Supplementary material

Appendix S1. Characteristics of the six study areas in which we conducted bird point counts using both human observers and autonomous recording units (ARUs). Total annual precipitation and mean annual temperature data are from the National Institute of Water and Atmospheric Research 29-year average (1981–2010). Area indicates the total size of all forest patch(es) within a reserve, not the size of the entire reserve. Number of sampling points/visits indicates how many sampling points were in each site and the total number of visits to that site across all repeated visits to sampling points. The sanctuary column indicates whether the site is a mammal-free sanctuary or not.

Study area	Latitude / longitude	Total annual precipitation (mm)	Mean annual temperature (°C)	Mean elevation (m)	Area (ha)	No. sampling points / visits	Sanctuary?
Maungatautari Ecological Reserve	38°02′58″ S, 175°33′36″ E	1200	13	442	3210	103/136	Yes
McElroy Scenic Reserve	36°27′32″ S, 174°41′32″ E	1400	16	88	150	20/104	No
Rotokare Scenic Reserve	39°27′14″ S, 174°24′35″ E	1400	13	221	215	25/98	Yes
Tarata Conservation Area	39°10′05″ S, 174°21′24″ E	1800	13	147	149	14/31	No
Tawharanui Regional Park	36°22′18″ S, 174°50′33″ E	1200	16	44	90	17/93	Yes
Te Tapui Scenic Reserve	37°48′38″ S, 175°37′23″ E	1200	13	269	2330	101/127	No

Appendix S2. Species detected across all study sites in 2017, indigenous status, and whether density was estimated or not for the species and the reason.

English name	Māori name	Scientific name	Indigenous status	Density estimated	Reason
Australian magpie	Makipae	*Gymnorhina tibicen* (Latham, 1802)	Introduced	Yes	
Bellbird	Korimako	*Anthornis melanura* (Sparrman, 1786)	Native	Yes	
Bush parrot	Kākā	*Nestor meridionalis* (Gmelin, 1788)	Native	No	<20 detections, species often detected as flyovers
Chaffinch	Pahirini	*Fringilla coelebs* (Linnaeus, 1758)	Introduced	Yes	
Common myna	NA	*Acridotheres tristis* (Linnaeus, 1766)	Introduced	Yes	
Common starling	NA	*Sturnus vulgaris* (Linnaeus, 1758)	Introduced	No	<20 detections
Eastern rosella	NA	*Platycercus eximius* (Shaw, 1792)	Introduced	No	<20 detections
Eurasian blackbird	Manu pango	*Turdus merula* (Linnaeus, 1758)	Introduced	No	Did not meet the equal availability assumption
European goldfinch	NA	*Carduelis carduelis* (Linnaeus, 1758)	Introduced	No	<20 detections
European greenfinch	NA	*Carduelis chloris* (Linnaeus, 1758)	Introduced	No	<20 detections
Fernbird	Mātātā	*Bowdleria punctata* (Quoy & Gaimard, 1830)	Native	No	<20 detections
Grey warbler	Riroriro	*Gerygone igata* (Quoy & Gaimard, 1830)	Native	Yes	
House sparrow	Tiu	*Passer domesticus* (Linnaeus, 1758)	Introduced	No	<20 detections, uses mainly edge habitat not forest interior
Morepork	Ruru	*Ninox novaeseelandiae* (Gmelin, 1788)	Native	No	Study not designed to observe nocturnal species
New Zealand falcon	Kārearea	*Falco novaeseelandiae* (Gmelin, 1788)	Native	No	<20 detections, species often detected as flyovers
New Zealand fantail	Pīwakawaka	*Rhipidura fuliginosa* (Sparrman, 1787)	Native	Yes	
New Zealand pigeon	Kererū	*Hemiphaga novaeseelandiae* (Gmelin, 1789)	Native	Yes	
North Island robin	Toutouwai	*Petroica longipes* (Garnot, 1827)	Native	Yes	
North Island saddleback	Tīeke	*Philesturnus rufusater* (Lesson, 1828)	Native	Yes	
Parson bird	Tūī	*Prosthemadera novaeseelandiae* (Gmelin, 1788)	Native	Yes	
Red-crowned parakeet	Kākāriki	*Cyanoramphus novaezelandiae* (Sparrman, 1787)	Native	No	<20 detections
Rifleman	Tītipounamu	*Acanthisitta chloris* (Sparrman, 1787)	Native	No	<20 detections
Sacred kingfisher	Kōtare	*Todiramphus sanctus* (Vigors & Horsfield, 1827)	Native	No	<20 detections
Shining cuckoo	Pīpīwharauroa	*Chrysococcyx lucidus* (Gmelin, 1788)	Native	No	<20 detections
Silvereye	Tauhou	*Zosterops lateralis* (Latham, 1802)	Introduced / naturalised	Yes	
Song thrush	NA	*Turdus philomelos* (Brehm, 1831)	Introduced	No	<20 detections
Stitchbird	Hihi	*Notiomystis cincta* (du Bus de Gisignies, 1839)	Native	No	<20 detections
Tomtit	Miromiro	*Petroica macrocephala* (Gmelin, 1789)	Native	Yes	
Whitehead	Pōpokatea	*Mohoua albicilla* (Lesson, 1830)	Native	Yes	

Appendix S3. Estimates of effective detection radius, τ, and 95% confidence intervals for 13 bird species detected across six indigenous forest sites in 2017 on the North Island of New Zealand, estimated by fitting distance sampling models (Buckland et al. 2001) to data from point counts conducted by human observers.

Species	τ	LCL	UCL
Bellbird	46.300	45.018	47.254
Chaffinch	33.174	30.880	36.601
Fantail	22.793	18.111	24.989
Grey warbler	50.962	47.807	51.976
Kererū	29.551	27.341	30.873
Magpie	85.173	82.551	88.923
Myna	41.967	38.962	44.495
North Island robin	32.657	30.795	33.617
Saddleback	54.129	52.610	56.192
Silvereye	24.168	21.953	28.734
Tomtit	16.345	15.345	16.569
Tūī	53.313	51.827	54.787
Whitehead	16.345	11.485	20.281

Appendix S4. Estimates of the scaling constant δ (a measure of the ratio of the effective detection radius between bird count data derived from ARU and human survey methods) and 95% confidence intervals produced using (1) the maximum likelihood approach (MLE δ) of Van Wilgenburg et al. (2017) where $\delta = \sqrt{\exp(\beta)}$ in generalised linear mixed effects models, (2) using the MLE approach over 50 repeated subsamples of 70% of the data (calibration δ), and (3) by estimating empirical ratios of mean bird count totals from ARU surveys to mean count totals from human surveys over 50 repeated subsamples of 30% of the data. A δ value of 1.0 indicates that ARU count data and human count data are the same.

		MLE			Calibration			Empirical	
Species	LCL	δ	UCL	LCL	δ	UCL	LCL	Ratio δ	UCL
Bellbird	0.744	0.835	0.936	0.730	0.833	0.949	0.712	0.827	0.943
Chaffinch	0.999	1.247	1.573	0.957	1.239	1.628	1.004	1.142	1.279
Fantail	0.859	0.967	1.091	0.838	0.962	1.105	0.926	0.998	1.071
Grey warbler	0.832	0.917	1.011	0.819	0.916	1.025	1.020	1.048	1.076
Kererū	0.682	0.814	0.971	0.644	0.793	0.975	0.876	1.031	1.186
Magpie	0.814	0.954	1.118	0.780	0.943	1.140	0.948	1.020	1.093
Myna	0.788	1.021	1.324	0.751	1.018	1.383	0.990	1.205	1.419
North Island robin	0.724	0.884	1.079	0.712	0.897	1.131	0.964	1.015	1.065
Saddleback	0.889	1.045	1.231	0.872	1.052	1.275	0.801	0.902	1.003
Silvereye	0.781	0.851	0.927	0.767	0.846	0.933	1.010	1.080	1.150
Tomtit	0.993	1.121	1.269	0.967	1.113	1.285	0.892	0.961	1.030
Tūī	0.851	0.919	0.993	0.841	0.919	1.004	0.929	0.975	1.021
Whitehead	0.784	0.967	1.193	0.755	0.963	1.230	0.942	1.029	1.115

References

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L (Eds.) 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford, Oxford University Press. 432 p.

Van Wilgenburg SL, Sólymos P, Kardynal KJ, Frey MD 2017. Paired sampling standardizes point count data from humans and acoustic recorders. Avian Conservation and Ecology 12: 69–83.