

A case of natural recovery after the removal of invasive predators – community assemblage changes in the avifauna of Burgess Island

STEFANIE M.H. ISMAR*

GEOMAR Helmholtz Centre for Ocean Research, Experimental Ecology, Düsternbrooker Weg 20, 24105 Kiel, Germany, and School of Biological Sciences, University of Auckland, PB 92019, Auckland 1142, New Zealand

KAREN A. BAIRD

Royal Forest & Bird Protection Society New Zealand, PO Box 108 055, Auckland, New Zealand

CHRIS P. GASKIN

400 Leigh Road, RD5, Whangateau, Warkworth 0985, New Zealand

GRAEME A. TAYLOR

Department of Conservation, PO Box 10420, Wellington 6143, New Zealand

ALAN J.D. TENNYSON

Museum of New Zealand Te Papa Tongarewa, P.O. Box 467, Wellington, New Zealand

MATT J. RAYNER

Auckland War Memorial Museum, PB 92018, Auckland, and School of Biological Sciences, University of Auckland, PB 92019, Auckland 1142, New Zealand

DEREK BETTESWORTH

64 McDonnell Road, RD8, Whangarei 0178, New Zealand

NEIL FITZGERALD

Landcare Research, Private Bag 3127, Hamilton, New Zealand

TODD J. LANDERS

Auckland Council, 1 The Strand, Takapuna, Auckland 0622, School of Biological Sciences, University of Auckland, PB 92019, Auckland 1142, and Auckland War Memorial Museum, PB 92018, New Zealand

MICHAEL J. IMBER†

Abstract Opportunities to monitor natural island ecosystem recovery following the eradication of introduced predators are rare, and provide a useful comparison for recovery programmes aided by active habitat restoration and species translocations. We present an assessment of the current avifauna on Burgess Island, Mokohinau Group, 2 decades after kiore (Pacific rat; *Rattus exulans*) removal. The 4 most abundant land bird species we recorded are red-crowned parakeet (*Cyanorhamphus novaezelandiae*), bellbird (*Anthornis melanura*), tui (*Prosthemadera novaeseelandiae*) and silvereye (*Zosterops lateralis*), all New Zealand native taxa. Our records confirm that 46 species now utilize the island's habitats, compared with 24 species reported from the literature during the last decades of rat infestation. We also confirm breeding of 9 seabird species by 2011, only 4 of which maintained breeding populations on Burgess Island prior to rat eradication. More than 20 years after predator removal, Burgess Island hosts a rich avifauna, and provides a valuable example of natural recovery following predator eradication without any further active restoration measures.

Ismar, S.M.H.; Baird, K.A.; Gaskin, C.P.; Taylor, G.A.; Tennyson, A.J.D.; Rayner, M.J.; Bettesworth, D.; Fitzgerald, N.; Landers, T.J.; Imber, M.J. 2014. A case of natural recovery after the removal of invasive predators - community assemblage changes in the avifauna of Burgess Island. *Notornis* 61 (4): 188-195.

Keywords habitat recovery; rat eradication; re-colonisation; species richness; terrestrial birds



Fig. 1. Bird count stations (1–12) on Burgess Island (main map), Mokohinau Group (top inset), in October 2010; bottom inset: typical habitat on Burgess Island, view towards Burgess Lighthouse from Station 9; photo credit S. Ismar.

INTRODUCTION

Alien mammalian predators and browsers have been major drivers of declines in native New Zealand bird populations on offshore islands (Imber 1975; O'Donnell 1996; Wilson *et al.* 1998; Moorhouse *et al.* 2003; Rayner *et al.* 2007). Establishing post-eradication records of natural recolonisations by native species to managed areas, and monitoring the recovery of populations are necessary steps in understanding and improving upon the success of control operations (Hutton *et al.* 2007; Ortiz-Catedral *et al.* 2009; Towns *et al.* 2012).

Burgess Island (Pokohinu; 35° 54' S, 175° 07' E) at 56 ha is the second largest island of the Mokohinau Group, and has remained free of alien mammals since the removal of feral goats (*Capra aegagrus*) by the Wildlife Service in 1973 (Whitaker 1974), and kiore (Pacific rat; *Rattus exulans*) in 1990

by the Department of Conservation (McFadden & Greene 1994). Moreover, this rat eradication was the first planned rodent eradication in the world to use aerial bait spreading methods (Towns & Broome 2003). Burgess Island is gazetted as a Scenic Reserve and a Lighthouse Reserve with open public access, while other islands in the Mokohinau Group are restricted access Nature Reserves, some of which are < 100 m distance from Burgess Island. The island was cleared of most native vegetation for lighthouse management and is being left to regenerate naturally. Apart from limited weed control activities and the demolition of the lighthouse keepers' houses, no habitat restoration of the island has been undertaken to date. Burgess Island thus provides a useful comparison to other islands (for example Tiritiri Matangi), where restoration is being conducted by planting operations and actively introducing native flora and fauna. Thus, areas that were previously mainly grass-covered are gradually being replaced with early successional species of shrub, specifically *Muehlenbeckia* and harakeke (*Phormium tenax*), and patches of forest in some areas.

Received 18 August 2014; accepted 7 November 2014

*Correspondence: sismar@geomar.de

†Deceased.

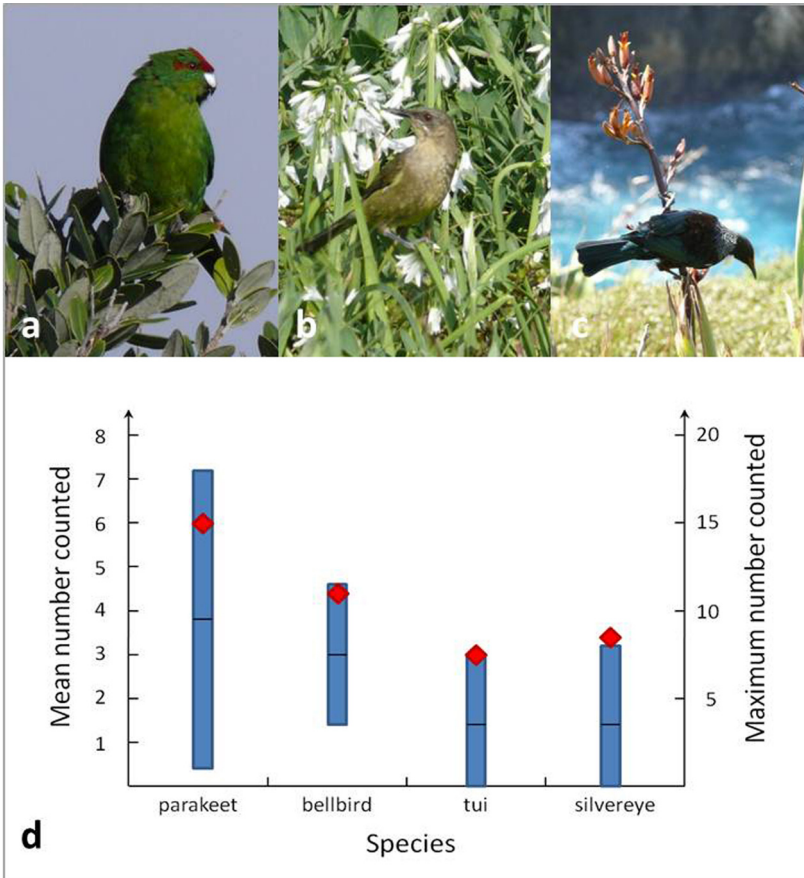


Fig. 2. The 3 most abundant terrestrial bird species on Burgess Island, Mokohinau Group, October 2010; photo credits S. Ismar (a) red-crowned parakeet (*Cyanoramphus novaezelandiae*), (b) bellbird (*Anthornis melanura*), (c) tui (*Prothemadera novaeseelandiae*), and (d) mean and maximum numbers of the 4 most abundant terrestrial bird species encountered on Burgess Island, Mokohinau Group, during 5-minute bird counts, October 2010; bars: mean number of birds \pm standard deviation; diamonds: maximum numbers of birds.

The aim of our study was to monitor the avian response to the removal of rats from Burgess Island. We compared the bird fauna recorded on the island before rat eradication, using data from peer reviewed literature and file reports (Sandager 1890; Veitch 1973; McCallum 1980) to observational data we collected during a 2010 research expedition and supplemented with bird observations from research trips between 2004 and 2013.

METHODS

Twenty years after rat eradication (McFadden & Greene 1994), we assessed terrestrial bird diversity on Burgess Island, Mokohinau Group (Fig. 1) in October 2010, employing 5-minute bird counts (Dawson & Bull 1975) between sunrise and 11:00 h at 12 evenly spaced stations on the island. In total, data from 60 counts conducted between 14 - 17 October 2010 was collated. Mean bird numbers and their standard deviations were calculated for all species seen or heard within a 200 m radius. Sightings of further species made by our team members during other research trips to Burgess Island (2004-2013)

are also included. Seabirds were monitored with extensive day-time ground searches for burrows, and capture and banding operations at night-time as part of ongoing seabird ecology projects by the authors and colleagues (see for example Ismar *et al.* 2012).

On 19 December 2011, during the red-billed gull (*Larus novaehollandiae*) breeding season, we took a series of ~40 photographs of the current colony on the Western cliff faces of the Cauldron. These images were then stitched together using the Photomerge tool in Adobe Photoshop CS® 5.5 creating a coherent 400 megapixel image, and all visible red-billed gull nest spots were numbered and counted; red-billed gull nest spots on nearby Bird Rock were counted on the same day the cliff-face pictures were taken.

RESULTS

The 3 most abundant bird species on Burgess Island during our October 2010 expedition were native taxa: red-crowned parakeet (*Cyanoramphus novaezelandiae*), bellbird (*Anthornis melanura*), and

tui (*Prothemadera novaeseelandiae*; Table 1, Fig. 2). Together with the next most common taxon, the silvereye (*Zosterops lateralis*), these species constituted > 65% of birds recorded during our counts.

The highest maximum counts were recorded for red-crowned parakeet and bellbird, with 15 and 11 individuals of each species sighted, respectively, during the same 5-minute count (Fig. 2). In total, 23 species were recorded during our 5-minute counts (Table 1), including 6 species of shore- and waterbirds. Additionally, a morepork (*Ninox novaeseelandiae*) was sighted on Burgess Island at night (13 October 2010; Fig. 3). Our mean counts of red-crowned parakeets indicate higher numbers than reported at the same season immediately after rat eradication in 1990 (1.91 ± 2.38 , McFadden & Greene 1994).

Since becoming rat-free, Burgess Island has transformed into a seabird biodiversity hotspot, with the island now known to support 7 species of burrowing Procellariiformes (Ismar *et al.* 2012): grey-faced petrel (*Pterodroma macroptera gouldi*), fluttering shearwater (*Puffinus gavia*), sooty shearwater (*Puffinus griseus*), little shearwater (*Puffinus assimilis*), common diving petrel (*Pelecanoides urinatrix*), and white-faced storm petrel (*Pelagodroma marina*), all of which were confirmed in our October 2010 research trip. In January 2011, black-winged petrel (*Pterodroma nigripennis*) was also observed (Ismar *et al.* 2012), as well as little penguin (*Eudyptula minor*), and red-billed gull (*pers. obs.*).

A count of the remnant Burgess colony of red-billed gulls in 2012 noted 57 birds on the Cauldron cliff face, and 72 birds on Bird Rock, of which some still appeared to be on nests, including about half a dozen grown chicks at each site (NF, *pers. obs.*, Fig. 4b). On occasion red-billed gulls were observed feeding on *Coprosma* berries growing on Burgess Island, moving from shrub to shrub in small flocks (CG, *pers. obs.*).

Further bird species sighted on Burgess Island during other expeditions were reef heron (*Egretta sacra*; seen in 2005, 2011 and 2013; CG, NF and AT, *pers. obs.*, respectively), wandering tattler (*Tringa incana*; 2005), long-tailed cuckoo (*Eudynamys taitensis*; 2005), kaka (*Nestor meridionalis*; 2006), New Zealand pipit (*Anthus novaeseelandiae*; 2010), rock pigeon (*Columba livia*; 2010), grey warbler (*Gerygone igata*; 2010 and 2011) (all previous species, CG, *pers. obs.*), and a white-fronted tern (*Sterna striata*; 2011) (GT, *pers. obs.*, Table 1). Adding to the species list of procellariids encountered on Burgess Island since 2004, a New Zealand storm petrel (*Pealeornis maoriana*) was sighted low overhead during a spotlighting operation in 2006 (DB and MI, *pers. obs.*), a Buller's shearwater (*Puffinus bulleri*) was caught on the ground on the Northern Headland in January 2011 (SI and GT, *pers.*



Fig. 3. Morepork (*Ninox novaeseelandiae*) sighted on Burgess Island 13 October 2010; photo credit S. Ismar.

obs.) and fairy prion (*Pachyptila turtur*), and flesh-footed shearwater (*Puffinus carneipes*; CG, DB, MI, *pers. obs.*) were sighted on the island at least once. The lighthouse acts as an attractant for nocturnal seabirds, also adding sightings of species which do not breed on Burgess Island, with a live Pycroft's petrel (*Pterodroma pycrofti*) found on the ground beside it in a storm in January 2011, a live Cook's petrel (*Pterodroma cookii*; CG, DB, MI, AT, *pers. obs.*) sighted by it, and another Cook's petrel found dead under it in February 2013. Sightings of Buller's and flesh-footed shearwaters hitting the glass have also been made, but so far without any of these large shearwaters observed killed (CG, *pers. obs.*).

DISCUSSION

The findings we summarise here indicate a notable increase both in land- and waterbird species using Burgess Island, as well as in the number of breeding species now inhabiting the island, post eradication of introduced mammals. While the available pre-eradication surveys may only constitute sparse information, they provide the sole basis against which post-eradication recovery can be compared. With our avifauna lists obtained from a number of trips over several years, we hope to provide a first post-eradication baseline for future monitoring of changes in avian community assemblage on Burgess Island. In comparison with our post-eradication records, McCallum (1980) recorded 18 avian species on this island in May 1979, summarising

Table 1. Bird species sighted (+) on Burgess Island by McCallum (1980) and during research expeditions in October 2010 (S. Ismar, K. Baird, C. Gaskin, D. Bettesworth), September 2011 (G. Taylor), and February 2013 (A. Tennyson); average abundances (+/- SD) of the species recorded within a 200 m radius in 5-minute bird counts in October 2010.

Species		McCallum (1980)	October 2010	September 2011	February 2013	Mean count	SD
Red-crowned parakeet	<i>Cyanoramphus novaezelandiae</i>	+	+	+	+	3.850	3.318
Bellbird	<i>Anthornis melanura</i>		+	+	+	3.033	1.707
Tui	<i>Prothemadera novaeseelandiae</i>		+	+	+	1.383	1.658
Silvereye	<i>Zosterops lateralis</i>	+	+	+		1.367	1.886
Welcome swallow	<i>Hirundo neoxena</i>	+	+	+	+	0.817	1.420
Red-billed gull	<i>Larus novaehollandiae</i>		+	+		0.650	2.956
Fantail	<i>Rhipidura fuliginosa</i>		+	+	+	0.483	0.833
Blackbird	<i>Turdus merula</i>	+	+	+	+	0.433	0.647
Skylark	<i>Alauda arvensis</i>	+	+	+		0.400	0.924
House sparrow	<i>Passer domesticus</i>	+	+		+	0.383	1.091
Chaffinch	<i>Fringilla coelebs</i>		+	+		0.300	0.646
Kingfisher	<i>Todiramphus sanctus</i>	+	+	+	+	0.283	0.666
Goldfinch	<i>Carduelis carduelis</i>	+	+		+	0.267	1.339
Southern black-backed gull	<i>Larus dominicanus</i>		+	+	+	0.217	0.613
Shining cuckoo	<i>Chrysococcyx lucidus</i>		+			0.200	0.480
Starling	<i>Sturnus vulgaris</i>	+	+	+	+	0.167	0.557
Australasian gannet	<i>Morus serrator</i>		+	+		0.117	0.372
Yellowhammer	<i>Emberiza citrinella</i>		+	+		0.117	0.555
Paradise shelduck	<i>Tadorna variegata</i>		+			0.117	0.904
New Zealand pigeon	<i>Hemiphaga novaeseelandiae</i>		+	+	+	0.050	0.387
Australasian harrier	<i>Circus approximans</i>		+	+	+	0.033	0.181
Dunnoek	<i>Prunella modularis</i>		+			0.017	0.129
Pied shag	<i>Phalacrocorax varius</i>	+	+	+	+	0.017	0.129
Morepork	<i>Ninox novaeseelandiae</i>	+	+				
Grey-faced petrel	<i>Pterodroma macroptera gouldi</i>	+	+	+	+		
Common diving petrel	<i>Pelecanoides urinatrix</i>		+	+	+		
Little shearwater	<i>Puffinus assimilis</i>		+	+	+		
Fluttering shearwater	<i>Puffinus gavia</i>		+	+	+		
Sooty shearwater	<i>Puffinus griseus</i>		+				
White-faced storm petrel	<i>Pelagodroma marina</i>		+		+		
Black-winged petrel	<i>Pterodroma nigripennis</i>				+		
White-fronted tern	<i>Sterna striata</i>			+			
Little penguin	<i>Eudyptula minor</i>	+	+	+	+		
Reef heron	<i>Egretta sacra</i>				+		

Table 1. Continued.

Cook's petrel	<i>Pterodroma cookii</i>				+
Flesh-footed shearwater	<i>Puffinus carneipes</i>				+
Little shag	<i>Phalacrocorax melanoleucos</i>				+
Kaka	<i>Nestor meridionalis</i>				+
Common myna	<i>Acridotheres tristis</i>				+
Song thrush	<i>Turdus philomelos</i>				+
Total		18	31	24	23

observations from a 9-day monitoring excursion to the Mokohinau Islands, during which camp was located on Burgess Island. McCallum (1980) confirmed breeding only for 2 species: little penguin and grey-faced petrel. Additionally, McCallum's (1980) avifauna resumé quotes sightings of 13 species from Sandager (1890): bellbird, tui, yellowhammer (*Emberiza citrinella*), shining cuckoo (*Chrysococcyx lucidus*) and long-tailed cuckoo, golden plover (*Pluvialis dominica*), wrybill (*Anarhynchus frontalis*), bar-tailed godwit (*Limosa lapponica*), fairy prion, Cook's petrel, Buller's shearwater, black petrel (*Procellaria parkinsoni*), and black-bellied storm petrel (*Fregatta tropica*), which may have been a New Zealand storm petrel, undiscovered at the time (Gaskin & Baird 2005). He also lists 3 species from Veitch (1973): rock pigeon, common diving petrel, and white-fronted tern, and 3 species from both these sources (New Zealand pipit, Australasian harrier, reef heron). If we assume that only the 24 species listed by Veitch (1973) and/or observed by McCallum (1980) survived on or frequented the island when rats were present, bird species richness has nearly doubled since the eradication in 1990. The number of confirmed breeding seabird species has also more than doubled from 4 (little penguin, grey-faced petrel in McCallum 1980; common diving petrel listed as rare breeders by Veitch 1973; and red-billed gull by Buddle 1947a,b; Fleming 1946; Gillham 1960) to 9 species (Ismar *et al.* 2012; this study).

Red-billed gulls were observed breeding in a small colony on an outlying rock by Sandager (1890), and reported breeding in large numbers on Burgess Island by Buddle (1947a,b), Fleming (1946), and Gillham (1960). Our collated colony information indicates a major decline in the distribution of red-billed gull colonies on Burgess Island (Gillham 1960; this study; Fig. 4). The reason for the decline in this species is uncertain but might be a result of changes in the marine environment affecting food availability. Similar declines in red-billed gull populations have been observed on other remote northern offshore islands (*e.g.*, Cuvier

Island) during the 1970s (Dick Veitch, *pers. comm.*). While the breeding population on Burgess has declined markedly (and overall the red-billed gull population at the Mokohinau Islands is no more than 250 pairs at 3 locations: Cauldron cliffs, Bird Rock, and Maori Rocks), winter aggregations of thousands of this species were seen feeding over fish schools in the vicinity of the islands in August 2012 and September 2013 (CG, *pers. obs.*). Research to identify the primary foraging grounds of Burgess Island breeding red-billed gulls, local prey availability during breeding season and its effect on fledging success at the colonies is warranted to assess potential impacts at sea and monitor potential future population recovery.

The gradually recovering shrub and forest vegetation, benefitting from the removal of both goats and rats, now offers diverse habitats for many passerines. Flowering and fruiting trees, such as pohutukawa (*Metrosideros excelsa*), *Coprosma* spp., and ngaio (*Myoporum laetum*), but also flax and some of the remaining introduced flowering plants (see *e.g.* onion weed; *Allium triquetrum*; Fig. 2), offer food for honeyeaters, pollen-feeding birds, and frugivores, and may even provide an additional food source for omnivorous waterbirds such as the red-billed gull. Our observations of red-billed gulls feeding on *Coprosma* berries confirm literature reports of this species taking native berries of taupata (*Coprosma repens*), ngaio and puka (*Merytasin clairii*), from the Mokohinau Islands and also the Three Kings Islands (Fleming 1946; Buddle 1947a; Oliver 1955; Hemmings 1988). Remarkably, 2 of the most common birds we sighted, tui and bellbird, were not reported by McCallum (1980); their re-colonisation illustrates the combined benefits of removed predation pressure and recovery of suitable food sources on Burgess Island.

The source population of the bellbirds and other native forest species that (re)colonised Burgess Island is an intriguing question, which calls for resolution employing genetic methods. Fanal Island constitutes the nearest potential source within the Mokohinau Island area, which held all 4 of the now

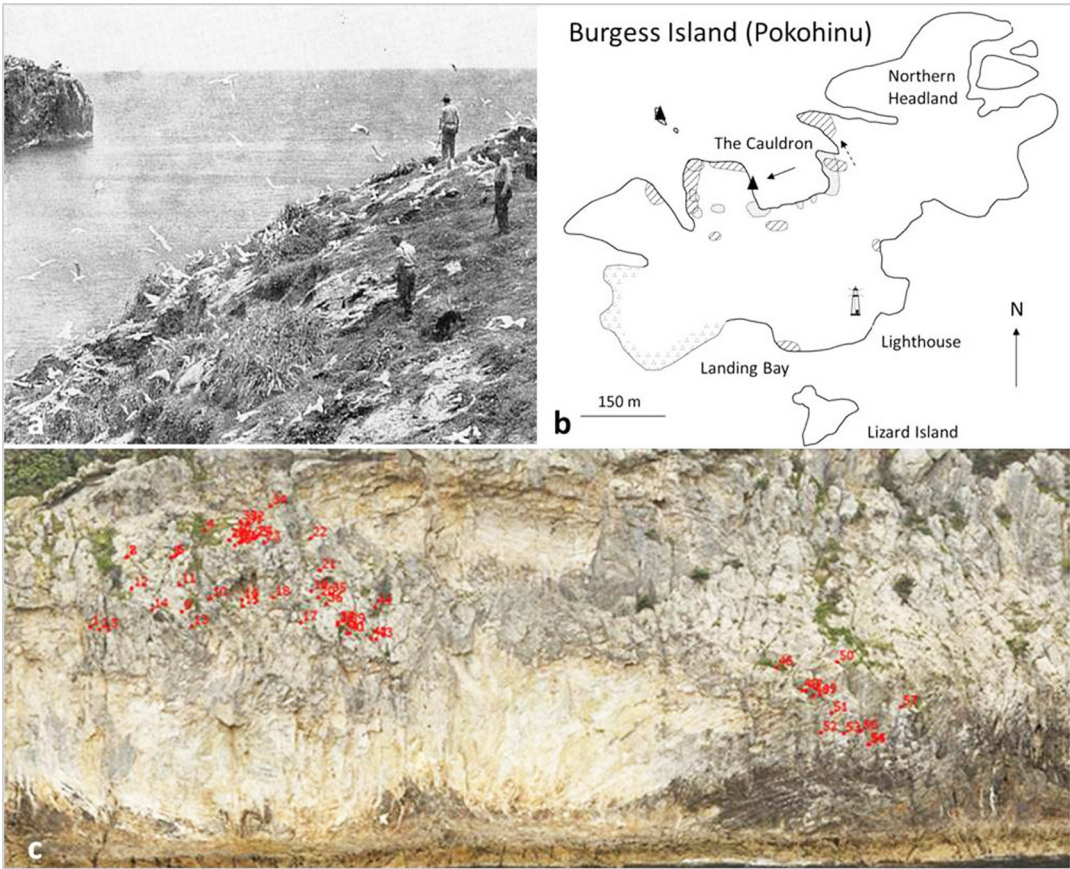


Fig. 4. Red-billed gulls (*Larus novaehollandiae*) breeding on Burgess; (a) red-billed gull numbers at the colony on the Eastern Blowhole Cliffs during Charles Fleming's visit to the island with Buddle in 1943, photo source Wilson 1959 (dashed arrow in (b): observer angle). (b) red-billed gull (RBG) colonies on Burgess Island in the 20th century, modified from Gillham 1960; irregular dotting after Buddle (1936), regular dotting after Fleming (1944), shading RBG breeding areas in 1957 after Gillham (1960), black triangles RBG breeding areas in 2011 (this study). (c) red-billed gull count on the same cliff as in (a) in 2012; photo credits N. Fitzgerald (solid arrow in (b): observer angle).

most abundant terrestrial bird species on Burgess: red-crowned parakeet, bellbird, tui and silvereye were recorded there amongst a list of 23 bird species by Bellingham (1980), at the same time McCallum made his observations on Burgess Island. Bellbirds now found on Burgess Island might also have originated from the Poor Knights Islands, which hold an endemic subspecies, or from Little Barrier Island (Te Hauturu-o-Toi), the Hen and Chicken Islands, or immediately from more remote mainland populations at Tawharanui, which itself constitutes a recent colonisation from Little Barrier Island (2005) (Brunton *et al.* 2008; Baillie *et al.* 2014). The long-distance flight capacity of bellbirds is illustrated by an observation we had of an individual flying in the direction of the Mokohinau Islands, sighted half-way between the Hen and Chicken Islands and Groper Island (Tatapihi) in February 2004 (CG, *pers.*

obs.). Silvereyes, while abundant in our survey, and also sighted during each of our research excursions, were not seen on the island in February 2013. This suggests that silvereye flocks observed on Burgess Island may be an ephemeral population.

Our results present a first assessment of avian species utilising the now predator-free habitat on Burgess Island more than 2 decades after rat eradication, confirming that a wide range of bird taxa have benefited from a long-term higher protection status of Burgess Island, including more controlled public access with clearly defined tracks keeping visitors away from vulnerable breeding sites. The diverse fauna Burgess Island hosts is presently vulnerable to rat reinvasion, for example from boats anchored close to shore, and vessels conducting landings. With the total of 46 bird species reported here, Burgess Island now hosts a rich avifauna, and

even though visitation and re-colonisation may initially have been slowed by its relative remoteness to the mainland, the island provides a vivid example of natural recovery following predator removal, without active restoration measures.

ACKNOWLEDGEMENTS

Many thanks to Adrien Lambrechts, and Kate J. Beer for their help in the field during our count data collection, numerous other field team members for their help during other research excursions to Burgess Island, Brett Rathe for enthusiastic logistic support, and Dick Veitch, Steph Borrelle and Colin O'Donnell as well as 2 anonymous referees for helpful comments on our manuscript. The research was funded by the Auckland Regional Council through the Coastal Environmental Fund, and by the University of Auckland, Faculty of Science. MJR was supported by Ministry for Research Science and Technology Postdoctoral Fellowship and the University of Auckland Faculty Research Development Fund and acknowledges Wendy Rayner for assistance during this research. We thank the DoC Warkworth Great Barrier Area Office for pre-trip assistance, Ngāti Rehua, Ngāti Manuhiri, and Ngāti Wai for kind permission of our research, and Jim Foye and Maritime New Zealand for kindly permitting us to use the Burgess Island field accommodation.

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