Forest recovery on the Otago Peninsula: Measuring 10 years of change, 2011-2021.

Vigorous understorey regeneration on Sandymount's northern slopes.

Prepared for the Otago Peninsula Biodiversity Group Trustees

September 2021

Nature Positive

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ecosystem restoration for people, climate and nature
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Executive summary

In April 2011, the Otago Peninsula Biodiversity Group (hereafter OPBG) commissioned the authors to establish 14 permanent vegetation plots to represent the regenerating forest types found across the Otago Peninsula[1]. Prior to these plots being established there was no systematic vegetation monitoring on the Peninsula[2], although an annotated list of vascular plants was prepared by Peter Johnson in 2004 and various inventories and surveys have been produced for particular reserves and habitat types. In February 2021, the plots were remeasured for the first time and by the same team. This report summarises the re-measure process and provides a high-level evaluation of the changes over those ten years as observed.

In 2011, data was collected using two standard[3] New Zealand forest assessment methods: the Permanent Plot Method For Monitoring Indigenous Forests (Hurst and Allen 2007) and the Foliar Browse Index (FBI) (Payton and others 1999). In 2021, the Permanent Plot method was repeated, and the DOC 2014 update of the FBI method was used[4]. These methods provide a broad range of information that give a good indication of forest health and development, including: the species diversity present, the vegetation structure from the ground to the canopy, regeneration dynamics and possum browsing intensity. The two methods are complementary because both long- and short-term changes in vegetation structure can be resolved. The permanent plots provide both fine-scale (at the single plot level) and large-scale (at the multi-plot landscape scale) information on vegetation community species composition and diversity.

Since 2011, the OPBG has been removing possums from the Peninsula. Possum control remains the primary focus of the Trust in working towards their 'Predator Free Peninsula 2050' vision, and it is complemented by other habitat restoration activities including planting native trees and exclusion of stock from some bush fragments. There is strong anecdotal evidence from the community on the peninsula of an increase in bird abundance and forest fragment health since the possum eradication was started. The vegetation plots provide scientific evidence of the forest's recovery status.

Results show that in most plots regeneration and successional forest development is strong. Indicators for this include a decrease in foliar browse evidence, an increase in sapling numbers and diversity and an increase in both canopy height and cover. It is clear that the degrading pressure of possum browse has decreased in the period between measurements, and this will have had a positive effect on the vigour of the developing forest communities with an abundance of palatable species. However, in two sites (Harbour Cone and Taiaroa Bush) continued stock access and grazing pressure is having a noticeable adverse effect on forest structure and regeneration processes.

If possum numbers continue to be kept low (or indeed if eradication is achieved) and stock are permanently excluded, then the forest patches sampled (and equivalent ones elsewhere on the Peninsula) will continue to mature, providing good representative habitat fragments for a range of native fauna and an important source of locally adapted propagules for any future restoration. It is important to note that because of the Peninsula's position in a transition zone between the wetter coastal forests to the south and the drier coastal forests to the north, as well as the range of aspects, altitudes, substrates, and the gradient of salt-water proximity, there are a wide range of forest communities present. The sub-set of these forest community types represented by the plots have all suffered from different intensities of pre and post European human disturbance including selective logging, clearance, cultivation of the cabbage tree, stock grazing, burning and weed invasions. In early European times, most of the Peninsula except for the sand country was still covered in forest (Forrest 1963). Therefore, the forest communities we see today are either highly disturbed original fragments or examples of relatively immature natural regeneration; in all cases it will take centuries of continued regeneration before the habitat structure returns to something resembling mature - with the podocarp canopy emergents characteristic of that state.

[1] See Kunzea Consultants 2011, Vegetation Recovery After Possum Eradication, A Monitoring Baseline, Unpublished report prepared for the OPBG.
[2] Previous plots had been established to assess rare coastal turf habitats, and one as part of the National Carbon Monitoring System.
[3] The permanent plot method was adapted by reducing plot size in proportion to the lower forest stature, as is commonly practiced.
[4] https://www.doc.govt.nz/Documents/conservation/threats-and-impacts/animal-pests/foliar-browse-index-field-manual.pdf

We trust that the data provided by the vegetation monitoring will support the OPBG's aims by scientifically confirming the increase in forest health that must in part be because of the long-term success of possum control in reducing numbers. We hope that the process of biodiversity regeneration on the Peninsula continues alongside other land uses, giving an enhanced sense of place, pride, and enjoyment in the natural character of the local environment for the people of the Peninsula, and the Dunedin community as a whole.

Project team

The 2021 team and their roles were as follows:

- Dr. Robin Mitchell - data collection, data analysis and report writing;
- Kate Ladley - data collection, data entry, data analysis;
- Richard Ewans – advice on Foliar Browse methods' alignment with the Predator Free Dunedin approach applied around the city;

Methodology

Sampling design

A total of 5 sites were chosen to establish the 14 permanent plots; they were: Varleys Hill, Taiaroa Bush, Sandymount, Harbour Cone and Peggys Hill. Figures 1 & 2 show the approximate locations of each plot. Appendix 1 gives GPS coordinates taken at corner A for each of the plots.

Factors considered in the original placement and overall distribution across the Peninsula of these plots for the baseline establishment were:

- Maximum feasible forest community diversity sampled based on the variation in known ecological drivers such as aspect, altitude, slope and soil type;
- Big enough forest patches in order to establish more than one independent plot in each patch, and to ensure plots were free from severe edge effects;
- Amenable landowners;
- Maximum spread across the possum control management zones established by the OPBG;
- Reasonably accessible and proximal to each other.

Figure 1: Locations of numbered permanent plots established overlaid onto NZTM Topo 50 maps (sheet CE18).

Figure 2: Locations of numbered permanent plots established overlaid onto NZTM Topo 50 maps (sheet CE17).

Permanent plot methodology

The plot locations and measurement methodology used in the 2021 re-measure were explained in detail in the baseline report (Kunzea Consultants 2011). For more information, readers are referred to the National Vegetation Survey section of the Landcare Research website[5] where the full and up to date methods manuals are available.

14 permanent vegetation monitoring plots were established based on the New Zealand Standard permanent vegetation plot and 'recce' methods of Hurst and Allen (2007 a & b) which has been widely applied throughout New Zealand. This large number of sites over the relatively small area of the Pensinsula is to sample the diversity of regenerating coastal forest types and development stages that exist on the Peninsula

Choosing the standard permanent plot method makes the OPBG baseline data-set content comparable with others around the country and has enabled submission of the dataset to the National Vegetation Survey (NVS) databank managed by Landcare Research in Lincoln. All data collected for OPBG in the permanent plots has been lodged with the NVS; the code for the 2011 baseline dataset is 'Otago Peninsula Biodiversity Survey 2011', and for the 2021 remeasure is 'Otago Peninsula Biodiversity Survey 2021'.

The deviation from the Hurst and Allen methodology was the use of a smaller plot size of 10 x 10 m (instead of the standard 20 x 20 m). A plot size of 10 x 10 m is commonly adopted in lower stature forest ecosystems because it is sufficient to sample the species diversity and structure present given the smaller tree size.

Photo 1: Yellow triangles are used at the edges of bush patches to help locate plots; the permolat markers below have bearings and distances to plots marked on them.

[5] https://nvs.landcareresearch.co.nz/Resources/FieldManual

Photo 2: Tagged tree 'stem' showing the unique tag code *SI 1693*.

Foliar Browse Index (FBI) methodology

For the 2021 re-measure the FBI method was updated after DOC 2014, resulting in two extra measurements being made for all trees in 2021. In 2011, stem use, die-back averaged for the whole canopy, total foliage cover and total canopy browse were measured; in 2021 in addition to the 2011 parameters, both die-back and browse were measured for the just the top third of the canopy.

The tag number and Diameter at Breast Height (DBH) of any stem used for the FBI technique was recorded on the permanent plot sheets; for sampled trees growing outside of the plots a tag was used to mark the tree and notes taken on its location (bearing and distance) using the permanent plot markers as reference points.

The number of individuals measured for each year, those measured in both years, and their species identity is shown in Table 1. In 2021, more individuals of fuchsia were targeted to bring the sample size up for this species. The few individuals not re-measured in 2021 were because the stem had died in the intervening decade.

Table 1: numbers and species identity of FBI stems measured in each year

Species	# 2011	# 2021	Double measurement
Broadleaf	2	1	1
Lancewood	3	3	3
Fuchsia	12	26	11
Whiteywood	25	24	21
Totals	42	54	36

Results & interpretation

Photo-text summary of changes in vegetation among the five sites

Varleys Hill

Varleys Hill data shows a drop in species diversity & number of saplings (probably due to a decrease in light levels penetrating to the ground layer combined with heavy rabbit grazing) but a biomass increase (as indicated by increase in stem diameters). The kanuka canopy is maturing (the area was heavily grazed with scattered trees and scrub vegetation until 1993) but is not yet old enough to see much senescence driving a succession into a more diverse regenerating forest. (Note, 2021 OPBG 02 is a close-up image of one of the seedling subplots also visible in the 2011 image).

OPBG 02 photo-monitoring point: left 2011, right 2021

Taiaroa Bush

Although Taiaroa Bush maintains a high species diversity (partly due to exotic species) and the canopy has grown in height slightly, the understorey and sapling layers are not developing because of the reasonably high stock grazing pressure (heavy cattle pugging was evident in several places in the vicinity of the plots); if stock access continues for an extended period then any canopy openings due to senescence and windthrow may not be replaced with younger trees and the forest could degrade.

OPBG 05 photo-monitoring point, left 2011, right 2021

Sandymount

At Sandymount, there has been a large increase in sapling diversity & sapling numbers. The forest here is undergoing rapid regeneration with stock having been excluded for c. 20 years at the time of survey (M. Parker pers. comm.) (Note same 'elbow' of Mahoe recognisable in both OPBG 07).


OPBG 07 photo-monitoring point: left 2011, right 2021

Harbour Cone

Rapid Manuka/Kanuka succession has occurred in plot 11 situated on the outer edge of the developing forest patch sampled at the site; what was a pasture edge/patch has is now under the heavily shaded Manuka canopy (Note, the 2021 picture OPBG 11BD runs along the tapeline [tape removed] visible in the 2011 picture). Grazing has been relatively light on this property since the DCC purchased it in 2008, allowing the rapid invasion of kanuka-manuka scrub into the pastureland. Elsewhere at the site the kanuka canopy has grown but low light levels and continued, albeit light, grazing pressure is preventing the kanuka performing a 'nurse crop' function, and the ground layer from developing the seedlings & saplings for this function to operate.


OPBG 11BD photo-monitoring point: left 2011, right 2021

Peggy's Hill
Whilst the number and diversity of saplings has seen modest growth here, there has been rapid understory regeneration, associated with a response to stock removal (the area was fenced to exclude stock in 2009). Average Stem diameter has remained stable here indicating a relatively stable canopy (in 2011 it was a reasonably diverse and mature relict canopy).

OPBG 13AD photo-monitoring point: left 2011, right 2021

Community type descriptions

To provide some feeling for the diversity and types of forest communities sampled among the 14 plots and how they have changed in the 10 years between measurement, brief descriptions of vegetation structure, canopy composition and community species diversity are given in Table 2 below.

Plot number	dominant characteristics		species diversity[6]	
	2011	2021	2011	2021
1	Low forest with a kanuka dominated canopy at a mean top height of 8 m	Low forest with kanuka dominated canopy at a mean top height of 10 m; species poor with mahoe and totara saplings developing into understorey.	30	14
2	Low forest with a canopy co-dominated by kanuka and mahoe at a mean height of 6.5 m	Low forest with a canopy co-dominated by kanuka and mahoe at a mean top height of 8 m; species poor. Totara present in the canopy and as saplings.	27	8
3	Low forest with an open canopy of broadleaf and fuchsia; species diverse understorey	Low forest with an open canopy of broadleaf, fuchsia, ribbonwood and mahoe at a mean top height of 7 m; species diverse understorey	56	55
4	Low forest with a mixed canopy (mean top height 6 m) of fuchsia, lancewood and mahoe;	Low forest with a mixed canopy (mean top height 6 m) of fuchsia, lancewood and mahoe; diverse understorey	51	43

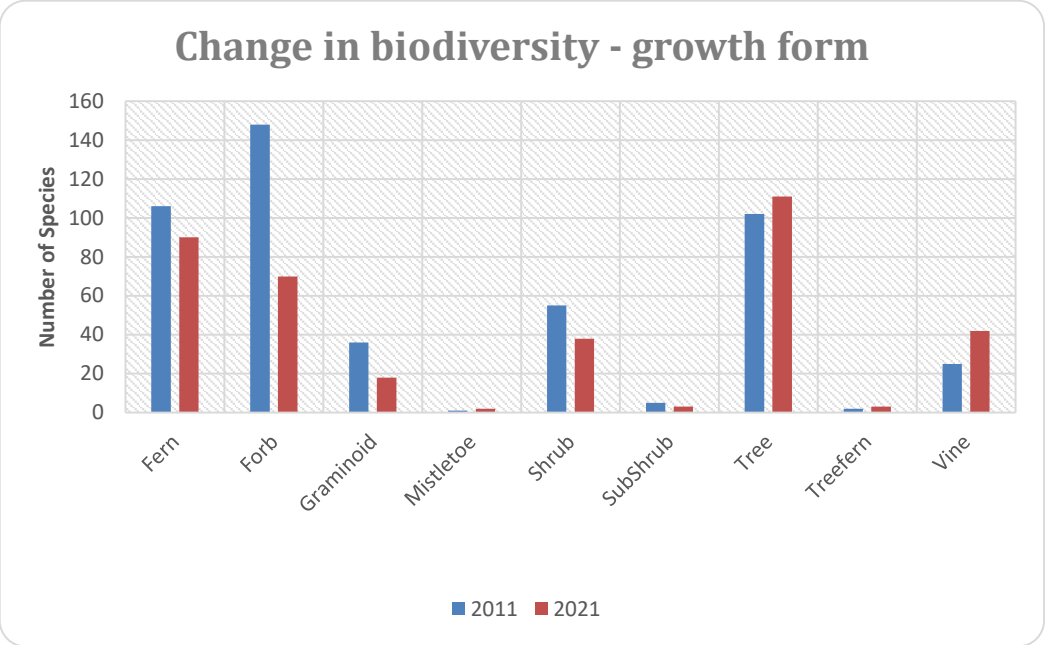
[6] Strictly speaking, the numbers given here are species d6ensity (i.e. the numbers of species found within the space sampled); true species 'diversity' , or, species 'richness' is the total number of species found 8within a community or ecosystem type at any given locality, therefore, true species richness for each of these sites would have been higher had a larg7er area than one plot been sampled. Nonetheless the term species diversity is used in its common meaning. 7

Plot number	dominant characteristics		species diversity[7]	
	2011	2021	2011	2021
5	Low forest with a mixed canopy of lacebark, marbleleaf, mahoe and fuchsia; mean top canopy height 8 m	Low forest with a mixed canopy of lacebark, marbleleaf, mahoe and fuchsia; mean top canopy height 8 m; diverse understorey	45	51
6	Low forest with a mixed open canopy of fuchsia and mahoe; 7 m mean top height	Low forest with a mixed open canopy of fuchsia and mahoe; 7 m mean top height; strongly developing understorey	33	21
7	Low forest with a canopy dominated by mahoe with common black mapou; mean top height 6 m	Low forest with a canopy dominated by mahoe with common black mapou; mean top height 7; vigorous saplings	24	27
8	Low forest with a mixed canopy of broadleaf, lancewood and the pohuehue vine; mean top height 11 m	Low forest with a mixed canopy of broadleaf, lancewood and the pohuehue vine; mean top height 11 m; developing understorey	25	24
9	Low forest with an open canopy dominated by kanuka and a lack of understorey or sapling cover; mean top height 10 m	Low forest with an open canopy dominated by kanuka and a lack of understorey or sapling cover; mean top height 12 m; reasonably diverse ground layer	34	27
10	Scrub with a closed canopy of kanuka, a lack of understorey cover; mean top height 6 m	Low forest with a closed canopy of kanuka, a lack of understorey or ground cover and a low species diversity; mean top height 7 m	21	8
11	Kanuka-manuka open canopy scrub	Kanuka-manuka scrub; canopy closing	32	22
12	Low forest with a mixed canopy of mahoe, pohuehue, fuchsia and marbleleaf; mean top height 6 m	Low forest with a mixed canopy of mahoe, pohuehue, fuchsia and marbleleaf; mean top height 7 m; developing understorey and sapling layers	37	28
13	Low forest with a canopy dominated by mahoe and common broadleaf; mean top canopy height 6 m	Low forest with a canopy dominated by mahoe and common broadleaf; mean top canopy height 7 m; developing understorey and sapling layers	26	20
14	Low forest with a canopy dominated by mahoe, some emergent totara; mean top height 6 m and a relatively diverse understorey	Low forest with a canopy dominated by mahoe and pohuehue, some emergent totara; mean top height 8 m; developing understorey and sapling layers	39	29
Total diversity	-	-	121	102

Table 2: Characterising features of the vegetation communities present at each of the 14 plots sampled.

[7] Strictly speaking, the numbers given here are species d6ensity (i.e. the numbers of species found within the space sampled); true species 'diversity' , or, species 'richness' is the total number of species found 8within a community or ecosystem type at any given locality, therefore, true species richness for each of these sites would have been higher had a larg7er area than one plot been sampled. Nonetheless the term species diversity is used in its common meaning. 7

Growth form



Graph 1: changes in growth form summed for all plots 2011 – 2021

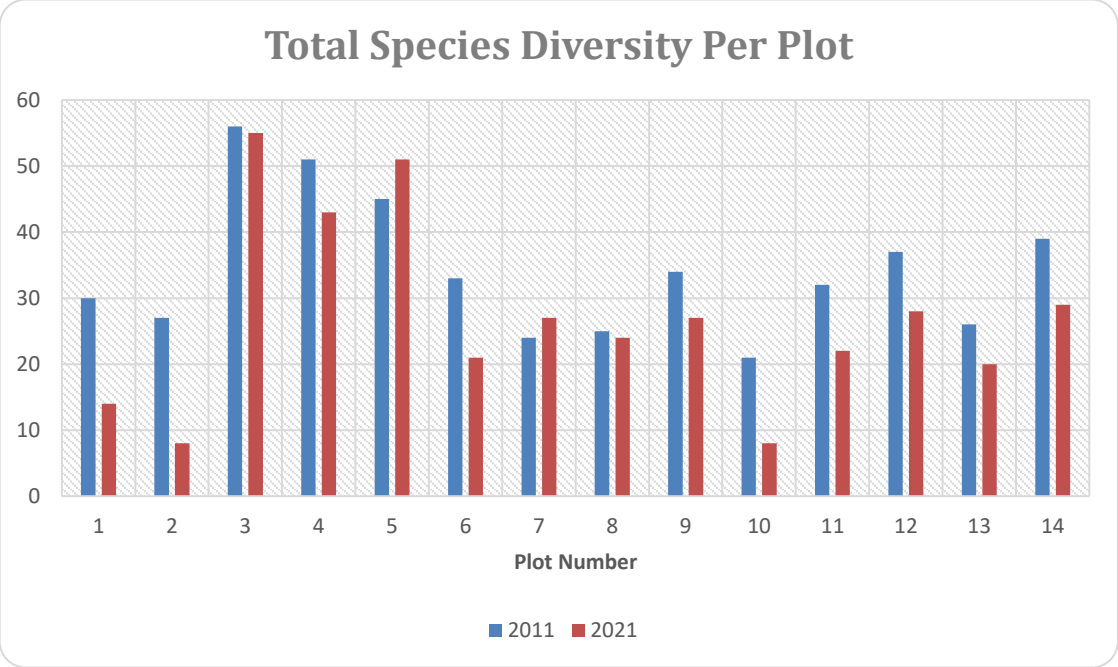
Graph 1 shows the data for total numbers of species identified in the plots classified by growth-form. This gives an impression of the overall change in structure of the developing forests. Of note is the decrease in forbs and the increase in trees and vines: these results indicate the gradual process of succession that is ongoing, moving the forests towards a more mature state.

Species diversity

Graph 2 shows species diversity change over time per plot. As noted in the footnote for the community type descriptions, these data do not provide a true or complete measurement of species diversity for the site or forest type. If larger plots were established, or more plots in each community type were established and their species records amalgamated, then species diversity recorded per forest community type / site would increase. Nonetheless, each set of plots would likely have sampled c. 80% of the total species diversity for the forest type represented at the site, and the data provide the ability to make comparisons among plots and forest types, and between plots and forest types over time.

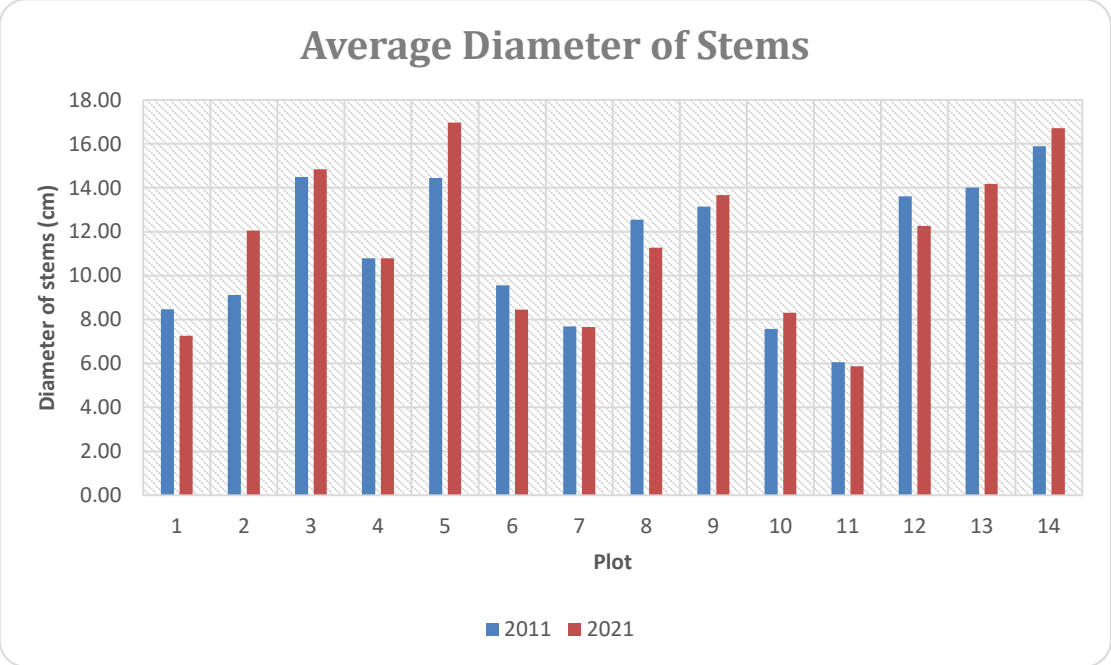
The total number of species found within the survey declined by 20% between 2011 & 2021 – from 121 to 102. Half of this drop is explained by the reduction of exotic species (from 32 to 23). The drop in exotic species is driven by the increased maturity and canopy closure of the forest making the environment less favourable for pasture weeds.

The variation among plots has increased markedly with a mean species diversity of 33 in 2011 and 27 in 2021, and the standard deviation having increased from 10 to 14. As indicated by the standard deviation, the range of plot diversity in 2011 was less at 21-56 compared to 8-55 in 2021. In 2011 the lowest diversity was found on the dry kanuka dominated slopes of Harbour Cone and the maximum on the upper northern slopes of Sandymount. In 2021, the same plots represented either end of the range, with the succession of the kanuka canopy (reducing light) on Harbour Cone, combined with continued grazing being the drivers of the marked reduction in diversity for that plot and this effect also giving rise to the increased diversity range.



Graph 2: Total species diversity per plot in 2011 & 2021[8].

Forest stature – tagged stem numbers and size



Graph 3 2011 – 2021 change in average stem diameter

Graph 3 Stem diameter (at breast height) data show an average weak trend for an increase. This is indicative of an overall increase in diameter for the tagged trees being moderated by an increase in number of smaller

[8] Some 2011 species records were revised based on the re-measure resulting in slight changes of species records and diversities recorded for some plots.

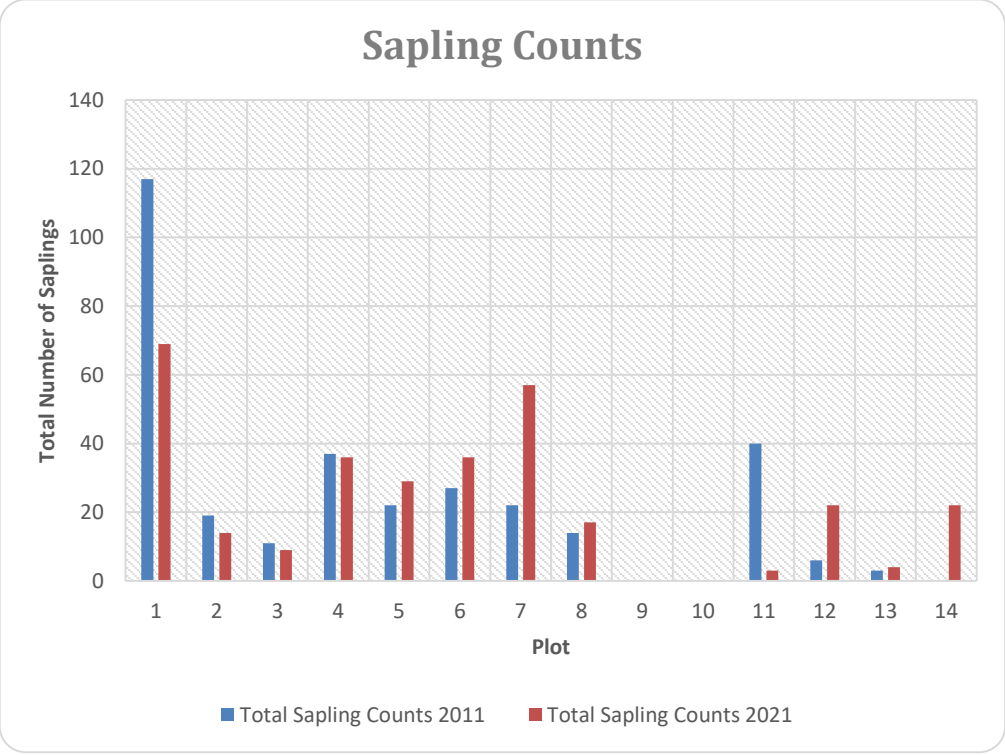
saplings (from regeneration) that brings the average down. All stems over 2.5cm diameter are measured in the methodology used; there was increase in the total number of stems of taggable size from 596 to 623. The combination of an increase in overall stem numbers and size indicates an increase in biomass consistent with an increase in forest structure & stature, and understorey / canopy health.

Saplings

Within each of the four subplots, trees and shrubs with a height of over 1.35m (breast height), but with a diameter at that height of <2.5 cm, are counted as saplings rather than as tagged 'stems'.

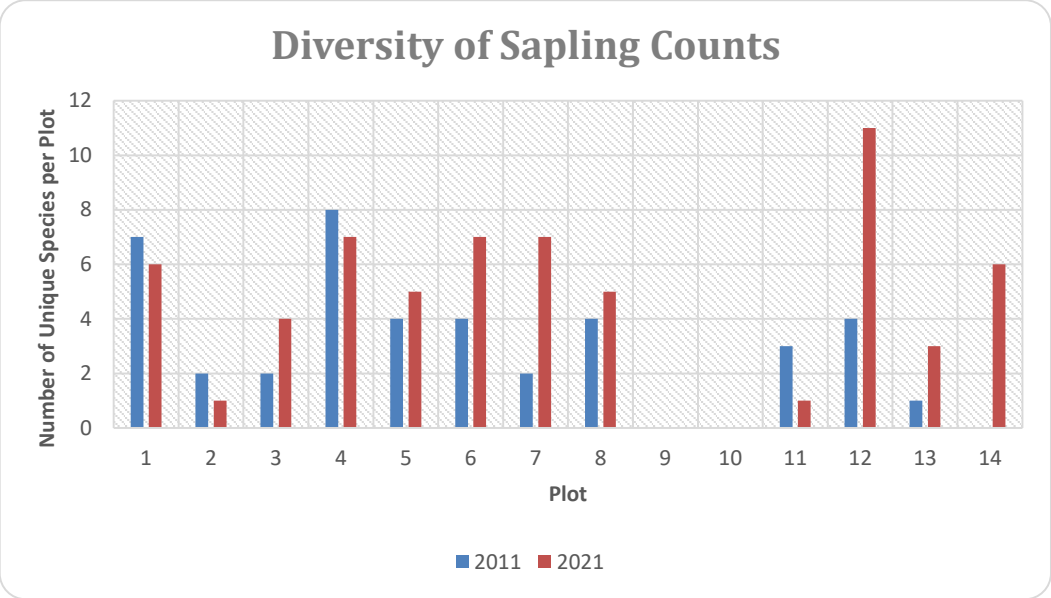
The abundance and diversity of saplings are a very important indicator of the health of a forest ecosystem; particularly in the case of the sites measured since they are in the process of regenerating from various states of degradation, and in the case of some sites from complete clearance.

Graph 4 showing total sapling counts below shows a marked increase in most plots – indicating strong regeneration. Plots 1, 2, 3 and 4 show a decrease in saplings. This is explained for plots 1 & 2 on Varleys Hill by the reduction in light levels associated with the maturation and closure of the kanuka canopy. The reduction in Plots 3 & 4 in Taiaroa Bush is explained by the continued high levels of stock grazing pressure in the unfenced part of that bush fragment sampled by the plots; in our opinion if this grazing pressure continues, then the bush here will degrade rather than regenerate over time. Plots 9 & 10 had no saplings recorded.



Graph 4: Total sapling counts per plot, 2011 & 2021

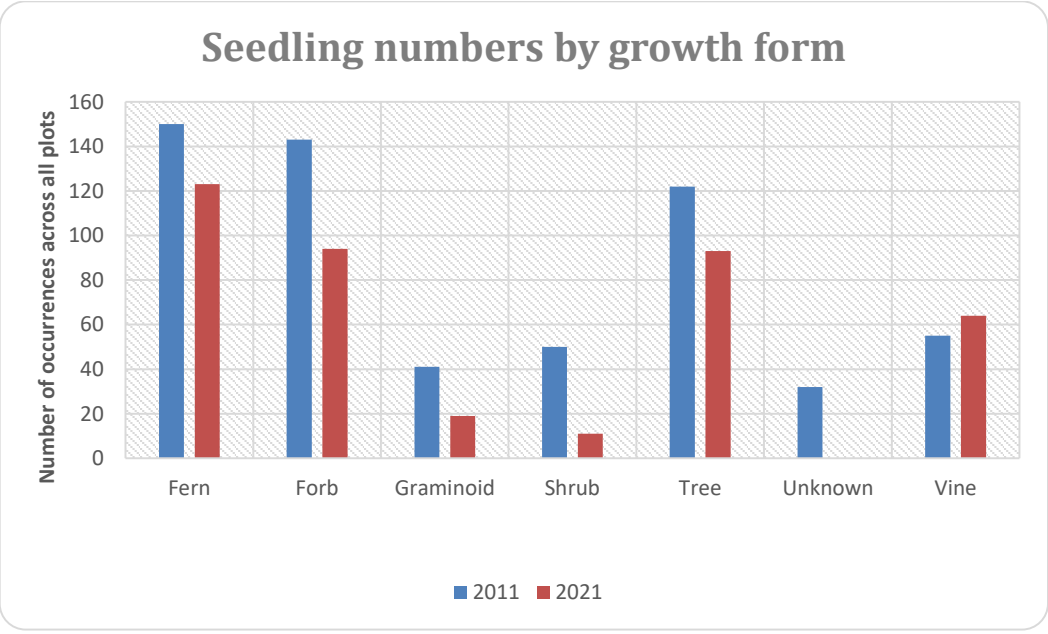
Graph 5 of sapling species diversity per plot below shows an increase in diversity for all plots but one that aren't dominated by a kanuka canopy. Plots 9 and 10 had no saplings recorded. As discussed previously, the development stage of the kanuka canopies in the plots of this characteristic sampled means that light levels are low and have reduced since 2011 resulting in a lower species diversity driven by a drop in the diversity and abundance of individuals in the lower tiers of vegetation (saplings and seedlings). The number of unique (per plot) species recorded as saplings totalled among all plots increased from 41 in 2011 to 63 in 2021. This is a very positive result indicating good recruitment, survival and regeneration.



Graph 5: Number of unique sapling species per plot in 2011 & 2021

Seedlings

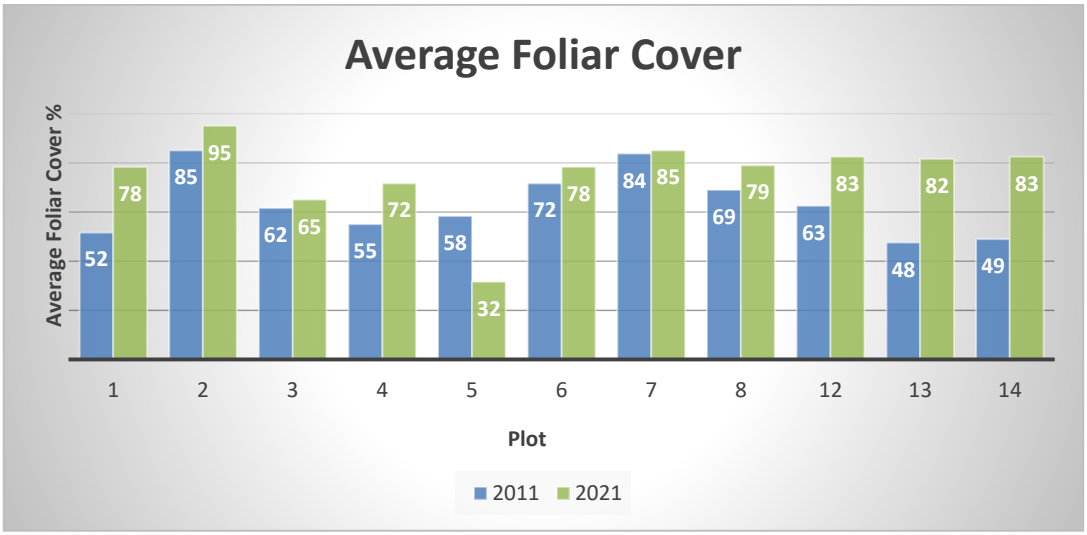
Graph 6 below shows that seedling numbers have decreased; this is probably a result of the increase in saplings and canopy cover (as a result of both maturity increases and greater canopy health from reduced possum-browse) shading out the ground layer. The total number of seedlings counted in all the seedling sub plots measured reduced from 593 in 2011 to 404 in 2021.



Graph 6: Seedling numbers by growth form

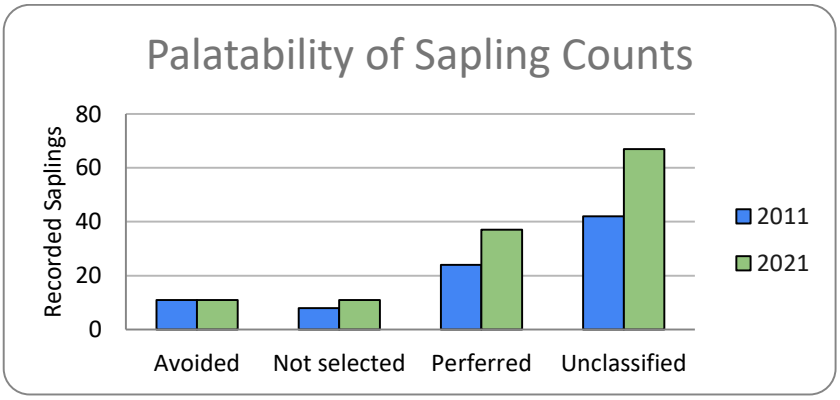
Foliar browse

The graph below shows average foliar cover to have increased in all plots but one, demonstrating a strong overall recovery in the health of the canopies among the sites and plots. It is expected that the possum control will have strongly contributed to this growth and recovery. Note that the Harbour Cone plots 9, 10 and 11 do not feature on this graph because of the absence of palatable species in the canopy owing to their early stage of post-pasture development and relative dryness of the sites producing a dominance of kanuka-manuka. The average foliar cover among all plots has increased from 63% to 76%, and the average whole canopy dieback has decreased from 41% to 21%. Interestingly, whilst die back and browse had decreased between 2011 and 2021, the percentage of stems with possum use recorded increased from 17% to 22% but the method in 2011 did not record intensity of use. Stem use was only recorded in three sites – Varleys Hill, Sandymount and Peggy's Hill.



Graph 7: Average foliar cover, 2011 & 2021[9]

Graph 8 shows clearly another key indicator of positive forest response to lower possum browing intensity – that there are higher numbers of saplings present from palatable species.



Graph 8: Palatability to possums of species represented in the sapling counts

[9] Its possible that some of the difference between the foliar cover measurements from the different years is explained by the seasonal difference in measurement timing (April in 2011 vs February in 2021), at least for the Fucshia species, however in the opinion of the authors this effect, if any, would not be marked enough to undermine the conclusion of an increase in foliar cover and canopy health.

Discussion

Over time, the permanent plots will provide information on the following questions, amongst others:

- Is possum control alone sufficient to allow for the long-term maintenance of forest canopy on the Otago Peninsula?
- Is there adequate regeneration of palatable and non-palatable canopy and sub-canopy trees and shrubs in high priority sites on the Peninsula?
- Has the reduction in possum densities allowed for increased establishment and growth of palatable seedlings on the forest floor?

From the data obtained in the first remeasure in 2021 it is apparent that possum control has had a clear positive effect on forest health with canopy foliar cover and palatable species' saplings increasing. However, reducing the effect of possums has highlighted that both possum control and stock exclusion will be required to support rapid regeneration of the mixed-hardwood forest fragments. Nonetheless, with the possible exception of Taiaroa Bush where stock damage is relatively intense, there is an ongoing process of forest recovery among the plots. The 'nurse' potential of the kanuka canopy at Harbour Cone would be optimised if the relatively light stock grazing there were eliminated. Due to a relative lack of local podocarp seed source enrichment planting could be considered to further assist development into diverse podocarp-broadleaved forests with rimu, miro, matai, totara and kahikatea once again being tall emergents over a broadleaf-dominated canopy.

The predominant landcover on the Otago Peninsula is pastureland with only c. 6%[10] supporting native forest or scrub. Within this area, the remnant native vegetation patches harbour a high diversity of coastal forest, scrub (14 types were recognised by Johnson, 1982) and turf habitats; therefore, the patches that remain are of very high conservation value to maintain representative biodiversity and to serve as nuclei and sources of locally adapted genetic material for any future regeneration and restoration that may be desired as societal and community priorities continue to change.

We would recommend the plots continue to be professionally remeasured at least every 10 years as this will build up the long-term story of forest regeneration on the Peninsula. However, much valuable, and interesting information can be gained through amateur ecologists measuring the following parameters at intervals of 5 years or more being enough to have a likelihood of detecting change:

- Stem diameter (growth rates);
- Sapling counts & repeat photo-monitoring (understorey regeneration dynamics);
- Canopy and sub canopy dominant species (community characterisation and mapping of successional pathways);
- Tier covers and heights (forest structure, canopy cover).

We would encourage the OPBG to establish links with the University who may have post-graduate ecology students seeking a vegetation baseline to build upon, or a data set to explore.

[10] Johnson 1982 measured all patches of native forest and scrub over .5 ha to arrive at a figure of 5.25 % coverage. No accurate repeat measurement has been made but the authors estimate this to have increased to 6% through restoration and natural regenerative expansion of some patches.

Additional items to this report

All data from the permanent plots has been lodged with the NVS and can be downloaded by request. The NVS names of the data-sets are 'Otago Pensinsula Biodiversity Survey 2011' & 'Otago Pensinsula Biodiversity Survey 2021'. A download copy was provided to OPBG with this report. Robin Mitchell & Kate Ladley have retained copies of the raw data sheets (2011 & 2021).

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APPENDIX ONE: Plot location mapping coordinates

Plot ID	NZTM co-ords		Map sheet reference		Map sheet ID
Plot number	East - Long	North - Lat	E	N	
1	1419360	4919692	194	197	CE17
2	1419891	4919877	199	199	CE17
3	1423030	4923531	230	235	CE18
4	1422497	4923388	225	234	CE18
5	1422469	4923414	225	234	CE18
6	1419543	4915722	195	157	CE17
7	1419636	4915788	196	158	CE17
8	1419753	4915802	198	158	CE17
9	1417926	4919676	179	197	CE17
10	1417933	4919604	179	196	CE17
11	1417906	4919634	179	196	CE17
12	1416112	4917769	161	178	CE17
13	1416095	4917828	161	178	CE17
14	1416116	4917881	161	179	CE17

APPENDIX TWO: Plot photo monitoring points & location summaries

Plot number	location descriptor	unique photo-monitoring point number (ref Appendix three)
OPBG 01	understory-canopy	OPBG 01
OPBG 02	seedling plot 5	OPBG 02
OPBG 03	C-AD	OPBG 03
OPBG 04	C-AD	OPBG 04
OPBG 05	A-BC	OPBG 05
OPBG 06	A-C	OPBG 06
OPBG 07	A-C	OPBG 07
OPBG 08	A-DC	OPBG 08
OPBG 09	A-D	OPBG 09
OPBG 10	B-A	OPBG 10
OPBG 11	A-B	OPBG 11 AB
OPBG 11	B-D	OPBG 11 BD
OPBG 11	D-C	OPBG 11 DC
OPBG 12	AB-C	OPBG 12
OPBG 13	A-D	OPBG 13 AD
OPBG 13	BC-AD	OPBG 13 BCAD
OPBG 14	B-A	OPBG 14 BA
OPBG 14	B-D	OPBG 14 BD

Interpretive notes: The corresponding '.jpeg' file name for each picture is listed in column 3. The location descriptor refers to the plot corners - the letter(s) before the dash refer to where the photo was taken from and the letter(s) after the dash refer to where the photo is pointing: thus, for example, the suffix 'BC-AD' means that the photo is taken half way between plot corners B and C and points to half way between plot corners A and D; whereas 'A-DC' is taken from corner A to between D and C. All photos in 2021 were taken from as close as possible to the original points and many were able to be verified as such from plot markings, however some may appear different in perspective owing to use of different lens zoom.

APPENDIX THREE: Photo monitoring points 2021 photos

Numbers are the unique identifiers listed in column three in Appendix Two

OPBG 01, Varleys Hill

OPBG 02, Varley's Hill

OPBG 03, Taiaroa Bush

OPBG 04, Taiaroa Bush

OPBG 05, Taiaroa Bush

OPBG 06, Sandymount

OPBG 07, Sandymount

OPBG 08, Sandymount

OPBG 09, Harbour Cone

OPBG 10, Harbour Cone

OPBG 11 AB, Harbour Cone

OPBG 11 BD, Harbour Cone

OPBG 11 DC, Harbour Cone

OPBG 12, Peggy's Hill

OPBG 13 AD, Peggy's Hill

OPBG 13 BCAD, Peggy's Hill

OPBG 14 BA, Peggy's Hill

OPBG 14 BD, Peggy's Hill

APPENDIX FOUR: Species list for whole survey, 2011 & 2021

Species latin name	Present 2011	Present 2021	Conservation Status
Aceana anserinifolia	1		Not Threatened
Acaena juvenca	1	1	Not Threatened
Acaena novae-zelandiae	1	1	Not Threatened
**Acer pseudoplatanus*	1		Exotic
**Agrostis capillaris*	1		Exotic
**Agrostis stolonifera*	1	1	Exotic
**Anthoxanthum odoratum*	1		Exotic
**Arctium minus*		1	Exotic
Aristotelia serrata	1	1	Not Threatened
Asplenium appendiculatum	1	1	Not Threatened
Asplenium bulbiferum	1	1	Not Threatened
Asplenium flabellifolium	1	1	Not Threatened
Asplenium flaccidum	1	1	Not Threatened
Asplenium gracillimum	1	1	Not Threatened
Asplenium hookerianum	1	1	Not Threatened
Asplenium lyallii	1	1	Not Threatened
Asplenium oblongifolium	1		Not Threatened
Astelia fragrans	1	1	Not Threatened
Australina pusilla	1	1	Not Threatened
Blechnum chambersii	1	1	Not Threatened
Blechnum colensoi	1	1	Not Threatened
Blechnum fluviatile	1	1	Not Threatened
Blechnum penna-marina	1	1	Not Threatened
Blechnum procerum	1		Not Threatened
Brachyglottis sciadophila	1	1	At Risk- Declining
Calystegia tuguriorum	1		Not Threatened
Cardamine debilis	1	1	Not Threatened
Carex geminata	1		Not Threatened
Carex species		1	Not Threatened
Carpodetus serratus	1	1	Not Threatened
**Cerastium fontanum*	1	1	Exotic
Chionochloa conspicua	1	1	Not Threatened
**Cirsium vulgare*	1	1	Exotic
Clematis foetida	1	1	Not Threatened
Clematis forsteri	1		Not Threatened
Clematis species	1		Not Threatened
Clematis paniculata		1	Not Threatened
Compositae		1	Unknown
Coprosma areolata	1	1	Not Threatened
Coprosma colensoi		1	Not Threatened
Coprosma crassifolia	1	1	Not Threatened

Coprosma propinqua	1	1	Not Threatened
Coprosma rhamnoides	1	1	Not Threatened
Coprosma rotundifolia	1	1	Not Threatened
Coprosma rubra	1	1	Not Threatened
Corokia cotoneaster	1	1	Not Threatened
**Crataegus monogyna*	1		Exotic
**Crepis capillaris*	1	1	Exotic
Cyathea dealbata	1	1	Not Threatened
Cyathea smithii		1	Not Threatened
**Cynosurus cristatus*	1		Exotic
**Dactylis glomerata*	1	1	Exotic
**Digitalis purpurea*	1	1	Exotic
**Dryopteris filix-mas*	1	1	Exotic
Earina mucronata	1	1	Not Threatened
Epilobium rotundifolium	1	1	Not Threatened
**Euphorbia peplus*	1	1	Exotic
**Festuca rubra*	1		Exotic
Fuchsia excorticata	1	1	Not Threatened
**Galium aparine*	1	1	Exotic
**Geranium molle*		1	Exotic
Gramineae	1	1	Unknown
Griselinia littoralis	1	1	Not Threatened
Helichrysum filicaule	1		Not Threatened
Herb	1		Unknown
Hoheria angustifolia	1	1	Not Threatened
**Holcus lanatus*	1	1	Exotic
Huperzia varia	1		Not Threatened
Hydrocotyle heteromeria	1	1	Not Threatened
Hydrocotyle moschata	1		Not Threatened
Hydrocotyle novae-zeelandiae	1	1	Not Threatened
Hymenophyllum demissum		1	Not Threatened
**Hypochaeris radicata*	1		Exotic
Hypolepis ambigua	1	1	Not Threatened
Hypolepis millefolium		1	Not Threatened
Ileostylus micranthus	1		Not Threatened
**Jacobaea vulgaris*	1	1	Exotic
Kunzea robusta	1	1	Threatened- Nationally Vulnerable
Lagenifera pumila	1		Not Threatened
Lagenophora strangulata	1	1	Not Threatened
Lastreopsis glabella	1	1	Not Threatened
Leptospermum scoparium	1	1	At Risk- Declining
Melicytus ramiflorus	1	1	Not Threatened
Mentha cunninghamii	1		At Risk- Declining
Metrosideros diffusa	1	1	Threatened- Nationally Vulnerable
Microsorum pustulatum	1	1	Not Threatened
Microtis oligantha	1		Not Threatened
Muehlenbeckia australis	1	1	Not Threatened
Muehlenbeckia complexa	1		Not Threatened
**Mycelis muralis*	1	1	Exotic
Myoporum laetum	1	1	Not Threatened
Myrsine australis	1	1	Not Threatened

**Nemesia floribunda*	1		Exotic
Orchid species	1		Unknown
Parsonsia heterophylla	1	1	Not Threatened
Pellaea rotundifolia	1	1	Not Threatened
Pennantia corymbosa	1	1	Not Threatened
Pittosporum eugenioides	1	1	Not Threatened
Pittosporum tenuifolium	1	1	Not Threatened
**Plantago lanceolata*	1		Exotic
Poa matthewsii	1	1	Not Threatened
**Poa pratensis*	1		Exotic
Podocarpus hallii	1	1	Not Threatened
Polystichum neozelandicum subsp. zerophyllum	1	1	Not Threatened
Polystichum vestitum	1	1	Not Threatened
**Prunella vulgaris*	1	1	Exotic
Pseudopanax crassifolius	1	1	Not Threatened
Pseudopanax edgerleyi		1	Not Threatened
Pseudowintera colorata	1	1	Not Threatened
Pteridium esculentum	1	1	Not Threatened
Pyrrosia elaeagnifolia	1	1	Not Threatened
Ranunculus multiscapus	1		Not Threatened
Ranunculus reflexus		1	Not Threatened
**Ranunculus repens*	1	1	Exotic
Ripogonum scandens	1	1	Not Threatened
**Rosa rubiginosa*	1	1	Exotic
Rubus cissoides	1	1	Not Threatened
**Rubus fruticosus*		1	Exotic
Rytidosperma species	1		Unknown
Rytidosperma unarede	1		Not Threatened
**Sambucus nigra*	1	1	Exotic
Schefflera digitata		1	Not Threatened
Schizeilema trifoliolatum	1	1	Not Threatened
Senecio minimus	1	1	Not Threatened
Solanum laciniatum	1		Not Threatened
**Solanum nigrum*	1		Exotic
Solanum species		1	Unknown
**Sonchus oleraceus*	1		Exotic
Sophora microphylla	1		Unknown
Stellaria decipiens	1	1	At Risk- Naturally Uncommon
**Stellaria media*	1		Exotic
Streblus heterophyllus	1	1	Not Threatened
**Taraxacum officinale*		1	Exotic
**Trifolium repens*	1	1	Exotic
**Ulex europaeus*	1	1	Exotic
Urtica ferox	1	1	Not Threatened
**Veronica arvensis*	1	1	Not Threatened
Veronica salicifolia	1		Not Threatened
TOTALS	**121**	**102**	