0029-4470

The bird community of Kaitoke wetland, Great Barrier Island

SANDRA H. ANDERSON
School of Geography and Environmental Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand. *sh.anderson@auckland.ac.nz*

JOHN OGDEN
School of Geography and Environmental Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand.

Abstract A quantitative survey of the bird community of Kaitoke wetland, Great Barrier Is., New Zealand between May 1998 and July 2000 using 5-minute counts recorded 33 species, most of which occurred in less than 10% of counts. The commonest species were North Island fernbird *(Bowdleria punctata)*, fantail *(Rhipidura fuliginosa)*, silvereye *(Zosterops lateralis)*, grey warbler *(Gerygone igata)*, welcome swallow *(Hirundo neoxena)* and (collectively) the exotic finches, yellowhammer *(Emberiza citrinella)*, chaffinch *(Fringilla coelebs)* and goldfinch *(Carduelis carduelis)*. Native wetland species also recorded were spotless crake *(Porzana tabuensis)*, banded rail *(Rallus phillipensis)*, Australasian bittern *(Botaurus poiciloptilus)*, pukeko *(Porphyrio melanotus)* and Australasian harrier *(Circus approximans)*. Distributional analysis of the commonest species (those occurring in more than 10% of counts) showed most had some association with a particular vegetation type(s), while few showed any change in conspicuousness with season. There was little apparent movement of birds associated with phenology of the main wetland plant species. The significance of Kaitoke wetland in providing habitat for a range of native wetland bird species is recognised. The current threat to this ecosystem from introduced pests and development pressure, and the paucity of data available on native wetland bird species to inform conservation management, is discussed.

Anderson, S.; Ogden, J. 2003. The bird community of Kaitoke wetland, Great Barrier Island. *Notornis 50(4)*: 201-209.

Keywords abundance; bird; distribution; season; vegetation; wetland; Great Barrier Island

INTRODUCTION

Extensive drainage of low-lying swamplands for agricultural use since European colonisation of New Zealand has led to the widespread loss of wetland ecosystems and the communities associated with them (Anon. 2000). Introduction of mammalian predators has also impacted on native bird populations, especially ground-dwelling and flightless species (King 1984; Holdaway 1989; Holdaway *et al.* 2001). Human-induced changes in abundance of native avian predators, such as the Australasian harrier, may be further pressuring bird populations (Pierce & Maloney 1989; Sanders & Maloney 2002). Consequently most of the native bird species associated with wetland habitats are now at least regionally rare (Molloy & Davis 1994; Ballie & Groombridge 1996; Heather & Robertson 1997), and their cryptic nature ensures that their status remains uncertain. Reliable assessment of the abundance of these species and their habitat requirements is critical to the conservation of wetland ecosystems.

Received 20 January 2002; accepted 25 August 2003

The objective of the study was to provide information on the status and dynamics of the bird community of Kaitoke wetland, and was one aspect of a larger study which included description of current vegetation associations of the wetland (Rutherford 1998), assessment of primary productivity and nutrient turnover (Pegman 1999), and analysis of pollen records from cores of the swamp in relation to past and current landscape change (Horrocks *et al.* 1999). A wildlife survey on Great Barrier Is. in 1980 (Ogle 1980) reported the persistence, among other native birds, of the wetland species Australasian bittern *(Botaurus poiciloptilus)*, banded rail *(Rallus phillipensis)*, spotless crake *(Porzana tabuensis)*, and North Island fernbird *(Bowdleria punctata)* at Kaitoke, and the current status of these birds was of particular interest.

Few studies have been made of bird communities in New Zealand wetlands, and there is little quantitative information on their composition. There is also little understanding of seasonal and habitat use patterns by bird species within swamp systems. The available literature tends to either suggest particular associations between bird species and certain plant communities (Kaufmann

1987; Elliot 1989), or a variable response by bird species to habitat depending on other factors such as predation (Onley 1982; Harris 1987). A better understanding of these associations would aid conservation management by improving our ability to assess wetland bird populations reliably, and identify particular habitat requirements. To address this gap, the study sought to identify bird species utilising Kaitoke wetland, and obtain a numerical index of each species related to their conspicuousness and abundance. The study also attempted to detect whether there was an association between any species and a particular vegetation type, and assess whether there was any seasonal change in the conspicuousness of species which could be explained by seasonal change in vegetation phenology. The findings are considered in light of management issues facing the Kaitoke bird community and its wetland habitat.

STUDY AREA AND METHODS

Kaitoke wetland covers approximately 320 hectares and drains northeast to the sea near the township of Claris (Fig. 1). A study of the vegetation communities of the wetland (Rutherford 1998) was used to identify seven broad vegetation types present, and these are described briefly in order of decreasing water level:

1. Deep water: raupo *(Typha orientalis)* and/or *Eleocharis sphacelata* association.
2. Open sedgeland: extensive *Baumea juncea* dominated community.
3. Gleichenia stands: umbrella fern *(Gleichenia dicarpa)* dominated sedge community.
4. Saltmarsh: estuarine community characterised by marsh ribbonwood *(Plagianthus divaricatus)* and oioi *(Leptocarpus similis)*.
5. Cabbage tree/flax community: permanent shallow water with cabbage tree *(Cordyline australis)* and/or flax *(Phormium tenax)* over sedge.
6. Wet meadow: drained swamp community bordering the saltmarsh, comprising rank exotic grasses and scattered manuka *(Leptospermum scoparium)*.
7. Dry manuka forest: regenerating gumland community dominated by *Leptospermum scoparium* with an understorey of *Gleichenia dicarpa*.

Two replicate series of points (A1-7 and B1-7) were selected, which represented each vegetation community twice (Fig. 1). At each point, a 5-minute count of all birds seen or heard within 50 m radius was made. The points were at least 150 m apart. Presence/absence of birds outside the 50 m range was noted. Presence of bird species on the lower tidal arm of the Kaitoke stream draining the wetland was also recorded from a vantage point en route from Kaitoke to Awana (see Fig. 1).

The stationary point-count method requires a single recorder familiar with birdcalls, as most identifications are based on sound. The method has been widely used in New Zealand (Clout & Gaze 1984; Gill 1989; Murphy & Kelly 2003) for surveys and to monitor population trends. Although transect methods may also be used to survey freshwater wetlands, these were not considered appropriate because the difficulty of the terrain and the cryptic nature of the resident bird species meant the likelihood of detection while traversing the wetland was low.

Playback lures were used during the survey to detect the presence of Australasian bittern, spotless crake and marsh crake *(Porzana pusilla)*, since these species are neither highly visible nor vocal. At each station, playback was limited to the species likely to be found in that habitat according to available literature, as per Ogle (1980) and Ogle & Cheyne (1981). The bittern lure was played at both meadow stations (6), since the only sighting of bittern previously had been in this area. The spotless crake lure was played at all freshwater stations (1,2,3,5 and 7) but not at the saltmarsh and meadow points. The marsh crake lure was played at the saltmarsh and deepwater stations (4 and 1) after a call resembling a marsh crake was heard at these points. Although this method required a degree of presumption, it was considered the only reasonable means of avoiding the repetitive and time-consuming use of playback for all species at every station.

A point series was covered each dawn (start time 10 mins before sunrise) and dusk (finish time 10 mins after sunrise), and each point series was replicated three times during each visit to the island. Series A took 130 minutes to complete, while series B took 90 minutes. For each replicate the time of day (dawn/dusk) was alternated, and the order of the stations with respect to sunrise/sunset was reversed. Visits were made in January (summer), April/May (autumn), July (winter), and September/October (spring) in order to detect any seasonality in the counts. The survey was conducted over 26 months, from May 1998-July 2000, allowing 2 visits for each season.

The five-minute count method does not provide a numerical population estimate, but gives a readily obtainable and comparable index for each species (mean number per 5-minute count) related to conspicuousness and abundance. The proportion of counts in which a species was detected was also calculated to provide a relative probability of detection. For species with a probability of detection greater than 10%, the mean number for each counting station in each season was square root transformed, and the results analysed using 2-way ANOVA, with 2 between-

Table 1. Bird species (native*) recorded in association with the Kaitoke swamp, in order of relative abundance ($X \pm$ s.e.) and probability of detection (%) per 5-min count, $n = 333$

Bird species recorded	Abundance	Probability of detection
Fernbird *(Bowdleria punctata)**	1.89 ± 0.12	59
Silvereye *(Zosterops lateralis)**	0.80 ± 0.08	32
Fantail *(Rhipidura fuliginosa)**	0.47 ± 0.04	35
Grey warbler *(Gerygone igata)**	0.37 ± 0.04	29
Welcome swallow *(Hirundo neoxena)**	0.33 ± 0.05	17
Yellowhammer *(Emberiza citrinella)*	0.14 ± 0.04	7
Chaffinch *(Fringilla coelebs)*	0.09 ± 0.02	6
Pukeko *(Porphyrio melanotus)**	0.09 ± 0.02	7
Blackbird *(Turdus merula)*	0.08 ± 0.02	6
Kingfisher *(Halycon sancta)**	0.06 ± 0.02	4
Kaka *(Nestor meridionalis)**	0.06 ± 0.01	5
Spotless crake *(Porzana tabuensis)**	0.06 ± 0.02	4
Banded rail *(Rallus phillipensis)**	0.04 ± 0.01	2
Pipit *(Anthus novaeseelandiae)**	0.04 ± 0.01	2
Thrush *(Turdus philmelos)*	0.03 ± 0.01	3
Australasian harrier *(Circus approximans)**	0.03 ± 0.01	2
Goldfinch *(Carduelis carduelis)*	0.02 ± 0.01	2
Dunnock *(Prunella modularis)*	0.02 ± 0.01	2
Tui *(Prosthemadera novaeseelandiae)**	0.02 ± 0.01	2
Skylark *(Alauda arvensis)*	0.02 ± 0.01	1
Pied shag *(Phalacorax varius)**	0.01 ± 0.01	1
House sparrow *(Passer domesticus)*	0.01 ± 0.01	<1
White faced heron *(Ardea novaehollandiae)**	0.01 ± 0.01	<1
Australasian bittern *(Botaurus poiciloptilus)**	<0.01	<1
Kereru *(Hemiphaga novaeseelandiae)**	<0.01	<1
Magpie *(Gymnorhina hypoleuca)*	<0.01	<1
Morepork *(Ninox novaeseelandiae)**	<0.01	<1
Indian myna *(Acridotheres tristis)*	<0.01	<1
Mallard *(Anas platyrhynchos)*		
Little black shag *(Phalacrocorax sulcirostris)**		
Greenfinch *(Carduelis chloris)*		
Starling *(Sturnus vulgaris)*		
Spur-winged Plover *(Vanellus miles novaehollandiae)**		

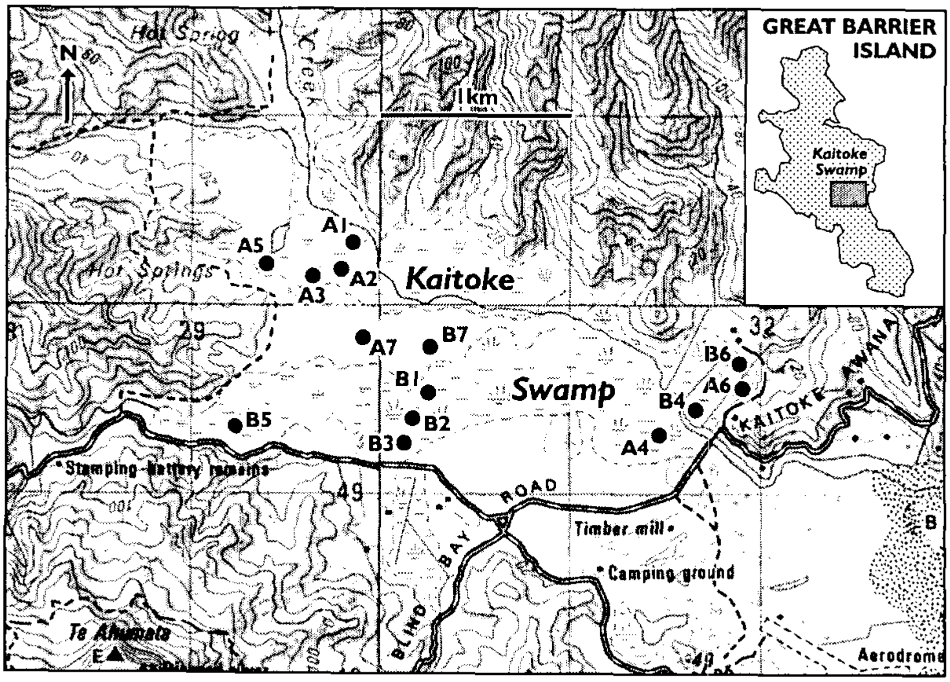

Fig. 1. Map of the Kaitoke Swamp showing roads (double line), track (dashed line), and series of point counts (A1-7 and B1-7) representing each vegetation type twice.

Table 2. Two-way ANOVA results (F, *P*) by bird species for vegetation and season (*n* = 56), * = *P* <0.05, ** = *P* <0.01, *** = *P* <0.005, ns = not significant.

Factor (df)	Species					
	N.I. Fernbird	Grey warbler	Finch	Silvereye	N.I Fantail	Welcome swallow
Vegetation (6)	6.51***	10.37***	3.15*	4.26**	4.68**	1.86 (ns)
Season (3)	1.75 (ns)	9.27***	0.73 (ns)	10.88***	1.28 (ns)	0.27 (ns)
Vegetation*Season (18)	0.60 (ns)	0.55 (ns)	1.16 (ns)	0.84 (ns)	0.59 (ns)	0.73 (ns)

Table 3. Mean numbers ± s.e. of common bird species for each vegetation type, *n* = 8 (Tukey's HSD, *P*<0.05, letters indicate groupings).

	N.I. Fernbird	Grey warbler	Finch	Silvereye	N.I. Fantail	Welcome swallow
Deep water	1.6 ± 0.3 (a)	0.2 ± 0.1 (c)	0.8 ± 0.2 (ab)	1.0 ± 0.3 (ab)	0.3 ± 0.1 (ab)	0.2 ± 0.1 (a)
Baumea juncea	3.6 ± 0.7 (a)	0.1 ± 0.1 (c)	0.4 ± 0.2 (ab)	0.5 ± 0.2 (ab)	0.2 ± 0.1 (b)	0.4 ± 0.1 (a)
Gleichenia dicarpa	2.7 ± 0.5 (a)	0.3 ± 0.1 (bc)	0.5 ± 0.1 (ab)	0.4 ± 0.2 (b)	0.3 ± 0.1 (b)	0.8 ± 0.2 (a)
Cabbage tree/flax	2.0 ± 0.7 (a)	0.3 ± 0.1 (bc)	0.1 ± 0 (b)	0.9 ± 0.1 (ab)	0.6 ± 0.1 (ab)	0.8 ± 0.6 (a)
Saltmarsh	2.0 ± 0.3 (a)	0.1 ± 0.1 (c)	0.3 ± 0.1 (ab)	0.3 ± 0.1 (b)	0.3 ± 0.2 (b)	0.4 ± 0.2 (a)
Manuka forest	1.4 ± 0.3 (ab)	0.9 ± 0.1 (a)	0.9 ± 0.2 (a)	1.4 ± 0.3 (a)	0.7 ± 0.1 (ab)	0.1 ± 0 (a)
Wet meadow	0.3 ± 0.1 (b)	0.7 ± 0.1 (ab)	0.5 ± 0.2 (ab)	1.1 ± 0.3 (ab)	0.9 ± 0.2 (a)	0 ± 0 (a)

groups factors (vegetation and season). The null hypotheses were that, for a given bird species their number would be the same a) in each vegetation type, and b) at each season. Species with a probability of detection less than 10% were not included in the analysis to avoid establishing an association that might occur randomly. Bird species encountered at the swamp but outside the survey limitations (ie. at further than 50 m radius, or observed only from the road vantage point) were listed without a numerical estimate.

Key plant species representative of each vegetation type were identified, and at each visit a general appraisal of the main phenology (flower or seed/fruit) of each species was made.

RESULTS

Thirty-three bird species were recorded as present in association with the wetland during the survey (Table 1). Twenty-eight of these were recorded during the point counts, but most (82%) had a relative probability of detection less than 10%. There was a higher proportion of native to exotic bird species (1.5:1), and native birds were considerably more numerous than exotic birds (10:1). The commonest species recorded at the swamp were North Island fernbird, silvereye *(Zosterops lateralis)*, grey warbler *(Gerygone igata)*, welcome swallow *(Hirundo neoxena)*, North Island fantail *(Rhipidura fuliginosa)* and exotic finches, especially yellowhammer *(Emberiza citrinella)*. These were the only species that occurred in sufficient numbers (probability of detection >10%) to allow analysis by vegetation type and season.

All of the common species except welcome swallow showed some effect of vegetation type on their abundance (Table 2). Fernbird numbers were significantly higher in the wetter vegetation types, where there was a low, dense understorey of sedge or *G. dicarpa* (1-5), than in the drained meadow community where an understorey was lacking (Table 3). Grey warblers, finches and silvereyes all tended to higher numbers in the manuka forest. Fantails were significantly more abundant in the meadow community than in the low vegetation of the *B. juncea*, *G. dicarpa* and saltmarsh communities.

Silvereye and grey warbler were the only species that showed a seasonal effect on their abundance (Table 2). Silvereye numbers were significantly higher in summer/autumn than winter (Table 4). The pattern for grey warbler was the reverse, with numbers significantly higher in winter/spring than in summer/autumn.

The interaction between season and vegetation type was non-significant for all bird species analysed (Table 2).

The native wetland species spotless crake, banded rail, bittern, pukeko *(Porphyrio porphyrio)* and Australasian harrier *(Circus approximans)* had a relatively low probability of detection (<10%) and were not included in the analysis. However because of their particular interest, the mean number for each counting station in each season was calculated, and an overall mean obtained for each vegetation type (Table 5) and each season (Table 6) to highlight any obvious trends in distribution or temporal conspicuousness. Spotless crake were recorded in low numbers throughout much of the swamp, but were most consistently

Table 4. Mean numbers ± s.e. of common bird species for each season, n = 14 (Tukey's HSD, $P<0.05$, letters indicate groupings).

	N.I. fernbird	Grey warbler	Finch	Silvereye	N.I. fantail	Welcome swallow
Summer	2.76 ± 0.50 (a)	0.23 ± 0.08 (b)	0.45 ± 0.14 (a)	1.36 ± 0.26 (a)	0.29 ± 0.05 (a)	0.46 ± 0.17 (a)
Autumn	1.24 ± 0.21 (a)	0.24 ± 0.10 (b)	0.43 ± 0.12 (a)	0.99 ± 0.14 (ab)	0.46 ± 0.12 (a)	0.29 ± 0.10 (a)
Winter	1.69 ± 0.32 (a)	0.49 ± 0.10 (a)	0.38 ± 0.11 (a)	0.31 ± 0.10 (c)	0.61 ± 0.13 (a)	0.44 ± 0.33 (a)
Spring	2.05 ± 0.50 (a)	0.51 ± 0.11 (a)	0.70 ± 0.15 (a)	0.54 ± 0.12 (bc)	0.52 ± 0.09 (a)	0.35 ± 0.10 (a)

Table 5 Mean numbers ± s.e. of native wetland bird species for each vegetation type, n = 8.

	Spotless crake	Banded rail	Pukeko	Australasian harrier	Australasian bittern
Deep water	0 ± 0	0 ± 0	0.02 ± 0.02	0.02 ± 0.02	0 ± 0
Baumea juncea	0.04 ± 0.03	0 ± 0	0.04 ± 0.04	0.06 ± 0.04	0 ± 0
Gleichenia dicarpa	0.02 ± 0.02	0 ± 0	0.1 ± 0.05	0.01 ± 0.01	0 ± 0
Cabbage tree/flax	0.25 ± 0.1	0 ± 0	0.15 ± 0.1	0 ± 0	0 ± 0
Saltmarsh	0 ± 0	0.02 ± 0.02	0.04 ± 0.04	0 ± 0	0 ± 0
Manuka forest	0.06 ± 0.06	0 ± 0	0.02 ± 0.02	0 ± 0	0 ± 0
Wet meadow	0 ± 0	0.21 ± 0.11	0.08 ± 0.05	0.05 ± 0.03	0.02 ± 0.02

Table 6 Mean numbers ± s.e. of native wetland bird species for each season, n = 14.

	Spotless crake	Banded rail	Pukeko	Australasian harrier	Australasian bittern
Summer	0.12 ± 0.06	0.00 ± 0.00	0.12 ± 0.06	0.00 ± 0.00	0.00 ± 0.00
Autumn	0.05 ± 0.03	0.00 ± 0.00	0.04 ± 0.03	0.01 ± 0.01	0.01 ± 0.01
Winter	0.02 ± 0.02	0.06 ± 0.04	0.01 ± 0.01	0.06 ± 0.03	0.00 ± 0.00
Spring	0.05 ± 0.05	0.07 ± 0.06	0.10 ± 0.04	0.00 ± 0.00	0.00 ± 0.00

encountered in the permanently shallow freshwater flax and sedge community of the upper swamp, and appeared to be more vocal in summer. Banded rail were recorded during the counts only in the estuarine saltmarsh and wet meadow vegetation of the lower wetland, and showed little overlap with spotless crake. Banded rail were also observed outside the counts at the mangrove edge of inlets, and in areas close to human activity such as road edges, lawns, and the natural hot springs in the upper reaches of the Kaitoke wetland, and were more conspicuous in winter and spring. A bittern was recorded once in autumn taking flight from the wet meadow in the lower reaches of the swamp, where one had been sighted previous to the survey in 1997 (J. Rutherford pers. comm.). A bittern, possibly the same individual, was also observed outside the counts feeding in the flooded raupo vegetation of the swamp opposite the police station at Claris 300 m distant. Pukeko occurred throughout the swamp, but were usually recorded at sites within 100 m of grass or road verges, and appeared more active over spring and summer. There is a possibility that pukeko may have been overestimated (and spotless crake underestimated) due to confusion with spotless crake of the softer calls in some instances. Australasian harriers were recorded over the open vegetation of the meadow as well as the central swamp, particularly during the winter. A harrier was also observed outside the counts roosting on a bed of dense *Baumea* and raupo vegetation at the Claris swamp.

Up to four brown teal *(Anas chlorotis)* were regularly recorded in the lower Kaitoke stream, and a pair was observed with ducklings in spring. Little black shags *(Phalacrocorax sulcirostris)* and pied shags *(Phalacrocorax varius)*, mallard *(Anas platyrhynchos)*, white-faced herons *(Ardea novaehollandiae)* and banded rail also frequented this area (Table 1).

Seasonal phenology appeared to differ between vegetation types (Table 7). The earliest season was in the drier shrubland, where most manuka flower occurred in the colder months, and seed during spring/summer. In the saltmarsh, sedgeland and shallow freshwater vegetation the flowering season for most species shifted to spring and seeding to summer. The season was latest in the deep-water vegetation, where most flowering occurred in summer and seed in autumn.

DISCUSSION

The majority of birds recorded at Kaitoke were either species with broad habitat ranges that also utilised the swamp, or wetland species persisting

Table 7 Phenology (flower, F, or seed/fruit, S) of wetland plant species representative of each vegetation type.

		Season			
Vegetation	Species	spring	summer	autumn	winter
Manuka shrubland	*L. scoparium*		S	F	F
Saltmarsh	*L. similis*	F S			F
	P. divaricatus	F	S		
Sedgeland	*B. rubiginosa*	F	S		F
	B. teritafolia	F	S		
	B. juncea		F	S	S
Shallow freshwater	*C. australis*	F	S		
	P. tenax	F	S		
	C. robusta	F	S	S	
Deep water	*B. articulata*	F	F	S	
	T. orientalis		F	S	
	E. sphacelata		F	S	

in low numbers. The exception was fernbird, an endemic wetland species which was the most abundant and conspicuous bird at Kaitoke. Although a significant proportion of the bird fauna associated with the wetland was exotic species, and changes in the bird community on Great Barrier Is. have occurred within relatively short time spans (Bell 1976b), exotic species remain numerically less important. Notable since the previous Great Barrier Is. survey (Ogle 1980) is the appearance in paddocks neighbouring the wetland of the self-introduced spur-winged plover *(Vanellus miles novaehollandiae)*, a change in status of magpie *(Gymnorhina hypoleuca)* from 'occasional visitors but not established as a breeding population' to breeding residents, and an apparent increase in the number of Indian mynas *(Acridotheres tristis)* (pers. obs.).

Kaitoke wetland is significant for its relatively large size and generally intact vegetation sequence from estuarine to freshwater. The wetland was rated outstanding as a result of the 1980 wildlife survey (Ogle 1980), and its unmodified state, as well as the persistence of all previously recorded native wetland bird species, confirms this status. Given the degradation of wetlands generally from development and invasion by weed and pest species (Owen & Sell 1985; Anon. 2000), swamps such as Kaitoke may represent important refuges for native wetland bird communities. Any assessment of change in abundance is prevented by a lack of quantitative data from the previous survey. Comparison with other wetland populations is also difficult given that the few existing studies report densities of birds or nests rather than relative abundance (Kaufmann 1987; Elliott 1989; Parker 2003). The abundance and detectability for all native wetland species except fernbird at Kaitoke suggests scattered populations at low density.

Changes in bird species' abundance with vegetation type were observed, as has been suggested in other studies of wetland systems. In some of these the association has been related to the wetness gradient (Elliott 1987) while in others the associations are explained by vegetation profile (Andrews 1995), or the presence of certain plant species (Elliott 1989). Predation pressure has also been suggested to influence habitat choice (Onley 1982; Harris 1987).

Fernbird abundance at Kaitoke was highest in the wetter habitats, and those with dense low vegetation. Harris (1987) also characterised optimal fernbird habitat as having a high ratio of water to land, while a preference for vegetation with a low dense ground layer is confirmed by Soper (1976), Best (1979), Barlow (1983), Harris (1987), Andrews (1995) and Ogle & Cheyne (1981). However these studies also showed a preference for hummocked vegetation, with fernbird only rarely occurring at any distance out into level reedbeds (Best 1979; Barlow 1983; Andrews 1995). An apparent lack of preference for hummocked vegetation over the level *Baumea juncea* sedgelands at Kaitoke suggests that local conditions may influence habitat choice. Fernbirds have been reported occupying a wide range of low damp habitats throughout New Zealand (Guthrie-Smith 1914, 1927; Blackburn 1967; Gray & Warburton 1974). On offshore islands, in the absence of predators, fernbirds live in high densities in the forest (Buddle 1941; Best 1979). On the mainland a high water to land ratio appears to be associated with a reduced ground predator population and the safe disposal of nestling faecal sacs in water so as not to attract potential predators (Harris 1987). Elevated sites appear to be used as calling posts (Best 1979) or signposts to the nest (Barlow 1983), but may function also as safe sites from ground predators. Hence flooded dense vegetation with some elevation above ground may afford the best protection to fernbirds on the mainland in the presence of mammalian predators. The absence of Norway rats *(Rattus norvegicus)* on Great Barrier Is.

may allow fernbirds to extend out into level wet sedgeland, where Norway rats would otherwise be the main threat. The absence of all mammalian predators, as on many offshore islands, may allow fernbirds to spread further into dry forest.

The remaining birds analysed for association with vegetation type have broad habitat ranges, and showed a trend of higher numbers in the drier vegetation bounding the wetland. Grey warblers are gleaning insectivores, while silvereyes utilise nectar, fruit and insects, and the finches are seedeaters. These species also frequent regenerating forest throughout New Zealand. Fantails, which are aerial insectivores, are common in a pasture/scrub landscape matrix.

Distribution of the native wetland species other than fernbird appeared consistent with other studies, which suggest plasticity of habitat use but local preferences for certain vegetation types. Spotless crake have been associated previously with surface water (Ogle & Cheyne 1981; Hadden 1993; O'Donnell 1994) and emergent vegetation over an understorey of sedge (Kaufmann 1987), although the combination of plants comprising this habitat varies between sites (Ogle 1980; Kaufmann 1987). At Kaitoke this habitat appeared to be the flooded flax-dominated sedge vegetation of the upper swamp. While Ogle & Cheyne (1981) also noted flax as a common component of spotless crake habitat, Kaufmann (1987) maintained that flax establishment deteriorates the preferred habitat of tussock sedge. However Onley (1982) highlights a wide range of habitats used by spotless crakes, and suggests choice may be associated with predator pressure. On the Poor Knights Islands, in the absence of mammalian predators, spotless crakes commonly occur in dry forest; on Raoul Island, in the presence of rats, nesting birds emerge from swampy areas into drier open habitat only after the young have hatched; and on the New Zealand mainland, in the presence of still more predators, spotless crake are always associated with thick marshy cover (Onley 1982).

The apparent lack of overlap in habitat use between spotless crake and banded rail has been noted previously (Ogle & Cheyne 1981). Frequent use of the lower saline edge of swamps by banded rail is also shown in studies of banded rail in Marlborough (Elliott 1989), where they are confined to saltmarshes, and in the northern North Island (Elliott 1987), where they frequent mangroves, although they are also known to occur in freshwater wetlands (Elliott 1987). Bittern have been sighted in swampy pasture elsewhere on Great Barrier Island (Ogle 1980), and Whiteside (1989) confirms that they move locally between feeding grounds. An apparent preference by pukeko for swamp edge and adjacent pasture is validated by the previous Kaitoke survey (Ogle 1980), as well as observations at Whangamarino on the mainland (Ogle & Cheyne 1981). Wetlands are the traditional hunting ground of Australasian harriers (Baker-Gabb 1986), and their use of low open vegetation is corroborated in studies throughout New Zealand (Baker-Gabb 1981a; Pierce & Maloney 1989).

Seasonal changes in bird species' abundance were less clear. Higher numbers of silvereye in the wetland over summer-autumn may be due to their attraction to the area by fruiting *Coprosma robusta* and cabbage trees during these months, while lower numbers in winter may be due to their subsequent dispersal in mobile flocks. Higher numbers of grey warblers detected over winter-spring may be related to their attraction to insects visiting flowering manuka in these months, as well as the increased vocal conspicuousness of this species in spring. No other movement of birds to the wetland in association with phenology events, such as honeyeaters to flowering flax or granivorous birds to the seeding sedges, was apparent from the counts. However, some movement in response to phenology may have gone undetected during the 3-month lapse between successive counts, as tui were observed on the flowering flax on other occasions (pers. obs.). Most records of seed-eating finches in the flooded vegetation were of birds in flight over the swamp. Seasonal change in the conspicuousness of native wetland bird species may occur; however there was insufficient information to suggest optimum times for assessing populations. Season appears to be more important as a predictor of bird species' abundance in wetlands used by migrant species (Weller 1994; Edwards & Otis 1999) or by species with seasonal requirements dictated by varying water level (Murkin *et al.* 1997).

The continued integrity of Kaitoke wetland and its bird community is threatened by introduced predators and plans for development. Although mustelids and Norway rats, both considered significant predators in wet habitats (Harris 1987; Parker 2003) are absent on Great Barrier Is., feral cats *(Felis catus)*, mice *(Mus musculus)* and ship rats *(Rattus rattus)* are present. Dogs *(Canis familiaris)* were heard on occasion in the forest margins, wild pig *(Sus scrofa)* sign was seen on the central swamp during the survey, and Australasian harriers hunted over the wetland. Few accounts are available of the relative importance of these predators on wetland birds. However cats introduced to pest-free Herekopare Is. in 1925 are known to have exterminated both banded rail and fernbird (Fitzgerald & Veitch 1985), and a cat at Whirinaki caught the only six spotless crake recorded for the area (St. Paul 1977). Cats are the main bird predators in braided river systems in the South Island (Sanders & Maloney 2002), and birds are the main diet item of cats in Hawkes Bay swampland during the breeding season (Langham 1990). Mice were responsible for 78% of predation at artificial fernbird nests at Omaha wetland (Parker 2003), identifying them as potentially important predators of wetland bird nests. A ship rat irruption on Big South Cape in 1964 was responsible for the rapid extinction of fernbirds on the island (Bell 1976a), while extinction of banded rail on outliers of the Solomon Islands has been attributed to predation and habitat alteration by humans and introduced rats, dogs and pigs (Steadman *et al.* 1990). Free ranging wild pigs on the Poor Knights Islands are known to have depressed spotless crake numbers, which increased rapidly after their removal (Onley 1982). Australasian harriers have been documented preying on passerines (Pierce & Maloney 1989; Sanders & Maloney 2002), particularly during the breeding season (Baker-Gabb 1981b), and are considered important predators of fernbird nests (Elliot 1978; Harris 1987). Niche expansion and increased density of these native avian predators since their arrival from Australia, as a result of ecological release from interspecific competition and differences in resource availability (Baker-Gabb 1986; Pierce & Maloney 1989), may be aggravating predation levels. Information on the distribution and abundance of predators within the Kaitoke wetland system is fundamental to assessing the status of the native wetland bird community, and interpreting any association between bird species and the habitat they utilise.

Subdivision in progress in the lower reaches of Kaitoke swamp is likely to adversely affect the system by altering drainage and structure. Bittern already appear to have retracted in distribution over the island due to habitat modification (Ogle 1980), and development will directly impact the only habitat where bittern have recently been observed at Kaitoke. Brown teal, which are a threatened endemic species under active management on the island, also breed in the lower tidal arm of the wetland. Land development and the reclamation of habitat have been responsible for loss of local populations of fernbird in other parts of New Zealand (Owen & Sell 1985).

The secretive nature of most native wetland bird species means that observations are few and little information is available on their ecology, population status, and breeding success. Available data can either be used to infer that they are more common than the number of records suggest (eg. Heather & Robertson 1997), or that the low numbers indicate serious population declines. Early last century Guthrie-Smith assured that 'unlike the warbler, waxeye and fantail, where the percentage of destruction both of eggs and young is very great, perhaps...one-third, the fernbird seems to suffer no great loss...(and) his metallic "click" "click" is likely...long to be heard in the land' (Guthrie-Smith 1927). However a recent study of fernbird at Omaha wetland north of Auckland suggests a breeding success as low as 22% (n = 21) (Parker 2003). The only information on nesting success for spotless crake on the mainland reports 36% predation of nests (n = 11). The scarcity of data on the breeding success of fernbird, banded rail, crakes and bittern makes assessment of their status speculative, while the lack of data on predator numbers and their impact on wetland habitats hinders management of these ecosystems. Similarly, a lack of quantitative data on wetland bird populations at different seasons prevents comparison between areas or identification of optimal times for accurately assessing these populations. Such information is necessary for the sustainable management of wetland communities like Kaitoke, and is recommended for future research.

ACKNOWLEDGEMENTS

World Wildlife Fund for Nature (New Zealand) provided financial support for this study. Dianne Brunton and Alan Rodrigo gave advice on the statistical analysis, and Igor Drecki supplied graphics. Ian Fraser, Kirsten Anderson and Kevin Parker assisted with fieldwork. Department of Conservation, Great Barrier Is. allowed access to the area, and Great Barrier Lodge provided logistical support.

LITERATURE CITED

Andrews, R. M. 1995. Habitat relationships of the North Island fernbird. Unpubl. MSc thesis, University of Auckland, Auckland.

Anonymous, 2000. The New Zealand biodiversity strategy; our chance to turn the tide. Wellington, Department of Conservation / Ministry for the Environment.

Baker-Gabb, D. J. 1981a. Breeding behaviour and ecology of the Australasian harrier *(Circus approximans)* in the Manawatu-Rangitikei sand country, New Zealand. *Notornis 28*: 103-119.

Baker-Gabb, D. J. 1981b. The diet of the Australasian harrier *(Circus approximans)* in the Manawatu-Rangitikei sand country, New Zealand. *Notornis 28*: 241-254.

Baker-Gabb, D. J. 1986. Ecological release and behavioural and ecological flexibility in marsh harriers on islands. *Emu 86*: 71-81.

Ballie, J.; Groombridge, B. 1996. IUCN red list of threatened animals. *International union for the conservation of nature.*

Barlow, M. 1983. Territories of South Island fernbirds. *Notornis* 30: 199-216.

Bell, B. D. 1976a. The Big South Cape Islands rat irruption. *in*: Dingwall, P.R.; Atkinson, I.A.E.; Hay, C.(ed.) *Ecology and control of rodents in New Zealand reserves*. Department of Lands and Survey, Wellington.

Bell, B. D. 1976b. Status of Great Barrier Island birds. *Notornis 23*: 310-319.

Best, H. A. 1979. Observations on habitat selection by South Island fernbirds. *Notornis 26*: 279-287.

Blackburn, A. 1967. Nesting of the Codfish Island fernbird. *Notornis 14*: 62-66.

Buddle, G. A. 1941. Birds of the Poor Knights. *Emu 41*: 56-68.

Clout, M. N.; Gaze, P. D. 1984. Effects of plantation forestry on birds in New Zealand. *Journal of applied ecology 21*: 795-816.

Edwards, N.; Otis, D. L. 1999. Avian communities and habitat relationships in South Carolina Piedmont beaver ponds. *American midland naturalist 141*: 158-171.

Elliot, G. P. 1978. The territorial behaviour and breeding biology of the South Island fernbird, *Bowdleria puncta-ta punctata*. Unpubl. BSc Hons thesis, University of Canterbury, Christchurch.

Elliott, G. 1987. Habitat use by the banded rail. *New Zealand journal of ecology 10*: 109-115.

Elliott, G. 1989. The distribution of banded rails and marsh crakes in coastal Nelson and the Marlborough Sounds. *Notornis 36*: 117-123.

Fitzgerald, B. M.; Veitch, C. R. 1985. The cats *(Felis catus)* of Herekopare Island, New Zealand; their history, ecology and affects on birdlife. *New Zealand journal of zoology 12*: 319-330.

Gill, B. 1989. Bird counts in regenerated urban forest at Auckland Domain. *Notornis 36*: 81-87.

Gray, R. S.; Warburton, B. 1974. Fernbirds on the hills west of Dunedin. *Notornis 21*: 82-83.

Guthrie-Smith, H. 1914. *Muttonbirds and other birds.* Melbourne and London, Whitcombe & Tombs.

Guthrie-Smith, H. 1927. *Birds of the water, wood and waste.* Melbourne and London, Whitcombe & Tombs.

Hadden, D. 1993. First spotless crake nest for the South Island. *Notornis 40*: 231-232.

Harris, W. 1987. The breeding biology of the South Island fernbird in the Otago wetlands. Unpubl. PhD thesis, Otago University, Dunedin.

Heather, B.; Robertson, H. 1997. *The field guide to the birds of New Zealand.* New York, Oxford University Press.

Holdaway, R. N. 1989. New Zealand's pre-human avifauna and its vulnerability. *New Zealand journal of ecology 12*: 11-25.

Holdaway, R. N.; Worthy, T. H.; Tennyson, A. J. D. 2001. A working list of breeding bird species of the New Zealand region at first human contact. *New Zealand journal of zoology 28*: 119-187.

Horrocks, M.; Ogden, J.; Nichol, S. L.; Alloway, B. V.; Sutton, D. G. 1999. A late Quaternary palynological and sedimentological record from two coastal swamps at northern Kaitoke, Great Barrier Island, New Zealand. *Journal of the Royal Society of New Zealand 30 (1)*: 27-47.

Kaufmann, G. 1987. Swamp habitat use by spotless crakes and marsh crakes at Pukepuke lagoon. *Notornis 34*: 207-216.

King, C. M. 1984. *Immigrant killers: introduced predators and the conservation of birds in New Zealand.* Auckland, Oxford University Press.

Langham, N. P. E. 1990. The diet of feral cats *(Felis catus* L.*)* on Hawke's Bay farmland New Zealand. *New Zealand journal of zoology 17*: 243-256.

Molloy, J.; Davis, A. 1994. Setting priorities for the conservation of New Zealand's threatened plants and animals. Wellington, Department of Conservation.

Murkin, H. R.; Murkin, E. J.; Ball, J. P. 1997. Avian habitat selection and prairie wetland dynamics: A 10-year experiment. *Ecological applications 7*: 1144-1159.

Murphy, D.; Kelly, D. 2003. Seasonal variation in the honeydew, invertebrate, fruit and nectar resource for bellbirds in a New Zealand mountain beech forest. *New Zealand journal of ecology 27*: 11-23.

O'Donnell, C. F. J. 1994. Distribution and habitats of spotless crakes in Canterbury. *Notornis 41*: 211-213.

Ogle, C. C. 1980. Wildlife and wildlife habitat of Great Barrier Island. Fauna Survey Unit rept. 24, New Zealand Wildlife Service, Wellington.

Ogle, C. C.; Cheyne, J. 1981. The wildlife and wildlife values of the Whangamarino wetlands. Fauna Survey Unit rept. 28 New Zealand Wildlife Service, Wellington.

Onley, D. 1982. The spotless crake *(Porzana tabuensis)* on Aorangi, Poor Knights Islands. *Notornis 29*: 9-21.

Owen, K. L.; Sell, M. G. 1985. The birds of Waimea inlet. *Notornis 32*: 271-309.

Parker, K. 2003. Ecology and management of North Island fernbird *(Bowdleria punctata vealeae)*. Unpubl. MSc thesis, University of Auckland, Auckland.

Pegman, A. P. M. 1999. Primary production-decomposition dynamics of *Typha orientalis*, *Gleichenia dicarpa* and *Baumea juncea* at Kaitoke swamp, Great Barrier Island (Aotea), New Zealand. Unpubl. MSc thesis, University of Auckland, Auckland.

Pierce, R. J.; Maloney, R. F. 1989. Responses of harriers in the Mckenzie basin to the abundance of rabbits. *Notornis 36*: 1-12.

Rutherford, G. 1998. The current vegetation of Kaitoke swamp, Great Barrier Island (Aotea). Unpubl. MSc thesis, University of Auckland, Auckland.

Sanders, M. D.; Maloney, R. F. 2002. Causes of mortality at nest of ground-nesting birds in the Upper Waitaki Basin, South Island, New Zealand: a five year study. *Biological conservation 106*: 225-236.

Soper, M. F. 1976. *New Zealand birds.* Christchuch, Whitcoulls.

St. Paul, R. 1977. A bushman's seventeen years of noting birds. *Notornis 24*: 65-74.

Steadman, D. W.; Pahlavan, D. S.; Kirch, P. V. 1990. Extinction biogeography and human exploitation of birds on Tikopia and Anuta Polynesian outliers in the Solomon Islands, South Pacific Ocean. *Bishop Museum occasional papers 30*: 118-153.

Weller, M. W. 1994. Seasonal dynamics of bird assemblages in a Texas estuarine wetland. *Journal of field ornithology 65*: 388-401.

Whiteside, A. J. 1989. The behaviour of bitterns and their use of habitat. *Notornis 36*: 89-95.