Comparisons between ABC 2019 bird-count results, the 2006-07 GBICT bird counts, and 2018 Windy Hill data.

John Ogden, for Great Barrier Island Environmental Trust.

June 2020.

Executive summary

1. Bird frequency data from the Aotea Bird Count 2019 (ABC 2019) survey by the Great Barrier Island Environmental Trust (GBIET) are compared with frequency data from an earlier survey, conducted on four dates in 2006/2007 by the GBI Charitable Trust (GBICT). The 'Summer 2007' data were used for comparisons.
2. Bird frequency is a relative (%) measure only, while bird density is an estimate of a real number – the actual number of the species per hectare. Both generally reflect abundance, except for strongly flocking species.
3. Both measures are strongly influenced by 'conspicuousness; which varies greatly between species, and diurnally and seasonally within species.
4. Bird density data derived from the 5-minute bird counts of the ABC 2019 survey are compared with 3-minute density estimates for the same species at Windy Hill Sanctuary (Windy Hill Rosalie Bay Catchment Trust; WHRBCT).
5. Overall average (all species) frequencies were not significantly different between the two years, nor was the ratio of introduced to native species. Native were about twice as frequent as introduced species.
6. Although some of the locations were in common, or similar, between ABC 2019 and GBICT 2007, these comparisons present difficulties because they involved slightly different methodologies, personnel, and dates. The requirement for additional independent data for interpretation of 'trends' is emphasised.
7. Overall the frequency results from ABC 2019 are similar to the earlier (GBICT 2007) results: similar groups of sites generally have similar species groups in the two years. This is particularly the case for habitats with fewer species.
8. Frequency data are relatively insensitive for picking trends, especially given the provisos over different methodologies. For most species no trends can be seen between the two surveys.
9. However, the results do indicate significantly increased frequencies for tui, kereru and grey warbler. Kaka has also likely increased, while pateke has declined. Trends for silvereye and fantail are hard to assess due to the known inter-annual variability in these species.
10. Kakariki was present only in the Okiwi area in low numbers in both surveys and there is no evidence of an increase despite some recent sightings elsewhere.
11. Introduced passerines, especially blackbird and chaffinch, may have increased, but the seasonal differences between the surveys confound this result, and there is no supporting data for an increase.
12. Grey duck has apparently become extinct on Aotea between the two surveys..
13. In comparison to Windy Hill, the density results for six species were higher in the ABC survey. This is probably mainly due to different methodologies (sample time length), but the different habitats and locations may also have contributed.
14. It is recommended that the same survey locations and techniques be used in future, but that consideration be given to (1) adding transects in some underrepresented habitat types, and/or (2), classifying all points with regard to the broad vegetation types of the Landcare Database.
15. It is pointed out that several wetland, coastal and marine species are not suited to the 5-minute community bird count as a census method. As these include several species of conservation concern, alternative monitoring strategies are required to gain information about their status on Aotea.

INTRODUCTION

This report describes some comparisons between the Aotea Bird Count 2019 (ABC 2019) results and results from earlier studies, mainly those done by the Great Barrier Island Charitable Trust (GBICT, later becoming the GBI Environmental Trust: GBIET) from 2006 to 2007, and the data from 2008 to 2018 from Windy Hill (Windy Hill Rosalie Bay Catchment Trust: WHRBCT). The GBICT 2006-7 survey was repeated four times and was intended to provide 'base-line' data prior to pest eradication on Great Barrier.

The site locations, methodologies and results for the ABC 2019 counts and the earlier GBICT counts have been fully documented in the relevant reports (*Aotea Bird Count: Results of the 2019 Survey*. Serena Williams for GBIET, 2020; *Final Report on Birds of Great Barrier Island 2006 – 2008*. John Ogden for GBICT, March 2009). The comparisons here concentrate on the bird frequency data, although some comparisons are also made with the density results from Windy Hill (*Bird Counts December 2017 and Analysis of a Decade of Data (2008 – 2017)*. John Ogden for WHRBCT), 2018; *Bird Counts December 2018*. John Ogden for WHRBCT, 2019). The results presented should be read in association with the Report on the 2019 ABC survey referenced above.

Frequency and density

Both these measures give an indication of the abundances of the different species. Although statistically different, they are related.

A species' frequency is the proportion of samples in which the species is found. It thus ranges from zero to 100%. This is a crude measure of the abundance of a species, but has the advantage of being easily obtained and readily comparable between surveys if the sample size (and methodologies) are the same. Clearly frequency is dependent on sample number and sample area – if more samples are taken frequencies will usually decline, as more zeros are likely to be registered. Likewise if sample area (or observation time in the case of birds) is increased, frequency will likely increase as there is more chance of getting the species in a large rather than a small sample. Thus, frequency is "non absolute" – it can be used for comparisons between data sets obtained in the same, or a very similar, way, but does not relate *directly* to the actual number of individuals of a species per unit area.

'Density' on the other hand is an estimate of the actual number of individuals per unit area. It is thus an "absolute" measure – there is a real density of birds of a particular species out there, and we are attempting to estimate that figure (with an appropriate error range). Different numbers of samples or sample sizes do not alter the nature of the density estimate, though they may of course influence its accuracy (the extent to which we think, statistically, that it measures the real number per unit area). Thus, density is a better measure of abundance, but it is much more difficult to obtain and subject to more variability between observers – in the ability to gauge distances for example. Density is also strongly influenced by non-random distributions – it is difficult to estimate densities of flocking birds compared to more territorially dispersed species.

The two measures usually both closely reflect the overall abundance of a species. If a species has a high density it is almost certainly seen or heard with a higher frequency. Conversely a species with a low frequency normally has a low density. The pattern of distribution (flocking) is the only factor really influencing differences between density and frequency in a species: a highly aggregated (flock) distribution can have a high overall density but a low frequency (because the individuals in the flock are all in one place). The difference between frequency and density actually gives a measure of species aggregation (flocking).

Conspicuousness

Both frequency and density estimates are influenced by bird 'conspicuousness'. Large noisy birds (e.g. kaka) are more conspicuous than small quiet birds (e.g. dunnock), and thus more likely to be counted. Conspicuousness varies between species and also both diurnally and seasonally within species. Some birds sing more in the morning than later (e.g. chaffinches). Some species are more conspicuous in certain seasons (e.g. kingfishers). Thus both frequency and density estimates are influenced by conspicuousness, and this can only be mitigated by making comparisons within, rather than between, species, and only if the sample times and locations are closely comparable in the data sets being compared.

Comments on comparative methodologies

Both the ABC 2019 and the GBICT 2007 used "five minute bird counts"[1], usually by three observers at each point. In 2019 the three-person teams recorded species within 25m of the point, but also noted more distant birds. The distance restriction allowed an estimate of density (birds within a circle of 25m = .1963 ha.. so multiply by 5.1 to get number per hectare). Including the birds outside the 25m circle in the frequency estimate allowed more valid comparison with the earlier 2006 frequency data. The ABC data are derived from 16 sites, at each of which were 5 points, replicated twice, on a transect line. Thus there were 160 points, but the frequency of a species *at any location* (transect) is based on 10 points, so can range from 10% if recorded only once, to 100% if recorded every time, with 10% steps between.

In both sets of counts (2019 and 2007), all birds were recorded, but in 2019 particular attention was paid to the correct counting of tui, kaka, kereru and kakariki. These were 'target species'.

The GBICT counts were done on four separate occasions: Winter (1/7/2006), Spring (30/9/2006), Summer (27/1/2007) and Spring (8/9/2007). Each occasion had a separate *Results* publication (Biodiversity Response Fund (AV 207 D.O.C) and an account in the *Environmental News* (Issues 7. 8. 9. 11. 13 and 16). For analysis, the transects were also grouped (in some cases transect points were split) into five broad 'habitat' types. These were: (1) montane bush; (2) manuka/kanuka bush; (3) lowland bush; (4) coastal bush, estuaries and shore areas; (5) roadside paddocks. The ABC counts were done on similar but not identical transects to the GBICT counts. In a few cases the two sets were closely similar, but usually they were approximate only (Table 1). In 2019 some quite new lines were also covered, but these are not included in this analysis.

[1] Hartley, L. J. 2012. Five-minute Bird Counts in New Zealand. *New Zealand Journal of Ecology,* 30 (3).

For comparison the GBICT 2007 Summer data were considered best to compare with the 2019 data (also done in Summer), although comparisons were also made with the overall average frequencies for all sample dates 2006 – 2007.

Other important provisos

Further provisos regarding the comparison of these two data sets are relevant. First, it is essential to recognise that the data sets represent only two points in time – 2007 and 2019. Consequently they cannot be used to infer 'trends' through time, unless those inferences are supported by other data. We must be aware that for most bird species there is great variability between years - 2007 may have been a bad year for certain species and 2019 a good year for it, but to interpret that as an increasing trend is clearly fallacious without additional information. Also of course the 'seasonal' sample dates were slightly different, the exact sample points were not identical, the people were different, and the method was also slightly different. Consequently, comparisons must be made with caution.

Statistical analyses

The Similarity Coefficient (2w/a+b)*100 was used to compare species frequencies in different habitat types; a and b are the totals for the two species frequency lists being compared, and w is the sum of the lowest values for species common to both lists. This coefficient ranges from 100 for identical data sets to 0 for sets with no species in common.

Most of the analysis was done using Chart in Microsoft Excel. This provided bar graphs (for which 95% Confidence Limits were calculated) and scatter diagrams with regression equations and estimates of 'Explained Variance' (r^2), from which the Correlation Coefficient (r) can be readily obtained. I also used the t-test function (2-tailed) within Excel to compare species frequencies between the two data sets. These statistics must be interpreted with care as they are based on % data and mostly on small samples (and bearing in mind the provisos about the field methods), but they provide another level of confidence when drawing conclusions.

RESULTS

Overall change in frequency

The first test was to establish if there wer any overall differences between the two years, using all species in all habitat types (Table 1). A slightly higher average frequency was obtained in 2019, but the difference is not statistically significant and taking into account the slightly different sampling method it is concluded that there is no discernable difference in the overall frequency of birds on the Island between the two years.

Table 1. Comparison of overall (all spp. all sites) frequencies in the two years

	2019	2007
Average	21.3	19.0
Std. dev.	28.2	23.3
95% C.L.	4.7	3.9

Comparisons between habitats

The first analyses were designed to see if the two data sets (2007 and 2019) had basically similar underlying features. Were the results from similar transects in the two years similar? The results in Table2, indicate that where the sites sampled were similar, the results were also similar. Similarity Coefficients for the paired montane, kanuka-manuka and lowland bush sites ranged from 64 to 89%, indicating good agreement. The coefficients based on 2007 averaged data were usually slightly higher than those based only on the 2007 Summer data, which presumably reflects the fact that the averages over 4 time periods generally included more species (Table 3). The Summer data is the most strictly comparable, and using this data the relationship between the number of species in the samples and their similarity is clear (Fig 1). The low species frequency sites (montane bush and kanuka areas) are grouped together. Likewise the lowland bush reserves and the mixed coastal areas (with some bush) are grouped, and the paddocks are distinct. This pattern is similar to that found in the more extensive ordination analysis of the 2007 data. (Fig 8 in *Final Report on Birds of Great Barrier Island 2006 – 2008*. John Ogden for GBICT, March 2009)).

Table 2. Site groups and similarity coefficients using frequency data from Summer and seasonal averages for 2007 and Summer 2019.

Habitat type	2007 sites	2019 comparatives	Sim Coeff % (Summer)	Sim Coeff % (Avg.)
Montane Bush	Needle Rock, Cooper'Castle	Needle Rock, Coooer's Castle	73	71
Kanuka	Harataonga, Cooper's Castle	Harataonga, Cooper's Castle, Te Paparahi, Windy Hill	69	89
Lowland Bush	Rangatawhiri Resv. Tryphena, Okiwi Resv.	Rangatawhiri Resv, Tryphena. Okiwi Resv	64	69
Coastal areas (part transects 2007)	Medlands, Awana, Okupu, Tryphena, Puriri Bay, Wairahi.	Awana, Okupu	51	58
Coastal paddocks (Part transects 2007)	Awana, Kaitoke S., Medlands, Mabey Rd., Okiwi airport.	Awana, Claris, Medlands	54	54

Table 3. Number of species recorded in different habitats in the two surveys.

Habitat type	Number of Introduced spp. recorded			Number of native spp. recorded		
	Summer 2019	Summer 2007	All seasons 2006-07	Summer 2019	Summer 2007	All seasons 2006-07
Montane Bush	**1**	2	3	8	9	9
Kanuka	3	5	9	9	9	10
Lowland Bush	**10**	6	15	15	12	16
Coastal areas (part transects 2007)	**11**	9	16	19	19	25
Coastal paddocks (Part transects 2007)	13	14	19	20	18	24
Average	8	7	12	14	13	17
Standard error (±)	5	5	6	6	5	8

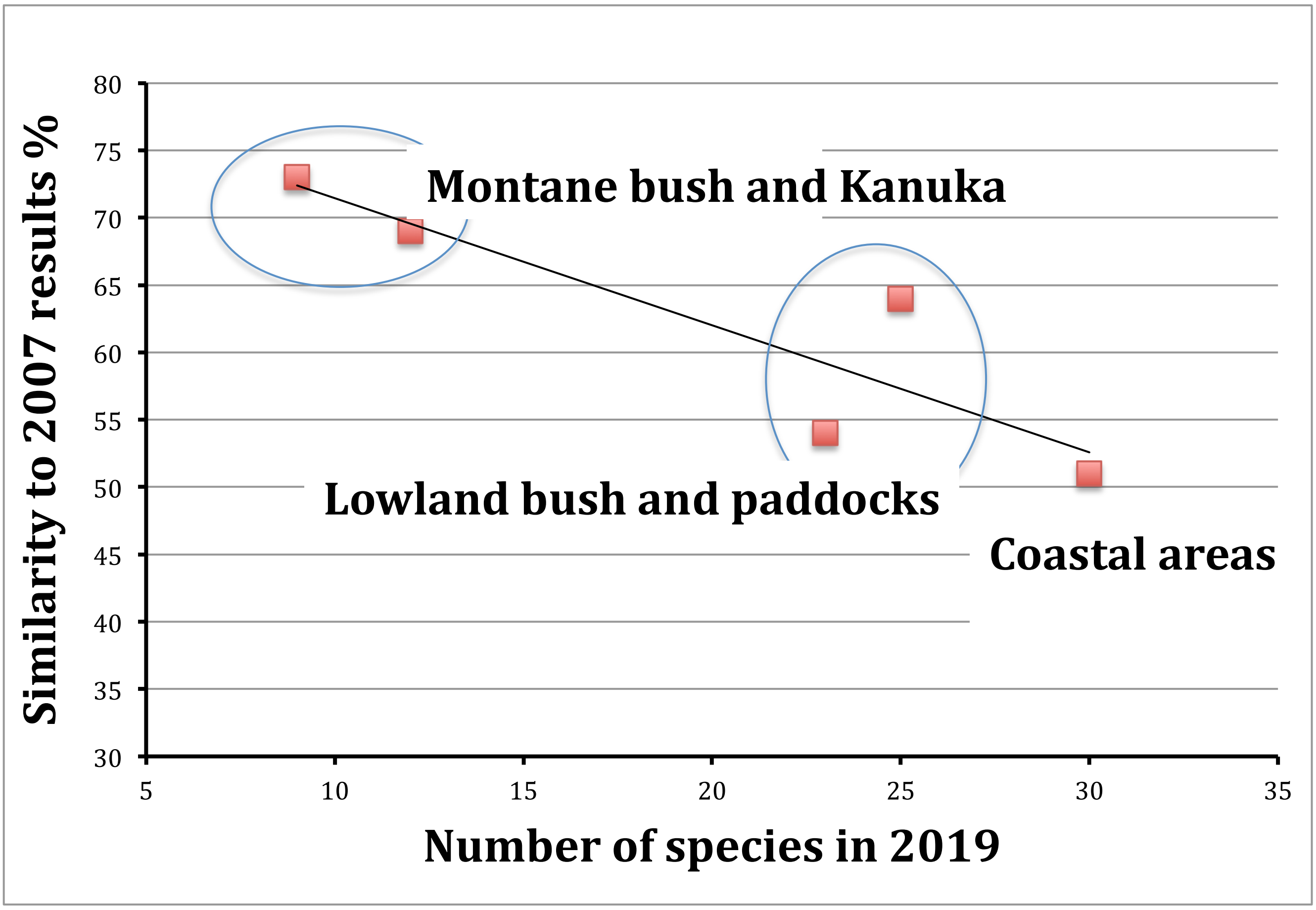


Fig. 1. Relationship between number of species recorded in sites and the similarity between the two data sets (2007 v. 2019 Summer). The vertical axis is the % similarity between the paired sites in the five groupings shown in Table 2.

In both years grey warbler, tui, kaka, and silvereye characterized the montane and kanuka forests, while lowland and coastal sites were characterized by tui, kingfisher and kaka, with grey warbler added to the top three in 2019. Paddocks had highest frequencies of pukeko and kingfisher, plus spur-winged plover in 2007 and silvereye in 2019. The relatively high importance of tui, kaka and kingfisher overall is shown by their high abundance in the 2019 data (Fig 3 of that Report). Grey Warbler and Silvereye were respectively 4th and 5th in abundance in 2019.

The site groups (or 'habitat') results show good overall agreement between the two years. The lower similarity coefficients (51 – 58%) between the lowland and paddock sites is to be expected, as not only were more species involved (up to 46 species in total) but also the transect groupings are much less well matched between the years

Introduced v. native species.

Numbers of species for these two categories are shown in Table 4. Itwas thought possible that the *relative* abundance (frequency) of introduced species could have changed over the years. The ratio introduced/native seems likely to show lower inter-annual variability than individual species frequencies.

Table 4 Ratio of introduced to native species in different habitat groups. Columns based either on total frequencies, or on a count of the number of species in each category. (Highest ratios in each habitat shown in red.

Habitat type	2019 Spp. frequency	2007 Spp. frequency	2019 Spp. Number	2007 Spp. Number
Montane bush	0.3	0.1	0.3	0.1
Kanuka & manuka	0.1	0.4	0.3	0.5
Lowland bush	0.6	0.3	0.7	0.5
Coastal mixed habitats	1	0.3	0.6	0.5
Coastal paddocks	0.7	1.1	0.7	0.8
Overall	0.54	0.44	0.52	0.48

The 2019 pattern of the ratio was similar whether total frequencies or simply the number of species were used (Table 3). Again the similarities between the 2007 and 2019 data are reassuring. Overall, native birds are c. twice as frequent as introduced species. The ratio was lowest in montane bush and kanuka dominated forest, and greatest in coastal areas close to habitations and paddocks. There was a slightly higher ratio of introduced species in 2019. Although this difference is not statistically meaningful, it might reflect an increase in some introduced species, partly balanced by a decrease in some others (see later).

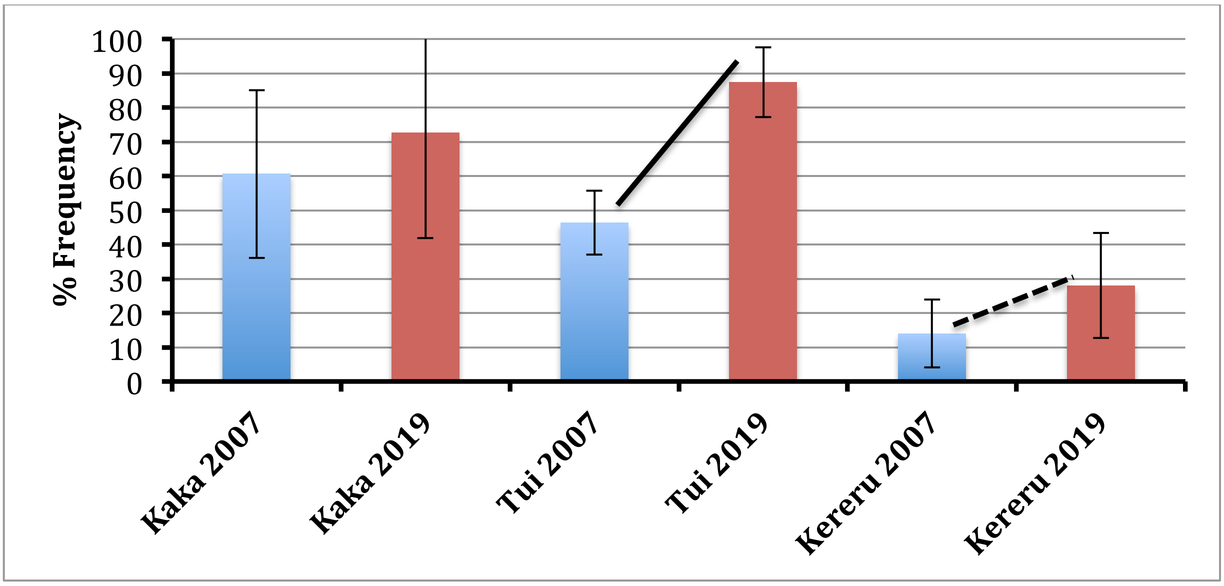
Individual native species differences

The key ('target') species, except kakariki, are shown in Fig 2. All species appear to show an increase in frequency in 2019, and this is statistically significant for tui (P = .00015***) and close to significance for kereru (P =0.1010 (*)). These differences reflect similar results at Windy Hill over the 2008 – 2017 decade. The increase between years for kaka is not statistically significant, as also at Windy Hill. However, the *densities* of all three species were significantly positively correlated at Windy Hill over the period

2018 – 11, giving weight to the validity of all three increases recorded here[2]. These coincidences with the results from Windy Hill imply upwards trends for all three species since 2007; clearly so for tui.

Kakariki was observed only in or close to the Okiwi Reserve in both years and its numbers are small[3]. The total population is hard to estimate and although observations have been made elsewhere on the Island (Awana, Hot Springs track, Medlands) since 2007, there is no clear evidence of any change of status.

Fig 2. Overall (all habitats) average % frequencies for key species in 2007 and 2019 (Means and 95% Confidence Limits). 2019 highlighted in red.



The small insectivorous (grey warbler, fantail) and omnivorous (silvereye) native species are shown in Fig 3. The apparent decline for fantail (P = .0523 *) occurred in all five habitats, suggesting it is a real difference between the years. However, no clear trend of decline has been observed at Windy Hill (2008-17) although a possible fall in density was indicated in the previous decade (2000 – 2011).[4]

Grey Warbler on the other hand has apparently increased at Windy Hill (2000 v. 2011; 2008 – 2017), and also in all habitats in the 2007 – 2019 comparison of this study (Fig 3). The 'trend' is not statistically significant due to the wide confidence intervals, but its generality suggests a real increase. Silvereye is similarly difficult to judge. For this species there is no clear evidence of change between the years, or in the Windy Hill data. Annual and seasonal variability is compounded by flocking activity, making frequency estimates less useful.

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[2] Report WHRBCT. *Bird Counts 2011*. JO6, 2012. Table 5 and Fig 10.

[3] Cook, A. 2012. *An investigation of the population size and distribution of tomtit and red-crowned parakeet on Mount Hobson/Hirakimata and the results of five-minute bird counts at four different sites on Great Barrier Island*. Report to the Great Barrier Island Charitable Trust. Pp.28.

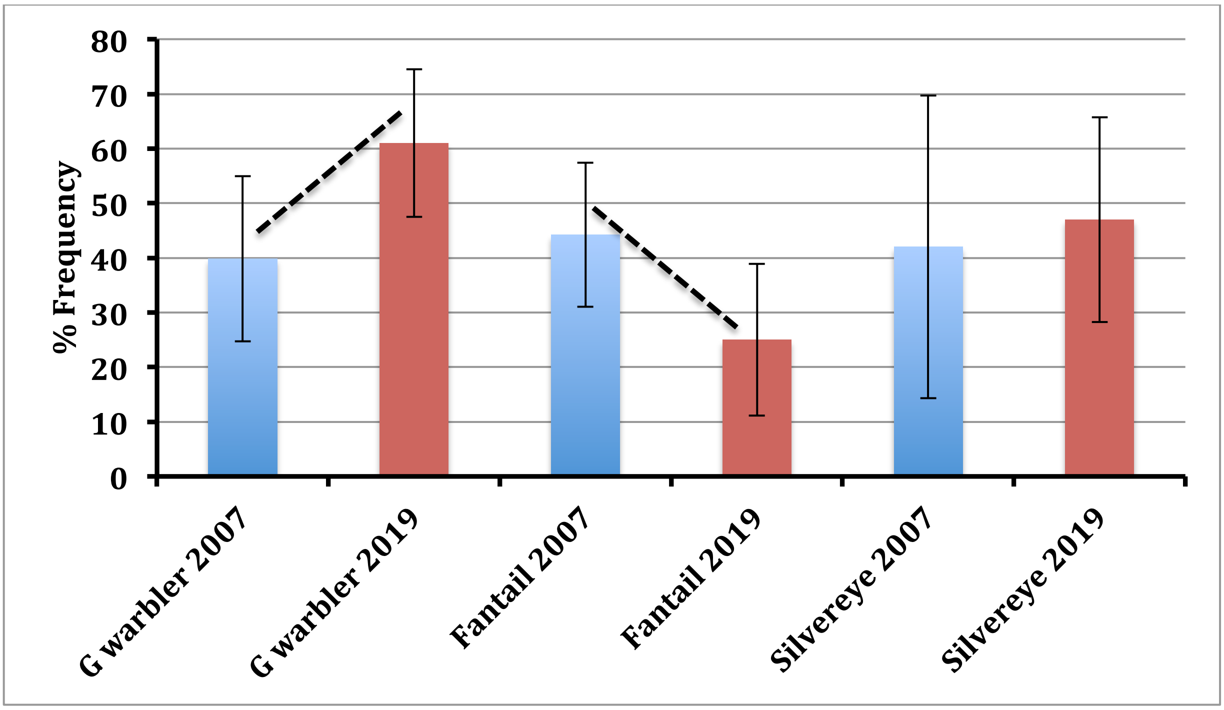
[4] Ogden, J. 2011. *Windy Hill Rosalie Bay Catchment Trust. Trends in Bird Abundances 2000-2011*. Report JO5. July 2011.

Other native species are generally less frequent, and have less supporting data, so that drawing conclusions from the 2007 – 2019 comparisons seems futile. However, a few species are worthy of comment.

Brown teal/pateke appears to have decreased in its preferred habitats. In 2007 frequencies were between 10 and 35%, but in 2019 the species was recorded only in coastal habitats with a value of 10%. This agrees with Island-wide pateke counts by D.O.C., which have also declined (personal communications with Louise Mack and George Taylor) and with personal observations at Awana and Kaitoke Creek.

Kingfisher/Kotare is a very conspicuous species between September and February. Earlier data indicated the possibility of an increase in the breeding population in the Awana area from 2002 to 2008, but also showed considerable inter-annual variability. There is no evidence of a change in status of this species over the time period 2007 - 2019.

Fig 3. Overall (all habitats) average % frequency for small native species in 2007 and 2019. (means and 95% C. L.). 2019 highlighted in red.

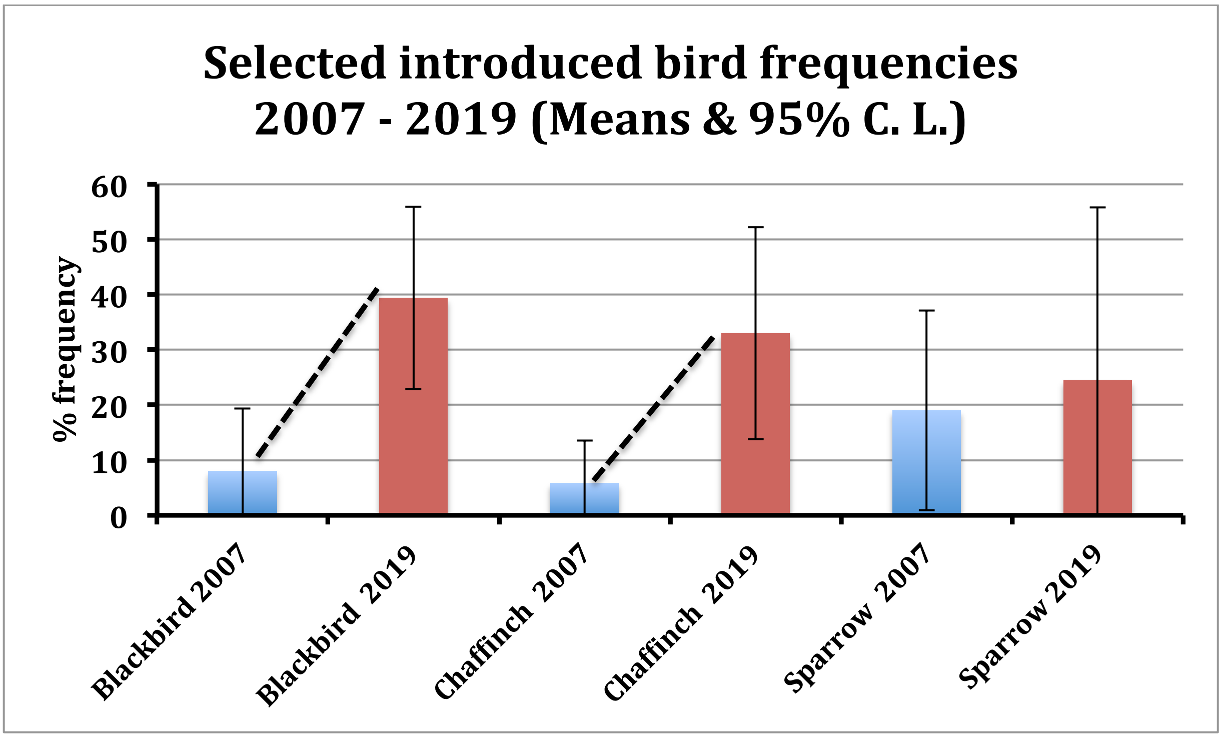


Individual introduced species differences

Both blackbird and chaffinch were more conspicuous in 2019 than in 2007 (Fig 4). Whether or not this represents a real increase is less certain, as the 2019 counts were earlier in the breeding season for both species, so the males may have been singing more vigorously. Though infrequent, these two species are also the commonest introduced species in the bush at Windy Hill, but their numbers show no clear trends there over the last decade. Sparrows show no significant difference between the two years.

The larger more conspicuous (louder) introduced species (myna, magpie and spur-winged plover) were all recoded at slightly lower frequencies in 2019 compared to 2007, but this does not necessarily indicate real declines. The ‚unbounded' method of counting in 2007 would have tended to record these species more frequently (see p.3). Personal observations over the last decade indicate an *increase* in mynas, at least in the Awana area. Spur-winged plovers are hard to judge as flocks may visit the Island periodically. Other noisy species, such as roosters and pheasants may have been 'over recorded' in 2007 due to the great distance allowed for recording.

Fig 4. Overall (all habitats) average % frequency for selected introduced passerines in 2007 and 2019. (means and 95% C. L.). 2019 highlighted in red.



Density results compared to those from Windy Hill

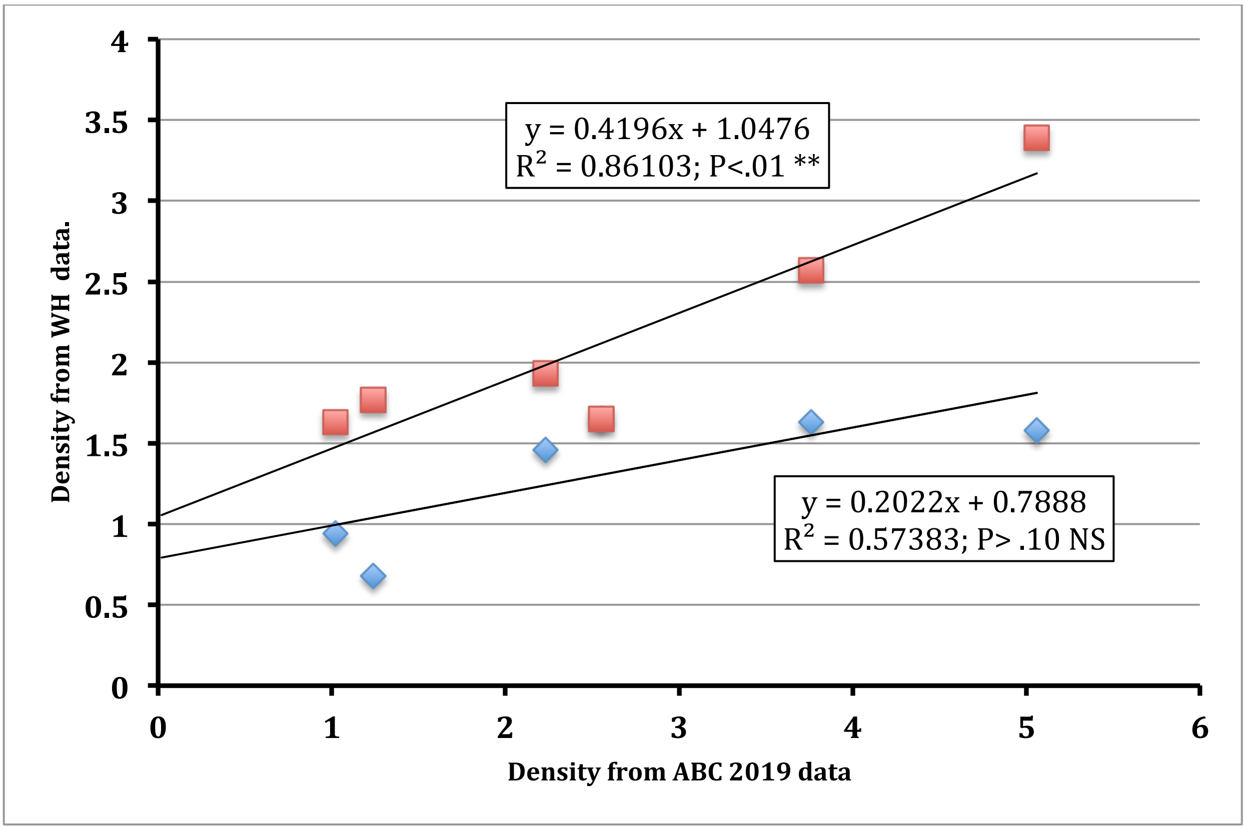
The density estimates were based on the same circle area (25m radius, 0.1963ha) in both the ABC and the Windy Hill data. However, counting was carried out for only thee minutes, at Windy Hill, rather than the more usual 5 minute count used by the ABC 2019. The longer period gives a greater chance of a species occurring within the sample area, and hence is likely to give a higher density estimate.

There is no *a priori* reason why the ABC 2019 densities and those from Windy Hill should agree, as they are from different locations, habitats and years. However, they should be of a similar magnitude, with probably higher estimates for the ABC data, as they are based on 40% longer sampling period (5 v. 3 mins). There is a statistically significant correlation for these six species between the ABC 2019 counts and the maximum observed at WH over the 2007 – 2018 period, although the 2018 data show poorer agreement. The ABC densities are generally above those recorded at Windy Hill by up to two birds/ha (tui).

Table 5. Density estimates (no./ha) for six species in the ABC 2019 counts and the data from Windy Hill.

Species	ABC 2019	WH 2018	WH max 2007 - 18
Tui	5.06	1.58	3.39
Kaka	1.24	0.68	1.77
Kereru	1.02	0.94	1.63
G. warbler	2.23	1.46	1.93
Silver eye	3.76	1.63	2.57
Fantail	2.55	1.65	1.65

Fig 5. Density estimates (no./ha) for six species in the ABC 2019 counts and data from Windy Hill 2007 – 18. The blue points are the WH 2018 results, the red are the maximum densities at Windy Hill over the 2007 to 2018 period. From left to right on the horizontal (x) axis the species are: kereru, kaka, grey warbler, fantail (points superimposed), silvereye and tui.



DISCUSSION and CONCLUSIONS

The difficulties and provisos required in comparing these data sets were discussed in the introduction and have been referred throughout the presentation of results. Keeping these considerations in mind, some more or less tentative conclusions can be reached.

Both data sets show the same five species as commonest, or at least 'most conspicuous'. There was also good agreement between the abundances of species observed in the same areas when similar transect lines were compared (Similarity Coefficients > 70%).

This applied particularly to the montane and kanuka dominated areas, which are distinct from other sites and have a smaller suite of species. The lowland bush, and the coastal areas with habitations and paddocks are less easily compared because the transect lines were mostly not the same, and because more bird species were involved. However, despite this, there was a fair level of agreement in species composition (Similarity Coefficients > 50%).

The 2019 'target species' all show increases since 2007, supported by other evidence. This conclusion (increased frequency and density) is clearly statistically significant for tui, and likely to be valid for kereru and kaka also. No conclusion can be reached about the abundance of kakariki as the samples are small and almost restricted to the Okiwi Reserve area.

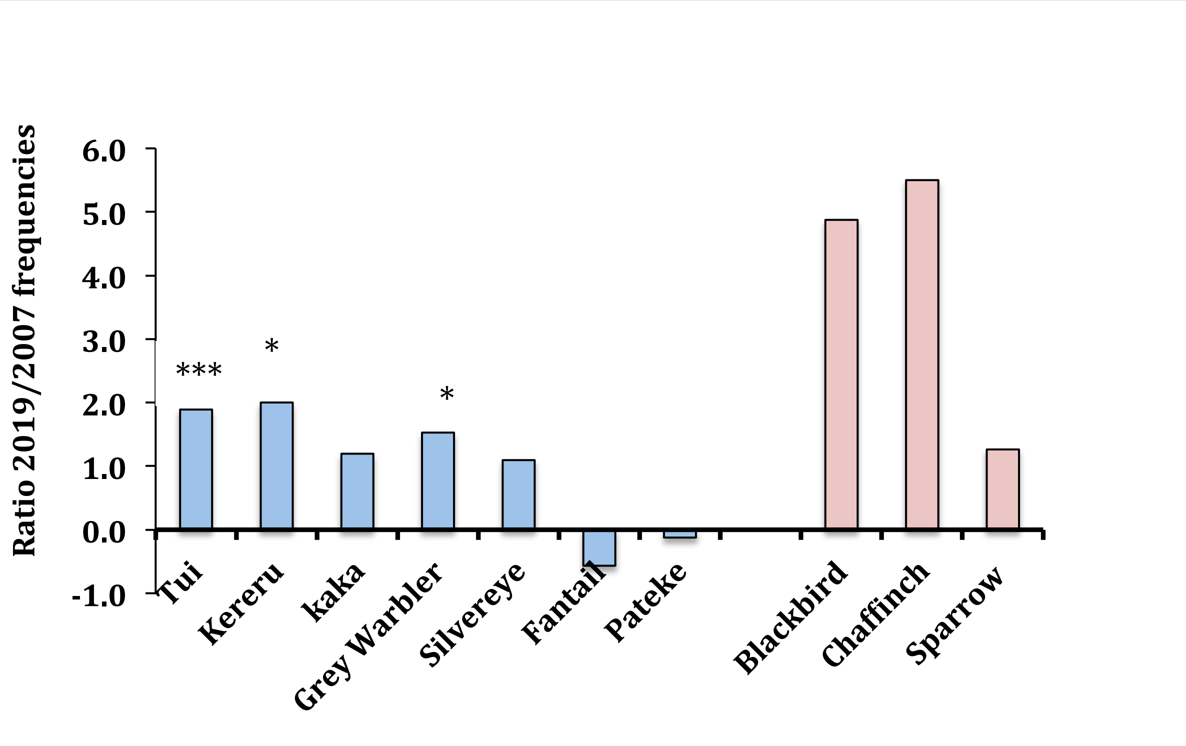
Amongst the smaller insectivorous birds, grey warbler shows a general increase, well supported by data from Windy Hill, but hard to interpret due to large numerical fluctuations from year to year and variable conspicuousness due to singing mainly during sunny weather. Fantail shows so much inter-annual variability that an apparent decline is even harder to assess. Both species are significantly reduced in the presence of rats (Windy Hill data), so fluctuations in rat numbers, weather patterns and food availability will all influence annual survivorship. For silvereye annual and seasonal variability is compounded by flocking activity, making frequency estimates less useful. No trends could be seen for this species.

Other native species were recorded only at low frequency or in a few sites, and as they have no, or little, supporting data, no evidence of change since 2007 can be given. An exception is brown teal/pateke, which shows a decline supported by D.O.C island-wide counts over the last few years.

The general conclusions outlined above are summarised in Fig 6. In only four cases, tui, kereru, grey warbler and pateke, does it seem probable that the differences between 2007 and 2019 are part of a longer trend. In the other cases the differences are indicative and worthy of future monitoring. This applies particularly to the introduced passerines.

Although the introduced/native ratio suggests an increase in the proportion of introduced species, this cannot be substantiated because several of the introduced species are very conspicuous and likely to have been 'over represented' in the 2007 data due to the methodology then being used. Blackbirds and chaffinches were recorded more frequently in 2019 (statistically significant at $P<.10$). However this could be due to the December (rather than late January) sampling date in 2019, as these species would probably both be singing more frequently earlier in the breeding season. The apparent trend for these two species is not substantiated by any other data so the high ratios in Fig 6 tell us nothing about temporal trends. Sparrows show no significant difference between the two years, though anecdotal information suggests an increase, especially in the Tryphena and Medlands areas. Flocks of > 100 sparrows and c. 60 goldfinches were observed at Medlands in May 2020.

Fig 6. Apparent relative increases and decreases for selected species discussed in text. Statistically significant 2007 to 2019 differences are asterisked ***only where also supported by other data.*** *Significance levels: P= <.001***; <.10*.*



Except in one case, species recorded earlier but apparently absent in 2019, cannot be assessed. However, grey duck (*Anas supercilliosa*) appears to have gone extinct on Great Barrier during the 2007 – 2019 period. The species was definitely present in 1980[5], was recorded once in the 2007 GBICT Survey (Eastern paddocks), and one was present on Oruawharo Creek in March 2008[6]. Since then there have been no other records. This mirrors the decline of this species throughout New Zealand, as a result of competition and breeding introgression with introduced mallard, which arrived on Great Barrier before 1964[6]. No completely new species were recorded in the 2019 survey, but it is noteworthy that spotted dove (*Streptopelia chinensis*) was present at Medlands, Okupu and probably Kaitoke in November 2019, and barbary (ring-necked) dove (*S. roseogrisea*) at Okupu in 2017. These species could possibly colonise Great Barrier from Auckland in future years.

RECOMMENDATIONS and COMMENTS FOR FUTURE SURVEYS

(1) The survey techniques, team sizes, transect locations, sample dates and points used in 2019 should not be changed, as this would result in the sort of difficulties of comparison as between the 2007 and 2019 data. Keeping everything as constant as possible is one of the key requisites of a monitoring regime. The 25m sampling circle is realistic and better than the 'unlimited' area used in 2007.

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[5] Ogle, C. C.1981. Great Barrier Island Wildlife Survey. *Tane* 27: 177-200.

[6] Ogden, J. 2009. *Final Report on Birds of Great Barrier Island 2006-2008.* GBICT. (Appendix 2).

Birds seen or heard outside 25m could still be recorded (and perhaps also analysed in future).

(2) The 2019 data would thus become the new 'base-line' data, although the earlier data (2007-7) and other counts (e.g. Windy Hill, Glenfern) should be consulted when considering trends.

(3) For these comparative purposes, frequency may be useful, so this statistic should be presented with the survey results along with the density estimates.

(4) However, a more targeted approach to habitat types should be considered, because different groups of species are found in different habitats. This could be accommodated in future by two 'modifications'. (1) Add some transect lines (5 points) in habitats currently under-represented (e.g. swamps/wet paddocks), or confounded with other habitats in the current layout. (2) Using the current transects, classify each point to a particular habitat type. This could be easily done in some cases, but with difficulty in others, where points are located between two or more habitats. In that case the 'predominant habitat' of the point could be assigned.

(5) If *individual points* were assigned to habitats, (and also to 'altitude', 'level of human presence', and 'pest control level' as in the current analysis), some more sophisticated analyses could be made.

(6) Given a set of clear criteria habitat types could be assigned by the field teams during the monitoring, or alternatively (probably better) by one person visiting all 80 survey points.

(7) If the habitat types were aligned with the Landcare Database2 Vegetation Types (or whatever database has superseded this) then, using the bird density data, it would be possible to estimate populations in each vegetation category and sum for total Island-wide population sizes for each species. (See Table 9.1 I in GBICT State if Environment Report 2010).

(8) A more targeted habitat analysis would also allow better comparisons between years, as for any species, habitats where it occurred would not be lumped with those in which it did not, as occurs in this report.

(9) The 'scattered transects five minute count' approach used here is adequate for the more widespread bird species, and involves many members of the public learning about birds and contributing to their conservation. However, it is quite inadequate for some species which are more restricted to particular habitats, or have other characteristics making them difficult to count by this method (e.g. nocturnal or crepuscular species or those which are usually in flocks). These are often the species of greatest conservation interest, but they require 'specialised' monitoring methods keyed to the particular species.

(10) Examples of species requiring different monitoring techniques on Great Barrier are as follows: rails and crakes (3 sp.); herons, spoonbill and bittern (4 sp.); penguins (1 sp.); gannet, gulls and terns (5 sp.); Shags (4 sp.); Petrels (4 sp.); Shearwaters (1 sp.); Waders (5 sp). These 27 species are mainly wetland, coastal or marine species. A few are being monitored already or have 'reports' (Black petrel, New Zealand dotterels, waders and bittern). Consideration should be given to another monitoring programme for these species involving more specialised approaches , such as counting nests or occupied burrows.

(11) There are also terrestrial species for which other approaches could be considered (in addition to the December 5-min survey). For example myna and starling roosts; active kingfisher nesting holes, winter finch flocks, could be counted.

ACKNOWLEDGEMENTS

Thanks to Serena Simmonds, for assistance with the data. Thanks also to Judy Gilbert for support with the WHRBCT results, to Louise Mack and George Taylor for comments on pateke, and to Emma and Kate Waterhouse for financial support through the GBIET.

SUPPLEMENTARY DATA (in folder: ABC Comparative)

The following supplementary data are available in electronic form:

1. **GBIET (2019) Frequency data (Serena Williams).xlsx**
2. **ABC Frequency ANAL 1 (Copy). xlsx [8 sheets]**
3. **ABC Freq Anal 2. xlsx [4 sheets]**