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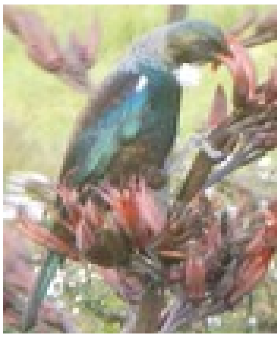
WINDY HILL ROSALIE BAY CATCHMENT TRUST

BIRD COUNTS DECEMBER 2016

REPORT JO 14. FEBRUARY 2017.



TUI NUMBERS in areas managed for rats (blue) and (red) unmanaged areas. Trend lines diverging.

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BIRD COUNTS: DECEMBER 2016

EXECUTIVE SUMMARY

Three-minute bird counts have been made in December, at the same points and mostly by the same observers at Windy Hill every year since 2000. The results have been reported annually, and the field and analysis methods described previously.

In 2016, two thirds of counts (216) were made in five separate locations within the Sanctuary area, which is managed to keep rodents at low numbers. The remaining third of counts (108) were made in five areas where rat numbers are monitored but no trapping or baiting occurs (the ‘unmanaged controls’ for this study).

The difference between managed and unmanaged areas, clear in all previous reports, remains so as more controls are added. Bird density in the managed area was double that in the unmanaged controls.

The overall a long-term trend of increasing numbers for most species in the Sanctuary continued. Tui and grey warbler show statistically significant increasing trends.

Kereru recovered again compared to previous years in the Sanctuary, but still show no clear trend.

Silvereye showed a marked increase in 2016, reversing an otherwise downward trend.

Silvereye frequency was compared with other small insectivore species and found to show no clear correlations. Grey warbler and fantail were however significantly positively correlated in the long-term sanctuary data sets.

Introduced species and ‘others’ were similar to previous years. Blackbird and chaffinch are the main introduced species, but neither are common in the areas counted.

The results are briefly compared with some recently published results (Ruffell & Didham 2017) and it is concluded that while some results appear to be in agreement, others are difficult to compare.

The persistent, if relatively small, differences between managed and unmanaged areas at Windy Hill may be some of the best data available illustrating the benefits for small insectivorous bird populations, of intensive pest reduction without total eradication.

INTRODUCTION

This report: This report is one of an annual series and is presented in the format used in the previous Reports. It covers the analysis of 3-minute bird count data sets from Windy Hill Rosalie Bay Catchment Trust Management Area in December 2016. Comparison is made between managed areas (in which rat numbers are kept low by the use of traps and bait stations) and unmanaged control areas. A new unmanaged area. Taumata, was included as a control in 2016, but may be managed in future. The 2016 data are compared with similar data collected each year since 2008 and trends are plotted.

Previous reports etc.: The bird monitoring project has been outlined in previous reports and papers. Reports before 2008 were by ECoRAP (Dr S. Ferreira and Anne-Marie Smit) and cover the period from the commencement of monitoring in 2000 to June 2008. The overall conclusions to be drawn from these earlier reports are summarised in Ogden, J. 2009. *WHRBCT Bird Counts December 2008*, and EcoRAP report: EC0006/12-8. *Bird Counts June 2008.* September 2008; all indicate general ecosystem improvement since restoration began in 2000[1].

Pest management within the Windy Hill Rosalie Bay Catchment Trust Sanctuary (WHRBCT): The WHRBCT is a community conservation organisation concerned with pest control and ecosystem restoration on fifteen mainly private properties in south-east Great Barrier Island. The managed area now covers c. 770ha, and the trust employs field staff and volunteers, mainly engaged in pest management, but also monitoring birds, reptiles, invertebrates, stream fauna and forest tree seedling populations as well as administration. One of the main strengths of the Trust has been in testing methodology (e.g. different rodent control and monitoring methods), reporting negative results, and providing transparency on the costs and benefits of its operations.

Vegetation at Windy Hill: As described in earlier Reports, the forest cover of the area forms a continuum from manuka dominance on ridges, through kanuka, to progressively richer and taller forest, especially in the valleys. The composition and structure of the kanuka dominated forest types – which cover most of the landscape - is changing as succession towards more mature canopies continues. This quite rapid change in forest structure and condition has been described[2] and should be kept in mind when assessing changing bird abundances.

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1 Ogden, J. & Gilbert, J. 2005. *Rodent trapping results from Windy Hill and Benthorn farm, Great Barrier Island: 1999-2004.* Ogden, J. & Gilbert, J. 2009. *Prospects for the eradication of rats from a large inhabited island: community based ecosystem studies on Great Barrier Island, New Zealand*. Biological Invasions: 11: 1705-1717*.* Ogden, J. 2009. Windy Hill Rosalie Bay Catchment Trust. *Bird Counts December 2008*, Report JO1. February 2009. Ogden, J. 2011. Windy Hill Rosalie Bay Catchment Trust. *Trends in Bird Abundance 2000 – 2011*. Report JO5. July 2011. Ogden, J. 2011. Windy Hill Rosalie Bay Catchment Trust. *Bird Counts December 2010,* Report JO4. February 2011.

2 Perry, G.L.W., Ogden, J., Enright, N. J. & Davy, L.V. 2010. Vegetation patterns and trajectories in disturbed landscapes, Great Barrier Island, Northern New Zealand. *New Zealand Journal of Ecology* 34(3): 311-323.

Bird monitoring: Bird monitoring has played an important part in evaluating the management actions of the Windy Hill Rosalie Bay Catchment Trust since 2000. Monitoring has been carried out over (some of) the same transects over this whole period. The necessity to compare different areas and vegetation types, and to replicate bird counts both spatially within a locality (e.g. ridge or valley) and at different seasons, was recognised, making this one of the longest and most comprehensive bird monitoring studies on private land in New Zealand. However, as the seasonal changes in species abundance/conspicuousness were not the prime focus of the work, since 2009 formal bird monitoring has been restricted to one week during December with a view to recording only data essential to assessing the long-term effects of predator management, and reducing costs. Work on sea-bird abundance has also been commenced following the discovery of black petrel nests within the Sanctuary, but this is not addressed here.

METHODS

Data collection

Three-minute bird counts were made at 54 point-stations on transect lines in five locations within the managed area (“The Sanctuary”) and in five unmanaged locations outside it (“The Controls”). These areas are named (or given abbreviations) in Table 1. The managed area refers to the c. 620 ha area in which rat trapping and bait stations are employed; rodent monitoring tunnels are employed in both managed and unmanaged areas.

All points were counted on six occasions, over a period of twelve days. The counting transects are each 150m in length, with count points marked by a stake at each end. Intermediate 50m points were *not* counted, but casual bird observations were noted. There were three observers, over the period 1st to 12th December. This team was reduced from previous years due to the illness of two employees. However, most locations were sampled by more than one observer. (Table 1).

The survey technique was as follows:

- At each station, birds were counted for 3 minutes.
- Individuals heard and/or seen were counted, with care taken to ensure that each individual was recorded once only.
- For each bird recorded, the distance from the station to the bird was estimated in 5m classes as follows: 0 -5m, >5-10m, >10-15m, >15-20m, >20-25m.

Since 2009 recorders have noted birds calling > 25m from the point or between points in the margins of the data sheet. This was done to make the counts more comparable with those carried out between 2006 – 2008 by the Great Barrier Island Charitable Trust[3].

3 Great Barrier Island Charitable Trust. Biodiversity Advice Fund AV 207; Final Report.

Table 1. Sample sizes, dates and observers for the December 3-minute counts, 2016[4]

Location	Points	Total counts (Points x 6 reps)	Start date	End date	Observers (1)
Ridges (R1 - R6)	12	72	4-Dec	9-Dec	R, H.
Valleys (V1 - V6)	12	72	4-Dec	9-Dec	R, H.
Benthorn	4	24	5-Dec	5-Dec	R.
Robin arera	4	24	2-Dec	6-Dec	R, H.
Rosalie Bay & Big Windy	4	24	2-Dec	5-Dec	Dv.
ALL SANCTUARY	**36**	**216**	**2-Dec**	**9-Dec**	**3 observers**
Old control	4	24	1-Dec	7-Dec	R, H.
Waterfall Bay control	4	24	1-Dec	1-Dec	Dv, H.
Rosalie Bay rd. control	4	24	5-Dec	12-Dec	H.
Taumata	4	24	5-Dec	12-Dec	H.
Little Goat control	2	12	5-Dec	7-Dec	H.
ALL CONTROLS	**18**	**108**	**1-Dec**	**12-Dec**	**3 observers**
TOTALS	***54***	***324***	***1-Dec***	***12-Dec***	***3 observers***

(1) Observers: H, Henry Cookson; R, Rachel Wakefield; Dv, Dave Harland.

In 2016 two thirds of counts (216) were made in five separate locations within the Sanctuary, and the remaining third (108) made in five unmanaged control locations. Disregarding the ‘additional’ birds, and bearing in mind the difficulty of visually or audibly assessing station-bird distances in forest, each station surveys an area of approximately 25m radius (1963.5m^2).

Data analysis

Analysis methodology has been given in more detail in previous reports. It is important to recognize that bird *conspicuousness* varies with species, vegetation type, season, time of day, weather conditions etc. Consequently 3-minute bird counts are difficult to interpret: they will not usually reflect the *actual number* of birds present. Consequently it is important to replicate counts and to be cautious in interpretation.

The 3-minute counts were usually carried out from c. 9.0AM to midday, but some repeats were in afternoons, until c. 3.0 PM. All stations were replicated six times, but the interval between replications varied from hours to days. Spreading the work between observers over a week has the advantage of ‘averaging out’ differences due to weather and possible

4 [WH 2017 anal 2016 data: Tabs 1, 2, 3 2016 .xlsx]

differences in observer ability. The total survey sample comprises 324 three-minute counts, representing a total of 16 hours of observations, but considerably more travel time.

Two ways of summarizing the 3-minute data are presented:

1) *Count frequency:* frequency for a species based on the number of times a species was recorded as present at a site, divided by the total number of site-counts (eg, if a bird was seen or heard on 25 occasions at the 72 station counts on Windy Hill ridges, it would have a frequency (on WH ridges) of 25/72 = 35%)
2) *Density(estimated number per hectare)*: based on the sum of the numbers counted at points at any one time (rather than simply 'present'). Counts per station are converted into per ha values by multiplying by 5.09296. The multiplier is 1/0.19635, i.e. the number of point centred sample areas of 25m radius in a hectare. Note that the separate distance categories recorded in the raw data have *not* been used to make more precise estimates of density.

   An important reason for adopting this simplified approach to data analysis and presentation is that there are serious doubts as to how reliable 3-minute count data are for estimating 'true' density (numbers per ha.). This is because what is really being measured is the 'conspicuousness' of the different species.

   The standard deviation (S) of the density estimates for each species have been converted into 95% Confidence Limits (95%CL = S/(sq. root N) * 1.96).

The first measure (count frequency) cannot exceed 1.0 (100%) for any species. When based on a large sample size (as here) the percentage value relates directly to the *probability* of recording the species at a site. Frequency is an easy measure to compare between sites and times, and is robust even when fieldwork is carried out by different observers.

Density is intended to be an absolute (nos./ha) figure rather than simply a relative value or probability. However, it is also influenced by differences in conspicuousness and, when most data sets contain many zero entries, is likely to have a wide variance. Density is estimated for each species in each location by: (1) assuming that the number counted for a species at a station in the field data represent the number of individuals < 25m from the station, and (2) converting the number of birds in the circle represented by 25m radius to a hectare sample by multiplying by 5.0929. This method takes no account of the detailed 'distance' measures (other than 'within 25m') and may underestimate small inconspicuous birds. It gives equal weight to a sighting or hearing at 5m as to one at 25m. However, more 'refined' analyses employing distance probability functions produce unrealistic estimates, especially for flocking species, which violate a fundamental assumption of the model[5]. As demonstrated in an earlier

5 The model assumes 'uniform distribution' of the items being sampled with respect to the sample transects (or points). Cassey, P. & McArdle, B. H. 1999. An assessment of distance sampling techniques for estimating animal abundance. *Environmetrics* 10: 261-278. See also: Cassey, P. 1999. Estimating animal abundance by distance sapling techniques. *Conservation Advisory Science Notes*. No. 237. Dept. of Conservation, Wellington. A key text is: Buckland, S. T. et al. 1993. *Distance Sampling. Estimating*

Report[6], frequency and density are strongly correlated statistically, so the former reflects the latter. This of course is to be expected – the more numerous a species is, the higher the probability that it will be recorded at any location.

The 95% Confidence limits (95% CL) used in the figures are a measure of the variability of the average estimate in the repeated counts[7]. Where confidence limits overlap between compared columns or points, we can conclude that there is no statistically significant difference between them. A more formal t- test almost invariably supports this interpretation. Where 95% CLs *do not* overlap it is likely that there is a real difference. This conclusion is particularly likely for situations where the lack of overlap is clear and repeated over several years (e.g. between WH Ridges and Control in 5 out of 7 years). However a more comprehensive analysis of variance (ANOVA), including all the data may be preferred. The wide variability indicates that selected pair-wise comparisons taken from such a larger body of data must be treated cautiously.

RESULTS

Frequency and density trends 2008 – 2016

Table 2 demonstrates that birds are generally about 20% more frequent in the managed than in the unmanaged areas. Frequency measures the % likelihood of seeing or hearing a bird within 25 m, in a 3-minute period. In 2016 the difference between managed and unmanaged areas appears to have declined, possibly reflecting an approaching plateau in bird frequency in the managed area. Individual species frequency data for 2016 are summarised in Table 3. The marked increase in % frequency of silvereyes, associated with a decline in grey warblers, is highlighted.

The overall frequency data are also shown in Fig 1, which illustrates the trend of increasing bird frequency in both managed and unmanaged areas. While the overall rate of increase in the unmanaged areas (dotted line in Fig 1) appears steeper, there is much more variability than in the managed area, so that the trend line is not statistically significant (Correlation Coefficient, r = 0..6320; P>.0.05). The more consistent trend in the managed area is highly statistically significant (r=0.9158; P<0.001) and is always higher than the unmanaged.

The density data (Fig 2), as expected, illustrate the same trends as the frequency data, but the correlation is less clearly significant (Correlation coefficient r = 0.6996, P < .05 for Sanctuary, not significant for unmanaged area). Taken with the frequency data, the bird abundance trend is clearly upwards. In 2016 the Sanctuary recorded 14 birds/ha compared to c. 7 in the controls.

Abundance of Biological Populations. Chapman and Hall. London, UK.

6 Windy Hill Rosalie Bay Catchment Trust. Bird Counts. December 2012, Fig. 9. (Report JO 7. March 2013.)

7 95% CL =(standard deviation/squareroot n)*1.96, expressed as ± the mean value

Table 2. Total bird frequencies (all species) in the managed and unmanaged (control) areas at Windy Hill over nine years. The % difference row is the relative increase of the managed over the unmanaged area, with the overall average in bold[8].

Transect	2008	2009	2010	2011	2012	2013	2014	2015	2016	Avg
Ridges	72	80	77	82	87	85	78	83	89	81.4
Valleys	73	73	78	82	87	83	86	92	85	82.1
Benthorn	88	81	77	73	85	85	91	87	100	85.2
Robin	60	69	77	81	90	83	79	92	92	80.3
Rosalie/BW						96	83	92	83	88.5
Old Control	58	29	50	71	83	75	71	50	71	62.0
Waterfall Bay control				56		50	67	50	83	61.2
Ros. Bay Rd. control								79	58	68.5
Taumata									96	96.0
Little Goat control								83	83	83.0
Avg managed	73.3	75.8	77.3	79.5	87.3	86.4	83.4	89.2	89.8	**82.4**
Avg unmanaged	58	29	50	63.5	83	62.5	69	65.5	78.2	**62.1**
Difference (%)	15.3	46.8	27.3	16	4.3	23.9	14.4	23.7	11.6	**20.4**

Table 3. Total bird frequencies by species in managed (Sanctuary) and unmanaged areas in 2016.

Species	**All Sanctuary**		**All Controls**	
	2015	**2016**	**2015**	**2016**
Kaka	25.5	22.2	11.9	14.2
Silvereye	14.3	28.1	8.3	20.0
Tui	39.3	43.9	9.5	11.7
Shining cuckoo	4.6	1.9	0.0	0.0
Grey warbler	32.9	28.1	34.5	16.7
Fantail	17.1	20.6	11.9	23.3
Kingfisher	11.6	17.5	3.6	14.2
Kereru	18.5	21.9	3.6	10.8
Robin	0.0	0.0	0.0	0.0
Other	5.5	7.5	3.6	3.3
All bird species	88.4	80.0	63.1	78.3

8 [WH 2017 anal 2016 data: Tabs 1, 2, 3. 2016. xlsx]

Fig 1. Average frequencies of all bird observations in managed and unmanaged areas over nine years[9].

Fig 2. Average density (all bird species) per ha. in managed (Sanctuary) and unmanaged areas over nine years[10].

Fig 3. Average density (all species) in managed (Sanctuary) and unmanaged areas in 2015 and 2016. Error bars are 95% Confidence Limits. Unmanaged is based on all five control areas monitored in 2016[11].

The divergence between managed and unmanaged areas is emphasised in Fig. 3[12]. Compared to the previous year there was an increase in bird density in both managed and unmanaged areas in 2016. Even though bird density has apparently increased in the controls, it remains much below that of the managed area, even excluding the relatively rich Benthorn area. Bird density in the Sanctuary is almost double that in the unmanaged areas. The difference assessed by a t-test is highly significant (P <<.001).

The total (all species) bird count density results for each area in each year are shown in Fig 4. and included in the Appendix.

The 2016 results show an increase in density over 2015 in the Benthorn and Robin areas. The new Taumata control area has a relatively high bird density for an unmanaged area, though it is not significantly different from the (old) control site.

Persistent patterns can be interpreted or at least used to guide other analyses – for example the ridges always have higher bird densities than the controls, with no overlap of confidence limits in five of the nine years. A paired t-test for these two data sets gives a probability due to chance (p) of .003, indicating a highly significant difference between them. The trends of increasing bird density at Benthorn and in the Robin area are also notable.

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9 [WH 2017 anal 2016 data. FIG 1 WH Sanctuary v Control 2016.xlsx]

10 [WH 2017 anal 2016 data: FIG 2 FIG 4 WH 2014 15 16 DENS ciomparisons.xlsx]

11 [WH 2017 anal 2016 data: FIG 3 WH 2016 ALL managed, all contrls.xlsx]

12 The small differences in total density between Figs 2 and 3 result from slightly different methods of averaging. Fig 2 follows previous graphs in which the averages for different sub-areas within the managed and unmanaged areas were added and divided by the number of areas – i.e. irrespective of the different sample sizes in different areas. Fig 3 takes account of the different sample sizes and is strictly more correct.

Fig 4. Overall average density of all bird species in the five managed and five unmanaged areas 2008 – 2016, with 95% Confidence Limits (Vertical bars above and below the averages). New controls included[13].

Large Fruit and nectar feeders (Fig 5)

Overall trends are still positive for tui and kaka, with the former trend being statistically significant (Correlation coefficient for tui in managed area: r= .8873 p <.01 **). The increase in tui in the managed area is much greater than in the unmanaged controls.

Kereru showed an increase in numbers overall, but the trend lines in both managed and unmanaged areas remain flat.

Despite annual fluctuations, kaka appear to be trending upwards, and are generally commoner in the managed area (average c. 0.5 birds/ha more) than the unmanaged. Like Kereru, but for different reasons, *actual kaka numbers* are hard to estimate. The conspicuousness of the birds, and their loud calls, tend to cause over-estimation. This observation however does not negate the difference between managed and unmanaged areas, or the time trends.

Substantial variation, confusing longer-term trends, can occur in counts from year to year (and place to place) in species which tends to move between fruiting or flowering trees as they become available, and which can be very conspicuous at some times (e.g. when displaying) but quite cryptic at others (e.g. kereru when feeding or close to nests).

Small insectivores and omnivores (Fig 6)

The numbers of these small birds show even more annual fluctuations than do the larger long-lived species, but all three species generally exhibit larger numbers in the managed areas.

Fantail and grey warbler seem to be continuing to increase at a similar rate in both managed and unmanaged areas, though grey warbler shows a marked decline since 2015 in both areas. As a result, the up-wards trend for grey warbler in the Sanctuary is no longer statistically significant at the 5% level. (r = .6503, p <.0.10). The apparent long-term decline in Silvereye noted in the 2015 data from the Sanctuary on the other hand appears to have been reversed. These results emphasise the difficulty of getting long-term trends for these species, in which conspicuousness, and real numbers, probably vary considerably from year to year.

The statistics in Table 4 suggest that most species show positive trends in both managed and unmanaged areas, but only grey warbler and tui show significant trends, and these only in the managed area. Kaka shows an increasing trend in the managed area, and fantail in the

13 [WH 2017 anal 2016 data: FIG 2 FIG 4 WH 2014 15 16 DENS comparisons.xlsx]

unmanaged, though neither of these reach statistical significance. Silvereye has a negative (or zero) trend in the managed area.

Table 4. Species density trends over 2008 – 2016.

Species	Managed Unmanaged	R^2	R Correlation coefficient	P (7 df)	Trend	Significance
Fantail	m	0.10591	0.3254	>0.10	+	NS
Fantail	u	0.22368	0.4729	>0.10	++	NS
Silvereye	m	0.02122	0.1457	>0.10	-	NS
Silvereye	u	0.02874	0.1695	>0.10	+	NS
Grey Warbler	m	0.42294	0.6503	<0.10	+++	*
Grey Warbler	u	0.09019	0.3003	>0.10	+	NS
Tui	m	0.78735	0.8873	<0.01	+++	**
Tui	u	0.03454	0.1858	>0.10	+	NS
Kaka	m	0.248	0.4980	>0.10	++	NS
Kaka	u	0.01172	0.1083	>0.10	+	NS
Kereru	m	0.00382	0.0618	>0.10	+	NS
Kereru	u	0.01716	0.1310	>0.10	+	NS

*Note. + indicates a positive trend, and – a negative trend with the strength indicated by the number of symbols. NS indicates not statistically significant (p >0.10). Asterisks indicate level of significance: * p<0.10, ** p<0.01.*

*Fig 5. Density/ha trends for three large fruit/nectar feeders over nine years. Vertical axis is in all cases estimated density per hectare. Horizontal axis is years commencing 2008. Blue: average of managed areas. Red: average of unmanaged controls. Trend lines are shown but confidence limit bars omitted for clarity. Dashed trend-line is for unmanaged areas. (Correlation coefficient for tui in managed area: r= .8873 p<.01 **).* [14]

14 [WH 2017 anal 2016 data: FIG 5 WH 2016].

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Fig 6. Density trends for small insectivore/omnivore species. Vertical axis is in all cases estimated density per hectare. Horizontal axis is years commencing 2008. Blue: Average of managed areas. Red: average of unmanaged controls. The green triangles are for Taumata in 2016. Trend lines are shown but confidence limit bars omitted for clarity[15]

Other species (Table 5)

Area	Black bird	Chaf finch	Hawk	Brown teal	Total Other
Ridges	1	1			2
Valleys	1			3*	4
Benthorn		3	1		4
Robin	4	1			5
Rosalie Bay					0
Control					0
Water Fall					0
Ros. Bay Rd					0
L. Goat Rd	2				2
Taumata					0
Total	9	2	1	2	17

* Adult plus 2 chicks.

As in most previous years blackbirds and chaffinches were the most conspicuous ‘other species’ recorded at sample points. Several species recorded spasmodically over the last few years were not recorded in 2016 (e.g. sparrow, thrush, morepork) but the overall results are similar, indicating that introduced passerines, though present, are not frequent.

Other ‘additional’ records (Table 6)

Birds heard or seen or heard while moving between points were noted on the sides of the data sheets. This additional recording was not done in a consistent manner and was intended only to supplement the more carefully obtained data set already presented. Additional counts in 2015 were adjusted in the controls by multiplying by 2.57 (i.e. 216/84) to allow for the lesser amount of time spent in the control areas. This adjustment was not applied in 2016 because the much reduced numbers counted between sample points indicates that between-point

15 [WH 2017 anal 2016 data: FIG 6 WH 2016.xlsx].

observations were not done as regularly in 2016 as in 2015. This was probably due to the reduced number of observers available in 2016. No conclusions can be drawn from the 2016 results on 'additional records', but the observation of one banded rail (Valley transect 3) is notable.

Table 6. Birds seen or heard while moving between sample points. Data are number of times the bird was seen or heard between points[16].

Species	Sanctuary 2015	Sanctuary 2016 (1)	Controls adjusted 2015	Controls 2016 (2)
Tui	47	4	16	2
Kereru	29	1	3	2
Kaka	28	1	10	5
Silvereye	17	1	8	1
Kingfisher	13	1	5	3
Grey Warbler	11	3	8	1
Fantail	9		5	3
Other	5	1*	0	0
Shine Cuckoo	1		0	0
Total	160	12	55	17

* *Banded* rail (1) Ridges, Valleys, Rosalie Bay-Big Windy, Benthorn and Robin areas combined. (2) Old Control, Waterfall, Little Goat, Rosalie Bay Rd. and Taumata combined

Comparison with tracking tunnel (rat frequency) data

These comparisons were not made in 2016. The 2015 results clearly demonstrated that high TT percentages were associated with low bird densities and vice versa over a 5-year period. There is no need to revise that conclusion[17].

'Small insectivore guild' frequencies 2000 – 2016.

Previous analyses of association between these species, based on the 2008 – 2011 data, showed a significant positive correlation between silvereye and grey warbler abundance and weak positive correlations between all three species [18].

These associations were re-analysed this year, but using frequency rather than density (Figs 7, 8 & 9). Density and frequency measures of abundance are highly correlated, but frequency

16 [WH 2014 & 15 Table 4 other spp.xlsx] *Seagate.*

17 See Fig 7 in Windy Hill Rosalie Bay Catchment Trust. Bird Counts December 2015. Report JO 11. February 2016.

18 Windy Hill Rosalie Bay Catchment Trust Bird Counts, December 2011. Report JO 6. March 2012.

might be more 'robust' in the sense that (for silvereye flocks in particular) it is not dependent on an accurate count of numbers. Also frequency values can be readily compared with other results obtained by different field teams over the last 16 years on Great Barrier (Table 8).

Fig 7. Grey Warbler v. silvereye frequencies in all Windy Hill and Control sites covering the full period 2008-16. The red point is the 2016 datum for Benthorn.

Fig 8. Fantail v. silvereye frequencies in all Windy Hill and Control sites covering the full period 2008 -16. The red point is the 2016 datum for Benthorn.

Fig 9. Fantail v. grey warbler frequencies in all Windy Hill Sanctuary and Control sites covering the full period 2008-16. The red point is the 2016 datum for Benthorn. [19]

The significant correlation between grey warblers and silvereyes found in 2012 (2008-11 data) was not upheld by the later analysis with more data (Table 7). However the trend of the relationship remained weakly positive, as were all the associations between these three species. The only confident result from the 2016 analyses is the positive relationship between grey warblers and fantail. Grey-warbler decline in the Windy Hill controls in 2016 may be reflected in the failure to record shining-cuckoos in those sites this year. Grey warbler and silvereye declined in unison at Glenfern (Table 8), with the latter being the only species to show an apparently *negative* response to the rat-proof fence[20].

Table 7. Correlations between species co-occurrences in the insectivore guild. The 2008 – 2016 results highlighted.

Species comparisons	R correlation coefficient	P probability of R by chance	Significance	Degrees of freedom
Grey w. / Silvereye (1)	0.585	<.010	**	17
Fantail / Silvereye (1)	0.141	>.10	NS	19
Grey w. / Fantail (1)	0.226	>.10	NS	18
Grey w. / Silvereye (2)	0.169	>.10	NS	43
Fantail / Silvereye (2)	0.085	>.10	NS	43
Grey w. / Fantail (2)	0.451	<.010	**	43
Grey w. / Fantail (2)	0.519	<.001	***	42(3)

(1) Density data from 2012 Report. (2) Frequency data analysed for this report. (3) Excluding the 2016 count only (red in Fig 9). See footnote 19 for 2016 data file.

The data in Table 8 are averages based on different sample sizes. They serve to indicate the great variability in frequency of these small birds. This variability compounds observer

19 The data for Figs 7, 8, 9 are in: WH FREQUENCIES Workbook2. xlsx

20 Analysis of 5-minute bird counts from Glenfern Sanctuary, Great Barrier Island: 2005 – 2006 (pre-fence) and 2010 – 2011 (post-fence). John Ogden & Phil Thomson Report February 2012.

differences, location differences and great differences in the seasonal conspicuousness of the species (see Ogden, 2009: Fig 2 in GBICT Final Report on the Birds of Great Barrier Island 2006-2008, Biodiversity Advice Fund AV 207). In most cases grey warblers are more conspicuous than silvereyes, but at Windy Hill this is not always the case. There has been a suggestion of a decline in silvereyes in the managed areas at Windy Hill, but the trend is not significant, and may have been reversed in 2016 (Fig 6).

Table 8. Comparative % frequencies of small insectivores from 5-minute bird counts at various bush locations on Great Barrier Island 2000- 2016.

Location and reference	Date	Grey warbler	Silver eye	Fantail
Kanuka–manuka Spring & Summer (1)	2006 - 7	80	60	63
Lowland bush Spring & Summer (1)	2006 - 7	60	47	57
Montane bush Spring & Summer (1)	2006 – 7	77	43	40
Glenfern Sanctuary (2) (pre-fence avg.)	2005-6	90	53	24
Glenfern Sanctuary (2) (post-fence avg.)	2010-11	70	30	34
Windy Hill (3)	May 2000	28	89	69
Windy Hill (3)	May 2011	28	53	39
Windy Hill (4)	Dec 2011	59	62	26
WH Sanctuary long-term avg.	2008 - 15	17	24.0	20
WH Sanctuary avg.	2016	33	28	25

(1) Data averages from summer and spring counts; Great Barrier Island Charitable Trust Final Report on Birds of Great Barrier Island 2006-2008. (2) Data averaged from Analysis of 5-minute bird counts from Glenfern Sanctuary, Great Barrier Island: 2005 – 2006 (pre-fence) and 2010 – 2011 (post-fence). John Ogden & Phil Thomson Report February 2012. (3) Windy Hill Rosalie Bay Catchment Trust. Trends in Bird Abundances 2000 and 2011, Report JO 5 July 2011. (4) Windy Hill Rosalie Bay Catchment trust, Bird Counts 2011. Report JO 6, March 2012.

DISCUSSION

As noted in earlier Reports, the density estimates for individual species are probably best regarded as 'indices of abundance' rather than reliable estimates of actual numbers per hectare. Overall density (all species) is probably more robust, and is the best estimate of density per hectare available for birds in the bush on Great Barrier. As demonstrated previously[21] frequency and density are highly correlated, but because density utilises all the numerical and some of the distance data, and is not limited to a maximum of 100, it is the better comparative measure between years at Windy Hill.

The long-term trend to increasing abundance of birds in the five managed compared to unmanaged areas, is statistically reliable. This is particularly clear for tui, a result supported by other studies (Innes et al. 2004; Ruffell & Didham, 2017). A recent analysis of 5-minute bird counts from 195 sites across the Auckland Region over a 6-year period (2009 – 2014:

21 Windy Hill Rosalie Bay Catchment Trust. Bird Counts December 2012. P. 12. (Report JO 7. March 2013).

Ruffell, J. & Didham, R. K. 2017), suggests that tui and kereru show significant increases as a result of pest control measures. Overall species richness and abundance also increased with pest control, though this was largely driven by these two species. This positive effect of pest control, also seen in the Windy Hill data, was most noticeable where total mammalian pest eradication had occurred at the sites.

Grey warblers and fantails are both predominantly insectivorous although they feed in quite different ways and are also to some degree separated by habitat preferences: fantails are more frequent in gullies with dense vegetation and taller trees (e.g. Valley data), grey warblers prefer higher ridges with a canopy of kanuka (e.g. Ridge data). Silvereyes are generally commoner in more open forest and along forest borders.

Silvereyes are only partially insectivorous, also feeding on flower nectar and small fleshy fruits. All three species are present throughout the year, but differ in conspicuousness at different seasons (i.e. singing/not singing) and real population sizes may vary seasonally. Silvereyes show flocking behaviour in winter, when mixed-species flocks are also frequent, implying some mutually beneficial interactions.

Habitat preferences, though clearly overlapping, might suggest a shift from silvereye to grey warbler to fantail abundance as forest succession proceeds. Any such trend must be very long-term and is obscured by the positive correlation between fantails and grey warblers in the current vegetation. However, the changing forest cover, and the degree to which the species compete for insects (especially in winter when small fruit and nectar are absent) might be more significant in driving population declines (or increases) in these birds than rat predation (cf. Ruffell and Didham 2017). Ruffell and Didham (2017) showed a negative effect of pest control measures on Grey Warbler occurrence, which was however more significantly correlated with higher forest cover at the sites. This did not apply to silvereye, which showed no significant relationship to either pest control or forest cover. Fantail was also not responsive to pest control. Other researchers have also shown that silvereyes (and in once case also grey warblers) do not increase measurably after pest control (Innes et al. 2004; O'Donnell & Hoare 2012). Both grey warbler and silvereye apparently declined after the construction of the predator exclusion fence at Glenfern Sanctuary (Table 8). However, this might have been driven by some severe winters between 2006 and 2011 rather than be an effect of the fence.

The apparent increase in silvereyes in 2016, reversing a declining trend, could be an artifact. Silvereyes had been observed pecking diphacenone baits attached to trees, and there was concern over possible mortality. The counting team may, as a consequence, have deliberately looked out for them, perhaps more so than in previous years. However, the difference between treatment and controls remains, and this, plus the overall increase argues for a minimal effect of toxins, even if silvereye numbers were overestimated this year.

Ruffell & Didham's (3017) conclusion that the small insectivores are unresponsive to pest reduction (unless total eradication is achieved) is derived from complex modelling of the interactions between bird abundance, pest control (of unknown success) and forest cover. In contrast, we have presented empirical results and simple analyses from Windy Hill to illustrate trends.[22] For these species, the persistent, if relatively small, differences between managed and unmanaged areas at Windy Hill may be some of the best data available illustrating the benefits of intensive pest reduction without total eradication.

Other evidence (e.g. reptile biomass) supports the conclusion of an improving ecosystem trend in the Windy Hill Sanctuary, and the current significant difference between managed and unmanaged areas. This improvement may be partly driven by the natural forest succession, but keeping the controls in mind, it can be reasonably accounted for by the management regime having greatly reduced rodent populations in the managed areas. The results are a strong justification for continuing high intensity rodent control. An estimate of > 2000 birds saved by this work in the Sanctuary every year was presented in 2015.[23] There is no reason to revise that estimate based on this year's results.

CONCLUSIONS

° The nine years of records of bird abundance from the managed areas at Windy Hill, show positive trends for both frugivores and insectivores, with statistically significant positive trends for tui and grey warbler.

° The downwards trend for kereru may have been halted, but no significant trend is apparent.

° Grey warbler frequency is significantly correlated with fantail frequency, but not with silvereyes.

° The 2016 results for silvereye and grey warbler are exceptional when compared to previous years. Silvereye may have reversed a downward trend evident in the Sanctuary over the past five years.

° The difference between rat-managed and unmanaged areas is clear. Managed areas have twice as many birds, and more species, than unmanaged areas. Tui are about 3 times as abundant in the managed areas.

° The new area – Taumata – is a useful addition to the controls. In 2016 the samples from this site recorded no tui.

Important conclusions carried over from previous Reports:
° The difference between bird densities in managed and unmanaged areas allows an estimate of bird loss rate.

22 Based on 54 point-sites, each sampled six times, and many of them sampled over nine years.
23 Windy Hill Rosalie Bay Catchment Trust Bird Counts December 2015. Report JO 11 February 2016.

° When extrapolated to similar vegetation over the whole of Great Barrier this leads to the conclusion that c. 85,000 birds are being lost to rat predation every year.
° These conclusions draw attention to the value of monitoring long-term trends which cut through the expected annual variability.

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RECOMMENDATIONS

1. That the current bird monitoring programme is continued in December each year.
2. That the current results are presented to all field workers at a meeting in April or May, and the field methodology reviewed with them in November.
3. That the total data set, over all years, is collated with a view to a more comprehensive analysis.

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John Ogden 19/2/2017

APPENDIX

These data are available in excel (.xlsx) files within the folder: WH 2016 RAW DATA accompanying the electronic version of this report.

Left side of each sheet, raw data as transcribed for analysis. Right side, density data.

Note that the values at the base of the left hand columns are (1) the count of cells with a number in the column, (2) the bird frequency, (3) the sum of numbers in the column. The numbers at the bases of the right hand columns are averages, standard errors and the 95% confidence interval.