Department of Conservation
Te Papa Atawhai

The impact of red deer (*Cervus elaphus scoticus*) in the Western Ruahines:

Evidence from exclosure plots

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Summary

Measurement of eight fenced exclosure plots established in the 1960s in forest on the western side of the Ruahine Forest Park from 1998 to 2005 found some differences between fenced plots and unprotected forest which could be attributed to the effects of browsing ungulates, mainly deer. However the overall condition of the forest appears to have improved since the plots were built.

Accounts from the 1960s describe widespread mortality and lack of recruitment which is no longer so apparent. Beech species, which are not highly palatable to deer, show very little difference between fenced and unfenced plots, suggesting that recruitment is possible with current deer densities. Other, more palatable species (broadleaf, raukawa, mahoe, coprosmas and *Pseudopanax)* tended to be more abundant in plots suggesting that their regeneration is inhibited in current conditions. Several key species (notably kamahi) that are highly palatable to deer and possums and which suffered severe dieback in the 1950s and 1960s show very little evidence of recruitment, even inside fenced plots, particularly in the southern part of the range. This suggests that conditions have been fundamentally changed and those species can no longer establish even in the absence of browse.

The plots sampled here cover a very small part of the range and results varied greatly from plot to plot, probably reflecting differences in forest type and environmental conditions. The tentative conclusions described above should be verified by re measurement of the widespread network of unfenced permanent forest plots.

Contents

1. Introduction 4

1.1. Aim 4

1.2. Impacts of deer on native vegetation 4

1.3. Forest of the Ruahine Range 5

2. Methods 7

2.1. Field methods 7

2.2. Analysis methods 7

3. Results 10

3.1. Alphabet 10

3.2. Triangle 12

3.3. Waterfall 15

3.4. Maropea Forks 18

3.5. Wakelings Hut 21

3.6. Maharahara 24

3.7. Peg Creek 27

3.8. Whakaurekau 30

3.9. Summary 33

4. Discussion 34

4.1. Variability between sites 35

4.2. Implications for management 37

5. Conclusions 39

6. Recommendations 39

7. Acknowledgements 40

8. References 41

9. Appendices 44

1. Introduction

1.1. Aim

This report compares vegetation in eight fenced plots in the western Ruahines with paired unfenced plots and earlier qualitative descriptions to assess: whether differences in vegetation structure and composition between the fenced and unfenced plots are consistent with the effects of deer browse and to what extent this has changed since the plots were established.

1.2. Impacts of deer on native vegetation

Introduced wild mammalian herbivores pose a serious threat to the conservation of New Zealand's remaining native forests (Nugent *et al* 2001). Deer were introduced into New Zealand in the late 19th Century and it was soon evident that they were reducing the density of under–story vegetation in many forests and altering the composition by preferentially browsing certain species.

Deer favour broadleaved, hardwood species such as large leaved–coprosmas, mahoe, broadleaf, fuchsia, fivefinger, and hangehange. When deer densities are high, or have reached high levels and then declined naturally, the growth of these plants is limited. Other plants, such as podocarps, tawa, beech, and horopito, are avoided and may increase in abundance (Forsyth et al. 2003). This pattern has been observed using exclosure plots (Allen et al. 1984, Stewart et al. 1987, Smale et al. 1995, Bockett 1997, Walls 1997, Wardle et al. 2001, Husheer 2005), comparing similar areas with different deer populations (Veblen and Stewart 1980) and relating forest characteristics through time to fluctuating deer populations (Stewart et al. 1987, Husheer et al. 2003, Husheer and Frampton 2005).

Deer inhibit the regeneration of many plant species which can result in unpalatable species benefiting from the decreased competition for light and nutrients and dominating a habitat. The subsequent removal of deer may not necessarily result in a direct reversal of their impacts (Nugent 2001, Coomes et al. 2003).

Although palatability is a useful tool for examining changes in plant composition it should be noted that species which are typically classified as unpalatable, like mountain beech, can be

impeded by deer browse (Husheer et al. 2003, Husheer and Robertson 2005). A similar relationship between high deer densities and poor regeneration of beech was hypothesized for the north eastern Ruahines (Widdowson 1960).

1.3. Forest of the Ruahine Range

Before the advent of red deer (*Cervus elaphus scoticus*), the forests of the Ruahine Ranges in the lower North Island, were described by well known explorer, Colenso (1884) as being rich and healthy. The vegetation of the Ruahines varies considerably with altitude. The basic pattern is of podocarp–broadleaf forest on the foothills, with mid–altitude beech or kamahi forest above, a belt of pahutea, and finally subalpine scrub and/or tussock grassland. There are also trends related to longitude.

Elder (1960) identified four main vegetation zones: northern, central, western and southern. To the north of the Mangatera red beech is dominant with emergent podocarps at low altitudes, co–dominant kamahi at middle altitudes and mountain beech with scattered hall's totara and pahutea on upper slopes. Red tussock grassland also occurs. The central forests are red beech at mid–altitudes, with mountain beech at the timberline. Forests south of the Mokai–Patea and west of the main divide were also red beech, but with pahutea and pink pine at higher altitudes. Broadleaf and lacebark were also common (Cunningham 1979). The central and western zones have dense leatherwood scrub above the timberline with snow tussock grasslands. The southern zone (below the Pohangina River) was dominated by kamahi with emergent rimu and northern rata on lower slopes and pahutea and halls' totara on upper slopes. There are no open tussock tops in this area, the highest parts being covered in dense leatherwood scrub. Seral scrub and low forest was dominated by fuchsia and wineberry (Elder 1965).

The vegetation has been modified by possums, goats and deer (some sika, but mostly red). Red deer probably entered the Ruahine Range about 1900 (Cunningham 1979). The red deer population increased rapidly until in approximately 1940 in the north–east and progressively later to the south (Widdowson 1960) they exceeded carrying capacity and subsequently crashed to a level with a more even balance between deer consumption and annual plant production (Nugent *et* al 2001). Since 1920, deer have had a profound and deleterious effect on the forests throughout the Ruahine Ranges (Cunningham 1979).

Deer control began in 1938, was halted by the war in 1938 but continued afterwards. The Forest Service undertook widespread (all catchments from Whakarekau south) shooting from helicopters in 1972–1978, which significantly reduced deer pellet density in those areas (Oaks 1983). Commercial helicopter hunting began in 1975 and also contributed to the decline. Helicopter hunting was restricted from the Pourangaki, Mangawhakariki and Oroua catchments in 1981 (ibid).

Deer pellet frequencies were highest when first measured in 1971, dropped considerably by 1976 and were still lower in 1983 (James and Beaumont 1971, Cuddihy 1977, Oaks 1983). Recently there have been suggestions that aerial harvest has declined, which may lead to increased deer densities but periodic remeasurement of a small subset of pellet lines since 2000 has not shown this (Hawcroft 2005).

Possums were first introduced in the 1883 (Cunningham 1979). By 1955 they occupied most of the range. Collapse of the rata–kamahi forest in the south was first noted in 1948 and was widespread by 1955 (Elder 1965). The massive loss of trees (largely kamahi in the canopy and fuchsia, pate and large leaved coprosmas in the subcanopy) from the Pohangina south has been attributed to the concerted effects of possums, deer and climate (James and Beaumont 1971, Rogers and Leathwick 1997). There were several attempts at possum control, the first in Opawe catchment in 1958 (Cunningham 1966) and continuing throughout the 1960s and 70s but at present the only control is around the limestone outcrop of Ruahine Corner (Mackintosh and Hawcroft 2005).

In 1962, the first of many exclosure plots (Cunningham 1979) were established throughout the Ruahine range to monitor the ongoing impacts of deer in an attempt to understand whether the forest has shifted into an alternative state by deer browsing, from which further directional change is unlikely to occur, or whether deer browsing is continuing to induce further shifts in vegetation composition (Husheer *et* al 2003). Ten exclosure plots in the western Ruahines (constructed in the 1960s and 1970s by the New Zealand Forest Service) have been re–measured since 1997, according to 20 × 20 protocols (Figure 1). Most of these were in podocarp/broadleaf forest. Results from the Pohangina plots, measured in 1997, have already been reported and show increased densities of kanono and other palatable species inside the fenced plots, and more horopito outside, in both the tree and sapling tiers. Differences in the seedling tier were less pronounced (Walls 1998).

2. Methods

This study draws on qualitative information from early published accounts of the study area and information collected by Department of Conservation staff from eight exclosure plots, each paired with an unfenced control, measured between 1999 and 2005.

Exclosure plot studies investigate the development of plant communities in the absence browsing animals (Allen *et* al 1984). These allow a direct comparison between browsed and unbrowsed sites and therefore indicate the species assemblages which may develop in the absence of browsing pressure (Bockett 1997, Coomes et al. 2003). The plant community development occurring inside the exclosure will result in a vegetation type which may or may not resemble that of the original (Allen *et* al 1984(Coomes et al. 2003).

2.1. Field methods

Data describing the structure and composition of the forest was collected from each exclosure plot using the method described in (Allen 1993) with some additional information (Dijkgraaf 2002).

Some exclosures were not large enough to accommodate a full 20x20m plot. In these cases a plan of the exclosure was drawn on site, showing the bearing and length of each fence and the dimensions of the area sampled.

2.2. Analysis methods

The eight exclosure plot pairs represent different forest types and have different histories, depending on when they were first constructed, whether they were ever open to deer, and when they were measured (Table 1). These differences make it inappropriate to lump the data together. Instead, results from each plot are presented separately. Analysis is based on a comparison of the density and composition of vegetation between the fenced plots and neighbouring controls. Four measures are used:

- Tree and sapling density (stems per m²)[1]

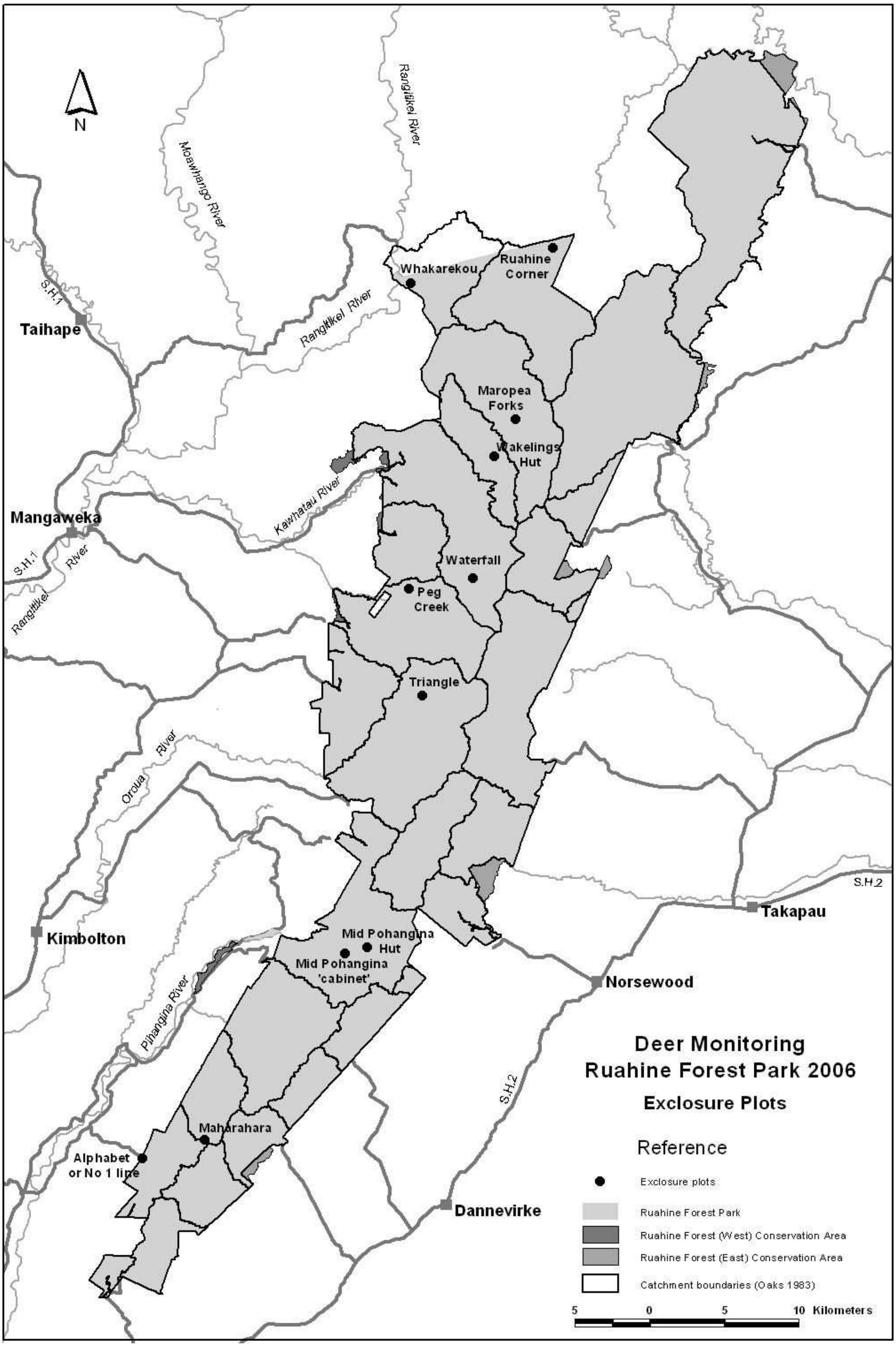
[1] Scale drawings were used to calculate the area inside irregularly shaped exclosures, so that densities could be calculated. Several drawings were not exact so areas are only approximate.

- Woody seedling density (plants per m²)
- Seedling frequency (proportion of subplots in which any plant in each palatability group is present)

Plants were grouped according to palatability to deer. Diet studies have shown that some plant species are sought out and consumed in higher proportions than they occur in the forest, while others are specifically avoided and others are ‘neutral’ – browsed in about equal proportion to their representation in the forest (Forsyth et al. 2002). Each plant species was classified as High, Neutral or Low palatability based on published reviews (Nugent 2001, Forsyth et al. 2002) supplemented with local knowledge. Plants unlikely to grow over 30cm – this included ground cover herbs, small ferns and grasses and was determined with reference to plant identification guides (Allan 1961, Johnson and Brooke 1998, Brownsey and Smith-Dodsworth 2000) – were categorized as ‘small’ and excluded from analysis. Plants for which no information could be obtained were classified as unknown.

Site	Catchment	Built	Survey	Altitude	Aspect	Vegetation type	Area
Alphabet or No 1 Line	Ross	1970	1998	420	na	Lowland northern rata & kamahi over tawa	382
Triangle	Oroua	1966	1999	950	na	Western red beech	261
Waterfall	Kawhatau		2001	1300	na	Central mountain beech	370
Maropea Forks	Maropea	1965	2001	900	296	Central red beech & mountain beech	176
Wakelings Hut	Waikamaka		2003	1025	217	Central red beech, mountain beech & toatoa	315
Maharahara	Opawe	1960	2003	950	0	Southern broadleaf over leatherwood & horopito	
Peg Creek	Pourangaki	1970	2005	1242	292	Western pahutea–toatoa	
Whakarekau	Whakarekau		2005	500	150	Lowland kahikatea & matai over hardwoods	

Table 1 Summary of exclosure plots



Map 1: Location of exclosure plots

3. Results

3.1. Alphabet

Alphabet exclosure was built in 1970. The fence was inspected in 1996 and was in reasonable condition. Minor repairs were carried out in 1997 and in 1999 it was in good condition. It was measured in 1998. There is no exact drawing of the plot available (bearings of the sides were not taken) but it is approximately rectangular with an area of 382m². The control plot is located in similar vegetation, but is slightly smaller, being a 15x20m rectangle (300 m²).

This area was not visited in the 1961–62 vegetation survey (Cunningham 1966). In 1983 vegetation inside the fence included more palatable species but was not very different to that outside (Oaks 1983).

3.1.1. Trees

Similar density of trees was recorded in the exclosure (0.16 stems/m²) and the control (0.15) but basal area was much higher in the exclosure (109 *c.f.* 43 m²/ha). The plots were dominated by large tawa and mahoe. More species were present in the exclosure including hangehange, pigeonwood and heketara (figure 1).

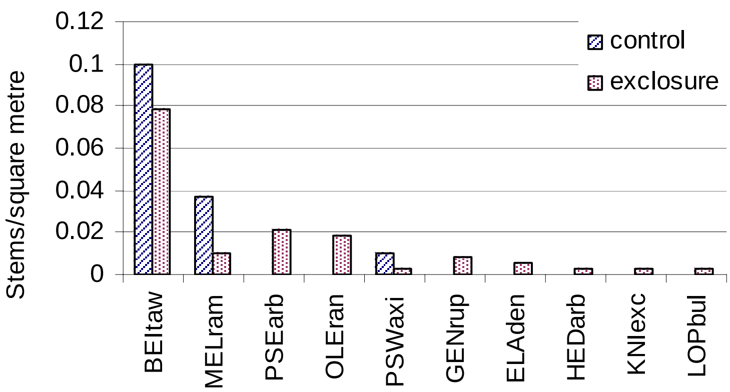


Figure 1 Density of the 10 most common species of tree (stems <3cm dbh)

3.1.2. Understorey

Density of woody saplings was higher in the exclosure (figure 2), which also contained a wider range of species and many more saplings of palatable species like mahoe, hangehange and

five–finger. The control plot had more supplejack (1.1 compared to 0.65plants/m²) and rata vines (0.07 compared to 0.0465plants/m²). Tree fern density did not vary between plots (data not shown).

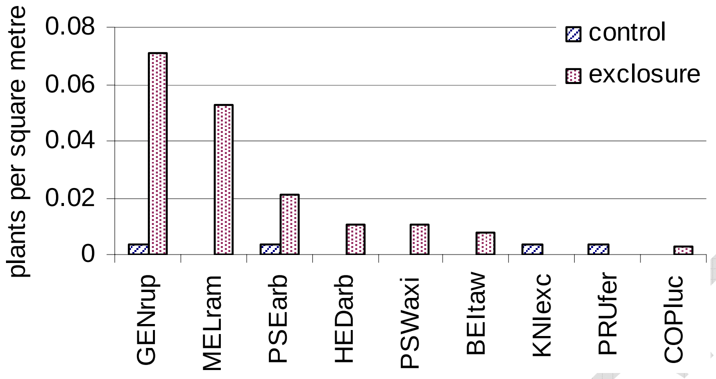


Figure 2 Density of the ten most common species of sapling

3.1.3. Seedlings

Plot	Trees and shrubs	Vines	Graminoids	Ferns
Control	13	3		9
Exclosure	10	3	1	8

Table 2 Number of species recorded in seedling subplots

Species were only recorded as present, not counted, so there is no information about seedling density for this plot. Frequency of seedlings for all palatability groups was higher in the exclosure plot than for the control (one seedling of neutral palatability, a hinau less than 15cm tall, was also recorded).

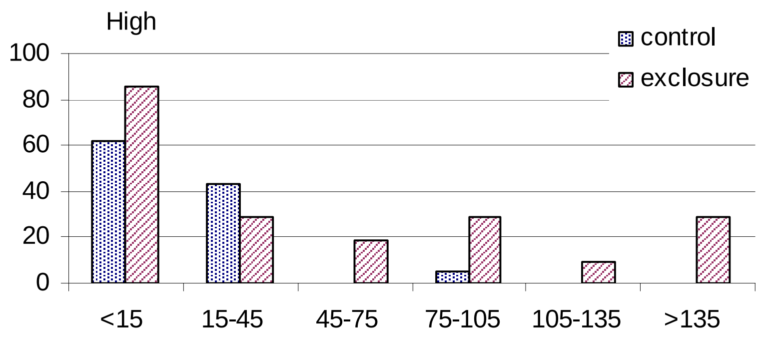
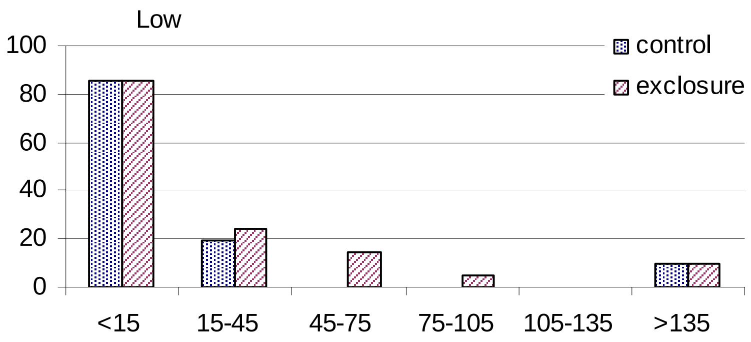


Figure 3 Frequency of seedlings in each height class by palatability (all species)



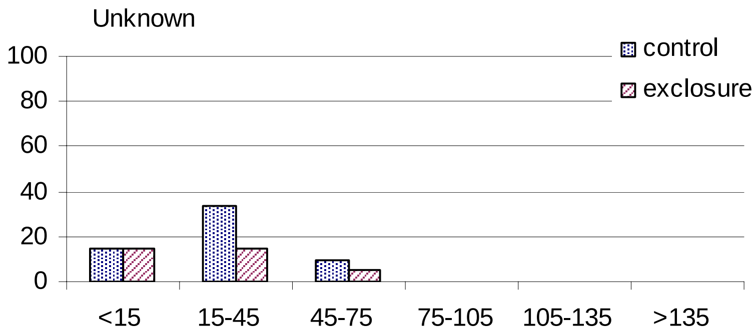


Figure 3 continued

3.2. *Triangle*

The Triangle exclosure plot was built in a canopy gap on a terrace above the Oroua River in 1966. It is roughly rectangular, with a total area of 261m². The plot was inspected in 1983 and was in a poor state with a large section of the fence down, and deer pellets inside the plot. This must have been remedied at some time because in 1996 it was in reasonable condition with minor repairs made in 1977. It was measured in 1999 and a rectangular control plot (300m²) was established in a nearby canopy gap.

The 1961–62 vegetation survey reported that goats, deer and hares were present in the red beech forest around the plot but that the forest was less damaged than elsewhere in the catchment where there was dense *Dicksonia lanata* and crown fern and sparse regeneration (Cunningham 1966). The plot was inspected in 1983 when broadleaf in the plot was noticeably bushy, although with some browse as the fence was damaged. Red beech seedlings appeared to be taller inside the plot (Oaks 1983).

3.2.1. Trees

Basal area was much higher in the exclosure than control (47 and 23 m²/ha respectively). Both plots were dominated by fivefinger and red beech but a greater range of species were present in the exclosure (Figure 4). Although more beech stems were tagged in the exclosure, the basal area of beech was greater in the control.

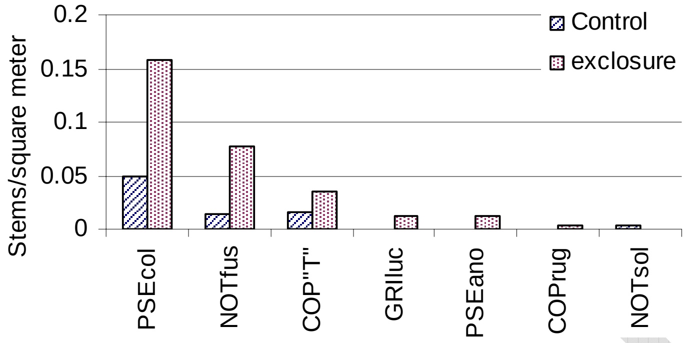


Figure 4 Density of tree stems (<3cm dbh)

3.2.2. Understorey

Sapling density was higher in the control plot (1.56 stems/m²) than the exclosure (1.21 stems/m²), due to the abundance of red beech and the small leaved coprosma species ‘T’ (Wilson and Galloway 1993). Eleven species of sapling were recorded in the exclosure, of which eight were recorded in the control. No treeferns or lianes were present. Epiphytes were not recorded.

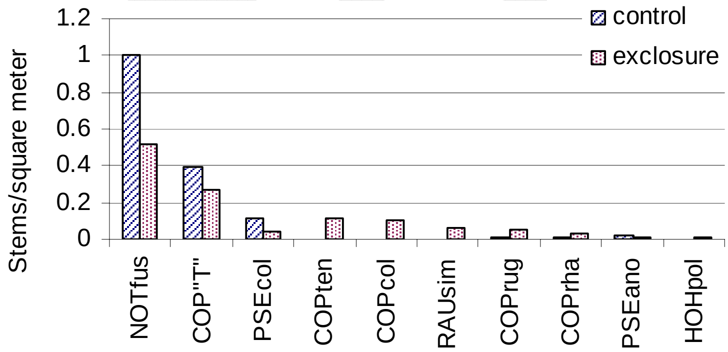


Figure 5 Density of the ten most common species of sapling

3.2.3. Seedlings

Seedling diversity was higher in the exclosure than in the control (Table 3). Density of woody seedlings was slightly lower overall.

Plot	Trees and shrubs	Ferns	Graminoids	Herbs
Control	9	6	1	6
Exclosure	13	3	3	4

Table 3 Number of species recorded in seedling subplots

Slightly more highly palatable seedlings were recorded in the exclosure, but variance was large (Figure 6)

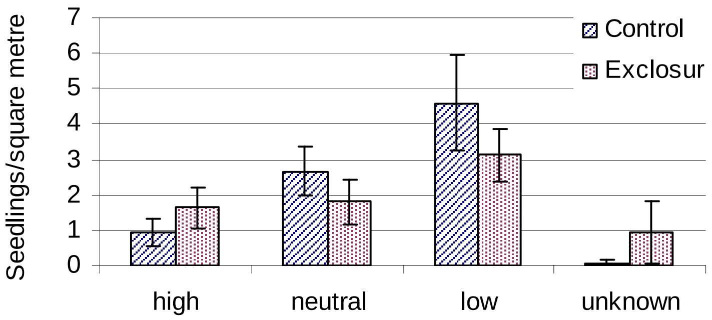


Figure 6 Mean density of woody seedlings over 15cm tall by palatability class (±SE)

There were no large differences in the frequency of seedlings in any height tier between the exclosure and the control plots (Figure 7).

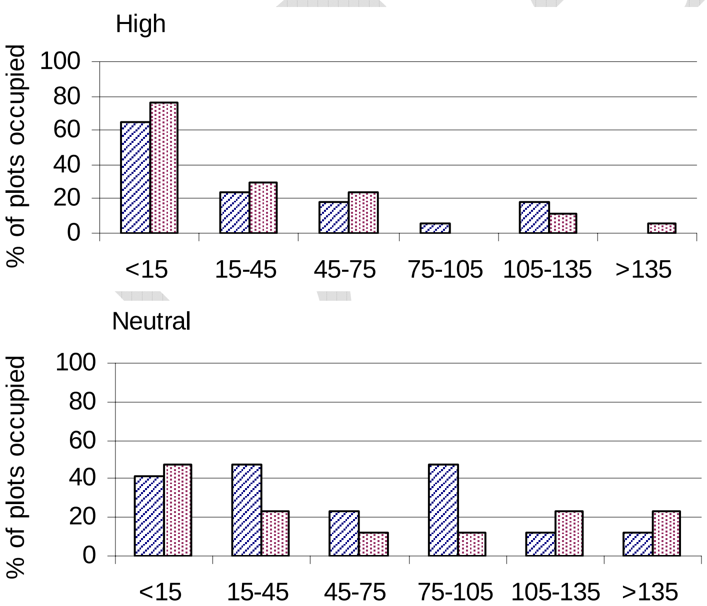


Figure 7 Frequency of seedlings in each height class by palatability (all species)

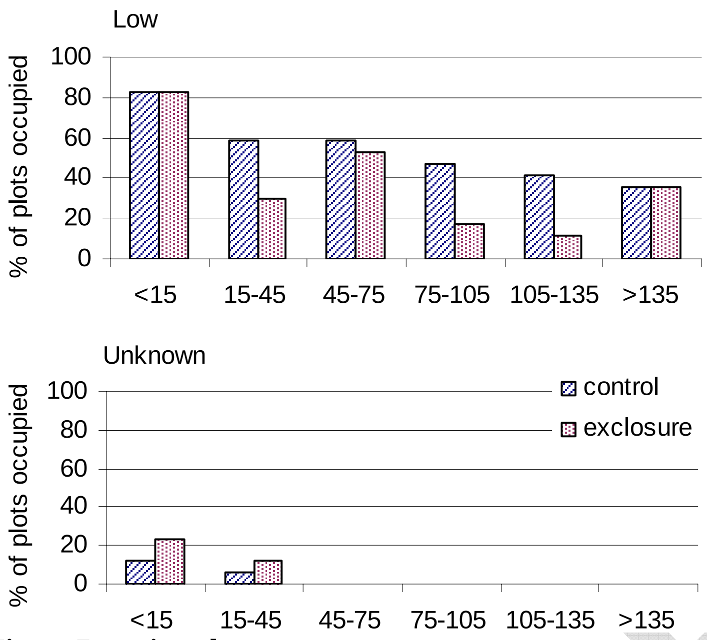


Figure 7 continued

3.3. *Waterfall*

This exclosure is in mountain beech forest near Waterfall Hut in the Kawhatau catchment. It was built in 1965 and is seven–sided, with an approximate area of 370m². It was inspected in 1983 and described as being in good condition. It was inspected and upgraded in 1997. An area within the fence of 15x19m (285m²) was measured in 2001 and a 20x20m control plot established nearby.

In 1962 the upper Kawhatau catchment was mountain beech with poor regeneration and obvious animal tracking (Cunningham 1966). In 1983, broadleaf seedlings of up to 60cm noted inside the fence and none outside (Oaks 1983).

3.3.1. Trees

The density of trees was similar (basal area of 56.8m²/ha in the exclosure, 51.8 in the control). Only two species were present. Mountain beech, mostly greater than 10cm dbh, dominated both plots.

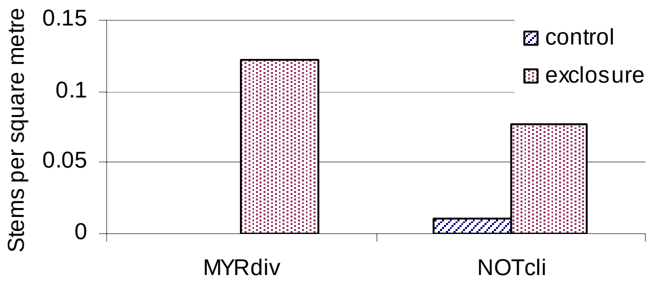


Figure 8 Density of tree stems (<3cm dbh)

3.3.2. Understorey

Saplings were much more common in the exclosure than in the control. The most common species was a small leaved coprosma similar to *Coprosma parviflora* (Wilson and Galloway 1993). Epiphytes, tree ferns and lianes were uncommon and were not recorded.

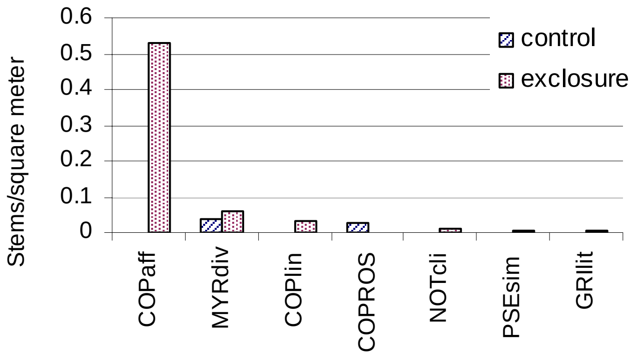


Figure 9 Density of saplings

3.3.3. Seedlings

A similar diversity of seedlings was recorded in the exclosure and control plots (Table 4). Density of woody seedlings was lower in the exclosure for all palatability classes (Figure 10)

Plot	**Trees and shrubs**	**Ferns**	**Graminoids**	**Herbs**
Control	8	4	2	5
Exclosure	7	4	2	6

Table 4 Number of species recorded in seedling subplots

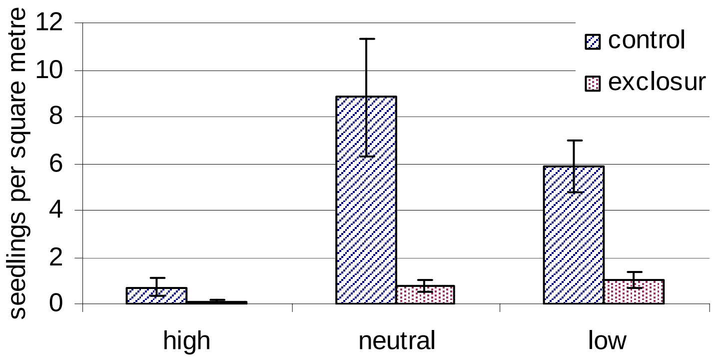


Figure 10 Mean density of woody seedlings >15 (±SE)

Seedlings were more frequent in the control plot than the exclosure, except for palatable species in the taller height classes (Figure 11).

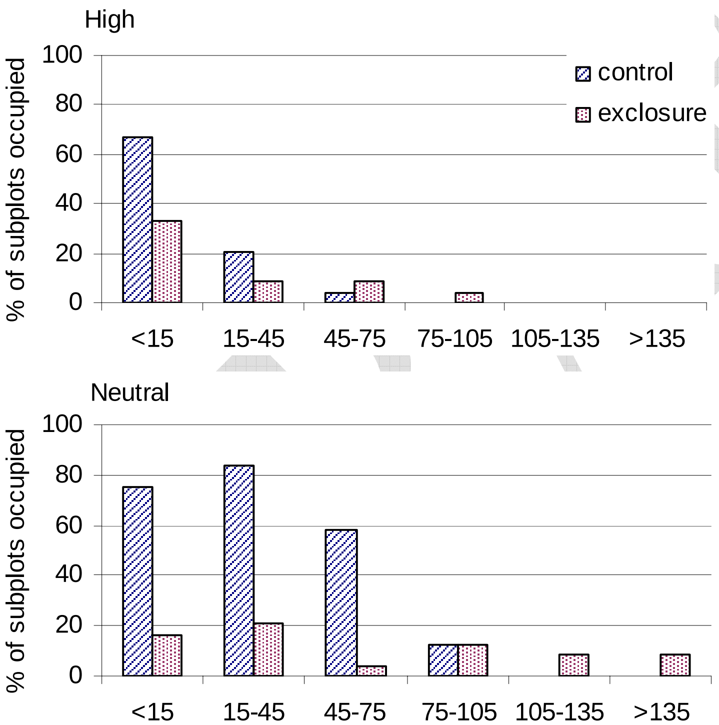


Figure 11 Frequency of seedlings by height class and palatability group (all species)

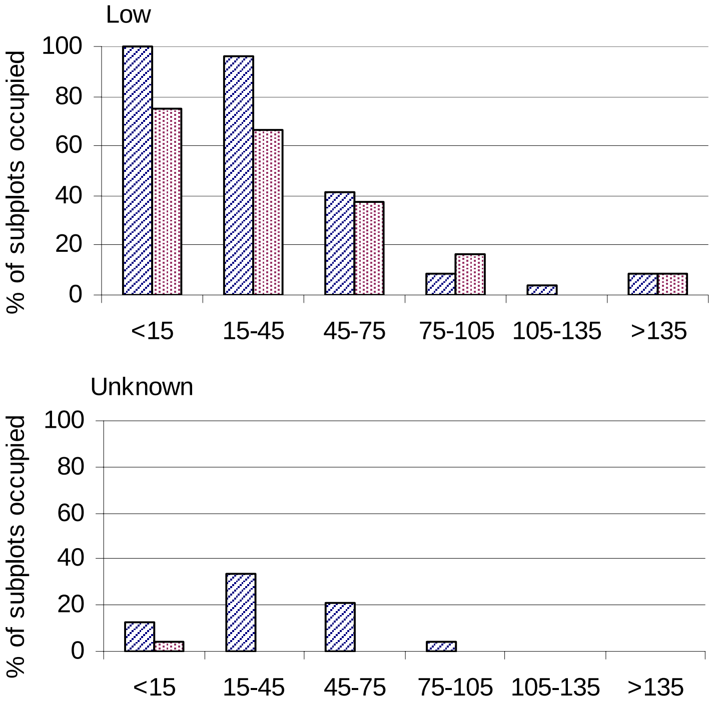


Figure 11 continued.

3.4. Maropea Forks

Maropea forks exclosure plot is located just above the hut in the Maropea catchment. It was built in 1965 and is roughly trapezoid with an area of approximately 176m². It was inspected in 1983, when it was described as being in need of repairs. Another inspection in 1996 found it was in poor condition but probably still keeping deer out. Repairs were made in 1997 and an inspection in 1999 described the condition as good. It was measured in 2001.

In 1962, the mountain beech forest in this area was heavily tracked, with no regeneration over 6 inches, and clearings were being enlarged by animals (Cunningham 1966). In 1983 Oaks reported regeneration of beech outside the fenced plot, and not much difference inside, except for the broadleaf that was growing well in the browse tier and outside the fence was heavily browsed.

3.4.1. Trees

Tree density was higher in the exclosure than the control (basal area of 57 and 32m²/ha respectively). The canopy was mostly mountain beech, especially in the control plot (Figure 12). Palatable marbleleaf, broadleaf and coprosmas were more common in the exclosure.

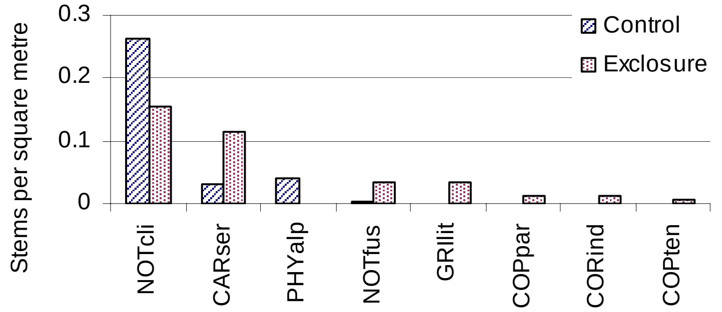


Figure 12 Density of tree stems (<3cm dbh)

3.4.2. Understorey

The sapling tier was denser in the exclosure than in the control plot (1.5 and 1.1 stems/m² respectively). Fifteen species were recorded, twelve in each plot. *Coprosma tenuifolia* and koromiko were recorded only in the exclosure, while totara and bush snowberry were recorded only in the control. Most species were more common in the exclosure, particularly beech, marbleleaf and small leaved coprosmas. No tree ferns and very few lianes were observed in either plot (V. Nicholls, pers. comm). There was one epiphytic coprosma in the control plot.

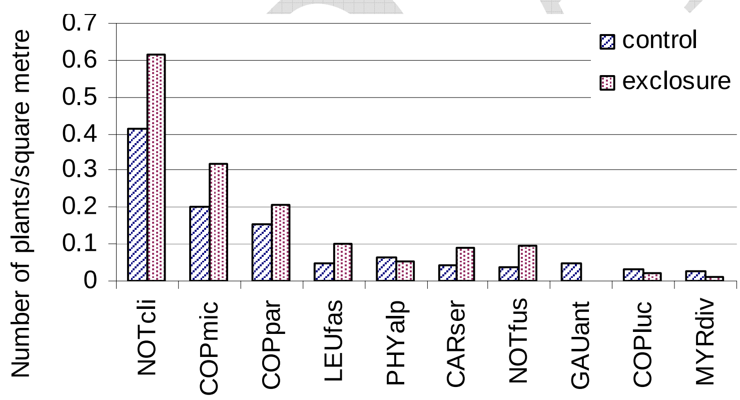


Figure 13 Density of the ten most common species of sapling

3.4.3. Seedlings

A wider range of woody species were recorded in seedling subplots in the control than in the fenced exclosure, including marbleleaf, snowberry, weeping matipo and fivefinger.

Plot	**Trees and shrubs**	**Ferns**	**Graminoids**	**Herbs**
Control	13	2	3	

Exclosure	8	1	3	1

Table 5 Number of species recorded in seedling subplots

The control plot also had a higher density of woody seedlings (Figure 14)

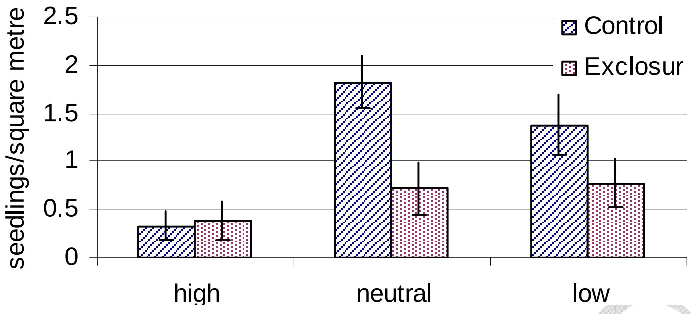
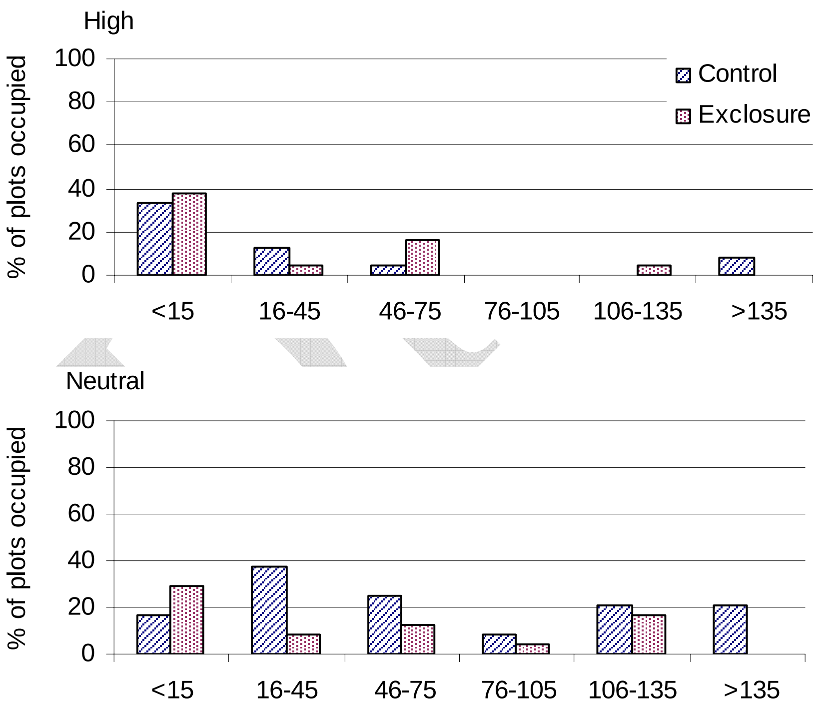


Figure 14 Mean density of woody seedlings over 15cm tall by palatability class (±SE)

There was no obvious difference in the frequency of seedlings between the plots. Tall seedlings were not uncommon in either plot (Figure 15).



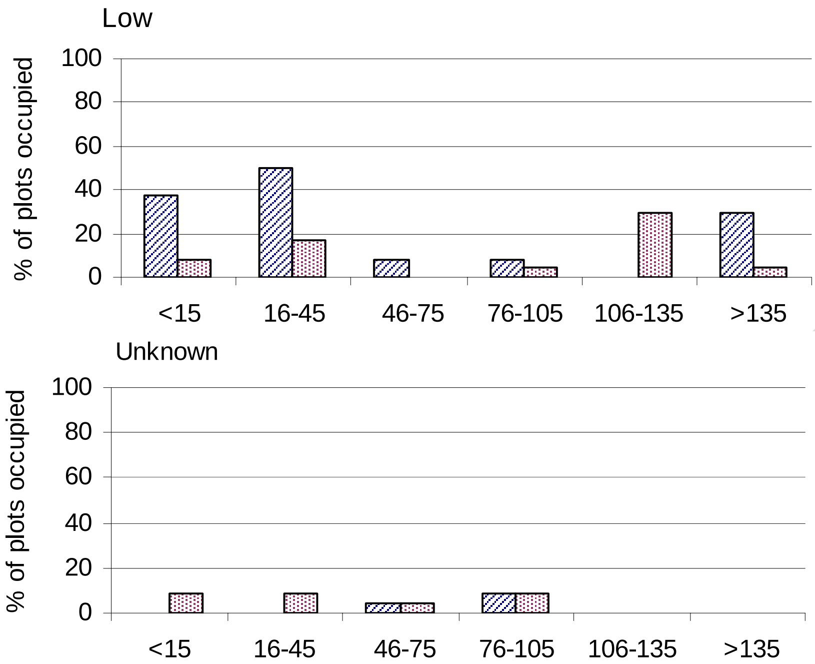


Figure 15 Frequency of seedlings in each height class by palatability (all species)

3.5. Wakelings Hut

The Wakelings Hut exclosure is in mountain beech–red beech–toatoa forest in Waikamaka Catchment. It is five sided and approximately 315m². The fence was in need of work in 1983. It was repaired in 1997. The exclosure was measured in 2003 and a 20x20m plot established nearby.

1960s descriptions of the Waikamaka report that the mixed beech forest below the Mokai–Patea was heavily damaged by animals, with *Dicksonia lanata* and bush rice grass but no regeneration (Cunningham 1966). In contrast Oaks (1983) reported regeneration of beech and toatoa both inside and outside the plot. He also noted “very little *Pseudopanax simplex* [now raukawa] inside the plot compared to outside”. In view of the results shown below this is probably a typing error.

3.5.1. Trees

The tree tier was of similar density in both plots (45.5m²/ha in the exclosure and 44.6 in the control). Palatable raukawa and stinkwood were only recorded in the exclosure (Figure 16)

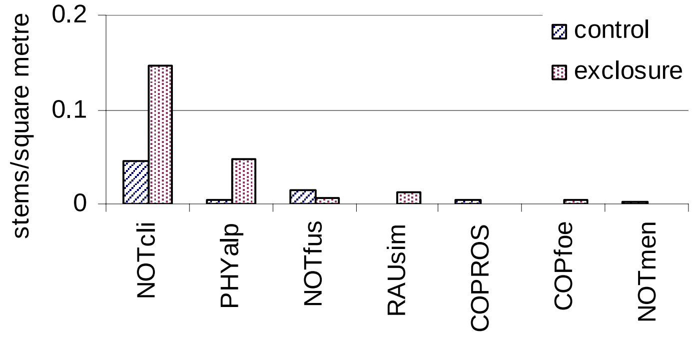


Figure 16 Density of tree stems (<3cm dbh)

3.5.2. Understorey

The understorey was much denser in the exclosure (3.2 stems/m²) than the control (1.62). Eighteen woody species were recorded in the sapling tier and four; gaultheria, broadleaf, *Pittosporum rigidum* and *Coprosma tenuifolium*, were only present in the exclosure while black beech and *Neomyrtus pedunculatus* were only in the control. Thirteen treeferns (*Cyathea smithii*) from 0 to 2m tall were recorded in the control and 2 in the exclosure. One epiphyte (*Peraxilla tetrapetala*) was recorded on a beech tree in the exclosure. Bush lawyer was the only liane recorded (in both plots).

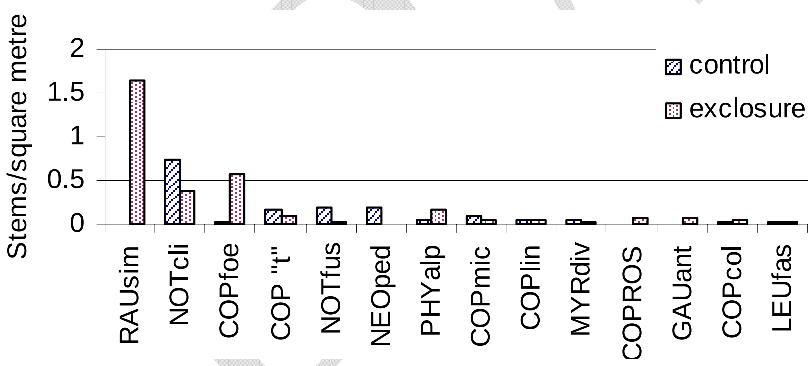


Figure 17 Density of the 14 most abundant species of sapling

3.5.3. Seedlings

A greater range of species was recorded in seedling plots in the exclosure than in the control.

Plot	Trees and shrubs	Lianes	Ferns	Graminoids	Herbs
Control	16		4	3	3
Exclosure	18	1	3	3	3

Table SS Number of species recorded in seedling subplots

Seedling density was also higher in the exclosure than the control, particularly for species of high palatability (Figure 18).

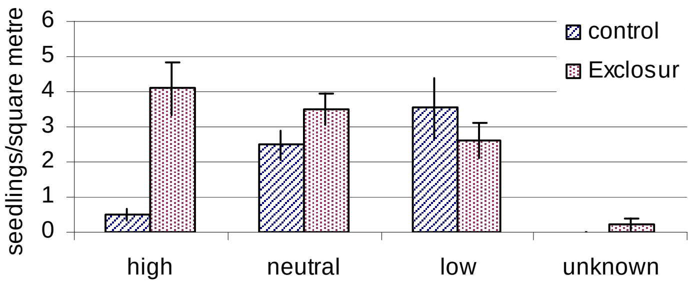
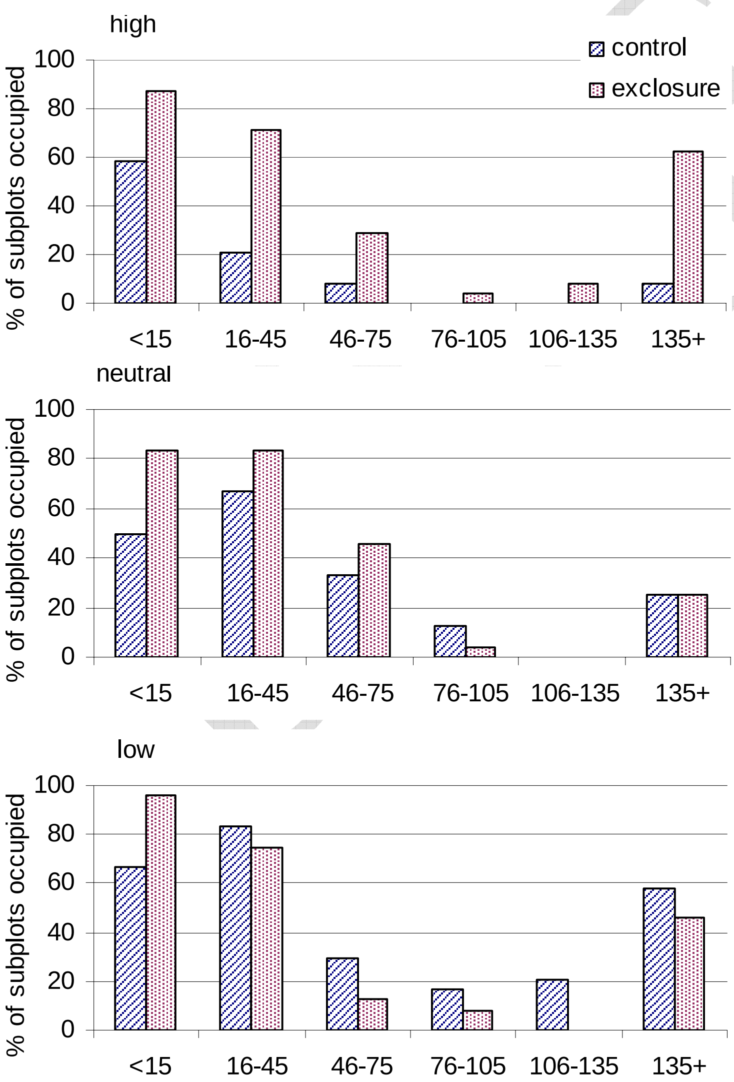


Figure 18 Mean density of woody seedlings over 15cm tall by palatability class (±SE)



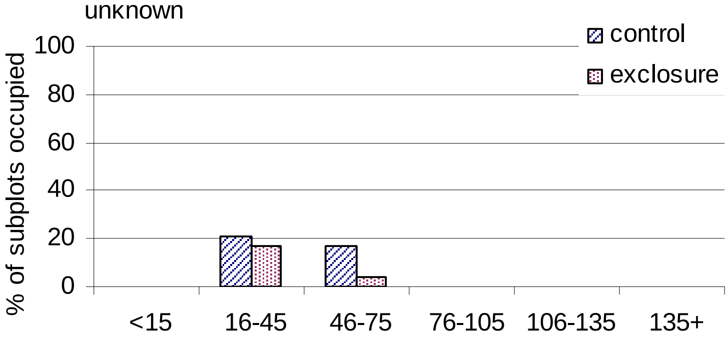


Figure 19 Frequency of seedlings by palatability class (all species)

3.6. Maharahara

The exclosure plot is located in leatherwood–peppertree shrubland below the Maharahara trig. It was constructed 1960–61. It was damaged by 1983 and rebuilt in 1999 but intermediate inspections noted that while condition was very poor there was no deer sign in the plot: they did not seem to be around. The new fence covers 20x20m: more than the original fence. The area contains goats as well as deer. Several were shot during data collection in 2003. Deer browse and goat browse could not be distinguished, so the generic term ungulates will be used.

The first description of vegetation in and around this exclosure was made in 1960, when it was at the pink pine–cedar–kamahi forest/scrub border. The forest was suffering severe defoliation (Cunningham 1966). The plot canopy was dominated by *Brachyglottis eleagnifolia*, with some *Olearia colensoi.* Pahautea, broadleaf, raukawa and a single kamahi were also present. The subcanopy was horopito with some *Coprosma parviflora*, stinkwood and one tree fern. Bush rice grass, prince of wale’s feathers, kiokio and prickly shield fern were common groundcover (Cunningham 1960). In 1983 palatable species were denser in the fenced area than outside but only broadleaf is named (Oaks 1983).

3.6.1. Trees

The canopy was low and bushy, with a few large, emergent broadleafs. Basal area was higher in the control (41 m²/ha) than the exclosure (19). The control plot was dominated by horopito and leatherwood, while raukawa and *Coprosma parviflora* were more common in the exclosure. The exclosure contained more tree species including *Brachyglottis eleagnifolia*, mountain cabbage

tree and pink pine. Two species of tree fern, ponga and wheki, were recorded in similar numbers in each plot.

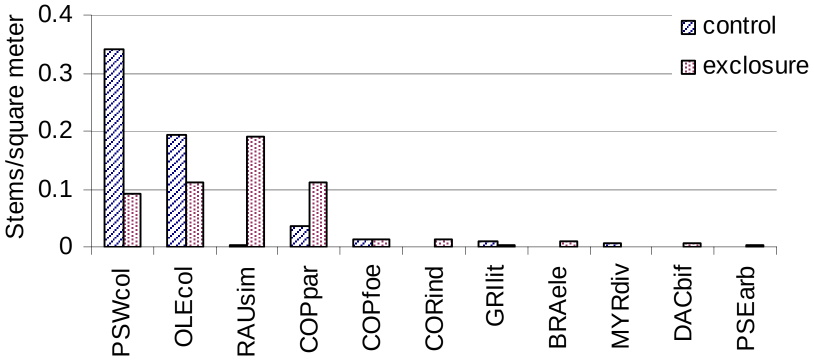


Figure 20 Density of tree stems[2]

3.6.2. Understorey

Saplings were denser in the fenced exclosure (0.93 stems/m²) than in the control (0.31). Saplings of 17 species were recorded, nine in the control plot and 14 in the exclosure. Horopito was most common in the control plot, and raukawa in the exclosure. Less abundant species, like kamahi and broadleaf, were more common in the exclosure but weeping matipo and marbleleaf were only recorded in the control plot.

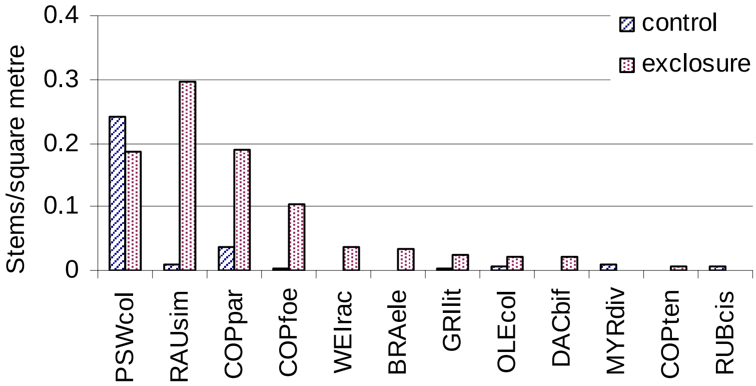


Figure 21 Densities of the twelve most abundant species of sapling

Rubus cissoides was the only liane recorded (2 stems in control plot). Only one woody epiphyte was recorded in the exclosure plot, whereas 27 woody epiphytes over 15cm were recorded in the control, including palatable species like kamahi, raukawa and stinkwood.

[2] Several plants crowned below 135cm. As long as one branch was > 3cm dbh at 135cm, stem diameter was measured below the point of crowning (often very close to the ground) and the plant counted as one stem.

3.6.3. Seedlings

Seedling diversity was higher in the exclosure than in the control (Table SS). Seedling densities per subplot also tended to be higher but variance was large (Figure 22)

Plot	Trees and shrubs	Vines	Ferns	Graminoids	Herbs
Control	12	1	9	2	4
Exclosure	13	0	14	3	6

Table SS Number of species recorded

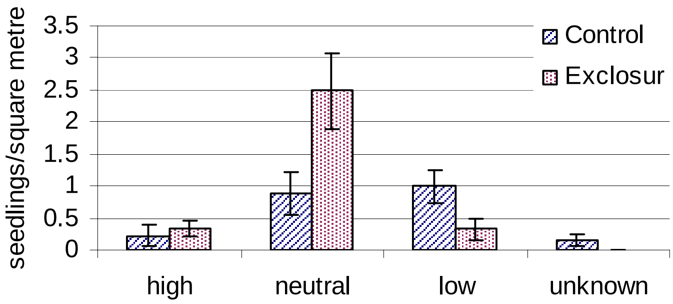
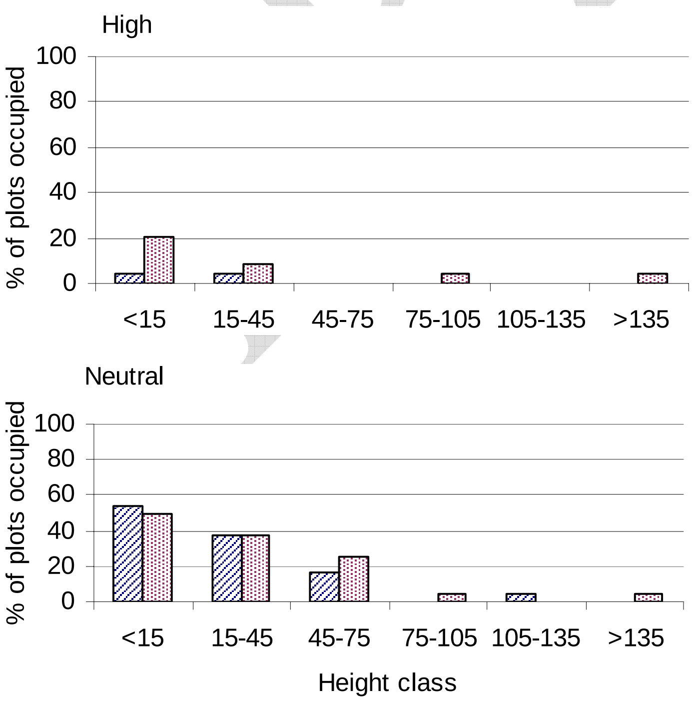


Figure 22 Mean density of woody seedlings over 15cm tall by palatability class (±SE)

Tall seedlings were more common in the exclosure than the control, especially for the high and neutral, but differences were not large (Figure 23).



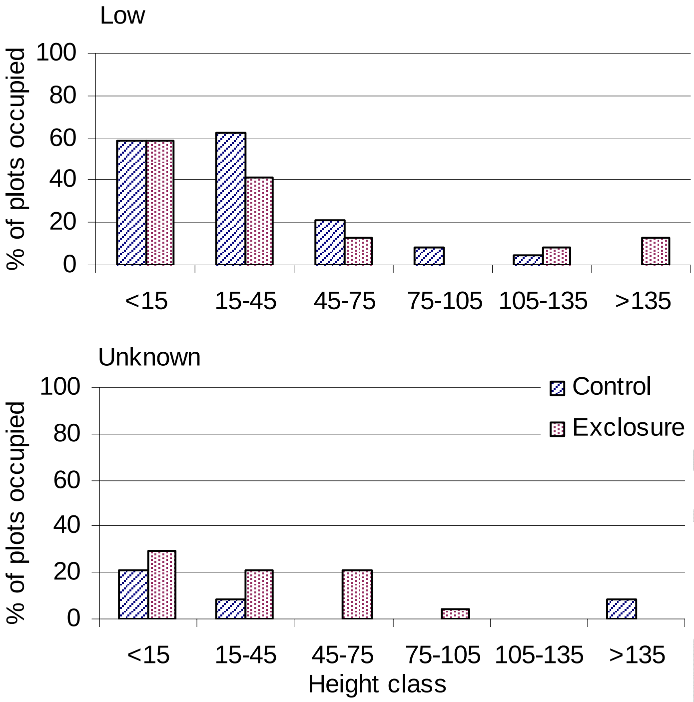


Figure 23 Frequency of seedlings by palatability class (all species)

3.7. Peg Creek

The Peg Creek exclosure is six–sided and covers approximately 195 m² of pahutea–toatoa forest in the upper part of the Pourangaki catchment. It was built 1970, inspected in 1983 and 1997 (good condition) and measured in 2005, when a standard 20x20m control plot was established nearby.

Early descriptions of the forest around Peg Creek are of a heavily used kaikawaka–kamahi belt, with abundant fresh deer sign and an open understorey (Cunningham 1966). In 1983 Oaks noted that broadleaf was growing in the browse range (15cm to 2m) inside the fence but not outside.

3.7.1. Trees

The basal area (indicator of canopy density) was much higher in the exclosure than in the control plot (256 compared to 81m²/ha). This includes several very large stems that were used to support the fence and probably reflects subjective siting of the exclosure. It was difficult to find a similarly dense canopy anywhere in the vicinity (A Hawcroft pers. obs.) Most species were more common in the exclosure than the control (Figure 24).

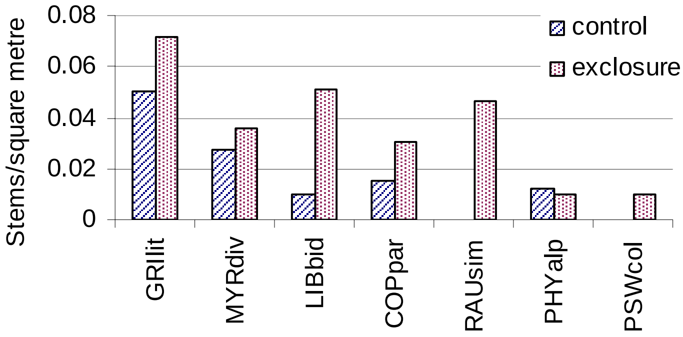


Figure 24 Density of tree (stems >3cm dbh)

3.7.2. Understorey

The understorey was dense and dominated by a range of small leaved coprosmas. Not all were identified to the species level. Fifteen species were identified, of which seven – broadleaf, stinkwood, marbleleaf, koromiko, shrubby snowberry and *Coprosma pseudocuneata* – were only present in the exclosure. One – hakeke– was only present in the control. Bush lawyer was recorded in both plots.

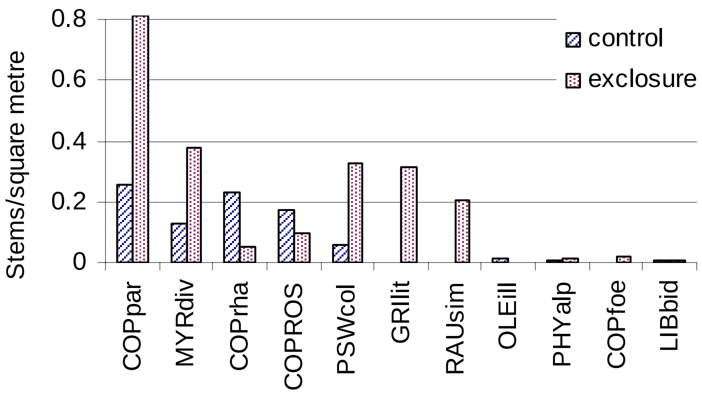


Figure 25 Density of the twelve most common species of sapling

3.7.3. Seedlings

A smaller range of species was recorded in the exclosure than the control plot. Fewer plots were sampled, only 14 as opposed to 24. The rare grass, *Anemanthele lessoniana*, was recorded in the exclosure plot.

Plot	Trees and shrubs	Ferns	Graminoids	Herbs
Control	12	2	3	12
Exclosure	7	1	3	5

Table SS: Number of species recorded in seedling subplots

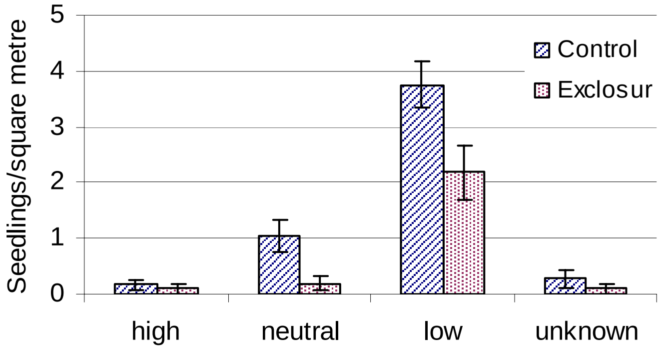
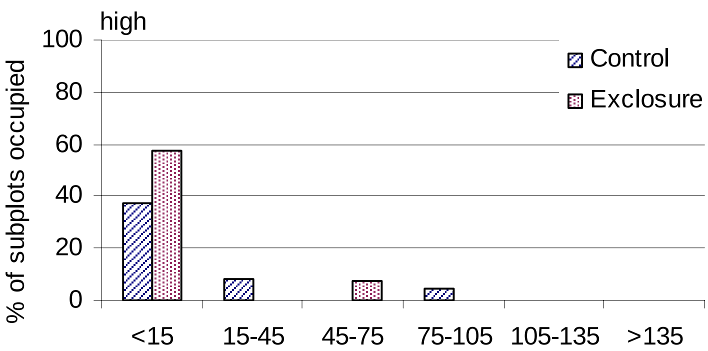
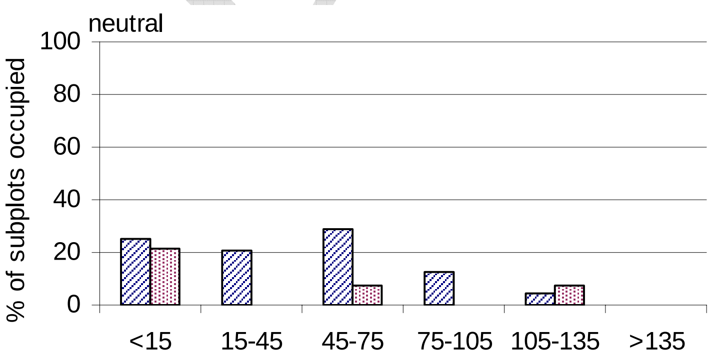


Figure 26 Mean densities of woody seedlings over 15cm tall by palatability class

Woody seedling densities were higher in the control plot than the exclosure, especially for species of low palatability. Taller seedlings were also more frequently recorded in the control.





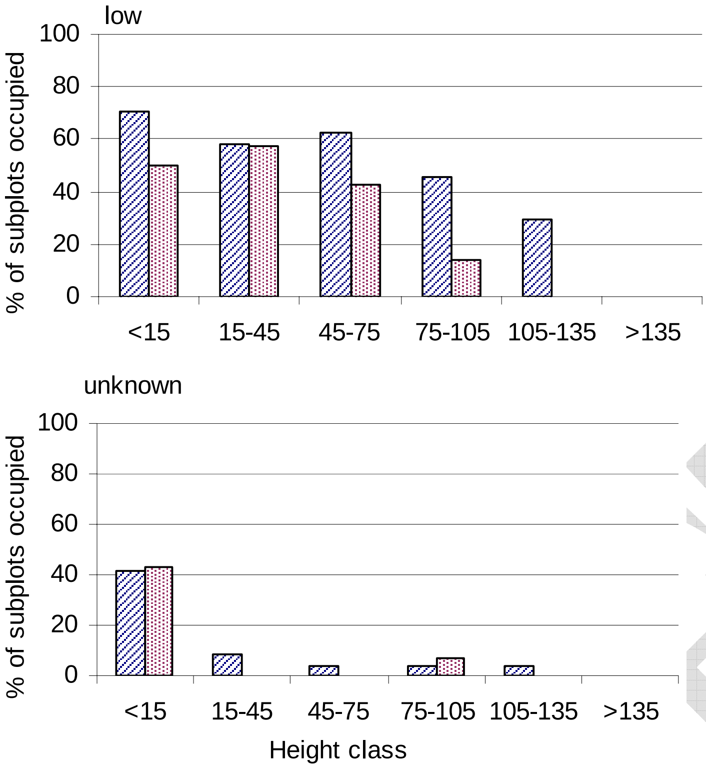


Figure 27: Frequency of seedlings by palatability class (all species)

3.8. Whakaurekau

The exclosure plot is located in podocarp forest beside a swampy clearing on a terrace above the lower Whakaurekau River. Built in ???, it is five sided, with an area of approximately 200m². It was in sound condition in 1983. Minor fence damage was repaired in 1996 and in 2005. It was measured in 2005 and a square control plot (400 m²) was established alongside the exclosure.

This site was not visited in 1962 (Cunningham 1966). Oaks (1983) noted the abundance of palatable species within the exclosure and severe browsing of mahoe outside the exclosure. At that time the exclosure contained a large amount of grass. Various grass species were evident in the 2005 exclosure measurement, the seedling subplots were certainly not dominated by grass.

3.8.1. Trees

Tree basal area was much higher in the exclosure than the control (276 and 86 m²/ha respectively). Kahikatea comprised most of the basal area in the exclosure plot as a few very

large trees had been used to support the fence. Marbleleaf, *Coprosma rotundifolia*, *Melicope simplex*, kaikomako and horopito dominated in the control plot (Fig 28). Kanono was only recorded in the exclosure plot and mahoe, lancewood, ribbonwood and rimu were more common in the exclosure plot (Figure 28).

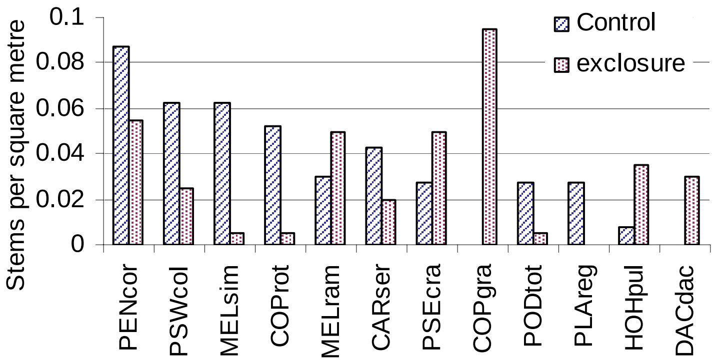


Figure 28: Density of 12 species with greatest number of stems > 3 cm dbh

3.8.2. Understorey

Sapling density was similar between the control plot (0.27 stems/m²) and the exclosure (0.25stems/m²). Saplings of 31 species were recorded, 26 in the control plot and 18 in the exclosure. *Melicope simplex*, *Coprosma rotundifolia* and horopito were most common in the control plot, and lancewood and mahoe in the exclosure (Figure 29).

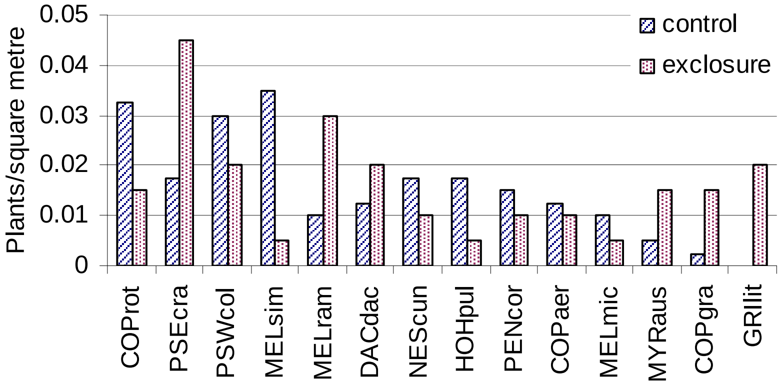


Figure 29: Density of fourteen most common species of sapling

Nine liana species were recorded. *Metrosideros colensoi* was most common in the exclosure and *Metrosideros diffusa* most common outside. Density of lianes was similar in the exclosure and control. Although not formally measured, epiphytic regeneration of broadleaf was noted on tree ferns in the control plot and control plot contained more epiphytic palatable saplings than the exclosure. (K. Steffens, pers. obs.)

3.8.3. Seedlings

Plot	Trees and shrubs	Ferns	Graminoids	Herbs
Control	12	5	2	3
Exclosure	9	4	1	4

Table SS: Number of species recorded in seedling subplots

Small seedlings were generally more common in the control than the exclosure (Fig 30). Tall seedlings of high palatability were more common in the exclosure than the control plot. There were no large differences in seedling frequency (Fig 31).

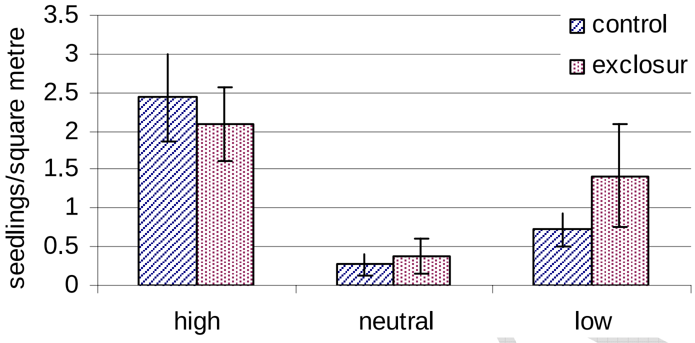
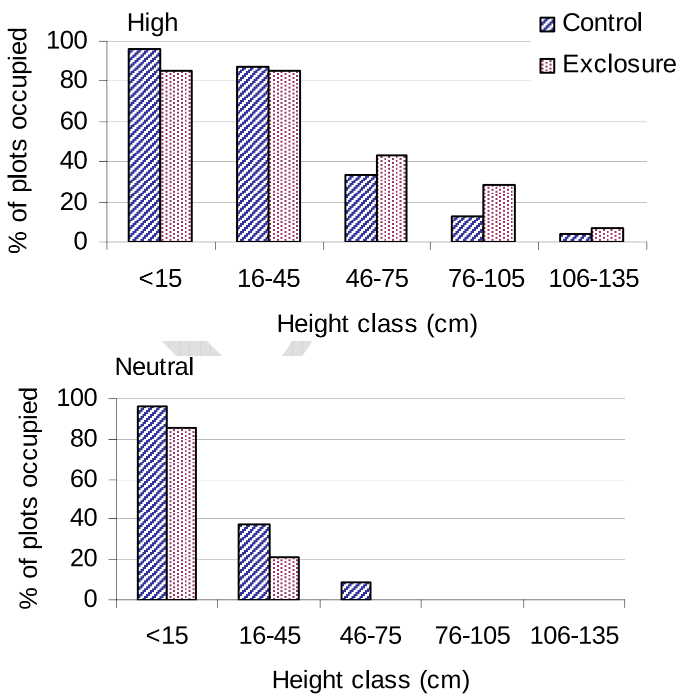


Figure 30 Mean densities of woody seedlings over 15cm tall by palatability class



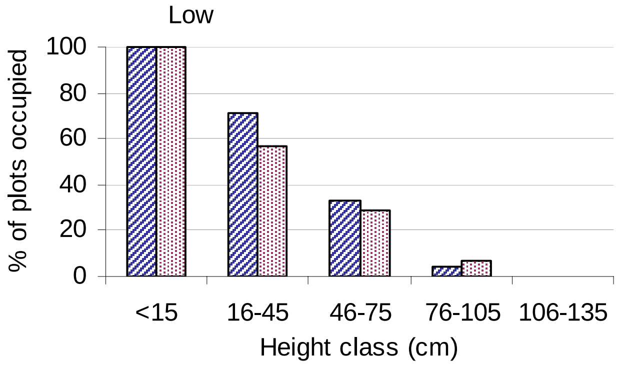


Figure 31: Frequency of seedlings by palatability class (all species)

3.9. Summary

Table 10 summarises plant density at each of the plots surveyed.

Site	**Trees**		**Saplings**		**Seedlings**		**Tall seedlings more frequent**
	Exclosure	Control	Exclosure	Control	Exclosure	Control	
Alphabet	0.157	0.15	0.35	0.026	not collected		yes
Triangle	0.295	0.083	1.21	1.56	7.49	8.27	no
Waterfall	0.088	0.12	0.64	0.065	1.87	15.41	yes
Maropea forks	0.36	0.33	1.53	1.09	1.88	3.54	no
Wakelings	0.22	0.07	3.19	1.62	10.38	6.52	yes
Maharahara	0.55	0.61	0.92	0.32	3.15	2.26	yes
Peg Creek	0.26	0.12	2.27	0.87	2.56	5.25	no
Whakarekau	0.48	0.47	0.32	0.33	3.88	3.43	no

Table 10: density (plants per metre^2) of trees, saplings and seedlings in all plots

4. Discussion

The differences between fenced and unfenced plots observed in the Ruahines show expected responses to reduced browsing: an increase of palatable species, particularly in the sapling and small tree tiers, but responses vary considerably between sites. The condition of forest in these areas has changed considerably since plots were built in the 1960s, but relatively little since 1983.

Overall, density of tree stems was similar between the exclosures and controls, but density of individual species varied. Exclosures tended to have higher densities of species of high or neutral palatability: coprosmas, *Pseudopanax*, broadleaf, hangehange and raukawa. Unpalatable species tended to be more abundant in control plots (horopito, beech). In several cases differences were due to one or the other plot including a few large, multi–stemmed trees. These slower–growing, canopy forming or emergent species since these are likely to have been established before the fences were built (in some cases were used *as* the fences). Species grow at different rates so that after 30 years some will show changes in all tiers of the forest while others will only show changes in the lowest tiers. In Te Urewera, 20 year old exclosures measured in the 1980s had higher densities of fast–growing, palatable trees and saplings such as hangehange, broadleaved coprosmas and *Pseudopanax* species and lower densities of horopito but slower growing species such as mahoe differed only in the sapling tier. Other species had established before plots were built and were unable to regenerate in current conditions even in the absence of animal browse (Allen et al. 1984). Changes in the density of small trees and saplings are more likely to reflect the effects of the exclosure.

Differences in sapling density were more consistent and more marked than in the tree tier. Six of the eight exclosures had greater sapling density than their paired controls, one was similar and one was more open. Coprosmas (except *C. rhamnoides*), raukawa, *Pseudopanax*, broadleaf, and mahoe tended to be more common in exclosures than control plots.

Differences were less clear in the seedling data. Densities were higher in the exclosure than control at three sites, about the same at one site and lower at three. At Waterfall, this difference was mostly due to plants in the 15–45cm tier and – as for those with overall higher density – taller seedlings (45+), especially of palatable species, were more common in the exclosure.

Other studies of exclosure plots have found minimal or inconsistent differences in seedlings or ground cover vegetation (Bockett 1997, Walls 1998, Wardle et al. 2001).

Seedling abundance is likely to be related to the degree of shading from higher layers of the forest. Some studies have reported increased densities of seedlings in areas where the subcanopy has been severely reduced by browse (Stewart and Burrows 1989). At two plots (Waterfall and Peg Creek) where seedling abundance was lower in the exclosure, the sapling tiers were particularly dense, but this was not the case at Maropea Forks and Triangle.

There is potential for confusion in identifying seedlings and in recording names accurately, particularly for graminoids and the small leaved coprosma species which were common in some plots (A. Hawcroft, pers. obs.)

Some differences between exclosures and controls are due to pre–existing factors, for example a fence being selectively placed around a particular habitat, such as a canopy gap or a particularly dense stand. The fence may also be located in an area with slightly different topography and microclimate. Small scale variations in soil moisture, fertility or light availability can influence growth rates.

4.1. Variability between sites

There are very large differences between plots in different locations. Allen et al's (1984) study of 17 exclosures in Urewera found relatively consistent trends, but the exclosures did not cover such a wide range of altitudes or forest types. Husheer et al (2005) used seven plots in seven catchments and four forest types in Aorangi and found considerable variance in results, so that only one species showed a significant difference using the aggregate data. Wardle *et* al's (2001) national level study of 30 ungulate exclosures also found that while some generalizations could be made about plant composition was lots of variation in whether differences were significant and what species were involved.

The differences between sites could be due to differences in deer density. Deer were first introduced to the north of the range and it is generally believed that there are more deer in the northern catchments (S. Robson, pers. comm.) This would suggest that the exclosures at Whakaurekau, Maropea Forks and Wakelings Hut should have greater differences between inside

and outside the plot, while differences would be smallest at Maharahara and Alphabet. Whakaurekau and Wakelings did show differences, particularly in the sapling tier, but these were less pronounced at Maropea Forks and larger in the southern plots.

Goats (whose effects cannot be distinguished from deer using exclosures) are present in low numbers throughout the western Ruahines, but are most dense in the southern part of the range (A. Mercer, pers. comm.) The large differences in Maharahara could be due to goats.

Deer use varies on a meso–scale, with northern aspects and gentle terrain preferred. Seral forest and grassy clearings also tend to be more heavily used (Nugent and Sweetapple 1989). In the Ruahines deer also target the upper forest near the treeline (James and Beaumont 1971) and there did seem to be larger differences at Peg Creek, Wakelings and Waterfalls compared to Triangle and Maropea forks (although at a lower altitude, Maharahara is near the tree line).

Variation between sites could also reflect differences in forest type and how quickly they can grow when the pressure of deer browse is removed. Fertile, well–drained sites are likely to support fast growing species which have the potential to come away when protected (Coomes et al. 2003). Whakarekau and Alphabet best represent this type of habitat in the Ruahines, and both did show quite large differences.

Finally, some exclosures have been damaged in the past. Both Triangle and Maropea Forks have had periods when the fences have been severely damaged and not repaired for some time, but so had the fence at Maharahara, which had results (more saplings and seedlings of palatable species) attributed to differences in browse pressure.

Forest condition has improved considerably since the 1960s. Cunningham's (1966) review mentions deer tracks, near complete lack of regeneration and groundcover dominated by unpalatable ferns and grasses at most sites in the central and western forests. These features were not apparent in the unfenced plots measured from 1999 to 2005. There did not appear to be any difference in production of beech seedlings and saplings in the fenced and unfenced plots.

The brief vegetation descriptions made by Oaks in 1983 suggest conditions much more similar to the present. He often reported regeneration of canopy species (particularly beech) both inside and outside the fences. However, palatable species like broadleaf, raukawa and mahoe were more

common in the fenced plots and were often heavily browsed where they were present outside. This corresponds with changes in deer pellet frequencies.

4.2. Implications for management

The exclosure plots studied here were established some time after deer had colonized the Ruahines. This means that the fenced areas do not show what the Ruahine forest would be like if deer had never been introduced because it is likely that successional processes in the vegetation would already have been altered (Allen et al. 1984).

Differences may be small between exclosures and controls at sites which have been damaged by the effects of browsing mammals and lost the potential to recover from that damage before plots were built (Coomes et al. 2003, Husheer 2005). Reduced deer numbers will not enhance forest regeneration at these sites. An example may be the southern Ruahines where unpalatable *Olearia colensoi* and horopito now cover large areas and *Brachyglottis eleagnifolia,* fuchsia, pate and raukawa are much less common (e.g.Cunningham 1966, James and Beaumont 1971). These plants physically fill the space that would have been occupied by kamahi and other palatable species and alter conditions for seedling germination and growth e.g. soil character (Wardle et al. 2001, Wardle et al. 2002, Coomes et al. 2003).

No kamahi was observed in the two exclosures in the southern part of the range, although Elder (1965) mapped this as the dominant species in those sites. It was also absent from Peg Creek, where it grew under the pahautea in the 1960s (Cunningham 1966). This species may be unable to regenerate even in the absence of deer. Several other species northern rata, tree fuchsia and pate were frequently observed by early botanists but underwent widespread mortality in the 1960s and 1970s (James and Beaumont 1971, Cunningham 1979). Except for several very large rata, these were rarely recorded in exclosures from 1999–2005.

The problem may be exacerbated by other herbivores. The Ruahines contain only small numbers of feral goats which are subject to ongoing DOC control, but possums are unchecked. Possums contributed to massive changes in vegetation structure in the southern Ruahines (Rogers and Leathwick 1997) but ungulates tend to have a greater influence over forest dynamics than possums (Nugent et al. 2001). It seems likely that as well as the current effects of herbivores, the past forest collapse has resulted in a loss of seed sources or changed conditions for recruitment so

that those very vulnerable species can no longer establish (Coomes et al. 2003, Husheer et al. 2003).

This study has some positive information about the potential of the western Ruahines to recover from deer impacts: none of the unfenced plots were dominated by weedy exotic species, beech regeneration is much improved, and there are still adequate seed sources for many species.

Beech species are not usually palatable to deer (Forsyth et al. 2002) but regeneration can be impeded at high densities (Allen and Allan 1997, Duncan et al. 2005, Husheer and Robertson 2005) as noted in the Ruahines in the 1960s. Effects tend to be more severe on the associated subcanopy species (Husheer et al. 2003)

Some regeneration of broadleaved, palatable species was recorded outside the fenced areas. There are opportunities for regeneration in inaccessible places: as epiphytes, on steep bluffs in dense tangles of fallen branches or unpalatable shrubs (Nugent *et* al 2001). This has been reported elsewhere (Mark, 1989) and was observed in several unfenced plots but these relatively low densities of palatable seedlings might not be enough. Sapling densities at least equal to current tree density are needed to ensure recruitment (Husheer and Frampton 2005) which were not achieved for broadleaved species in control plots.

These plots sample only a very small part of the Ruahines and it is hard to assess whether recruitment is viable at a landscape scale. Scattered surviving mature kamahi and some tall seedlings have been observed in the Pohangina catchment (S. Husheer, pers. comm.) Measurement of the widespread network of unfenced 20x20 plots or analysis of data collected in the 1980s would provide better information about this.

5. Conclusions

Since the 1960s deer have had an effect on forest composition, reflected by the relative abundance of palatable species – broadleaf, raukawa, mahoe, *Pseudopanax* and large leaved coprosmas – in the tall seedling and sapling tiers. These species would benefit from further reduction in deer numbers.

Forest in the central and western Ruahines appears to be in better condition now than in the 1960s and 70s, probably reflecting the large drop in deer density since that time. Beech seedlings and saplings were often more common outside fenced plots and occasional juveniles of the palatable species listed above were recorded outside fences.

There may be some species which are unable to regenerate even when deer numbers are very low. Kamahi, fuchsia, northern rata and pate are highly palatable to deer and possums and were once abundant but were very rarely observed in the recent measurement.

The plots sample a very small area. Remeasurement of the unfenced 20x20 plots throughout the range, or analysis of the data collected in the early 1980s would clarify whether the conclusions reached here apply more generally.

6. Recommendations

The exclosure plots should be maintained and re–measured at regular intervals as an indicator of the state of the Ruahine forests in the absence of deer browse.

Remeasurement of the widespread 20x20 plot network should be carried out to assess:

- whether beech and other species in the central and western forests will be able to regenerate in sufficient numbers to replace the current canopy under low deer densities
- the abundance of kamahi and other highly vulnerable species, particularly in the south, to determine whether there are sufficient remnants to justify attempts to restoration.

Undertake monitoring to assess the impact of deer on non–forest habitat, specifically the open tussock grasslands.

7. Acknowledgements

Thanks to all Pohangina Field Centre and Palmerston North Area staff involved in data collection, plot maintenance and writing trip reports.
To people who read the draft ALWAYS GET SOMEONE TO DO THIS

8. References

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9. Appendices

Plot	Measured	Data	Analysis
Alphabet or No 1 Line	1998	WANCO–44131	WANCO–44144
Triangle	1999	WANCO–21381	WANCO–44075
Waterfall	2001	WANCO–44667	WANCO–44687
Maropea Forks	2001	WANCO–27275	WANCO–44106
Wakelings Hut	2003	WANCO–44135	WANCO–44629
Maharahara	2003	WANCO–43925	WANCO–44052
Peg Creek	2005	WGNHO–212349	
Whakarekau	2005	WANCO–44137	WGNHO–237892

Table 1: Location of Excel files used in preparing this report.

Scientific name	Code	Palatability	Form	Name
Acaena species	ACAENA	S	H	Bidibid
Alseuosmia pusilla	ALSpus	N	W	
Anaphalioides species	ANAPHAL	S	H	A daisy
Aristotelia serrata	ARIser	H	W	wineberry
Asplenium bulbiferum	ASPbul	H	F	Hen and chickens fern
Asplenium gracillimum	ASPgra	H	F	Hen and chickens fern
Astelia species	ASTELI	N	H	Bush flax
Astelia fragrans	ASTfra	N	H	Bush lilly
Astelia solandri	ASTsol	H	H	Kowharawhara
Beilschmiedia tawa	BEItaw	L	W	Tawa
Blechnum capense	BLEcap	L	F	Kiokio
Blechnum species	BLECHN	?	F	A hard fern
Blechnum discolor	BLEdis	L	F	Crown fern
Blechnum filiforme	BLEfil	S	F	Thread fern
Blechnum fluviatile	BLEflu	S	F	Kiwakiwa
Blechnum minus	BLEmin	?	F	Kiokio
Blechnum penna-marina	BLEpen	S	F	Alpine hard fern
Blechnum procerum	BLEpro	L	F	Small kiokio
Blechnum vulcanicum	BLEvul	S	F	Triangular kiokio
Brachyglottis eleagnifolia	BRAele	H	W	
Brachyglottis rotundifolia	BRArot	H	W	Muttonbird scrub
Calystegia tuguriorum	CALtug	?	V	New Zealand bindweed
Carex species	CAREX	L	G	A sedge
Carex lurida	CARlur	L	G	Sallow sedge
Carpodetus serratus	CARser	H	W	marbleleaf
Chionochloa conspicua	CHIcon	?	G	Bush tussock
Chiloglottis species	CHILOG	S	H	Green bird orchid
Chionochloa species	CHIONO	?	G	A tussock
Coprosma aff. parviflora *	COPaff	N	W	
Coprosma species ‘t’ in Eagle	COP"T"	N	W	
Coprosma ciliata *	COPcil	N	W	
Coprosma colensoi	COPcol	N	W	
Coprosma foetidissima	COPfoe	H	W	stinkwood

Coprosma linariifolia	COPlin	N	W	Mikimiki, yellow wood
Coprosma lucida	COPluc	H	W	Shining karamu
Coprosma microcarpa	COPmic	N	W	Small seeded coprosma
Coprosma parviflora *	COPpar	N	W	Leafy coprosma
Coprosma pseudocuneata	COPpse	N	W	
Coprosma rhamnoides	COPrha	L	W	
Coprosma species	COPROS	N	W	A coprosma
Coprosma rugosa	COPrug	L	W	
Coprosma tenuifolia	COPtef	H	W	
Cortaderia fulvida	CORful	?	G	toitoi
Corybas species *	CORYBA	S	H	A spider orchid
Cyathea dealbata	CYAdea	L	F	Ponga
Cyathodes juniperina	CYAjun	L	W	Prickly mingimingi
Cyathea smithii	CYAsmi	L	F	Katoke, soft treefern
Dacrydium biforme	DACbif	L	W	Pink pine
Dicksonia lanata	DIClan	L	F	Tuokura, stumpy treefern
Dicksonia squarrosa	DICsqu	L	F	Wheki
Elaeocarpus dentatus	ELAden	N	W	Hinau
Epilobium species	EPILOB	S	H	A willowherb
Freycinetia banksii	FREban	H	V	kiekei
	fungi	S	CRY	
Gaultheria antipoda	GAUant	N	W	Bush snowberry
Gaultheria depressa	GAUdep	N	W	Bnowberry
Gaultheria species	GAULTHE	N	W	A snowberry
Grammitis species	GRAMMI	S	F	A strap fern
	GRASS	?	G	A grass
Griselinia littoralis	GRIlit	H	W	Broadleaf
Griselinia lucida	GRIluc	H	W	Puka
Hedycarya arborea	HEDarb	H	W	Pigeonwood
Histiopteris incisa	HISinc	L	F	Water fern
Hoheria populnea var. *lanceolata Hook.f. (*incl. *H.sexstylosa)*	HOHpop	H	W	Lacebark
Hymenophyllum demissum	HYMdem	S	F	Filmy fern
Hymenophyllum species	HYMENO	S	F	A filmy fern
Hymenophyllum multifidum	HYMmul	S	F	Filmy fern
Hypochoeris radicata	HYPrad	S	H	Catsear

Hypolepis rufobarbata	HYPruf	L	F	Sticky pig fern
Juncus species	JUNCUS	L	G	A rush
Lagenifera strangulata	LAGstr	S	H	Parani
Lagenifera species	LAGENI	S	H	A New Zealand daisy
Lagenifera pumila	LAGpum	S	H	Paptaniwha
Lastreopsis glabella	LASgla	?	F	Smooth fern
Lastreopsis microsora	LASmic	L	F	
Leptopteris superba	LEPsup	L	F	Prince of wale's feathers
Leucopogon fasciculatus	LEUfas	L	W	Mingimingi
Libocedrus bidwillii	LIBbid	?	W	Pahautea
Libertia pulchella	LIBpul	S	H	Small iris
	lichens	S	CRY	
Luzula species	LUZULA	L	G	A woodrush
Luzuriaga parviflora	LUZpar	S	H	Lantern berry
Melicytus micranthus	MELmic	?	W	Shrubby mahoe
Melicytus ramiflorus	MELram	H	W	Mahoe
Metrosideros colensoi	METcol	L	V	Climbing vine
Metrosideros diffusa	METdif	I	V	White climbing rata
Microlaena avenacea	MICave	L	G	Bush rice grass
Microsorum pustulatum	MICpus	H	F	Hound's tongue fern
	moss	S	CRY	
Muehlenbeckia complexa	MUEcom	?	V	Scrub pohuehue
Myrsine australis	MYRaus	H	W	Red matipo
Myrsine divaricata	MYRdiv	L	W	Weeping matipo
Neomyrtus pedunculata	NEOped	L	W	Rohutu
Nertera ciliata	NERcil	S	H	
Nertera depressa	NERdep	S	H	Bead plant
Nertera species	NERTER	S	H	A bead plant
Nertera villosa	NERvel	S	H	
Nothofagus solandri var. cliffortioides	NOTcli	L	W	Mountain beech
Nothofagus fusca	NOTfus	L	W	Red beech
Nothofagus solandri	NOTsol	L	W	Black beech
Olearia colensoi	OLEcol	?	W	Leatherwood
	ORCHID	S	H	An orchid
Oxalis species	OXALIS	S	H	Oxalis

Oxalis magellanica	OXAmag	S	H	Oxalis
Parsonsia capsularis	PARcap	L	V	Small flowered jasmine
Parsonsia heterophylla	PARhet	L	V	New Zealand jasmine
Parsonsia species	PARSON	L	V	New Zealand jasmine
Pennantia corymbosa	PENcor	N	W	Kaikomako
Phyllocladus alpinus	PHYalp	L	W	Toatoa
Pittosporum rigidum	PITrig	?	W	
Podocarpus hallii	PODhal	L	W	Hall's totara
Polystichum richardii *	POLric	N	F	Shield fern
Polystichum vestitum	POLves	L	F	Prickly shield fern
Pratia angulata	PRAang	S	H	Pratia
Prumnopitys ferruginea	PRUfer	L	W	Miro
Pseudopanax anomalus	PSEano	L	W	
Pseudopanax arboreus	PSEarb	H	W	Fivefinger
Pseudopanax colensoi *	PSEcol	H	W	Threefinger
Pseudowintera axillaris	PSWaxi	L	W	Lowland horopito
Pseudowintera colorata	PSWcol	L	W	Horopito
Pteris macilenta	PTEmac	?	F	Shaking brake
Ranunculus reflexus	RANref	S	H	Bush buttercup
Raukaua simplex	RAUsim	N	W	Raukawa
Rubus cissoides	RUBcis	N	V	Bushlawyer
Rubus species	RUBUS	N	V	A bushlawyer
Schizeilema species	SCHIZE	S	H	
Carex species	sedge	?	G	A sedge
Stellaria parviflora	STEpar	S	H	Native chickweed
Streblus heterophyllus	STRhet	?	W	Turepo
Uncinia species	UNCINI	L	G	A hookgrass
Viola species	VIOLA	S	H	Native violet
Viola cunninghamii	VIOcun	S	H	Native violet
Weinmannia racemosa	WEIrac	H	W	Kamahi

Table 2: Species recorded: code name, palatability and form (fern, graminoid, herb, woody species, cryptogamminae)

* indicates species which have been revised but could not be renamed since it was not clear which new species they were.