Measuring the success of pest control on vegetation regeneration at Ackers Point, Stewart Island:

The permanent plot method

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Diploma in Environmental Management

(ENVR6002)

October 2014

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Cover photo: Western side of Ackers Point, Stewart Island
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Abstract

The current impact of introduced browsing and grazing mammals on the vegetation of New Zealand is widely perceived as an ecological disaster involving severe depletion of the plant cover and widespread accelerated erosion. To halt this trend, much effort has been put into reducing the number of introduced pests. In order to measure the success of pest eradication, ecological change needs to be studied. Permanent sample plots have long been recognised as the most robust approach for measuring changes in forests.

Ackers Point Reserve is located at the tip of a peninsula that forms the southern headland of Halfmoon Bay, Stewart Island. In 2002, the Halfmoon Bay Habitat Restoration Project at Ackers Point was established. The aim of the project is to restore local ecosystems, increase the native bird population and to provide a safe environment for the re-introduction of threatened Stewart Island fauna. In 2004 an intensive mammalian pest control program at Ackers Point Reserve was conducted. Prior to the commencement of the program, baseline vegetation sampling utilizing twelve randomly selected permanent plots, was undertaken. In 2014 the permanent plots were re-surveyed to investigate the affect continued mammalian pest control is having on vegetation regeneration within the reserve. Vegetation within each plot was recorded into seven different height categories: cotyledons, 0-15 cm, 15-30 cm, 30-45 cm, 45-135 cm, 135 cm-200 cm and >200 cm. Canopy cover percentage was recorded using the Foliar Browse Index method.

The monitoring of these plots in 2014 found that the diversity of seedlings had changed when compared with the last survey conducted in 2006. Light demanding species such as manuka and fuchsia were less frequent in 2014 due to the increase in canopy cover (mean increase of 2.5%) that had occurred since 2006. Canopy cover increased due to the reduction of the possum population; 443 possums have been eradicated since 2004. Supplejack seedlings showed a marked increase since 2006. Supplejack seeds are a favoured food source for rats. Therefore, the increase in supplejack seedlings may be due to a decline in the rat population; 11556 rats have been eradicated since 2004. It was identified that saplings are still only present in low numbers within the reserve. The lack of increase in the abundance of saplings may be the result of plant species being heavily retarded by deer browse to the point where they are completely absent from the browse level (30 – 200 cm). Findings show that kamahi is the most predominant tree species within the reserve, providing canopy cover for five out of the twelve plots. Kamahi produces a thick canopy which limits the light available for the understory, which may explain the reduced number of angiosperm seedlings and saplings present in the understory. No sightings of rare, threatened or significant biota were recorded during the 2014 survey.

In order to restore natural ecosystems, ensure a natural progression from seedling to trees and create the required habitat for an increase in native bird population, it is recommended that the near total removal of deer should be carried out at Ackers Point Reserve.

Acknowledgements

First and foremost, I would like to thank Natalie Miedema for her guidance and support as my supervisor for the duration of this project. In addition, I would like to thank Steven Gorinski for his assistance with the collection of data and to Debashis Dutta for sharing his extensive botanical knowledge when required.

Acknowledgements must also be made to Letitia McRitchie and Denise Hayes from the Stewart Island/Rakiura Community & Environment Trust for providing accommodation and hospitality throughout the duration of my visit.

Finally, thanks to my family for their support during this project.

Contents

Tables and Figures

1. Introduction

1.1 Introduced pests

New Zealand's unique flora and fauna has evolved and thrived over millions of years in complete isolation from predatory mammals (Fleet, 1986). However, their isolated way of life began to change 650-1000 years ago (Parsons et al., 2006) with the arrival of humans. Since the arrival of humans many of New Zealand's unique biota has become extinct or is currently suffering from population decline as a result of habitat degradation, habitat loss, fragmentation and pest infestation (Parsons et al., 2006) (Figure 1.1). New Zealand has now lost over 40% of its prehumen terrestrial bird species and currently has the world's highest proportion of threatened avifauna (Gillies et al., 2003). For many of the currently threatened species, the primary cause of their decline has been predation and competition by introduced species (Parsons et al., 2006). New Zealand's native vegetation has not developed the required mechanisms; chemical defences and rapid growth, needed to cope with heavy browse (Forsyth, Coomes, Nugent, & Hall, 2002). The current impact of introduced browsing and grazing mammals on the vegetation of New Zealand is widely perceived as an ecological disaster involving severe depletion of the plant cover and widespread accelerated erosion (Veblen & Stewart, 1982). The continued threat to canopy cover has even led to complete removal of forest pockets (Sweetapple & Nugent, 2004). Introduced pests eat flowers, fruits, seeds and seedlings, altering the structure and composition of the native forest (Eddowes, 2007) and contributing to the slow speed of vegetation regeneration (Wilson, William, Webster, & Allen, 2003).

Figure 1.1 Rat about to enter a Blue Penguin (*Eudyptula minor)* nest, Ackers Point, Stewart Island.

1.2 Fighting back

To halt the trend of native ecosystem degradation and allow existing native species to recover and thrive, much effort has been put into species management and habitat rehabilitation in New Zealand (Parsons et al., 2006). Control or eradication of these alien predators and competitors can greatly improve the local productivity and survival prospects of threatened native wildlife (Parsons et al., 2006). Areas on the New Zealand mainland that contain key habitats can be intensively controlled by poisoning and trapping to reduce the number of introduced predators (Parsons et al., 2006). The resulting intention is to restore populations of threatened wildlife and allow natural ecosystems to recover (Parsons et al., 2006). Due to the constant threat of reinvasion from surrounding areas, the focus is placed on controlling pests to as low as possible densities rather than total eradication of pests (Gillies et al., 2003)

1.3 Monitoring change

In order to measure the success of pest eradication, ecological change needs to be studied. A number of individuals and agencies have developed methods for monitoring indigenous forest for conservation purposes and ecological understanding (Craig, 1989); aerial photography (McKelvey, 1973), tree measurement (Meads, 1976), large-scale surveys (Batcheler & Craib, 1985) and repeat understorey photography (Mark, 1978). Permanent sample plots have long been recognised as the most robust approach for measuring changes in forests (Allen, 1993; Rose, Pekelharing, & Platt, 1992; Stewart, Wardle, & Burrows, 1987). The permanent plot method is designed to allow changes in species diversity, composition and community structure to be studied within the understory (Allen, 1993).

1.4 The preservation and restoration of Ackers Point, Stewart Island

Ackers Point is the tip of a peninsula that forms the southern headland of Halfmoon Bay, Stewart Island. The area has a maximum width of approximately 500 m and the altitude reaches no more than 68 m (Meurk & Wilson, 1989). The area is named after Lewis Acker, the first person to occupy the area in the early 19th century. The area was cleared and grazed but has since been allowed to regenerate naturally. The site was declared a scenic reserve in 1980 by the Department of Conservation (DOC), however stock was allowed to graze the area as late as 1989. By 1989 all logging and casual cutting had ceased (Meurk & Wilson, 1989). The site is highly accessible to the public. A maintained walking track leads from the start of the reserve to the lighthouse at the end of the peninsula (Department of Conservation, 2014). Extensive coastal views can be seen from the lighthouse and the South Island can be seen on a clear day (Department of Conservation, 2014).

In 2002 DOC handed over the management of Ackers Point Reserve to the Stewart Island/Rakiura Community and Environmental Trust (SIRCET). SIRCET established the Halfmoon Bay Habitat Restoration Project (HMBHRP) at Ackers Point (Figure 1.2). The aim of the project is to restore local ecosystems, increase the native bird population around Halfmoon Bay and to provide a safe environment for the re-introduction of threatened Stewart Island fauna. The flagship species for this project is the South Island Saddleback (*Philesturnus carunculatus carunculatus*) (SIRCET, 2013). In 2004 SIRCET began an intensive mammalian pest control program at Ackers Point Reserve (SIRCET, 2013). Prior to the commencement of the program, the Bay of Plenty Polytechnic Science department were invited to monitor vegetation regeneration within the reserve following pest control and to report back long term effects and trends. Baseline vegetation sampling utilizing twelve randomly selected permanent plots was undertaken in Autumn 2004 (Jones & Watchman, 2004). The permanent plots were again visited and sampled in 2006 (Dooley, 2006). Dooley (2006) reported that seedling numbers had quadrupled and sapling numbers had tripled since the 2004 sample was undertaken and pest control carried out.

Figure 1.2 HMBHRP information sign at the entrance to Ackers Point Reserve, Stewart Island.

1.5 Aim

This study aims to investigate the effect continued mammalian pest control is having on vegetation regeneration at Ackers Point reserve.

1.6 Objective

The objective of this report is to provide survey results and an assessment of current vegetation regeneration at Ackers Point reserve, to SIRECT and other interested parties.

2. Methods

2.1 Study site

Ackers Point is a twelve hectare headland (Meurk & Wilson, 1989) which forms the southern end of Halfmoon Bay, Stewart Island (Figure 2.1). Annual rainfall is approximately 1500 mm, and the site is well drained (Meurk & Wilson, 1989). The area was declared a scenic reserve in 1980 by DOC and was still allowed to be grazed until 1989 (Meurk & Wilson, 1989). After all farming had ceased the vegetation was allowed to regenerate naturally (Meurk & Wilson, 1989).

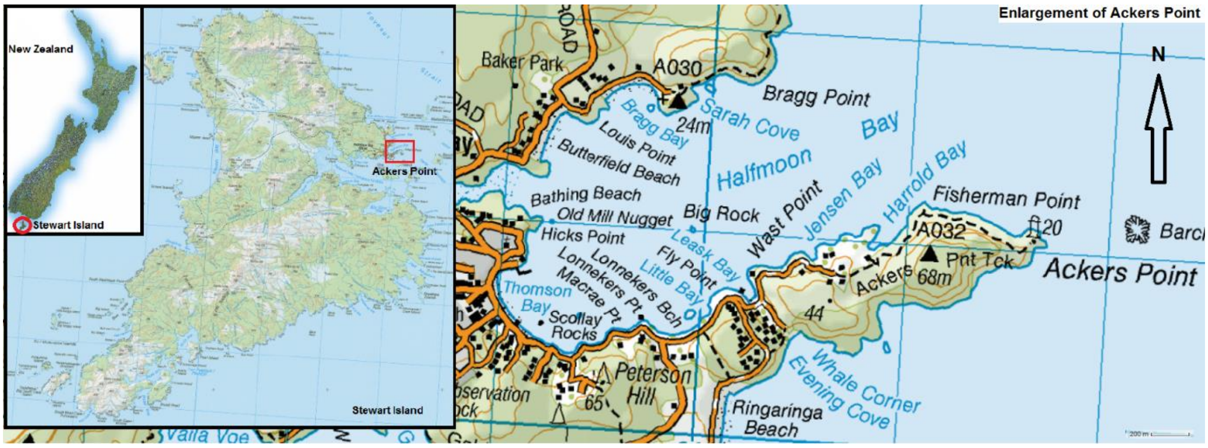

Figure 2.1 Map showing location of Ackers Point, including enlargement.

A biological survey of the site was carried out in 1989 (Meurk & Wilson, 1989) and categorised the remaining vegetation into four main types. The first vegetation type is lowland podocarp/angiosperm forest which dominates the majority of the area excluding some of the coastal rim. Predominant species in this category include kamahi (*Weinmannia racemosa*), kapuka (*Griselinia littoralis*), coprosmas (*Coprosma spp*.), mapou (*Myrsine australis*), manuka (*Leptospermum scoparium*), and putatputaweta (*Carpodetus serratus*) (Meurk & Wilson, 1989). Supplejack *(Ripogonum scandens*) is also common in places (Meurk & Wilson, 1989). The second vegetation type is the coastal fringe. Muttonbird scrub (*Brachyglottis rotundifolia*) is the dominant species with mapou, coprosmas, inaka (*Dracophyllum longifolium*) and manuka (Meurk & Wilson, 1989). Wind battered coastal sites are also occupied by kokomuka (*Hebe elliptica*), akeake (*Olearia avicenniafolia*) and ongaonga (*Urtica ferox*), a species which is locally common but occurs at only a few locations on the island (Meurk & Wilson, 1989; Wilson, 1994). The final two vegetation types are minor vegetation on barren land (rocks and banks) and gullies dominated by fuchsia (*Fuchsia excorticata*) (Meurk & Wilson, 1989).

2.2 Study dates

This permanent plot survey was carried out between 30th March 2014 and 6th April 2014. During these dates all twelve previous established permanent plots were visited and re-surveyed.

2.3 The permanent plot method

In 2004, twelve permanent plots were randomly selected (Jones & Watchmen, 2004) using RANDBETWEEN function in Microsoft Excel, from 89 existing bait stations located at the study site (Appendix 1). Based on the outcome of the random selection, permanent vegetation plots were set up within a 5 m radius from the allocated bait station. The permanent plots were shaped in a square measuring 5 m x 5 m; total area of 25 m². Each corner of the permanent plot was marked with a blue permolat triangle penetrated with an aluminium peg and labelled with the words “VEG PLOT” and a corresponding number (Figure 2.2).

Figure 2.2 Permanent plot marked out with rope, Ackers Point, Stewart Island. Insert showing a blue permolat triangle indicating the permanent plot corner.

Rope was used to form a boundary between the permanent plot pegs and all vegetation within each plot was recorded into seven different height categories: cotyledons, 0-15 cm, 15-30 cm, 30-45 cm, 45-135 cm, 135-200 cm and >200 cm. Each plot was divided into four quadrants (2.5 m x 2.5 m) using rope for ease and improved accuracy. Data collected was used to calculate vegetation densities and mean populations. Vegetation classified as having a high ruminant-preference to ungulates (Table 2.1) was analysed to determine the effects of any vegetation browse. The diameter at breast height (DBH) was also recorded for vegetation over 200 cm. The diameter measurement was recorded at approximately 135 cm from ground height using diameter tape. Data collected was used to calculate basal area information. Dead trees and epiphytes were not recorded.

Table 2.1 Native plant species with high ruminant-preference (Sweetapple & Nugent, 2004).

Species	***Preference***
Asplenium bulbiferum	High
Astelia spp.	High
Freycinetia baueriana	High
Coprosma grandifolia	High
Coprosma lucida	High
Griselinia littoralis	High
Melicytus ramiflorus	High
Myrsine australis	High
Olearia rani	High
Ripogonum scandens	High
Schefflera digitata	High
Weinmannia racemosa	High

Creeping ground ferns, vines, and grasses (when individual clumps were undistinguishable) were recorded using the following abundance values (Allen, 1993):

- occasional (O) 5 – 25% of plot covered
- common (C) 25 – 50% of plot covered
- abundant (A) 50 – 75% of plot covered
- very abundant (VA) 75 – 100% of plot covered

Canopy cover percentage was recorded using the Foliar Browse Index method; a visual assessment utilising the foliage cover scale while standing in the permanent plot centre (Payton, Pekelharing, & Frampton, 1999). Compass bearings of slopes and general topographical observations were noted, including visual drainage assessments.

General forest observations that may be relevant to assessing the health or recovery of vegetation were also recorded. This included such things as:

- the presence of any rare, threatened or significant species
- the canopy and sub-canopy species present
- signs of possums, deer or rats
- signs of possum trunk scratches, browse or mammalian faeces
- the presence and distribution of weeds

All vegetation was identified using Wilson's Field guide: Stewart Island plants (1994).

3. Results

3.1 Diversity and height classes

There was a decrease in plant species diversity in 2014 (33 species recorded) compared to 2006 (39 species recorded). A total of 2572 seedlings/saplings were recorded in all plots in 2014 compared to 2121 seedlings/saplings recorded in 2006. There was a marked decrease in the mean number of cotyledons in 2014 (1.41 ± 0.53 (95% CI) per m^2) compared to 2006 (3.32 ± 1.33 (95% CI) per m^2) (Figure 3.1). However, small seedlings (<15 cm category) in 2014 (5.03 ± 2.89 (95% CI) per m^2) more than doubled compared to their abundance in 2006 (2.06 ± 0.91 (95% CI) per m^2) and trees (>200 cm) more than doubled (0.48 ± 0.24 (95% CI) per m^2 compared to their abundance in 2006 (0.18 ± 0.09 (95% CI) per m^2) (Figure 3.1).

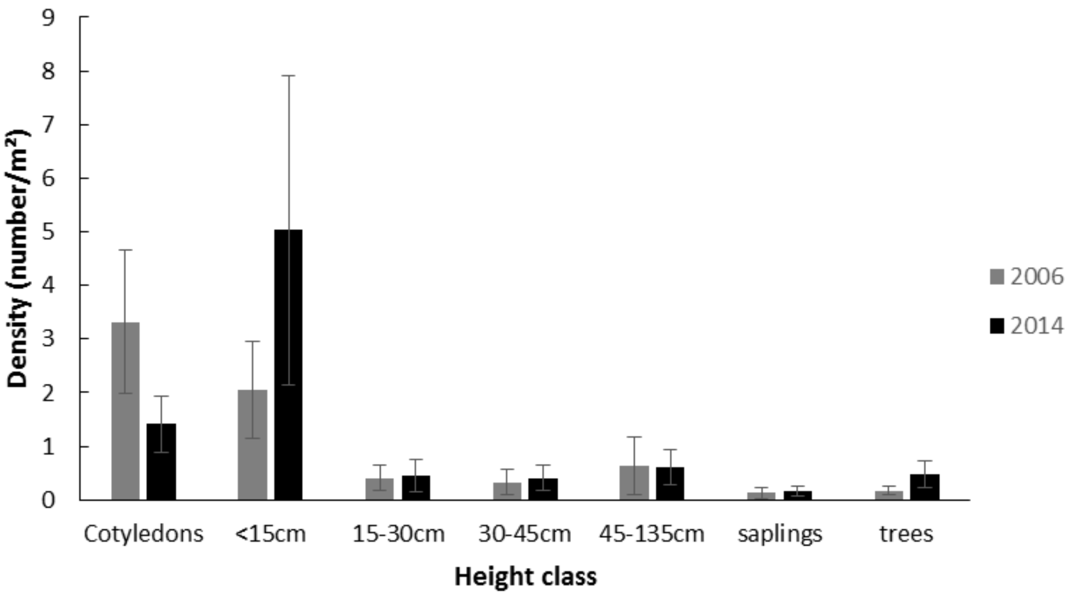

Figure 3.1 Mean abundance recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

When height classes were combined the mean number of seedlings recorded in 2014 (7.32 ± 3.45 (95% CI) per m^2) increased compared to 2006 (6.12 ± 1.38 (95% CI) per m^2) and was almost 45 times greater than recorded in 2004 (0.16 ± 0.04 (95% CI) per m^2) (Figure 3.2). The number of saplings recorded in 2014 (0.77 ± 0.38 (95% CI) per m^2) remains very similar to that recorded in 2006 (0.78 ± 0.58 (95% CI) per m^2) with only a slight decrease of 0.01 per m^2 (Figure 3.2). Although there was change in the number of individuals recorded in each height class since 2006, this was not statistically significant (seedling P value = 0.45, sapling P value = 0.99, $P > 0.05$). As previously stated from both the 2004 and 2006 survey, a decrease in survivorship was also present in 2014 as each species increased in height.

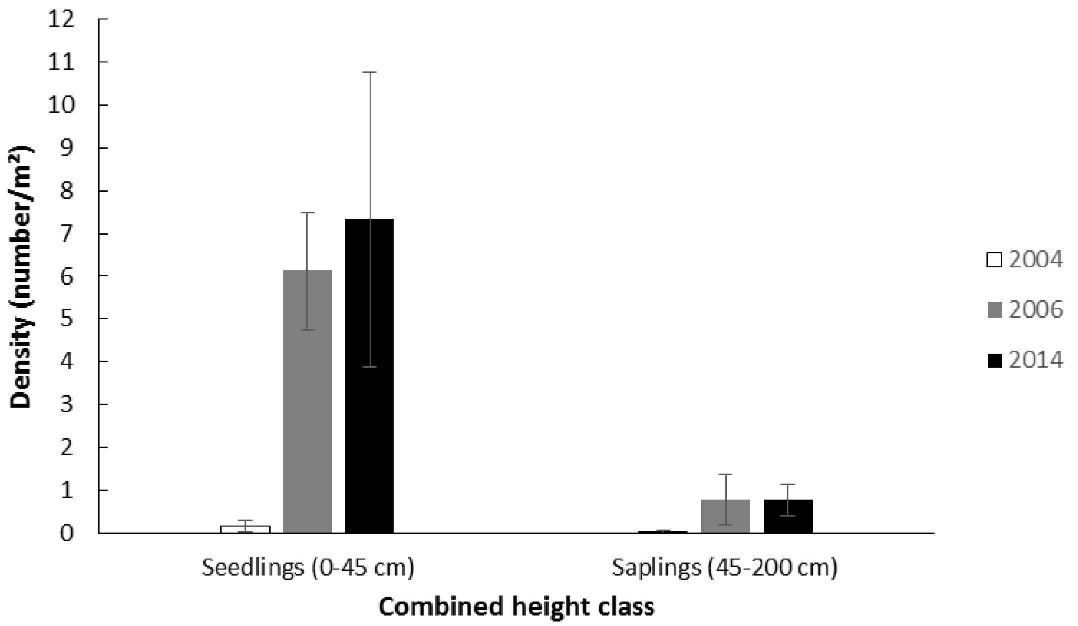

Figure 3.2 Mean abundance of combined height classes, Ackers Point, Stewart Island: 2004, 2006 and 2014 (± 95% confidence intervals).

3.2 Individual species and high preference palatability

Thin-leaved coprosma (*Coprosma areolata*) was again the most abundant species recorded (Figure 3.3), Thin-leaved coprosma accounted for 39.54% of all individuals recorded. Thin-leaved coprosma dominated all height classes except the tree class where it was the second most abundant species (Figure 3.3). When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

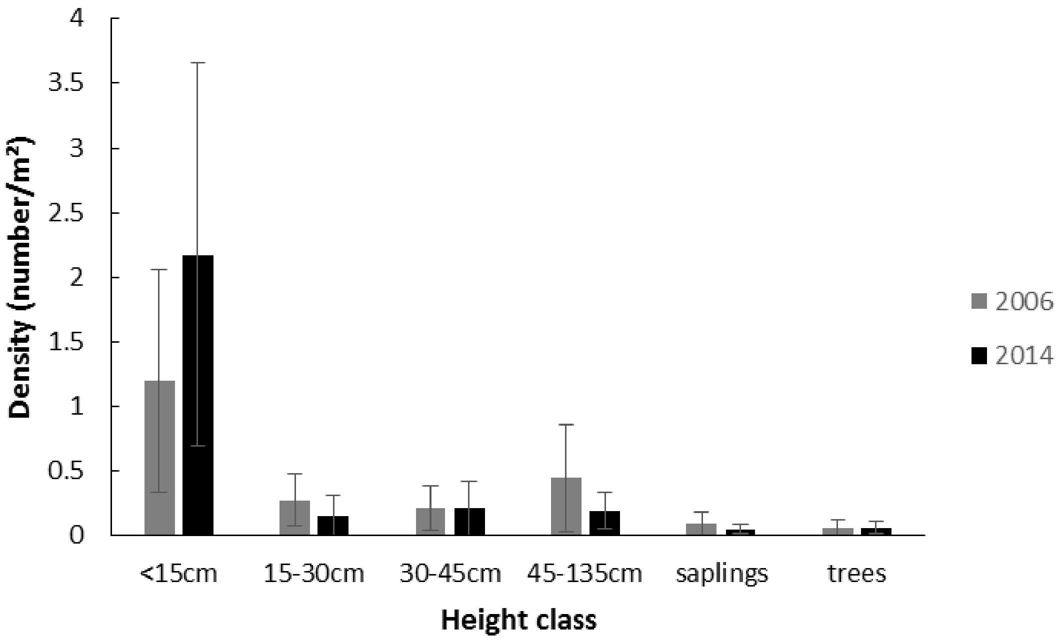

Figure 3.3 Mean abundance of *Coprosma areolata* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

The second most abundant species overall was supplejack (*Ripogonum scandens*) (Figure 3.4). Supplejack accounted for 15.43% of all individuals recorded. Although being the second most abundant species, supplejack was only present in two height classes; 0-15 and trees (Figure 3.4). Supplejack was the most abundant tree species (Figure 3.4), which accounted for 43.24% of all trees recorded. When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

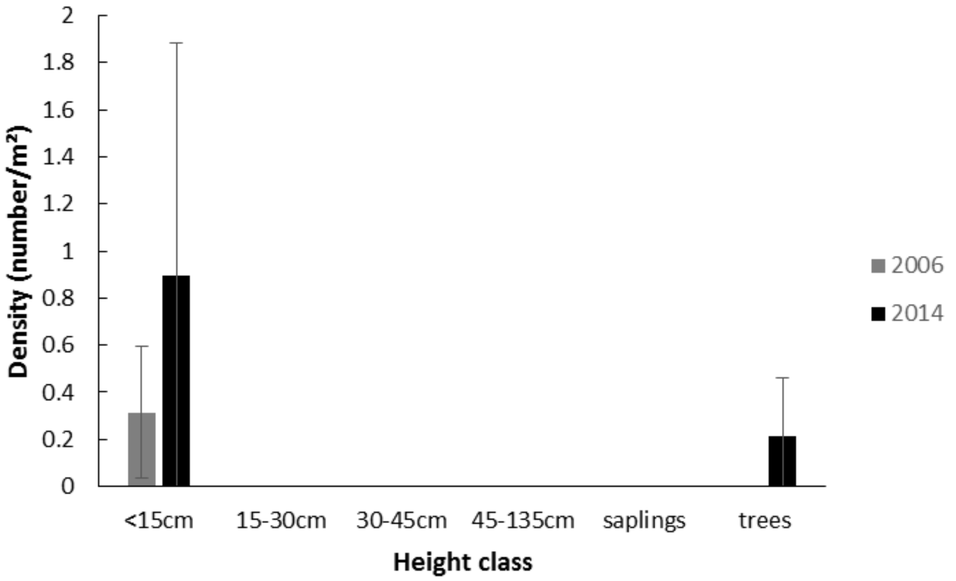

Figure 3.4 Mean abundance of *Ripogonum scandens* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

The third most abundant species overall was kamahi (*Weinmannia racemosa*) (Figure 3.5). Kamahi accounted for 7.34% of all individuals recorded. When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

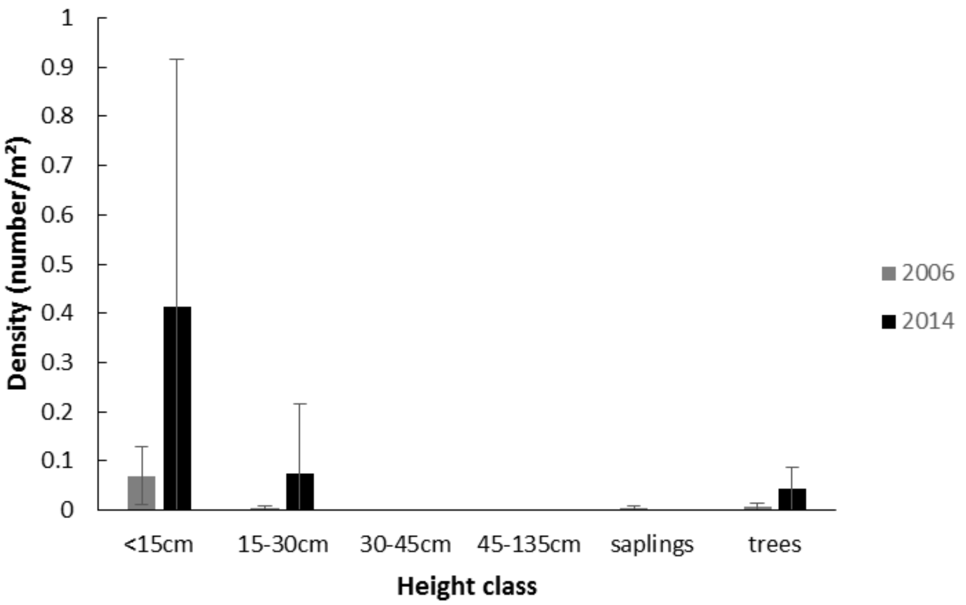

Figure 3.5 Mean abundance of *Weinmannia racemosa* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

The fourth most abundant species overall was stinkwood (*Coprosma foetidissima*) (Figure 3.6). Stinkwood accounted for 7.11% of all individuals recorded. When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

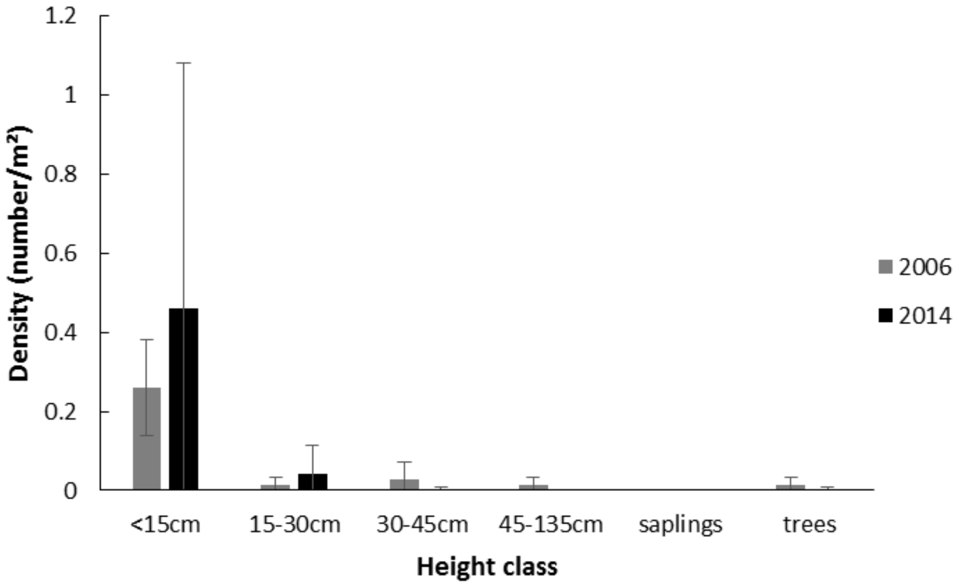

Figure 3.6 Mean abundance of *Coprosma foetidissima* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

The fifth most abundant species recorded overall was kapuka (*Giselinia littoralis*) (Figure 3.7). Kapuka accounted for 4.28% of all individuals recorded. However, kapuka was only present in one height class; 0-15 cm (Figure 3.7). When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

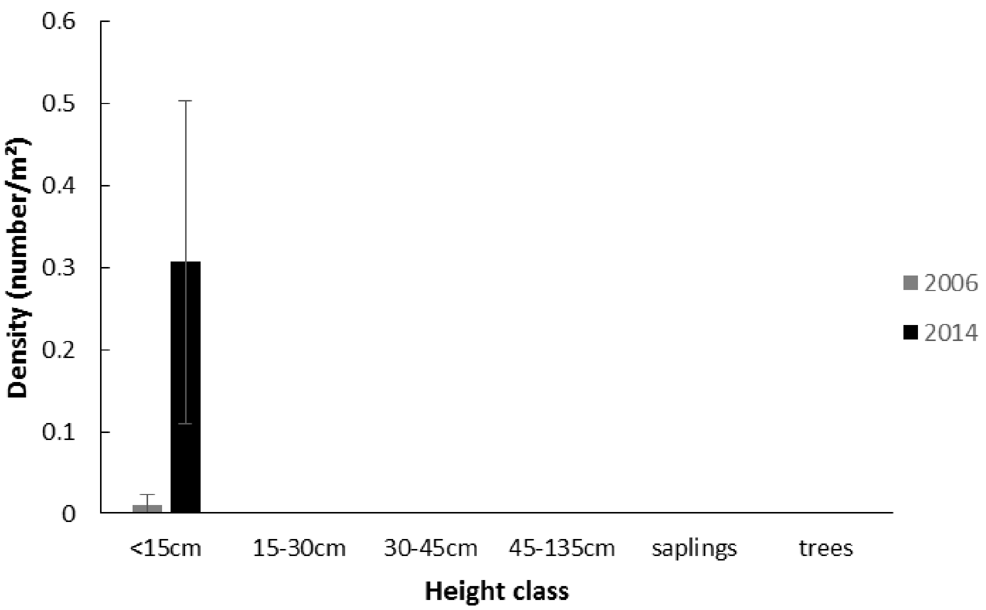

Figure 3.7 Mean abundance of *Giselinia littoralis* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

Sweetapple and Nugent (2004) classify supplejack, kamahi and kapuka as having a high ruminant-preference to ungulates. Two more species recorded during the 2014 survey that are also classified as having a high ruminant-preference to ungulates (Sweetapple & Nugent, 2004) were mapou (*Myrsine australis*) and pate (*Schefflera digitata*). Mapou was the fifteenth most abundant species recorded (Figure 3.8). Mapou accounted for 0.56% of all individuals recorded. When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

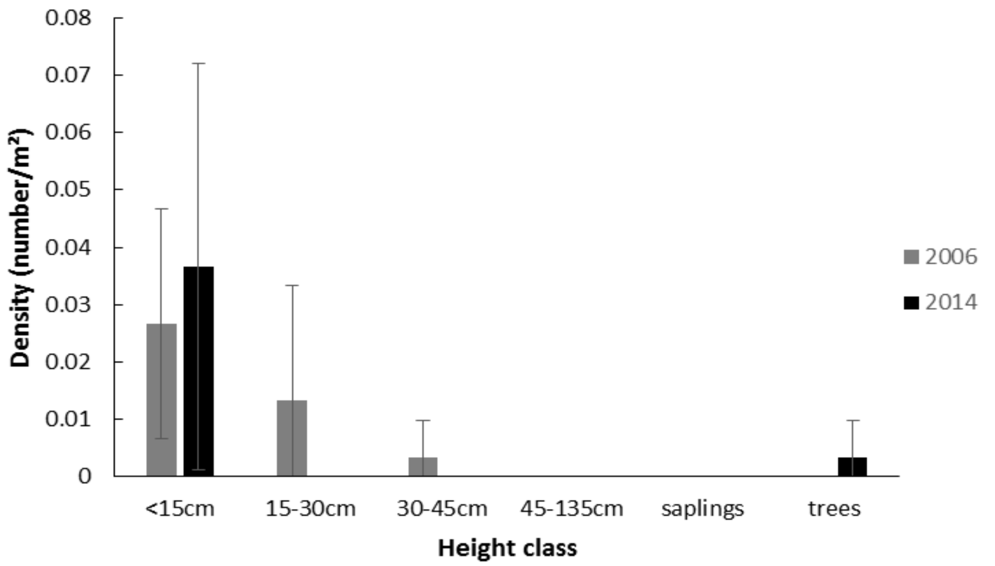

Figure 3.8 Mean abundance of *Myrsine australis* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

Pate was the sixteenth most abundant species (Figure 3.9). Pate accounted for 0.51% of all individuals recorded. When compared with 2006 all height classes showed no statistically significant change (all P values >0.05).

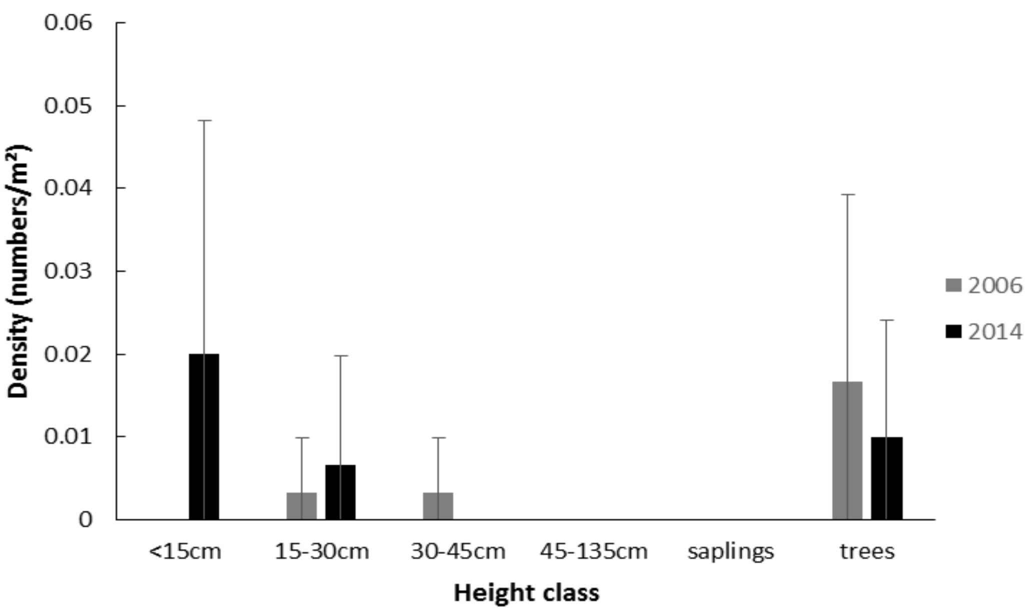

Figure 3.9 Mean abundance of *Schefflera digitata* recorded in each height class, Ackers Point, Stewart Island: 2006 and 2014 (± 95% confidence intervals).

3.3 Canopy cover

There was an increase in the mean percentage of canopy cover recorded in 2014 (47.5%) compared to 2006 (45%) (Figure 3.10). Although there was a mean increase recorded since 2006, this was not statistically significant, P=0.78 (P value >0.05).

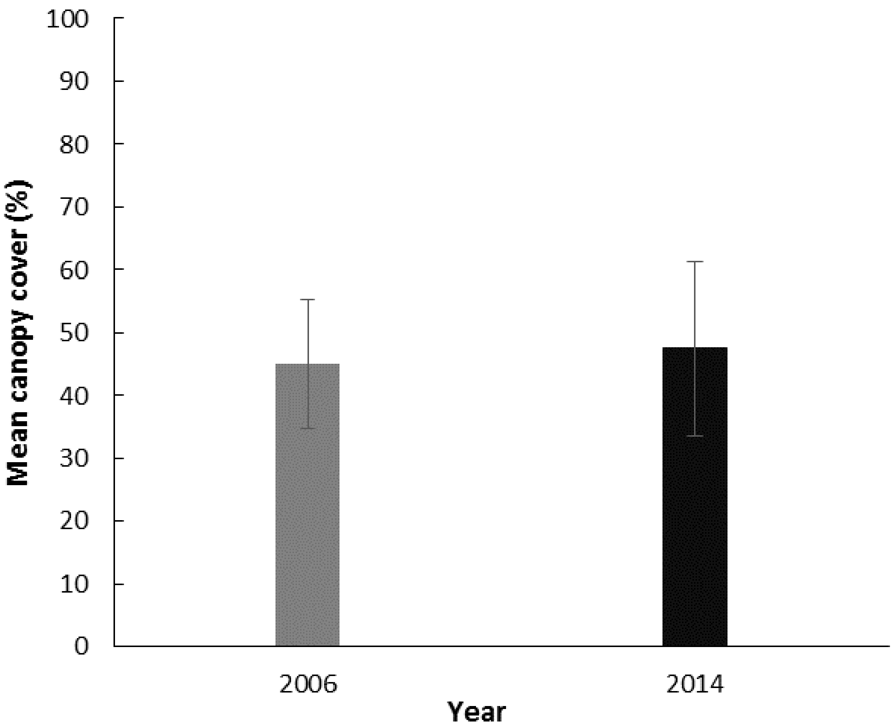

Figure 3.10 Mean percentage of canopy cover, Ackers Point, Stewart Island: 2006 and 2014 2014 (± 95% confidence intervals).

3.4 Basal area

Kamahi (*Weinmannia racemosa*) trees had the largest mean basal area recorded during the 2014 survey (21.38 m²/ha), more than three times the mean basal area of any other tree (Figure 3.11). Fuchsia (*Fuchsia excorticata*) was second (6.91 m²/ha) followed by thin-leaved coprosma (*Coprosma areolata*) (2.21 m²/ha), putaputaweta (*Carpodetus serratus*) (1.86 m²/ha), manuka (*Leptospermum scoparium*) (1.77m²/ha), pate (*Schefflera digitata*) (1.03 m²/ha) and muttonbird scrub (*Brachyglottis rotundifolia*) (1.01 m²/ha) (Figure 3.11). Mingimingi (*Coprosma propinqua*), mapou (*Myrsine australis*), stinkwood (*Coprosma foetidissima*) and *Coprosma "little red fruit"* were also recorded but with very small basal areas/ha (Figure 3.11).

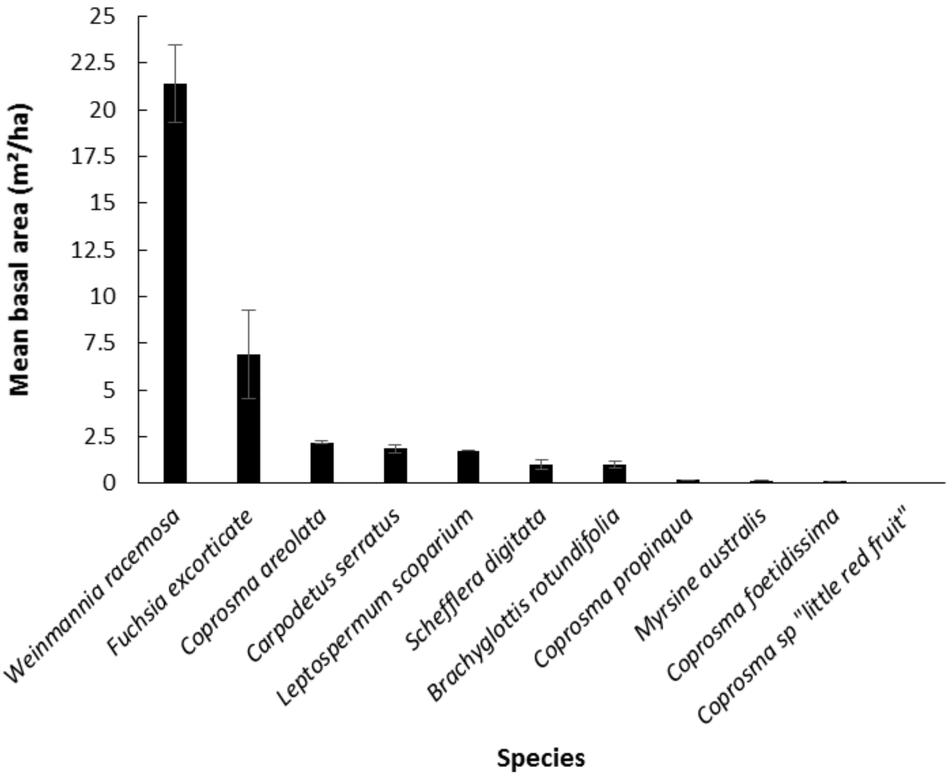

Figure 3.11 Mean basal area of tree species, Ackers Point, Stewart Island: 2014 (± 95% confidence intervals).

Plot 3 had the highest total basal area (208.35 m²/ha), almost three times as much as plot 8 (79.27 m²/ha) which recorded the second highest (Figure 3.12). Plot 3 contained the largest tree recorded in 2014, a kamahi (73.4 DBH) (Appendix 2). Plots 4, 5, 6, 9, 10 and 11 had very similar total basal areas (Figure 3.12). Plot 7 and 12 contained no trees (Figure 3.12).

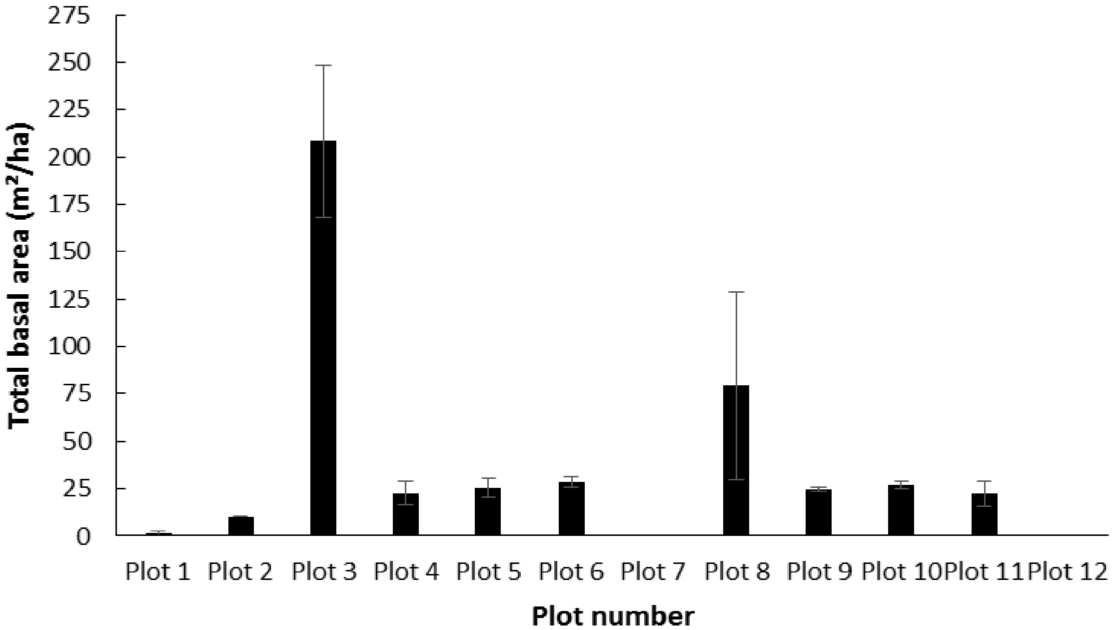

Figure 3.12 Total basal area of each permanent plot, Ackers Point, Stewart Island: 2014 (± 95% confidence intervals).

4. Discussion

Vegetation showed an increase in the abundance of seedlings in 2014 (7.32 ± 3.45 (95% CI) per m²) when compared to 2006 (6.12 ± 1.38 (95% CI) per m²). The increase in the abundance of seedlings shows a positive trend since the 2004 pest eradication programme began. Although this increase was not statistically significant (P value = 0.45, P >0.05), this could be contributed to the relativity small sample size (twelve plots). The number of saplings recorded in 2014 (0.77 ± 0.38 (95% CI) per m²) remained very similar to the 2006 survey (0.78 ± 0.58 (95% CI) per m²). The lack of increase in the abundance of saplings shows that there are factors present which restrict vegetation from developing beyond the seedling height category.

4.1 Seedlings

The diversity of seedlings (0 – 45 cm) was different during the 2014 survey when compared to 2006. In 2006 fuchsia and manuka were the most abundant seedlings. It is known that both these species are very light demanding (Handford, 2000). There was an increase in canopy cover recorded in 2014 (mean increase of 2.5%), which causes a decrease in available light. This would explain the low number of these two species recorded in 2014. It appears that access to light was also a major contributing factor for low seedling density. The lowest density of small seedlings and cotyledons recorded in 2014 was at a site containing a very thick fern and flax covering, denying species the required light levels needed for germination and growth (Davies-Colley, Payne, & Elswijk, 2000).

The three most abundant seedlings in 2014 were thin-leaved coprosma, supplejack and kamahi (Figure 3.3, 3.4 and 3.5). Thin-leaved coprosma are very hardy plants that can easily adapt to different habitats (Lee & Johnson, 1984). Thin-leaved coprosma are also not limited by sunlight levels (Ogden, 1985) and therefore the increase in canopy cover will not affect their abundance. The berries of thin-leaved coprosma are also an important and favoured food source for many native birds (Lee & Johnson, 1984), which will always ensure wide dispersal of their seeds. Thin-leaved coprosma also has a rapid growth rate when compared to other native plants (Lee & Johnson, 1984). The marked increase in supplejack seedlings recorded in 2014 (0.90 ± 0.88 (95% CI) per m²) compared to 2006 (0.31 ± 0.28 (95% CI) per m²) may be directly linked to the removal of rats (*Rattus spp*.) in the area. Supplejack seeds are a favoured food source for rats (Campbell, 2002). Therefore, the increase in supplejack seedling abundance may be the result of a decline in the rat population; 11556 rats eradicated since 2004 (SIRCET, 2013). However, before the fight against rats is declared a success it must also be noted that natural variations (favourable seasonal conditions, an increase in pollinators and seed distributors) are known to vary between years (Campbell, 2002). It may be that supplejack experienced an exception year for the production of seeds and this could explain the spike in the abundance of seedlings shown in the 2014 survey (Figure 4.1). Future surveys will eventually remove these natural variations and report on the true trends (Campbell, 2002).

Figure 4.1 Thick pocket of supplejack and fuchsia at Ackers Point, Stewart Island (2014) (Photo: S. Gorinski).

Meurk & Wilson (1989) identify kamahi as being the most predominant tree species at Ackers Point. The 2014 survey confirms this as five out of the twelve sites are surrounded by kamahi canopy. It is for this reason that kamahi seedlings will always be represented in larger numbers. Only if kamahi trees were removed from the area would we ever see a decrease in kamahi seedlings. All twelve plots were assessed as having good drainage. Plot seven had the highest seedling diversity of all the plots surveyed. The plot contained storm damage, three fallen trees (fuchsia, putaputaweta and pate), leaving a large hole in the canopy. This explains the high diversity of seedlings as multiple species occupy the area and compete for the extra available sunlight (Pausas & Austin, 2001).

4.2 Saplings

Saplings (45 cm – 200 cm) are still struggling to establish themselves at Ackers Point. The lack of increase in the abundance of saplings may be caused by the remaining deer (*Odocoileus virginianus*) population still present in the Ackers Point Reserve; an estimated twelve individual deer (SIRCET, 2013). Ungulates (deer and goats) are responsible for the destruction of many indigenous forest ecosystems (Atkinson, 1964), including the compaction of soil, barking of trees and shrubs and vegetation browsing. Of most concern is the understory browsing deer carry out, leading to complete removal and regeneration of palatable species (Allen, Payton, & Knowlton, 1984; Wilson, Ruscoe, Burrows, McElrea, & Choquenot, 2006). Nugent, Fraser, & Sweetapple (2001) state that even in low numbers (approx. two deer/km^2) deer browse can cause localised extinction of certain plant species. Of all the vegetation species recorded during the 2014 survey, five species (supplejack, kamahi, kapuka, mapou and pate) are classified as having a high ruminant-preference to ungulates (Sweetapple & Nugent, 2004) (Table 2.1). Findings indicate that these five species are able to regenerate in large quantities due to the abundance of mature trees (Figure 3.3, 3.5, 3.7, 3.8, and 3.9). However, when all the high preference species were combined only two individual plants were recorded in the browse level (30 cm – 200 cm). The absence of high ruminant-preference plants clearly shows that these species are heavily retarded by deer browse to the point where they are completely absent from the surveyed plots (Figure 4.2). Near total removal of deer is required in order to protect the most highly preferred species within such ecosystems (Nugent, Fraser, & Sweetapple, 1997).

Figure 4.2 Two deer browsing in a permanent plot at Ackers Point, Stewart Island (2014).

4.3 Canopy cover

Canopy cover increased (mean increase of 2.5%) since the 2006 survey. The canopy cover increase is a direct response to the removal of possums (*Trichosurus vulpecula*); 443 possums eradicated since 2004 (SIRCET, 2013), and the subsequent reduction in browse pressure (in particular for kamahi and fuchsia). There is multiple evidence that shows the adverse effects that possums have on native forest vegetation (Batcheler, 1983; Cowan, 1991; Esler, 1978; Leathwick, Hay, & Fitzgerald, 1983). The loss of mature trees due to browsing can create a forest with a lower canopy, less palatable species, and a less diverse range of biota (Campbell, 1990). In order to have successful reintroduction of endangered species, it is important to restore the canopy ecosystems and retain the current canopy height (Atkinson, Campbell, Fitzgerald, Flux, & Meads, 1995). A quarter of all indigenous forest canopy is vulnerable to possum browse (Cowan, 1991). Certain tree species can be used as indicators for possum population increase (Nugent, Whitford, Innes, & Prime, 2002). Kamahi will show canopy decline after an increase of 20 % in the possum population (Nugent, Whitford, Innes, & Prime, 2002). Fuchsia will show canopy cover decline after an increase of only 5 % in possum population (Nugent, Whitford, Innes, & Prime, 2002). In 2014, there were five plots surrounded by kamahi canopy cover and three plots surrounded by fuchsia canopy cover. All kamahi and fuchsia surrounded plots showed an increase in canopy cover, this suggest that the possum population has been reduced to a small enough population to allow for positive regeneration of the canopy cover (Figure 4.3).

Figure 4.3 2014 Satellite photo showing the thick canopy cover at Ackers Point, Stewart Island (source "Ackers Point" Google Earth, DigitalGlobe 2014, 6 September 2014)

4.4 Basal area

Kamahi trees had the highest mean basal area recorded in 2014 (21.38 m^2/ha). The mean kamahi basal area/ha calculated for all of New Zealand's angiosperm forest (using 232 independent plots) is 7.1 m^2/ha (Allen, Bellingham, & Wiser, 2003). Therefore the basal area recorded at Ackers Point is almost three times the national average (Allen, Bellingham, & Wiser, 2003), which shows the dominance that kamahi has at the study area. However, there is evidence that shows a negative relationship between the presence of kamahi and other angiosperm species (Lusk, 2002). Kamahi is considered too strong when competing for available resources (Lusk, 2002). This results in the limited presence of other canopy species in kamahi dominated forest pockets (Lusk, 2002). The thick canopy cover that kamahi has, which limits the light available for the understory, is also presumably responsible for the reduced development of angiosperm seedlings and saplings present in the understory (Lusk, 2002). Plots three and eight had the highest total basal areas, 208.35 m^2/ha and 79.27 m^2/ha respectively. Plots three and eight were the only plots located on the ridge top and therefore have the most access to available sunlight. This shows that trees with the most available sunlight will become larger than those that do not (Davies-Colley, Payne, & Elswijk, 2000). As there was no historical basal area data available from the previous surveys, trends cannot be established.

4.5 General discussion

There was an observed absence in the amount of birdlife seen and heard during the 2014 survey. Previous surveyors (Dooley, 2006) have noted the presence of Stewart Island weka (*Gallirallus australis scotti*) and Stewart Island robin (*Petroica australis rakiura*) whilst carrying out surveys. No sightings of rare, threatened or significant biota were recorded during the 2014 survey. A thirteenth plot was found during the 2014 survey. The new plot was noted down and surveyed. The collected data has been included in Appendix 2 for future comparison.

5. Conclusion and recommendations

5.1 Conclusion

The Halfmoon Bay Restoration Project aims to restore the natural ecosystems at Ackers Point Reserve, increase the native bird population and provide a safe habitat for the re-introduction of threatened Stewart Island fauna. In order to achieve this aim, mammalian pests must be controlled to allow for the vegetation to regenerate and provide adequate habitat for native species. Pest control began in 2004 and permanent vegetation plots have been established and monitored frequently in order to report any changes in vegetation structure as a result of the pest control. The monitoring of these plots in 2014 found that the diversity of seedlings was different when compared with the last survey conducted in 2006. Light demanding species such as manuka and fuchsia were less frequent in 2014 due to the increase in canopy cover (mean increase of 2.5%) that had occurred since 2006. Canopy cover increased due to the reduction of the possum population; 443 possums eradicated since 2004. Supplejack seedlings showed a marked increase since 2006. Supplejack seeds are a favoured food source for rats. Therefore, the increase in supplejack seedlings may be due to a decline in the rat population; 11556 rats eradicated since 2004. It was identified that saplings are still only present in low numbers within the reserve. The lack of increase in the abundance of saplings may be the result of plant species being heavily retarded by deer browse to the point where they are completely absent from the browse level (30 – 200 cm). Findings show that kamahi is the most predominant tree species within the reserve, providing canopy cover for five out of the twelve plots. Kamahi produces a thick canopy, which limits the light available for the understory, which may explain the reduced number of angiosperm seedlings and saplings present in the understory. No sightings of rare, threatened or significant biota were recorded during the 2014 survey.

5.2 Recommendations

In order to restore natural ecosystems, ensure a natural progression from seedling to trees and create the required habitat for an increase in native bird population, it is recommended that the near total removal of deer should be carried out at Ackers Point Reserve.

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Appendix 1 – Permanent plot locations

Plot	Grid reference (GPS)
1	East 2140507, North 5356997
2	East 2140985, North 5357161
3	East 2140958, North 5357095
4	East 2140701, North 5356823
5	East 2140683, North 5356921
6	East 2140613, North 5356965
7	East 2140908, North 5356995
8	East 2140865, North 5357079
9	East 2140627, North 5357096
10	East 2140687, North 5357177
11	East 2140580, North 5357023
12	East 2140740, North 5356962
13	East 2140932, North 5356912

Appendix 2 – 2014 Raw data

Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 1 **(A1-T1)**		3								
35% Canopy cover	*Uncinia spp.*			3	2					
Fuchsia canopy	*Coprosma areolata*					19		4	2	1.3,6.1
North facing, gentle slope	*Blechnum banksii*		2	4						
Well drained	*Fuchsia excorticate*		1							
	Dicksonia squarrosa								1	
	Rumohra adiantiformis		3	5	8	8				
	Astelia fragrans							2		
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 2 **(A6-T6)**		44								
65% Canopy cover	*Coprosma areolata*		144	24	25	14		1		
Kamahi dominated canopy	*Brachyglottis rotundifolia*		4	6						
North facing slope, well drained	*Ripogonum scandens*		3						33	
Deer feces	*Blechnum banksii*		5							
	Giselinia littoralis		3							
	Weinmannia racemosa		10							
	Coprosma foetidissima		2							
	Rumohra adiantiformis		2	5						
	Schefflera digitata								1	17.9
	Coprosma grandifolia		2							
	Uncinia spp.			1						
	Cortaderia richardii			1						
	Carpodetus serratus			1						
	Coprosma rotundifolia		1							
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 3 **(A8-T15)**		48								
75% Canopy cover	*Weinmannia racemosa*			22					6	13.7,23.5,13.6,12.0,7.1,8.8,73.4
Kamahi & Supple Jack Canopy	*Coprosma foetidissima*			11					1	6.9
Flat, North/East Facing	*Ripogonum scandens*		75						23	
well drained	*Giselinia littoralis*		17							
	Histiopteris incisa		4							
	Coprosma areolata		6							
	Dicksonia squarrosa							1	2	
	Blechnum discolor		1	3	1	2				

Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 4 **(A9-T7)**										
25% Canopy cover	*Weinmannia racemosa*								1	21.9
South Facing, Steep, well drained	*Brachyglottis rotundifolia*		2	3				3	2	6.0, 6.9
Large slip in plot	*Coprosma areolata*				3				1	12.5
Kamahi & Muttonbird Scrub canopy	*Blechnum banksii*		8		1					
	Dicksonia squarrosa								1	
	Blechnum discolor				1					
	Carpodetus serratus		1							
	Histiopteris incisa		2							
	Rumohra adiantiformis			1	1	1				
	Uncinia spp.	C								
	Rubus cissoids	C								
	Pteridium esculentum	O								
	Acaena novae-zealandiae	C								
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 5 **(A11-T6)**		71								
65% Canopy cover	*Coprosma areolata*		195	11	1			1		
Kamahi & Supplejack canopy	*Giselinia littoralis*		16							
South facing gentle slope	*Brachyglottis rotundifolia*		12	1						
Lots of deer sign	*Coprosma rotundifolia*		1							
Well drained	*Weinmannia racemosa*		74						3	9.8,18.9,18.9
	Ripogonum scandens		38						5	
	Coprosma foetidissima		97	2						
	Carpodetus serratus		2							
	Myrsine australis		5							
	Blechnum banksii		1	1						
	Dicksonia squarrosa					1			4	
	Rumohra adiantiformis		3			1				
	Uncinia spp.		1	4						
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 6 **(A1-T6)**		23								
45% Canopy cover	*Blechnum discolor*				11	16				
Mutton Bird scrub & Fuchsia canopy	*Coprosma areolata*		35	3		4			4	7.9,7.6,8.7, 14.9
West facing gentle slope	*Blechnum banksii*		5	1		1				
Well drained	*Giselinia littoralis*		3							
	Brachyglottis rotundifolia				1	4			2	17.2,2.5
	Myrsine australis		1							

	Rumohra adiantiformis				2	1				
	Astelia fragrans				1					
	Weinmannia racemosa		1							
	Dicksonia squarrosa					4			1	
	Histiopteris incisa		3							
	Fuchsia excorticate								1	13.8
	Ripogonum scandens		1							
	Coprosma foetidissima		2		1					
	Aristotelia serrata			1						
	Blechum sp. Black spot		1							
	Uncinia spp.	O								
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 7 **(A10-T6)**		53								
55% Canopy cover	*Schefflera digitata*		2	2						
Marble Leaf dominated canopy	*Coprosma areolata*		14	5		1				
South facing, medium slope	*Rumohra adiantiformis*		1	5	3	2				
well drained	*Brachyglottis rotundifolia*		15	4	2					
Fallen fuchsias, Mamaku, Marble leaf,	*Blechnum banksii*		8		1	2				
and 7 fingers laying across approx	*Weinmannia racemosa*		4							
50% of area. Appears recent storm	*Carpodetus serratus*		9	1	1					
damage	*Blechnum discolor*		2		1					
	Giselinia littoralis		9							
	Ripogonum scandens		3						3	
	Cyathea medullaris							1	1	
	Fuchsia excorticate		2							
	Dicksonia squarrosa				1					
	Asplenium flaccidum		1							
	Acaena novae-zealandiae		O							
	Uncinia spp.		O							
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 8 **(A4-T11)**		47								
65% Canopy cover	*Fuchsia excorticate*								1	49.5
7-finger & Fuchsia canopy	*Rumohra adiantiformis*		2		2					
Top of ridge, well drained	*Coprosma areolata*		45	1	25	6		1		
	Ripogonum scandens		141							
	Coprosma foetidissima		17							
	Histiopteris incisa		29							
	Blechnum discolor							7		

	Dicksonia squarrosa				2			2		
	Uncinia spp.		3							
	Blechnum banksii		2		2	1				
	Schefflera digitata		4						2	4.9,7.0
	Cyathea medullaris								2	
	Acaena novae-zealandiae		1							
	Metrosideros diffusa								1	
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 9 **(A3-T9)**		37								
35% Canopy cover	*Blechnum discolor*					4		2		
Rough tree fern canopy	*Blechnum banksii*		19	3	3	4				
Gentle slope, well drained	*Astelia fragrans*				2	17		2		
North West facing	*Coprosma areolata*		66		8	6		3	1	2.6
	Dicksonia squarrosa							2	3	
	Coprosma rotundifolia		2		2	1				
	Weinmannia racemosa		2						3	5.5,10.6,12.3
	Coprosma sp "little red fruit"		3		4	3			1	2.4
	Carpodetus serratus		1	1	1				5	6.8,2.6,3.6,5.5,2.0
	Giselinia littoralis		23							
	Coprosma foetidissima		13							
	Myrsine australis		1						1	7.6
	Cyathea medullaris		2						2	16.3,7.5
	Pteridium esculentum				1	3				
	Uncinia spp.	C								
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 10 **(A4-T2)**		27								
45% Canopy cover	*Coprosma areolata*		22					2	6	7.3,6.2,6.4,3.1,5.3,2.9
Marble Leaf and Aerolata canopy	*Blechnum banksii*		13			2				
North West facing	*Blechnum discolor*				1	28		2		
Gentle slope, well drained	*Giselinia littoralis*		1							
Crown fern suffocating coverage	*Pteridium esculentum*							1		
	Carpodetus serratus		4						3	19.8,13.4,6.2
	Astelia fragrans							3		
	Coprosma propinqua		9						3	3.5,5.5,5.3
	Coprosma rotundifolia							1		
	Myrsine australis		3							
	Brachyglottis rotundifolia		1							
	Cardamine corymbosa		2							

	Uncinia spp.	O								
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 11 **(A2-T1)**		7								
15% Canopy cover	*Dicksonia squarrosa*					4		3		
Manuka Dominated canopy	*Blechnum discolor*				1	10				
West facing slope, well drained	*Leptospermum scoparium*					2			1	26
Thick fern cover	*Coprosma sp "little red fruit"*				2	2				
	Carpodetus serratus					3				
	Coprosma areolata			1		8		3	5	3,1.1,2.4,2.2,3.9
	Coprosma foetidissima		7							
	Berberis darwinii			1						
	Giselinia littoralis		1							
	Blechnum banksii	O								
	Uncinia spp.	O								
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 12 **(A9-T2)**		64								
45% Canopy cover	*Coprosma areolata*		125							
Kamahi canopy	*Weinmannia racemosa*		33							
Ridge top, well drained	*Dicksonia squarrosa*								6	
Lots of deer feces and prints	*Ripogonum scandens*		8							
	Giselinia littoralis		19							
	Myrsine australis		1							
	Carpodetus serratus		6							
	Brachyglottis rotundifolia		8							
	Blechnum banksii			1						
	Asplenium flaccidum		1							
	Cardamine corymbosa		2							
	Rumohra adiantiformis		2							
Site Information	***Species***	Cotyledons	<15cm	15-30cm	30-45cm	45-135cm		saplings	trees	dbh (cm)
Plot 13 **(A9-T5)**		15								
50% Canopy cover	*Weinmannia racemosa*		4						1	14.2
Kamahi & Marble leaf canopy	*Ripogonum scandens*		71							
South facing gentle slope	*Brachyglottis rotundifolia*		6	3						
Well drained	*Rumohra adiantiformis*		1	1						
	Dicksonia squarrosa							1	4	
	Coprosma areolata		24	3						

	Blechnum discolor				1	2				
	Carpodetus serratus								1	28.6
	Giselinia littoralis		7							
	Blechnum banksii		2							