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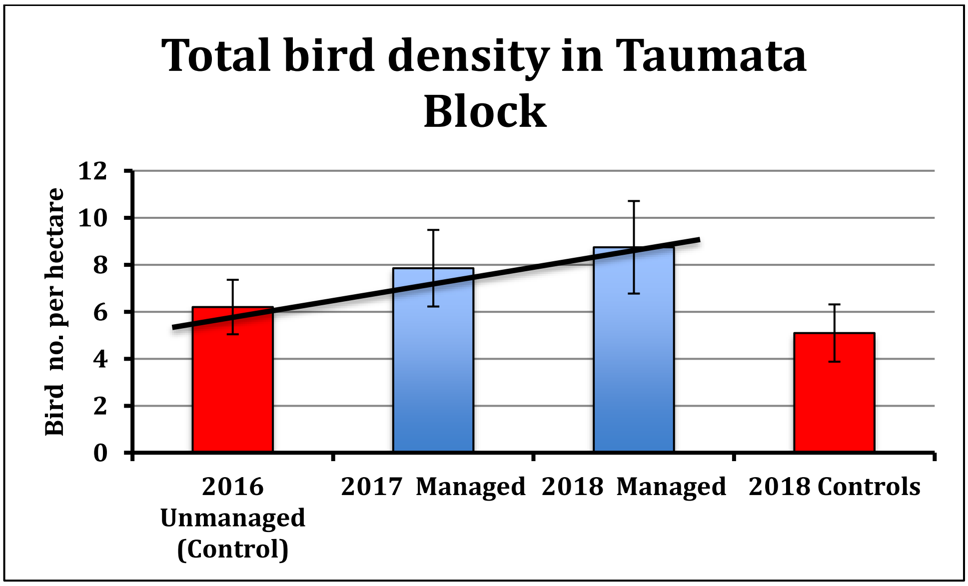
WINDY HILL ROSALIE BAY CATCHMENT TRUST

BIRD COUNTS DECEMBER 2018

REPORT JO 16. February 2019.



The graphic shows the steady increase in bird density since the commencement of rat management on the Taumata Block in 2016. The current bird population in the block is also significantly greater than the 2018 unmanaged controls (far right bar).

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BIRD COUNTS: DECEMBER 2018

EXECUTIVE SUMMARY

Since 2000 the Windy Hill Rosalie Bay Catchment Trust has undertaken a programme of pest management, aimed at reducing rats to low numbers in The Sanctuary. The managed area has increased through time and four (unmanaged) control sites have been designated.

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 2018, three transect sites were monitored in the Taumata Block, and two new control sites (Rosalie Bay and Station Rock) designated. Consequently 276 counts were made in nine separate managed areas, and 96 in four locations designated controls.

In 2018, here was a general downturn in overall bird abundance (frequency and density) in the Windy Hill Sanctuary and Controls, but the 2017 *increase* in ‘total bird density’ continued in the Taumata block.

The difference between managed and unmanaged areas, clear in all previous reports, remains clear. This difference (3.4 birds/ha./annum) can be used to estimate bird mortality due to rats (or conversely, bird survivorship in their absence). This is analysed for the Taumata Block in 2018, indicating that hundreds of birds are being saved there each year.

It is suggested that the long-term trends of increasing bird abundance in the Sanctuary have levelled since c. 2012, and that the downturn in 2018 is variability due to weather, food supplies, observer variables or other unknown causes. It might represent simply fluctuations about a longer-term average, which has reached a plateau in equilibrium with present low rat numbers.

It can be argued that the aims of the original (2000) monitoring program have been fulfilled; the rat management regime is demonstrably successful.

Consequently a review of the aims of the monitoring programme, and the methodologies to be applied in future seems warranted. Some alternatives are suggested.

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 (WHRBCT) Management Area– also referred to as 'The Sanctuary' - in December 2018. 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. The new managed area, Taumata, is mostly treated separately.

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. These summaries indicate general ecosystem improvement since restoration began in 2000[1].

Pest management within the WHRBCT Sanctuary: The WHRBCT is a community conservation group focussed on pest control and ecosystem restoration on fifteen mainly private properties in southeast Great Barrier Island. The managed area now covers c. 770ha. The Taumata Block (property of Derek Bell) covering a further 137 ha. was included in the managed area in 2016. The trust employs up to six field staff and volunteers, mainly engaged in pest management, but also monitoring birds, reptiles, invertebrates, stream fauna and forest tree seedling populations. Project administration, finances etc. are supervised by the Trust and mainly carried out by Judy Gilbert, the Trust's manager. One of the main strengths of the Trust has been in testing methodology (e.g. different rodent control and monitoring methods), reporting all results, whether positive or negative, 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.

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

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[1] See also: 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.

has been carried out over some of the same transects over this whole period, and new areas have been added. 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 predictable and similar each year, and were not the prime focus of the work, they were discontinued. 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. In 2013 it was demonstrated that reducing the number of points on the 150m transects from four to two did not alter the species rankings or density estimates. This reduction had other advantages, such as reducing possible point overlap, and it freed up some operator time to get data from other areas and increase the 'control' sample size.

METHODS

Data collection

Three-minute bird counts were made at 46 point-stations on transect lines in nine locations within the managed area ("The Sanctuary") and at 16 point-stations in four unmanaged locations outside it ("The Controls") (Table 1). The Sanctuary or managed area refers to the c. 770 ha area in which rat trapping and bait stations are employed; rodent monitoring tunnels are also employed in both managed and unmanaged areas. Note that in 2018 three locations (Taumata Bush, Taumata Rosalie Bay Road, and Taumata (Little Goat Road) which were unmanaged controls in 2016 were allocated to the 'managed' category. In total more points were counted in 2018 than previously, and in particular the number of control locations and point-stations was increased, with the addition of a new area (Station Rock Rd.).

All points were counted on six occasions, over a period of nine days, giving a total of 372 3-minute observations. 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 four observers, over the period 5st to 13th December. All locations were sampled by two observers (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.

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) and this is taken as the sample area for estimating density.

Since 2009 recorders have noted 'additional' 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 and 2008 by the Great Barrier Island Charitable Trust[3]. These data are treated separately as they are not as precise as the 3-minute counts, but have the potential to 'pick up' birds not seen, or not calling, at the sample points.

Table 1. Sample sizes, dates and observers for the December 3-minute counts, 2018.

Location	Points	Total counts (Points x 6 reps)	Start date	End date	Observers (1)
Ridges (R1 - R6)	12	72	5-Dec	12-Dec	R, A, K, H.
Valleys (V1 - V6)	12	72	5-Dec	12-Dec	R, A, K, H.
Benthorn	4	24	13-Dec	13-Dec	A, K.
Robin area	4	24	7-Dec	13-Dec	A, H.
Big Windy	2	12	5-Dec	13-Dec	K, H
Rosalie Bay managed	2	12	5-Dec	13-Dec	K, H
Taumata (Little Goat Rd)	2	12	5-Dec	11-Dec	H, A.
Taumata (Bush)	4	24	5-Dec	12-Dec	H, A.
Taumata (Rosalie Bay Rd)	4	24	5-Dec	11-Dec	H, A.
ALL SANCTUARY	**46**	**276**	**5-Dec**	**13-Dec**	**4 observers**
Old control (Windy Hill)	4	24	7-Dec	12-Dec	A, K.
Waterfall Bay control	4	24	10-Dec	10-Dec	H, A.
Rosalie Bay rd. control	4	24	5-Dec	13 Dwc	H, K.
Station Rock rd.	4	24	7-Dec	12-Dec	A, K.
ALL CONTROLS	**16**	**96**	**5-Dec**	**13-Dec**	**3 observers**
TOTALS	***62***	***372***	***5-Dec***	***13-Dec***	***4 observers***

(1) Observers: K, Kevin Parsons; H, Henry Cookson; R, Rachel Wakefield; A, Abby Naismith.

Data analysis

Analysis methodology has been given in more detail in previous reports. 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; 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 differences in observer ability. The total survey sample comprises 372 three-minute counts,

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

representing c. 19 hours of observations, but considerably more travel time (estimated c. 200 person-hours).

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

1) *Count frequency:* frequency for a species is 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 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. If the species is present at all stations recorded it will have a frequency of 100% irrespective of how many are present at each station. When based on a large sample size (as here) the percentage value relates directly to the *probability* of recording the species at a station in the time period of the observation. 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 an absolute figure (an estimate of actual numbers per hectare) rather than simply a relative value, percentage 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 radius from the station, and (2) converting that number of birds 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 produced unrealistic estimates, especially for flocking species, which violate a fundamental assumption of the model[4]. As demonstrated in an earlier

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[4] 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

report[5], 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.

Statistical methods

The 95% Confidence limits (95% CL) used in the figures, are a measure of the variability of the average estimate in the repeated counts[6]. Where confidence limits overlap extensively between compared averages, we can conclude that there is no statistically significant difference between them. A more formal *t- test* almost invariably supports this interpretation, but is a more sensitive test, especially where data points can logically be paired, as, for example, when comparing the same species across the same sites in two different years.

T-tests. Where 95% CLs *do not* overlap it is likely that there is a real difference. This conclusion is usually supported by *t-test* results giving low *p* (probability) and 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). T-tests measure the probability that two means (derived from two sets of data) are likely to be different, or alternatively just different estimates of the overall mean of both data sets. Statistical probability is the probability of the observed statistic value being due to chance alone – thus $p< 0.05$ means that there is less than 5% probability that the value (*t*, or *r*) is due to chance sampling, or conversely that there is a 95% chance that it represents a real 'significant' difference. Different levels of probability are usually represented by asterisks as follows: p<.05 *; <.01 **: <.001 ***. The more stars, the more 'significant' the result.

The wide variability in the Windy Hill bird count results implies that selected pair-wise t-tests taken from such a large body of data must be treated cautiously; using a probability value of < 0.05 (5%), five out of every 100 such tests could be incorrectly regarded as 'significant'. Consequently low levels of significance ($p < 0.10$ (*) or $p < 0.05$ *, should be regarded skeptically unless supported by other results. (*Analysis of Variance* ANOVA might be considered preferable for multivariate data sets such as bird species densities at *n* stations in *y* locations with 2 treatments (managed, unmanaged) over *N* years but has not been used here).

The Correlation Coefficient is a robust statistic for comparing two data sets that can be paired, such as bird density in sequential years, or species A with species B over a series of years. *Spearman's Rank Correlation Coefficient* compares ranks; for example, from commonest bird to rarest in two sites or time periods. Both correlation coefficients range from +1 (when the variable values or rankings exactly agree) to -1 (when the compared data sets are exactly opposite).

Conservation, Wellington. A key text is: Buckland, S. T. et al. 1993. *Distance Sampling. Estimating Abundance of Biological Populations.* Chapman and Hall. London, UK.

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

[6] 95% CL =(standard deviation/squareroot n)*1.96, expressed as ± the mean value

RESULTS

Overall bird frequency trends 2008 – 2018

Frequency measures the % likelihood of seeing or hearing a bird within 25 m, in a 3-minute period. Table 2 demonstrates that birds (all species combined) are generally about 17% more frequent in the managed than in the unmanaged areas. The *low* frequency obtained for Benthorn in 2018 is noteworthy. Individual species frequency data for 2018 are summarised in Table 3. The data demonstrate a marked drop in tui frequency compared to previous years in all sites, and the increase in fantail in the managed areas.

Table 2. Total bird frequencies (all species) in the managed and unmanaged (control) areas at Windy Hill since 2015. The % difference row is the relative increase of the managed over the unmanaged area[7]. The highlight draws attention to the exceptionally low frequency at Benthorn in 2018.

Transect	2015	2016	2017	2018	Avg 11 years 2008 - 18. (1)
Ridges	83	89	92	87	82.9
Valleys	92	85	90	85	83.1
Benthorn	87	100	83	62	82.9
Robin	92	92	71	75	79.0
Big Windy	92	83	83	100	89.5
Rosalie Bay managed				75	75.0
Taumata RB			79	71	75.0
Taumata Bush			75	83	79.0
Taumata Little Goat			92	83	87.5
Old Control	50	71	79	54	62.8
Waterfall Bay control	50	83	75	50	61.6
Ros. Bay control	79	58	75	63	68.8
Station Rock Rd (2)	83	83		67	77.7
Avg all managed	89.2	89.8	83.1	80.1	81.5
Avg Taumata mgd			82.0	79.0	80.5
Avg unmanaged	65.5	73.8	76.3	58.5	67.7
Difference (%)	26.6	17.9	8.2	27.0	17.0

(1) The data from 2008 to 2017 are given in Table 2 of the previous (2018) report.
(2) Little Goat Control in 2015, 16. Note that Little Goat is situated on the Taumata boundary and was re-allocated from Control to Managed in 2017.

[7] Tables 2 and 3 see: [WH 2017 2018] Tabs 1,2,3 2017 data.xlsx.

The overall frequency data are also shown in Fig 1, which illustrates the trend of increasing bird frequency in both managed and unmanaged areas, and the decrease in all three 'locations' in 2018. While the overall rate of increase in the unmanaged areas (lower dotted line in Fig 1) is steeper, there is much more variability than in the managed area. Despite the drop in 2018, the trend in the managed areas remains positive and significant ($r = .6638$, $p < .05$) . The more consistent trend in the managed area is closer to the theoretically maximum possible frequency (100%) than the unmanaged.

Table 3. Frequencies by species in managed (Sanctuary) and unmanaged control areas: 2015 to 2018.

Species	All Managed Areas				All Unmanaged Controls			
	2015	2016	2017	2018	2015	2016	2017	2018
Kaka	25.5	22.2	15.7	13.2	11.9	14.2	13.1	6.3
Silvereye	14.3	28.1	12.9	16.5	8.3	20.0	10.1	20.8
Tui	39.3	43.9	48.6	28.5	9.5	11.7	28.1	16.7
S. cuckoo	4.6	1.9	1.4	0.2	0.0	0.0	1.1	1.0
G. warbler	32.9	28.1	29.2	18.0	34.5	16.7	35.0	12.5
Fantail	17.1	20.6	17.7	29.4	11.9	23.3	14.4	13.5
Kingfisher	11.6	17.5	8.1	8.2	3.6	14.2	9.1	4.2
Kereru	18.5	21.9	17.3	14.1	3.6	10.8	7.6	3.1
Other	5.5	7.5	9.9	2.3	3.6	3.3	4.5	6.3
All species	88.4	80.0	81.9	80.2	63.1	78.3	80.6	58.3

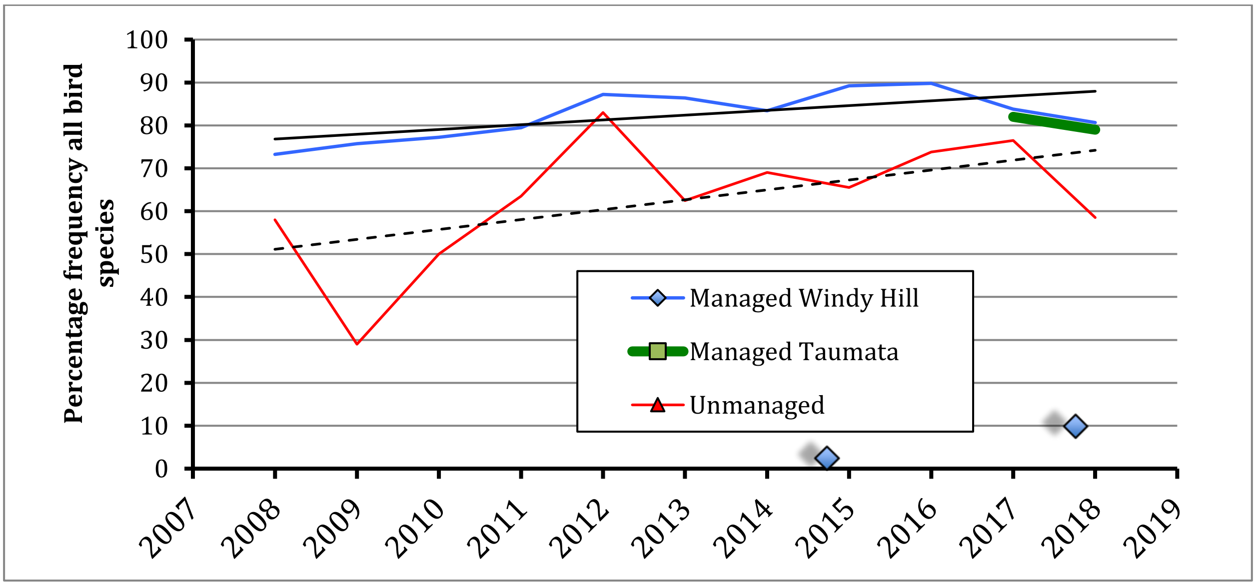

Fig 1. Frequency trends for all species over 11 years in Managed areas (Taumata separate – green squares), and unmanaged control areas. Solid significant linear trend line for managed areas and dashed (non-significant) trend for unmanaged controls.

Species density trends 2008 – 2018.

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

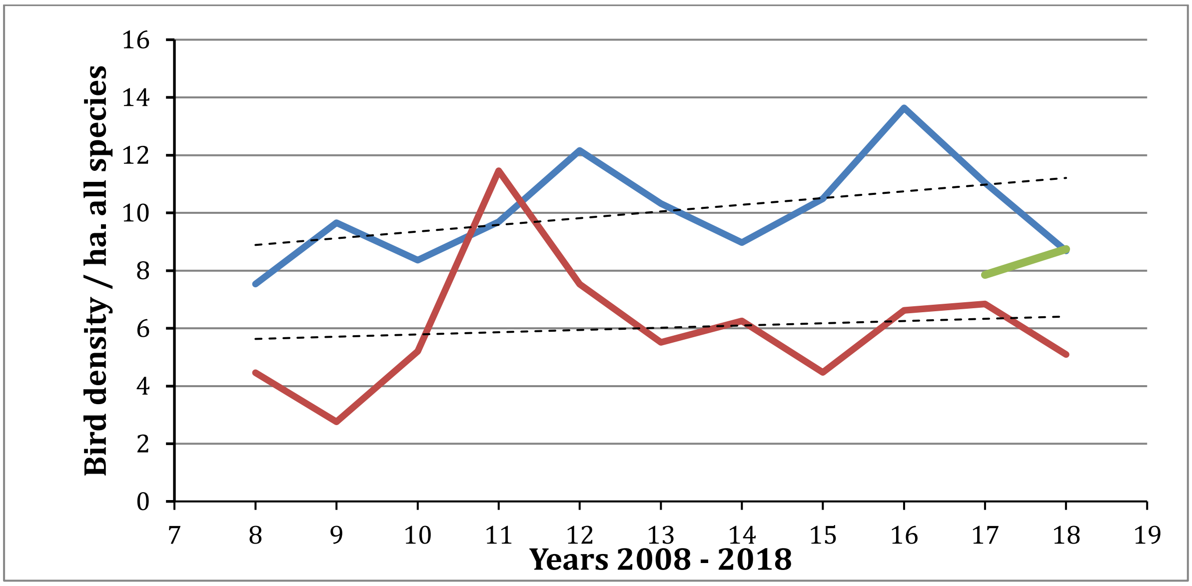

Fig 2. Average density (all bird species) per ha. in managed (Sanctuary;upper blue line) and unmanaged areas (lower red line) over ten years. The green line and triangles are the data for the Taumata managed area. The dashed trend lines are not statistically significant.

The density data (Fig 2), as expected, illustrate the same trends as the frequency data, but the difference between managed (Sanctuary) areas and the unmanaged controls is clearer. Although, the reduced density in the managed areas in 2018 has brought the previously significant trend line down to non-significance, taken with the frequency data, the bird abundance trend is still clearly upwards. Two years of rat control in Taumata appears to have shifted that area from being similar to the unmanaged controls, to being similar to the managed areas in the Sanctuary. In 2018 the Sanctuary recorded c.9 birds/ha. compared to c. 5 in the control, which is a marked reduction from 2017. Taumata on the other hand increased in bird density to c. 9 birds/ha.

Overall trends for the larger frugivores are given in Fig 3, and for the smaller insectivorous or omnivorous species in Fig 4. The figures clearly indicate the generally larger numbers of all species in the managed areas compared to the unmanaged controls, and also indicate the generally increasing trends over time. The marked downturn for tui in 2018, in both the Sanctuary and the controls was also mirrored in the Taumata block, strongly suggesting that the data are reliable: there was a real decrease in tui conspicuousness this year. Kereru show a similar decline in all three locations, but kaka show an apparent increase in the Taumata Block. All three species are generally commoner in managed compared to unmanaged areas.

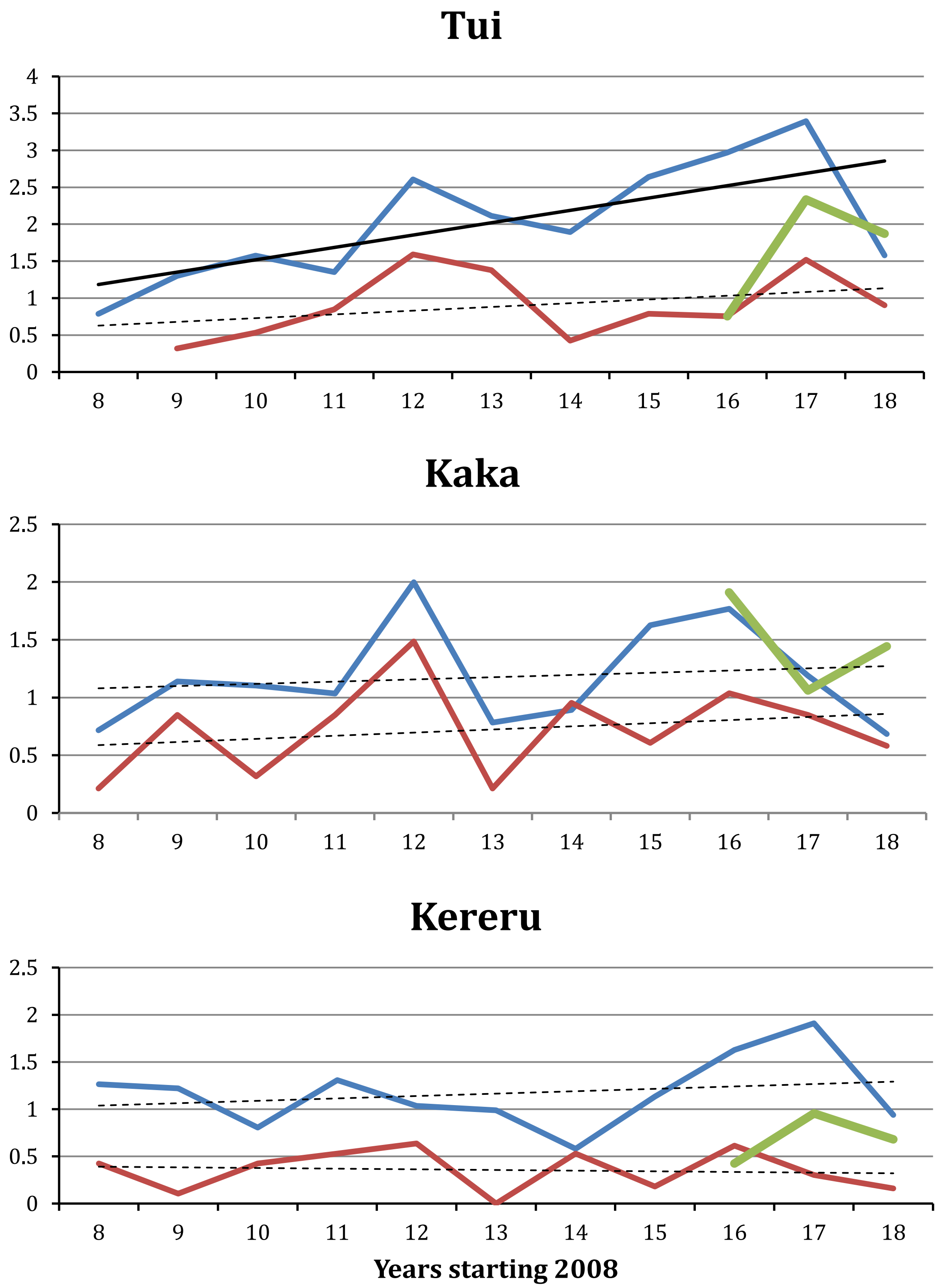

Fig 3. Trends in density/ha. for tui, kaka and kereru over 2008 – 2018. Managed areas indicated in blue, unmanaged in red. Taumata shown in green. Linear trend lines shown solid where statistically significant, otherwise dashed.

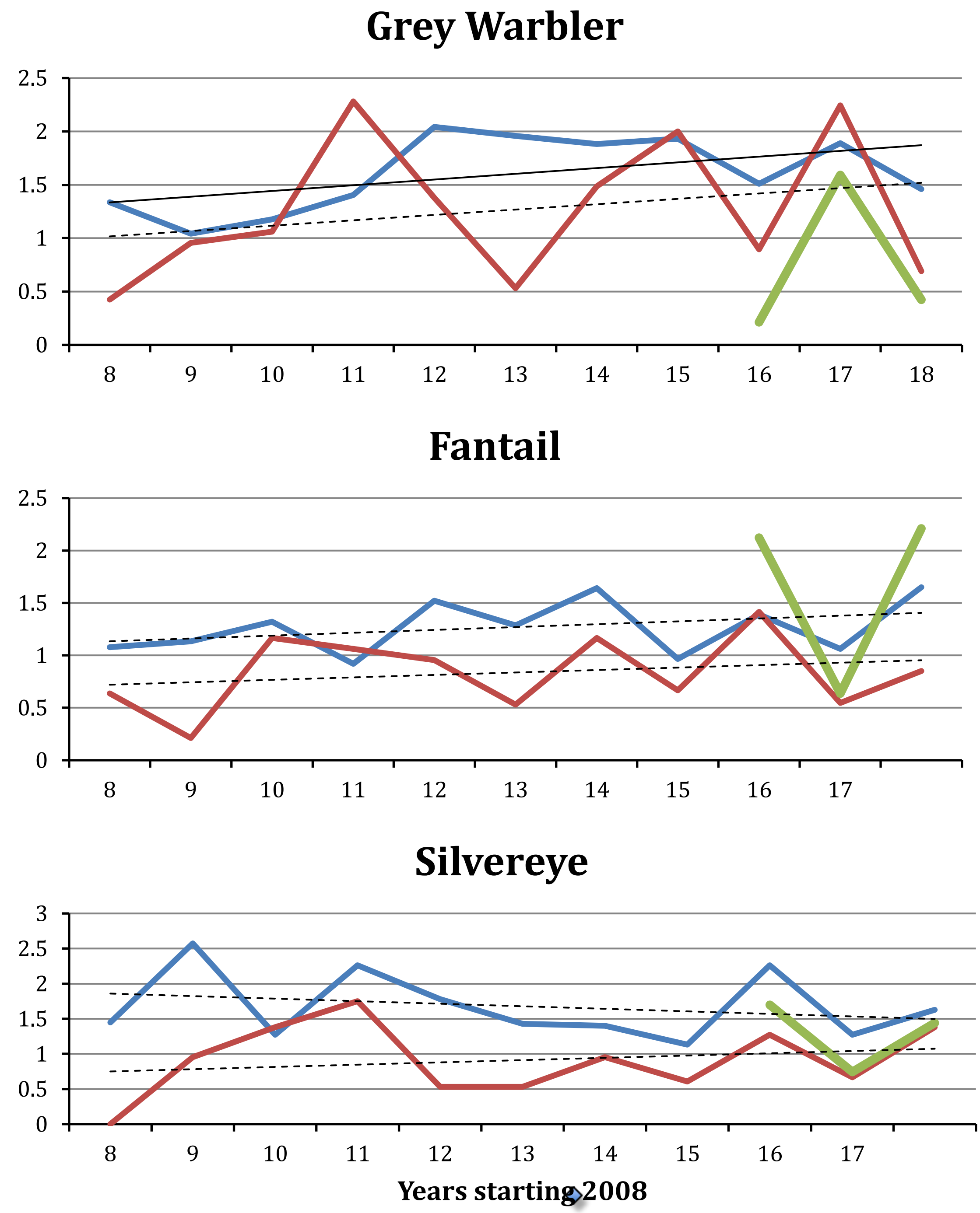

Fig 4. Trends in density/ha. for smaller insectivores over 2008 – 2018. Managed areas are indicated in blue, unmanaged controls in red, and the Taumata samples in green. Linear trend lines are shown solid where statistically significant, otherwise dashed.

The numbers of small insectivores show more annual fluctuations than do the larger long-lived species, but all three species (grey warbler, fantail, silvereye) generally exhibit larger numbers in the managed areas. Previous long-term trends, though mainly non-significant, were maintained. Only silvereye shows a (non-significant) negative trend (reduction) in managed areas. Grey warbler appears to have increased similarly in both the managed and control areas, although there is more variability in the unmanaged areas. In 2018 there was a marked increase in fantails in all sites, most notably at Taumata. All three species show similar fluctuations at all three 'locations' over the last three years, which supports the view that the data reflect real changes in bird abundance rather than random counting fluctuations.

Fig 5. Shows the density data for 2018 for all species in grouped sites, with 95% Confidence Limits. Only where there is no overlap in Confidence Limits (for example, between controls and the Ridge and Valley sample set for grey warbler, or between the controls and the Taumata data for fantails) can a real difference be reasonably assumed. In every case the controls, although having lower averages, overlap with at least two of the three managed area samples.

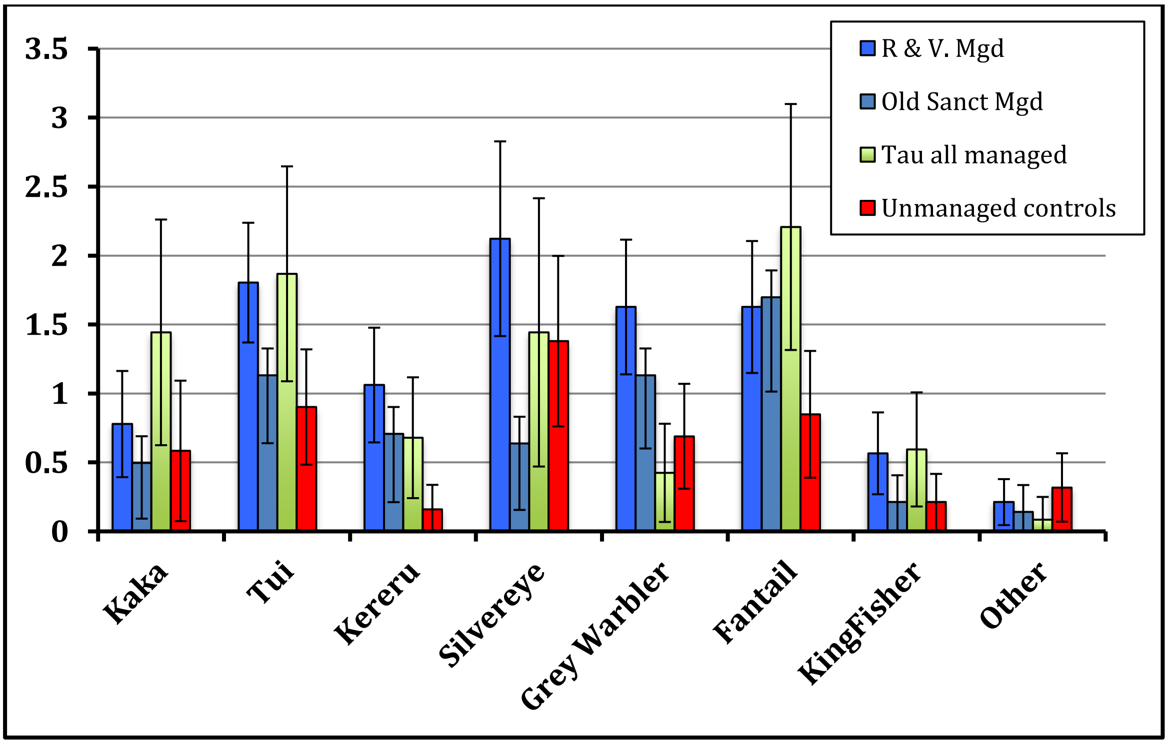

Fig 5. Species densities in grouped sites, with 95% Confidence Intervals. The red columns are the controls (see key). R & V stands for the Ridge and Valley samples from the managed area at Little Windy Hill. 2018 data.

The complexity of Fig 5 is simplified in Fig 6, which shows the total (all species lumped together) bird densities in the four grouped sites. Overall both the Ridge & Valley samples, and the Taumata samples, have significantly higher densities than the unmanaged controls. Other managed sites were not significantly different from the controls in 2018.

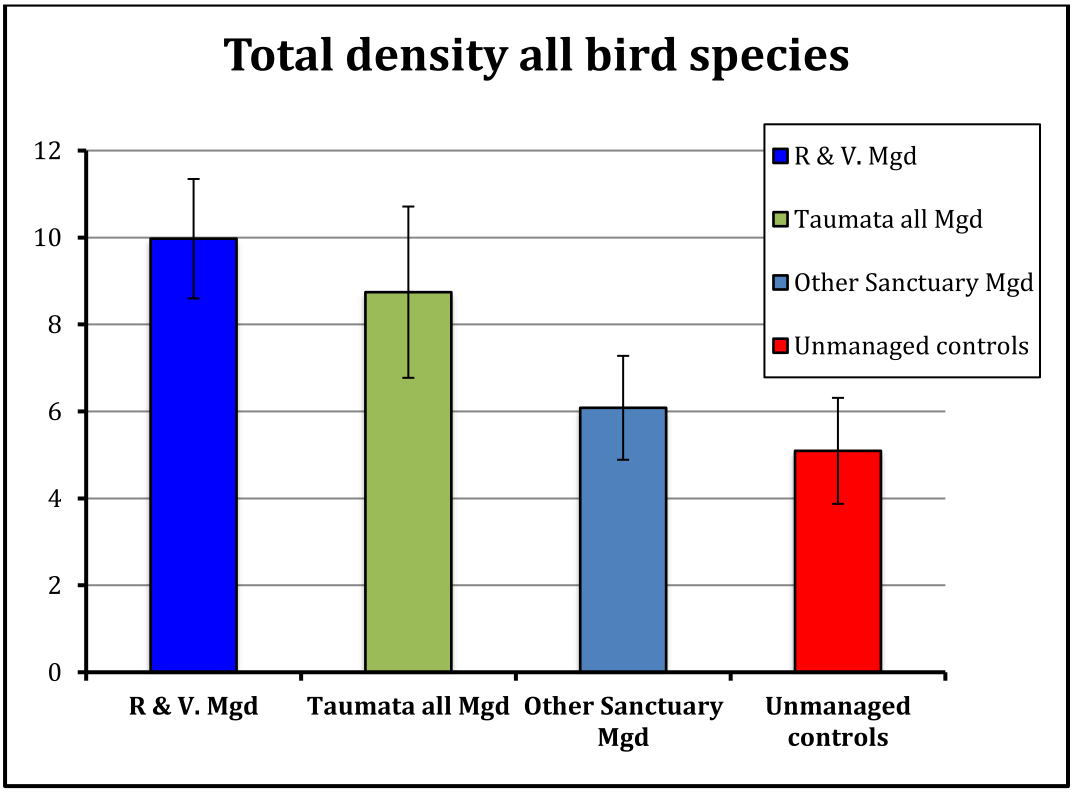

Fig 6. Overall differences in bird densities in three managed (grouped) sites and the grouped controls in 2018. The vertical axis is the estimated average number (all birds) per ha. The capped lines are 95% Confidence Limits for the mean.

Other species (Table 4)

The density of other species was low, as in previous years. Kingfisher was the commonest (most conspicuous) species, especially in the Taumata Block. As per the long-term averages (Table 6 in 2018 Report) kingfisher were slightly more prominent in the valley than the ridge transects, and shining cuckoos more prominent in controls than managed areas, but in both cases the samples are much too small to draw conclusions. "Others" comprises mainly the introduced species; chaffinch had 7 records overall, blackbird 5 and thrush 2. The only 'other' recorded at Taumata was a harrier hawk. Chaffinches, blackbirds or other introduced species were not recorded at Taumata. A banded rail was recorded once on a Ridge transect.

'Additional' marginal records - birds noted between sample points (Table 5)

Birds heard or seen while moving between points were noted on the margins 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. The species were ranked according to the number of times they were noted in sheet margins and compared with the rankings obtained for the same areas using the frequency data (Table 5). The Spearman Rank Correlations and t-tests are summarised in Table 6.

Table 4. Density per 10 ha. rounded to whole number.

Site	Shining Cuckoo	Kingfisher	Others
Ridge	1	5	3
Valley	0	6	1
Benthorn	0	0	0
Big Windy	0	8	0
Ros Bay mgd	0	4	0
Robin	0	0	4
Sanctuary avg.	**0.2**	**3.8**	**1.3**
Taumata L. G.	0	0	0
Taumata R. B.rd.	0	4	2
Taumata Bush	0	11	0
Taumata mgd.avg.	**0.0**	**5.0**	**0.7**
St. Rock Con.	2	2	8
R.B. Con	0	4	2
Old Con.	0	2	2
W. B. Con.	0	0	2
Control avg.	**0.5**	**2.0**	**3.5**

Table 5. Ranks of species in marginal observations and in frequency in 3-minute samples, according to grouped sites'. San. = all Sanctuary transects; Tau.= all Taumata; Con. = all control transects. Low numbers indicate high ranking – 1st, 2nd etc. Tied ranks are averaged. The 1st and 2nd ranked species are highlighted. Kereru is underlined in the Sanctuary.

RANKS of marginal observations

Site	Kaka	Silvereye	Tui	Shine Cuckoo	Grey Warbler	Fantail	KingFisher	Kereru	Other	Sum ranks
San.	4.0	6.50	3.0	8.50	6.50	2.00	5.00	1.00	8.50	45.0
Tau.	3.0	5.00	2.0	8.00	4.00	1.00	8.00	6.00	8.00	45.0
Con.	4.0	2.00	6.5	8.50	4.00	1.00	6.50	4.00	8.50	45.0
Avg O'll	3.6	4.50	3.8	8.33	4.83	1.33	6.50	3.67	8.33	

RANKS of Frequency data

Site	Kaka	Silvereye	Tui	Shining cuckoo	Grey Warbler	Fantail	Kingfisher	Kereru	Other	Sum ranks
San.	6.0	4.00	2.0	9.00	3.00	1.00	7.00	5.00	8.00	45
Tau.	3.0	4.00	1.5	9.00	7.00	1.50	6.00	5.00	8.00	45
Con.	5.5	1.00	2.0	9.00	4.00	3.00	7.00	8.00	5.50	45
Avg O'all	4.8	3.00	1.8	9.00	4.67	1.83	6.67	6.00	7.17	

Table 6. Statistics for rank correlations between marginal (between station) observations and frequencies from 3-minute bird counts.

Comparison of marginal observations v. 3-minute count frequencies	R Spearman Rank Correlation	't' statistic	'p' with 7 degrees of freedom
All Sanctuary	0.6250	2.1183	0.10
All Taumata	0.8625	4.5093	.01**
All Controls	0.5583	1.7806	ns
All data	0.8736	4.7498	.01**

Overall the rankings obtained from the more ‘casual’ between station records reflect the rankings obtained from species frequencies (Table 6). This suggests that the Frequency results do indeed predict what, in general, a more casual observer would actually experience. Only the controls, with lesser bird densities and fewer observations, show no correlation. Fantails were ranked highly this year in both data sets. As in previous years kereru was commonly noted between sample points in the Sanctuary area, but this species was one of the least frequently ranked in the Controls (and Taumata). Differences for other species are generally small and with such small numbers they are not individually significant.

Changes in the Taumata Block from 2016 – 2018

The 137 ha. Taumata Pest Management Area, owned by Derek Bell, was added to the Sanctuary in 2016. In that year three sites were set up as controls (unmanaged), but became managed for rats in 2017. A new control, Station Rock Rd, was set up, but it seems best to compare the Taumata data with all the controls rather than specifically with the nearby Station Rock control.

The increase in bird density over the first year gave an indication of the bird population responses (nesting success) after one year with a much reduced rat population in the Taumata Block. The continued increase in 2018, while not reaching statistical significance, occurred during a period when overall bird densities *declined* throughout the Windy Hill Sanctuary and the Controls. Consequently this is a more significant outcome than it might seem at face value (Fig 7). The difference being made in the Taumata Block is emphasised in Fig 8, which contrasts the Taumata bush transect with the Sanctuary controls. There is no overlap of Confidence Intervals, and the difference is highly statistically significant ($p < 0.001$***). Figs 7 and 8 are combined on the cover of this report.

These data, and the differences between years can be used to provide estimates of the actual saving made in terms of increased birds – that is, eggs and chicks not predated by rats and surviving into adulthood (Table 7). The figures are ‘best estimates’ only and should not be thought of as definite numerical outcomes. Both methods of estimating increased survival indicate a substantial increase in bird breeding and survival over the two year period in the Taumata Block.

Table 7. Estimates of birds saved per annum on the Taumata Block as a result of management. Estimate (1), with 95% Upper and Lower Confidence Bounds, is based on the average 2018 difference between bird numbers in the Taumata Block and all controls, Estimate (2) is based on the actual increase in estimated density in Taumata over the two years, 2016 – 2018.

Location	No of counts	Density birds/ha.	95% Confidence interval	Upper limit birds/ha.	Lower limit birds/ha.
Taumata Bush	24	10.2	3.2	13.4	7.0
Taumata All	60	8.7	2.0	10.7	6.8
Station Rock Control.	24	7.6	3.3	11.0	4.3
All Controls	96	5.3	1.2	6.5	4.1
Difference, Managed Bush v. Station Rock Control	48	2.5	3.3	5.8	0.0
Difference, All Taumata Managed v. All controls	156	3.4	1.6	5.0	1.9
Birds 'saved' per ha. based on All Taumata data 2018		3.4		5	1.9
Estimate (1). Birds 'saved' in 137 ha. Taumata Block/annum (1)		465.8		685	260.3
Estimate (2). Birds 'saved' in 137 ha. Taumata Block/annum(2)		174.4			

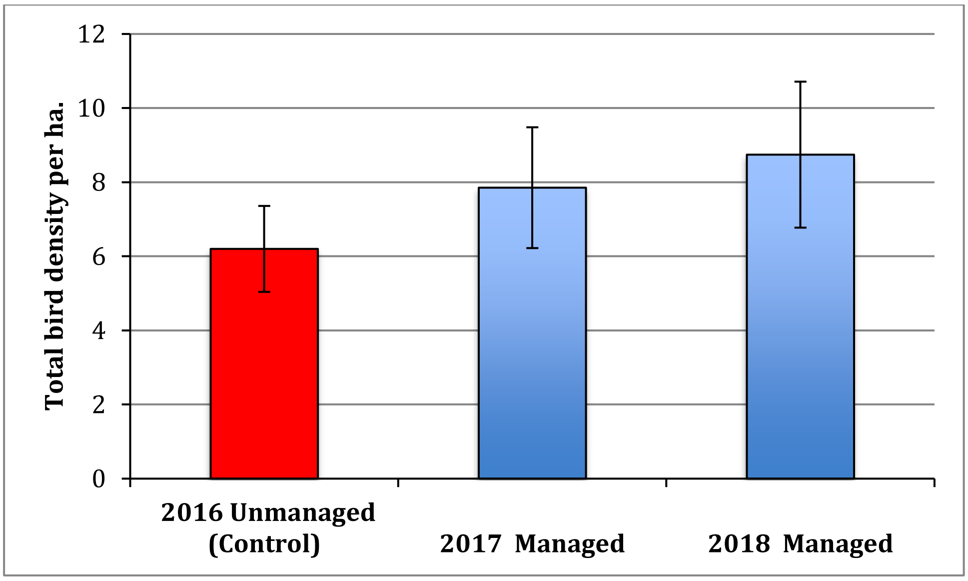

Fig 7. Total bird density with 95% Confidence Limits in the Taumata Block in three years.

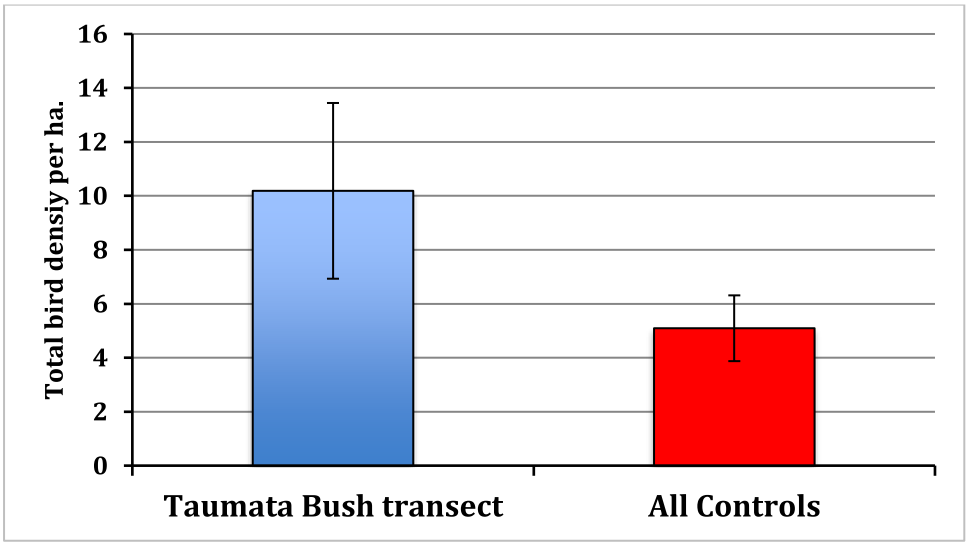

Fig 8. Difference between total bird density in the managed bush transect at Taumata, and the four unmanaged controls in 2018. The 'T' lines shopw 95% Confidence Limits.

DISCUSSION

Review of previous conclusions

As concluded in earlier Reports, much evidence (e.g. reptile biomass) supports the conclusion of an improving ecosystem trend in the Windy Hill Sanctuary. 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. An estimate of > 2000 birds saved by this work every year in the 770 ha. Sanctuary, was presented in 2015[8], and revised *upwards* in 2018. These results are a strong justification for continuing high intensity rodent control.

In the previous report data from 10 years of management at Windy Hill were statistically analysed (2018 Report)[9]. When all bird species were lumped together, the data showed a statistically significant increase in the managed area over ten years. The unmanaged (control) areas, showed a slight increase, but this was not statistically significant (2018 Fig 2 and Table 4). The increase in the unmanaged controls could be ascribed to 'spill-over' from the managed areas. All individual species (except silvereye) showed increases in the managed areas: strongly significant for tui, and also significant for grey warbler (2018 Table 4) but there were no significant trends in the unmanaged controls. There were highly significant differences between individual bird species densities between the managed areas and the control, with more in the managed areas, except for grey warbler.

The time trends, and the differences between managed and unmanaged areas all reflected the rodent tracking tunnel results, which clearly showed that there were significantly more rats in the unmanaged areas and significantly fewer birds (2018 Fig 12a,b.). Conversely, with fewer rats there were clearly more birds. The difference due to rats was expressed as birds saved (eggs or chicks not eaten). In the 770 ha. of the Windy Hill Sanctuary, this amounted, on average to c. 3500 birds annually. (Extrapolated to the whole unmanaged forest and scrub area of Great Barrier Island it amounted to c. 100,000 birds per annum. This huge figure was supported by estimates made independently and using different methods)[10].

2018 downturn.

In 2018, bird numbers reduced overall. The gains of the past few years appear to have been reversed. This downturn coincided with an upturn in rat abundance (tracking tunnel – TT - percentages) in four of the seven monitored locations, but the two main areas, Windy hill and Big Windy, showed TT declines *and* bird declines, so no clear correlation with changes in rodent numbers can be demonstrated. If the decline in the bird counts cannot be ascribed to rats, then it must either (a) be due to some other cause(s), or (b) be an artefact of the sampling.

Plant phenology has not been monitored on Great Barrier, so it is impossible to know if a reduction in food supply this year, perhaps weaker flax flowering, could have contributed to reduced nesting success and/or bird mortality. Bird numbers, mainly driven by tui numbers, have been generally increasing since 2014, and numbers could have been so high that any reduction in food supply would be detrimental. Alternatively, birds may have simply left the Sanctuary area for locations offering more food. Lacking relevant data, speculation is not warranted, but casual observations indicate a reduction in tui numbers elsewhere on the Island. Variations in the weather may have contributed: some anomaly in the weather pattern

[8] Windy Hill Rosalie Bay Catchment Trust Bird Counts December 2015. Report JO 11 February 2016.

[9] These analyses were t-tests and correlation coefficients, based on means. They were consequently highly conservative; had they been based on *all* the raw data the degrees of freedom would have been dramatically increased and higher levels of statistical significance (< p) almost certainly obtained for all tests.

[10] Innes et al. 2010. *New Zealand Journal of Ecology* **34** (1): 86-114.

in 2018 compared to previous years might have caused reduced nesting success, or increased mortality, we do not know. The weather in the particular week of the sampling could have been influential, causing birds to be less vocal or less conspicuous.

The possibility of the low bird count this year being an artefact of the sampling warrants consideration. One strength of the Windy Hill bird-monitoring programme has been that it has generally been carried out by the same group of observers on the same transects at the same time of year. Moreover, an attempt has been made to mix observers on different transects and at different replicate times. In general one observer has not been responsible for one site and another observer for another site, which would confound the sites with the observers. However, with a limited team size and a restricted timeframe, complete 'randomisation' of observers between sites and times is not possible. Many studies have shown that there are frequently significant differences between observers, even when these are quite unconscious. Cross-checking between observers helps, but cannot totally eliminate the effect of 'observer bias'. Thus, it is possible that, with a reduced team including one novice in 2018, observer differences may have been a factor. However, this seems unlikely to be the full explanation for the reduced overall numbers or the apparent increase in fantails.

Managed areas v. Controls

The difference between the rat-managed and unmanaged areas remains clear, as in earlier years. The increased number of control sites and their consistent sampling regime strengthens the comparison. However, relatively small samples (12) from some of the managed areas are problematical. While these areas (Big Windy, Taumata Little Goat Road, and Rosalie Bay Managed) create a better geographical coverage, their small sample sizes present a difficulty if averages are further averaged with areas such as the Ridges and Valleys of Windy Hill, where the sample size is much larger. The differences can be allowed for by weighting (based on n) but there is a case for standardising sample sizes to a minimum of 24 (or multiples thereof), which might involve amalgamating sites or deleting one or more of them. Also, ideally the bird monitoring sites need to be clearly linked to the TT sites.

As pointed out in the Results, the *up-turn* in the Taumata block seems to reflect a genuine increase in the bird population. The very marked *downturn* in bird numbers at Benthorn is associated with increased tracking tunnel %s (5 to 9%) but these TT levels are still too low to account for the decline. Movement of birds from Benthorn to other areas might be a factor, as also might the fact that site was sampled mainly by one observer and all on one mainly overcast morning. Thus although 24 counts were made, the sample really represents only a very brief time period on one day. Maybe it was just a quiet morning.

The difference between the bird density estimates for managed and control areas gives an estimate of the number of birds per hectare per annum being eliminated in the unmanaged areas. The coincidence of this with higher tracking tunnel percentages, demonstrated in the 2018 Report, strongly implies that rats are the cause. Many independent observations and photographic evidence by researchers throughout New Zealand support this conclusion.

The Taumata Block

The results from two years of management in the Taumata block suggest a significant increase in bird density, driven mainly by increases in tui and grey warbler in 2017 and fantails in 2018.

An example of the way in which comparison of bird density between managed and unmanaged areas can be used to give a measure of 'outcomes' is given in Table 7. The amalgamated Taumata data (with the biggest sample size and smallest spread of confidence interval) was chosen for comparison with the average of all controls. This difference (3.4 birds/ha[11].) with its confidence interval, suggests that somewhere between 260 and 685 birds were saved in the Block. A difference of this magnitude presumably causes the increase in the bird population each year. Although the average estimated increase *between years*, while positive, does not reach this range, it does suggest the addition of c. 174 birds/annum. Given the uncertainties of these estimates, this difference is of no moment; more impressive is the fact that both ways of making the estimate give a positive result suggesting that hundreds of birds are being added to the block each year. In 2018 many of these additions at Taumata were short-lived fantails, but this Block continued to show increased bird numbers despite declines elsewhere.

The monitoring programme in the future

As the managed area continues to increase, the job of maintaining the rat control, and monitoring outcomes, increases. It is timely to consider the purpose of the bird monitoring, and perhaps to question this use of limited resources, which might be directed to alternative uses.

The main purpose of commencing bird monitoring at Windy Hill was presumably to establish the efficacy of the rat control programme, first by the user of traps, later by the use of a combination of traps and various toxins.

Monitoring provides long data sets, which allow trends and population shifts to be identified, giving insight into the dynamics of the ecosystem. If alternative rat control methods are tested experimentally, the outcomes of such changes can be seen in the light of previous data trends. That being so, a clear case can be made for retaining the monitoring system with minimal change. Longer data sets will always be valuable.

However, if the aim was primarily to demonstrate that rats are slowly destroying the Great Barrier forest ecosystem, particularly through killing birds, then it can be reasonably claimed that that aim has been fulfilled. It is clearly established that reducing rat numbers sufficiently will increase bird survivorship and other ecosystem components will also benefit. Not only is this now demonstrated beyond reasonable doubt at Windy Hill by the difference between managed and unmanaged areas, but it is also well supported by abundant data from elsewhere in New Zealand.

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[11] This figure is the same (3.45) as that calculated in 2016 from the 2010-2015 data from all Managed and Unmanaged sites in the Sanctuary.

The temporal trends in bird frequency and density at Windy Hill showed steady increases until 2012. Since then, the trajectories have tended to flatten. For example in Fig 1 (and Fig 2) a straight horizontal line could be fitted through the data since 2012. This year's reduced results raise the possibility that a plateau has been reached, with bird numbers overall in equilibrium with low rat numbers. Fluctuations around this (relatively high) level of bird abundance might reflect weather, food availability or the vagaries of sampling, rather than the influence of rats. If this is so overall, it might still not apply equally to all species – given adequate food resources, tui might be able to increase further in the presence of a few rats, while kereru, which is very susceptible to egg predation, might not. A special monitoring regime for these key species and perhaps also grey warbler, should be considered as an alternative to the current 3-minute all-species system.

The Taumata Block results indicate again that the management (rat reduction) regime has rapid and measurable effects on the bird populations. It seems clear that the methodology, (including periodic changes in that methodology) is having beneficial results for birds, and, by extrapolation, other ecosystem components known to be adversely affected by rats.

Bird monitoring was commenced at Windy Hill in 1999, and results have been reported annually since then. Various modifications, both to field methods and method of reporting have occurred since then, but the overall beneficial results of rat management have been clearly demonstrated. A review of the previous ten years was presented in the last report (March 2018). This demonstrated the success of the methodology. The above considerations suggest that a review of the bird monitoring is timely. The following alternatives are suggested:

1. Continue monitoring as at present (justified as background data against which to test alternative rat control methods etc.)
2. Continue with a reduced sub-set of the monitored areas. This would have the advantage of possibly freeing up some worker time, while maintaining worker skills and providing annual comparability of data. Pairing sites (managed & control) with similar vegetation should also be attempted as it might give insights into the role of successional vegetation change.
3. Continue monitoring, but directing attention to key 'indicator' species (tui, kereru and grey warbler).
4. Stop the annual bird monitoring; declare that the aims of the monitoring programme have been achieved, so it can be discontinued. This might require further publicising the results, but note that it does not preclude starting the monitoring programme again in future if there is a good reason (e.g. Island-wide pest eradication)

CONCLUSIONS

° Although *long-term* trends of increasing bird populations were maintained in 2018, never-the-less there was an apparent downturn in bird numbers in that year.

° The increasing trend in tui, so clearly shown for the last few years, was not maintained in 2018. Kereru likewise declined.

° In 2018 fantail (and silvereye) increased, while grey warbler declined everywhere.

° Overall bird frequencies and densities may have reached a plateau since c. 2012, in equilibrium with the low rat numbers in the managed areas, so that the differences in annual totals now reflect variability due to causes other than rat numbers.

° Reasons for the 2018 downturn, might relate to bird behaviour, food availability, climatic variables in the sampling week or observer variability.

° The difference between rat-managed and unmanaged areas is unequivocal. Managed areas generally have almost twice as many birds, and more species, than unmanaged areas. This difference was not so marked in 2018, but was still clear.

° The Taumata Block demonstrates the speed with which conservation gains can be made with the management regime employed.

° The Taumata Block continued to increase in overall bird abundance, despite the general downturn elsewhere. It is suggested that hundreds of birds are being added to this block per annum.

° The annual monitoring regime, started twenty years ago, may have fulfilled its aims: four alternative monitoring regimes are outlined for consideration.

RECOMMENDATIONS

1. That the aims of the current bird monitoring programme are reviewed.
2. That the current results are presented to all field workers at a meeting in April or May.
3. Should the monitoring programme continue much as in the past, the field methodology should be reviewed with the field team in November.
4. If a new monitoring system is envisaged, the field team should be involved in it's planning.
5.

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John Ogden. March 2018.
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APPENDICES

These data are the count and density data for each species at each count point. They are available in excel (.xlsx) files within the folders **WH DATA 2018** and/or the following three files:
WH 2018 CON DATA.
WH 2018 MNGD Bent, BW, Robin. Taumata(2) DATA.
WH 2018 Ridges & Valleys.

Hard copy can be provided if requested: ogden.trees34@gmail.com