North Island kokako (*Callaeas cinerea wilsoni*) translocations and establishment on Kapiti Island, New Zealand

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ABSTRACT

Thirty-two kokako (*Callaeas cinerea wilsoni*) were translocated to Kapiti I. between 1991 and 1997 to establish a viable 'insurance' population since the species is threatened on the New Zealand mainland. Kokako were translocated from remnant mainland populations at Little Barrier I., Mapara Wildlife Reserve, and Mount Bruce National Wildlife Centre (a captive rearing facility). Population growth may at various times have been limited by an unrecognised male sex bias, by accidental poisoning, and by annual variation in food availability and mate choice behaviour of translocated kokako. The number of pairs (14) and presence of at least seven young birds in April 2003, balanced sex ratio, and the adequate amount of suitable habitat (at least 200 ha) indicate that the established kokako population on Kapiti I. appears likely to be self-sustaining. Monitoring provided valuable information about the lack of breeding females, to which managers responded by translocating young female kokako to Kapiti I. Lessons learnt from monitoring kokako on Kapiti I. are relevant to other translocations of kokako and perhaps other species.

Keywords: *Callaeas*; Callaeidae; kokako, translocation; monitoring; management, New Zealand, Kapiti Island, conservation reserve.

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1. Introduction

North Island kokako (*Callaeas cinerea wilsoni*) is an endangered forest passerine of the endemic New Zealand wattlebird family—Callaeidae. Other members of the family are either extinct (huia *Heteralocha acutirostris* and South Island kokako *Callaeas cinerea cinerea*); or endangered (North Island saddleback *Philesturnus carunculatus rufusater* and South Island saddleback *Philesturnus carunculatus carunculatus*; Heather & Robertson 1996).

Less than 400 pairs of NI kokako exist, and predation, primarily by ship rats (*Rattus rattus*) and brushtail possums (*Trichosurus vulpecula*), has been identified as the main reason for their decline (Innes et al. 1999; Innes & Flux 1999). Intensive management of introduced pests has reversed the decline of some mainland kokako populations and kokako have also been translocated to Little Barrier I., Tiritiri Matangi I. and Kapiti I. (Fig. 1) as insurance against mainland extinction (Innes & Flux 1999). Kokako have also been translocated to mainland sites at Cowan Wildlife Reserve (King Country), Pikiariki Ecological Area (Pureora), and Hunua Ranges (Auckland) to supplement existing populations and Trounson Kauri Park (Northland) to establish a new one.

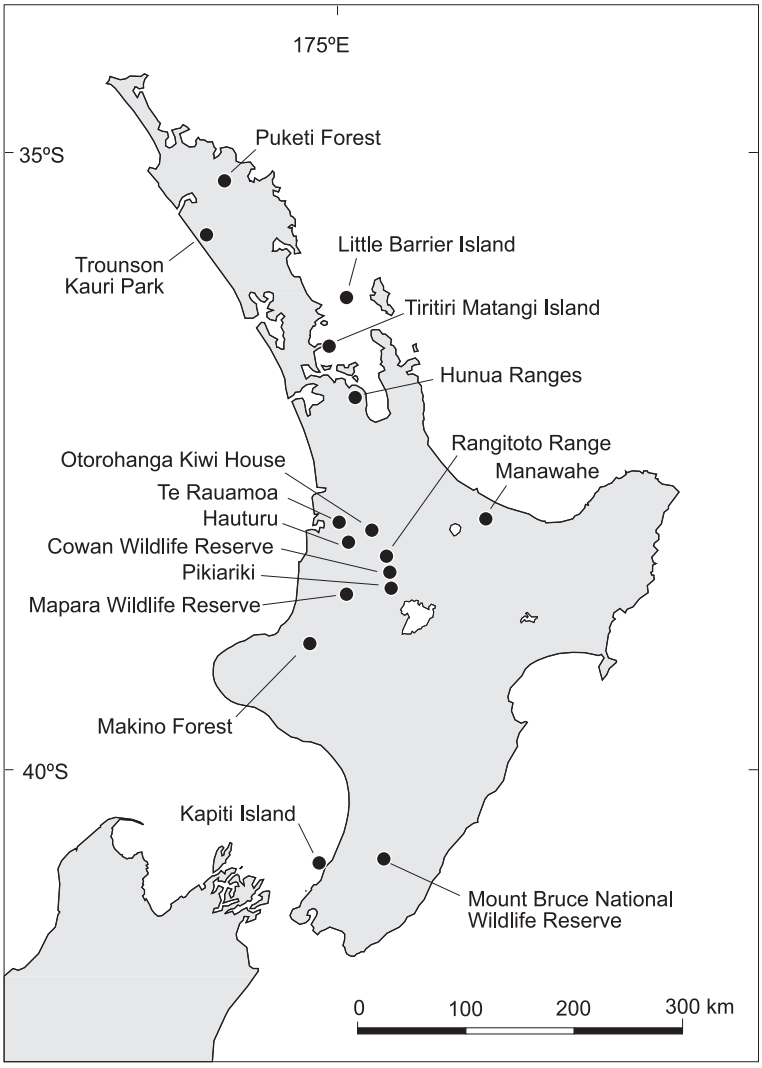

Figure 1. Map of locations from which kokako were sourced for Kapiti I., and other kokako locations mentioned in the text.

Prominent naturalists Leonard Cockayne and James Drummond visited Kapiti I. in 1907 and 1908, respectively. They strongly advocated the translocation of native birds to the island. Drummond wrote 'the Huia, the North Island thrush and crow [kokako], and the saddleback might be liberated on Kapiti Island' (Maclean 1999). Unsuccessful attempts to capture and translocate kokako to Kapiti I. were made by the caretaker Stan Wilkinson in 1927 (Maclean 1999). Kokako were first introduced to Kapiti I. during 1991–1994 from various mainland forest remnants, then from Little Barrier I. (1995–96), Mapara Wildlife Reserve (a healthy King Country population) in 1996, and Mount Bruce National Wildlife Centre (1995-96; Fig. 1) a captive rearing and breeding facility. The establishment of a self-sustaining population was slow, and in 1997 only 18 kokako were on the island despite the translocation of 32 individuals in the previous six years.

Translocation of species has been a commonly used conservation tool in New Zealand, but few translocations have been intensively monitored (Armstrong & McLean 1995; McHalick 1998). The translocation of kokako to Kapiti I. was based on considerable planning (Lovegrove unpubl. 1988; Brown unpubl. 1990; Rasch 1992) including the recommendation that breeding success and survivorship monitoring be conducted.

The aims of this paper are to emphasise the value of monitoring translocations, to examine the reasons for the slow establishment of a viable kokako population on Kapiti I. and to identify lessons for future translocations of kokako and other species.

2. Study area

Kapiti I. (1965 ha) is a rugged island lying five km off the southwest coast of the North Island of New Zealand (Fig. 2). Cliffs, rising to 500 m (a.s.l.) at the highest point, flank the western side of the island and numerous streams and gullies dissect its eastern slopes. Tall podocarp forest once covered Kapiti I. but it was largely deforested by Maori and European fires and then by farming in the 19th and early 20th Century (Maclean 1999). The island's vegetation has regenerated both naturally and by restoration plantings. The island is now a mosaic of forest and scrub with some grassland. Tawa (*Beilschmiedia tawa*), kohekohe (*Dysoxylum spectabile*) and northern rata (*Metrosideros robusta*) are the dominant canopy species in the more mature forest areas, but scrubland dominated by kanuka (*Kunzea ericoides*) and fivefinger (*Pseudopanax arboreus*) is the most common vegetation type. Kapiti I. was gazetted a Nature Reserve in 1897 (Maclean 1999).

Cattle (*Bos taurus*), sheep (*Ovis aries*), goats (*Capra hircus*), pigs (*Sus scrofa*) and feral cats (*Felis catus*) were eradicated from Kapiti I. between 1916 and 1934. Possums were eradicated in 1986. The eradication of Norway rats (*Rattus norvegicus*) and kiore (*Rattus exulans*) in 1996 cleared the island of its last introduced mammalian pests. Several endangered bird species including North Island saddleback, NI kokako, hihi (*Notiomystis cincta*), takahe (*Porphyrio*

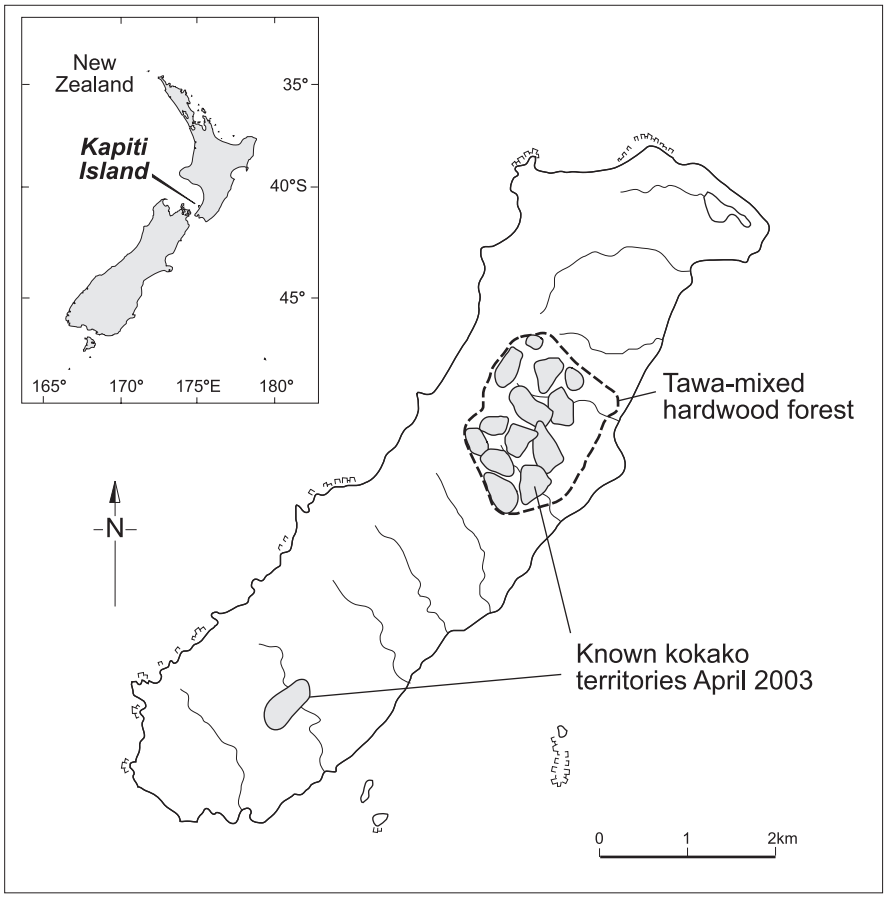

Figure 2. Map of kokako territories and mature hardwood forest on Kapiti I. in April 2003.

mantelli) and little spotted kiwi (*Apteryx owenii*) have since been introduced to the island, which now boasts prolific birdlife and healthy forest and attracts about 10 000 visitors a year (Maclean 1999).

3. Kokako translocations

Altogether 32 kokako were translocated to Kapiti I. between 1991 and 1997 (Table 1, Appendix 1). Twelve adult kokako of unknown age and sex (though subsequent analysis suggests that 10 were probably males) were sourced from various remnant mainland populations at Te Rauamoa (Waikato, four birds), Hauturu (Waikato, one bird), Manawahe (Bay of Plenty, five birds) and Makino (Taranaki, two birds) and translocated to Kapiti I. between 11 December 1991 and 7 April 1994. Seven kokako were translocated from Little Barrier I. between 15 June 1995 and 14 March 1996 (Fig. 1). The Little Barrier I. kokako population was itself established from up to 32 kokako from the Waikato and Rotorua regions, translocated between 1981 and 1988 (Brown 1989). Five young birds were sourced for Kapiti I. from Mapara Wildlife Reserve (a managed mainland population) between 25 October 1996 and 8 November 1996. Mount Bruce National Wildlife Centre also contributed one old bird (Grandma) and seven juveniles from the captive breeding programme between 14 September 1994 and 24 January 1997. The Mount Bruce birds were progeny of birds sourced from the Rangitoto Ranges (Waikato) and Te Rauamoa (Waikato).

TABLE 1. NUMBERS OF KOKAKO TRANSFERRED FROM DIFFERENT SOURCE POPULATIONS AND ISLAND-BRED THAT WERE PROBABLY PRESENT ON KAPITI I. IN APRIL 2002.

SOURCE POPULATION & DATES OF TRANSLOCATION	NO. TRANSFERRED & ISLAND-BRED	NO. RECORDED, KAPITI I. 2001/02
Central North Island forest remnants (1991–94)	12	0
Little Barrier Island (1995–96)	7	3
Mount Bruce National Wildlife Centre (1995–96)	8	2*
Mapara (1996)	5	5
Kapiti Island-bred (1994–2002)	31	29
TOTAL	63	39

* Two birds not seen over the 2001/02 breeding season (Tane & Aruhe) were subsequently seen on 26 November 2002.

4. Methods

4.1 CAPTURE AND TRANSLOCATION TECHNIQUES

Kokako were caught in mist-nets (with pockets) hung in canopy gaps within the forest and kokako lured into them using pre-recorded song (Flux & Innes 2001a). They were fed high-energy sugar/fruit water drinks and transported from the capture sites to holding aviaries in well-ventilated and secure boxes. Kokako were subsequently transported by car and then boat to Kapiti I. where they were hand-released (Flux & Innes 2001a) soon after arrival.

4.2 BANDING AND TRANSMITTERS

All kokako released on Kapiti I. were banded using 'E' size stainless steel metal bands and various coloured plastic bands so that each individual bird had a distinctive band combination. Most nests were climbed to and chicks banded between 10 and 20 days of age but not all chicks were banded before fledging. Transmitters attached as 'backpacks' using 2 mm diameter soft, spun-polyester braid (Flux & Innes 2001a) were placed on a total of 19 kokako (prior to their arrival on Kapiti I.) to monitor movements, survival and breeding attempts.

4.3 POPULATION CENSUS AND ROLL CALLING

Walk-through surveys to census the kokako population have been carried out in most years since 1994. They involved walking the main tracks on Kapiti I., stopping every 200–300 m, listening for song and if none was heard playing mew calls and song tape. The locations of kokako seen and heard were recorded and individual band combinations were also recorded (Flux & Innes 2001a).

Roll calling was used to monitor survival of individual adult territorial kokako during the aerial poisoning operation to eradicate rats. Territories were mapped and individuals relocated before and after the poison operation (Empson & Miskelly 1999).

4.4 TERRITORY MAPPING AND MONITORING BREEDING SUCCESS

Kokako are territorial, and pairs establish in discrete areas of four to 14 ha (Innes & Flux 1999). Individuals and pairs were located and followed over repeat visits and their movements were mapped (each season) until the boundaries of their territory were roughly defined. Nests were located by close observation of different behaviours (e.g. nest building, secretive behaviour, male carrying food to an incubating female, and both birds carrying food to chicks). Once nests were located, the frequency and nature of visits enabled the observer to monitor the nesting attempt, and the fledging of chicks provided the measure of nesting success (Flux & Innes 2001a).

Intensive monitoring of kokako on Kapiti I. commenced in 1994 (Brown unpubl. 1995; McGirr unpubl. 1996; Moore unpubl. 1997; Thurley unpubl. 1998; Clearwater & Moorcroft unpubl. 1999; Clearwater unpubl. 2000; Gorman et al. unpubl. 2001; Gorman & Moorcroft unpubl. 2002, 2003).

5. Results

5.1 KOKAKO POPULATION SIZE, 2002 AND 2003

Thirty-nine kokako, including eight pairs, were thought to be present on Kapiti I. in April 2002 (Table 1). At least 35 kokako, including 14 pairs and seven young single birds were present in April 2003 (Gorman & Moorcroft unpubl. 2003).

5.2 KOKAKO SURVIVORSHIP AND LIKELY CAUSES OF MORTALITY

Only 10 of 32 translocated kokako remained on Kapiti I. in April 2002 (Table 1).

It is likely that none of the 12 kokako introduced to Kapiti I. prior to 1995 is still present. Five birds were not seen following their release and fates are only known for two of the remaining birds: Buzz was found partially eaten on her nest and was probably preyed on by a harrier hawk (*Circus approximans*); Manu was relocated from Kapiti I. to Otorohanga Kiwi House to break up a male/male pair bond in an attempt to promote further breeding of Taranaki kokako to preserve Taranaki kokako genes.

Only three (Feisty, Sapida, and Funf) of seven kokako translocated from Little Barrier I. were known to be alive on Kapiti I. in April 2002. The fate of the remaining four Little Barrier kokako (two of which were female) is unknown, but they disappeared about the time of the rat eradication programme.

Five of the eight Mount Bruce birds were possibly alive on Kapiti I. in April 2002. Only two birds were sighted during the 2001/02 breeding season. Tane and Aruhe, though not sighted then, were sighted on 26 November 2002. Te Rangi was last seen in 2001 and may have been alive in April 2002. Of the remaining three birds, Grandma was found dead soon after transfer and probably died due to the stress of transfer; Koha and Te Rongopai are presumed dead.

All five Mapara kokako were alive in April 2002 and 29 of 31 kokako fledged on Kapiti I. were also alive in April 2002. Of the Kapiti-bred birds Awhero has not been seen since 1994 and Oracle since 2000. Awhero is presumed dead, while Oracle may be present but undetected.

The proportions of kokako from different sources that constitute the Kapiti I. kokako population have changed dramatically through time, with increasing importance of young kokako bred on the island itself (Fig. 3).

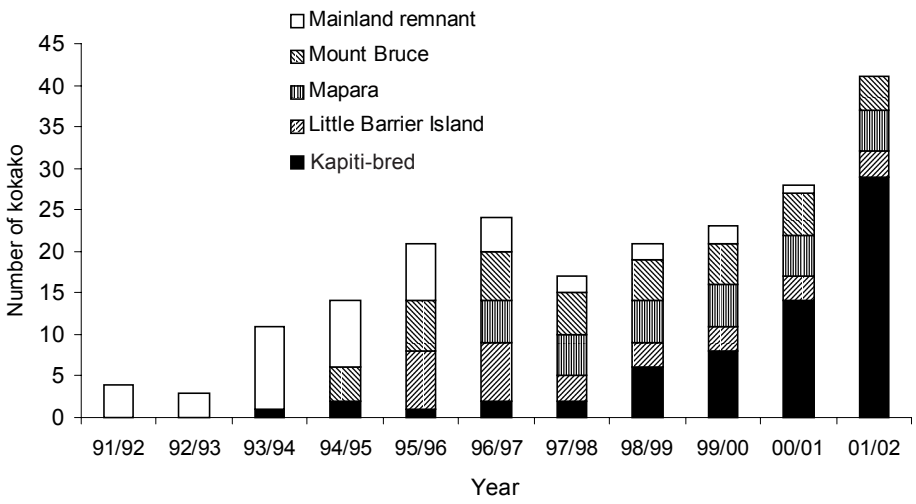

Figure 3. Change in the proportion of kokako from different source populations on Kapiti I. between 1991 and April 2002.

5.3 KOKAKO PRODUCTIVITY

5.3.1 Number of pairs attempting to breed

The number of pairs attempting to breed per season on Kapiti I. has increased from one in 1993/94 to at least seven in 2001/02 as the number of male/female pairs has increased (Table 2). Only one of four pairs attempted to breed over the 1995/96 breeding season and no chicks were produced. One pair was assumed to have been a male/male pair and two pairs established late in the season. The one pair that attempted to breed lost the female (preyed on at the nest). At this stage only two chicks were known to have fledged on Kapiti I. and one of these had not been seen since January 1994.

TABLE 2. KAPITI I. KOKAKO BREEDING ATTEMPTS AND CHICKS FLEDGED BETWEEN 1993/94 AND 2001/02 AND ORIGINS OF PARENT BIRDS.

SEASON	NO. OF PAIRS	NO. OF PAIRS ATTEMPTING	NO. OF ATTEMPTS	SUCCESSFUL PAIRS, ATTEMPTS	CHICKS FLEDGED	PARENT BIRDS' ORIGIN*
1993/94	2	1	?	1, 1	1	Bay of Plenty (1 probable)
1994/95	2	1	1	1, 1	1	Bay of Plenty (1)
1995/96	4	1	1	0, 0	0	N/A
1996/97	3	1	1	1, 1	1	Little Barrier I. (1)
1997/98	5	1	1	0, 0	0	N/A
1998/99	7	6	12	3, 4	4	Mapara (3) Mount Bruce/Kapiti I. (1)
1999/00	7	4	5	2, 2	2	Little Barrier I. (1) Mapara (1)
2000/01	8	6	7	5, 5	7	Little Barrier I. (1) Mapara (4) Kapiti I./Mount Bruce (2)
2001/02	9	7	14	6, 10	15	Little Barrier I. (3) Mapara (6) Kapiti I./Mapara (2) Kapiti I./Mount Bruce (4)

* (*n*) = Number of fledged chicks of that parentage

The initial lack of females and the subsequent disappearance of some (preyed on and possibly poisoned) meant that only one pair attempted to breed (fledging one chick) in the 1996/97 season. Of the three pairs present that year one was male/male and a second was recently formed. Only one of five pairs attempted to breed over the 1997/98 season, primarily due to a poor fruiting year.

The breakthrough for kokako productivity on Kapiti I. occurred over the 1998/99 breeding season, when six of seven pairs attempted to breed and four chicks fledged. Subsequently four of seven pairs attempted to breed over the 1999/2000 season (two chicks fledged), six of eight pairs over the 2000/01 season (seven chicks fledged) and seven of nine pairs over the 2001/02 season (15 chicks fledged) (Table 2; Appendix 2).

5.3.2 Number of chicks fledged per successful nest

The number of chicks fledged per successful nest on Kapiti I. was initially low (1.55 chicks/nest) compared with Mapara (1.96 chicks/nest). A sample of 16 nests was closely monitored between 1994 and 2000. From these, only 13 eggs hatched (from an unknown number laid) and eight chicks fledged. Known egg fates include that three were preyed on, one was tipped out of the nest by tree fern growth, and six were either infertile or the embryo died. Of the five chicks that failed to fledge, two died in the nest and the other three outcomes are unknown, but two chicks were considerably lighter in weight than their siblings. A harrier hawk and a long-tailed cuckoo (*Eudynamys taitensis*) are thought to be responsible for the two known predation events.

Productivity per nest has increased dramatically since then, with five pairs fledging two chicks per nest on seven occasions over the 2000/01 and 2001/02 seasons. No pairs fledged more than one chick prior to 2000/01. As a consequence, the total number of chicks fledged increased from nine by April 2000 to 31 by April 2002 (Table 2).

5.3.3 Origins of kokako that formed pairs

Thirteen pairs of kokako formed between October 1993 and January 2002 (Table 3). Eight pairs were of birds from the same source populations, four pairs included a Kapiti-bred bird and only one pair consisted of birds with different origins (excluding pairs with a Kapiti-bred bird).

TABLE 3. KAPITI I. KOKAKO PAIRS, DURATION OF PAIRING, SEX, ORIGINS, STATUS AND BREEDING SUCCESS.

YEAR	NAME	SEX	ORIGINS	COMMENTS
1993–96	Rua	M	Manawahe	Pair remained together until the female was preyed on at the nest. Fledged 2 chicks.
	Buzz	F	Manawahe	
1992–2000	Manu	M	Taranaki	Male/male pair. Manu transferred to Otorahonga on 4 May 2000.
	Lexxi	M	Taranaki	
1996	Bonny	M	Te Rauamoa	Probable pair. No observed breeding. Pair disappeared at time of poison drop.
	Consolation	F	Little Barrier I.	
1995–2002	Toro	M	Kapiti I.	Fledged 3 chicks.
	Te Wharekohu	F	Mount Bruce	
1996–2002	Feisty	M	Little Barrier I.	Fledged 6 chicks.
	Funf	F	Little Barrier I.	
1997–2002	Aruhe	M	Mount Bruce	Pair not found over 2001/02 but re-located in 2002/03. Siblings. No observed breeding.
	Tane	F	Mount Bruce	
1997–2002	Phaethon	M	Mapara	Fledged 6 chicks.
	Gelsemeum	F	Mapara	
1998–2002	Theca	M	Mapara	Fledged 8 chicks.
	Delphi	F	Mapara	
1998–2002	Te Mauri	M	Mount Bruce	Fledged 4 chicks.
	Bilbo	F	Kapiti I.	
2000–02	Rapunzel	M	Mapara	Fledged 2 chicks.
	Amadeus	F	Kapiti I.	
2000–02	Kennedy	M	Kapiti I.	No observed breeding.
	Sapida	F	Little Barrier I.	
2001/02	Jarinda	M	Kapiti I.	Unsuccessful breeding attempt in 2001/02.
	Aleisi	F	Kapiti I.	
2001/02	Enigma	?	Kapiti I.	No observed breeding.
	Koekoea	?	Kapiti I.	

6. Discussion

6.1 MALE BIAS IN INITIAL TRANSFERS

Translocations of 12 kokako from unmanaged remnant mainland populations resulted in only one pair that bred successfully. The most likely explanation for this low productivity is that the translocated birds were predominantly males (females incubate and are therefore vulnerable to predation on the nest) and potentially old (intense predation limits recruitment of young and can even prevent it at unmanaged sites on the mainland; Innes et al. 1999). Male and female kokako are visually indistinguishable, but more recent analysis of morphometric data strongly suggests that all but two of the 12 early translocations were male birds (Flux & Innes 2001b).

The poor breeding success from the early translocations, together with a developing ability to gender birds by morphometrics, led the Kokako Recovery Group (KRG) to review the use of birds from remnant sites (KRG unpubl. data). The Group responded by transferring predominantly young birds (including known females) from captivity (Mount Bruce National Wildlife Centre), or healthy breeding populations (Mapara Wildlife Reserve and Little Barrier I.) to Kapiti I. between September 1994 and January 1997.

This management response was critical, as it allowed new pairs to establish and successfully breed so that a viable population (at least 25 pairs) of kokako could establish. At least 14 pairs of kokako are now established on Kapiti I. (Gorman & Moorcroft unpubl. 2003).

6.2 IMPACTS OF 1996 POISON DROP

Two aerial poison operations were conducted in September and October 1996 to eradicate Norway rats and kiore from Kapiti I. (Aikman unpubl. 1997; Empson & Miskelly 1999). The risk to kokako was assessed prior to the eradication operation and thought to be very low, as 293 kokako had previously been monitored through 1080 cereal bait poison operations, and only four had disappeared at the time of monitoring (Flux & Innes 2001a). The Kapiti I. operation differed from previous monitored operations because brodifacoum was used as the toxin rather than 1080, and cinnamon (a bird repellent) was not added to the bait due to the potential risk of deterring the target rodent species (Empson & Miskelly 1999).

The Kapiti I. rat eradication undoubtedly benefited a wide range of species (Empson & Miskelly 1999). However, six kokako that disappeared around the time of the rat eradication may have been poisoned, but monitoring (Flux & Innes 2001a) was not intense enough to provide confidence that this was the cause. However, Empson & Miskelly (1999) report the disappearance of two kokako (presumed to have been accidentally poisoned) of eleven monitored. Therefore, the impacts of the 1996 rat eradication on kokako are not clear.

However, the disappearance of two females left only three known females, two of which had produced a total of nine fledglings as of April 2002.

6.3 MATE-CHOICE IN RELATION TO DIALECT

Translocated kokako on Kapiti I. appeared to select mates from the same source populations, and such pairings have occurred sooner than those between birds of mixed origin (Rowe unpubl. 2002). Where mixed origin pairings have occurred, one member has usually been a young bird from Kapiti I. Detailed monitoring enabled this pattern to be detected. Rowe (unpubl. 2002) suggests that young Kapiti-bred birds have paired with translocated birds because they have learnt elements of the translocated birds' song. The inability of translocated birds to find mates with the same song dialect could hinder the establishment of new populations, at least in the short term until young locally bred birds become available.

The translocation of kokako (and potentially other songbird species) from as few source populations as possible would optimise the chances of establishing a self-sustaining population because birds should more easily find mates. Males and females from the same source population should be translocated to mainland populations such as at Puketi (Northland), where only males remain. Although translocated females would be unlikely to choose Puketi males as mates (preferring males from the same source population), their female offspring would probably pair with Puketi males (Stephanie Rowe pers. comm.), thereby preventing the loss of Puketi kokako genes.

6.4 PRODUCTIVITY AND FOOD AVAILABILITY

Not all kokako pairs attempt to breed in all seasons, and productivity per pair varies greatly between seasons due to differences in food availability (Innes & Flux 1999). Early prolonged fruiting and flowering can result in early, prolonged breeding and increased fledging rates. Extended prolific fruiting and flower years on Kapiti I. (1998/99 and 2001/02) resulted in most pairs attempting to breed and 19 chicks successfully fledging (Clearwater & Moorcroft unpubl. 1999; Gorman & Moorcroft unpubl. 2002). Seven chicks also fledged over the 2000/01 season despite a short (though prolific fruiting and flowering) season because most pairs that attempted to breed were successful with their first attempts (Gorman et al. unpubl. 2001). In contrast, the 1997/98 and 1999/2000 seasons were short, with limited fruiting and flowering, and few pairs attempted breeding and only two chicks were produced (Thurley unpubl. 1998; Clearwater unpubl. 2000).

6.5 POOR PRODUCTIVITY PER NEST

Intensive monitoring of nesting attempts, including measures of clutch size, hatch rate, fledging rates of hatched chicks (rather than fledging rates per nest or per season) and reasons for failure of nesting attempts, are needed to accurately explain productivity per nest. Reasons for failure of nesting attempts are notoriously difficult to determine with confidence (Brown et al. 1998) and only partial information has been obtained on clutch size, hatch rate, and fledging rates on Kapiti I. Predation rates, food quality and quantity (see above), breeding experience, and natural events (e.g. storms and tree fern growth) can all influence productivity.

Predation of eggs, chicks and incubating females is a major factor threatening kokako populations on mainland sites (Innes et al. 1999). Kapiti I. has no mammalian predators, but potential avian predators include harrier hawk, morepork (*Ninox novaeseelandiae*) and long-tailed cuckoo. Harriers and long-tailed cuckoos have been suspected of nest predation on various occasions, but predation rates do not appear to be high. A harrier hawk was observed unsuccessfully attacking a kokako nest, and predation sign left at another nest was consistent with that of a harrier. Also, female kokako were observed chasing long-tailed cuckoos away from their nests on at least two occasions on Kapiti I.

Low numbers of eggs produced per nesting attempt, low egg hatching rates, and chick deaths in the nest have contributed to the low productivity of kokako on Kapiti I. Successful attempts produced only single chicks per clutch prior to the 2000/01 breeding season on Kapiti I., but pairs frequently fledge two or three chicks per nest at mainland sites (Innes & Flux 1999). Seven of 14 successful attempts have fledged two chicks in the 2000/01 and 2001/02 breeding seasons but no nests have fledged three chicks. The reasons for the generally low but improving productivity per nest on Kapiti I. are not clear.

6.6 RELATIVE IMPORTANCE OF LIMITING FACTORS

6.6.1 Breeding females

Breeding females are critical to the establishment of any population. Probably only two of the 12 birds from remnant populations were female. Only one of these survived to breed and she was preyed on during her third breeding season, having produced only two young, one of which disappeared while the other was a male. Therefore a population of kokako would not have established on Kapiti I. if no more than the 12 birds from remnant mainland populations had been translocated. A population of kokako did establish on Little Barrier I. from between 28 and 32 birds (the records are incomplete) translocated from mainland sites, probably including six females (Ian Flux pers. comm.). Further translocations of kokako from remnant populations (with few if any females) might not have resulted in kokako establishing on Kapiti I.

6.6.2 Rat eradication operations

It is not possible to determine if kokako were poisoned during rat eradication operations. The worst-case scenario is that two females were killed leaving three known females, two of which subsequently bred producing nine fledglings (sex ratio unknown). Therefore, even in the worst-case scenario, mortality from rat eradication operations would probably not have prevented the establishment of kokako on Kapiti I.

6.6.3 Dialect-determined mate choice

Kokako pairing may have been slowed because of the lack of potential mates with similar song (Rowe unpubl. 2002) although pairs still established between birds from the same origin and those of mixed origin (mostly including Kapiti-bred birds). Therefore dialect-determined mate choice did not significantly limit the establishment of a kokako population on Kapiti I.

6.6.4 Relatively low productivity

Kokako productivity was considered to have been affected by seasonal variation in food availability, as on the mainland, but egg production and egg and chick survival appeared to be lower than at Mapara and other mainland sites. The reasons for this are not clear. However, relatively low productivity has not prevented a steady increase in the number of females, breeding pairs, and chicks fledged. Therefore, although relatively low productivity may have slowed kokako establishment on Kapiti I., it has not prevented it.

6.7 LONG-TERM VIABILITY AND CARRYING CAPACITY

The establishment of a viable kokako population on Kapiti I. seems assured now that 14 pairs and at least seven young birds were present in April 2003 (Gorman & Moorcroft unpubl. 2003). The kokako population in Mapara Wildlife Reserve was recovered from five pairs, using intensive pest control (Bradfield & Flux unpubl. 1996). Trends such as the increasing number of pairs, improved sex ratio and balanced age structure all bode well for the establishment of a healthy kokako population on Kapiti I.

Low genetic variability was reported from several kokako populations (Hudson et al. 2000), but was debated by Double & Murphy (2000). Genetic theory suggests that, in isolated populations without migration, genetic drift and inbreeding can further reduce genetic variability and lead to inbreeding depression, which may have deleterious effects (Frankham 1995; Lacy 1997). However, Craig (1990) argued that many New Zealand bird populations have passed through small population bottlenecks without deleterious effects and that small populations are not necessarily at risk from inbreeding depression. The varied sources of the Kapiti I. kokako population should provide sufficient genetic variability to minimise the risk of inbreeding depression in the short to medium term. Future translocations could be carried out to further increase genetic variability if the Kapiti I. kokako population declined and inbreeding depression was thought to be the cause.

The carrying capacity of Kapiti I. for kokako is hard to determine because territory size and the extent of suitable habitat there is unknown. Also carrying capacity will change as the island's vegetation regenerates after a history of farming and burning. Mixed hardwood tawa habitat is limited to approximately 200 ha (10% of the island) (Fig. 2), kanuka (*Leptospermum ericoides*) and kohekohe forest constitutes approximately 600 ha (30%), and low vegetation, wetlands and shrublands make up the remaining 1165 ha (60%).

Kokako can establish territories in different habitats, and the average territory size decreases as populations increase. For example, on Tiritiri Matangi I. kokako live and breed in a mixed environment of introduced wattle (*Racosperma* sp.) forest and native shrubland. However, mainland populations and Little Barrier I. kokako favour mature diverse forests (Innes & Flux 1999). Territory size is extremely variable, but assuming an average territory size of 8 ha, as at Mapara, Kapiti I. should support at least 25 pairs in the mature mixed hardwood tawa forest (where nearly all kokako have established territories). Pairs may also establish in less complex forest as have Tane and Aruhe (Fig. 2).

6.8 MONITORING AND LESSONS FOR OTHER TRANSLOCATIONS

Monitoring can be expensive initially but cost-effective in the long-term. Monitoring of kokako on Kapiti I. proved valuable because it detected the initial absence of breeding; it then provided information that indicated possible reasons for this and thereby triggered the translocation of young female kokako that enabled the potential establishment of a viable population in due course. Blood testing (to determine sex) has subsequently been developed (Double & Murphy 2000) and could be used to select individuals for future translocations.

In addition, monitoring was used in an attempt to measure the impact of the rat eradication on kokako. Despite the unknown number of kokako killed, it seems that future aerial operations in which baits lack cinnamon would need to take risks to kokako into consideration. Operations with such baits are not carried out on the mainland, and Little Barrier I. is the only island kokako population where rat eradication is intended. Little Barrier I. has a large kokako population (Innes & Flux 1999) that is unlikely to be at risk from a poison operation to eradicate rats. Nevertheless, individuals will be at risk, and a sample of the population should be monitored to properly assess the impact of such an operation.

The importance of vocalisation to mate choice was identified through monitoring, and subsequently attracted research effort. The results from Kapiti I. (supported by extensive international research) suggest that kokako (and potentially other songbird species) should be translocated from as few source populations as possible to maximise the chances of pairs forming and populations establishing (Rowe unpubl. 2002).

This paper illustrates the variety of risks for establishment of small translocated populations. Although many translocations have been successful without monitoring, many have failed (Duncan & Young 1999). From our experience of

translocation of kokako on Kapiti I, we believe that robust monitoring is essential to support, justify and direct management and minimise the risk of failure.

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Appendix 1

ORIGIN AND STATUS (APRIL 2002) OF KAPITI ISLAND KOKAKO

NAME	SEX*	SOURCE	RELEASED/ FLEDGED	COMMENTS	LAST SEEN ALIVE†
Bonny	M	Te Rauamoa	11 Dec 91	Paired with Consolation. Disappeared at time of poison drop.	31 Aug 96
Clyde	M	Te Rauamoa	11 Dec 91	Presumed dead.	(at release)
Dirk	M	Te Rauamoa	23 Dec 91	Presumed dead.	(at release)
Mist	M	Hauturu trig	23 Dec 91	Paired with Koha. Presumed killed by poison drop.	18 Sep 96
Houdini	M	Te Rauamoa	7 Feb 93	Presumed dead.	17 Oct 94
Rua	M	Manawahe	7 Mar 93	Paired with Buzz. Presumed dead.	18 Apr 96. Possibly 26 Jul 96
Punga	M	Manawahe	7 Mar 93	Presumed dead.	(at release)
Buzz	F	Manawahe	7 Mar 93	Paired with Rua. Killed on nest. Found dead Dec 95.	17 Sep 95
Bumble	M	Manawahe	7 Mar 93	Presumed dead.	7 Mar 93 (release)
Manu	M	Taranaki	1 Sep 93	Transferred to Otorahonga to split male/male pair bond with Lexxi.	Removed 4 May 2000
Lexxi	M	Taranaki	1 Sep 93	Male previously paired with Manu (another male). Presumed dead.	11 Apr 2001
Rereatu	F	Manawahe	7 Apr 94	Presumed dead.	(at release)
Grandma	F	Mount Bruce	14 Sep 94	Found dead soon after transfer 4 Oct 94.	16 Sep 94
Koha	F	Mount Bruce	14 Sep 94	Paired with Mist. Presumed dead.	23 Nov 95
Awhero	?	Kapiti I.	Jan 94	Young of Rua and Buzz. Presumed dead.	5 Dec 94
Toro	M	Kapiti I.	Jan 95	Young of Rua and Buzz. Paired with Te Wharekohu.	Alive
Aruhe	M	Mount Bruce	2 May 95	Paired with Tane (sibling). Not seen over the 2001/02 season.	Alive, 26 Nov 2002
Tane	F	Mount Bruce	2 May 95	Paired with Aruhe (sibling). Not seen over the 2001/02 season.	Alive, 26 Nov 2002
Consolation	F	Little Barrier I.	15 Jun 95	Paired with Bonny. Presumed killed by poison drop.	31 Aug 96
Peter	M	Little Barrier I.	15 Jun 95	Disappeared at time of poison drop.	18 Sep 96
Te Wharekohu	F	Mount Bruce	22 Sep 95	Female paired with Toro.	Alive
Agathis	F?	Little Barrier I.	7 Mar 96	Disappeared at time of poison drop.	29 Jun 96
Feisty	M	Little Barrier I.	7 Mar 96	Paired with Funf.	Alive
Sapida	F	Little Barrier I.	7 Mar 96	Paired with Kennedy.	Alive
Jammy	?	Little Barrier I.	14 Mar 96	Disappeared at time of poison drop.	12 Aug 96
Funf	F	Little Barrier I.	14 Mar 96	Paired with Feisty.	Alive
Te Rangi	?	Mount Bruce	18 Mar 96	Not seen over the 2001/02 season.	28 Jan 2001
Te Rongopai	?	Mount Bruce	18 Mar 96	Presumed dead. Moving signal 5 Jan 97.	5 Sep 96
Theca	M	Mapara	25 Oct 96	Paired with Delphi.	Alive
Delphi	F	Mapara	8 Nov 96	Paired with Theca.	Alive
Rapunzel	M	Mapara	8 Nov 96	Previously paired with Delphi. Paired with Amadeus.	Alive
Phaethon	M	Mapara	8 Nov 96	Paired with Gelsemeum.	Alive
Gelsemeum	F	Mapara	8 Nov 96	Paired with Phaethon.	Alive
Bilbo	F	Kapiti I.	Jan 97	Young of Feisty and Funf. Paired with Te Mauri.	Alive

NAME	SEX*	SOURCE	RELEASED/ FLEDGED	COMMENTS	LAST SEEN ALIVE†
Te Mauri	M	Mount Bruce	24 Jan 97	Paired with Bilbo.	Alive
Kennedy	M	Kapiti I.	Jan 99	Young of Phaethon and Gelsemeum. Paired with Sapida.	Alive
Oracle	?	Kapiti I.	Feb 99	Young of Delphi and Theca. Presumed dead.	1 Mar 2000
Amadeus	F	Kapiti I.	Jan 99	Young of Bilbo and Te Mauri. Paired with Rupunzel.	Alive
Aleisi	F	Kapiti I.	Mar 99	Young of Phaethon and Gelsemeum. Paired with Jarinda.	Alive
Enigma	?	Kapiti I.	Dec 99	Young of Feisty and Funf. Paired with Koekoea.	Alive
Jarinda	M	Kapiti I.	Jan 00	Young of Delphi and Theca. Paired with Aleisi.	Alive
Koekoea	?	Kapiti I.	Jan 01	Young of Feisty and Funf. Paired with Enigma.	Alive
Thor	?	Kapiti I.	Jan 01	Young of Phaethon and Gelsemeum.	Alive
Cruzon	?	Kapiti I.	Jan 01	Young of Phaethon and Gelsemeum.	Alive
Malvina	?	Kapiti I.	Jan 01	Young of Delphi and Theca. Paired with Hauman.	Alive
Mulder	?	Kapiti I.	Jan 01	Young of Delphi and Theca.	Alive
Hanuman	?	Kapiti I.	Jan 01	Young of Bilbo and Te Mauri. Paired with Malvina.	Alive
Tarawera	?	Kapiti I.	Feb 01	Young of Toro and Te Wharekohu.	Alive
Harry	?	Kapiti I.	Jan 02	Young of Gelsemeum and Phaethon.	Alive
Figaro	?	Kapiti I.	02	Young of Amadeus and Rapunzel.	Alive
Vigga	?	Kapiti I.	02	Young of Toro and Te Wharekohu.	Alive
Burgoo	?	Kapiti I.	02	Young of Toro and Te Wharekohu.	Alive
Arampa	?	Kapiti I.	Mar 02	Young of Gelsemeum and Phaethon.	Alive
Dougal	?	Kapiti I.	02	Young of Bilbo and Te Mauri.	Alive
Zebedy	?	Kapiti I.	02	Young of Bilbo and Te Mauri.	Alive
Apollo	?	Kapiti I.	Apr 02	Young of Delphi and Theca.	Alive
Fortuna	?	Kapiti I.	Apr 02	Young of Delphi and Theca.	Alive
Giovanni	?	Kapiti I.	Apr 02	Young of Amadeus and Rapunzel.	Alive
Gaza	?	Kapiti I.	Apr 02	Young of Feisty and Funf.	Alive
Unnamed 1	?	Kapiti I.	Jan 02	Young of Delphi and Theca.	Alive
Unnamed 2	?	Kapiti I.	Jan 02	Young of Delphi and Theca.	Alive
Unnamed 3	?	Kapiti I.	Feb 02	Young of Feisty and Funf.	Alive
Unnamed 4	?	Kapiti I.	Feb 02	Young of Feisty and Funf.	Alive

* Estimated from leg measurements or known from observed breeding activity

† Believed alive if seen over the 2001/02 breeding season

Appendix 2

KNOWN NESTING HISTORY OF KAPITI ISLAND KOKAKO

PAIR	SEASON	NEST	NO. OF EGGS	NO. OF CHICKS	NO. OF KNOWN FLEDGED	CHICKS/FATE
Rua/	1993/94	?	?	?	1	Awhero
Buzz	1994/95	1	1	1	1	Toro
	1995/96	1	?	0	0	Failed during incubation.
		2	1	0	0	Nest predation.
Feisty/	1996/97	1	2	2	1	Bilbo fledged, Goblin missing.
Funf	1997/98	1	?	0	0	Failed during incubation.
	1998/99	1	?	0	0	Failed during incubation.
		2	1	0	0	Nest tipped.
		3	?	0	0	Failed during incubation.
	1999/00	1	1	1	1	Enigma
	2000/01	1	2	1	1	Koekoea
	2001/02	1	?	?	2	Unnamed 3 & 4
		2	?	?	1	Gaza
Toro/	1998/99	1	1	0	0	Abandoned after laying.
Te Wharekohu		2	?	0	0	Possible predation.
	1999/00	1	2	0	0	Probable predation.
	2000/01	1	2	1	1	Tarawera
	2001/02	1	?	?	2	Vigga, Burgoo
		2	2	2	0	Windsor did not fledge.
Bilbo/	1998/99	1	1	1	0	Haggis (missing)
Te Mauri		2	1	1	1	Amadeus
	1999/00	1	1	1	0	Tempest (died in nest)
		2	?	0	0	Failed during incubation.
	2000/01	1	1	1	1	Hanuman
	2001/02	1	2	0	0	Probable predation.
		2	?	0	0	Failed (cause unknown).
		3	?	?	2	Dougal, Zebedy
Delphi/	1998/99	1	1	1	1	Oracle
Theca	1999/00	1	2	1	1	Jarinda
	2000/01	1	2	2	2	Malvina, Mulder
	2001/02	1	?	?	2	Unnamed 1 & 2
		2	?	?	2	Apollo, Fortuna
Phaethon/	1998/99	1	2	1	1	Kennedy
Gelsemeum		2	2	2	1	Aleisi (fledged), Rhapsody (missing)
	2000/01	1	2	2	2	Thor, Cruzon
	2001/02	1	?	?	1	Harry
		2	?	?	1	Arampa

PAIR	SEASON	NEST	NO. OF EGGS	NO. OF CHICKS	NO. OF KNOWN FLEDGED	CHICKS/FATE
Tane/	1998/99	1	3	0	0	Failed during incubation.
Aruhe		2	1	1	0	Chick died in nest.
	2000/01	1	?	0	0	Both nests failed after incubation
		2	?	0	0	commenced.
Amadeus/	2001/02	1	?	?	1	Figaro
Rapunzel		2	?	?	1	Giovanni
Aleisi/	2001/02	1	1	0	0	Infertile or predation.
Jarinda						