Snares Islands vegetation monitoring plots 1987 to 2010

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Cover image – Snares crested penguin colony among *Olearia lyallii* forest, *Stilbocarpa robusta* and *Poa tennantiana* grassland, main Snares Island, October 2010 (Richard Ewans)

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Snares Islands vegetation monitoring plots 1987 to 2010

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Summary

The results from three measurements (1987, 1998, 2010) of thirty permanent vegetation plots on the Snares Islands are described. The plots were established in 1987 to investigate the long-term impacts of wildlife on vegetation and the stability of the plant communities on the main Snares Island. The results suggest a general expansion of woody species on the island and a decline in some grassland and herbaceous species. Plots that were the location of past or present Snares crested penguin colonies appeared to be the plots that changed the most. Plots within forest were the most stable over the time period.

The results are consistent with the main vegetation processes described in previous research papers from The Snares which are driven by abiotic and biotic factors. The biotic factors are natural in that they are unaffected by introduced mammals which have never made it to the island. From a conservation management perspective the permanent vegetation plots on The Snares are low priority work compared to a comprehensive assessment of the demographics and trends of two threatened plant species (*Anisotome acutifolia* and *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands)) and the continuation of control work on two introduced adventive plant species (*Poa annua* and *Stellaria media*).

1. Introduction

The Snares Islands commonly referred to as 'The Snares' are the least remote of New Zealand's subantarctic islands being located at (48°01'S 166°36'E) approximately 100km south-south-west of the South Cape of Stewart Island. There are two vegetated islands (North-east or main Snares Island and Broughton Island) and a number of rock stacks around the coast, with a chain of small bare islands known as the Western Chain 3km south-west of the main Snares Island. The total land area is 328 hectares.

Most of the main island is forested with the dominant tree species being *Olearia lyallii*. This is a distinctive feature as the only other subantarctic island with forest is Auckland Island which has coastal rata forest (Rance & Patrick, 1988). Another key feature is the lack of introduced mammals and their associated effects on the flora and fauna. Introduced mammals never made it to The Snares which makes this island group one of the very few in New Zealand that has never been affected by colonising mammalian pests.

The Department of Conservation (DOC) administers The Snares as a Nature Reserve (the highest level of legislative protection available in New Zealand) with access by permit only. The DOC Southern Islands Area Office manages and/or permits all work undertaken on The Snares. The land-based marine mammal fauna includes numerous New Zealand sea lions (*Phocarctos hookeri*), some New Zealand fur seals (*Arctocephalus forsteri*), with the occasional visiting southern elephant seal (*Mirounga leonine*) and leopard seal (*Hydrurga leptonyx*).

The abundance and density of seabirds is the most impressive feature of the fauna on The Snares with millions of sooty shearwaters (*Puffinus griseus*) and tens of thousands of Snares crested penguins (*Eudyptes robustus*) on the islands between spring and autumn each year. The total number of bird species recorded from the islands is 99 (Miskelly et al., 2001) and includes a species of snipe endemic to The Snares (*Coenocorypha aucklandica huegeli*) and a number of albatross species.

Scientific research on a number of aspects of the biology and ecology of the residents of The Snares began in earnest in the early 1960's and has continued since then. The vegetation plots reported on here were established on a Canterbury University Zoology Department expedition to The Snares during 1986-7. They were re-measured over two trips in 1998 while DOC and National Institute for Water and Atmospheric Research (NIWA) parties were on the island studying aspects of seabird biology. The latest re-measurement of the plots in October 2010 was carried out as part of a trip to count Snares crested penguin nests on the main Snares Island and Broughton Island by DOC and an ongoing study of Salvin's albatross (*Diomedea salvini*) on the Western Chain by NIWA. Detailed logistics of the vegetation work carried out on the 2010 trip are described variously in Lake (2010), Lake and Ewans (2010), and Lake and Ewans (2011).

The botany and main vegetation processes of The Snares are described in Hay et al. (2004) and Rance & Patrick (1988). Hay et al. (2004) report that there are only 20 vascular plant species extant on The Snares. Four species are of particular interest from a conservation management perspective, two introduced weeds (*Poa annua* and *Stellaria media*) and two threatened plants (*Anisotome acutifolia* and *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands)). The main vegetation processes are successional and are caused by a combination of abiotic and biotic factors such as climate change, wind, salt spray, heavy rain,

seabird burrowing, seabird colonial nesting, and sealion occupation. This report describes the results from the three measurements of the permanent vegetation plots on The Snares and addresses priorities for future vegetation monitoring on the islands.

2. Objectives

The vegetation plots on the Snares were established with the objectives of investigating the long-term impacts of wildlife on vegetation and the stability of the plant communities on The Snares.

3. Methods

3.1 Field methods

The plot methodology has differed somewhat in each measurement. Details of the plot locations and the logistics of the 2010 plot re-measurement are in Lake (2010) and Lake and Ewans (2010). In the original 1987 survey, thirty permanent vegetation plots (either 5x5m or 10x10m) were subjectively located to include examples of the most widespread plant communities, examples of communities unique to The Snares, and examples in areas subject to current or past modification by high seabird densities (Miskelly et al., 1987).

1987

Plot species composition and plant cover were drawn onto graph paper sheets to map the plot. All species present were recorded with the addition of a seedling class (undefined) for the two dominant forest species (*Olearia lyallii* and *Brachyglottis stewartii*). A category for burrows was also recorded. Some trunks where epiphytes were present were shown on plot maps. Individual tussock stools and sooty shearwater burrows were mapped. There was no specified cutoff to distinguish ground from canopy cover in the report on this survey or on the original plot maps. Photographs of each plot were taken.

1998

5x5m plots were divided into 25 1x1m subplots while 10x10m plots were divided into 25 2x2m subplots. The vegetation cover of each species was mapped onto sheets of graph paper for each subplot on each plot. Vegetation below 1m in height was classed as ground cover and vegetation above 1m height was classed as canopy for the two dominant forest species (*Olearia lyallii* and *Brachyglottis stewartii*). Where total canopy cover exceeded 20% this class was mapped on a separate graph paper sheet. On the plot maps individual tree trunks were generally not shown although trunks at ground level supporting epiphytes were shown. Horizontal trunks were taken as being part of the canopy where >1m above the ground. Epiphytes were marked and shown on the ground tier maps. Photographs of each plot were taken from the original photopoint where possible and from some additional vantage points if it was considered useful. Twenty-eight of the original 30 plots were relocated and sampled (plots 10 and 18 were not re-measured). All species present were recorded along with categories for bare peat, dead *Poa astonii* stumps and dead *Hebe elliptica*. No fauna related measures (e.g. number of sooty shearwater burrows) were recorded.

2010

Percent cover for all species present was recorded along with categories for bare ground and dead *Hebe elliptica*. A mean top height score was also recorded for *Hebe elliptica* on some plots but not others. For the two dominant forest species (*Olearia lyallii* and *Brachyglottis stewartii*) percent cover was recorded for 2 height classes; <1m and >1m. Some plots were subdivided to make percent cover measurements more precise but none were mapped. No fauna related measures (e.g. number of sooty shearwater burrows) were recorded. Photos of all plots measured were taken. Twenty-five of the original 30 plots were relocated and sampled (plots 9, 10, 13, 19 and 20 were not re-measured).

3.2 Data analysis

For the 1987 report (Miskelly et al., 1987) the abundance of each species was calculated and expressed as percent occurrence in 1x1m subplots for each plot. This is a misleading way to express abundance as a very small ground tier species widely distributed around the plot could end up with the same percentage as a totally dominant canopy species e.g. 95%. This method also requires the subdivision of plots to the same level as the 1987 survey which is time consuming and mostly unnecessary. To provide comparability between the 1987 measurement and other years, the original 1987 graph paper plot maps were reassessed to gain a percentage cover estimate for each plot. Occasionally this was little more than a best guess as some plot maps were difficult to read accurate covers off but provides considerably more precise figures than the original expression of abundance. In 1998 the percentage cover of each species was calculated directly from the graph paper sheet plot maps while in 2010 the percentage cover of each species was calculated in the field.

Percent cover for each species in each year was graphed in stacked bar charts for each plot and presented in four plot groups (Forest, Grassland, Threatened species/endemics and Other). Only plots that were measured at least twice were graphed which meant that plot 10 was omitted. Species that had been recorded as present (p) or <0.1% were given scores of 0.5% to maintain a consistent numerical variable of percent cover. A number of inconsistently used categories were omitted. These were burrows, bare ground, bare peat, dead *Hebe elliptica*, dead *Poa astonii* stumps, and the *Olearia lyallii* and *Brachyglottis stewartii* seedling categories. The tussock hybrid named *Poa poppelwellii* (*P. astonii* x *P. tennantiana*) was only measured in 1987, so for analysis percent covers for this minor species in 1987 were split between its putative parent species on pro rata basis per plot. There appeared to be some confusion between *Olearia lyallii* and *Brachyglottis stewartii* canopy on two plots (6 and 23) in some years as evidenced by inverse changes in percent cover of both species on the same plot in the order of 60-70% cover between measurements. In these cases the majority identification was taken as correct and data adjusted accordingly.

All graphs were produced using R version 2.9.2 (R Development Core Team, 2009).

4. Results

Figures 1 to 4 below are stacked bar charts in plot groups showing the percent cover of each species in each year on each plot. Summaries of the main trends are described beneath each bar chart. Table 1 below shows the species codes used in Figures 1 to 4 and their species and common names, and Maori names where applicable.

Table 1. Species codes, scientific names and common/Maori names of plant species on The Snares.

Species code	Species name	Common name/Maori name
aniacu	*Anisotome acutifolia*	
aspobt	*Asplenium obtusatum*	shore spleenwort/paranako
bledur	*Blechnum durum*	
braste	*Brachyglottis stewartiae*	Stewart Island tree groundsel
calant	*Callitriche antarctica*	
cartri	*Carex trifida*	muttonbird sedge
colmus	*Colobanthus muscoides*	
cramos	*Crassula moschata*	shore stonecrop
hebell	*Hebe elliptica*	shore koromiko/kokomuka
isocer	*Isolepis cernua*	slender clubrush
lep snares	*Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands)	
olelya	*Olearia lyallii*	subantarctic tree daisy/tupare
poaann	*Poa annua**	annual poa
poaast	*Poa astonii*	blue shore tussock
poaten	*Poa tennantiana*	
polves	*Polystichum vestitum*	prickly shield fern/puniu
stedec	*Stellaria decipiens*	
stemed	*Stellaria media**	chickweed/kohukohu
stirob	*Stilbocarpa robusta*	

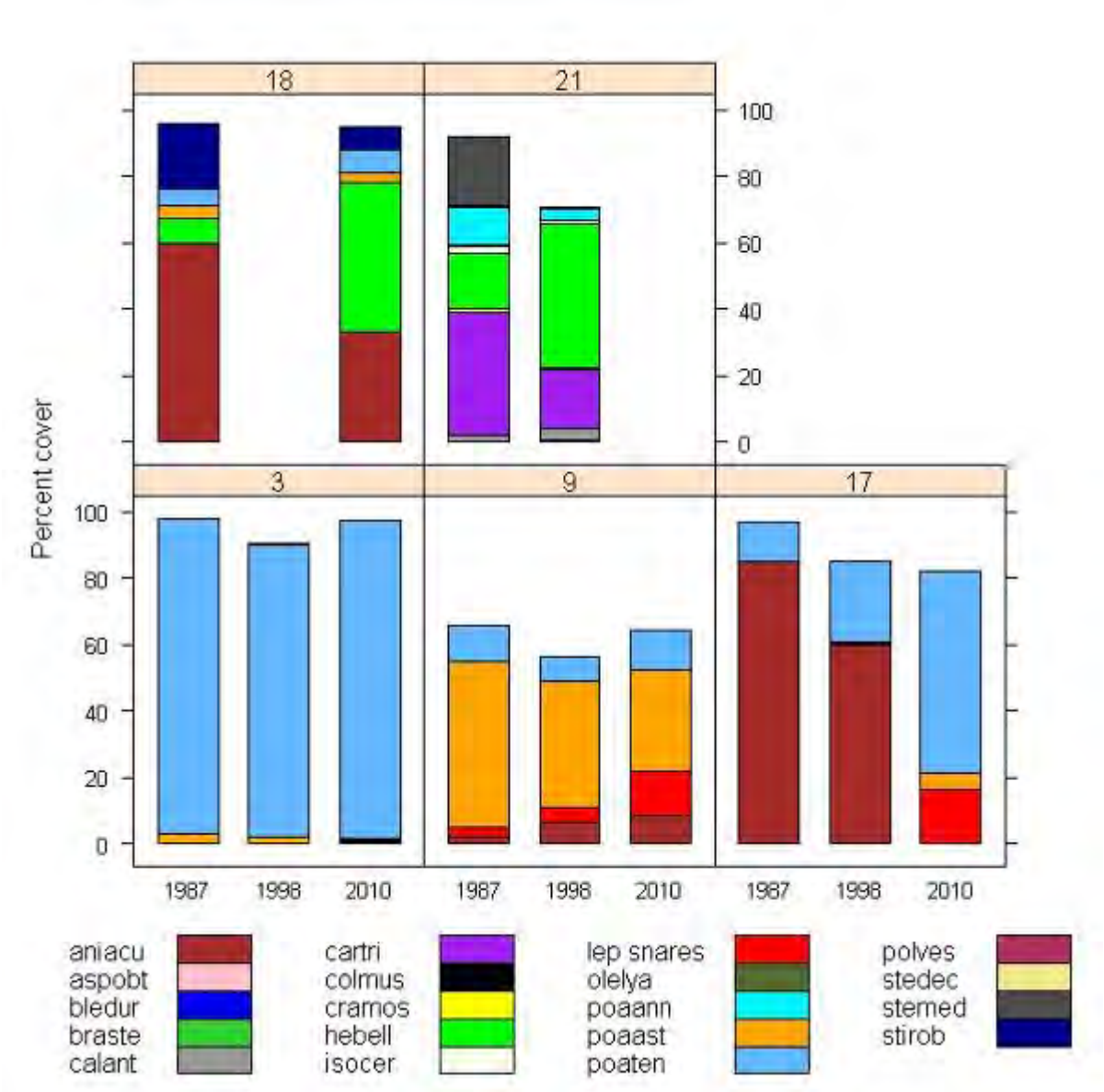
* introduced species

Overall results on the plots showed an expansion of woody species (*Olearia lyallii* and *Hebe elliptica*), and a decline in *Anisotome acutifolia* and *Poa tennantiana* along with some other herbaceous species. The vegetation communities in the Forest plot group (10 plots) remained

stable across the time period with the exception of three plots from which *Poa tennantiana* was much reduced or disappeared. This was the most stable vegetation community.

Other vegetation plots groups were less stable. Three of the six plots in the Grassland plot group remained stable compared to only one of eight plots in the Other plot group. Some of the plots that did not remain stable over the time period changed slowly and with only minor changes in species composition and abundance. On others there was rapid turnover of vegetation types and abundance, particularly in association with current or previous penguin colonies.

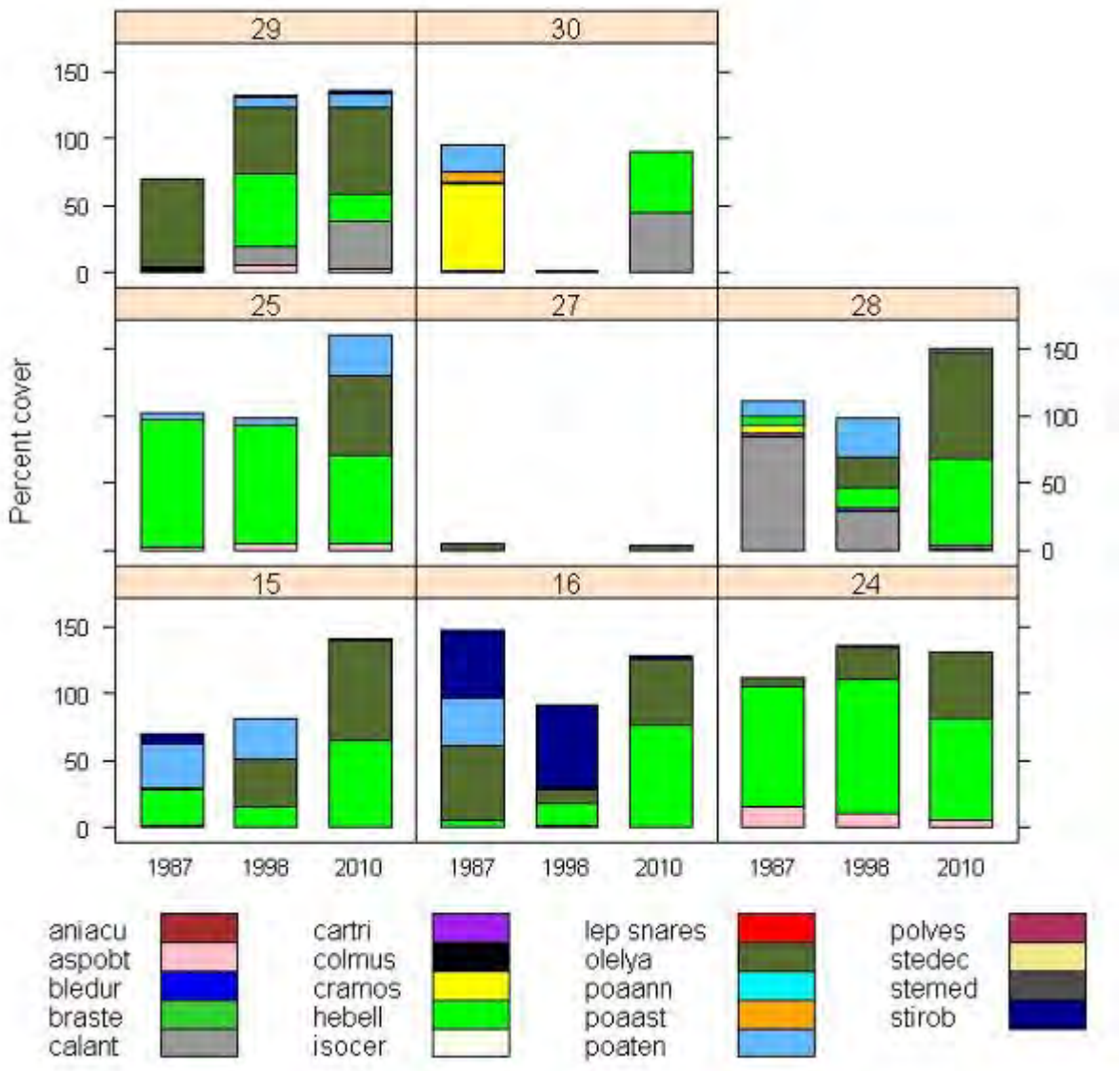
Figure 1. Percentage cover of all plant species on each plot in each year for the plot group Threatened species/endemics.



The plot group Threatened species/endemics was grouped based on the presence of either or both of *Anisotome acutifolia* and *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) in any year on the plots. Plot 21 recorded a presence of *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) in 1987 which was not recorded in 1998. Plot 3 recorded a presence of *Anisotome acutifolia* in 2010 which had not been recorded before on this plot.

The largest change occurred on plot 17 where *Anisotome acutifolia* went from being dominant to non-existent in association with an expansion of the *Poa tennantiana* grassland and the arrival of *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) on the plot in 2010. *Anisotome acutifolia* also declined on Plot 18 where *Hebe elliptica* expanded. Plot 9 remained relatively stable with slight increases in the covers of both threatened species.

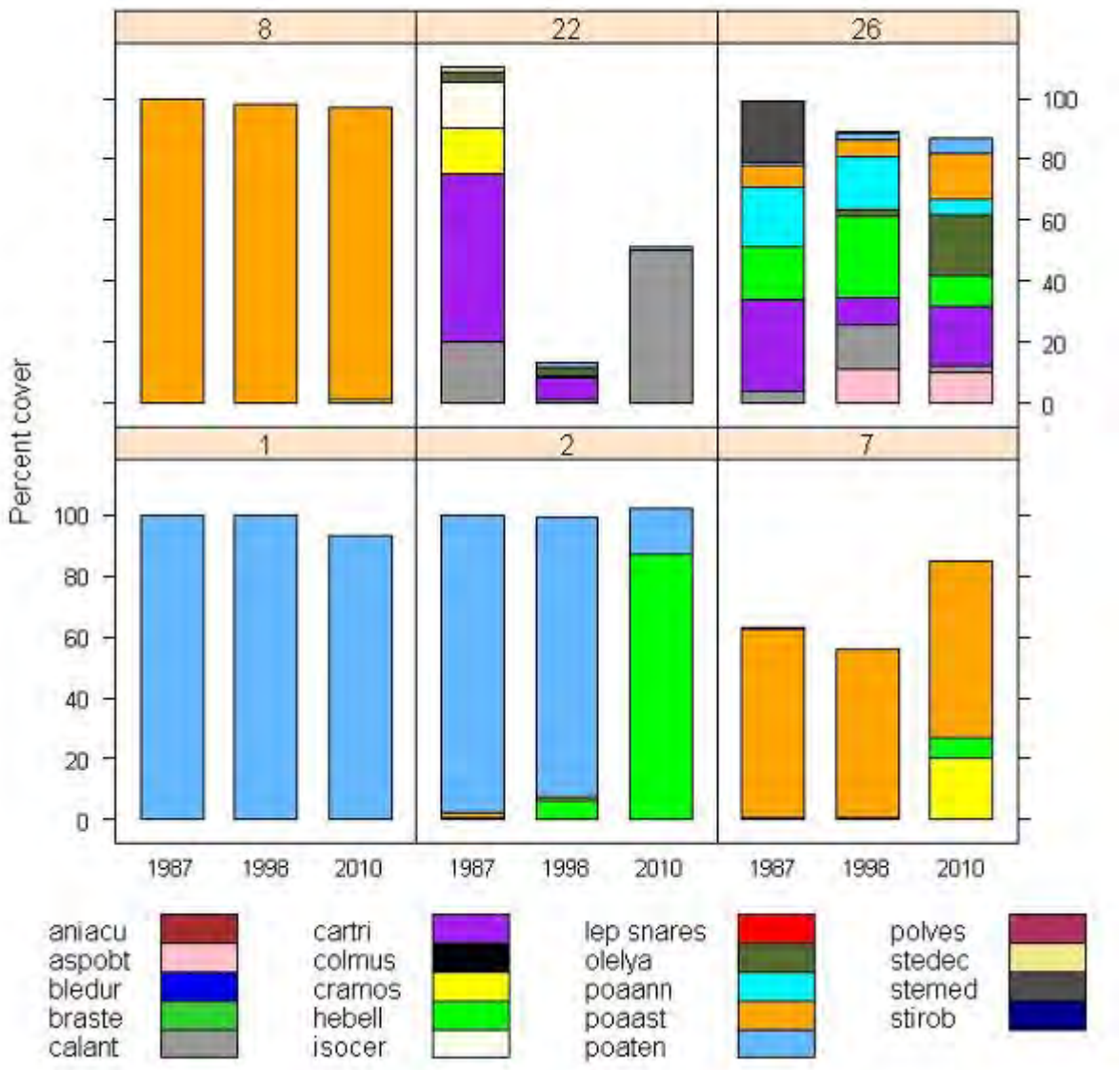
Figure 2. Percentage cover of all plant species on each plot in each year for the plot group Other.



The plot group Other is grouped from the 1987 plot classifications which did not fit well into the other groups. Plots 27-30 were originally classified as current or past Snares crested penguin colonies, plots 24 and 25 were classified as *Hebe elliptica* dominated plots, and plots 15 and 16 were classified as *Stilbocarpa robusta* plots. Plots 15 and 16 recorded the decline of *Stilbocarpa robusta* and *Poa tennantiana* from the plots and their replacement by woody species *Hebe elliptica* and *Olearia lyallii*. Plots 24 and 25 recorded increasing *Olearia lyallii* over the existing *Hebe elliptica* shrubland.

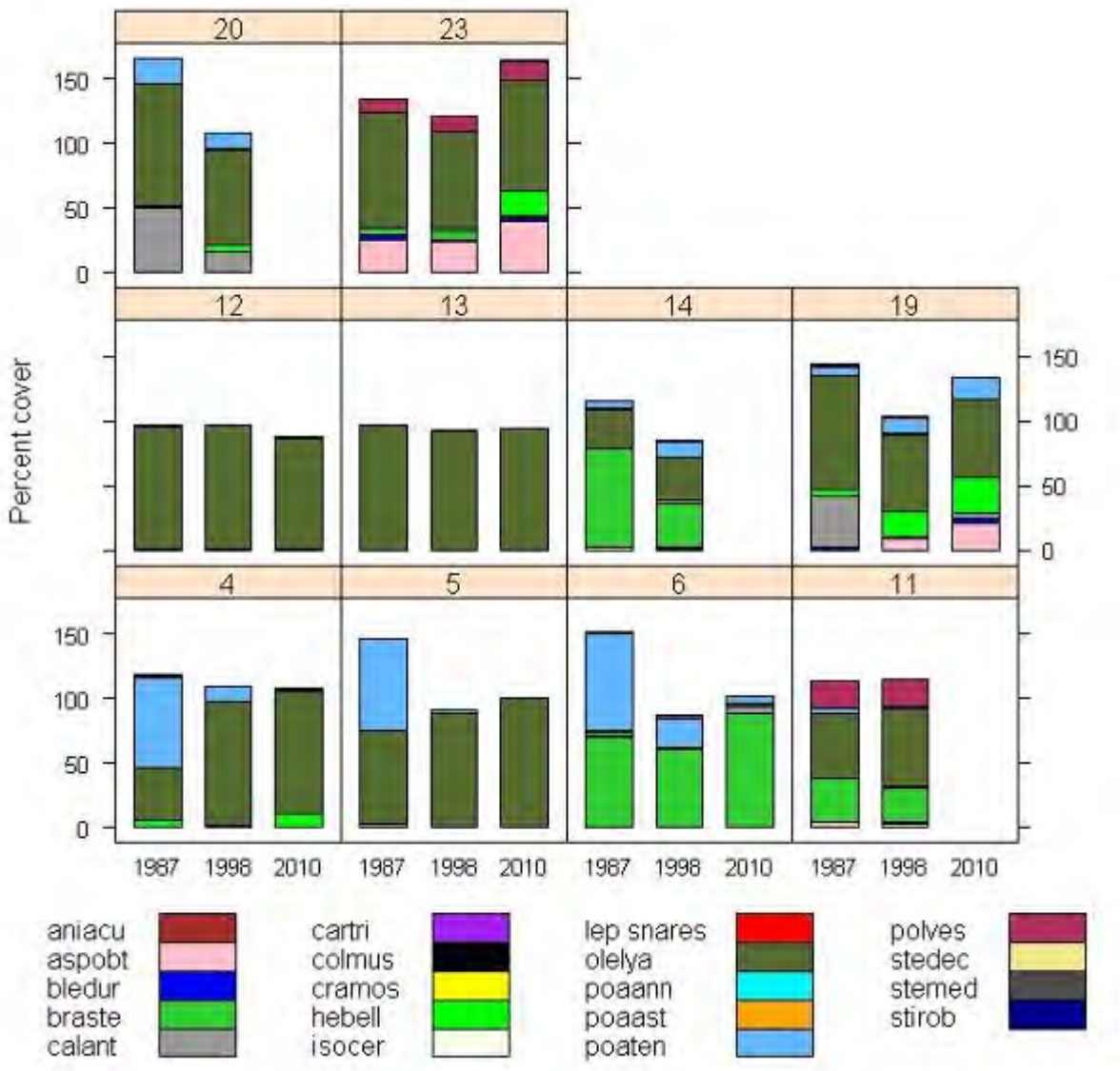
Plot 27 remained stable with very little vegetation on the plot while Plot 29 became slightly more diverse with consistent *Olearia lyallii* cover. Plots 28 and 30 recorded the largest changes of this group. Plot 28 went from low herbaceous vegetation (*Callitriche antarctica*) to *Hebe elliptica* under a canopy of *Olearia lyallii*. Plot 30 has cycled from mostly herbaceous vegetation in 1987 to virtually no live vegetation in 1998 (the plot was mostly dead *Hebe elliptica* shrubland), to a mix of live and dead *Hebe elliptica* with some *Callitriche antarctica*).

Figure 3. Percentage cover of all plant species on each plot in each year for the plot group Grassland.



The plot group Grassland is made up of plots that were originally classified as being dominated by grass or sedge species. Three of the Grassland group plots remained stable throughout the period. Plot 26 which is near the huts on The Snares recorded an expansion of *Olearia lyallii* and a decline of the adventives *Poa annua* and *Stellaria media*. Plot 2 recorded a large increase is *Hebe elliptica* which is replacing the grassland of *Poa tennantiana*, while Plot 22 recorded loss of diversity of herbaceous species and the sedge *Carex trifida* and has become a monoculture of the small herb *Callitriche antarctica* in association with the expansion of a Snares crested penguin colony.

Figure 4. Percentage cover of all plant species on each plot in each year for the plot group Forest.



The Forest plot group is comprised of plots dominated by the trees *Olearia lyallii* and/or *Brachyglottis stewartiae*. The Forest plot group was the most stable of the groups with most plots recording little change. The most notable trend was the decline of the grass *Poa tennantiana* from plots 4, 5, and 6. These plots were all classified as *Poa tennantiana* under *Olearia* when they were established in 1987 (although plot 6 is under a canopy of *Brachyglottis stewartiae*).

5. Discussion

5.1 Vegetation plots

The results described above need to be interpreted with a note of caution for several reasons. Firstly, the data from the 1987 survey is unlikely to be highly accurate because of the methodology used and the quality of some of the plot mapping. Secondly, because the plots have been selectively located (i.e. non-randomly) and are clustered around the area between Hoho Bay and Punui Bay it is not possible to make inferences about vegetation changes over the whole island from the patterns seen at the plot level. Lastly, because information on animal presence and/or abundance was not collected in a consistent way (or at all in some years) it is not possible to make definitive statements about the causes of vegetation change from the data collected.

However, the changes seen at the plot level do fit broadly into the vegetation dynamics outlined in Hay et al. (2004) which are driven by abiotic and biotic factors. The abiotic factors are mostly climate related. Long term fluctuations in climate may result in widespread vegetation changes on the islands, while at the local scale salt spray and wind damage can cause dieback of the *Olearia lyallii* forest and other vegetation while heavy rain can create peat exposures. The biotic factors relate mostly to the abundance of seabirds on the island and to a lesser extent the sea lions.

Sooty shearwaters nest in their millions on the island from October to early May and their faeces, dead chicks and eggs manure the peat, while their burrows can undermine trees making them more vulnerable to wind. Adults and large chicks line their nests with leaves, debris, young seedlings and grass which leaves the forest floor bare and saplings rare (Hay et al., 2004). Sealion occupation and travel compounds this effect in some areas.

Snares crested penguin colonies are occupied from mid-September till the end of May and have conspicuous effects on the vegetation with ground cover of established colonies being mostly mud. Most colonies are re-formed each year but when the birds invade a new area or abandon a colony successional changes in the vegetation occur, sometimes rapidly. At newly established colonies the trees, shrubs and/or tussocks eventually die out, probably due to the toxic levels of salts introduced to the peat and mud by the birds (Hay et al., 2004). When colonies are abandoned, herbaceous species such as *Callitriche antarctica* (mostly), *Crassula moschata*, *Carex trifida* and *Isolepis cernua* become established and are succeeded in time by *Hebe elliptica*. The hebe shrublands are eventually succeeded by *Olearia lyallii* forest if the site remains stable. If penguins recolonise the site, the cycle returns to the mud stage.

Overall in the last 30-40 years there appears to have been an expansion of the main woody communities around the main island, particularly *Hebe elliptica* shrubland. This may be related to climate change generally, fluctuations in seabird or sealion densities, or recovery from previous human disturbance at some sites such as the hut sites on The Snares (Hay et al., 2004).

The expansion of woody vegetation on the island such as *Olearia lyallii* and *Hebe elliptica* is supported by the patterns observed on plots 2, 4, 5, 6, 15, 16, 18, 21, 26, and 28. The decline in *Poa tennantiana* from plots 4, 5, and 6 is also consistent with the overall expansion of woody species.

Plots 22, 27, 28, 29, and 30 are all plots currently or previously impacted by Snares crested penguin colonies. Plot 27 which is the site of a stable penguin colony showed no change while Plot 29 showed a small amount of change. This plot was classed as a new penguin colony in 1987. The other penguin affected plots showed lots of change. Plot 22 which was an expanding penguin colony recorded decreasing grassland vegetation turning to monoculture of *Callitriche antarctica*. Plot 28, which was a vacated penguin colony in 1987, recorded increasing grassland and woody vegetation. Plot 30, a vacated penguin colony in 1987 in which the birds have returned to probably periodically for a number of years at a time, cycled from herbaceous vegetation through a generation of *Hebe elliptica* and in 2010 was a mix of live and dead *Hebe elliptica* and herbaceous vegetation. This plot illustrates the speed at which turnover and succession can occur on the plots in association with Snares crested penguins.

The decline in the adventives *Poa annua* and *Stellaria media* from plot 26 are due to periodic weed control work carried out on these species and possibly increased use of some sites by New Zealand sea lions.

5.2 Threatened flora

Anisotome acutifolia

The decline in *Anisotome acutifolia* on the vegetation plots is consistent with some anecdotal observations and is concerning from a threatened species perspective. However it is difficult to make any firm conclusions as a full census has never been carried out and no specific monitoring of this species is in place. Patches of the species may simply have moved away from the vegetation plots. Two of the four *Anisotome acutifolia* locations (South-West Promontory and Broughton Island) shown on the vegetation map in Hay et al. (2004) were not visited in 2010 as the team did not have the Hay et al. (2004) map at the time of the trip.

The threat status of *Anisotome acutifolia* is listed as an At Risk-Naturally Uncommon with the qualifiers of Island Endemic and One Location in New Zealand (de Lange et al., 2009). This almost certainly not a true reflection of how threatened this plant actually is given how little is known about it, its restricted distribution on The Snares, and the fact that it is endemic to The Snares. Based on the limited current information the threat classification is likely to change to Threatened-Nationally Critical (pers. comm, Peter de Lange, October 2010).

Lepidium aff. *oleraceum* (c) (CANU 5995; Snares Islands)

Lepidium aff. *oleraceum* (c) (CANU 5995; Snares Islands) is an acutely threatened coastal cress with a very limited distribution. It is currently thought to be restricted to three islands in New Zealand (The Snares, Auckland Island and at least one of the south-western Titi Islands), however the Auckland Islands population is probably extinct with no records for over a century and there are no recent records from Titi Islands (Brian Rance, pers. comm., 6 September 2011). This makes the Snares Islands population the critical population for this species. The threat status of *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) is listed in the Taxonomically Indeterminate listings as Threatened-Nationally Critical with the qualifiers of Island Endemic and Range Restricted (de Lange et al., 2009).

Lepidium aff. *oleraceum* (c) (CANU 5995; Snares Islands) was previously thought to be *Lepidium oleraceum* s.s. which is now known to be confined to the northern South Island, North Island, Mangere and Kermadec Islands. The Snares plant is not closely related to

Lepidium oleraceum and will be treated as a different species when a current taxonomic review of the genus is completed (pers. comm, Peter de Lange, February 2011).

On The Snares this species typically lives on exposed coastal cliffs in association with the grasses *Poa astonii* (it is often around dead tussock stools) and *P. tennantiana*, sometimes with *Hebe elliptica* and often near feeding sites of brown skua (*Catharacta skua lonnbergi*). It was only occasionally present along clifftops fringed with *Olearia lyallii* forest during the 2010 survey. Transect monitoring this species was established in 2010 on the same trip the vegetation plots were measured on (see Lake and Ewans, 2011) and a census carried out which concluded the population on The Snares was in good health.

A full census and establishment of long term formal monitoring of the *Anisotome acutifolia* population, and the expansion of the transect monitoring of *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) to include sites where it is currently not present but may expand or move into would be prudent from a conservation management perspective. These should be the highest priority vegetation tasks on The Snares.

6. Conclusions and recommendations

The patterns observed on the Snares Islands vegetation plots over the last 23 years, such as the expansion of woody species and the patchy high turnover associated with penguin colonies, appear to be in line with those processes previously described in research papers. Due to the lack of introduced mammals on The Snares these changes could be considered to be entirely natural. For this reason, and because the plots are subjectively located and are mostly clustered around one small part of the island, from a conservation management perspective the vegetation plots reported on here are currently of less importance than other tasks.

Future vegetation work should prioritise assessing the demographics and trends in the populations of the two threatened species on the islands (*Anisotome acutifolia* and *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands)). Although the long term status of these species is likely to be dependant only on natural processes, The Snares is the only place on earth where *Anisotome acutifolia* is currently known to exist and one of only three islands where *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) is known from. Therefore the conservation of these species is of paramount importance in terms of vegetation work on the islands.

A secondary priority is the maintenance of the control programme on the two introduced adventive species (*Poa annua* and *Stellaria media*) to maintain and enhance the ecological integrity of the vegetation communities on The Snares. Lastly, the vegetation plots reported on here should be re-measured when possible only after the other priority work is completed in order to maintain the long term dataset of which there are few on subantarctic islands, and even less in forested communities on these islands. The plots should be maintained also as reference points in case of future invasion by introduced species. Future re-measurements will be considerably less time consuming than past ones now the plots can be located with GPS and the data collection has been simplified.

7. Acknowledgements

The DOC Southern Islands Area Office, specifically Pete Mclelland and Andy Roberts who supported the 2010 trip, and Jo Hiscock (team leader) who organised the trip and helped with plot field work. The 1986-7 team who set the plots up and the field workers who helped Sue Lake re-measure the plots in 1998. NIWA researchers who let us backpack on their trip. Liz Metsers helped with plot field work, data storage and GIS. Michelle Gutsell whose budget funded the authors' time on the trip. The good ship Tiama and her captain Henk Haazen and mate Steve Parsons. The NIWA crew Matt Charteris (who helped with plot field work) and Jeremy Carroll. A big thanks to you all.

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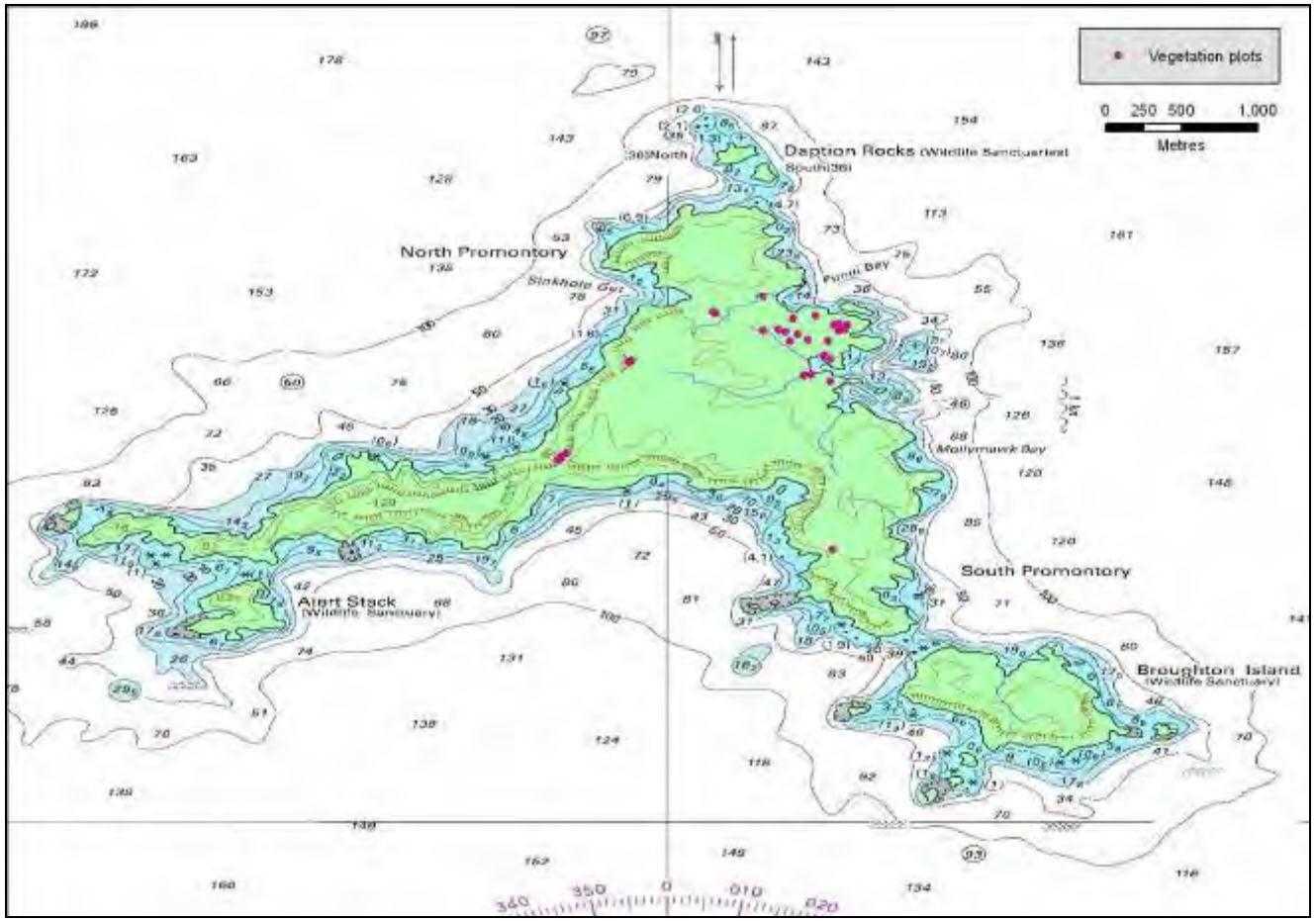
Appendix 1. Map of Snares Island vegetation monitoring plot locations



Appendix 2. Plot classifications

Plot	Plot classification 1987	Plot grouping 2011	Years measured
1	*Poa tennantiana*	Grassland	1987, 1998, 2010
2	*Poa tennantiana*	Grassland	1987, 1998, 2010
3	*Poa tennantiana*	Threatened species/endemics	1987, 1998, 2010
4	*Poa tennantiana* under *Olearia*	Forest	1987, 1998, 2010
5	*Poa tennantiana* under *Olearia*	Forest	1987, 1998, 2010
6	*Poa tennantiana* under *Olearia*	Forest	1987, 1998, 2010
7	*Poa astonii*	Grassland	1987, 1998, 2010
8	*Poa astonii*	Grassland	1987, 1998, 2010
9	*Poa astonii* and *Lepidium*	Threatened species/endemics	1987, 1998, 2010
10	*Polystichum* under *Olearia*	N/A	1987
11	*Polystichum* under *Olearia* and *Senecio*	Forest	1987, 1998
12	Bare Peat under *Olearia*	Forest	1987, 1998, 2010
13	Bare Peat under *Olearia*	Forest	1987, 1998, 2010
14	Bare Peat under *Olearia* and *Senecio*	Forest	1987, 1998
15	*Stilbocarpa*	Other	1987, 1998, 2010
16	*Stilbocarpa*	Other	1987, 1998, 2010
17	*Anisotome*	Threatened species/endemics	1987, 1998, 2010
18	*Anisotome*	Threatened species/endemics	1987, 2010
19	*Callitriche* under *Olearia*	Forest	1987, 1998, 2010
20	*Callitriche* under *Olearia*	Forest	1987, 1998
21	*Carex* and *Scirpus*	Threatened species/endemics	1987, 1998
22	*Carex*	Grassland	1987, 1998, 2010
23	*Asplenium* under *Olearia* and *Senecio*	Forest	1987, 1998, 2010
24	*Hebe*	Other	1987, 1998, 2010
25	*Hebe*	Other	1987, 1998, 2010
26	mixed tussock and herb	Grassland	1987, 1998, 2010
27	stable penguin colony	Other	1987, 2010
28	vacated penguin colony	Other	1987, 1998, 2010
29	new penguin colony	Other	1987, 1998, 2010
30	vacated penguin colony	Other	1987, 1998, 2010

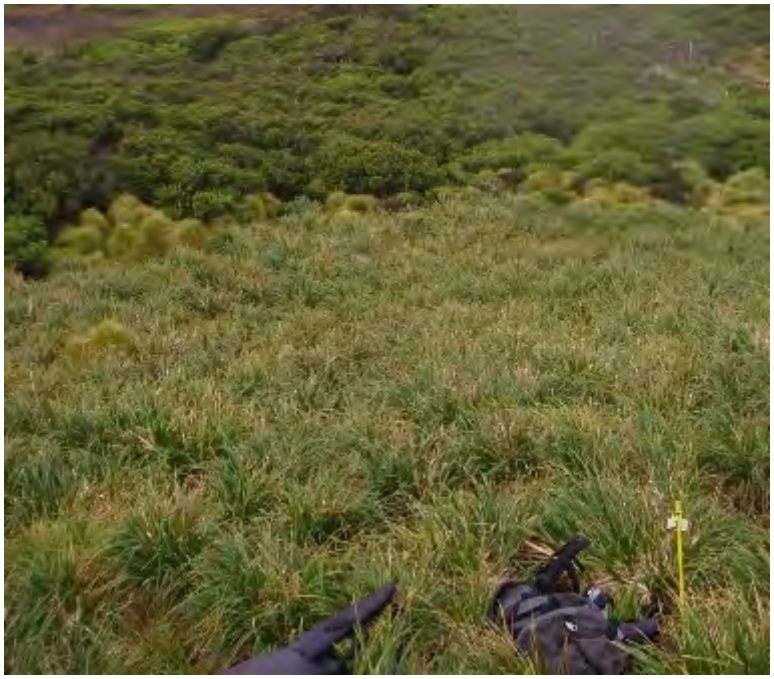
Appendix 3. Selected photopoint comparisons 1998-2010

The photopoint comparisons below were selected to illustrate some of the vegetation patterns on the plots over time. Not all the plots had good photopoint comparisons between years and these have not been included. Photos of the plots were taken by the 1987 survey party but have not been able to be located. Plots are titled with the 2010 plot groupings and 1987 plot classifications, then a brief description of any vegetation patterns over time.

Plot 1 Grassland; *Poa tennantiana* – no change.

1998

2010



Plot 2 Grassland; *Poa tennantiana* – large expansion of *Hebe elliptica*.

1998

2010

Plot 3 Threatened species/endemics; *Poa tennantiana* – very little change, the endemic species *Anisotome acutifolia* is present in 2010 on this plot where it was not recorded on the 1987 or 1998 measurements.

1998

2010

Plot 7 Grassland; *Poa astonii* – little change, the sooty shearwater (titi) 'runway' in the 2010 photo shows the muddy areas being colonised by *Crassula moschata*.

1998

2010

Plot 8 Grassland; *Poa astonii* – no change.

1998

2010

Plot 9 Threatened species/endemics; *Poa astonii* and *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) – decreasing *Poa astonii* with a slight increase in the endemic *Anisotome acutifolia* since 1987 and a 10% increase in the endemic *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands) between 1998 and 2010.

1998

2010

Plot 12 Forest; Bare peat under *Olearia* – no change.

1998

2010

Plot 16 Other; *Stilbocarpa* – disappearance of all large *Stilbocarpa robusta* from the plot between 1998 and 2010 with a simultaneous increases in *Hebe elliptica* and *Olearia lyallii*.

1998

2010

Plot 17 Threatened species/endemics; *Anisotome* – disappearance of large patch of *Anisotome acutifolia* between 1998 and 2010 with a corresponding increase of *Poa tennantiana* and the arrival of *Lepidium* aff. *oleraceum* (c) (CANU 5995; Snares Islands).

1998

2010

Plot 22 Grassland; *Carex* – with increased use by Snares crested penguins this plot changed from a diverse wet grassland plot dominated by *Carex trifida* and various herbs in 1987, to remnant *Carex trifida* and bare ground in 1998, to bare ground with around 50% cover of the herb *Callitriche antarctica* in 2010.

1998

2010

Plot 23 Forest; *Asplenium* under *Olearia* and *Senecio (Brachyglottis)* – little change, a slight increase in *Asplenium obtusatum* and *Hebe elliptica* between 1998 and 2010.

1998

2010

Plot 25 Other; *Hebe* – changed from a *Hebe elliptica* dominated plot in 1987 and 1998 to *Hebe elliptica* and *Olearia lyallii* being co-dominant in 2010.

1998

2010

Plot 26 Grassland; mixed tussock and herb – diverse plot impacted by sealions, species mix similar over the years monitored although the introduced *Poa annua* has declined since 1998 due to periodic control work.

1998

2010

Plot 28 Other; vacated penguin colony – changed from being mostly herbaceous and grassland vegetation in 1987, to half herbaceous/grassland half woody species mix in 1998, to being dominated by woody species *Olearia lyallii* and *Hebe elliptica* in 2010.

1998

2010

Plot 30 Other; vacated penguin colony – changed quickly from a herbaceous community dominated by *Crassula moschata* in 1987, through a cycle of live *Hebe elliptica* which had died by 1998, to mostly live *Hebe elliptica* and *Callitiche antarctica* in 2010. The plot was part of a penguin colony again in 1998 and 2010.

1998

2010