Trends in deer densities and deer-palatable forest species on Stewart Island

Summary report from Stewart Island Forest Health Survey 1998-2000

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- Deer pellet frequencies are low to moderate at many sites on Stewart Island, but Mason Bay and Chew Tobacco Bay had high pellet densities in 1999.
- Sites with high deer frequencies often corresponded with high possum pellet frequencies.
- Deer diet information has shown that white-tailed deer diet on Stewart Island is highly varied, and includes fresh and fallen leaves as well as fruits.
- Stand basal area has increased, while stem density has decreased, over 20 years on Stewart Island, reflecting maturing forests, where trees are getting larger and stands are thinning out. As the forest continue to thin out, regeneration of canopy and sub-canopy trees will be very important.
- Our study found no evidence to suggest deer threaten population structures of the main canopy tree species in the long term. However, greater rates of recruitment inside exclosures compared with outside does suggest that survivorship of seedlings and saplings may be lower when deer browse the understorey.
- Overall, woody seedlings and saplings have increased in density over 20 years on Stewart Island. This includes some species known to be browsed on by deer.
- Some highly palatable species are not regenerating adequately on the forest floor to replace the canopy trees. Regeneration rates of highly palatable species on pest-free Bench and Ulva Islands are much higher than on Stewart Island.
- Because many species rely on high light conditions for seedling growth, removal of deer browsing does not necessarily mean these species will regenerate underneath the current forest canopy structure.

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Deer pellet frequencies

Introduction

Deer pellet frequencies were assessed in 1981 and 1999 on permanently marked transect lines around northern Stewart Island, and on new lines in Chew Tobacco Bay, Port Adventure and Port Pegasus in 2000. The presence of a fresh deer pellet within circular plots of 114cm radius, at 20m intervals along the transects, was recorded. The percentage of plots with at least one pellet assessed for each transect resulted in a "percent pellet frequency" for each site.

Objectives

1 To estimate the frequency of deer (both white tailed deer - *Odocoileus virginianus* and red deer - *Cervus elaphus*) in northern and southern Stewart Island.

2 To quantify the trends in animal frequency between 1980/81 and 1998/99 in northern Stewart Island.

Reliability of the method

This method has been used extensively by the New Zealand Forest Service, and has been continued in some sites around the country by Department of Conservation. It provides a measure of the relative abundance of deer when measurements are repeated on lines over time. Rainfall data collected at Halfmoon Bay School confirmed that for the previous 7 months before the 1981 and 1999 study, a similar rainfall occurred. This was used to confirm that the number of pellets present on the forest floor was not affected by varying levels of rainfall in the two survey periods, and was likely to reflect real changes in the deer population, thus allowing justifiable comparisons between 1981 and 1999 data.

Results

Results for pellet frequency assessments for deer and possums are provided in Fig 1. The possum pellet frequency graph has been included here to highlight that trends between species were similar in some sites (e.g. Mason Bay), and that changes in possum pellet frequencies were much greater than for deer at most sites. Note that the scale on the y-axis is different between the two graphs – generally, possum pellet frequency was greater than for deer. Line locations are described in Table 1.

Results varied between lines, with some sites standing out as "hot spots" for deer (see Fig 1). On some lines, frequencies were the same in 1981 and 1999, such as lines 3-25 (where error bars overlap, indicating no significant difference). At one line (33 – Rakeahua) pellet frequency dropped between 1981 and 1999; and in 3 sites, pellet frequency increased significantly, with dramatic increases at Mason Bay (line 44) and Mason Head (line 50). Pooling all lines from Northern Stewart Island together, the mean pellet frequency increased slightly from 3.0 ± 0.57% in 1981 to 5.6 ± 1.2% in 1999 (paired t-test, t_{10}=2.94, p=0.015, Bellingham and Allan 2002). Despite an increase, this is considered to be a low pellet density (see Table 2).

Higher pellet frequencies were recorded from Chew Tobacco Bay and Port Adventure, with 20% frequency and 12% respectively. These results have not been directly compared with previous surveys, as they were not repeat measures of original transect lines. These areas have been the focus of previous monitoring efforts by Forest Research Institute scientists Glenn Stewart and Larry Burrows, and deer numbers in these areas

have previously been considered too high to allow regeneration of many palatable hardwood shrub species (Stewart & Burrows 1989).

New lines were established at random in Port Pegasus (lines Peg1-Peg8). Moderate deer pellet frequencies were reported from Scout Bay (Peg3 & 4), but otherwise low pellet frequencies were present.

Table 1. Key to line locations

Line number	*Line location*	*Number of pellet plots*
3	Bungaree	123
6	Rollers	59
10	Yankee	100
15	East Ruggedy	144
18	Benson Peak	83
25	Thomson Ridge	78
33	Rakeahua	90
40	Doughboy Bay	80
44	Wreck Creek – Mason Bay	80
47	Freshwater	106
50	Mason Head	104
PA	Port Adventure	100
CT	Chew Tobacco Bay	75
Peg1	Port Pegasus	40
Peg2	Diprose Bay	74
Peg3	Scout Bay	40
Peg4	South Scout Bay	70
Peg6	Albion Inlet	60
Peg7	Red Beach	60
Peg8	Broad Head	78

An earlier survey of animal pellet frequency was carried out at Chew Tobacco, Port Adventure and Port Pegasus by New Zealand Forest Service (Ross 1977). They considered the following classes of pellet frequencies were suitable for interpretation (Table 2).

Table 2. Assessment of pellet frequency (from Ross 1977)

% of plots with pellets present	*Assessment*
1-5	Low animal population
6-15	Moderate
16-25	High
>25	Extremely high

Deer diet information

The only deer rumen study carried out on Stewart Island was done by New Zealand Forest Service staff in 1985, and was reported on by Nugent & Challies (1988). The full list of plant species is reported in Table 3. As you will see, white-tailed deer feed on a wide range of species, including fresh and fallen leaves and fruits.

Table 3. White-tailed deer diet data from 27 rumens sampled by NZFS in 1985, Nugent &.Challies (1988).

Item			Numbers of samples in which item present in following %s				
Plant material			<1%	1-5%	>5%	Mean dry weight of samples	
Seaweeds							18.51
		Porphyra columbina	1	0	0	0.02	
		Unidentified brown seaweed	0	1	11	18.49	
Fungi							0.17
		Bracket, gilled & other	7	1	0	0.17	
Lichens							0.25
		Cladonia sp.	1	0	0	0.01	
		Unidentified lichens	2	0	1	0.24	
Ferns							1.65
	Hen and chicken fern	Asplenium sp.	10	0	0	0.05	
	Palm-leaf fern	Blechnum "capense"	1	0	2	1.2	
		Blechnum sp.	8	1	0	0.15	
	Tree-fern	Dicksonia squarrosa	8	1	0	0.09	
	Finger fern	Grammitis sp.	1	0	0	0.01	
	Hounds tongue fern	Phymatodes diversifolium	7	0	0	0.06	
	Prickly shield fern	Polystichum vestitum	1	0	0	0.04	
	Bracken	Pteridium esculentum	1	0	0	0.01	
		Unidentified leaves and stems	10	0	0	0.04	
Trees & shrubs							58.61
	Stinkwood	Coprosma foetidissima	14	5	4	1.99	
	Shiny karamu	Coprosma lucida	1	2	0	0.13	
		Coprosma sp - large leaved	9	3	0	0.42	
		Coprosma sp - small leaved	3	2	0	0.21	
	Rimu	Dacrydium cupressinum	3	2	2	1.09	
	Turpentine scrub	Dracophyllum sp	4	4	1	0.75	
	Broadleaf	Griselinia littoralis	0	7	19	21.7	
	Southern rata	Metrosideros umbellata	9	6	2	1.19	
	Red matipo	Myrsine australis	8	4	3	1.26	
	Tree daisy	Olearia arborescens	8	6	1	1.17	
	Leatherwood	Olearia colensoi	0	4	10	10.16	
		Olearia sp.	1	2	0	0.22	
		Pittosporum sp leaves	6	4	1	0.75	
		Pittosporum sp fruit	3	1	0	0.09	
	Lancewood	Pseudopanax crassifolius leaves	3	2	1	0.67	
		Pseudopanax crassifolius fruit	0	1	0	0.07	
		Pseudopanax edgerleyi	1	0	0	0.02	

	Three-finger	Pseudopanax simplex leaves	2	2	4	3.59	
		Pseudopanax simplex fruit	0	0	1	0.59	
		Pseudopanax sp	3	2	4	2.05	
	Muttonbird scrub	Senecio reinoldii	3	10	11	8.28	
	Kamahi	Weinmannia racemosa	11	3	1	0.86	
		Unidentified leaves, stems & roots	16	7	1	1.08	
		Unidentified fruits	1	0	1	0.27	
Climbers							0.07
	Supplejack	Ripogonum scandens	1	0	0	0.02	
	Bush lawyer	Rubus sp.	2	0	0	0.05	
Herbs							9.5
		Luzuriaga parviflora	3	1	0	0.12	
		Nertera depressa	4	0	1	0.3	
		Nertera sp.	5	0	0	0.02	
	Flax	Phormium tenax	0	1	5	7.14	
		Phormium sp.	2	3	2	1.76	
		Thelymitra venosa	0	1	0	0.14	
		Unidentified	4	0	0	0.02	
Cushion and mat plants							0.02
		Mitrasacme novae-zelandiae	3	0	0	0.02	
Grasses							8.36
	Wire rush	Empodisma minus	0	1	0	0.05	
		Gahnia sp.	0	1	0	0.05	
	Bush rice grass	Microlaena avenacea	1	0	0	0.02	
	Hook grass	Uncinia sp.	4	0	0	0.03	
		Unidentified rush	9	5	1	0.92	
		Unidentified sedge	9	11	3	1.99	
		Unidentified grasses	8	5	8	5.3	
Unidentified plant material			6	2	1	2.43	2.43
Animal material							0.43
Miscellaneous		Deer hair	18	2	0	0.17	
		Insect larvae	5	1	0	0.07	
		Misc. animal tissue	4	1	0	0.19	
Totals						100	100

Deer impacts on forest regeneration

Introduction

As part of the Stewart Island Forest Health project in 1998-2000 we monitored the impacts of deer browsing on Stewart Island by comparing unfenced forest plots with exclosure plots, fenced to exclude deer browsing since 1979. Also, comparative studies have been carried out between the widespread unfenced plots on Stewart Island, with plots on Bench and Ulva Islands, which have no deer or possums present. Methods follow Allen (1993). Key results from these studies are presented here.

Objectives

1. To assess changes in forest structure and composition in northern Stewart Island over approximately 20 years.
2. To investigate the influences of introduced browsing animals on forest regeneration.
3. To compare the forest structure and composition on Stewart Island with islands where rats, deer and possums are absent (Ulva Island), and where deer and possums are absent (Bench Island).
4. To assess the impact of possums on the health of kamahi - rimu - southern rata forest in northern Stewart Island, and compare with health of forests where possums are absent (Bench and Ulva Islands).
5. To determine the extent to which tree ferns contribute to the basal area of kamahi – rimu – southern rata forests of Stewart Island and the pest-free islands.
6. To determine whether, and to what extent, animal control will be necessary in Stewart Island for: (1) the prevention of further canopy dieback and (2) the regeneration of palatable species.

Key results

Exclosure plots - trees

All exclosure plot results are derived directly from Bellingham & Allan 2002.

In the deer exclosures, basal areas and densities of trees ≥2.5cm dbh (diameter at breast height) were not different from their adjacent unfenced plots (controls) in any of the censuses (1979, 1984 and 2000; paired t-tests, all $p>0.11$). This means that information about the undergrowth in the exclosures and control plots are comparable. Stand basal areas increased over 21 years within deer exclosures and in control plots (Table 4).

While tree stem densities within exclosure plots increased significantly over 21 years, they did not in the control plots (Table 4). Recruitment rates of stems ≥2.5cm dbh of all species combined were much greater in deer exclosures than in controls over the study period, but mortality rates were not different.

Tree fern (*Cyathea smithii, Dicksonia squarrosa*) stem densities and basal areas, measured only in 2000, did not differ between exclosures and controls (Table 4).

Exclosures plots – seedlings and saplings

Inside exclosures, the density of seedlings of all woody species increased significantly between 1979 and 2000 (paired t-test, $p=0.032$ *), in contrast to the adjacent control plots where there was no change in density (paired t-test, $p=0.25$). Sapling densities of all woody species were not different between exclosures and controls in either 1979 or 2000. Although the highly palatable broadleaf (*Griselinia littoralis*) was present in four of five exclosures, negligible recruitment occurred over 21 years; no saplings were recorded

in exclosures and seedlings (>15 cm tall, at 0.166m^{-2}) were only recorded in one exclosure.

Table 4. Tree characteristics in exclosure and control plots on Stewart Island (data from Bellingham & Allan 2002). (* means statistically significant, when $p<0.05$, ** and *** mean highly significant, when $p<0.01$, 0.001 respectively, NS means non-significant).

		1979	2000	Significance
Tree basal area (m^2/ha, ± 1 S.E.)	Exclosures	58.4 ± 10.2	68.8 ± 11.8	P=0.047 (*)
	Controls	81.5 ± 22.6	91.2 ± 22.5	P=0.006 (**)
Tree stem density (#/ha, ± 1 S.E.)	Exclosures	885 ± 165	1215 ± 208	P=0.004 (**)
	Controls	880 ± 205	870 ± 130	P=0.93 (NS)
Tree fern basal area (m^2/ha, ± 1 S.E.)	Exclosures	-	5.76 ± 2.21	P>0.37 (NS)
	Controls	-	3.18 ± 1.31	
Tree fern stem density (#/ha, ± 1 S.E.)	Exclosures	-	485 ± 240	P>0.37 (NS)
	Controls	-	410 ± 201	

Unfenced plots - trees

Tree basal area for all species combined (≥2.5 cm dbh) increased on Stewart Island over the 20 year interval, while stem density decreased in the widespread and northern plots (Table 5). In the plots around Chew Tobacco Bay and Port Adventure (eastern plots), stem density increased while basal area did not change significantly, and was much lower than the other plot networks (Table 5).

Table 5. Stand basal area and stem density summary for unfenced plots on Stewart Island (results from Bellingham & Allan 2002).

		1981	1999/2000	Significance
Tree basal area (m^2/ha, ± 1 S.E.)	Widespread plots	73.0 ± 2.52	75.3 ± 2.7	P=0.004 (**)
	Northern plots	71.3 ± 5.54	78.7 ± 5.60	P<0.001 (***)
	Eastern plots	42.1 ± 4.42	43.6 ± 4.45	P=0.48 (NS)
Tree stem density (#/ha, ± 1 S.E.)	Widespread plots	3115 ± 257.4	2526 ± 195.5	P<0.001 (***)
	Northern plots	3431 ± 768.7	2978 ± 759.5	P=0.023 (*)
	Eastern plots	951.4 ± 113.4	1546 ± 252.9	P=0.032 (*)
Tree fern basal area (m^2/ha, ± 1 S.E.)	Widespread plots	-	2.3 ± 0.64	
	Northern plots	-	3.1 ± 0.74	
	Eastern plots	-	5.9 ± 1.1	

For trees ≥2.5 cm dbh, annual mortality rates were higher than recruitment rates across all species combined in the widespread and northern plots, reflecting thinning of smaller stems (see Table 1, Bellingham & Allan 2002). In contrast, in the eastern plots around Chew Tobacco Bay and Port Adventure, mortality and recruitment rates were not different and were greater than in all other plot groups (Bellingham & Allan 2002). The only plot network where recruitment exceeded mortality was within deer exclosures, reflecting ingrowth of small stems.

Unfenced plots - seedlings and saplings

Despite slight increases in mean deer pellet frequency, and increasing basal area, there were also increases in seedling and sapling densities across unfenced plots in northern Stewart Island, including some species palatable to deer, such as *Coprosma foetidissima.*

Seedlings increased in density significantly in the widespread plots between 1981 and 1999 for all species combined and for stinkwood (*Coprosma foetidissima*), rimu (*Dacrydium cupressinum*) and miro (*Prumnopitys ferruginea*) (Table 6). Sapling desnities increased in the widespread plots for all woody species combined and for stinkwood, rimu, Hall's totara (*Podocarpus hallii*) and pepperwood (*Pseudowintera colorata*). None of the eight species reported on in Bellingham and Allan showed declines in seedling or sapling densities. Stinkwood also increased in the eastern and northern plots networks, with a 150 fold increase in the eastern plots, far exceeding the densities of other woody seedlings.

Table 6. Mean seedling and sapling densities per square metre ± 1 S.E. for all woody species and eight individual canopy tree and shrub species in 47 widespread plots in northern Stewart Island, in 1981 and 1999 (from Table 2, Bellingham & Allan 2002). Significance values are p-values for tests between years.

	Seedling density/m^2			Sapling density/m^2		
	1981	1999	Significance	1981	1999	Significance
All species	1.07 ± 0.160	2.84 ± 0.339	<0.0001 (***)	0.085 ± 0.011	0.21 ± 0.031	<0.001 (***)
Stinkwood	0.363 ± 0.113	0.906 ± 0.152	<0.0001 (***)	0.032 ± 0.0049	0.084 ± 0.018	0.005 (**)
Rimu	0.028 ± 0.011	0.049 ± 0.013	0.046 (*)	0.001 ± 0.0004	0.003 ± 0.001	0.006 (**)
Broadleaf	0 ± 0	0.003 ± 0.002	0.17 (NS)	0.0001 ± 0.0001	0.0001 ± 0.0001	0.57 (NS)
Rata	0.001 ± 0.001	0.004 ± 0.002	0.16 (NS)	0.0001 ± 0.0001	0.0001 ± 0.0001	0.79 (NS)
Hall's totara	0.032 ± 0.0093	0.043 ± 0.012	0.28 (NS)	0.002 ± 0.001	0.004 ± 0.001	0.010 (*)
Miro	0.017 ± 0.005	0.060 ± 0.016	0.009 (**)	0.0003 ± 0.0002	0.002 ± 0.001	0.055 (NS)
Pepperwood	0.008 ± 0.005	0.016 ± 0.0056	0.33 (NS)	0.001 ± 0.0003	0.004 ± 0.001	0.002 (**)
Kamahi	0.031 ± 0.011	0.034 ± 0.010	0.78 (NS)	0.011 ± 0.0031	0.009 ± 0.002	0.33 (NS)

Patterns in regeneration in relation to deer pellet indices

Regression models were calculated to determine whether certain factors were more important than others in predicting changes in seedling and sapling densities on the widespread plots between 1981 and 1999. These are reported on in full in Bellingham & Allan, and the key points are summarised here. Densities of seedlings of rimu and pepperwood between 1981 and 1999 increased as pellet indices increased around the widespread plots, and the same was the case for sapling densities of miro, Hall's totara and miro. These are all known to be unpalatable to deer. In contrast, stinkwood seedling densities increased where deer pellet density declined, and increases in stinkwood sapling densities were negatively related to 1981 deer pellet density indices (Bellingham & Allan 2002).

Offshore islands comparisons

Comparisons between Stewart Island plots with Bench and Ulva Island plots were not reported on in Bellingham & Allan (2002), so some key findings from the data are presented in this section. Also, only 8 dominant species were reported on previously, so this section provides additional information on some highly palatable species which are under threat by both possum and deer browsing.

3-finger (Haumakaroa/*Raukaua simplex*) seedlings and saplings are virtually absent from the forest floor on Stewart Island, and only occur on treefern trunks and in the crowns of large trees. When they do occur on the forest floor, they are sometimes protected from deer browsing by fallen logs in canopy gaps. In contrast, they grow in high densities on pest-free Ulva and Bench Islands. The same is also true for a number of other species, including large-leaved species such as shiny karamu (*Coprosma lucida*), broadleaf (*Griselinia littoralis*), lancewood (*Pseudopanax crassifolius*). Many of these species are also palatable to possums.

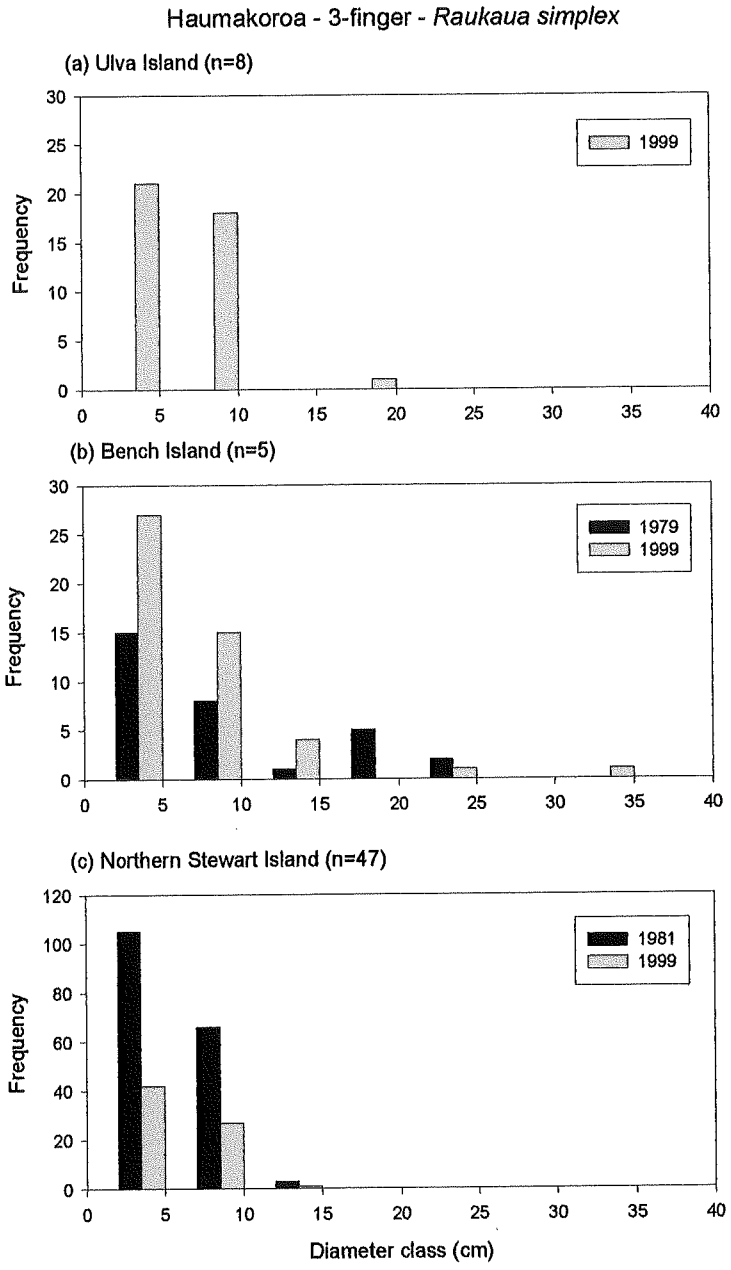

Figure 2. Tree frequencies of three-finger on (a) Ulva Island, (b) Bench Island, and (c) Stewart Island. This species is in rapid decline on Stewart Island.

When species are palatable to both possums, as adult trees, and deer, as seedlings, their future is uncertain on Stewart Island. The rate of decline of three-finger trees on Stewart Island is alarming, and is illustrated by Figure 2. On Bench Island, there has been adequate recruitment to result in an increase in tree numbers between 1979 and 2000, whereas on Stewart Island, adult trees have died and have not been replaced. It appears that within about 20 years the present population of ground-dwelling three-finger trees may be extinct. Similar patterns are present for other highly palatable species.

Table 7. Mean seedling and sapling densities per square metre in 1999. Stewart Island results are from 47 widespread northern plots; Ulva Island 8 plots; Bench Island 5 plots. Results for Haumakaroa (3-finger) are in bold.

	Seedling density/m^2			Sapling density/m^2		
	Stewart Is	Ulva Is	Bench Is	Stewart Is	Ulva Is	Bench Is
All species	2.84	2.515	1.161	0.21	0.459	0.222
Stinkwood	0.906	0.248	0.166	0.084	0.034	0.030
Rimu	0.049	0.062	0.011	0.003	0.009	0.002
Broadleaf	0.003	0.097	0.122	0.0001	0.016	0.004
Rata	0.004	0	0.011	0.0001	0	0
Hall's totara	0.043	0.124	0	0.004	0.026	0
Miro	0.060	0.021	0	0.002	0.0008	<0.001
Pepperwood	0.016	0	0	0.004	0.0017	0.002
Kamahi	0.034	0.014	0	0.009	0.017	0.008
3-finger	**0.033**	**0.504**	**0.210**	**0.002**	**0.058**	**0.088**
Lancewood	0.021	0.235	0	0.002	0.126	0.013
Red matipo	0.008	0.062	0.044	<0.001	0.013	0.003
Shiny karamu	0	0.090	0.011	0	0.004	0.008

Table 7 shows seedling and sapling densities across all plots in northern Stewart Island, and on Ulva and Bench Islands. Additional data for palatable species has been added to show how much more abundant many species are on the pest-free islands (often an order of magnitude greater). Many of these palatable species are important flowering and fruiting trees, which are important food sources for insects and birds. Note that for Stinkwood, seedling and sapling densities are quite low on the pest-free islands compared to Stewart Island. This is most likely due to the competition from a wide variety of other tree and shrub species on the pest-free islands.

Discussion

Greater rates of recruitment of trees over 21 years inside exclosures compared with outside does suggest that survivorship of seedlings and saplings may be lower when deer browse the understorey. Despite this, our study found no evidence to suggest white-tailed deer threaten population structures of key canopy tree species on Stewart Island in the long term (Bellingham & Allan 2002). However, seedlings of some highly palatable sub-canopy species will be restricted to sites out of reach of deer browsing, and their ability to grow to mature fruit-bearing trees is largely unknown. We do not know whether loss of some species from the forest floor will lead to their extinction, but this may occur, so requires further research.

Tree ferns

The exclosure results showed no significant difference for tree fern basal area or stem density between exclosures and controls, but this may be due to the small sample of 5 paired plots. There were obvious signs of deer browsing on young stems of *Dicksonia squarrosa* throughout Stewart Island forests. This will be further investigated with the newly established exclosure plots.

Future survey and monitoring proposed

To better understand the impacts of possums, rats and deer on the regeneration of key palatable species, we are currently establishing new fenced exclosure plots which exclude deer but allow possum and rat access. We have chosen sites with fairly open canopy for these exclosures, so we can monitor regeneration of species which often require high light availability, such as broadleaf. Seven of these exclosures will be placed in a site due to receive possum control: Yankee River block A5. One exclosure will be within the

smaller site within this block which will also receive rat control. Seven exclosures will also be located within the block adjacent to A5 - A3, around Rollers and Bungaree, where no possum control is currently proposed. These two blocks were chosen because they have extensive baseline monitoring with existing plots and pellet lines. We intend to address the following questions with the information collected on the exclosures and on adjacent unfenced plots next to each exclosure, and on existing unfenced plots:

1. Does possum and/or rat control allow the regeneration (growth and survival) of key palatable species on Stewart Island?
2. How long will it take key palatable species to grow through to sapling height inside and outside deer exclosures on Stewart Island, in the presence and absence of possum control?
3. Does removal of deer browsing on Stewart Island allow regeneration of palatable species to occur, or is additional management required (e.g. removal of fern ground cover)?

Also, to better predict the survivability of key palatable species, we need to investigate their potential to grow as epiphytes, by studying growth, flowering, fruiting and seed production of individual plants living on tree-fern trunks and in the crowns of adult trees. An understanding of their seed viability will also help us predict the long-term survivorship in Stewart Island forests.

Any future management of deer would focus on the growth and survivorship of key palatable species, rather than actual numbers of deer, as this is difficult and expensive to monitor, and is not focussed on the conservation outcome – regeneration of key palatable species, and maintenance of biodiversity. The most likely scenario for control would be to lower deer numbers for a period of time, sufficient to allow seedlings and saplings of broadleaf, 3-finger, lancewood and shiny karamu to grow through the deer browse tier in a high priority site on Stewart Island. This would ensure these species are retained as a component of the ground-dwelling flora of the island, for future generations. By monitoring tagged individuals of the key palatable species, it will be possible to make predictions on how long deer numbers would have to be lowered for. This monitoring is currently being used to guide management in the Kaweka Forest Park.

References

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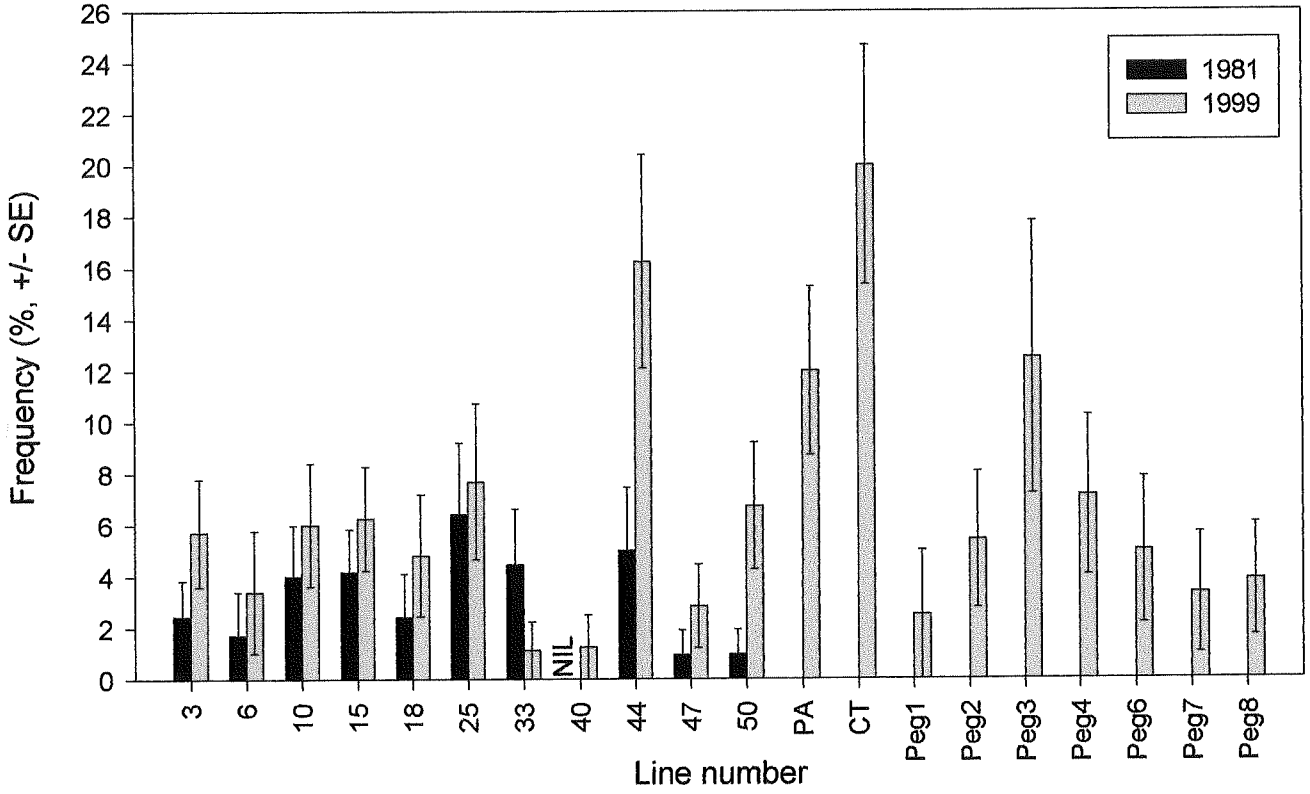
(a) Deer pellet frequency in Northern and Southern Stewart Island



(b) Possum pellet frequency in Northern and Southern Stewart Island

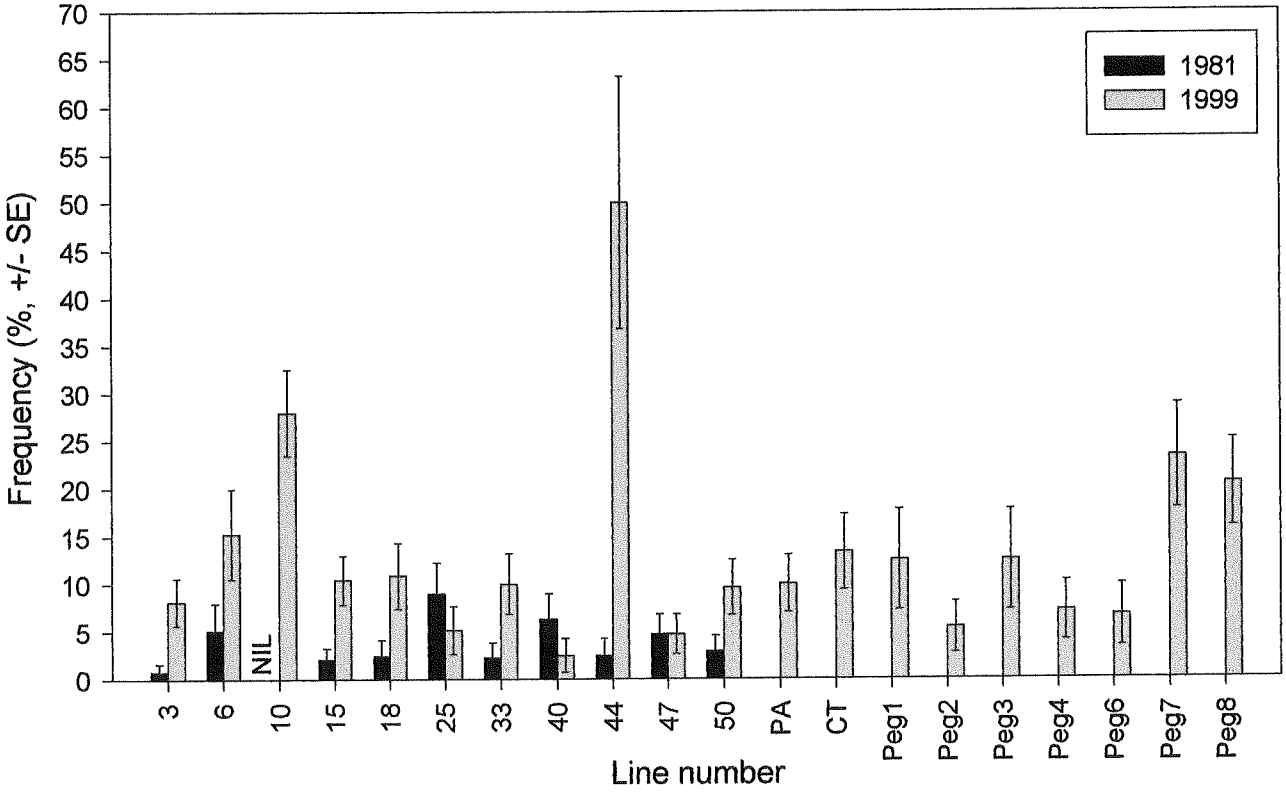


Fig 1. Pellet frequency summary data from Stewart Island forest health survey. Error bars show Standard Error.