BAY OF PLENTY REGIONAL COUNCIL
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Foliar Browse Index Monitoring Report 2018

Ohope Scenic Reserve

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Cover photo: Kohekohe *(Dysoxylum spectabile)* – Heather MacKenzie Support Environmental Scientist, canopy at Plot 7 Line 1

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Part 1:
Introduction

Foliar Browse Index (FBI) monitoring was established in Ōhope Scenic Reserve in February 2008 as part of a monitoring programme to assess the outcome of possum control operations. Re-measures were carried out in 2009, 2010, 2012, 2014 and 2018. In 2012 kamahi *(Weinmannia racemosa)* was added as an extra tree species at existing plots as well as kohekohe *(Dysoxylum spectabile)* trees at plots where none were previously monitored, as recommended in Beattie (2010).

During this measure in 2018, mangeao (*Litsea calicaris)* was removed as an indicator species due to the high level of mortality in monitored trees since monitoring was established in 2008. This mortality or 'die back' of apparently healthy mangeao is occurring across Waikato and Bay of Plenty (including areas subject to possum control) and its cause is not well understood (Gardner & Dick, 2002).

The number of kohekohe and kamahi trees monitored was increased during this re-measure by adding more trees at both existing plots and with the addition of more lines/plots. This increased the total number of plots with kohekohe to 46, and kamahi to 33.

The following report gives an overview of the current levels of possum impacts on selected tree species within Ōhope Scenic Reserve, and looks at changes between the six measures (2008, 2009, 2010, 2012, 2014 and 2018). It also establishes a baseline measure with kohekohe and kamahi with the existing and the new trees.

Part 2:
Background

Ōhope Scenic Reserve is located in the Taneatua Ecological District in the coastal and semi-coastal bioclimatic zone and comprises coastal cliffs and hill country (Wildland Consultants, 2018). Coastal areas of the reserve contain nationally significant examples of pōhutukawa forest while the inland areas of hill country contain rewarewa (*Knightia excelsa*)-kānuka (*Kunzea robusta*)-pōhutukawa (*Metrosideros excelsa*) forest (Beadel at al., 1999).

Ōhope Scenic Reserve is part of a larger area that is strategically important for biodiversity protection as it contains a relatively large example of pohutukawa (*Metrosideros excelsa*) dominant forest, a nationally rare vegetation type and supports populations of a number of nationally threatened and regionally uncommon flora and fauna species (Wildland Consultants, 2010).

Ōhope Scenic Reserve is administered by the Department of Conservation (DOC) and jointly managed with Ngāti Awa through the management committee, Te Tapa Toru ā Toi. Bay of Plenty Regional Council (BOPRC) contributes co-funding for a range of plant and animal pest management activities (particularly rat and possum control) in the Reserve and Whakatāne Kiwi Trust are heavily involved with mustelid trapping and other predator control activities (BOPRC, N.D.).

Possum control has been an important part of the animal pest management regime that has been occurring within the Reserve and adjacent sites (Mokorua Bush Scenic Reserve). Possums impact native vegetation by browsing on foliage, fruit and seeds. Possum browse can cause canopy dieback and eventual death of plants, prevents regeneration of preferred species (altering forest composition), and reduces food availability for native fauna.

Possums have been controlled sporadically in the Ōhope Scenic Reserve with traps and cyanide from 1991 through to 1997, using brodifacoum in bait stations (150 m x 150 m spacings) in 2005, and using feratox in bait stations (75 m x 75 m spacings) from 2008-2010. The Residual Trap Catch Index for the Reserve was 13%-14% in 2006 and 2007; and has been consistently measured below 1% since late 2008.

No further possum control operations have occurred within the site since 2010, but bait stations have been filled bi-annually with pindone for control of rats; and feratox has been applied in adjacent sites (including Ngāti Awa Kawenata to the south). Operations in adjacent sites have likely helped limit possum reinvasion into the Reserve.

In order to determine the level of possum impacts and canopy vegetation response to possum control in the Ōhope Scenic Reserve, the FBI standard methodology (DOC, 2014) was used. For a more in-depth discussion of the background to this monitoring programme, refer to Blackwell (2008), MacKenzie (2009), Beattie (2010), MacKenzie (2012), or Bevan (2015).

Part 3:
Methodology

Foliar Browse Index (FBI) monitoring is a ground based method used throughout New Zealand to assess canopy health and possum browse levels on selected tree species. In the Ōhope Scenic Reserve, kohekohe, mangeao and kamahi are surveyed. Trees are given scores for foliage cover, stem use, browse, dieback, fruiting and flowering, based on an indicator species assessment sheet. For a more detailed explanation of the assessment sheet, and further detail on the FBI method, refer to DOC (2014).

Five lines were established in 2007 within the Ōhope Scenic Reserve on existing stoat trapping and bait station lines, with a total number of 63 plots, and a maximum of three trees per species at each plot. The removal of all mangeao trees and others due to mortality or views being obscured, left only 28 plots out of the 63 plots established in 2007. Kamahi was added in 2012, as an additional tree species as recommended in Beattie (2010), along with some additional kohekohe at plots where they were not previously recorded. This increased the sample size of kohekohe from 29 to 31 plots. During this (2018) re-measure, more trees and plots were added to increase sample size (50 plots containing each indicator species being the minimum sample size recommended in DOC, 2014). A total of 1 line, 11 plots, and 62 new trees (47 kohekohe and 15 kamahi) were added. This brings the total number of kohekohe plots to 46 and the number of kamahi plots to 33.

As the addition of new trees essentially creates a new sample population and unmatched pairs, the data has been analysed separately for each addition of new trees. The data for the trees originally established in 2008 has been analysed for all re-measures. Kamahi established in 2012 has been analysed for the years 2012 to 2018. The trees added in 2018 were not used in statistical analyses against previous measures, they will, however, give an increased sample size for future comparisons.

For further details on the establishment of the FBI lines in the Ōhope Scenic Reserve, refer to Blackwell (2008), MacKenzie (2009), Beattie (2010), MacKenzie (2012), and Bevan (2015). Monitoring was carried out in February 2008, February 2009, February/March 2010, February 2012, February to April 2014 and March 2018. Many parameters measured by the FBI methodology vary seasonally, so to maintain consistency in scores between years, future measures should be carried out in February.

Data were analysed using the statistical package R (v3.3.1).

Part 4:
Results

Results displayed in this report are calculated using plot means, making the plot rather than individual trees the sample unit. The minimum distance between plots of 100 m ensures independence between the samples (DOC, 2014).

Below are results for foliage cover, possum browse and canopy dieback for monitored kohekohe and kamahi (years 2012 to 2018 only) for 2008, 2009, 2010, 2012, 2014 and 2018. Dead and unscorable trees have been excluded from the standard analyses and are discussed separately. Prior to the addition of trees in the current re-measure, the number of kohekohe plots declined from 29 to 28 and kamahi from 29 to 27. Data from previous years has been recalculated to exclude these plots to allow comparison of results between sampling periods; therefore, results may vary from previous year's reports. Wilcoxon Matched Pairs Test was used to test the significance of changes in mean foliage cover, browse and dieback scores for plots over the monitoring period, based on a 95% confidence interval.

4.1 Foliage cover

Table 1 *Mean foliage cover (plot) for 2008-2018 of monitored trees in Ōhope Scenic Reserve. Two values for kohekohe in years 2012 and 2014, three values for kohekohe in 2018 and two values in 2018 for kamahi are for additional plots.*

Species	Year	n (plots)	Mean foliage cover (%)	Standard deviation
Kohekohe	2008	28	66	10.99
	2009		69	9.88
	2010		75	8.92
	2012	28 / 30	71 / 71	11.49 / 11.15
	2014		85 / 85	8.76 / 8.45
	2018	28 / 30 / 46	76 / 75 / 75	7.03 / 7.38 / 7.57
Kamahi	2012	27	59	10.07
	2014		62	13.48
	2018	27 / 33	57 / 57	13.45 / 11.65

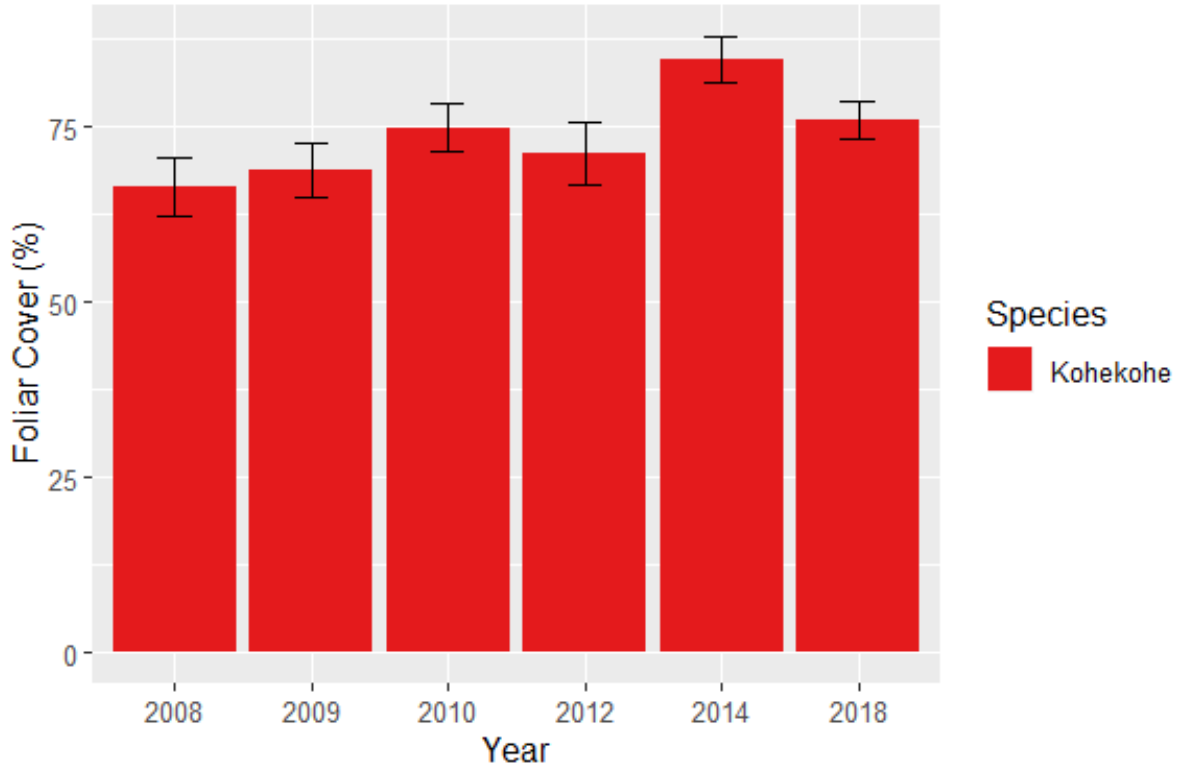

Figure 1 *Mean foliage cover (per plot) with 95% confidence intervals of monitored trees established in 2008.*

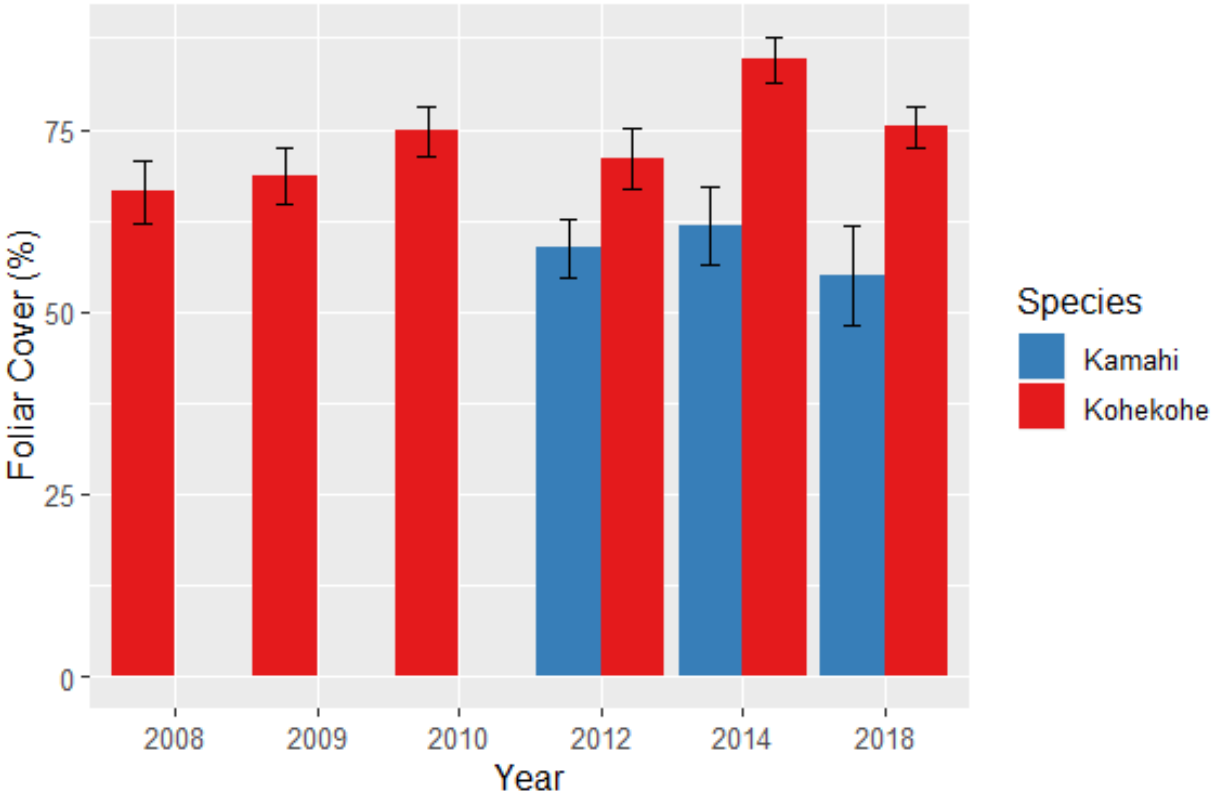

Figure 2 *Mean foliage cover (per plot) with 95% confidence intervals of monitored trees established in 2012. Mean foliage for years 2008 to 2010 have been added for comparison.*

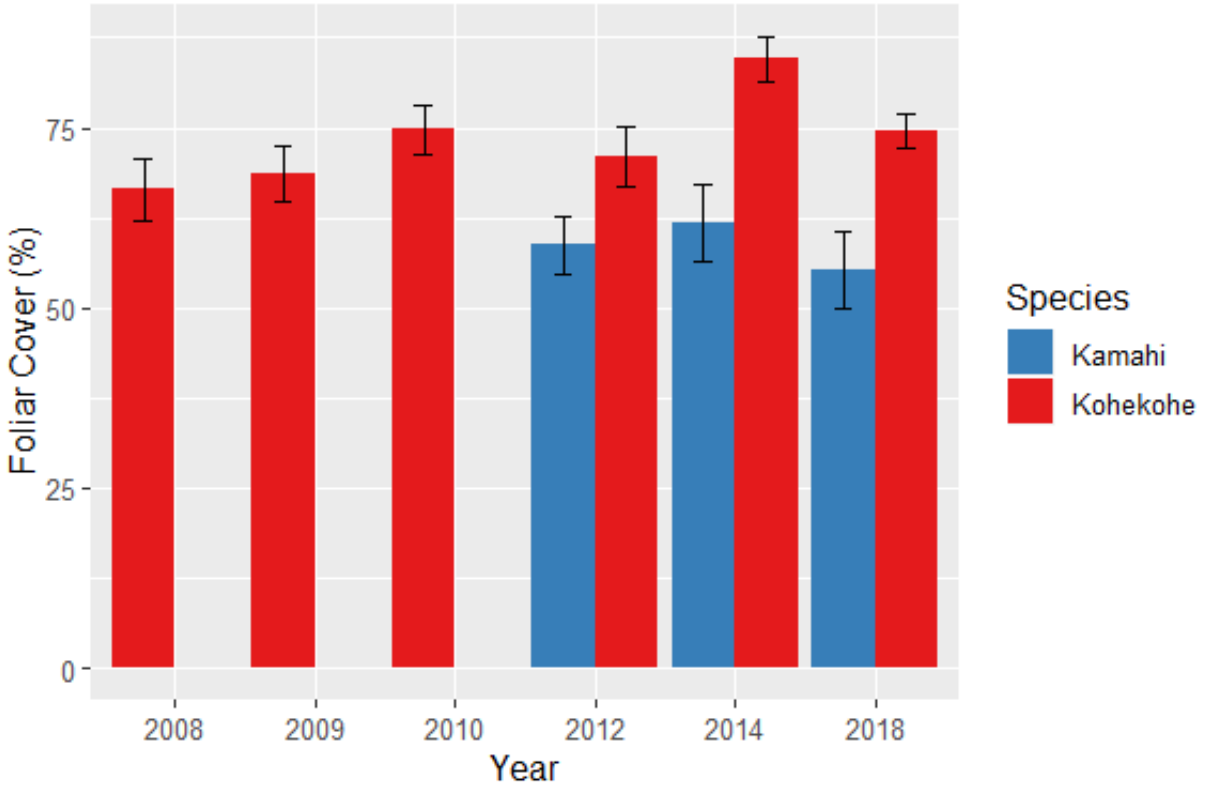

Figure 3 *Mean foliage cover (per plot) with 95% confidence intervals of monitored trees added in 2018. Mean foliage cover for years 2008 to 2012 have been added for comparison.*

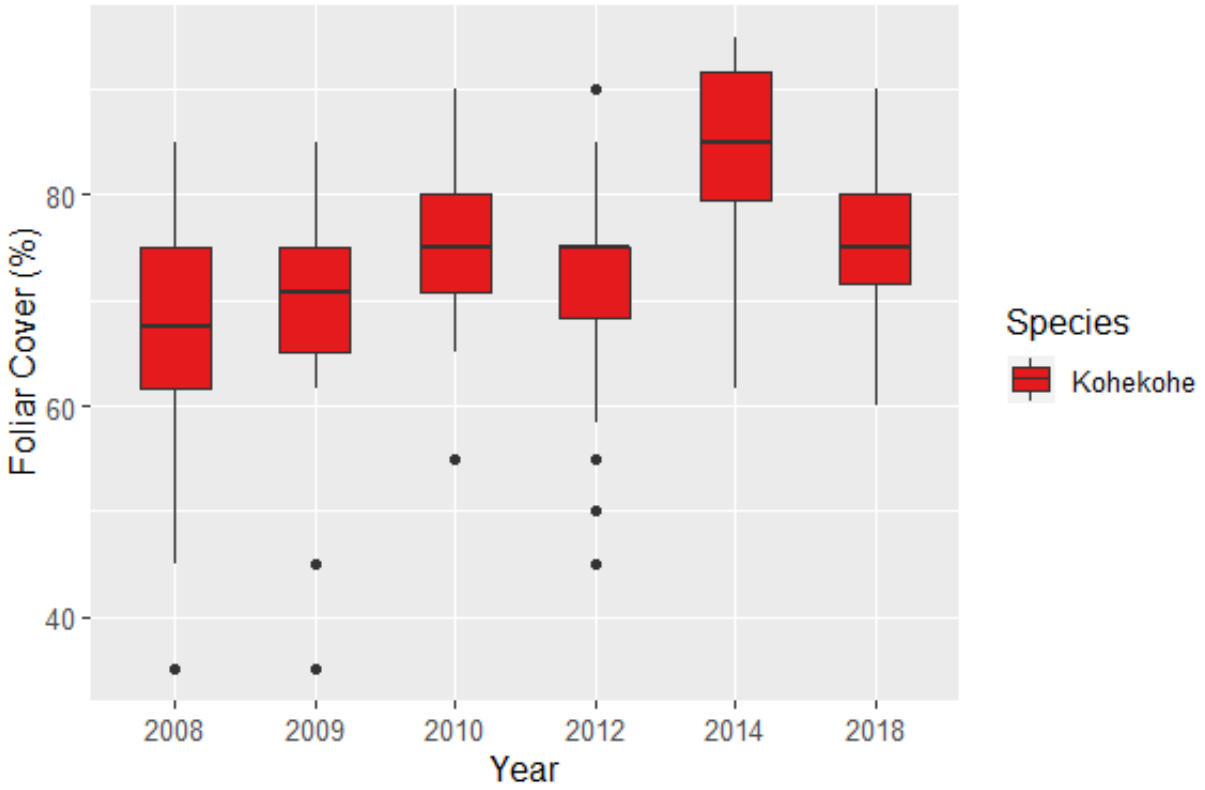

Figure 4 *Boxplot showing mean foliage cover (per plot) of monitored trees established in 2008.*

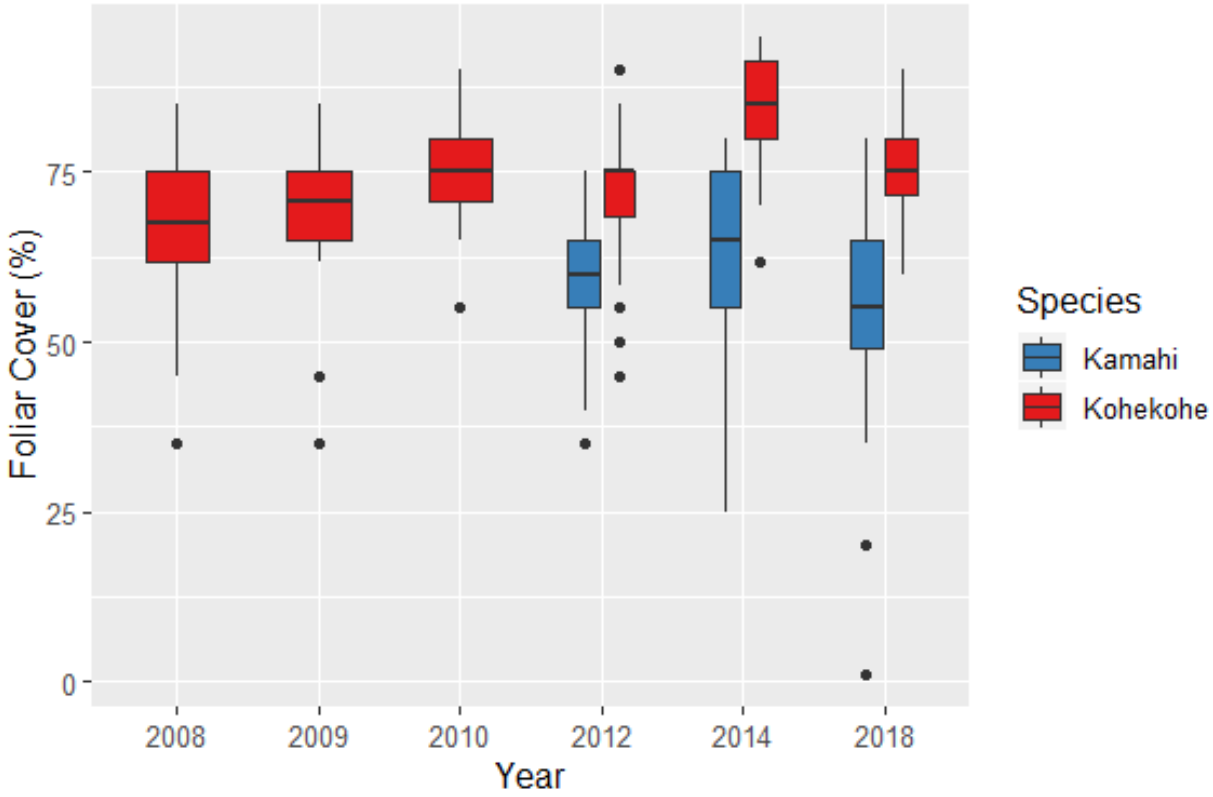

Figure 5 *Boxplot showing mean foliage cover (per plot) of monitored trees added in 2012. Years 2008 to 2010 have been added for comparison.*

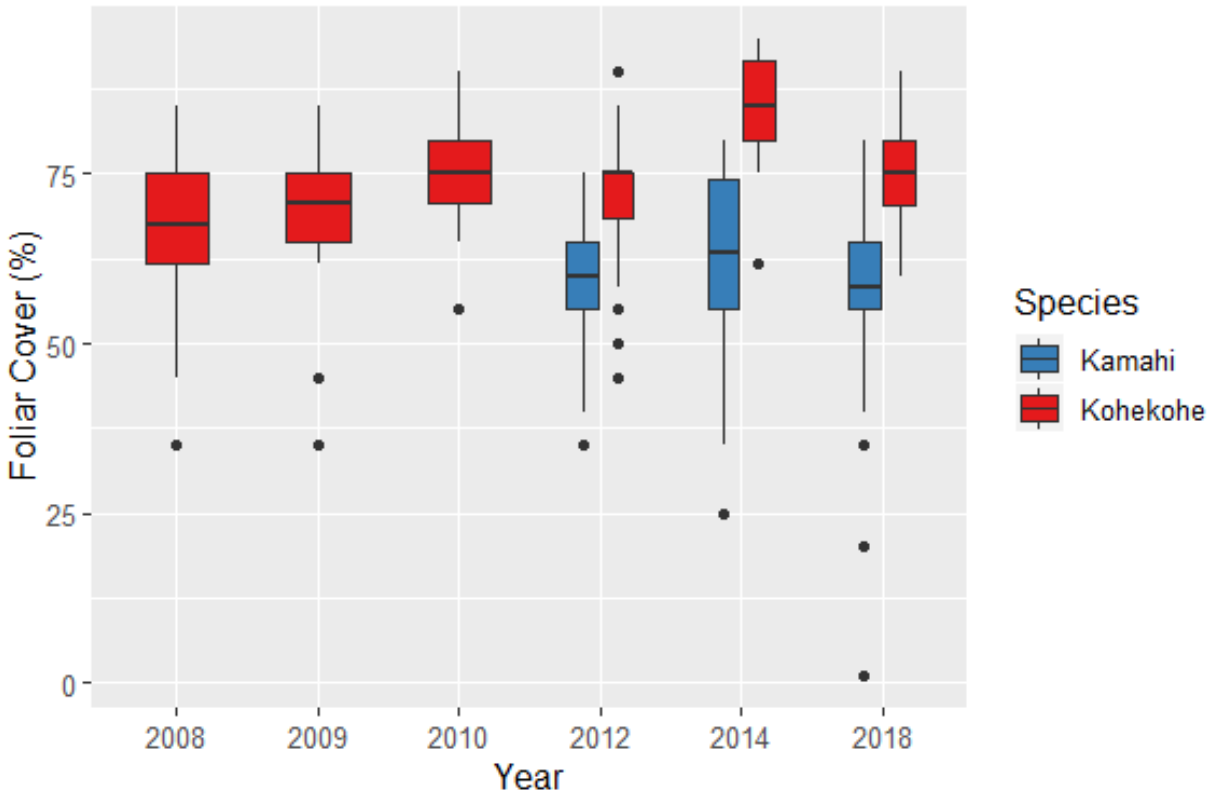

Figure 6 *Boxplot of mean foliage cover (per plot) of monitored trees added in 2018. Years 2008 to 2014 have been added for comparison.*

4.1.1 Kohekohe

Kohekohe mean foliage cover in this re-measure was greater than in 2008, 2009 and 2012, similar to 2010 and lower than in 2014. Differences from 2018 are statistically significant (P<0.05) for all years except 2010, though actual differences in means are relatively small (maximum 10%).

4.1.2 Kamahi

Kamahi mean foliage cover in this re-measure is similar to the first measure of kamahi in 2012, and slightly (5%) lower than in 2014. Though small, the difference between 2018 and 2014 was found to be statistically significant (P=0.007).

4.2 Browse

Table 2 *Mean browse whole (plot) and percentage of plots with browse for monitored trees in Ōhope Scenic Reserve. Two values for kohekohe in years 2012 and 2014, three values for kohekohe in 2018 and two values in 2018 for kamahi are for additional plots.*

Species	Year	n (plots)	% Mean browse whole	% Plots with browse
Kohekohe	2008	28	5.73	32.14
	2009		1.41	35.71
	2010		0.09	3.57
	2012	28 / 30	0 / 0	0 / 0
	2014		0 / 0	0 / 0
	2018	28 / 30 / 46	0 / 0 / 0	0 / 0
Kamahi	2012	27	0	0
	2014		0	0
	2018	27 / 33	0 / 0	0 / 0

No browse was observed in 2018 on monitored kohekohe or kamahi and has not been observed since 2012.

4.3 Dieback

Table 3 *Mean dieback whole (plot) and percentage of plots with dieback for monitored trees in Ōhope Scenic Reserve. Two values for kohekohe in years 2012 and 2014, three values for kohekohe in 2018 and two values in 2018 for kamahi are for additional plots.*

Species	Year	n (plots)	% Mean dieback whole	% Plots with dieback
Kohekohe	2008	28	3.69	14.29
	2009		2.65	3.57
	2010		5.03	28.57
	2012	28 / 30	2.95 / 2.92	3.57 / 3.33
	2014		4.58 / 4.44	28.57 / 26.67
	2018	28 / 30 / 46	4.96 / 4.79/ 4.35	25.00 / 23.33 / 23.91
Kamahi	2012	27	8.04	33.33
	2014		19.33	100.00
	2018	27 / 33	25.71 / 24.82	92.60 / 96.88

4.3.1 Kohekohe

The number of kohekohe plots with dieback has varied over the years with higher levels recorded in 2008, 2010, 2014 and 2018 (~14-29%), compared to 2009 and 2012 (3-4%) (Table 3).

The number of plots with kohekohe die back in this re-measure was similar to that recorded in 2010 and 2014. Mean dieback has increased very slightly over time (with statically significant differences between 2009 and 2018 P=0.020 for those trees established in original survey in 2008) but on the whole is similar between years and relatively low (<5%).

4.3.2 Kamahi

The number of kamahi plots with dieback has increased notably from 33% of plots in 2012 to 93% of plots in 2018. Mean dieback also increased significantly from 8% in 2012 to 26% in 2018 (P<0.001).

Two kamahi trees died between 2012 and 2014 and a further five died between 2014 and 2018. These trees have been excluded from the analysis for the data series (see 4.4 Dead trees for data analysis).

4.4 Dead trees

All dead trees were excluded from the current analyses. From 2012 to 2014, two kamahi trees died. A further five kamahi died from 2014 to 2018. No tagged kohekohe have died throughout the survey years.

This small sample size of tree species does not allow for in-depth statistical analysis of tree mortality. DOC (2014) discusses the requirement of a minimum of 200 trees for each species to allow for an 80% chance of detecting possum control impact on tree survival rates. There was also no possum browse recorded on any of the trees that died during the survey.

An increase in kohekohe recruitment was observed as kohekohe trees with a diameter at breast height (DBH) greater than the minimum 5 cm requirement were available to be added to the sample.

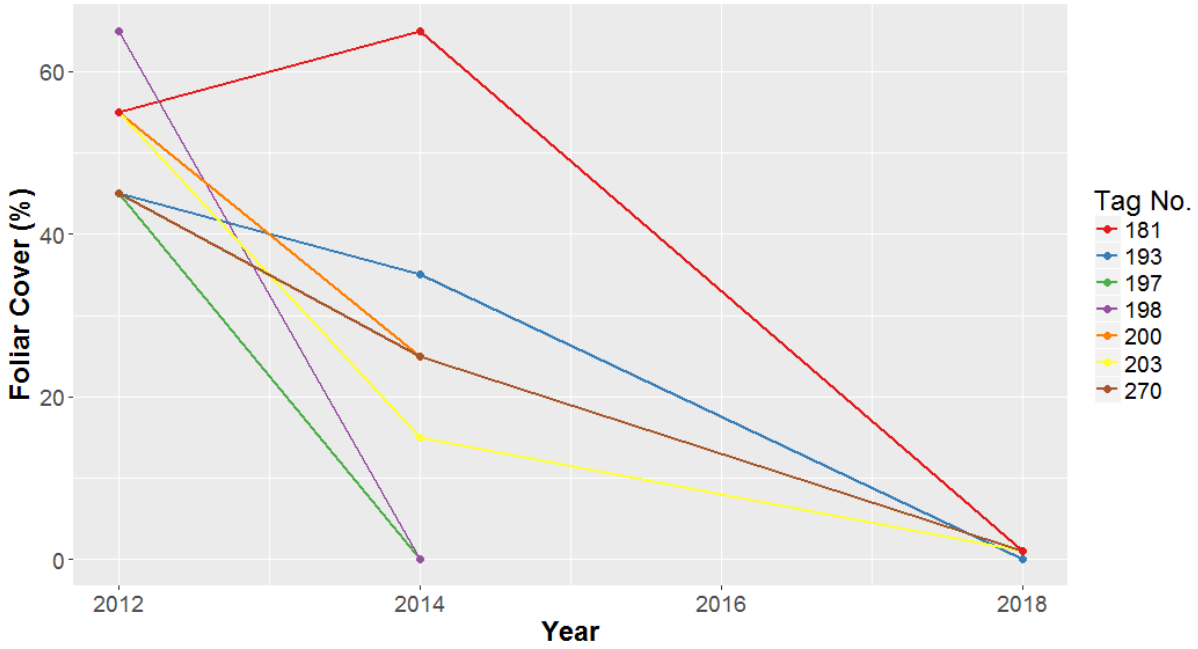

Figure 7 *Decreasing foliage cover for the seven kamahi trees recorded as dead throughout the survey years.*

Part 5:
Discussion

Maintain current sample sizes for kohekohe and kamahi, although they have not met the recommended 50 plots (DOC, 2014). It is not efficient to invest more time and money to increase sample sizes further. The current data is already fragmented over numerous years and the addition of more trees/plots would complicate this future.

5.1 Kohekohe

Mean foliage cover of kohekohe in Ōhope Scenic Reserve is similar to that measured on Red Mercury Island (Stewart, 2000), a possum free island in the Coromandel. This score suggests that possums at their current density are not having a significant effect on kohekohe within the reserve. This is further supported by no observed browse since 2012, as well as low canopy dieback scores.

While FBI scores for kohekohe indicate good canopy health and improvements since 2008, improvements haven't been very large. Kohekohe has been shown to respond rapidly to low possum abundances (Nugent, Whitford, Innes & Prime, 2002), so it's likely some recovery had already resulted from possum control undertaken prior to 2008 (RTCI in 2008 was already near the 10% generally recommended to protect kohekohe).

Although, there was an increase in the number of plots with dieback observed from 2009 to 2010, Beattie (2010) attributed this increase to observer variation and it is likely the 25% increase from 2012 to 2014 is also due to observer variation. It is important to maintain low possum numbers as kohekohe is a preferred species for possums, and increased possum numbers are likely to directly affect kohekohe as the canopy, regeneration and recruitment processes are all likely to be affected.

The small sample size (28 plots in 2008) may be the result of historic possum impacts reducing the recruitment of kohekohe, and therefore restricting kohekohe distribution within Ohope Scenic Reserve (MacKenzie, 2009). The sample size was increased in 2012 with the addition of trees at two plots (three trees) and then increased again in 2018 to 46 plots (38 trees). The increased sample size still does not reach the recommended 50 required to reliably detect (with 80% probability) whether a 10% change in foliage cover is statistically significant (DOC, 2014), but does provide information on the condition of these trees and the impact of possums across the sample. Because kohekohe is one of the most preferred species for possums, it is often one of the first to show impacts when possum numbers begin to increase, and although small, the sample should be maintained and monitored at regular intervals. Kohekohe seedling survival is heavily impacted by possums (Buddenhagen & Ogden, 2003). The fact that new kohekohe recruits were present since the previous surveys and had greater DBH than the required 5 cm, meant these trees were available to be added to the survey. This suggests possum impacts are low enough within the reserve to allow improved tree recruitment. Results from vegetation monitoring within the reserve will be able to confirm recruitment rates. There is an increase in the number of seedlings as well as the recruitment of kohekohe through to tree

life stage when looking at result from the permanent plot network (Wildland Consultants, 2018).

5.2 Kamahi

The small sample size of kamahi (27 plots in 2012) was increased to 33 plots (11 trees) in 2018. The sample size is still below the recommended sample size of 50 required to reliably detect (with 80% probability) whether a 10% change in foliage cover is statistically significant (DOC, 2014). However, the data still provides important information on the condition of these trees and the impact of possums across the sample.

Average dieback of kamahi trees continues to increase. Since 2012, seven kamahi trees have died of which none had browse observed, therefore, there is no evidence to suggest that possum browse is linked to the increased dieback in kamahi. A study (Bellingham *et al.*, 1999) into the long-term effects of possum browse on conifer/broad-leaved forests showed the cause of kamahi dieback is unknown and can proceed over a long period. Increases in dieback may be attributable to observer differences, environmental factors, or storm/salt damage. Die back of kamahi in coastal areas has been observed following severe storms (Veblen & Stewart, 1980) and the Reserve has been affected by cyclones in recent years (e.g. Cook and Debbie).

The study also found that the possum control occurring was having little effect in alleviating the decline in vulnerable species such as kamahi. Kamahi in Ōhope Scenic Reserve should continue to be monitored, as kamahi are susceptible to possum browse and will provide an indication of possum impacts and abundance where browse is detected.

Part 6:
Conclusion

Good levels of foliage cover in Ōhope Scenic Reserve and zero browse observed since 2012 (corresponding with very low possum RTCIs). These results show possum are having a negligible impact on kohekohe. Kohekohe is a particularly palatable species, and low levels of impact on this species suggests a low level of impact on vegetation within the reserve generally.

Increasing levels of die back on kamahi between 2008 and 2018 are unlikely to be the result of possum damage as no browse has been observed since 2012.

Overall, possum impacts remain low within the reserve at levels unlikely to impact vegetation. It is important that possum numbers remain low to prevent any detrimental effects on canopy health and forest processes.

Part 7:
Recommendations

- Continue to undertake FBI monitoring on a five yearly basis (next monitor in February 2023).
- Continue to maintain low possum numbers in order to ensure canopy health and forest processes are maintained over time.
- Maintain current sample size for kohekohe and kamahi.
- Investigate using multilevel models to analyse all data in response to the complexity created by additional trees over time.
- Foliar Browse Index studies in similar forest types not subject to possum control, would provide an interesting comparison against which to assess FBI results in Ōhope Scenic Reserve.

Part 8:
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