushes. It is likely that this regular disturbance regime would have been beneficial to *P. micromega* and other orchid species.

Pterostylis micromega was then later re-found at Tangiwai Bog in the late 1980's by Bruce Irwin who found only a few plants. Growing with it was *Prasophyllum* aff. *patens* which is also threatened with a threat rank of nationally vulnerable. Dan Hatch also collected there in 1945 (AK213962). *Spiranthes sinensis* was also found closer to the main road. By this time the surrounding land had been in forestry for decades and the wetland vegetation had grown without any major disturbance events for decades. However low numbers of cattle grazed within the forest and swamp margins in winter and would have caused some disturbance on the edges. Bruce Irwin then showed this site to Cathy Jones (DoC Conservancy Botanist at that time). In 1992 Cathy located 3 small *Pterostylis micromega* plants, two flowering and one with a seed head, along with 30 flowering plants of *P*. aff. *patens* (DoC, Bioweb entries). Where the orchids were found, a small area of electric stock proof fence was built, to prevent being eaten and destroyed by cattle grazing. In 1994 another survey was undertaken and only four *P*. aff. *patens* were found outside of the fenced area and no *Pterostylis micromega* were found. In 2000 some of the mature *Pinus radiata* adjoining the wetland were felled and new seedlings were planted. Winter cattle grazing ceased at this time.

Today, Tangiwai bog is part of Karioi Forest which is crown land leased to Winstones Pulp International for forestry. Winstones Pulp and the Department have a close working relationship because of being adjoining landowners and additionally because they obtained Forest Stewardship Council Accreditation" in 2001. This accreditation gives them better market access on the basis that they manage threats to non–production forest areas such and native forest, wetlands and riparian areas. The Tangiwai Bog and the *Pterostylis micromega* population there is recognized as being highly significant. Winstones have encouraged the department to participate in its management.

In 2002 43 plants of the swamp greeenhood were found when visited by myself and the New Zealand Native Orchid Group. All plants were recorded in the various growth stages; rosette, in bud, in flower, with a seed head, and if the bud was browsed (Table 1). Numbered stakes were placed where orchids were found and all plants counted within 30cm radius of the stake. Only a small part of the wetland was actually searched, however further north into the wetland from the road the vegetation became very dense with taller manuka, coprosma species and flax which was unlikely habitat. Apart from one small patch, all of these orchids were outside of the fenced area. No *P*. aff. *patens* were found at this time or in subsequent years.

In August 2004 the electric fence was moved to encompass all *Pterostylis micromega* known (the area cut) to protected any damage from cattle grazing. Winstones and the Department agreed to trial the re–introduction of winter cattle as it was though that some light grazing could be beneficial by allowing space for wetland species that require disturbance. The effects of cattle grazing on the wetland will be annually assessed in autumn and a decision will be made whether grazing can occur that year.

Monitoring, management and results

Repeat monitoring in wetlands can often be highly detrimental creating tracks and modifying local drainage patterns especially around the particular monitored plots or species. Excessive impact was observed when monitoring *Pterostylis micromega* and *Prasophyllum* aff. *patens* at the National park wetland, which allowed a stream to form resulting in a changed in vegetation composition. At Tangiwai Bog it was decided to monitor as least as possible to prevent damage to the wetland and orchids, as the impact caused could easily compromise the effects of the cutting alone. As such no monitoring of vegetation change (height, density and composition) was undertaken or regular fluctuations in water table height. Notes have been made on vegetation height composition and presence of any weed species when monitoring took place in each January. Photos were taken before and after cutting and again in January, showing the change in vegetation height and structure.

As a result of the successful outcome of David Norton's and Peter de Lange's research (2001) into fire and the abundance of *Corybas carsei* at Whangamarino wetland, a decision was made to undertake some vegetation clearance in winter, which occurred on 23 August 2002. Two small areas were cleared where some of these orchids occurred; one patch 3m x 7m inside the north–west corner of the fenced area; and 3m x 10m adjacent to this area but out side of the fence. All of the cut slash was collected and put into a pile. This site was later revisited again by me and members of the New Zealand Native Orchid Group on 4 January 2003, when 57 plants were found (see table 1). The greatest increase in plants occurred around Stake 1 where the vegetation was cut and it was decided to change this stake into a 2.5x 1.5m plot, for ease of monitoring (Table 2).

In late August 2003 and August 2004 additional cutting orchid where orchids where present, covering approximately 12m x 12m in 2003, which included the only part of the area cleared in 2002 plus some new area. In August 2004 all of the areas previously cleared were cut along with an additional 30m^2 adjacent to it. Orchid monitoring was undertaken on the 11th January 2004 and 27th January 2005 (Tables 1 & 2). Several new patches were found in 2005 and new stakes were placed near them. In 2005 of significance was a substantial increase in plants near stakes 2 and 5, so another plot 1.6x1.6m was established to replace these stakes.

Table 1: The total number of plants of the swamp greenhood (*Pterostylis micromega*) in various growth stages at Tangiwai Bog.

DATE	Number of Plants of *Pterostylis micromega* in various growth stages				
	Rosettes	**in Bud**	**in flower**	**with seed–heads**	**Total**
07/01/2002	30	10	3	0	43
4/01/ 2003	36	14	7	0	57
11/01/2004	67	30 (2 were browsed)	22	10	137
27/01/2005	101	73 (15 were browsed)	21	7	202

Table 2: Number of Plants of *Pterostylis micromega* in various growth stages around stake 1 or following 2003, plot 1 (2.5m x 1.5m)

DATE	Number of Plants of *Pterostylis micromega*				
	Rosettes	**in buds**	**in flowers**	**with Seed–heads**	**Total**
07/01/2002	3	3	2	0	8
4/01/ 2003	15	6	3	0	24
11/01/2004	35	5	13	9	62
27/01/2005	47	27 (5 were browsed)	7	4	

Prior to cutting the vegetation was dominated by dense *Baumea rubiginosa* with clumps of tall flax, manuka and divaricating coprosma species. Very little open space or open water was present. Occasional mounds of moss occurred below the *Baumea* layer. Cutting resulted in the removal of all shrubs and a reduction in height and density of the *Baumea rubiginosa* and flax. Some manuka shrubs and large flax plant were left intact. Additionally it opened up many smaller gaps bare or vegetation on the soil surface. The dominant plants (*Baumea rubiginosa*, *Baumea tenax*, *Schoenus pauciflorus*) respond very quickly to being cut and by January each year form reasonable vegetation cover.

Discussion and Conclusions

It appears that clearance of native wetland vegetation around known *Pterostylis micromega* is a highly successful method to increase its abundance. This is similar to what David Norton and Peter de Lange identified for *Corybas carsei* at Whangamarino wetland. In addition to the swamp greenhood there appears to have been a increase in abundance of the grass orchid (*Microtis unifolia*), several species of spider orchid (*Corybas*), sundew (*Drosera binata*) and native violet (*Viola cunninghamii*). Cutting reduces the height and density of the dominant wetland vegetation allowing for increased habitat for lower growing wetland herbs. It is therefore likely that winter cutting of wetlands may be also beneficial to a range of other wetland herbaceous plants.

Initially weeds such and Yorkshire fog grass (*Holcus lanatus*) and lotus (*Lotus pedunculatus*) appeared to increase in abundance. However this seems to be seasonal as they appeared to decrease significantly in January 2005, which was likely due to death as a result of the sustain period of inundation from Feb. 2005 to early Jan. 2005. On 27th January they only occurred on raised mounds well above the base water table height.

This basic research seems fairly conclusive, however as no control (e.g. a site with orchids and no clearance) was also monitored, the increase could have been due to another factor, such as regular tramping. However even though the areas of uncut swamp have been searched adjacent to the cut areas no plants have ever been found there. All of the increase in abundance has been within the cut areas, which is a small area of approximately 44m^2. Most of the increase in abundance appears to be below ground vegetative spread, or seedlings that have arose in very close proximity to the existing plants (1–2m). There have been no new plants found well away from the previously marked plants.

Anecdotal evidence suggests that the water table of this wetland is falling and the vegetation is changing as a result. This is probably due to the removal of the ground water by the adjoining mature *Pinus radiata* trees. No standing water was seen in August 2003 and January 2004. This is “drying–out” is likely to be the main reason for the local extinction of *Prasophyllum* aff. *patens*, which requires almost permanent water amongst *Baumea* wetland areas. However from February 2004 to January 2005 the wetland was completely full as a result of extreme rainfall over that period. If this “drying–out” continues it may also result in a decrease in abundance of *Pterostylis micromega*.

It is envisaged that the management of *Pterostylis micromega* at the Tangiwai bog will be expanded. Larger areas of wetland vegetation will be cut to allow for increased orchid habitat. Additionally at the nearby Paramanawera Swamp more scientific study has been commenced at the where three plots with orchids (10 x 10m) have been cleared while three similar plots have been left intact. Monitoring of orchid abundance and vegetation composition and structure are occurring.

Other management techiques that should be attempted are translocation and prescribed burning. Translocation of clumps and the surrounding soil may be a method of more quickly increasing its abundance especially as its habitat requirements become better understood. Prescribed burning as a management technique is not an option at Tangiwai Bog as this wetland is within a production forest and is therefore too much of a financial risk. However, prescribed burning should be attempted elsewhere on conservation land where threatened orchids occur, along with detailed pre and post vegetation monitoring to measure change.

References

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Coastal cress monitoring in West Coast Conservancy

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Summary
Two coastal cress species have been monitored in West Coast Conservancy since 1998. Photos proved very useful for relocating transects. Marking individual *Lepidium flexicaule* with coloured paperclips and recording locations along permanent baselines enabled successful relocation of individuals to answer the question how long-lived this species is. Most individuals lived for less than two years, but a few lived for over three years. Irregular intervals between measurements complicated data analysis. Excel was suitable for storing small amounts of data, but became cumbersome with large datasets containing multiple measurements of the same individuals. Separating individual Lepidium naufragorum proved difficult in some cases making comparisons of numbers between surveys difficult. There was no significant change in numbers between 2000-2002.

Introduction
All of New Zealand's coastal cress species are threatened to some degree, with one species already extinct (de Lange et al 2004)[1]. The causes of coastal cress decline include mammalian and insect herbivory, diseases spread from cultivated Brassicaceae, over-collecting, loss of habitat due to coastal development, loss of associated seals and seabirds and competition with invasive weeds (Norton et al 1997; Norton & de Lange 1999).

The Department of Conservation's coastal cress recovery plan (Norton & de Lange 1999) outlines the actions required for the recovery of these species. One objective of the plan is to establish a detailed monitoring programme assessing trends in coastal cress population abundance in order to allow more accurate assessments of conservation status. This paper describes the West

[1] There are a number of additional taxa that have yet to be named – all of these are also threatened to some degree.

Coast Conservancy's contribution to achieving this objective. This paper has a focus on which methods worked and which didn't.

The species

Two coastal cress species are known from the West Coast, and both were part of this monitoring programme. The nationally vulnerable *Lepidium flexicaule* (Fig 3) occurs in southern Tasmania and New Zealand. In the North Island of New Zealand, this species was last recorded in 1934. In the South Island, *L. flexicaule* is currently known from about twenty West Coast sites from Cape Farewell south to Point Elizabeth. Habitats include coastal turfs, the strand line of bouldery beaches and limestone talus (Norton & de Lange 1999; Rogers 1999). Plants begin life as a basal rosette of leaves from which low growing flowering stems extend during spring. Fruiting occurs from late summer to early autumn.

Lepidium naufragorum is one of the West Coast's few endemic species (Garnock-Jones & Norton 1995). It is found at about ten sites along the West Coast from Tauranga Bay south to Cascade Point and has a threat classification of sparse (de Lange et al 2004). It is similar to *Lepidium flexicaule*, but has a more upright growth habit and the brighter green leaves have sharply serrate pinnae. It is known from open sites either in rock crevices or on organic or mineral soils in the zone between coastal shrubland and the high tide mark. Fur seals are present at many sites.

The monitoring for each of these species is described separately in the remainder of this paper.

***Lepidium flexicaule* monitoring**

Objective

The primary objective of monitoring was to determine how long-lived *Lepidium flexicaule* is in the wild. Although the species is known to persist for many years in cultivation, little is known about longevity in the wild. Autecological information such as this will assist with developing suitable management protocols for the species.

Total counts (census) were also made at two sites to provide information on long-term population trends to enable more accurate assessment of threat status (sensu Molloy et al 2002).

Study Area

Two separate sites, about 80 m apart were selected at Dolomite Point (often referred to as Pancake Rocks) on the coastal edge of Paparoa National Park. Dolomite Point was selected as the West Coast's intensive monitoring site as it is an easily accessible site with good numbers of *Lepidium flexicaule*.

Site 1 is adjacent to the Putai (main blowhole) viewing platform at the top of a limestone sea cliff among old wave wash channels (Fig 1). Plants are very exposed to wind and salt spray. White-fronted terns and spotted shags have regularly roosted here, with the terns recently nesting successfully. Vegetation cover is generally patchy, with associated species including *Isolepis cernua, Lobelia anceps, Apium prostratum*, and *Crassula helmsii*.

Site 2 is more sheltered, situated at the base of a limestone bluff about 30m from the high tide mark (Fig 2). Vegetation cover is denser at this site, with *Isolepis cernua* the dominant species. Other species include *Lobelia anceps, Apium prostratum, Disphyma australe* and *Hebe elliptica*.

A census was also undertaken at the southern limit of *Lepidium flexicaule*, Point Elizabeth near Greymouth, at irregular intervals. At this site *Lepidium* grows in a sloping coastal turf and in talus at the base of muddy limestone bluffs.

Methods

Monitoring began in October 1998. The initial intention was to monitor at six monthly intervals and review this after the first full year's data collection. Due to other work taking priority, the first remeasurement did not take place until July 1999. Subsequent remeasurements occurred at six monthly intervals until April 2001, with a final measurement occurring in March 2002.

The beginning and end of transects bisecting the sites were marked by driving 150 mm galvanized nails into the ground. A baseline tape was stretched between these two nails. Individual *Lepidium flexicaule* were carefully searched for. Due to the high numbers of small seedlings and the difficulty in separating some individuals which grew in dense clumps detailed information was only recorded for a subset of individuals. At site 1 this was a much lower proportion of the total population than at site 2.

For this subset of individuals, their position was recorded to the nearest centimetre by running another tape at right angles from the baseline tape and giving a direction to indicate which side of the tape the plant lay on. For example, one individual's coordinates were 6.57 m east along baseline, 2.60 m north of baseline. This enabled relocation of individual plants. New individuals were tagged on each visit except the final one.

Plant size from leaf tip to leaf tip was measured along the longest axis and along the axis at right angles to this. Plants were individually marked with a numbered metal tag (Fig 3a). At the time of remeasurement it was noted that many of these had been removed by nesting terns, and for others it was difficult to be sure which plant the tag belonged to. Following a suggestion from Nick Singers (Botanist, Tongariro-Taupo Conservancy), coloured paper clips were used for subsequent measurements. Eight different colours were available and were spread throughout the site to ensure adjacent plants were marked with different colours. The paper clip was partially unfolded, the open loop placed around the base of the plant and the straight end pushed into the soil (Fig 3b).

Notes were usually, but not always, made on the general health of the plant, the presence of the oomycete *Albugo candida,* and flowering and fruiting. All information was recorded onto a datasheet with headings specific to the project; subsequently the data was entered into an Excel spreadsheet DME://BULAO-1669.

A full count (census) of individuals was also undertaken at Site 2 and at Point Elizabeth.

Analysis

Each individual plant was assigned to a six month age interval. Two groups of plants were of unknown age: those tagged in the first survey in 1998, and those that were still alive at the last survey in 2002. For those plants that were first tagged in 1998, the initial measurement of the plant was taken to be indicative of its age. All plants that had both measurements less than 50mm were assumed to be less than six months of age, and were assigned the age interval 0-6 months at the time of tagging. This decision was based on measurements of plants that were tagged as small seedlings, and were therefore of roughly known age. These measurements showed that all plants younger than 6 months had no measurement greater than 50mm (Fig. 4). As this figure shows, there are some individuals for which this is likely to underestimate age, i.e. some plants might be older than 6 months even they have no measurements greater than 50mm. All other newly tagged plants with one measurement over 50mm were assigned the age interval 7-12 months.

The longevity estimates were further confounded by the unequal sampling intervals. The major problem was the July 1999 measurement, which occurred 9 rather than the desired 6 months after the initial measurement. Individuals measured at this point were assigned an age class based on the assumption they were also present in March 1999.

Those individuals that were definitely known to have died (tag in ground but no plant found) were differentiated from those individuals that were presumed dead (no plant or tag found at location where individual had been recorded from). Given the careful search effort, it is likely that the majority of presumed dead plants had in fact died.

A basic size index was calculated by taking the average of the longest axis and the axis perpendicular to this.

Results

Actual death of tagged *Lepidium flexicaule* was able to be determined about 60% of the time. 58% of tagged *Lepidium flexicaule* at Site 1 lived for less than one year. A further 33% survived for up to two years. Only 2% had survived for more than three years (Table 1 provides raw data). At Site 2 a greater proportion of individuals survived for one to two years (51% with 34% surviving for less than one year). Again, only 2% survived for more than three years (Table 1 provides raw data).

On average, of the individuals which had died or were presumed dead by the end of the study, 48% lived for less than one year and 38% lived for one to two years (Table 2).

Fruiting was recorded on only 20% of the individuals monitored during the course of the study. No individuals less than six months old fruited, while almost all individuals between 2½ and 3½ years old fruited (Table 3). Four individuals fruited for two successive years, and one of these fruited for three successive years. The estimates of the proportion of plants fruiting is likely to be an underestimate as additional notes were not always made and fruiting could only be confirmed during site visits. It is possible some plants fruited and died before any evidence of fruiting could be recorded.

The average size of *Lepidium flexicaule* was relatively consistent at Site 2, but varied greatly at Site 1 (Fig. 5). The average size was greater at Site 2 for the initial three measurements, but lower at this site for most of the remaining measurements.

The total population of plants with one measurement than 50mm varied from a high of 56 to a low of 26 plants at Site 2 (Fig. 6), and from a high of 72 to a low of 46 at Point Elizabeth (Fig. 7). Variation seemed to be as great within years as it was between years. Lowest numbers were recorded during winter measurements.

Mapping of individuals to aid relocation provided additional information on spatial recruitment patterns. The data collected at Site 2 was of most interest because there was a considerable area of apparently suitable habitat adjacent to the site where *Lepidium flexicaule* grew. However, the results clearly show little establishment away from parent plants (Fig 8). In addition, regular searches were made of seemingly suitable turf habitat within a 30m radius of this site but no additional *Lepidium flexicaule* were found.

Discussion

One of the key objectives of the monitoring programme was to ascertain the longevity of *L. flexicaule*. The results show that on average about half of the population lives for more than one year. Individuals 6-12 months old can produce seed. Thus, for *Lepidium flexicaule* it is reasonable to define mature individuals as those over 6 months old. A definition of mature individuals is important as number of mature individuals is a key criterion for assessing threat status (Molloy et al 2002). Based on the data presented here, individuals with at least one axis longer than 50mm are very likely to be over 6 months old.

Prior to the initiation of monitoring, it was presumed that *Lepidium flexicaule* was very short-lived. However, four years of monitoring confirms that *Lepidium flexicaule* individuals can persist for at least 3½ years in the wild, but the bulk of the population lives for less than 2½ years. These older plants can reproduce in successive years, and thus their contribution to the viability of the population is far out of proportion to their scarcity.

There were differences between the two sites monitored. At Site 2, individuals tended to live longer. At Site 1, turnover was greater but individuals generally appeared healthier, although there was no indication from the data collected that they were more likely to seed. However, the size data did suggest that on average individuals at Site 1 achieved a greater size. This reflected the observations that these individuals appeared healthier.

The overall population of *Lepidium flexicaule* appeared to be relatively stable at both, Site 2 and Point Elizabeth. There was as much within year as between year variation in numbers. At Site 2, numbers were lowest for winter measurements. This is not surprising given that many individuals die after fruiting and any seedlings would not be large enough to be classed as adults using the 50mm size criterion. Although the trend at Point Elizabeth appears to be one of increasing numbers and that at Site 2 one of decreasing numbers, longer term monitoring is needed to confirm this. Possible reasons for these patterns were noted during the course of monitoring. The vegetation at Site 2 appears to have become denser over time which is less favourable for *Lepidium flexicaule* establishment. In contrast, there have been a number of small-scale disturbances at Point Elizabeth that have created open limestone talus well suited to *Lepidium flexicaule* establishment.

The evidence of poor establishment away from adult plants probably reflects poor dispersal rather than lack of suitable establishment sites. As cress seed is slightly sticky in pre-human New Zealand, birds and seals were likely to have been important dispersal agents. The loss of these animals must have reduced the ability of coastal cresses to disperse. These animals also created favourable habitat by disturbing sites and raising soil fertility (Norton et al 1997).

Lessons

Coloured paperclips in combination with location coordinates worked well for marking individual plants. Plant death was able to be confirmed on 60% of occasions.

Irregular intervals between measurements made analysis of longevity much more complicated. As a result, the age intervals are at best estimates.

Excel was used for data analysis. Each individual plant was given a unique record number and data on a range of parameters recorded in adjacent columns. Tools used in Excel to summarise the data included sorting, filters, pivot tables and graphs. These were adequate for the type of data collected. A database with linked tag number and data tables would be the ideal way to manage this sort of data. A quick glance at DME://BULAO-1669 will show that after seven measurements the Excel spreadsheet was becoming very cumbersome and the chances of data entry error had increased.

A census of this species proved relatively easy because it tended to be located in discrete patches and individuals could usually be separated. It is not worth counting seedlings for two reasons. Firstly they are difficult to count accurately because when seedlings are present there tends to be a lot of them. Secondly it is the number of mature plants that is of interest for assessment of threat status. Thus the presence of seedlings should be noted, but counts restricted to mature plants.

Photos proved to be very useful in relocating transects. This was particularly important at a high public use site such as Dolomite Point where marking of transects was done as discretely as possible.

Impact on work programmes

Establishment of the monitoring at Dolomite Point took four person days. Remeasurements took two person days. These were generally able to be completed around the time the monitoring was planned with the weather being the main limiting factor. The exception to this was the March 1999 measurement which was delayed until July 1999 due to other priority work taking precedence.

Lepidium naufragorum **monitoring**

Objective

A census was undertaken to determine the overall status and distribution of *Lepidium naufragorum* on its national stronghold, Taumaka (one of the Open Bay Islands off the West Coast near Haast).

A further objective was to establish surveillance monitoring to inform whether management interventions were necessary. A secondary objective was to determine whether the weeds broad-leaved dock (*Rumex obtusifolius*) and broad-leaved plantain (*Plantago major*) were having any impact on *Lepidium naufragorum* numbers.

Study Area

Taumaka is one of the two main Open Bay Islands. *Lepidium naufragorum* is mainly found along the northern shore of the island in a coastal herb community along with *Carex comans*, *Poa annua* and *Crassula moschata.* The remainder of the island is low forest and scrub dominated by kiekie (*Freycinetia banksii*) and pohuehue (*Muehlenbeckia australis*) with *Hebe elliptica* along the coastal margins (Burrows 1972).

Methods

The distribution of *Lepidium naufragorum* along the northern shore of Taumaka was mapped between 25 and 27 January 2000. Over each small section of shore, typically 10-40m long depending on where gaps in the population were, the number of individuals was visually estimated. It was assumed that *Lepidium naufragorum* doesn't grow on the steeper southern side of the island.

From this map, six of the ten shore sections that contained over 50 plants were randomly selected as sites for monitoring. It was considered that sections of shore with fewer than 50 plants would not provide useful results for the intended level of monitoring. An additional transect was established at the south-western end of the island to improve geographic spread.

At each of these seven sites a 20m long transect was established (Fig. 9). Each end was marked by an orange plastic track marker secured into the rock with a 5mm stainless steel dyna bolt. A 20m tape was strung tightly between the two bolted markers. 0.5m x 0.5m quadrats were located at 0.5m intervals on the uphill side of the tape resulting in a count of 40 quadrats along the transect. The number of live *Lepidium naufragorum* individuals and the presence of broad-leaved plantain and broad-leaved dock rooted within each quadrat were recorded.

In some cases *Lepidium naufragorum* individuals were multi-stemmed and in other cases what appeared to be separate individuals grew in tight clusters making it difficult to accurately identify what an individual was. In subsequent years cover was also recorded to provide supporting information on *Lepidium naufragorum* abundance.

This information was recorded onto a basic datasheet developed with headings specific to the project and the data was entered into an Excel spreadsheet held in the Haast Field Centre, with a copy in West Coast Conservancy DME://WSCCO-21053.

Analysis

Transects were treated as the replicates and average *Lepidium naufragorum* counts and weed frequency calculated and plotted in Excel.

Results

Although there were fluctuations in the number of *Lepidium naufragorum* counted between the three years, these differences were not significant (Fig. 10). The main fluctuations occurred on transect 2, with 29, 113 and 35 individuals counted in the three consecutive years. If transect 2 is excluded the trend is more stable, but lower numbers were present in 2002.

The presence of the weed broad-leaved plantain remained steady at an average of about 10 quadrats per transect. The weed broad-leaved dock was rarely present, with the highest average being almost 3 quadrats per transect in 2001.

Discussion

The results provide a useful baseline from which to measure future changes in abundance of *Lepidium naufragorum* at its stronghold. From the limited data collected to date there is no evidence of decline. Future increases in weed abundance or reduction in habitat availability e.g. as a result of recolonisation of the upper shore by the island's fringe of *Hebe elliptica* since a major storm around 1990 (H. Best pers. comm.. to D. Neale) could lead to declines.

The two weed species of interest are most widespread in the northeastern sections of the shore. The broad-leaved plantain is widespread, typically occurring in small patches of soil along the Hebe fringe that is also the preferred habitat of *Lepidium naufragorum*. Its presence throughout the seaward shore suggests that it may have reached its maximum potential distribution and therefore its maximum density.

In contrast the broad-leaved dock extends onto the shore only in the area out from the seal hide 200m from the Hut, and casual observations suggest it is spreading from here (H. Best pers.

comm.. to D. Neale). It also occupies favoured *Lepidium naufragorum* habitat, and the potential for it to spread along the shore from here is considerable.

Lessons

The orange markers proved to be a durable method for marking transect ends. Photos were invaluable in relocating these markers, particularly as the original GPS coordinates did not appear to be accurate.

Locating quadrats at exactly the same location at each monitoring is likely to be impossible, particularly where the ground is undulating. In later measurements a plum bob dropped from the transect was used to decide where to locate each quadrat. The plum bob was also used to trace around the quadrat margin whilst another person held the quadrat horizontally on particularly undulating terrain.

Separating individual *Lepidium naufragorum* proved difficult in some cases making comparison of numbers between surveys difficult. Where several stems were radiating out from a single point they were counted as one individual. Where there appeared to be divisions (i.e. patches of bare soil) between clusters of stems originating from a single point this was counted as multiple plants. Measuring cover in addition to counts may provide a more accurate reflection of trends in *Lepidium naufragorum* abundance.

Detailed internal reports of the 2000 and 2002 monitoring events were completed within seven months of the field work (Neale et al 2000; Newton 2002). These reports both communicated the results and provided recommendations for future monitoring. Producing these reports in a timely manner ensured the work was not forgotten.

Acknowledgements

Thanks to Suzan Dopson, Dave Norton & Peter de Lange for getting us started on this work, to the other DOC staff and volunteers who assisted with the monitoring, and to the owners of Taumaka for permission to work there.

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Table 1: Longevity of tagged *Lepidium flexicaule* individuals at two sites at Dolomite Point, Paparoa National Park.

	Site 1 (n=121)				Site 2 (n=88)			
Age interval (months)	Alive	Dead	Presumed dead	Total	Alive	Dead	Presumed dead	Total
0-6		1		1		3	2	5
7-12		40	29	69		10	15	25
13-18		2	9	11	3	2		5
19-24	5	14	10	29	6	26	8	40
25-30	1	2	2	5	1	4	1	6
31-36		2	1	3		5		5
37-42	2		1	3	2			2
Total	8	61	52	121	12	50	26	88

Table 2: Percentage frequency in each age class of tagged *Lepidium flexicaule* individuals summed across two sites at Dolomite Point, Paparoa National Park. Only dead or presumed dead individuals are used. N=189.

Age interval (months)	Alive	Dead	Presumed dead	% dead and presumed dead in each age class
0-6		4	2	3.2
7-12		50	44	49.7
13-18	3	4	9	6.9
19-24	11	40	18	30.7
25-30	2	6	3	4.8
31-36		7	1	4.2
37-42	4		1	0.5

Table 3: Number of fruiting *Lepidium flexicaule* in each age class.

	Site 1 (n=121)		Site 2 (n=88)	
Age interval (months)	No fruiting	Fruiting	No fruiting	Fruiting
0-6	1	0	5	0
7-12	62	7	23	2
13-18	9	1	3	2
19-24	24	4	32	8
25-30	3	2	3	3
31-36	0	3	1	4
37-42	0	3	1	1

Preliminary results on the impacts of possum browse and possum control on threatened palatable species (*Pittosporum patulum*, *Alepis flavida* and *Peraxilla tetrapetala*) in the Lake Ohau Catchment

Nicholas Head

Introduction

Pittosporum patulum is a highly palatable small tree species of beech forests and adjoining sub-alpine communities mainly on the eastern South Island of New Zealand. It is known sporadically from North West Nelson to the upper Waitaki valley (Rogers & Walker in press).

Anecdotal evidence suggests that *P. patulum* is going through a prolonged phase of population decay and decline throughout its natural range due to browsing by introduced herbivores in particular possum (Rogers & Walker). *P. patulum* is listed as a nationally endangered species by the Department of Conservation (Hitchmough 2002).

The Temple and Huxley Valleys are assumed to contain the best populations of *P. patulum* and mistletoe remaining in New Zealand. This project will analyse the monitoring data collected on *P. patulum* from a possum control operation undertaken in the Temple valley.

Objectives

The objective of this project is to clarify the impacts possum browse is having on populations of *P. patulum*, in the Temple and Huxley valleys.

Methods

Monitoring of *P. patulum* (and mistletoe) was undertaken prior to possum control in April 2002 to provide baseline data on the status (condition etc) of P. patulum before possum control. Annual monitoring has occurred. To limit seasonal and observer bias, monitoring is undertaken at the same time of year, and to date by the same people.

Data Collection - *Pittosporum patulum*

A total of 693 individual plants of *P. patulum* were tagged and recorded as follows.

- For each site a standard recording sheet was filled out to collect both general information on the site and specific information on the plants present including
- Aspect , altitude, habitat type, slope
- tag number assigned to an aluminium tag attached to the plant;
- height and diameter measured
- age class based on a foliar score using leaf characteristics (1-4) 1=seedling, 2=sapling, 3 sub-adult, 4=adult;
- defoliation score as an estimate of the percentage of browse (0-3) 0= no browse, 1=1-33%, 2=34-66%, 3=67-100%;
- dieback score is an estimate of conspicuous presence of dead branches or branchlets (but not recently defoliated live twigs), recorded as (0-3) 0= no dieback, 1=1-33%, 2=34-66%, 3=67-100%

Mistletoe

Mistletoe monitoring was established in accordance to the best practice for survey and monitoring of Loranthaceous mistletoe (Dept Conservation 2002). This requires that a minimum of 50 plants is randomly selected from the (representative) population and measured in accordance to the mistletoe Foliar Browse index outlined.

Possum Operation

The general aim was to reduce possum numbers to the lowest possible level.
Residual Trap Catch (RTC) monitoring was undertaken (in accordance with the National Possum Control Association standard procedure (NPCA)) before the poison operation to determine possum abundance. This monitoring returned average RTC figures for the Temple and Huxley valleys at 19.7% and 19.4% respectively.

Data Analysis

Data was entered into an excel spread sheet in a format suitable for analysis using the statistics software package R1·3·1 (copyright 2001, The R Development Core Team). *P. patulum* data was sorted into age classes to enable analysis between years on each age class. The data collected for each plant was matched to enable direct comparison of the same plant between years.

Analysis of height was undertaken using paired t-tests (data was considered sufficiently normal to use parametric tests of significance). Non parametric (chi-square) tests were used to analyse changes in browse frequency data. For age class 3 and 4 in the Temple, browse frequencies were added together for analysis to provide a greater sample size.

For mistletoe paired t-tests were used to analyse foliage cover and total size. Analysis of changes in mistletoe size were assessed by combining the three measures taken for each plant (width 1, width 2, length) to determine gross changes in plant size based on its volume, using the following Microsoft excel calculation (w1*w2*L)^(1/3). Non-parametric (Chi square) tests of significance were used to analyse changes in browse frequency.

Results

Pittosporum patulum

Changes in overall browse class frequencies in the treatment area on all age classes (seedling, sapling, sub-adult, adult) show a significant decrease in browse over the two years of this study (Fig. 3-6, seedlings= $X^2 18.497$, df=3, P=<0.001; saplings =$X^2 119.09$, df 3, P=<0.001, sub-adults and adults combined X^2 21.8 df=3, P=<0.001). However, light browse (browse class 1) frequencies increased between the two years on seedling (32%-43%) and sapling age classes (35%-41%), but these increases are balanced by declines in moderate and heavy browse (browse class 2&3), from 10%-4%, 13%-3% for seedlings, and 14%-6%,14%-9% for saplings (Fig. 3&4). Moderate and heavy browse declined for all age classes post poison in the treatment area (Fig. 3-6). The greatest reductions in moderate and heavy browse occurred in sub-adult and adult trees (Fig. 5&6), with no plants in these categories recording a browse class score of 2 or 3 in 2003, although there is a small sample size in these categories. A significant reduction in moderate and heavy browse also occurred in seedling age classes in the treatment area between 2002 and 2003, declining from 10% to 4 % and 13% to 3% respectively (Fig. 3&4).

In the non-treatment area an opposite effect is apparent. Significantly higher frequencies of heavier browse occurred between the two years on most age classes (this analysis is limited to seedling and sapling age classes due to an absence of sub-adults and adults in the Huxley) (Fig. 1&2, seedlings= $X^2$13.83, df=3, P=<0.01; saplings= $X^2$50.48, df=3, P=<0.001). The seedling stage was the more heavily browsed age class than the sapling stage between the two years. In particular the seedling stage showed a decrease from 29% to 9% in the browse free plants, and a 23% to 36% and 17% to 30% increase in moderate and heavy browse respectively (Fig. 1). The percentage of lightly browsed saplings, however, in the non-treatment area decreased from 11% to 5% which is an unexpected result, as is a decline in heavy browse from 49% to 34% on saplings. These unexpected results in the sapling class in the non-treatment area are consistent with mean height increases for this age class in this area, which showed a significant increase in height between the two years (Table 3, se=12, t=-3.97, df=149, P<001). This may suggest that sapling *P. patulum* are relatively free from debilitating browse during this age class. Alternatively this result highlights that other browsers in addition to possums are operating.

As highlighted above, light browse changes between 2002 and 2003 in both the treatment and non-treatment areas were less conclusive. Contrasting the general trend of less browse post poison in the treatment area, light browse increased from 32% to 43%, and 35% to 41% for seedling and sapling age classes in the treatment area respectively (Fig. 3&4). Conversely, in the non-treatment area light browse on seedlings and saplings decreased from 30% to 25% and 24% to 21%, which is an unexpected result (Fig. 1&2).

Significantly more *P. patulum* plants were dead and/or went missing, which are presumed to have died (tags were found) in the non treatment area (17%) over the two years of the study than the treatment area (6%) (Fig.10, $X^2 = 24.64$, df = 1, P <0.0001). Some of this difference is due to a windfall event which destroyed 7 plants in the non-treatment area, but this only accounts for a 2% difference. Almost all of missing plants are in the seedling age class, and in addition to seedlings being generally more impacted by heavy browse than saplings in the non-treatment area, indicates potential susceptibility to loss at this stage in the lifecycle.

In the treatment area increases in mean height occurred for all age classes, but only the mean increases for seedlings and saplings were significant (Table 3;seedlings t=-2.016, df=101, p=0.047; saplings, t=-3.970, df=149, p<0.000). A similar result was found for saplings in the non-treatment area which also showed a significant mean increase in height (Table 3; t=-6.201, df=253, P<0.000). This positive growth response for the sapling age class in both treatment and non-treatment areas may provide further evidence for a browse safe period at the sapling stage of *P. patulum*'s lifecycle. Conversely, mean height of seedlings in the non-treatment area declined by 24mm between the two years (Table 3). This was the only age class to decline in mean size. Although not statistically significant (Table 3, se=14.01, t=1.71, df=42, p=0.095) this result is consistent with other findings of this study which highlights potential vulnerability of the seedling age class to possum browse.

Mistletoe

Overall there was a trend toward improved mistletoe condition in the treatment area after possum control. The non-treatment area contrasts this with generally declining mistletoe condition.

Mean foliage cover in the treatment area increased significantly from 61% to 67% between the two years (Fig. 9 &Table 1, se=1.91, t=-2.824, df=128 P=0.006). A contrasting result was obtained from the non-treatment area, with a highly significant reduction in foliage cover from 63% to 50% occurring (Fig. 9 & Table 1, se= 3.357, t=3.971, df=55, P=0.000).

Increases in overall mean size (volume) of mistletoe plants occurred in both the non-treatment and treatment areas, but neither increase was significant (Table 2). A slightly larger mean increase occurred in the treatment area, which is consistent with the corresponding improvement foliage cover. Conversely, the increase in size for the non-treatment area is inconsistent with the decline in foliage cover in this area. This is potentially due to size measurements not distinguishing between dead and living plant material, i.e. dead and/or defoliated branches are included with the size measurements, but also potentially highlights the difficulty of measuring accurately the size of plants when they are high in host trees (most of the Huxley mistletoe were assessed from a distance being much higher up in their host tree compared to those in the non-treatment area).

Significant differences in defoliation class frequencies occurred in the treatment area between the two years resulting in an overall reduction in browse (Fig. 8. X^2=36.16, df=4, P=<0.001). With the exception of minor defoliation (browse score 0.5), which increased from 5% to 9% after possum control in the treatment area, the percentage of plants in all other browse classes declined, indicating a improvement in condition of mistletoe in the treatment area after possum control. Similar declines also occurred in the non-treatment area for defoliation class 1 and 2. This potentially conflicts with other results of this study that show reduced foliar cover between the two years in the non-treatment area. These reductions are balanced somewhat by an increase in severe browse (browse class 4) in the non-treatment area, which increased from 5% to 20% between 2002 and 2003 (Fig. 7). The percentage of un-browsed plants in the non-treatment area remained similar at 26% and 25% in 2002 and 2003, as did the percentage of stage 3 browsed plants. Overall in the non-treatment area there was a tendency for increasing browse (Fig. 7. X^2=36.66, df=3, P=<0.001).

Discussion

Preliminary results from this study provide evidence to support possum damage occurring to *P. patulum* and mistletoe in the Temple and Huxley valleys, with significant differences observed between the treatment and non-treatment areas. Over all there is a trend toward less browse and less heavy browse post possum control in the treatment area compared to the non-treatment area on both mistletoe and *P. patulum.* Changes in light browse frequencies are, however, less clear.

Mistletoes in the treatment area have responded rapidly through increased foliage cover, and less browse observed occurring to plants after possum control. This response is consistent with other studies that have shown that mistletoe condition improves with the reduction in possum numbers (Ladley and Kelly 1996, Ladley et al 1997, de Lange & Norton 1997, Sessions et al 2001). Other indicators of improved mistletoe condition were less clear, such as increased size, but this may be a lag in response given the short amount of time that has elapsed since possum control. This is also a reflection of the pointless waste of time it is collecting 'estimated ' size data from plants that are inaccessible. Over time, with on going possum control, mistletoe condition can be expected to improve. Ongoing monitoring of mistletoe should provide more information on responses to reduced possums in the future.

Changes in browse class frequencies between the two years in the treatment and non-treatment areas in this study provides evidence for possum browse on *P. patulum*. Changes in heavy browse scores in particular, suggest possums are impacting on *P. patulum*. For example, heavy browse decreased in frequency after the control of possums in the treatment area, whereas in the non-treatment area heavy browse tended to increase. This suggests, therefore, that heavy browse is likely to be the result of possums rather than other potential browsers.

Further evidence of a positive response in *P. patulum* to reduced browse pressure is shown by the significant increase in mean height observed for seedling and sapling age classes. However, significant mean height increases did not occur for sub-adult and adult plants, despite a reduction in browse on these age classes. This may be due to sub-adults and adults being close to their maximum height potential, so mean height increases in these age classes may not be so obvious despite being released from browse pressure. Changes in foliage cover over time may be better a better assessment of plant response in relation to reduced possum numbers.

Significant increases in mean height also occurred for saplings in the non-treatment area between the two years. This potentially suggests that this age class is less vulnerable to possum browse generally than seedlings and adults. The morphology of saplings, being tall, sparsely vegetated and unable to support a possum weight, may provide a level of freedom from possum pressure, especially at the apical end of plants allowing continual growth. Not until saplings become large enough (adults) to support the weight of a possum would they become vulnerable to serious browse. The pattern observed in the Huxley, with relatively abundant and healthy saplings, in contrast to a decaying seedling age class and decimated adult age class potentially supports this.

An assumption is that adults are more vulnerable to death from severe possum browse. This was a pattern observed during the course of this study, with few living adults remaining in the Huxley, compared to the Temple valley. Although a decrease in moderate and heavy browse occurred on adult size classes in the treatment area after possum control, more time is required to provide greater clarity of the longer term impacts of possum browse on adults. In addition, until a bigger sample of living adult plants in the non-treatment area is included in the monitoring, this assumption is treated with caution due to a lack of replication for this age class between treatment areas.

The connection between light browse and possums is unclear. Highlighting this is decreased light browse on seedling and sapling plants in the non-treatment area, but an increase in light browse on the same age classes in the treatment area. This result contrasts with the general pattern observed for each area, in particular for heavy browse, and highlights that other browsers may be operating, such as insects, which are mistakenly scored as possum browse. Alternatively this result may reflect observer difficulties in scoring broad browse classes and separating mammal browse from other influences of degradation.

Conclusion

Preliminary results from this study highlight possum browse is a threat to *P. patulum* and mistletoe in the Temple and Huxley valleys. In particular, the results of this study suggest that heavy browse sign observed on plants is likely to be the result of possums. Light browse is less clear, however, for both *P. patulum* and mistletoe. This potentially highlights a lack of response time for plants post poison, and/or other browse influences operating. This study also suggests that possum impacts vary for *P. patulum* depending on the growth stage of *P. patulum's* lifecycle.

Ongoing monitoring will also provide better clarity on the impacts of *P. patulum* and mistletoe generally because plants will have more time to respond to possum control. Future monitoring will require careful and accurate assessment of browse classes, with particular attention paid to scoring possum impacts, as opposed to other browse and/or damage events, such as insects. In addition to the current monitoring regime, recording of new seedlings for both *P. patulum* and mistletoes when they occur in established 'plots' should be incorporated into the current monitoring regime. This will serve as an additional indicator of potential possum impacts on these species over time.

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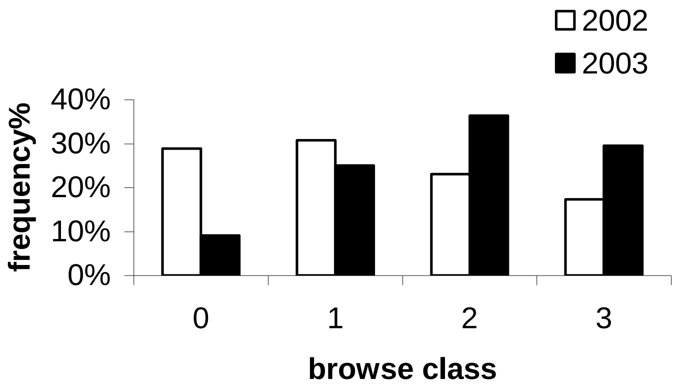

Figure 1. Browse class frequency changes for foliar stage 1 (seedlings) in the non-treatment area between 2002 and 2003 (n= 2002 -2003: 0 = 15 - 4; 1 = 16-11; 2=12-16; 3= 9-13)$X^2$13.83, df 3, P=<0.01.

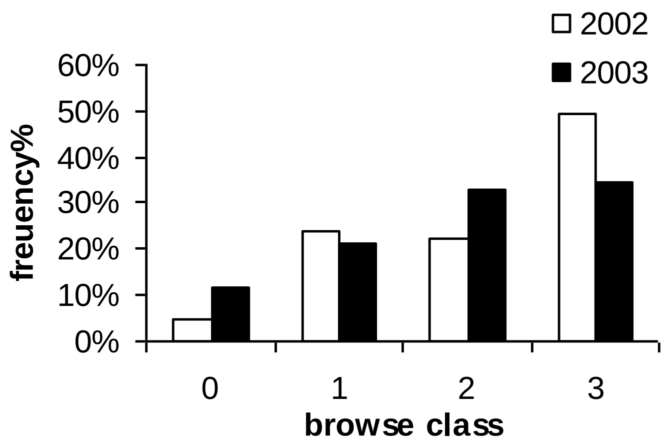

Figure 2. Browse class frequency changes for foliar stage 2 (saplings) in the non-treatment area between 2002 and 2003 (n= 2002 -2003: 0 = 14 -29; 1 = 73-54; 2=69-83; 3= 152-88). $X^2$50.48, df 3, P=<0.001

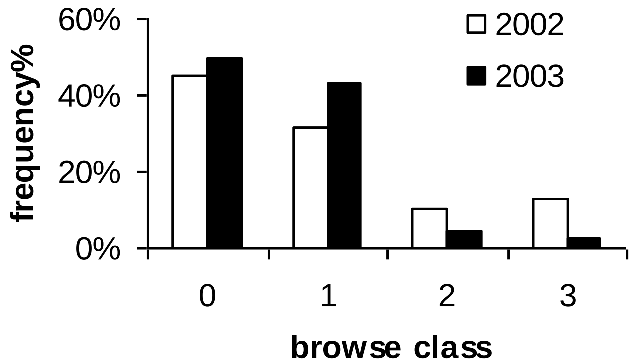

Figure 3. Browse class frequency changes for foliar stage 1 (seedlings) in the treatment area between 2002 and 2003 (n= 2002 -2003: 0 = 48 -56; 1 = 34-49; 2=11-5; 3= 14-3). $X^2$18.497, df 3, P=<0.001

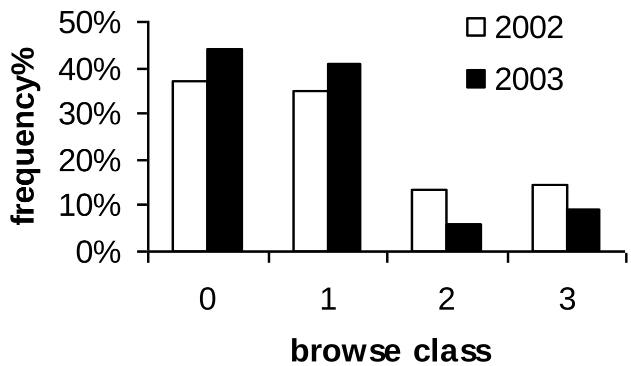

Figure 4. Browse class frequency changes for foliar stage 2 (saplings) in the treatment area between 2002 and 2003 (n= 2002 -2003: 0 = 60 -64; 1 = 56-60; 2=22-9; 3= 23-13). $X^2$119.09, df 3, P=<0.001

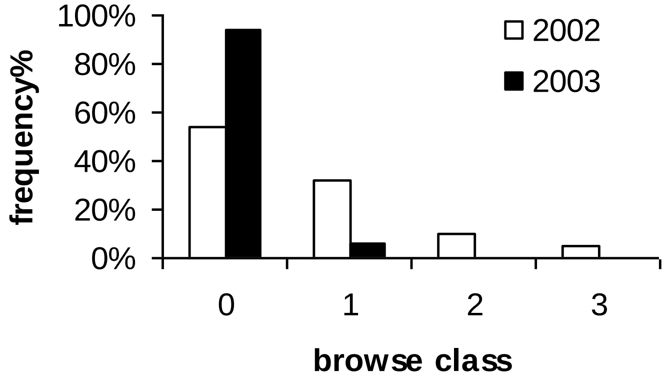

Figure 5. Browse class frequency changes for foliar stage3 (sub-adult) in the treatment area between 2002 and 2003 (n= 2002 -2003: 0 = 21-29; 1 = 13-2; 2=4-0; 3= 2-0). X^2 21.8 (age class 3&4 combined), df 3, P=<0.001

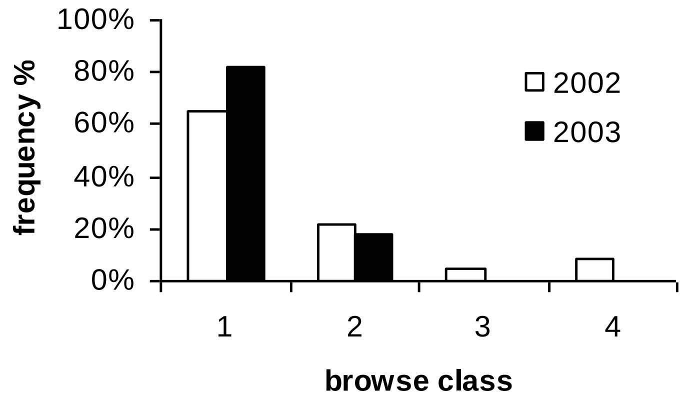

Figure 6. Browse class frequency changes for foliar stage 4 (adult) in the treatment area between 2002 and 2003 (n= 2002 -2003: 0 = 15-14; 1 = 5-3; 2=1-0; 3= 2-0). X^2 21.8 (age class 3&4 combined), df 3, P=<0.001

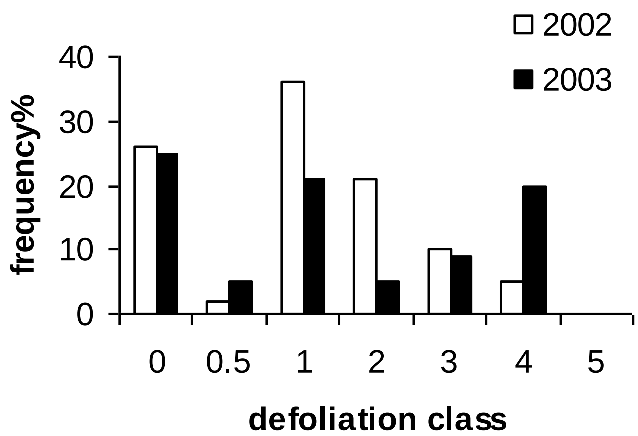

Figure 7. Browse class frequency changes in mistletoe non-treatment area between 2002 and 2003 (n for 2002/2003 0= 15-14, 0.5=1-3, 1=21-12, 2=12-3, 3=6-5, 4=3-11, 5=0). $X^2$36.16, df 3, P=<0.001

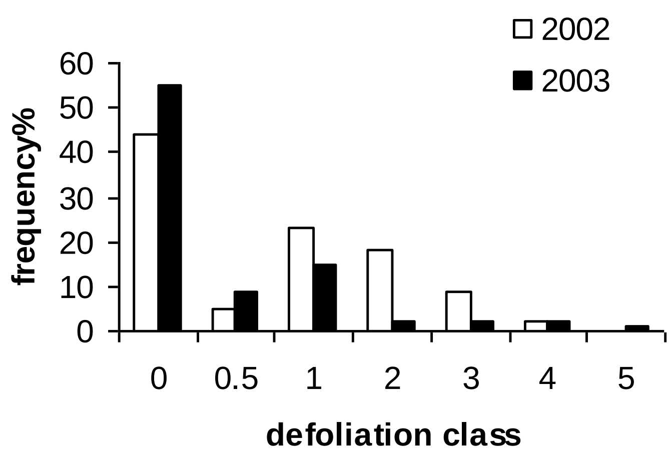

Figure 8. Browse class frequency changes in mistletoe, treatment area between 2002 and 2003(n for 2002/2003 0= 58-72, 0.5=6-12, 1=30-19, 2=24-3, 3=12-2, 4=2-2, 5=0-1). $X^2$40.1, df 3, P=<0.001

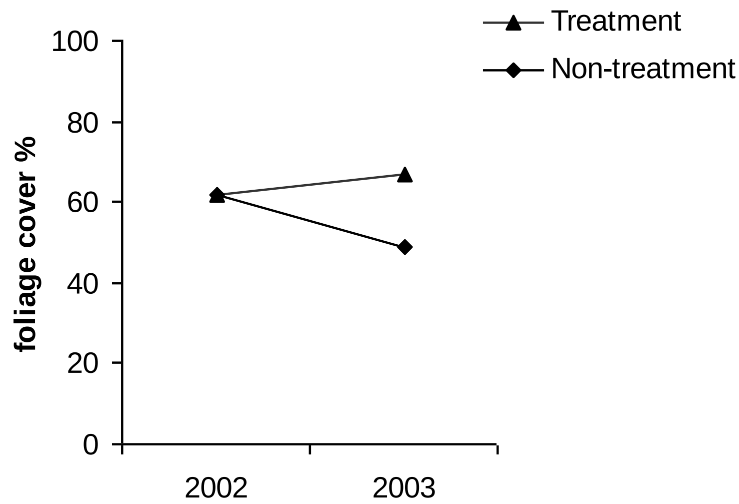

Figure 9. Mean change in foliage cover in treatment and non-treatment areas between 2002 and 2003.

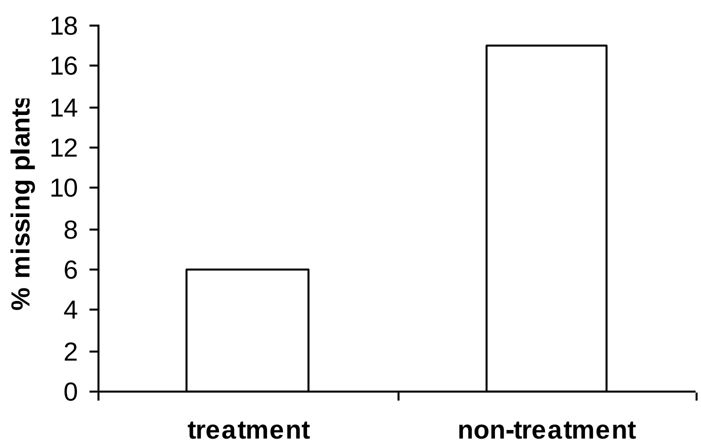

Figure 10. Percentage of missing plants in the treatment (n=24) and non-treatment (n=62) area between 2002 and 2003. X^2 24.64, df 1, P=<0.0001

Table 1. Mean foliage cover changes in mistletoe in treatment and non-treatment before and after treatment (2002 and 2003)

	Before Mean ± se (n)	After Mean ±se (n)	t	df	P
Foliage cover Treatment area	61.53 ± 2.58 (129)	66.92± 2.539 (129)	-2.2824	128	0.006
Foliage cover Non-treatment area	62.98±3.978 (56)	49.65±4.741 (56)	3.971	55	0.000

Table 2. Mean size changes in mistletoe in the treatment and non-treatment area before and after treatment (2002 and 2003).

	Before Mean ± se (n)	After Mean ±se (n)	t	df	P
Size Treatment area	696.25±62.30 (133)	749.34± 54.94 (133)	-1.544	132	0.125
Size Non-treatment area	475.06±73.291 (58)	505.46±4.741 (58)	-1.3073	57	0.197

Table 3. Mean height changes in *P. patulum* per age class for the treatment and non-treatment area between 2002 and 2003.

	Before Mean ± se (n)	After Mean ±se (n)	t	df	P
Age Class 1 (seedlings) Treatment	513.93±25.43 (102)	529.22±25.96 (102)	-2.016	101	0.047
Age Class 2 (saplings) Treatment	1286.17±49.32 (150)	1334.10±50.42 (150)	-3.970	149	0.000
Age class 3 (sub-adult) Treatment	2250.66±106.99 (38)	2270.97±137.16 (38)	-.214	37	0.832

Age Class 4 (adult) Treatment	3793.16±208.31 (19)	3794.74±205.83 (19)	-.029	18	.977
Age class (seedlings) Non-treatment	395.28±36.53 (43)	371.16±34.87 (43)	1.710	42	0.095
Age Class 2 (saplings) Non-treatment	1110.16±33.07 (254)	1155.75±33.92 (254)	-6.201	253	0.000

Cook's scurvy grass, *Lepidium oleraceum* Forst f., monitoring on Matariki Island (May 2002 – December 2004)

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Introduction

All ten of New Zealand's indigenous coastal *Lepidium* taxa are in decline and considered threatened in some way (de Lange, et al. 2004). Five entities occur within the *Lepidium oleraceum* agg.; one described species (*L. oleraceum* s.s.) plus an additional four undescribed taxa which have been treated as distinct entities in the most recent threat assessment. The *Lepidium oleraceum* s.s. taxon that is the subject of this paper is classified as Nationally Endangered by de Lange et al. (2004), and is thought to have undergone considerable declines in recent times. Comments made by (Kirk 1891) and (Cheeseman 1914, Cheeseman 1925) on the rapid decline they observed in coastal cresses contrast with the reports of the abundance of *Lepidium oleraceum* (Cook's scurvy grass) when James Cook voyaged here in the 1700's and famously used the plants as a food source (Norton and de Lange 1999). The decline has continued to the present day. *L. oleraceum* no longer occurs on the mainland of the North Island, it is known from just one mainland site in the South Island, and is otherwise found in small populations on off–shore islands or rock stacks.

The declines that have been observed over the years are difficult to quantify as there has been no long–term monitoring of any of the cress species (Norton and de Lange, 1999). In order to address this issue a key recommendation of the Coastal Cresses (nau) Recovery Plan (Norton and de Lange, 1999) is for increased monitoring of coastal cress populations. Objective 7 of the recovery plan is to establish detailed monitoring programmes that assess trends in population abundance through time for at least three representative populations within each of the six geographical areas that the *Lepidium oleraceum* species complex occurs.

One of the potential sites where intensive monitoring could reliably be established and carried out in most weather conditions, is on Matariki Island in the Firth of Thames (Figure 1). It is a small island of about 0.2 ha, the largest of several islands in a group owned by Ngati Maru.

Figure 1: Matariki Island.

Of the threats to extant populations of cresses, the oomycete parasite, *Albugo candida* (also referred to as white rust), recorded from wild populations of New Zealand cresses since the 1950's, has been cited as a causal factor in the declines of more recent times (Norton and de Lange, 1999). While there have been many studies on the effects of white rust on brassicas in the international literature, (e.g. (Alexander and Burdon 1984, Jacobson, et al. 1998, Verma and Petrie 1980) research has only recently begun assessing the effect of the white rust on populations of New Zealand *Lepidium* species. The white rust is found on the Matariki Island plants.

The ability to detect white rust infection by eye can occur when plants are exhibiting symptoms of the disease. It is characterised by local and systemic symptom expression (Ferreira and Boley 1991). Local symptom expression is observed as white pustules or "blisters' on the leaves. Systemic infections result in abnormal growth, distortion and sterility of flowers and inflorescences (Ferreira and Boley 1991). Plants can have the parasite but not show visible sign of any infection (asymptomatic infection, Jacobson et al. 1998; Tristan Armstrong, pers. comm.).

The monitoring programme underway investigates population size fluctuations, plant growth rates, reproductive cycles and the incidence and level of local symptom expression of the white rust parasite on individual plants over time.

This report is based on initial findings from data that has been collected to date. Data collection will continue, less intensively over time, until population threats, trends, reproductive ecology, natural population variation and rates of change can be evaluated.

Methods

Monitoring has been carried since May 2002. All individuals on the island, other than seedlings less than 100 mm high, have been tagged and mapped.

For each tagged individual the following data are collected at 3–monthly intervals:

- Height
- Width
- Flower presence
- Fruit/seed presence
- % of leaves of plant with symptomatic white rust (*Albugo candida*) infection

From these data population change over time can be determined. Recruitment and mortality rates can be ascertained and monitored. Seasonal effects on plant growth rates, symptomatic white rust effects on plants and ultimately individual plant longevity can also be evaluated.

Results

Population size, recruitment and mortality.

Population size has fluctuated during the time period of monitoring from 90 individuals in May 2002 to 79 individuals in December 2004 (Figure 2). The population peaked at 93 individuals in November 2002 and dropped as low as 69 individuals in September 2004.

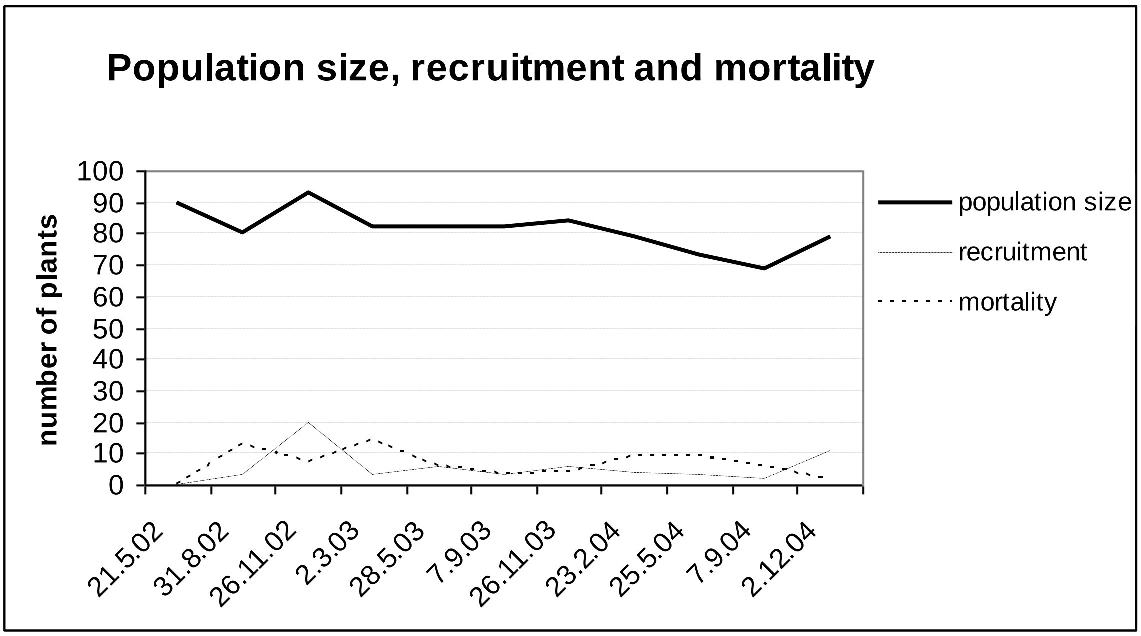


Figure 2: Population fluctuation over time.

New recruits entering the population peaked in November 2002, but otherwise have either kept pace with deaths or fallen below the death rate during the time monitored. There is no seasonal effect on either recruitment or mortality.

White rust (*Albugo candida*) presence

Local symptom expression has varied over the time monitored (Figure 3).

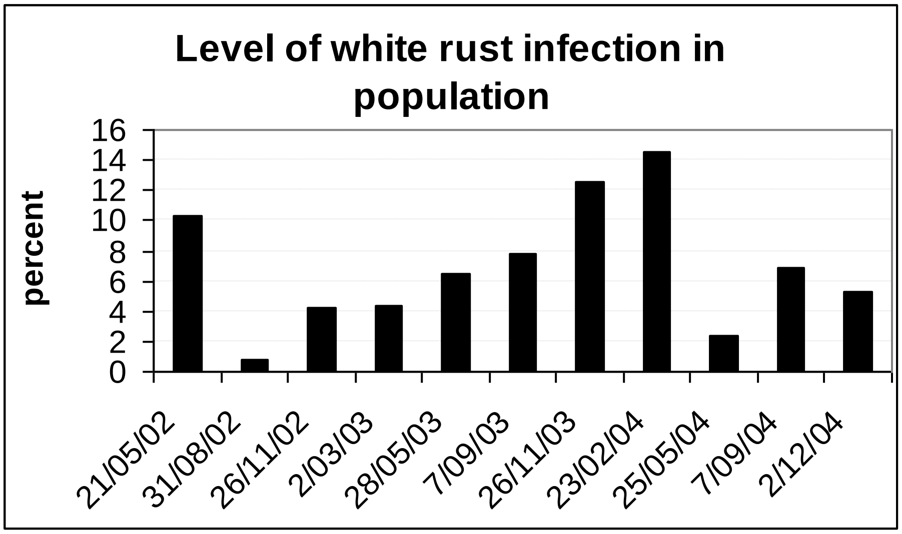


Figure 3: The percentage of leaves on individual plants that show white rust (*Albugo candida*) infection averaged for the population.

The variation in local symptom expression of white rust infection throughout the population could be due to a number of reasons. Firstly, seasonal effects may influence infection levels, such that high levels are observed in spring due to wet, warm conditions and low levels observed in summer due to dry conditions. Looking at the average levels of infection throughout the population, there does not appear to be a seasonal effect. Secondly, plants may die following infection. All of the individuals that have been followed since May 2002 that are still alive have expressed local symptoms of infection at some stage, therefore plants do not die following infection. Thirdly, it may be the severity of infection that affects plant mortality. The percentage of leaves with symptomatic white rust infections in the period prior to death were categorised to assess this (Figure 4). The majority of plants that died during the monitoring period exhibited no sign of white rust infection during the period prior to death (32 of 69). Fourthly, it may be the case that all plants that get heavily infected die. Of 33 recorded instances of white rust infection observed on greater than 50 % of the plants leaves, three plants were dead by the following monitoring visit (i.e. 9.1%) and a further three died after lower infection levels were recorded for them. One individual that had a score of 100% white rust infection, had subsequent levels of 30, 10 and 5% over the following visits. The plant is still alive. Plants that are heavily infected do not die very often.

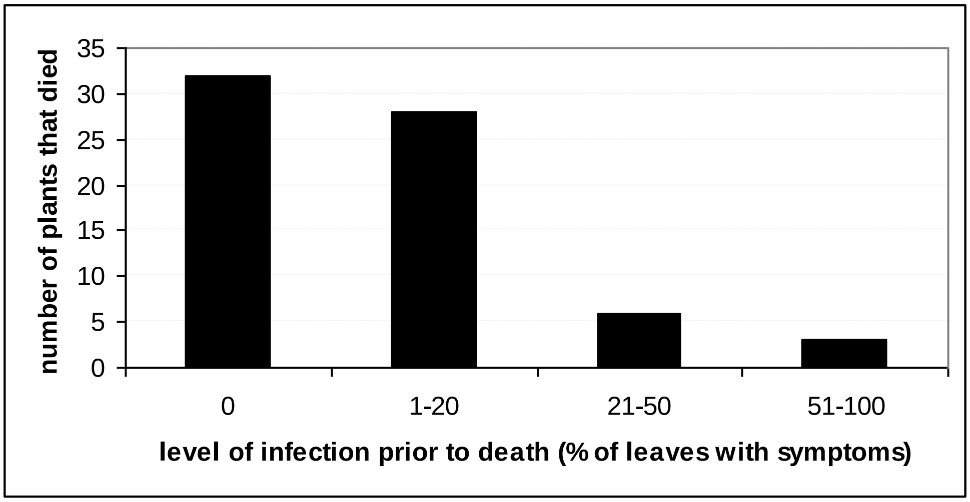


Figure 4: White rust infection prior to mortality by category.

Systemic infection causing distortions in flowers and seeds has not been observed in the Matariki Island population since monitoring began.

Flowering and fruiting

Flowering occurs all year and although the numbers of plants flowering varies from visit to visit, there does not appear to be any seasonal effect on numbers of flowering plants. During one site visit only one plant was fruiting, suggestive of a previous period when flowering was also low.

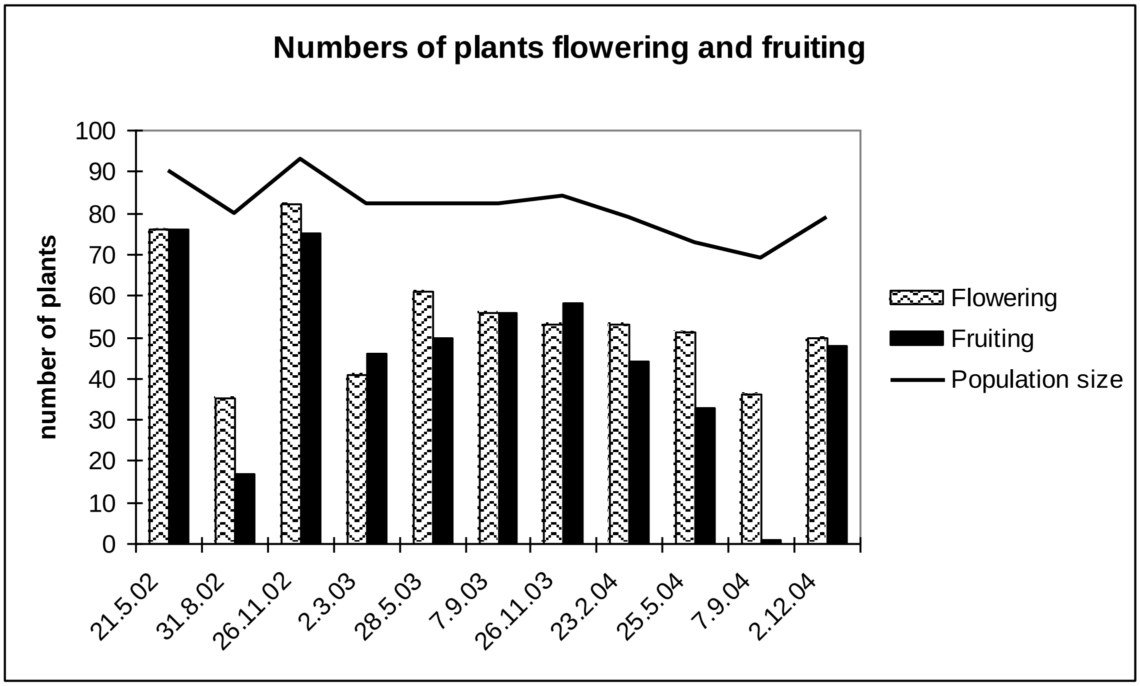
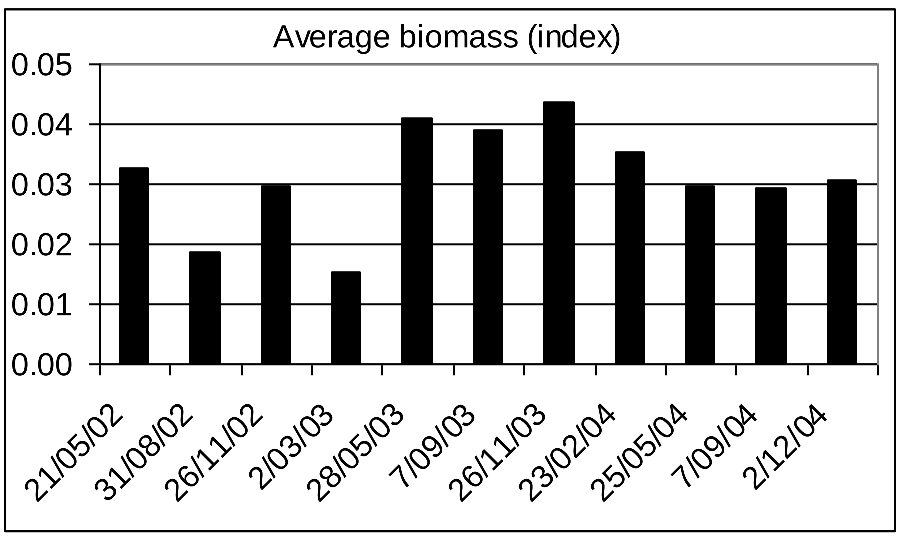


Figure 6: Numbers of plants flowering and fruiting on each site visit with population size along the top.

Plant size fluctuates over time. Plants are often observed with extensive dieback and vigorous re–growth from near the base of the plant.



Eight plants have resprouted after being recorded dead. This is likely to be an under–estimate as the re–sprouting of a dead plant can only be confirmed when a tag is still attached to the plant.

Conclusions

Population numbers fluctuate over the course of the year caused by recruitment and mortality that occurs throughout the year.

It appears that local symptom expression of the white rust parasite has no relationship to mortality with respect to the population of *Lepidium* on Matariki Island. All plants on the island that have been alive since monitoring began have exhibited symptoms of the parasite at some stage. These plants do not necessarily get more heavily infected once sign of infection is evident and they do not usually die after symptoms are expressed.

Flowering occurs year round although fluctuations occur. Apart from one visit when only one plant was fruiting over a two and a half year time span, plants also produce seed year round. Although the lack of fruit on plants indicates a corresponding period prior to the visit with a lack of flowering individuals, this can not be attributed to annual or seasonal fluctuations.

Extensive dieback and basal re–growth is commonly observed on plants. In extreme cases, plants have been recorded dead but have sprouted back to life by the following monitoring visit. This type of growth pattern results in considerable fluctuation in biomass throughout the life of a typical plant.

Future work

While there is no obvious seasonal effect on growth patterns, recruitment, mortality or levels of white rust infection, weather conditions in the maritime environment may have over–riding influences over plant population dynamics. Environmental and climatic factors, such as rainfall, drought periods and prevailing wind direction, will be investigated to determine possible effects on plants. These aspects, along with further results from ongoing monitoring, will be addressed in a future paper.

Effects of the white rust parasite on the population require further investigation for threat assessment. Plant growth, reproductive effort and seed viability may be affected by the parasite during the asymptomatic phase.

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Monitoring of Coastal Annuals in Northland

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Introduction

A number of threatened plants in Northland occur on the coast or offshore islands. Examples include Holloway's crystalwort (*Atriplex hollowayi*), coastal cress (*Rorippa divaricata*), the tiny gentian *Sebaea ovata* and native puha (*Sonchus kirkii*) all of which complete their life cycle over summer. Northland Conservancy monitors both Holloway's crystalwort, which is increasing its range due to an intense summer restoration program and Sebaea which was successfully translocated to Pouto dune wetlands in 2002.

Factors to consider when monitoring annual plants

There are several factors to consider when setting up monitoring programs for annuals. The most important of these is timing because plants must be large enough to be recognizable and also in sufficient numbers to monitor. Most annuals grow in summer and this is often the busiest time of the year for fieldwork so monitoring has to be tailored around other work as well as the Christmas holiday period. It is important therefore to design a realistic program that will answer the research or management questions without over committing staff resources.

Monitoring may also need to be more intense for plants which, like Sebaea, have a short lifecycle. In addition plants may be at different stages within their lifecycle so it might be quite difficult to compare the progress of individual plants until all the data are analyzed at the end of the season.

Accessibility of the site may control how frequently, if at all, monitoring can occur. Threatened coastal annuals tend to occur at remote sites where access is limited or even on offshore islands. In addition access is sometimes controlled by the tide and access to coastal wetlands may be impeded by high water levels. To save resources monitoring at remote sites should tie in with other work if possible or with management activities.

The key to annual plants is in the seed bank as most rely on a good seed set from season to season and some are so influenced by weather patterns that population numbers can be variable from year to year and may even exhibit the extreme " boom and bust" cycles observed in Holloway's crystalwort. In addition many coastal annuals have a long seed viability so population counts or monitoring must be done for a number of seasons before a pattern will emerge. For annuals long-term population trends are needed to determine the true status of a species. Probably the best gauge of whether a critically endangered annual is recovering is its spread into new available habitats and this can be ascertained by good distribution and census data.

Monitoring Phases

There are four phases to monitoring annuals:-

- Survey/population census - checking recent and historic sites where plants have occurred as well as potential habitats within seed dispersal range.
- Setting up monitoring – designing program within resources and to answer specific research or management needs. Selecting population(s) or subsets to monitor. Designing monitoring sheets and database.
- Monitoring - marking plants, carrying out monitoring, filling in datasheets and entering information into database.
- Write-up – End of year report which keys back to research/management questions. Considers why the monitoring is being done and how the information is going to be used both in the short and long-term.

Marking plants

Locating plants using GPS is important. Physically marking plants for monitoring programs in the coastal environment can be quite difficult especially in exposed sites or in less stable habitats such as beaches, eroding banks or ephemeral wetlands. Small plastic garden tags, where there is enough soil or sand to support them, works well and a cheap alternative is to cut triangles of plastic milk containers and mark them with permanent pen. Tying tags to plants is another option in thin soils. Full population census may also require that plants are marked when they are counted especially if plants are germinating over a long period of time. Pushing coloured paperclips into the ground next to plants is one way of doing this but these can be hard to see. Another method which works well in sand or wetland situations is marking plants with long coloured straws. These can either be removed once plants are counted or left in situ until the next count. During recounts straws can be exchanged for ones of a different colour. Once the plants have died back they can be simply marked with a short straw and these can be left until the following season if required. Plastic straws break down in the sunlight but are reliable markers for two years depending on the environment. Other marking systems which have been found useful on beaches are marker posts and long wires with plastic numbered tags. On beaches where the public have access signage or advertising may need to be considered especially if it is desirable that the public are directed away from the plants being monitored.

Case studies

Holloway's crystalwort – Far North

Annual crystalwort survey focuses on population census and distribution information for the plant. Monitoring seeks to track success of wild plants and plantings in terms of survivorship and seed set. This information is used to design the operational plan and select planting sites for the following seasons work.

Holloway's crystalwort is a soft stemmed critically endangered beach annual in the family Chenopodiaceae. It occurs in open beach environments at the high tide mark where storms, king tides and mass sand movement are a feature. Crystalwort used to widespread on east coast beaches as far south as Wellington but is now found only in the Far North. Threats and reasons for its decline are browsers (including rabbits and hares), trampling by wild stock and horses, pig damage, weed competition, storms, four wheel drive vehicles on beaches, habitat destruction and, in the past sand mining and over collection by zealous botanists.

Crystalwort germination starts around November with flowering and fruiting occurring throughout the summer until late autumn. Seed is dispersed by sand movement and ocean currents and seed may remain buried in the sand for many years before it is unearthed and germinates. Yearly population counts which started in 1990 showed that numbers were quite unstable. By 2000 after four years of very low counts in only two sites, it appeared that the plant may be on the brink of extinction. Bequest funding then kicked off an intense rescue program which included summer restoration planting, fencing, weed and rabbit control, sandbagging during storms, monitoring and seed collection. Wild numbers of plants for the last two seasons have been in their hundreds with a range extension south in 2003/04! Recovery work focuses on building up the seed bank by planting and protecting plants on site.

Population census and survey of crystalwort outside its current range is an important part of the project especially now that the plant appears to expanding back into former habitats. Monitoring of a selection of wild and planted crytalwort is undertaken fortnightly. This is important for planted crystalwort in order to find out which sites and what management techniques produced the best survival and seed crop. This information is used when reviewing the program for next year. Good notes are also kept about each site including information on sand movement, animals and weather patterns since the previous monitoring. Seed is collected off wild plants for storage and cultivation for next season and provenances are recorded to ensure that a wide range of genetic material is represented. Figure 1 is an example of a plot sheet. Relocation of individual plants in planted plots is made easier by line planting. Line planting is acceptable here because the beaches are remote and the plants used are annuals.

Sebaea ovata – Pouto dune lands

The objective of the survey and monitoring program at Pouto is to determine which sites planted Sebaea grows in most successfully and to determine if a viable wild population of Sebaea will establish as a result of the translocation from Wanganui.

Sebaea is a tiny critically endangered yellow-flowered gentian which grows in wetlands especially near the coast. Like crystalwort the seed floats on water and it is dispersed during winter flooding. It used to be widespread throughout the country but in New Zealand is now confined to coastal wetlands at Wanganui where it is failing. In 2001 Wanganui staff identified areas of what looked to be ideal habitat for Sebaea at Pouto Peninsula on the North Kaipara Head. The idea was to reintroduce seed grown plants to Northland to re-establish it in a conservancy where it had become extinct. In November 2002 three hundred

Sebaea were planted on Maori and DOC managed land at Pouto. Monitoring was undertaken by iwi every two weeks until the plants died back in January. Plants on the Maori land did well and set seed but only some plants on the DOC land survived because water levels at the DOC managed site were unstable and the area dried out before the plants had chance to set seed. The following season (summer 2002) 120 wild plants were found on the Maori land and the project was heralded an instant success! Local iwi were particularly pleased that they were now kaitiaki of this taonga from Wanganui iwi with whom they have links. 380 more seed grown plants were planted back into the habitat and also into two other sites which were thought to be more suitable than the original DOC sites. We have yet to see what 2004 brings.

Pouto is an extensive and remote site with access controlled by the tides so employing local iwi to do the monitoring was helpful especially over the Christmas period. Time had to be taken when the project started to provide enough support so that iwi were confident with the methodology and could run the project independently. Because each wetland was unique in terms of its water level and stability this meant that survivorship and growth rates were variable at each site and tracking this by monitoring has been important for planning future plantings. Just revisiting habitats throughout the season gave iwi and staff a better picture of additional sites which would be suitable for Sebaea. Once again survey and population census is an important part of the monitoring program Figure 2 is the Sebaea monitoring plot sheet used at Pouto.

Figure 1 Example of part of a monitoring sheet for planted crystalwort

Site	**Area**	**Grid Ref.**	**Seed batch**	**No. plants**	**Date planted**	**Monitor date**	**Comments**
1	Waikuku	119 528	AS5	15	08/10/02	08/01/03	0 live,Site scoured by tide
2		115 513	AS5	14		08/01/03	8 live,4 yellowng Seed<50, sugg. Last seed take
1	Tom Bowling	094 534	AS1	41		08/01/03	33 live, 4 yellowng av. 400mm. seed > 100
2		086 529	AS3	28		08/01/03	24 live 16 yellowng Av. 200mm. seed >100
1	Whareana	112 492	AS2	24	15/10/02	08/01/03	21 live, 1 yellowng Light sand drift…..
2		112 493	AS2	21		08/01/03	19 live 17 yellowng Av height 30mm,. mod sand drift…

Figure 2 Example of part of a Sebaea field monitoring sheet.

SEBAEA OVATA TRANSLOCATION – POUTO NORTHLAND GPS locality: XXX

Area: Causeway	**Plot:** 3	**Recorder:** Christopher Thompson	**Date:** 23/12/03
Total no: 124	**No Alive:** 94	**No Dead:** 30	**Original No:** 150

Plant no.	Condition	Height	Branching	Fertility	Other
1	H	10	5	NIL	
2	H	17	7	MB-HF	
3	H	18	5	LB-HF	
4	H	12	5	HB-LF	
5	<50%	20	10/ 3	LB-HF	Browning off

KEY: **Condition** H=high, <50%=less than 50% dried off, >50%= greater than 50% dried off, D=dead **Branching** number of main branches **Fertility** B= buds F=flowers C=capsules E=empty capsules (Low, Med, High – L M H) Note – fertility can be a combination of buds, flowers and capsules

Monitoring of the rare grass *Simplicia laxa* at Castle Rock, Old Man Range, Otago

John W. Barkla & Trudy C. Murdoch

Introduction

The endemic grass genus *Simplicia* was founded by Thomas Kirk in 1897 and comprises two species; *S. buchananii* and *S. laxa*. *S. laxa* is the type of the genus and was described from a composite of specimens gathered from eastern Wairarapa and Otago (Kirk 1897). Despite the early Wairarapa record, *S. laxa* is currently only known from five Otago sites. In the most recent threat classification listing (de Lange et al 2004) it was assigned the status of nationally endangered.

Following Kirk's description, the species was not collected again until Ian Ritchie found it in 1969 on the Old Man Range, Central Otago (Zotov 1971). In 1993 Peter Johnson searched in the same vicinity and found the species at Castle Rock, concluding that this was also the site of Ritchie's 1969 collection (Johnson 1995). Johnson carried out a detailed inspection of the site, identified four cleft and ledge sites where *S. laxa* grew, and prepared a site diagram (Johnson op. cit.).

A population count at Castle Rock in March 1993 identified 76 plants. Further counts were carried out in 1996 (87 plants) and 1997 (105 plants). Some difficulty was experienced in assessing what constituted an individual plant due to its mat habit.

Several other important events happened between 1995 and1997:

- An inspection revealed that stock camping in one area important for *S. laxa* had completely removed all the vegetation.
- Castle Rock became a conservation area (as a result of tenure review) with a consequential need to determine appropriate management, especially whether to continue to allow grazing.
- The exotic tussock hawkweed (*Hieracium lepidulum*) was observed invading *S. laxa* sites and herbicide control was initiated.

The site

Castle Rock is a massive schist tor about 150 x 60 m and some 40 m high. It sits at 700 m altitude on an undulating hill slope of north-east aspect amongst short tussock grassland of hard tussock (*Festuca novae-zelandiae*) and silver tussock (*Poa cita).* This is farming-induced vegetation that, through fire and grazing, has replaced an earlier forest and shrub cover of which matagouri (*Discaria toumatou*), *Coprosma propinqua* and *Olearia odorata* still remain.

Monitoring Objective

A decision was made in 1997 to refocus the monitoring effort to better understand change in abundance under different stocking regimes. The objective was:

- To monitor the change in cover of *S. laxa* and *H. lepidulum* in
  - a destocked area ("Big slot fenced")
  - an area which has never been grazed ("Top Slot")
  - an area subject to continued grazing ("Big Slot east" and "Big Slot west")

Method

A stock-proof fence was constructed across the entrance to a small rocky alcove located in "Big slot". S. *laxa* habitat within each of the three treatment areas was sectioned off into contiguous 30 cm long plots, extending out 10 cm from the base of rock walls. Each plot division was marked with a numbered metal tag affixed to the ground with wire. Sixty-seven sampling units were created.

The cover of *S. laxa* and tussock hawkweed within each sampling unit was estimated in six cover classes on a yearly basis.

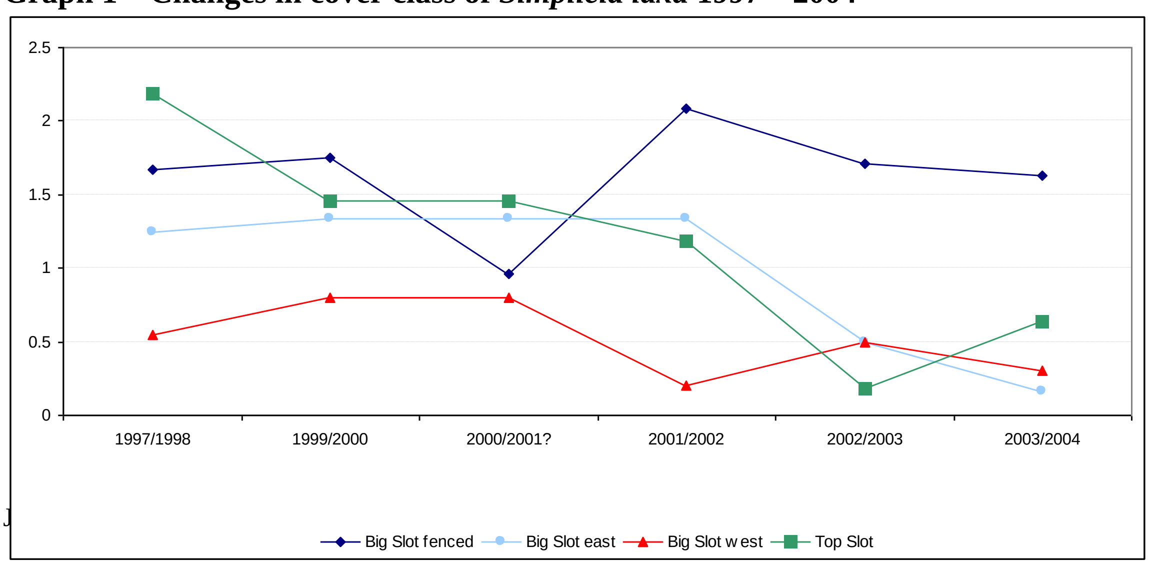
Percentage cover	Class
0	0
<1	1
1-5	2
6-25	3
26-50	4
51-75	5
76-100	6

Data were entered into a excel spreadsheet and graphed.

Results

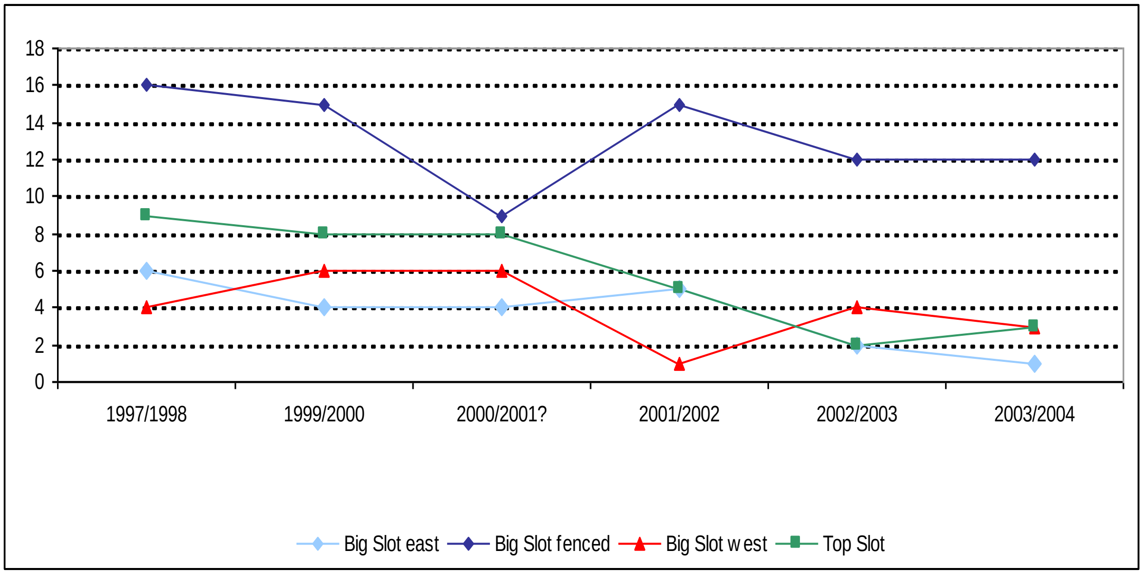
The cover of *S. laxa* has been maintained in the destocked area but has declined in all other monitored areas (graph 1).

Graph 1 – Changes in cover class of *Simplicia laxa* 1997 – 2004



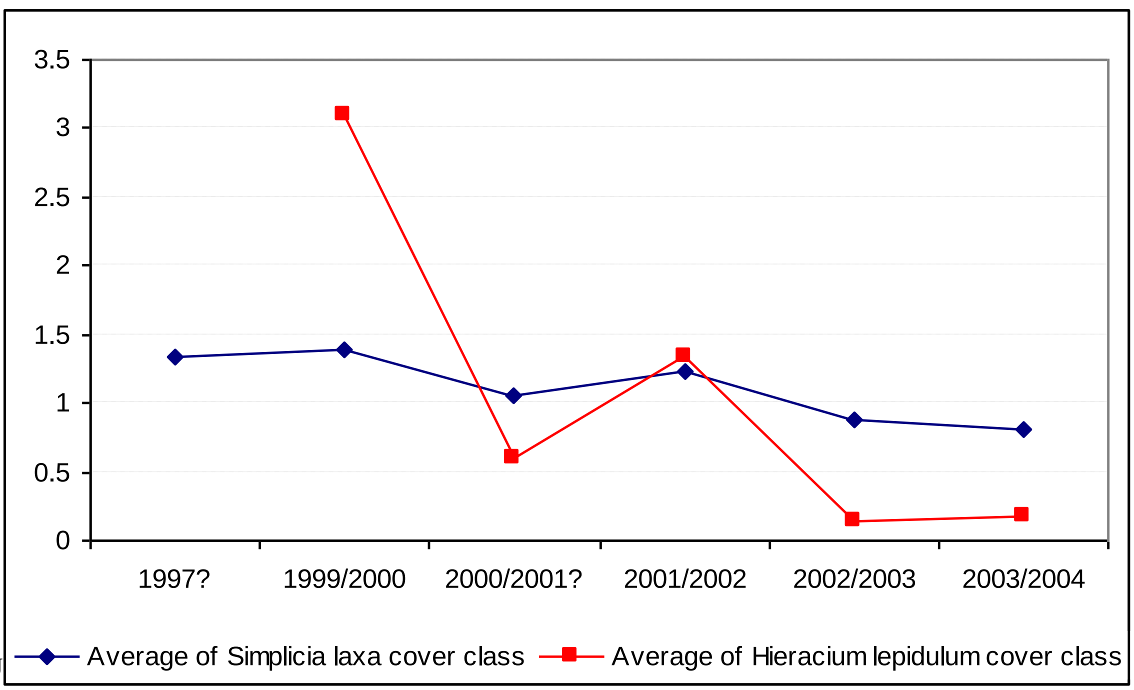
The number of plots containing *S. laxa* has declined under all stocking regimes however that decline has been greatest in the area which has never been grazed (graph 2).

Graph 2 – Number of plots with *S. laxa* 1997 - 2004



Average cover of *S. laxa* has declined slightly while cover of tussock hawkweed has undergone a steep decline and stabilised at a very low presence (graph 3).

Graph 3 – Average cover of *S. laxa* and *H. lepidulum* 1997 - 2004



Discussion

- The monitoring method works well because it is simple and has been tailored to reflect the habit and habitat of the target species. While cover assessments have so far been restricted to *S. laxa* and the weed we believe most threatens it, it would be easy to include other species if it were thought useful to do so.

- The relative stability of cover of *S. laxa* at the site from which stock were excluded in 1997 has given the Area confidence to proceed with excluding stock from two other sites where ongoing decline has been recorded. "Big slot east" and "Big slot west" have now been fenced at either end preventing stock passage. The decline in cover of *S. laxa* at other monitored areas is a concern and suggests other factors not related to grazing, may need to be considered.

- The decline of tussock hawkweed since herbicide control was initiated and its now very low presence in plots suggests this is an effective control strategy that should be continued.

- It has been helpful to have some strategic context to the monitoring (in this case a recovery plan) and commitment at the Area Office to the long-term nature of the project and the need to competently collect, store and analyse the data.

- Caution should be exercised in extrapolating the findings from this experiment to other *S. laxa* sites e.g. North Otago limestone, where the ecological setting and history of disturbance have led to a different suite of competitive grasses and weeds.

Future Directions

Management of the Castle Rock site and associated monitoring needs are likely to be influenced by our emerging knowledge of ecological pattern and processes in the dryland zone. In particular there is increasing evidence that reconstruction of woody components of the ecosystem to provide the micro-climate and shading regimes we postulate would have occurred here prior to human intervention, may provide an environment more conducive to *S. laxa*.

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Finding the right button hole - determining habitat preferences of pygmy button (*Leptinella nana*)

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Abstract

Pygmy button *(Leptinella nana)* is monitored at two riparian sites in Rai Valley, North Marlborough, to determine habitat preferences and the attributes that characterise these habitats, as well as the effects of stock, flooding and drought. Permanent quadrats are used to map the fate of sub-populations over five years following the removal of stock. A permanent transect is monitored over three years to assess population trends of pygmy button and to compare attributes of the sample sites which support pygmy button with sample site attributes where pygmy button is absent.

Results indicate that despite its ability to thrive in high light environments, pygmy button is unable to occupy these sites *in situ* due to competition by other herbs, especially exotic swarding grasses. Pygmy button cannot tolerate low light environments and occurs most often under an open forest canopy with a grazed, sparse understorey and ground cover. The removal of stock results in loss of some sub-populations due to the shading effects of understorey recovery. Despite its ability to spread vegetatively, sub-populations of pygmy button exhibit site fidelity which correlates strongly with hummocky micro-topography, a ground cover of turf dicot herb and moss associates, and high trampling impacts by stock.

Results can be applied to speculate where pygmy button originally occurred in the landscape, to predict where further populations of pygmy button might still occur, to determine the suitability of potential translocation sites for pygmy button and to indicate what habitat restoration actions are most appropriate for pygmy button. Strengths and weaknesses of the monitoring and data analysis techniques are discussed.

Introduction

Pygmy button *(Leptinella nana,* Asteraceae*)* one of New Zealand's smallest and most threatened native daisies. It is only known from three widely disjunct localities where it occupies three distinct habitat types: under riparian treeland on river silts (Rai Valley, North Marlborough), under coastal tussockland on loess (Makara, Wellington), and associated with tracks on basaltic outcrops (Port Hills, Canterbury). Habitat commonality appears to be the maintenance of bare ground and an open canopy by a variety of disturbance regimes. Pygmy button has never been found anywhere else and is currently ranked as nationally endangered.

Pygmy button was first discovered in the Rai Valley by botanist Thomas Kirk earlier last century, but was only recognised as a distinct species by Dr David Lloyd in 1972 (Lloyd). It was rediscovered near Bulford Bridge on the banks of the Rai River by Lloyd in the late 1960's and by the author in 1992. This site is a small beech-podocarp remnant frequently prone to flooding and associated silt deposition. It was fenced from cattle and population monitoring set up in 1994.

The Rai River is characterised by having a shallow bed in relation to adjoining low-lying alluvial terraces and associated swales, backwaters and depressions and is therefore prone to frequent flood events throughout most of its length.

Figure 1: *Leptinella nana,* pygmy button. Size of patch *c.* 50x30mm. Note diminutive yellow inflorescence near centre of photo.

A further 137 populations were found at 99 riparian sites during a Department of Conservation survey of the Rai River in March 2001. Monitoring was set up at the site of the largest population (Hills Road) in the same year. This site has predominantly a willow canopy and, unlike the other sites, is grazed by sheep.

Despite the ease at which *Leptinella nana* can be cultivated and maintained in a full sun environment, almost all of the sites at which it was discovered during the survey were under an open forest canopy.

Aims of Monitoring

Monitoring aims were to:

- track changes in the population at Bulford Bridge as a result of fencing this site from cattle access,
- determine what environmental factors are responsible for any population changes,
- determine the habitat preferences of pygmy button at the Hills Road site, and
- use these data to expand pygmy button habitat and establish new populations.

Methods

Two different monitoring techniques were employed to fulfil these aims. Tracking population changes and correlating these to environmental factors involved mapping changes in sub-population distribution and cover over time, using both quadrats and a transect.   The transect was also used to investigate the habitat preferences of *Leptinella nana.*

The Bulford Bridge population was mapped by setting up a $0.5m^2$ quadrat (subdivided in 6x6 squares) over each of the 7 known sub-populations occurring there. None of the sub-populations occupied more than $0.5\ m^2$ at the time and very few rosettes occurred outside any of the quadrats. For each quadrat, two of the diagonals were marked by permanent stakes to allow for repeat measurements. The sub-population of *Leptinella nana* within each quadrat was repeatedly mapped by hand to monitor distribution and cover changes. As a back-up, one overview photograph and six close-up photographs were taken to cover each quadrat. The photos and hand-drawn maps were at a scale so as to be able to discern individual *L. nana* rosettes. Quadrats were monitored in June 1999, May 2001 and August 2004. Upon the discovery of additional nearby populations across the river during the March 2001 survey, two more quadrats were set up there (i.e. outside the fence) to act as controls.   Cattle had free access to these sites. The area covered by *Leptinella nana* within each quadrat was calculated by planimeter (cm^2). Site characteristics of each population were recorded, including degree of canopy cover, understorey development, landform micro-relief, proneness to flooding and degree of siltation.

Figure 2: *Leptinella nana* fenced site, Bulford Bridge, Rai Valley - a narrow riparian stand of totara, black beech, silver beech, matai forest.

Figure 3: Example of overview photo and hand-drawn map of *Leptinella nana* (yellow polygons) within the same permanently marked 0.5m^2 quadrat (control quadrat 9 (beech), 2004). The yellow polygons are individual rosettes and rosette clusters of *Leptinella.*

A 274m permanent transect was set up at Hills Road after its discovery during the March 2001 survey. It is the largest area of *Leptinella nana* known. The population is scattered along 300m of low river terrace within the Rai River flood zone and is entirely under a light canopy of crack willow (*Salix fragilis)* with little or no understorey. Monitoring was undertaken four times over three years from May 2001 to August 2004. In the first two monitoring sessions *Leptinella nana* presence/absence data were collected from 547 sampling points at 0.5m intervals. In the second, third and fourth monitoring sessions sample points were increased to sample areas of 50x50mm^2 to optimize the sample size. Also in year 4, a 200mm belt transect (100mm either side of the permanent transect) was run and additional data were collected within a 100mm radius of each 0.5m station. These data included:

- % cover of pygmy button (to the nearest 10%),
- % bare ground (to the nearest 10%),
- main ground cover type (mossfield, herbfield, grassland, bare ground, debris),
- landform type (depression, flat, gentle mound, mound, gentle riser, riser, tree base), and
- degree of stock trampling impact (none, low, moderate, high, very high).

The last four habitat attributes were thought to be the ones most likely to correlate with abundance of pygmy button at each station. It is also relevant to note that over a six month period in 2000/2001, Nelson and Marlborough experienced the driest summer on record. The transect was set up and initial data gathered at the end of this period.

Figure 4: Hills Road *Leptinella nana* sheep-grazed habitat under willow canopy showing part of transect. Rai River at the right of the photo. Note flat, riser and tree base landforms.

Results & discussion

Quadrat data

Two of the original seven sub-populations of *Leptinella nana* disappeared during the 5 years subsequent to the Bulford Bridge site being fenced from cattle (1994-1999),. Figures 5-8 depict the changes in abundance and distribution of four of the remaining five sub-populations between 1999 and 2004. The changes in cover for each sub-population are graphed in figure 9. By 2004, all but one of the fenced sub-populations had totally, or almost totally, disappeared. Against this trend, the one remaining sub-population had a nett increase in ground cover over this period. In contrast to most of the fenced sub-populations, those within the two control quadrats over the river, and which had been continuously exposed to the effects of cattle, had maintained a high degree of cover.

Disappearance of *Leptinella nana* from the fenced area was due to a number of environmental factors. Quadrats 2 and 5 occupied depressions which, as a result of regular flood events, retained water for significant periods and also acted as silt traps. It appears that *Leptinella* could not persist with the degree of inundation and siltation at those sites. Quadrat 6 was on the bank of the river and subject to the full force of the river during floods. A series of flood events gradually stripped away the ground cover and substrate at this site. The disappearance of *Leptinella* in Quadrat 7 appeared to be entirely due to shading caused by the dense regeneration of robust ground cover species and understorey shrubs resulting from the removal of cattle. Flood events inhibited regeneration after the erection of the fence but were not severe or frequent enough to prevent the development of dense undergrowth (Figure 10). By contrast, cattle have kept the unfenced side of the river devoid of woody understorey and dense ground cover (Figure 11).

It is notable that contrary to the other fenced sub-populations, *Leptinella nana* in Quadrat 4 increased in cover over the 5 year quadrat monitoring period. The micro-site for this species is an old cattle track which is worn into a gentle depression on the terrace. This appears to have allowed water to have ponded for an optimal period during floods so as to inhibit all but a moss and *Leptinella* ground cover and thereby maintaining an open understorey directly along the track. Had the track depression been any deeper the sub-population may have succumbed to inundation and siltation in a similar manner to those in Quadrats 2 and 5.

Transect data

Presence/absence data collected along the Hills Road transect is graphed on figure 12. Both the initial point intercept data of May 2001, and the subsequent 5cm^2 area intercept data of subsequent monitorings, show a decline in the frequency of *Leptinella nana* encountered along the transect from the previous year. Environmental variables such as micro-topography, frequency and severity of flood events, canopy cover and amount of shading all appeared to be constant over the 3 years and so could not be correlated with *Leptinella* decline. What appeared to have decreased, but was not measured initially, was the amount of bare ground, linked with a corresponding increase in cover of grass and dicot herb associates - mainly *Poa annua*. It is speculative at this stage but it is possible that the extreme drought of 2000/2001 favoured *Leptinella nana* at the expense of less drought-tolerant species so that it was able to increase its cover with the reduction of competition. The population may have been enjoying a flush upon its discovery in March 2001. The subsequent decrease in *Leptinella* abundance could therefore have been due a contraction back to the most favourable microhabitats as competitors reinvaded the sites they relinquished during the drought.

Figure 13 shows the temporal and spatial patterning of *Leptinella nana* along the transect over the four monitoring sessions. Despite the reduction in frequency of *Leptinella* over the 3 years, it is apparent that plants along the transect show a similar spatial pattern from year to year indicating that there are attributes about the sites where *Leptinella* is present that are maintaining it at those sites.

Conversely, there may also be qualities about the sites where *Leptinella* has consistently not been encountered, that exclude it.

Figure 14 shows total *Leptinella nana* presence/absence at 0.5m intervals along the first 50m sample of the transect, pooled over the four monitoring sessions. This is plotted linearly against the landform type (flat or non-flat) recorded at each of the 0.5m sample sites. It clearly shows a strong negative correlation between *Leptinella nana* presence and flat landforms, i.e. *Leptinella* is largely confined to non-flat landforms. This correlation is consistent throughout the length of the transect (274m). When landforms were teased out and further analysed against *Leptinella* presence (figures 15 & 16) it showed that despite the dominance of flat landforms along the transect, there was an almost total avoidance of them by *Leptinella* and a distinct preference for risers, mounds and tree bases. Unlike the Bulford Bridge quadrat site, depression landforms were not favoured by *Leptinella.*

When the main vegetation cover at each 0.5m sample site was analysed against *Leptinella nana* presence/absence at those sites, it showed that herbfield was the most common cover on the non-flat landforms where *Leptinella* was present (figure 17). While some of the contribution to the dominance of herbfield was partly attributable to *Leptinella* itself, it was usually a minor component, the most common herb dominants being *Hydrocotyle heteromeria, H. elongata, Cardamine debilis* agg., *Dichondra* aff. *brevifolia* and *Sagina procumbens.* Significantly, these are turf-forming species - their low stature allowing *Leptinella nana* to co-occur. There is also a limited ability for *Leptinella nana* to co-occur with *Poa annua*, especially on risers. This appears to be due to the lower density of vegetation on the steeper micro-topography, as well as the regular scuffing effect of sheep hooves on the sloping surface keeping this landform less vegetated. Grassland and herbfield were the most common cover types occurring at sample sites along the transect (216 and 201 sites respectively, out of 547 sites) while mossfield was relatively uncommon (55 out of 547 sites). Despite its paucity, mossfield had the highest percentage of *Leptinella nana* occurrence (16.5%) of sampled cover types, followed by herbfield (9.5%) (figures 18 & 19). Also of interest was the strong association between *Sagina procumbens* and *Leptinella nana*, to the extent that *Sagina* could often be used as an indicator of *Leptinella* presence.

The types of trampling impacts by sheep observed at the Hills Road site were localised removal of ground cover on main access routes along the river coupled with associated minor pugging, as well as scuffing of soil and vegetation off the sides of mounds and the faces of risers. Sample sites with moderate impacts were the most numerous, accounting for over half the sites (figure 20), while there were relatively few sample sites with very high or no trampling impacts (21 and 51 respectively out of 547 sites),). In contrast, *Leptinella nana* occurred in a smaller percentage of moderately impacted sites (5%) than all the other trampling categories (figure 21), and sites with high and very high impacts had the greatest percentage of *Leptinella nana* occurrence (9% and 15% respectively). As expected, there was a strong inverse relationship between severity of trampling and ground cover. This suggests that habitats created by severe sheep trampling are better suited to *Leptinella nana* than less disturbed habitats. Its ability to withstand high substrate disturbance and physical damage, albeit at low densities, presumably allows it to take advantage of such sites where competition is minimised from species less able to cope with these conditions.

It is interesting to note that the Hills Road site, which supports the largest known population of *Leptinella nana*, occurs along the only stretch of river in the Rai catchment where sheep are the primary grazing stock. This may indicate that *Leptinella nana* has a preference for, or better ability to withstand, sheep grazing/trampling impacts than those of dairy cattle.

Management implications

These results have important implications for management of habitat for *Leptinella nana*. Most populations appear to require a semi-shaded habitat open to grazing – typically a riparian strip of forest with an open understorey and turf ground-cover. Grazing pressure at these sites results in little or no recruitment of canopy trees. The consequence of this is that the habitat can only support *Leptinella* for the life of these trees. This management conundrum may be solved by "spelling" from stock some of a network of *Leptinella* sites, such as has happened at Bulford Bridge, for as long as to allow canopy species to recruit to a successional stage able to withstand stock activity, before reinstating a grazing regime. *Leptinella* will almost certainly be shaded out from these sites as understorey recovers, but can be re-introduced from the remaining network of sites once new grazing has re-created a sufficiently open understorey. This management possibility would have the effect of "pulsing" canopy species at *Leptinella* sites.

The occurrence of *Leptinella nana* under crack willow also raises the possibility of riparian revegetation using deciduous native species such as *Plagianthus regius, Hoheria angustifolia* and *Sophora microphylla*. All these species occur naturally along the river but have been reduced to small treeland remnants. They originally would have been the dominants of an extensive and distinctive floodplain community which, due to their open canopies and deciduousness, may have been an important original habitat for *Leptinella*.

Determining landform and vegetation type preferences of *Leptinella nana* provides a predictive tool for finding new populations within the Rai, and other river systems. This knowledge is also important in helping to identify potential translocation sites where establishment of new populations of *Leptinella nana* will have the greatest chances of success.

The results certainly indicate that the main pre-human habitat for *Leptinella nana* in the Rai catchment was centred on the banks and flood channels of the Rai River. A diminutive mat herb which is not shade-adapted and requires minimal competition would not have survived in the almost totally forested pre-human landscape of the Pelorus-Rai catchment. Habitat whose openness is maintained by a regular disturbance regime is entirely consistent with the nature of the Rai River riparian zone and the ecological requirements of *Leptinella nana*.

Strengths and limitations of monitoring methods and data analysis

The quadrat and transect methods used were repeatable, relatively simple to execute, inexpensive and not too time consuming, each taking around one day to complete. The quadrat maps and photographs of *Leptinella nana* are an effective tool for tracking small-scale changes in distribution and density against other site variables. The method is well-suited to a range of other low-growing, high-turnover species where individual genets cannot be easily discerned, such as mat rosette herbs where each rosette is relatively short-lived, but persistence and spread at a site is by vegetative reproduction.

As with all permanent monitoring, its utility as a comparative tool is dependent on the permanence of the pegs marking the quadrat corners and transect ends. For flood-prone environments and sites accessible to stock, aluminium stakes were found to be not sturdy enough. Cut-down warratahs and 10mm stainless steel square tubing driven down to a minimum depth of 0.5m adequately withstood sites disturbances.

Ideally, more quadrat replicates, especially of the grazed sites, should have been set up. Also, for the transect monitoring, it was difficult to initially determine the right scale of sampling required to optimize the usefulness of the *Leptinella nana* presence/absence data. In hindsight a sample area of $100 \times 100 mm^2$ every 0.5m would have been a more robust scale.

It was unfortunate that the transect monitoring was not set up before the severe drought of 2000/01 as this would have provided more conclusive data about the response of *Leptinella nana* to drought *in situ*. Also, the monitoring should ideally have been undertaken at a similar time each year – monitoring at different seasons may have confounded results.

Regular visitation to these sites over a number of years has proved invaluable in being able to become familiar with the processes and dynamics of the riverine community supporting *Leptinella nana*. This has contributed towards an insight of the environmental factors influencing population dynamics of *Leptinella nana* and has informed the choice of factors to monitor.

The data have not been analysed statistically and it is therefore possible that some of the results are not statistically significant. Also, the compound nature of the transect data is such that multivariate analysis would be useful in determining the relative importance of environmental factors and their interactions in respect of *Leptinella nana* habitat preference.

Conclusions

While *ex situ* cultivation indicates that *Leptinella nana* is able to thrive in high light conditions, the survey of sub-populations along the Rai River shows that it is almost totally confined to semi-shaded sites under an open forest canopy with little or no understorey. Its apparent ability to withstand drought better than other herb associates also indicates an adaptation for open, high-light environments. Moreover, its absence from closed forest and its extirpation from open forest after understorey recruitment indicate that it cannot survive in high shade environments. Its inability to compete with taller statured or short swarding ground cover species, especially exotic grasses, which dominate the open sites along the Rai River, means that *Leptinella nana* can now survive only at semi-shaded sites, presumably where competitors are less aggressive but where there is still adequate light.

The open nature of the understorey is largely maintained by a combination of stock grazing/trampling and flooding. Monitoring strongly indicates that *Leptinella nana* is adapted to moderate flooding and can withstand heavy grazing/trampling. The ability of *Leptinella* *nana* to withstand grazing, high substrate disturbance and physical damage from stock, albeit at low densities, presumably allows it to take advantage of such sites where competition is minimised from species less able to cope with these conditions.

However, in the absence of stock, flooding alone is generally not enough to check understorey recovery and resultant increasing shadiness. On the other hand, some sites are more affected by flooding than others and can maintain localised open understoreys to allow *Leptinella nana* to persist. Where effects of flooding became severe, such as causing substrate stripping, excessive siltation, or prolonged ponding of depressions, this negatively impacted *Leptinella* sub-populations, even to the extent of local extinction.

Quadrat results confirm small-scale changes in distribution and density of *Leptinella nana* sub-populations over time as a result of varying rates of rosette mortality and rhizomatous recruitment. At a larger scale though, the transect results indicate site fidelity of sub-populations over time – in many cases there appeared to be ecological barriers to vegetative spread beyond the sites it occupied.

Transect data indicates that *Leptinella nana* appears to prefer convex and sloping landforms such as mounds, risers and tree bases and to avoid flat or near-flat landforms. This resulted in two types of distribution patterns for *Leptinella* along the river terrace. In the case of risers, this promotes linear distribution patterns, while the sporadic occurrence of mounds and tree bases results in a similar sporadic distribution pattern for *Leptinella*. The main vegetation types in which *Leptinella nana* occurred were mossfield and herbfield, although mossfield was not a common ground cover. These vegetation types occurred most frequently on non-flat landforms supporting *Leptinella*. Presumably it is the turf habit of the moss and dicot herb species that allows for the co-occurrence of *Leptinella nana*. The reason for *Leptinella's* preference for hummocky landforms and how some of these landforms promote a dicot herb cover instead of grass is less clear. There appears to be less grass competition on risers, partly due to their steepness and partly due to scuffing by sheep hooves. Mounds and tree bases may be naturally more drought-prone; able to trap optimum silt loads during floods to maintain turf, or as raised landforms, are more frequently targeted for browsing by sheep than the flats, thereby promoting turf.

The requirement of *Leptinella nana* habitat to be both grazed and semi-shaded to maintain *Leptinella,* has medium- to long-term management implications in respect of recruitment of beech, matai, and totara. These canopy trees are becoming moribund or being lost to stochastic events and their recruitment is not evident in the heavily grazed riparian forest required by *Leptinella*. Pulsing recruitment into the canopy by temporarily spelling sites from stock, followed by phased re-introduction of stock and *Leptinella* may be a solution.

Habitat preference data will be useful in predicting where further populations of *Leptinella nana* might occur and where it might be successfully translocated. Riparian restoration using deciduous trees native to the Rai catchment may also provide suitable habitat for *Leptinella nana* as implied by its persistence under crack willow.

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