THE CAPE TO CITY PROGRAMME: BASELINE BIRD COUNTS IN TREATMENT AND NON-TREATMENT AREAS

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Abstract

This report describes the results of bird and small mammal counts, undertaken in 2015/16, in three areas relevant to the *Cape to City programme*: in *Cape Sanctuary* on the Cape Kidnappers headland; in the 26,000 ha *Cape to City* footprint, and in the 20,000 ha *Cape to City* non-treatment area, to the south and west of the footprint. The counts are 'baseline' in that they were taken before the winter of 2016, the start date of predator control within the *Cape to City* footprint.

The results show that the abundance of forest birds in the three counting areas is currently influenced mainly by forest type and predator management. In general, native birds were most abundant in native forests while introduced birds were most abundant in exotic forests. Grey warbler and tui are currently the most abundant native species in the counting areas. *Cape Sanctuary,* with its intensive predator control and species management programmes, had three species of native birds that were recorded only there. It also had another five species of native bird that were much more numerous in the sanctuary than elsewhere, with bellbird being a notable example.

The counts in wetlands showed pateke are currently much more abundant in *Cape Sanctuary* than elsewhere, but there were otherwise few differences in waterfowl and shore bird abundance in the counting areas. In all counting areas, large wetlands had more wetland birds (species and individuals) than small wetlands.

The counts along roads in open country revealed no differences in game bird abundance in the footprint and non-treatment area. The same was true of rabbits, possums (roadkills) hedgehogs (road kills) and various selected open country birds (mainly pests) whose numbers might be influenced by top-predator control in the footprint.

A primary aim of the *Cape to City* programme is to make the footprint safe for endangered birds, to reduce and then eventually eliminate the differences that exist now in the bird communities of the sanctuary and footprint area. The baseline counts have quantified exactly what those differences are. Some species of *Cape Sanctuary* origin are already attempting to establish in the *Cape to City* footprint. The degree to which they are likely to succeed is discussed in the report, with pateke and kakariki identified as key indicator species.

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Introduction

The *Cape to City* programme is a multi-agency initiative that aims to evaluate the economic and biodiversity consequences of large-scale, low-cost predator control in an agricultural landscape in coastal Hawkes Bay. The programme specifically addresses whether the control of top predators - possums, cats, ferrets, stoats and weasels - produces economic benefits for farmers (by reducing levels of disease in livestock) and biodiversity benefits for the wider region.

The *Cape to City* treatment area is currently about 26,000 ha (Fig. 1). It extends southwards from the Cape Kidnappers Peninsula to the southern end of the Maraetotara Plateau, and westwards from the Pacific coast to the township of Havelock North. Most of the land within the footprint is erosion-prone hill-country, farmed for sheep and beef. About 2% of the footprint is covered in native vegetation, and 7% in pine plantations (*Pinus radiata*) of varying ages. The Maraetotara River lies entirely within the footprint, providing valuable riverine habitat in what is typically a summer-dry landscape. Recent native riparian plantings along the middle sections of the river have further enhanced its value as a habitat for wildlife.

A key feature of the *Cape to City* footprint is that it borders *Cape Sanctuary* (Fig. 1) a privately-owned 2500 ha sanctuary for wildlife on the Cape Kidnappers Peninsula. *Cape Sanctuary* supports a diverse assemblage of native birds, many currently absent from the *Cape to City* footprint, and some absent altogether from other parts of Hawkes Bay. One of the aspirations of the *Cape to City* programme is to bring the name of the programme to life - to enable endangered wildlife to move from the sanctuary to neighbouring towns, enriching the urban avifauna community, and the lives of the people who live there. The research question is thus whether low-cost, expansive predator control will make the *Cape to City* footprint habitable for endangered wildlife, providing safe places for permanent occupation, and safe steeping stones for the journey from the sanctuary to neighbouring towns.

The programme also seeks to determine whether top predator control within the footprint changes the abundance of some bird species already present - in particular waterfowl and game birds, and various pest species (eg. mynahs) that might become even more numerous and troublesome in the absence of predators.

The purpose of this document is to report baseline measurements of bird abundance in three areas relevant to the *Cape to City* programme: in *Cape Sanctuary*, in the neighbouring 26,000 ha footprint of *Cape to City*, and in a non-treatment area bordering the southern and western sides of the *Cape to City* footprint. The measurements are 'baseline' in that they were taken before the winter of 2016, the start date of predator control within the *Cape to City* footprint. The intent is to repeat the counts each year for the next five years, effectively creating a series of treatment and non-treatment comparisons, both within the footprint itself, and between the footprint and neighbouring areas. It will take two years to roll out predator control across the entire *Cape to City* footprint, and 3-5 years for the benefits of the programme to become fully measurable.

Methods

i) Bird Counts

Birds were counted in open farmland, in patches of woody vegetation, and on wetlands and ponds, both within and near the *Cape to City* footprint (Fig. 1).

ii) Counts in forests

The 5-minute count technique of Dawson and Bull (1975) was used to count birds in spring and autumn along fixed transects in woody vegetation in treatment and non-treatment areas. The 5-minute count technique is not the most modern counting technique currently available but it has a long history of use in New Zealand, with the benefit that valuable sets of comparative information are available from many different habitat types and locations.

In this study, counts were made in pine plantations and native forests and shrublands, with transect lengths varying from 500 m to 2000 m, depending on patch size (Table 1). A general description of each count site is given in Table 2. The counting sites in native forest within the footprint were clumped on the Maraetotara Plateau in patches of mature cutover tawa/podocarp forest (Fig. 2) all less than 65 ha in size. These are the only sizable patches of mature native forest in the footprint.

Table 1: *Number of transects and 5-minute bird counting stations in exotic and native forest in the three areas relevant to the C2C programme.*

FOREST TYPE	CAPE SANCTUARY	CAPE TO CITY FOOTPRINT	CAPE TO CITY NON-TREATMENT
Exotic : Number transects & counting stations	2 (24)	6 (59)	3 (40)
Native: Number transects & counting stations	1 (24)	4 (38)	1 (10)

The counting sites in exotic pine forests were spread more evenly throughout the footprint, though four transects were deliberately placed alongside or close to *Cape Sanctuary*, to detect species dispersing out of it. The pine forests selected for counts in both treatment and non-treatment areas were all larger than 100 ha in size, and - with one exception - were all at least 23 years old. The exception was a dense stand at *Cape Sanctuary*, which was planted in 1996. Apart from being younger than the rest, this stand was also the only one that was largely unpruned and un-thinned,

Fig. 1: *The C2C footprint, encircled by the red line, with coloured patches depicting the extent and type of woody vegetation. The southern boundary of Cape Sanctuary is indicated by the black line running across the base of the Cape Kidnappers Peninsula. The non-treatment area borders the southern and western side of the footprint. Map kindly supplied by the HBRC. In the legend, RAPS are Recommended Areas for Protection.*

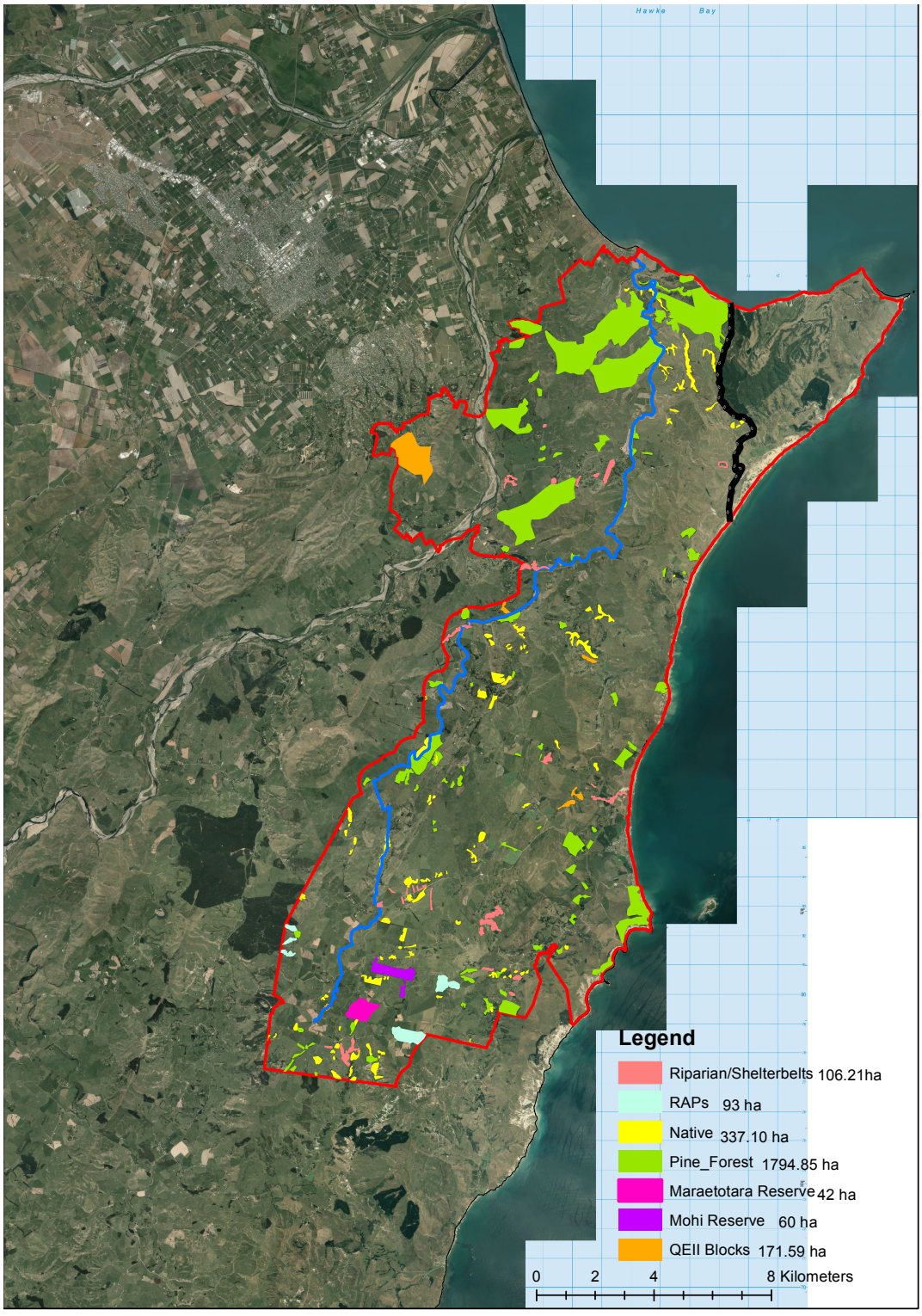

Fig 2: *Variation in counting sites. Top row: un-managed (left) and managed (right) plantations of P. radiata. Bottom row: indigenous forest at young (left) and older (right) stages of succession.*

giving it a unique set characteristics (Fig. 2) intermediate between those of native forest and highly managed exotic forest. In particular, light levels within the stand were low, and the ground beneath the trees was covered in litter (pine needles) rather than exotic grasses and blackberry, the ground cover typically associated with more open managed stands (Fig. 2). The forests within the 'exotic forest' category were therefore variable, even though they all were all planted with *P. radiata.* The same was true of the native forest category, with the kanuka dominated shrublands in *Cape Sanctuary* having less complexity than the mature forests on the Mareatotara Plateau. The counts in most native and exotic forest sites detected species living in neighbouring grasslands, as well as those within the forests themselves. This was inevitable given their relatively small size and rural locations. In four of the pine transects, there were also influences from nearby native vegetation, particularly from thin strands of kanuka in steep gullies and waterways, within the

exotic plantings. In some places, the ribbons of kanuka also contained specimen trees, mainly karaka and titoki. The categories of 'native' and 'exotic' in Table 1 are therefore not as distinct as their names imply.

Table 2: *Description of the 5-min bird counting transects in Cape Sanctuary, the C2C footprint, and the C2C non-treatment area.*

TRANSECT #	NAME	LOCATION	DESCRIPTION
1	Bondi's Ridge	Cape Sanctuary	Transect along a ridge in dense, un-thinned stand of *P. radiata*, bordered by steep gullies with mature kanuka and other native species. GR: 39° 39.997S, 177° 1.594E
2 & 4	Rough Block	Cape Sanctuary	Transects through a steep and deeply dissected 200 ha stand of mature kanuka forest, with specimen titoki, rewarewa, karaka, wharangi and tree ferns in the moist gullies. GR: 39° 40.290S, 177° 2.342E
3	Lavender Pines	Cape Sanctuary	Transect through a mature stand of pruned *P. radiata* on a sloping hill face, bordered on one side by a steep gully with mature kanuka and other native species. GR: 39° 39.293S, 177° 1.857E
5	Julian Gully	C2C footprint, alongside Cape Sanctuary	Transect through a steep-sided gully, with mature pruned pine forest on the slopes and a thin strand of kanuka in the bottom of the gully. GR: 39° 39.582S, 177° 1.311E
6	Te Mata Peak	C2C footprint, on the southern slopes of Te Mata Peak, on the edge of Havelock North, 10.7 km from Cape Sanctuary	Transect up a steep and deeply dissected gully containing a stand of redwoods and a near-continuous strip of native vegetation dominated by kawakawa, karaka, ngaio and mahoe. Grazed farmland and limestone cliffs on both sides. GR: 39° 42.031S, 176° 53.940E
7	Winirana Forest, East 1	C2C footprint, part of a large plantation of *P. radiata*, 2.64 km from Cape Sanctuary	Transect along the edge of a 50 m wide, 50 m deep dissected gully with cliffs on both sides; gully bordered by grassland on one side and mature *P. radiata* on the other; gully itself colonised by kanuka, kowhai, titoki and karaka, with dense clumps of blackberry in some places. GR: 39° 39.602S, 176° 59.575E
8	Winirana Forest, East 2	C2C footprint, 2.3 km from Cape Sanctuary	Transect through a mature stand of pruned *P. radiata* on a sloping hill face and river terrace, with two count stations on the edge of a small steep gully with mature kanuka and other native species. GR: 39° 39.908, 176° 59.467E

TRANSECT #	NAME	LOCATION	DESCRIPTION
9	Winirana Forest, East 3	C2C footprint, in the same exotic plantation as transects 7&8, 3.2 km from Cape Sanctuary	Transect follows a forestry road through mature *P. radiata*, with 4 count stations along the edge of a small steep gully with kanuka, kowhai, mahoe, and other native shrubs. GR: 39º 39.098S, 176º 59.296E
10	Winirana Forest, West 1	C2C footprint, in the western side of the Winirana plantation, 3.2 km from Cape Sanctuary	Transect follows a gently sloping ridge through mature, pruned *P. radiata*, with an understory of exotic grasses and clumps of blackberry. Last two count stations are alongside a steep gully with specimen titoki, mahoe, kowhai, kanuka, and various weeds (mainly cotoneaster and banana passionfruit). GR: 39º 38.908S, 176º 59.479E
11	Craggy Range	C2C footprint, 600 m from the Tuki Tuki River and 8 km from Cape Sanctuary	Single transect through the middle of a large *P. radiata* plantation along the side of Craggy Range. Thick ground cover of pine slash over topped by a near-continuous layer of blackberry. GR: 39º 42.889S, 177º 56.847E
12	Mohi Bush Scenic Reserve	C2C footprint, Maraetotara Plateau, 22.3 km from Cape Sanctuary	Single transect following existing walking tracks down the length of the 61 ha reserve. Cutover tawa/podocarp forest, with pigeonwood, fuschia, mahoe, nikau and supplejack. GR: 39º 51.372S, 176º 53.988E
13	Maraetotara Scenic Reserve	C2C footprint, Maraetotara Plateau, 23.2km from Cape Sanctuary	Transect runs through the centre of the 23 ha DOC administered reserve. Same forest type as Mohi Bush, with some large specimen podocarps and a dense understory of supplejack. GR: 39º 52.144S, 176º 53.366E
14	100 acre Bush	C2C footprint, Maraetotara Plateau, 23km from Cape Sanctuary	Transect runs through centre of the privately-owned QEII covenanted, 44 ha reserve. Same forest type as Mohi Bush. GR: 39º 52.607S, 176º 54.549E
15 &16	Hapua Forest	Non treatment C2C site, alongside Kahuranaki Rd, 23 km from Cape Sanctuary	Two 1 km long transects through undulating terrain in a large, intensively managed *P. radiata* forest with an understory of introduced grasses and blackberry. GR: 39º 49.547S, 176º 50.227E
17	Arborfield Forest	Non treatment C2C site, alongside Kahuranaki Rd, 25 km from Cape Sanctuary	2 km long transect through the southern end of a highly managed *P. radiata* forest. Two of 20 counting stations are near large ponds fringed with willows. GR: 39º 50.907S, 176º 50.457E

TRANSECT #	NAME	LOCATION	DESCRIPTION
18	Elsthorpe Bush	Non treatment C2C site at Elsthorpe near the southern end of the C2C footprint, 32 km from Cape Sanctuary	DOC administered small unlogged podocarp/ totara/tawa remnant in two separate compartments, 100 m apart. 6 counting stations in the eastern reserve, 4 in the western one, all within 200 m of farmland, a road, and the township itself. GR: 39° 55.133S, 176° 48.967E

iii) Responses to broadcast calls in forests

On each of the transect lines established for the five minute counts, calls of various native species were broadcast through an amplifier to elicit responses from individuals that might have otherwise been missed in the five minute counts. The usual procedure was to undertake 5 minute counts at 100 m intervals on the outward journey along a transect, and then to broadcast calls at every second count station (200 m intervals) on the way back. The calls of robins, tomtits and whiteheads were always played at each broadcast site, with the order changing from site to site. The calls used were those on the *Birds of New Zealand* phone app., released by Auckland University Press. Each call from each species was played for 30-60 seconds, followed by a minute of listening, during which responses (if any) were noted. Robins and whiteheads typically approached the source of a broadcast call, whereas tomtits usually stayed put but responded by singing. On the Mararetotara Plateau, the calls of rifleman were also broadcast along with those of the other species.

iv) Counts in wetlands

In spring and autumn, waterfowl and other wetland species were counted in a selection of ponds and lakes (Table 3) in each of the three counting areas (*Cape Sanctuary, Cape to City* footprint, and *Cape to City* non-treatment area). All ducks were viewed through a *Kowa Prominar* 25-60x telescope, enabling them to identified accurately, even under low light conditions. During counts on small farm ponds with cover on the banks, an observer walked round the perimeter clapping along the way, to flush ducks out of hiding. On large lakes, counts were made from just one or two positions affording good coverage.

v) Counts in farmland

Birds and various mammals were counted along road routes twice in spring and twice in autumn in both the *Cape to City* footprint and in the *Cape to City* non-treatment area. The counts were undertaken by two people in a vehicle moving at about 30 km - 50 km per hour in the first three hours of daylight on two consecutive days - the footprint on the first morning, and the non-treatment area on the next. One person drove while the other counted. The footprint route was 100 km long, and the non-treatment route 102 km. Each route was broken into 8 sections and counted

separately, giving 8 counts per trip along each route. Each section always had the same start and finish positions. No-exit roads were counted on the way down, but not on the way back.

Species counted included small mammals (alive and road kills), gamebirds (pheasant and Californian quail), waterfowl (puddle ducks and paradise shelduck), various 'pest' species including magpie and pukeko, and selected large native species (kereru, harrier) whose numbers might be influenced by top-predator control.

vi) Data management and analysis

The counts were analysed with programme SYSTAT. Copies of the data files are available from the author.

***Table 3**: Description of the wetland counting sites in Cape Sanctuary, the C2C footprint, and the C2C non-treatment area.*

POND OR WETLAND #	NAME	LOCATION	DESCRIPTION
1	Reservoir	Cape Sanctuary	2.4 ha reservoir, 5-10 m deep, created to store water for irrigation. Surrounded by flax and other native vegetation on three sides, grassland on the eastern bank. GR: 39° 39.741S, 177° 1.988E
2	Double dam 1	Cape Sanctuary	0.3 ha farm pond in bottom of steep gully, fringed with grassland and shrubs on the eastern bank and mature kanuka on the western side. Immediately to the south of Double Dam 2 and almost contiguous with it. GR: 39° 39.557S, 177° 2.439E
3	Double dam 2	Cape Sanctuary	Also about 0.3 ha and with the same features as Double Dam 1. GR: 39° 39.515S, 177° 2.478E
4	Rough Gully Pond	Cape Sanctuary	0.15 ha farm pond, in rough farmland. Surrounded by specimen kanuka and several large *radiata* pines. GR: 39° 39.582S, 177° 2.811E
5	Bob & Heather's pond	Cape Sanctuary	0.1 ha pond, with fenced and protected flax plantings on its western bank. GR: 39° 39.265S, 177° 2.974E
6	Central Yards	Cape Sanctuary	0.15 ha farm dam, with protected flax plantings and specimen willows at the shallow end. GR: 39° 39.999S, 177° 3.311E

POND OR WETLAND #	NAME	LOCATION	DESCRIPTION
7	Rangaiika Yards	Cape Sanctuary	0.7 ha farm dam, fringed by *P. radiata* plantations and with a dense stand of raupo in the dam itself at the northern end. GR: 39º 39.153S, 177º 4.397E
8	North Rangaiika Dam	Cape Sanctuary	0.7 ha farm dam, with a small pond at its eastern end. Fringed by open grassland. GR: 39º 39.753S, 177º 4.544E
9	Central Rangaiika Dam	Cape Sanctuary	0.8 ha farm dam, fringed by open pasture, apart from a small clump of shrubs on its northern bank. GR: 39º 39.787S, 177º 4.168E
10	Roads ponds & Bondi's Ridge	Cape Sanctuary	Cluster of 3 small ponds, c. 0.1 ha in total, surrounded mainly by open grassland and specimen shrubs, alongside main access road to Cape Sanctuary. GR: 39º 39.557S, 177º 1.631E
11,12, 13	Angus Gordon 1, 2, 3	C2C footprint, 50 m - 450 m from Cape Sanctuary	Cluster of 3 small ponds, c. 0.1 ha in total, surrounded by open grassland. c. 39º 40.256S, 177º 0.969E
14	Angus Gordon 4	C2C footprint, 680 m from Cape Sanctuary	0.7 ha pond, with occasional stands of raupo along its edges. Otherwise surrounded by open grassland. GR: 39º 39.986S, 177º 0.807E
15, 16, 17	Winirana Forest 1,2,3	C2C footprint, c. 3.0 km from Cape Sanctuary	Cluster of 2 small ponds, c. 0.1 ha in total, surrounded by open grassland, and one small pond surrounded by exotic forest. c. GR: 39º 39.766S, 176º 59.200E
18	Winirana Forest 4	C2C footprint, c. 2.8 km from Cape Sanctuary	0.65 ha pond, in the midst of mature exotic forest, with clumps of blackberry overhanging the water in some places. GR: 39º 39.852S, 177º 59.376E
19	Matt Neilson 1	C2C footprint 5.3 km from Cape Sanctuary	5.0 ha natural lake, fringed by raupo and specimen exotic trees. GR: 39º 38.843S, 176º 57.839E
20	Matt Neilson 2	C2C footprint, 5.0 km from Cape Sanctuary	7.8 ha lake, fringed with clumps of specimen exotic trees. GR: 39º 39.054S, 176º 57.589E
21	Matt Neilson 3	C2C footprint, 5.6 km from Cape Sanctuary	0.3 ha pond, fenced, surrounded by willows. GR: 39º 38.784S, 176º 57.661E
22	Matt Neilson 4	C2C footprint, 5.2 km from Cape Sanctuary	0.1 ha pond, protected from stock, and fringed with flax and young native plantings. GR: 39º 41.841S, 177º 1.474E
23	Haupouri	C2C footprint, 80 m from Cape Sanctuary	2.8 ha pond, with grazed pasture on all sides

POND OR WETLAND #	NAME	LOCATION	DESCRIPTION
24		removed from sample	
25	Taurapa, Ocean Beach Road	C2C footprint, c. 3.9 km from Cape Sanctuary	2.0 ha dam surrounded by grazed pasture. GR: 39º 43.929S, 176º 59.384E
26		removed from sample	
27	Lake Lopez	C2C footprint, 7.0 km from Cape Sanctuary	9.0 ha natural pond, made larger with excavations and additional impoundment. Fenced from stock and surrounded by mixed age plantings of native and exotic trees. Continuous low-intensity trapping for mammalian predators along lake margin. GR: 39º 43.700S, 176º 56.750E
28	Waimarama River Estuary	C2C footprint, 11.4km from Cape Sanctuary	River estuary of variable size (1ha-3 ha) depending on tide and river conditions, fringed by willows on its western side. GR: 39º 48.623S, 176º 59.589E
29	Snow Stewart wetlands, Okaihau Road	C2C footprint, 11.7 km from Cape Sanctuary	Ephemeral wetlands, > 20 ha following heavy rain, dry after prolonged drought. Grazed by cattle. GR: 39º 48.929S, 176º 57.504E
30		removed from sample	
31	Te Awanga township duck pond	C2C non-treatment, 4.8 km from Cape Sanctuary	0.5 ha natural wetland, on the land side of a small gravel dune. Raupo at the eastern end, specimen willows on the northern side, road and houses on western side. GR: 39º 37.977S, 177º 59.041E
32	Maraetotara River Estuary	C2C non-treatment, 4.6 km from Cape Sanctuary	2.6 ha river estuary, fringed by pasture and specimen willows on its eastern side and a motor-camp on its western side. GR: 39º 38.009S, 176º 59.211E
33	Tuki tuki River mouth backwater, Haumoana side	C2C non-treatment, 9.7 km from Cape Sanctuary	Tidal backwater and wetlands, c. 0.5 ha in total, surrounded by flax and rushes. GR: 39º 36.162S, 176º 56.576E
34	Haumoana township Pond 1	C2C non-treatment, 9.5 km from Cape Sanctuary	Shallow 0.5 ha partly tidal impounded gravel dune wetland, with year-round algae blooms. GR: 39º 36.229S, 176º 56.911E
35	Haumoana township Pond 2	C2C non-treatment, 9.4 km from Cape Sanctuary	1.7 ha brackish pond, inland side of gravel dunes, with large roosting and perching trees at its southern end. GR: 39º 36.398S, 176º 56.966E
36	Tuki tuki River mouth backwater, Clive side	C2C non-treatment, 10 km from Cape Sanctuary	Tuki tuki river estuary and associated backwaters, up to 20 ha in extent at high tide. GR: 39º 35.888S, 176º 56.546E

POND OR WETLAND #	NAME	LOCATION	DESCRIPTION
37	Oxidation Pond, Richmond Road West	C2C non-treatment, 11.7 km from Cape Sanctuary	8.7 ha impounded gravel dune wetland with inflow from adjoining sewage treatment plant. GR: 39º 34.864S, 176º 55.971E
38	Oxidation Pond, West 2	C2C non-treatment, 11.9 km from Cape Sanctuary	Long and narrow 1.5 ha oxidation pond, immediately to the west of Pond # 37. Tidal with extensive areas of rush on its seaward side. GR: 39º 34.563S, 176º 55.762E
39	Oxidation Pond, East of Richmond Road	C2C non-treatment, 11.2 km from Cape Sanctuary	2.2 ha long and narrow oxidation pond, with the same characteristics as Pond 37 GR: 39º 35.344S, 176º 59.320E
40	Oxidation Pond, Richmond Road West	C2C non-treatment, 11.2 km from Cape Sanctuary	Long and narrow 0.5 ha oxidation pond, running down the seaward side of Pond 39. GR: as for Pond 39
41	Tutaekuri River mouth	C2C non-treatment, 14.2 km from Cape Sanctuary	Narrow, tidal 1.2 ha impounded river mouth, fringed with raupo. GR: 39º 33.662S, 176º 55.404E
42	Waitangi Pond 1	C2C non-treatment, 14.2 km from Cape Sanctuary	6.7 ha wetland, with a vegetation-covered island in the middle, on the north bank of the Ngaruroro River. Separated from Pond 43 by a railway line. GR: 39º 33.818S, 176º 55.200E
43	Waitangi Pond 2	C2C non-treatment, 14.2 km from Cape Sanctuary	1.0 ha long, narrow pond, fringed with raupo, willows and other vegetation. Sandwiched between the Napier/Hastings railway line and the Napier/Clive coastal road. GR: 39º 33.841S, 176º 55.313E
44	Arborfield Forest, Pond 1	C2C non-treatment, 21.8 km from Cape Sanctuary	0.6 ha pond with willows and rushes, surrounded by mature exotic forest. GR: 39º 51.012S, 176º 50.782E
45	Arborfield Forest Pond 2	C2C non-treatment, 21.3. km from Cape Sanctuary	1.8 ha pond, with same features as Pond 44. GR: 39º 50.590S, 176º 50.954E
46	Pekapeka Swamp 1	C2C non-treatment, 21.8 km from Cape Sanctuary	0.1 ha patch of open water in a 98 ha raupo-covered wetland alongside SH2. GR: 39º 42.688S, 176º 47.152E
47	Pekapeka Swamp 2	C2C non-treatment, 23.2 km from Cape Sanctuary	2.0 ha patch of open water in raupo swamp, 1.5 km south of Pond # 46. GR: 39º 43.269S, 176º 46.071E

Results

1) *General introduction*

The analyses in Section A and Section B compare the number and relative abundance of forest and wetland birds respectively in the three counting locations relevant to the programme (*Cape Sanctuary*, the *Cape to City* footprint, and the *Cape to City* non-treatment area). These analyses describe the baseline situation, including the degree to which various endangered species are currently dispersing out of *Cape Sanctuary,* before the onset of top predator control in the *Cape to City* footprint.

The analyses in Section C compare the abundance of selected farmland birds and small mammals (predators and rabbits) in the *Cape to City* footprint and the adjoining *Cape to City* non-treatment area, as determined by road counts, prior to the onset of top predator control.

A. Forest bird abundance in *Cape Sanctuary*, the *Cape to City* footprint, and the *Cape to City* non-treatment area.

i) General description of the forest bird communities in the counting areas

In all three counting areas, the forest bird communities comprised a mix of native and introduced species (Table 4). On average, 6 species were recorded in each count - usually about half native and half introduced, representative of the mixed assemblages typically found in rural landscapes throughout the region.

Table 4: *Number of species detected per 5 minute count* ± S.D. *in forested habitats in all three counting areas combined.*

STATISTIC	NATIVE	INTRODUCED	TOTAL
Minimum per count	0	0	0
Maximum per count	10	6	12
Mean per count	3.2±1.73	2.76±1.33	5.97±2.01
Mean percentage	52%	48%	

In each of the three counting areas (*Cape Sanctuary*, the *Cape to City* footprint, and the *Cape to City* non-treatment area) the composition of the avian community (mix of species encountered) and the abundance of individual species (mean number per count) varied with forest type: native bird species were generally most abundant in native forest, while introduced bird species were generally most abundant in exotic (*P. radiata*) forest (Table 5). There were also significant differences between areas within forest types: *Cape Sanctuary* had more native species per count than the *Cape to City* footprint and *Cape to City* non-treatment area, in both forest types. Conversely,

introduced species were slightly more numerous in the *Cape to City* footprint, in both forest types.

ii) Species recorded in counts

A total of 30 species (16 native and 14 introduced) were recorded in forests and a further 9 species (3 native and 6 introduced) were heard calling in nearby farmland or seen flying over forested areas (Table 5). Amongst natives, three insectivores (grey warbler, fantail, silvereye), two honeyeaters (tui and bellbird), one frugivore (kereru), one generalist predator (kingfisher) and one carnivore (harrier) were present in all three counting areas. These are New Zealand's most

Table 5: *Abundance of native and introduced bird species (mean number per count± S.D.) in indigenous and exotic forest in each counting area. Sample sizes shown for 'native' species also apply to the 'introduced' and 'total' categories. F values relate to tests of significance between areas within the same forest type. For example, within the indigenous forest category, native bird species were more abundant in Cape Sanctuary than in the other two counting areas ($F = 12.74$, $p < 0.0001$). ns = not significant.*

SPECIES TYPE	FOREST TYPE	CAPE SANCTUARY		CAPE TO CITY FOOTPRINT		CAPE TO CITY NON TREATMENT		F (ANOVA)
Native	Indigenous	N=96	4.95±1.67	N=133	4.05±1.18	N=40	4.05±1.33	12.74***
	Exotic	N=95	3.62±1.47	N=237	2.54±1.51	N=138	1.81±1.06	47.9***
Introduced	Indigenous	1.94±1.08		2.42±1.39		2.25±1.39		4.03*
	Exotic	2.88±1.22		3.21±1.32		2.92±1.09		3.51*
Total	Indigenous	6.88±2.12		6.48±1.67		6.30±2.20		1.79 ns
	Exotic	6.50±2.05		5.75±1.99		4.74±1.43		26.7***

common and widespread native forest and open-country birds, ubiquitous in most modified landscapes and forest types. Grey warbler and tui were recorded in more than 50% of all counts, and currently appear to be the most widespread and numerous species of native forest bird in the *Cape to City* footprint and its immediate hinterland.

At the other end of the abundance continuum, six of the 16 native forest dwellers (identified with an asterisk in Table 6) were recorded only in or alongside *Cape Sanctuary*, where they have been recently reestablished following decades of absence; all of these species are otherwise rare or absent in lowland Hawkes Bay. The records of rifleman in the *Cape to City* footprint came from forest remnants on the Mareatoara Plateau where a small natural population has survived against the odds. It is the only known population of rifleman in lowland Hawkes Bay, apart from a recently reestablished one in *Cape Sanctuary* (where they were not detected during the counts). Currently,

rifleman easily qualify as the rarest, most taxonomically significant, and 'least expected' native bird inhabitant in the *Cape to City* footprint.

The 14 introduced species recorded in counts (Table 6) were generally more widespread than the native species, with most (78%) detected in all three counting areas. Californian quail and pheasant were not recorded in the *C2C* non-treatment area though they are both known to be present there; and mynas, a near obligate inhabitant of towns, rural settlements and farm buildings, were recorded just once in forests in the counting areas.

iii) Species abundance

Straightforward comparisons of species abundance in each of the three counting locations are confounded by forest type, because the proportion of counts in indigenous and exotic forest varied between the three counting locations (Table 1). The analyses for each species in Tables 7a and 8a are therefore 'controlled' for forest type, so 'like' is compared with 'like'.

The native species separated into two distinct groups; those with a strong preference for indigenous forest, and those with no marked preference for either indigenous or exotic forest (Table 7a & Table 7b). The first group included tomtit, silvereye, rifleman, bellbird, tui, kereru, shining cuckoo, kakariki and saddleback, while the second group included robin, grey warbler, whitehead, fantail, kingfisher, harrier and kaka.

The higher abundance of tui, bellbird, kakariki and kereru in indigenous forest was expected given the scarcity of some of their main foods (nectar and fruit) in pine plantations. Similarly, the widespread distribution of generalist insectivores such as grey warbler and fantail was also expected given that both indigenous and exotic forests satisfy their feeding and nesting requirements. There were, however, some results that were not predictable at the outset, with the notable examples being the differences in habitat preferences of tomtits and robins (congeneric species with apparently similar diets), the lack of a close correlation between the abundance of shining cuckoos and grey warblers, their obligate brood hosts (the warblers in pine forests have fewer cuckoos to contend with) and the apparent lack of habitat preferences amongst kaka at *Cape Sanctuary*, a result that is almost certainly a reflection of the ability of observers to detect their calls from a considerable distance, rather than a reflection of the kaka's actual habitat use.

The results also show that most native species varied significantly in abundance between counting areas, independently of their preference (if any) for a particular forest type. As expected, the six native species (robin, tomtit, whitehead, kaka, kakariki, and saddleback) that were recently released in *Cape Sanctuary* were significantly more abundant in *Cape Sanctuary* than in the other counting locations (Tables 7a & 7b). Bellbirds and harriers were also more abundant in Cape Sanctuary than elsewhere - the only native non-introduced inhabitants of the sanctuary to exhibit this trend.

Table 6: *Native and introduced birds recorded in indigenous and/or exotic forest in the 5-minute counts. The species listed in the last section of the table are 'casuals' that were detected in the counts but are not inhabitants of forests. An asterisk denotes a species that has recently been released in Cape Sanctuary (McLennan, 2013).* ✓ *indicates confirmed detection in the counting area.*

SPECIES	SCIENTIFIC NAME	CAPE SANCTUARY (# COUNTS 195)	C2C FOOTPRINT (# COUNTS 370)	C2C NON TREATMENT (# COUNTS 178)
		Native		
Robin*	*Petroica australis*	✓	✓	
Tomtit*	*P. macrocephala*	✓	✓	
Grey warbler	*Gerygone igata*	✓	✓	✓
Whitehead*	*Mohoua albicilla*	✓	✓	
Fantail	*Rhipidura fuligi-nosa*	✓	✓	✓
Silvereye	*Zosterops lateralis*	✓	✓	✓
Rifleman*	*Acanthisitta chloris*		✓	
Bellbird	*Anthornis melanura*	✓	✓	✓
Tui	*Prosthemadera novaeseelandiae*	✓	✓	✓
Kereru	*Hemiphaga novaeseelandiae*	✓	✓	✓
Kaka*	*Nestor meridionalis*	✓		
Red crowned kakariki*	*Cyanoramphus novaezelandiae*	✓		
Kingfisher	*Halcyon sancta*	✓	✓	✓
Saddleback*	*Philesturnus carunculatus*	✓		
Harrier	*Circus approximans*	✓	✓	✓
Shining cuckoo	*Chrysococcyx lu-cidus*	✓	✓	✓

SPECIES	SCIENTIFIC NAME	CAPE SANCTUARY (# COUNTS 195)	C2C FOOTPRINT (# COUNTS 370)	C2C NON TREATMENT (# COUNTS 178)
		Introduced		
Chaffinch	*Fringilla coelebs*	✓	✓	✓
Greenfinch	*Carduelis chloris*	✓	✓	✓
Goldfinch	*C. carduelis*	✓	✓	✓
House sparrow	*Passer domesticus*	✓	✓	✓
Yellow hammer	*Emberiza citrinella*	✓	✓	✓
Redpoll	*Carduelis flammea*	✓	✓	✓
Hedge sparrow	*Prunella modularis*	✓	✓	✓
Blackbird	*Turdus merula*	✓	✓	✓
Thrush	*T. philomelos*	✓	✓	✓
Magpie	*Gymnorhina tibicen*	✓	✓	✓
Starling	*Sturnus vulgaris*	✓	✓	✓
Myna	*Acridotheres tristis*			✓
Californian quail	*Callipepla californica*	✓	✓	
Pheasant	*Phasianus colchicus*	✓	✓	
		Casuals		
Paradise shelduck	*Tadorna variegata*	✓	✓	✓
Masked lapwing	*Vanellus miles*	✓	✓	✓
Cormorant	*Phalacrocorax carbo*		✓	
Welcome swallow	*Hirundo tahitica*	✓	✓	✓
Turkey	*Meleagris gallopavo*		✓	✓
Peafowl	*Pavo cristatus*		✓	

SPECIES	SCIENTIFIC NAME	CAPE SANCTUARY (# COUNTS 195)	C2C FOOTPRINT (# COUNTS 370)	C2C NON TREATMENT (# COUNTS 178)
Rook	*Corvus frugilegus*		✓	
Skylark	*Alauda arvensis*	✓	✓	✓
Rock pigeon	*Columba livia*	✓	✓	✓

Tui and kereru were significantly more abundant outside of *Cape Sanctuary* than in it, with numbers sometimes exceeding 5 individuals per count in mature forest remnants that have no equivalents in *Cape Sanctuary*. For these two predation-limited species, habitat quality apparently trumps predatory affects from rats and mustelids as a factor determining abundance, at least in places where possums are intensively controlled.

There were fewer significant preferences for a particular forest type amongst the introduced species, and the preferences that were evident were generally towards exotic forest (Table 8a & 8b). Greenfinches, goldfinches and house sparrows were especially numerous in pine plantations in spring when they moved in to breed. Many of the counts at this time were conservative, simply noting the presence of 5+ individuals, when perhaps twice as many birds were calling within listening range. The preference of starlings for indigenous forest - the only introduced species to exhibit it - was also driven by seasonal breeding requirements, with the birds nesting in spring in holes in tree trunks and dead spars, a resource rare in pine plantations.

Most of the introduced territorial species with a year-round presence were equally abundant in both forest types. This group included three ground-feeders that fossick for invertebrates in litter (blackbird, song thrush and hedge sparrow) and one open-country species (magpie) that uses woody vegetation for nesting and perching. Chaffinch was the only introduced territorial species with a consistently higher abundance in exotic forest, a reflection of the importance of pine seed in their omnivorous diet, and their ability to extract it year-round from both litter and cones.

In general, most of the introduced species were equally abundant in all three counting areas (Table 8ab & 8b). Blackbirds and thrushes were less common in *Cape Sanctuary* than elsewhere, as were the finches, but differences between areas were generally small. Pheasants were more abundant in *Cape Sanctuary* than elsewhere, probably because they are released there from time to time.

In summary, the baseline counts show that: 1) most native birds are more abundant in indigenous forest than exotic forest; 2) native forest bird abundance and distribution currently varies between the three counting areas, mainly because of *Cape Sanctuary*, one of the region's biodiversity hotspots; 3) native species richness and abundance in *Cape Sanctuary* is largely a consequence of

the re-introduction and predator-management programmes undertaken there over the past 10 years; 4) current differences in native bird abundance in the C2C footprint and the C2C non-treatment area are generally small and insignificant; 5) introduced birds are generally more common in exotic forests than indigenous forests; 6) most of the finches use exotic forests seasonally for breeding; 7) territorial introduced species are less numerous in *Cape Sanctuary* than elsewhere; and 8) the C2C footprint and C2C non-treatment area currently support similar communities of introduced birds.

These are the starting conditions of the C2C experiment. If top predator control within the C2C footprint makes it safe for occupation by threatened and predation-sensitive native birds, then the avian communities of *Cape Sanctuary* and the C2C footprint should converge over time. In particular, the number of species confined to *Cape Sanctuary* should diminish. Simultaneously, the avian communities of the C2C footprint and non-treatment area should gradually become less similar as threatened species of *Cape Sanctuary* origin settle and establish in the C2C footprint.

iv) Response of forest birds to broadcast calls

In both *Cape Sanctuary* and the C2C footprint, broadcast calls did not increase detection rates of robins, tomtits and whiteheads, even though some individuals responded quickly to them by either calling or approaching. Overall, detection rates in counts preceded by broadcast calls were the same as those in standard 5-minute counts not preceded by broadcast calls (Table 9). This result held in both counting areas where robins, tomtits and whiteheads were present (*Cape Sanctuary* and the C2C footprint).

Although the broadcast calls failed to increase *average detection probabilities* of small, territorial native insectivores, they did increase overall detection rates, simply because they took time to undertake and required observers to remain in the field for longer than they otherwise would have. They increased monitoring effort. Furthermore, the fact that they sometimes elicited approaches was also useful; on one occasion it resulted in the discovery of a small population of robins in the C2C footprint that might have otherwise been missed.

Table 7a: *Mean number per 5-minute count ± S.D. of native birds in indigenous (I) and exotic forest (E) in the three counting areas. Results of significance tests are given in Table 7b.*

SPECIES	CAPE SANCTUARY		C2C FOOTPRINT		C2C NON-TREATMENT	
	I N=96	E N=95	I N=133	E N=237	I N=40	E N=138
Robin	0.44±0.74	0.40±0.88	0	0.04±0.23	0	0
Tomtit	0.35±0.56	0.19±0.42	0	0.02±0.14	0	0
Grey warbler	0.53±0.68	1.12±0.87	1.56±1.18	1.09±1.0	1.5±1.13	1.56±0.99
Whitehead	0.30±0.77	0.16±0.42	0	0.01±0.11	0	0
Fantail	0.50±0.80	0.46±0.78	0.68±0.81	0.77±0.99	1.37±1.41	0.51±0.75
Silvereye	0.75±1.35	0.17±0.43	0.77±1.34	0.43±1.07	0.33±1.02	0.20±0.62
Rifleman	0	0	0.39±0.82	0	0	0
Bellbird	4.34±1.17	1.41±1.53	0.47±0.77	0.22±0.72	0.18±0.45	0.03±0.17
Tui	2.22±2.0	1.19±1.42	3.33±1.35	0.79±1.18	3.12±1.68	0.29±0.54
Kereru	0.33±0.71	0.02±0.14	1.21±1.20	0.10±0.44	1.75±1.82	0.007±0.08
Shining Cuckoo	0.22±0.49	0.03±0.18	0.11±0.35	0.09±0.36	0.43±0.84	0.03±0.21
Kaka	0.12±0.45	0.07±0.36	0	0	0	0
Kakariki	0.44±0.89	0.20±0.52	0	0	0	0
Kingfisher	0.46±0.77	0.21±0.41	0.17±0.51	0.04±0.20	0.43±0.84	0.04±0.21
Harrier	0.21±0.50	0.12±0.38	0.05±0.12	0.06±0.24	0.03±0.16	0.06±0.24

Table 7b: *Summary of results and findings for native birds, analysed by forest type and counting area.*

SPECIES	FOREST TYPE	LOCATION
Robin	Similar abundance in indigenous and exotic forest. $F = 0.102$, $p < 0.750$. (Analysis confined to Cape Sanctuary)	Significant difference between treatment areas. $F = 61.6$, $p < 0.0001$. Most abundant in Cape Sanctuary
Tomtit	More abundant in indigenous forest. $F = 5.26$, $p < 0.02$. (Analysis confined to Cape Sanctuary).	Significant difference between treatment areas. $F = 68.5$, $p < 0.0001$. Most abundant in Cape Sanctuary

SPECIES	FOREST TYPE	LOCATION
Grey warbler	No clear preference for exotic or indigenous forest, with results differing between areas	No significant difference between C2C treatment and non-treatment areas, but abundance in both of these locations higher than in Cape Sanctuary $F = 24.2$, $p < 0.0001$
Whitehead	Similar abundance in indigenous and exotic forest. $F = 2.57$, $p < 0.110$. (Analysis confined to Cape Sanctuary)	Significant difference between treatment areas. $F = 34.3$, $p < 0.0001$. Most abundant in Cape Sanctuary
Fantail	Similar abundance in indigenous and exotic forest in all locations. $F = 0.104$, ns,	Most abundant in the C2C non treatment area. $F = 5.2$, $p < 0.006$.
Silvereye	More abundant in indigenous forest in all areas. $F > 10.0$ in all comparisons; $p < 0.001$.	No significant differences between areas ($F = 1.95$, p = ns; analysis restricted to indigenous forest)
Rifleman	Only recorded in indigenous forest ($F = 63.2$, $P < 0.000$, but known to use exotic forest in Cape Sanctuary.	Only recorded in C2C treatment area ($F = 13.3$, $p < 0.001$)
Bellbird	More abundant in indigenous forest in all areas (F range 18.5 to 222.7; $p < 0001$).	Markedly more common in Cape Sanctuary than elsewhere. $F = 591.7$, $p < 0.0001$).
Tui	Markedly more abundant in indigenous forest in all areas. F range 16.6 to 620.7, $p < 0.0001$).	Less abundant in Cape Sanctuary than in the C2C treatment and non-treatment areas ($F = 12.9$, $p < 0.0001$)
Kereru	Markedly more abundant in indigenous forest in all areas. F range 17.8 to 278.5, $p < 0.0001$).	No significant difference between C2C treatment and non-treatment areas, but abundance in both of these locations higher than in Cape Sanctuary $F = 25.7$, $p < 0.0001$
Shining cuckoo	More abundant in indigenous forest in all areas (F range 9.3 to 12.5; $p < 0.002$).	Small but significant differences between areas. $F = 6.46$; $p < 0.002$
Kaka	Similar abundance in indigenous and exotic forest. $F = 0.46$, $p < 0.450$. (Analysis confined to Cape Sanctuary)	Only recorded in Cape Sanctuary ($F = 14.3$, $p < 0.001$)
Kakariki	More abundant in indigenous forest. $F = 5.04$, $p < 0.026$. (Analysis confined to Cape Sanctuary).	Only recorded in Cape Sanctuary ($F = 51.3$, $p < 0.0001$)

SPECIES	FOREST TYPE	LOCATION
Saddleback	Only recorded in indigenous forest. F = 14.2, P< 0.000.	Only recorded in Cape Sanctuary (F= 16.0, p < 0.001)
Kingfisher	Preference for indigenous forest in Cape Sanctuary (F = 7.74, p< 0.006) but not in other areas ((F =1.19, p< 0.276).	No difference between Cape Sanctuary and C2C non treatment area, but abundance in both of these sites higher than in C2C footprint (F=7.38, p < 0.001)
Harrier	Generally more abundant in indigenous forest than exotic forest (F= 10.67, p < 0.001) though no significant difference at Cape Sanctuary	More numerous at Cape Sanctuary than elsewhere (F =4.64, p < 0.01)

Table 8a: *Mean number per 5-minute count ± S.D. of introduced birds in indigenous (I) and exotic forest (E) in the three counting areas. Results of significance tests are given in Table 8b.*

SPECIES	CAPE SANCTUARY		C2C FOOTPRINT		C2C NON-TREATMENT	
	I N=96	E N=95	I N=133	E N=237	I N=40	E N=138
Chaffinch	0.72±0.87	1.98±1.29	0.89±1.15	2.14±1.46	1.75±2.1	2.60±1.72
Greenfinch	0.87±1.43	1.24±1.41	0.45±0.81	1.91±196	0.18±0.81	1.28±1.84
Goldfinch	0.17±0.52	0.19±0.49	0.30±0.71	0.59±1.10	0.28±0.93	0.38±0.74
House sparrow	0.10±0.45	0.39±1.07	0.06±0.32	0.49±0.1.37	0.18±0.81	0.51±2.64
Yellow hammer	0.05±0.30	0.01±0.10	0	0.08±0.39	0.05±0.32	0
Redpoll	0.01±0.10	0.07±0.33	0.07±0.39	0.02±0.16	0	0.04±0.28
Hedge sparrow	0.07±0.33	0.07±0.44	0.03±0.24	0.07±0.28	0	0.01±0.12
Blackbird	0.38±0.57	0.35±0.63	0.94±1.07	0.56±0.84	0.73±1.06	1.46±1.15
Thrush	0.01±0.10	0.32±0.67	0.23±0.67	0.08±0.32	0.05±0.22	0.18±0.47
Magpie	0.62±0.94	0.90±0.99	1.06±1.21	1.03±1.15	1.00±1.36	0.81±1.24
Starling	0.03±0.23	0.02±0.14	0.11±0.39	0.14±0.49	0.70±1.22	0
Myna	0	0	0	0	0	0.01±0.18
Californian quail	0.03±0.18	0	0.01±0.09	0.01±0.09	0	0
Pheasant	0.02±0.14	0.12±0.32	0	0.05±0.23	0	0

Table 8b: *Summary of significance tests and findings for introduced birds, analysed by forest type and counting area.*

SPECIES	FOREST TYPE	LOCATION
Chaffinch	Markedly more abundant in exotic forest. $F = 136.4$, $p < 0.000$.	Small but significant difference between treatment areas. $F = 5.8$, $p < 0.003$, with lowest numbers in Cape Sanctuary (comparison restricted to exotic forests).
Greenfinch	Markedly more abundant in exotic forest. $F = 69.6$, $p < 0.000$.	Small but significant differences between treatment areas. $F = 7.2$, $p < 0.001$, with highest numbers in the C2C footprint (comparison restricted to exotic forests).
Goldfinch	More numerous in exotic forest $F = 9.88$, $p < 0.002$.	Significant difference between treatment areas $F = 8.76$, $p < 0.0001$. Most numerous in C2C footprint. Comparison restricted to exotic forests
House sparrow	Significantly more abundant in exotic forests in all three counting areas. $F = 11.89$, $p < 0.001$	No significant differences between treatment areas. $F = 0.143$.
Yellow hammer	No significant difference between exotic and indigenous forests. $F = 0.69$	No significant differences between treatment areas. $F = 1.48$.
Redpoll	No significant difference between exotic and indigenous forests. $F = 0.03$	No significant differences between treatment areas. $F = 0.056$
Hedge sparrow	No significant difference between exotic and indigenous forests. $F = 0.328$	No significant differences between treatment areas. $F = 2.39$
Blackbird	No significant difference between exotic and indigenous forests. $F = 0.915$	Markedly more common in C2C footprint and C2C non treatment area than Cape Sanctuary $F = 47.2$, $p < 0.000$).
Thrush	No significant difference between exotic and indigenous forests. $F = 0.819$	Less abundant in Cape Sanctuary than in the C2C treatment and non-treatment areas ($F=5.99$, $p < 0.003$)
Magpie	No significant difference between exotic and indigenous forests. $F = 0.299$	No significant difference between C2C treatment and non-treatment areas, but abundance in both of these locations higher than in Cape Sanctuary $F = 4.42$, $p < 0.0001$

SPECIES	FOREST TYPE	LOCATION
Starling	More abundant in indigenous forest (F = 6.8; p<0.009).	More abundant in the C2C non treatment area. F = 4.31, p < 0.014
Myna	Not analysed because of near zero counts in both forest types.	Not analysed because of zero or near zero counts in all treatment areas
Californian quail	Not analysed because of near zero counts in both forest types.	Not analysed because of zero or near zero counts in all treatment areas
Pheasant	Not analysed because of near zero counts in both forest types.	Scarce in all three treatment areas but significantly more abundant in Cape Sanctuary. F = 6.42, p <0.002

Table 9: *Number of robin, tomtit and whitehead detections at Cape Sanctuary in standard 5-minute counts, and in counts following the broadcasting of robin, tomtit and whitehead calls.*

SPECIES	CAPE SANCTUARY		C2C FOOTPRINT	
	5-min counts N = 191	Broadcast calls N = 96	5-min counts N = 370	Broadcast calls N = 303
Robin	52 (27%)	23 (24%)	7 (2%)	12 (4%)
Tomtit	47 (25%)	17 (18%)	5 (1.4%)	2 (0.6%)
Whitehead	31 (16%)	4 (4%)	3 (1%)	1 (0.3%)

B). Wetland bird abundance in *Cape Sanctuary*, the *Cape to City* footprint, and the *Cape to City* non-treatment area.

i) General description of the wetland bird communities in the treatment areas

A mix of waterfowl, waders and wetland birds were recorded in the counts, most native to New Zealand with Australasian distributions (Table 10). The number of individual birds recorded in a single count varied from 0 to 543, with large wetlands having more birds overall, and more species, than small ones. Wetland complexity (the presence or absence of rushes and other tall vegetation), season (inside or outside the duck shooting season) and sanctuary status (hunting allowed or not allowed) also influenced wetland bird abundance.

Mallard ducks including mallard/grey hybrids were the most numerous species of duck in the counting areas (50% of 2835 ducks recorded) followed by grey teal (21%), Australasian shoveler (11%) and paradise shelduck (8%). 'Pure' grey ducks with no external evidence of mallard

hybridisation were the rarest waterfowl (0.3% of 2835 ducks) behind New Zealand scaup (2%) and pateke (6.9%).

Table 10: *Species recorded in the wetland counts, with a tick indicating presence in the counting area. Gulls (three species) and terns (two species) were not counted, even though they were seen in some areas.*

SPECIES	SCIENTIFIC NAME	CAPE SANCTUARY (# COUNTS 20)	C2C FOOTPRINT (# COUNTS 24)	C2C NON TREATMENT (# COUNTS 47)
		Native		
Brown teal	*Anas aucklandica*	✓	✓	
Grey teal	*Anas gracilis*	✓	✓	✓
Grey duck	*Anas superciliosa*		✓	✓
Paradise duck	*Tadorna variegata*	✓	✓	✓
Australasian shoveler	*Anas rhynchotis*		✓	✓
New Zealand scaup	*Aythya novaeseelandiae*		✓	✓
Pukeko	*Porphyrio prophyrio*	✓	✓	✓
New Zealand dabchick	*Poliocephalus rufopectus*	✓	✓	✓
White faced heron	*Ardea novaehollandiae*	✓	✓	✓
Royal Spoonbill	*Platalea regia*			✓
Little shag	*Phalacrocorax melanoleucos*	✓	✓	✓
Little black shag	*Phalacrocorax sulcirostris*			✓
Black shag	*Phalacrocorax carbo*		✓	✓
Pied Stilt	*Himantopus himantopus*	✓	✓	✓

SPECIES	SCIENTIFIC NAME	CAPE SANCTUARY (# COUNTS 20)	C2C FOOTPRINT (# COUNTS 24)	C2C NON TREATMENT (# COUNTS 47)
Banded dotterel	*Charadrius bicinctus*			✓
Black fronted dotterel	*Charadrius melanops*			✓
New Zealand dotterel	*Charadrius obscurus*			✓
Spur-winged plover	*Vanellus miles*	✓	✓	✓
Variable oystercatcher	*Haematopus unicolor*			✓
		Introduced		
Mallard duck	*Anas platyrhynchos*	✓	✓	✓
Black swan	*Cygnus atratus*	✓	✓	✓
Mute swan	*Cygnus olor*		✓	
Canada goose	*Branta canadensis*		✓	✓
Feral goose	*Anser anser*		✓	✓
Australian coot	*Fulicia atra*		✓	✓

Pukeko, New Zealand dabchick, white-faced heron, little shag, pied stilt, spur-winged plover and black swan were present in all three counting areas and locally common on some wetlands. The dotterels (3 species) and variable oystercatcher were recorded mainly in river estuaries, or on shingle beaches on the seaward side of some coastal ponds. Royal spoonbills were recorded only in large, coastal ponds.

ii) Rare and threatened wetland species

Eight species with a threat classification (Robertson et al. 2012) were recorded and counted in the wetland surveys, and a further three threatened species were seen but not counted. The first group included grey duck (*Nationally Critical*); banded dotterel, New Zealand dotterel and New Zealand dabchick (*Nationally vulnerable*); pateke and variable oystercatcher (*Recovering*); and black shag and little black shag (*Naturally uncommon).* The second group included black-billed gull (*Nationally Critical*); and Caspian tern and red-billed gull (*Nationally vulnerable).* Australasian bittern *(Nationally endangered)* were also present in some of the monitored wetlands but were not detected

during the counts.

For various reasons, only three of the threatened wetland species listed above (pateke, dabchick and black shag) are potentially useful indicators of the success of the C2C predator management programme, with pateke the only certain one. Pateke are currently confined mainly to *Cape Sanctuary*, where they were successfully re-established in 2008/2009 following the release of captive-bred individuals. They are now locally numerous there, on both small and large ponds, with some flocks exceeding 40 individuals (Table 11). A few pairs and individuals were recorded in the C2C footprint, within 3 kilometres of *Cape Sanctuary*, but current rates of settlement within and beyond the footprint appear to be extremely low.

Dabchick are currently present on all large ponds in the three counting areas, with autumn counts sometimes exceeding 20 individuals (Table 11). They degree to which dabchick are predation-limited is not known but it is highly likely Norway rats and stoats prey on their eggs and chicks; their relative abundance in the counting areas might therefore change over time as the C2C predator control programme unfolds. Currently, dabchick abundance (mean per count) does not vary significantly between counting areas ($F = 2.83$, $P = 0.064$).

The usefulness of black shags as indictors of predation intensity is also uncertain, partly because current rates of predation on eggs and chicks are not known, and partly because only one breeding colony is currently present in the counting areas, obviating the opportunity for treatment and non-treatment comparisons. The colony of about 40 nests is in trees on a cliff face in the lower Maraetotara River, at the northern end of the C2C footprint. It was discovered while undertaking bird counts in a neighbouring forest, and is a welcome and significant ecological feature in a landscape that otherwise has few breeding colonies of threatened native birds. A much smaller breeding colony of little shags (non-threatened) is currently in willows in Te Awanga lagoon, in the non-treatment area.

iii) Abundance of common species in the three treatment areas

Simple comparisons of species abundance in each treatment area were confounded by pond size, with the C2C footprint and the C2C non-treatment having more large ponds (> 1.5 ha) than *Cape Sanctuary* (Table 12). Area comparisons involving *Cape Sanctuary* were therefore restricted to ponds < 1.5 ha in size.

In general, the common and wide-ranging species of waterfowl, such as mallard, grey teal and shoveler, were equally plentiful in the C2C footprint and C2C non-treatment areas (Table 13). The only exception was paradise duck, which was significantly more abundant in the footprint than the non-treatment area - a result entirely attributable to the bird's moulting behaviour, and their predilection to congregate in large numbers on Lake Lopez (within the footprint) during the

Table 11: *Pateke and dabchick abundance (total recorded) in the three counting areas, spring 2015 - autumn 2016. N= number of counts. P = proportion of wetlands present. Pateke are currently significantly more abundant in Cape Sanctuary than elsewhere (ANOVA tests on mean number per count, $F = 22.56$, $p < 0.001$).*

SPECIES	CAPE SANCTUARY N = 20		C2C FOOTPRINT N = 24		C2C NON-TREATMENT N = 47	
	Sum	P	Sum	P	Sum	P
Pateke	187	0.90	6	0.12	3	0.06
Dabchick	13	0.40	48	0.23	29	0.29

Table 12: *Number of ponds in each size class in the three counting areas.*

WETLAND SIZE (HA)	CAPE SANCTUARY	C2C FOOTPRINT	C2C NON-TREATMENT
< 0.25	4	7	1
0.251 - 1.50	5	3	8
> 1.5	1	7	8

moulting season. Little shags were most abundant in the coastal oxidation ponds than in the freshwater ponds in the non-treatment area.

Similar results were obtained when the comparisons were restricted to small ponds less than 1.5 ha in size, with few or no differences in the abundance of common waterfowl in *Cape Sanctuary* and the C2C footprint.

To summarize, the baseline wetland counts show: 1) with the exception of paradise shelduck, common waterfowl (including all species hunted in season) are currently equally abundant in all three counting areas when the effect of pond size is controlled; 2) pateke are currently much more abundant in *Cape Sanctuary* than the other counting areas; 3) NZ dabchicks are currently spread more-or less evenly through the three counting areas on large ponds, greater than 0.5 ha in size; and 4) there is a breeding colony of black shags in the Maraetotara River catchment, which may respond to predator control in the C2C footprint. However, any response will be difficult to evaluate because there are no comparable colonies in the non-treatment area.

Table 13: *Baseline abundance (mean per count± S.D) of common species of waterfowl and wetland birds in the C2C footprint and C2C non-treatment areas.*

SPECIES	C2C FOOTPRINT N=24	C2C NON-TREATMENT N=47	SIGNIFICANCE (ANOVA)
Mallard	16.7 ± 35.9	20.1 ± 26.5	F = 0.204, ns
Paradise shelduck	7.58 ± 21.3	0.3 ± 1.0	F = 5.5, p< 0.021
Grey teal	12.8 ± 49.9	5.9 ± 16.9	F = 0.731, ns
Australasian shoveler	3.17 ± 10.1	5.2 ± 17.9	F = 0.272, ns
New Zealand Scaup	2.25 ± 7.79	0.06 ± 0.32	F = 3.74, 0.057
Black swan	7.90 ± 21.5	8.0 ± 23.3	F = 0.0, ns
Little shag	0.08 ± 0.28	1.5 ± 2.5	F = 8.17, 0.006

C). Mammal, game bird and selected open-country bird abundance in the *Cape to City* footprint and the *Cape to City* non-treatment area.

i) Mammals

Small mammals were seen much less often than birds during the road counts through farmland. Rabbits were seen most often (Table 14) followed by hares and possums (as road kills). Even so, all of these animals were encountered at a rate of less than one individual per 10 kilometres. Predators were even rarer still: cats were seen on just 8 occasions (5 alive, 3 road kills), stoats just once, and ferrets and weasels on no occasions. Mammal abundance did not differ significantly between the C2C footprint and the C2C non treatment area, with rabbits in particular being recorded in almost identical numbers in each counting area.

ii) Game birds, waterfowl and selected open country birds

The results for game birds (pheasant and Californian quail) and waterfowl were similar to those of mammals with relatively low counts overall, and no significant differences in abundance between treatment areas (Table 15). Most of the waterfowl in Table 15, regardless of species, were either standing in paddocks or alongside small ponds. Bird species frequently regarded as pests (feral goose, feral turkey, magpie, and pukeko) were relatively common and widespread, with magpie having the dubious distinction of being the most numerous pest species (and the most frequent roadkill) in both counting areas. Pukeko was significantly more numerous in the footprint than the non treatment area. Harriers were equally abundant in both treatment areas, matching the distribution of roadkills (which they frequently scavenge) and the distribution of rabbits (which they frequently hunt).

Table 14: *Small mammal abundance in the C2C footprint and C2C non-treatment area, as measured in early morning road counts through farmland.*

SPECIES & STATUS	C2C FOOTPRINT (N = 48)		C2C NON-TREATMENT (N = 56)		ANOVA
	Mean ± SD	Total for all counts	Mean ± SD	Total for all counts	Significance
Rabbit (alive)	1.42 ± 2.35	68	1.49 ± 2.50	73	F = 0.02, ns
Rabbit (road kill)	0.25 ± 0.53	12	0.22 ± 0.69	11	F = 0.04, ns
Hare (alive)	0.60 ± 1.72	29	0.18 ± 0.44	9	F = 2.73, ns
Hare (road kill)	0	0	0.02 ± 0.14	1	F = 0.01, ns
Possum (road kill)	0.21 ± 0.58	10	0.10 ± 0.37	5	F = 1.16, ns
Stoat (alive)	0.021 ± 0.14	1	0	0	ns
Stoat (road kill)	0	0	0	0	-
Cat (alive)	0.104 ± 0.371	5	0	0	F = 3.85, p= 0.052
Cat (road kill)	0.021 ± 0.14	1	0.041 ± 0.20	2	ns
Hedgehog (alive)	0	0	0.02 ± 0.14	1	ns
Hedgehog (road kill)	0.063 ± 0.245	3	0.18 ± 0.44	9	F = 2.78, ns

To summarise, the baseline road counts tell a consistent story - the C2C footprint and non-treatment area currently have similar populations of open-country birds and mammals. The counts also show that the current sampling intensity is not sufficient to detect population changes of rare predators, at least over the short term.

Table 15: *Abundance of game birds and selected open-country species in farmland in the C2C footprint and C2C non-treatment areas.*

SPECIES	C2C FOOTPRINT (N = 48)		C2C NON-TREATMENT (N = 49)		ANOVA
	Mean ± SD	Total for all counts	Mean ± SD	Total for all counts	Significance
Californian quail	2.2 ± 6.0	106	0.78 ± 1.61	38	F = 2.57, ns
Pheasant	0.56 ± 1.58	25	0.31 ± 0.68	15	F = 1.08, ns
Duck (mainly mallard)	2.04 ± 4.72	78	1.20 ± 3.43	59	F = 2.73, ns
Paradise shelduck	1.50 ± 2.39	72	2.79 ± 5.0	137	F = 2.66, ns
Magpie	4.21 ± 3.97	203	4.92± 5.90	241	F = 0.44, ns
Pukeko	2.85 ± 6.04	137	0.18 ± 0.61	9	F = 9.5, p = 0.003
Feral Goose	0.58 ± 3.18	28	1.90 ± 7.54	93	F = 1.24, ns
Feral Turkey	3.14 ± 6.32	151	1.18 ± 2.9	58	F = 3.87, p= 0.052
Harrier	0.33 ± 0.63	16	0.650 ± 1.13	32	F = 2.95, ns
Spur wing plover	2.19 ± 4.13	105	1.14 ± 2.47	56	F = 2.29, ns

Discussion

The bird and small mammal monitoring programme in late 2015 and early 2016 achieved its primary aim. It quantified the current differences in species abundance and species richness in the three treatment areas, before the onset of top predator control in the C2C footprint. It confirmed *Cape Sanctuary* as a hotspot for native birds, and it confirmed that the C2C footprint and the C2C non-treatment area currently support similar communities and numbers of birds and small mammals.

The counts in woody vegetation showed that native birds were most abundant in native forests and introduced birds were most abundant in exotic forests. Exotic forests managed for clear-wood production, with wide spacings between trees, were largely devoid of native species except for a few canopy-feeding generalists (greywarbler, fantail and silvereye); 'clear-wood' plantations currently predominate in the three treatment areas. Dense stands of *P. radiata*, with a ground cover of litter rather than grass and blackberry, provided habitat for a wider range of native insectivores,

including robin, tomtit and whitehead, indicating that such forests could be used to create additional habitat for these species in rural landscapes if they were planted and managed for this purpose.

The variation in habitat quality evident in exotic forests was also evident in native forests, with the predominately young kanuka dominated native forests in *Cape Sanctuary* having fewer nectar and fruit-eating species of birds than the old-growth forests in the footprint and non-treatment areas. The monitoring programme highlighted the importance of all types of native vegetation for native species, including small and thin strands of roadside vegetation, used periodically by both insectivores and fruit eating species.

An important feature of the C2C footprint and C2C non-treatment area is their general lack of woody vegetation, both indigenous and exotic. The largest patches of vegetation in both areas are currently plantations of *P. radiata*, all due for harvest in the next 1-5 years. The counts indicate their removal will mainly affect introduced birds rather than native ones, but the losses of these forests will further reduce forest cover in a landscape that already has little of it. The proposed indigenous plantings within the footprint over the next 5-10 years, mainly along the banks of the Maraetotara River, will not be sufficient to offset the removal of mature exotic plantations, but will provide much-needed additional habitat for native birds.

The degree to which threatened native birds of *Cape Sanctuary* origin colonise the C2C footprint following the onset of top-predator control will ultimately be determined by four factors: 1) the success of the predator control programme; 2) the quantity and quality of habitats available for occupation within the footprint itself, 3) the ability and propensity of individual species to disperse over open farmland from *Cape Sanctuary* to isolated patches of forest within the C2C footprint, and 4) the extent to which the sanctuary generates a supply of potential colonists for the C2C footprint. The expectation and underlying premise of the *Cape to City* programme is that threatened species of *Cape Sanctuary* origin will become more numerous in the footprint over time if predator numbers within the footprint are reduced to levels that allow threatened species to survive. In other words, the expectation of colonisation is based largely on the first of the four factors listed above, rather than the combination of all of them.

Does the failure to recognise the other factors matter? The answer is no for some species and yes for others. Pateke will undoubtedly become more numerous in the C2C footprint when predators are reduced to acceptable levels. Ponds and wetlands suitable for pateke occupation are plentiful and widely distributed in the footprint, the ducks fly over open farmland, and *Cape Sanctuary* is already producing a steady stream of dispersers that are attempting to establish elsewhere. Pateke 'tick all boxes' and are likely to be the best avian indicator of the success of the C2C programme. Red-crowned kakariki are in the same category, though their use of the footprint may be seasonal. They too are already visiting the C2C footprint, with recent reports from as far afield as the Maraetotara Plateau. Kakariki are also likely to feed in urban gardens, potentially making them the most noticeable and most reported of *Cape Sanctuary's* avian exports.

The successful establishment of the other threatened species in the footprint is less certain, at least in the immediate future. Kaka and saddleback are currently establishing in *Cape Sanctuary* and are unlikely to produce 'surplus dispersers' for at least 5 years. The small insectivores (robin, tomtit and whitehead) are producing dispersers, but it is uncertain if there is sufficient suitable habitat at the northern end of the footprint to allow them to establish viable populations there. Some 4-5 pairs of robins have already colonised a small kanuka-filled gully in the northern footprint, but they have now filled it up, and there is no room for population increases. A single robin (and a tomtit) was also seen recently in a ribbon of native forest in Te Mata Park on the outskirts of Havelock North.

The habitat restrictions are much less severe at the southern end of footprint in the old growth forests on the Maraetotara Plateau. Robin and tomtit from other parts of Hawkes Bay were translocated to these forests in the winter of 2016, to begin the process of population establishment there, and it is highly likely that these founders will be joined later by dispersers from *Cape Sanctuary*. The small insectivores are therefore likely to eventually have a patchy distribution in the C2C footprint, with small, confined populations at the northern end and larger, more expansive populations, at the southern end. The exotic forests in the middle of the footprint could have a valuable role as stepping stones, ensuring robin, tomtit and whitehead genes travel at least occasionally from one end of the footprint to the other.

In most years, the dispersers out of *Cape Sanctuary* will include non-threatened species as well as threatened ones. Some of the kereru and tui produced in the sanctuary will inevitably travel further afield, visiting forest patches within the footprint to both feed and breed. The outflow of bellbirds from the sanctuary is probably already substantial, with the sanctuary the likely origin of most of the individuals detected in neighbouring areas. One likely consequence of successful pest control in the C2C footprint is that it will reduce and then perhaps eliminate altogether the substantial difference in bellbird abundance that exists now between the sanctuary and the other treatment ares.

To summarise, a successful C2C programme would produce the following outcomes for native birds in the C2C footprint: a marked increase in the abundance and distribution of pateke and kakariki; viable populations of robins, tomtits and whiteheads in suitable habitats; an overall increase in the abundance of kereru, tui, and bellbirds; and increased breeding success of various species (rifleman included) already resident in the old growth forests on the Maraetotara Plateau. These outcomes would profoundly change the avian community in the footprint, increasing both native species dominance and levels of endemism. Liberations of kiwi and whio in the footprint, proposed for 2018, will further boost these already significant biodiversity gains.

From a human and landowner perspective, the expected changes in the native bird community in the footprint will be noticeable, welcome and (for some) enriching. The sightings of robin and tomtit in Te Mata Park have generated excitement and hinted at what is yet to come. Some positive and welcome population increases may also be evident amongst introduced birds, with quail and pheasant the top contenders. Positive population changes amongst introduced waterfowl will be

more difficult to detect, given that mallards and shovelers range widely, quickly equalizing any local increases that predator control in the footprint might produce. Lastly, the counts will also show whether rabbits increase following the removal of top predators, a concern for some landowners, both within and beyond the footprint.

The next 5-years of monitoring promise to be informative and interesting.

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