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"Acoustic anchoring" and the successful translocation of North Island kokako (*Callaeas cinerea wilsoni*) to a New Zealand mainland management site within continuous forest

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Abstract In Jul and Aug 2005, 18 North Is kokako (*Callaeas cinerea wilsoni*) were released into a 450-ha area of New Zealand native forest subject to intensive control of introduced mammalian predators. The area, Ngapukeriki (near Omaio, Bay of Plenty, New Zealand), lies within a 13,000-ha matrix of native and exotic forest subject to lower and variable degrees of predator control. In contrast to most previous kokako translocations, this project employed 3 tactics to maximise the likelihood that kokako would remain in the target area: 1) many birds were released in a short period; 2) playback of kokako song was broadcast in the release area (potentially creating an "acoustic anchor"); and 3) a kokako pair was held at the release site in an aviary. Most birds approached to within 20 m of playback speakers, some approaching repeatedly. Several interactions between released birds were observed, including vocal interactions and instances of birds associating with one another temporarily. Visits to the aviary pair were rare. On 13 Apr 2006, all 8 trackable birds and 4 birds whose transmitters had failed remained in the core management area; locations of remaining birds (with lost or non-functional transmitters) were unknown. At least 5 territorial pairs had formed, and 1 chick was known to have fledged. To our knowledge, this was the 1st time song playback had been used as an attractant in a terrestrial bird reintroduction.

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INTRODUCTION

The endangered North Is kokako (*Callaeas cinerea wilsoni*) is one of New Zealand's iconic, endemic forest birds, known for its beautiful song. Once widespread throughout the North I, they are now restricted to scattered populations in forest patches and on offshore islands. Their dramatic decline, caused by loss of habitat and predation by introduced mammals, triggered efforts to save them from extinction beginning in the 1980s (Innes & Flux 1999).

These efforts, in particular intensive predator control programs, have allowed kokako numbers to increase in most remaining populations

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(Bradfield & Flux 1996; Innes & Flux 1999; Innes *et al*. 1999; Burns *et al*. 2000). As these populations have expanded, interest has also grown in the possibility of re-establishing populations of kokako elsewhere. Where suitable habitat is available and predator numbers can be controlled, self-sustaining populations of kokako can be established; the species' attractive song and significant public profile make it a desirable species for community groups engaged in the establishment and management of native forest reserves. In the late 1990s, the New Zealand Department of Conservation began translocating kokako to areas away from those supporting the residual populations. Most recipient areas have been islands – in some instances, literal islands such as Kapiti I (off the southwestern coast of the North I, or Tiritiri Matangi (Hauraki Gulf, northern North I). Kokako have also been released to 2 "habitat islands," Boundary Stream Mainland Island (802 ha) and Pukaha/Mt Bruce Wildlife Reserve (945 ha), which are both relatively small, isolated patches of forest that kokako, being poor fliers, cannot colonise naturally and are unlikely to leave. In reintroductions to such islands or island-like systems, the "safe" managed area constitutes the whole "island" and dispersal is of little concern.

Another possibility for translocation is to introduce kokako into "management islands," areas of habitat with intensive predator control which are contiguous with areas of unmanaged forest. The difficulty with this type of translocation is that kokako released in the managed area can wander widely (see Appendix) and they may leave the safety of the predator-control area. In such situations, the problem is in ensuring that the birds remain in target areas, to maximise their chances of surviving and reproducing successfully.

One potential methodology was suggested by the wanderings of juvenile kokako. Young birds may travel substantial (considering their limited flight ability) distances but generally settle near other kokako (Innes *et al*, *unpubl. data*). This behaviour is not surprising. Research on several species suggests the presence of conspecifics often attracts dispersing juveniles; the presence of adults may indicate that the area contains potential mates, food, nesting sites, or other important resources (Ahlering & Faaborg 2006). Because kokako are much more conspicuous vocally than they are visually, it is likely that their patterns of dispersal are influenced by the song of conspecifics. This suggests that providing social cues as well as suitable habitat may encourage released birds to remain in or revisit target management areas and thus improve the success of translocations. In 3 previous translocations of kokako to large, continuous areas, very few birds (3-4 individuals) were released, which may have limited possibilities for social interactions and mate choice. Only 1 of the 11 individuals released in the 3 projects settled in the release area: the other birds left the management areas or died before breeding. The success of these translocations may have been improved by the release of more birds, but larger releases to such habitats were not attempted.

In Jul and Aug 2005, 18 kokako were released into Ngapukeriki, a 450-ha area of native forest in which predators were being controlled intensively. Although kokako formerly occurred in the area, they had been absent for at least 30 years, with the most recent reported sightings being in the 1960s throughout the Raukumara Ranges, including at Whanarua Bay and the Raukokore River (north of Ngapukeriki) and the Motu River (south of Ngapukeriki) (Lavers 1978).

There were no physical barriers to prevent the birds leaving the management area. The translocation plan included 3 potential social attractants for released birds. The 1st was the simultaneous release of several birds at a time, as kokako may be less likely to wander away from the release site if they can interact with conspecifics immediately on release. One pair of kokako was also held temporarily in an aviary at the release site as a potential source of social interaction for released birds. Finally, we used playback of song recorded from the source population to simulate a dawn chorus of resident kokako in the release area: this was the 1st use of an "acoustic anchor" during the attempted reintroduction of a terrestrial bird. The potential attractants could not be tested independently, nor was it possible to incorporate a no-attractant control into the translocation project. We therefore did not aim to establish whether any one of these techniques alone affected settlement behaviour. Instead, our aims were to determine whether their combined use might improve translocation success (relative to previous non-island kokako translocations), and whether released birds could be attracted to played-back song of conspecifics, or to live kokako, or to both.

STUDY AREA and METHODS

Release site

Ngapukeriki is an area of native forest protected by an Nga Whenua Rahui covenant, located near Omaio in the Bay of Plenty, North I, New Zealand. It consists of a core area of 450 ha in which rats (*Rattus* spp.), stoats (*Mustela erminea*), brush-tailed possums (*Trichosurus vulpecular*), and feral goats (*Capra hircus*) are controlled intensively. Feral pigs (*Sus scrofa*) and deer (*Cervus* spp.) are also present but controlled less intensively. The site is surrounded by a less-intensively-managed area (control only) of 1800 ha, where only possums and goats were controlled. The covenanted land is located within

13000 ha of continuous pine plantation and native forest near Raukumara Forest Park. Control of introduced mammals in the core area is by a system of traps and bait stations following contours at 3 elevations below the main ridgelines, as well as the along the ridgelines themselves.

Source population

The source population of kokako for the translocation occupied the central area of the Northern Te Urewera Ecosystem Restoration Project's "mainland island" at Otamatuna. Here an area of 900 ha has been subject to intensive predator control since 1996, and the program has seen the kokako population grow from an estimated 18 birds to over 96 pairs. Permission was granted to capture up to 20 individuals from the population for translocation to Ngapukeriki. Otamatuna and Ngapukeriki are *c*.75 km apart, and separated by areas of native and exotic forest and of agricultural and pastoral land.

Recording and playback preparation

Calls and songs of kokako pairs were recorded on 3-8 Apr and 15-19 Jun 2005 from an area immediately surrounding the Otamatuna hut (Ogilvies and Tawai Ridges). Most birds were unbanded, but separation of recording sites ensured that 3 different pairs were recorded. None of the recorded birds was translocated to Ngapukeriki, but immediate neighbours of recorded birds were. All translocated birds were sourced from the same dialect area as the recorded pairs; it is likely that most translocated kokako were familiar with the vocalisations of one or more of the recorded birds.

Recordings were made with an Audio-Technica® 815b shotgun microphone, Rolls® microphone pre-amplifier, and a Sony® TCD-D8 Digital tape recorder with a sampling rate of 44.1 kHz. In most instances, pairs were stimulated to sing by playing back kokako song recorded in the same area in Dec 2000 or in the Pongakawa Ecological Area (Bay of Plenty) in 2004. Playback was used for a maximum of 5 min at a time, and attempts to record pairs were abandoned if they did not respond with song after 3 playback attempts.

Recordings were transferred to an Apple PowerBook® G4 computer using SoundStudio 2.1.1 (Kwok 2003). Because kokako song elements vary significantly in volume, it was necessary to modify the amplitudes of many elements. Amplitude modification allowed soft notes to remain audible during playback while limiting distortion of the loudest notes. For each recording, the loudest notes ("I's" and "mews" – Molles *et al*. 2006) were modified using a Gaussian-shaped fade envelope. This routine reduced the amplitude of the vocalization to *c*.66% of its original volume with smooth transitions out of and back into the rest of playback. The total length of audio for the routine was 3× the approximate length of the vocalization. After the loudest notes had been faded, the entire recording was bandpass filtered to reduce extraneous noise (450 Hz to 10000 Hz at 100 samples), then normalized to 25.1% (-12dB). Normalization set the loudest vocalizations at a level deemed during testing to be a good trade-off between maximizing playback volume and minimizing distortion. Sound levels measured *c*.1 m off the ground were 76 dB at 10 m for the loudest notes in the playback tracks. These maximum sound levels applied to occasional, brief (<0.25 s), periods in the playback; most notes had substantially lower volumes.

Each playback track was built by editing recordings from 1 pair of kokako obtained over 1 or 2 days. To create the playback tracks, recordings were edited to create 4 5-minute song clips (vocalization types described in Molles *et al*. 2006): 5 min of soft "tooks", with occasional louder notes; 5 min of mixed "mews" and "tooks" (25-30 "mews"/"I's" per 5 min); 2 × 5 min of themes (labeled A and B), with occasional "tooks" and "mews" (11-12 themes, and 15-20 "mews"/"I's" 5 min^{-1})

These clips were combined into 45-min tracks as follows: 0-5 min,"mews" and "tooks" (whole clip); 5-10 min, themes A; 10-12 min, "tooks" (1st 2 min); 12-17 min, themes B; 17-18 min, "tooks" (3rd min); 18-20 min, "mews" and "tooks" (last 2 min); 20-25 min, themes A (2nd half then 1st half); 25-30 min, "tooks" (whole clip); 30-35 min, themes B (2nd half then 1st half); 35-40 min, "mews" and "tooks" (whole clip, with 2 themes); 40-45 min, "tooks" (whole clip).

To increase variety, a 2nd 45-minute track was created by rearranging song elements. Two full themes from each theme section were cut and pasted into a section of "mews" and "tooks", and similar-length series of "mews" and "tooks" were cut and pasted back into theme sections. The resulting track had the same length and sound composition as the original, but with a slightly different sequence. The 2 tracks were loaded onto an iPod mini (Apple Corporation®, model A1051), from which they could be played in random order each morning.

Acoustic anchor

Initial setup

Each anchor consisted of an iPod mini and a speaker/amplifier powered by a 12-V battery with a daily timer. For each setup, the iPod mini, battery timer (Flash® 16720 clock switch) and pre-amplifier (TOA Corporation®, model CA200 or Precision Audio®, model PA-100) were placed in a plastic box with a bag of silica gel. The box and battery (Exide Technologies®, Sonnenschein model A512-40 G6) were placed (wrapped in a plastic tarpaulin) at the base of the speaker tree. The speaker (MW®, model

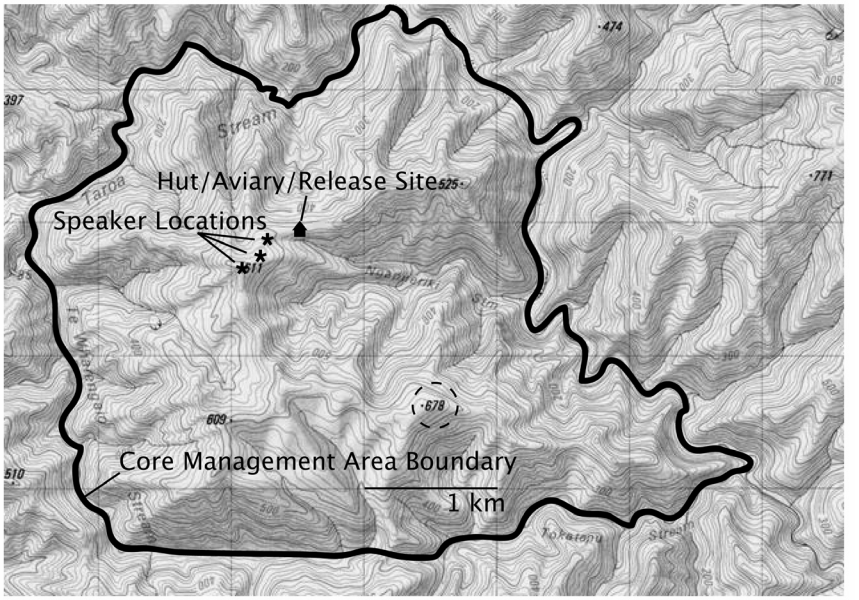

Fig. 1 Map of Ngapukeriki study area, North I, New Zealand. Solid black line, boundary of core predator control area. Locations of acoustic anchor speakers, area high point, aviary, and hut also shown. All kokako were released <50 m of hut.

MW6902) and a 2nd sack of silica gel were placed in a waterproof bag, which was placed in a brown or green pillowcase. Speakers were positioned 5-10 m off the ground using ropes looped over a tree limb close to the trunk. A double rope was used (a rope attached to each side of the speaker) so that the speaker's direction could be adjusted, and to improve stability in strong winds. The speaker cable was led along the ropes down to the playback setup beneath the tree.

iPod minis were set to play using the alarm function linked to a playlist that included the 2 45-minute song tracks. The alarm time was set for just after sunrise and adjusted as necessary to keep the start of playback within 10 min of sunrise. After playing the 2 tracks in the playlist, the iPods automatically turned off. The large battery timers were set to be on for the same period.

Speaker locations

Three anchor speakers were placed along a ridgeline, at elevations of *c*.570-620 m. The speakers were located 200-430 m from the flight aviary and release site (at *c*.480 m elevation), with 150 m between speakers A and B and 140 m between speakers B and C (Fig. 1). Sounds broadcast by speaker A were audible at the aviary where 1 pair of kokako was held between the 1st and 2nd releases. Audibility of the speakers varied with terrain, dropping quickly downslope. However, on a still day speaker A was audible *c*.1.5 km away where there were no intervening ridges.

Bird capture, banding, and transfer

Birds were lured into mist nets using playback of kokako song or alarm calls. Only 1 true pair was caught; the remainder were unpaired birds, or pair members caught without their mates. Birds were kept in a temporary tent aviary at the capture site until transfer. All birds were weighed, measured, banded, and fitted with radio transmitters (7pn single-stage harness-mount, *c*.7 g: SirTrack Ltd.; Havelock North). Feather, blood, and cloacal swab samples were collected for genetic determination of sex and disease screening before transfer. All birds were transported to Ngapukeriki by helicopter.

Four birds (3♂♂, 1♀) were transferred to the flight aviary at Ngapukeriki on Jun 30. Birds were placed in 3 aviary bays separated by shadecloth (the female and 1♂ housed together). One male died within 24 h of transfer. The remaining birds were exposed to a single-speaker playback on most mornings between 1 Jul and 21 Jul (Table 1) from a speaker 200 m away from the aviary to determine whether aviary-held birds would vocally respond to playback. Had they remained silent, it would have suggested that translocated and released birds might find the playback threatening, but aviary-held birds vocalised regularly on both playback and non-playback days and often counter-sang with the playback. Details of maintenance of the aviary birds are available from the corresponding author.

On 21 Jul, 7 birds (4♀♀, 3♂♂) were transferred from Otamatuna and released directly into the forest at Ngapukeriki. One male from the flight aviary was also released; the 2 retained birds (1♂, 1♀) were then free to use the entire aviary.

On 13 Aug, an additional 4 females and 4 males were transferred directly from Otamatuna to the forest at Ngapukeriki. The aviary-held male and female were released shortly after this direct release.

Table 1 Timing of events during re-introduction of North Is kokako (*Callaeas cinerea wilsoni*) at Ngapukeriki, North I, New Zealand, Jul - Aug 2005.

Date	Event
30 Jun	4 birds transferred to flight aviary at Ngapukeriki
1–6, 8–12, 15–18 Jul	1-speaker playback broadcast to aviary-held birds
20–21 Jul	Full anchor playback (3 speakers), from dawn for 1.5 h every morning; testing equipment
21 Jul	1st release: 4♀♀, 3♂♂ directly from Otamatuna, 1♂ from aviary; 2 birds (1♂, 1♀) in aviary
22–30 Jul	Full anchor playback (3 speakers), from dawn for 1.5 h every morning
31 Jul–10 Aug	No playback
11–13 Aug	Full anchor playback (3 speakers) resumed; testing equipment and monitoring behaviour of previously-released birds following resumption of playback
13 Aug	2nd release (4♀♀, 4♂♂ directly from Otamatuna, 1♀, 1♂ from aviary); no birds in aviary
14–18* Aug	Full anchor playback (3 speakers), from dawn for 1.5 h every morning

* Earliest possible end date for playback. Observers left area on 18 Aug but playback continued until batteries died. Latest possible end date was 23 Aug.

Playback regime

The playback schedule was designed to be flexible as this was the 1st use of acoustic anchoring in a kokako release. We set an initial target playback period of 7-10 days for each release, and planned to stop playback if speakers appeared to attract predators or triggered aggressive interactions between released birds. Following the initial period, playback would stop and would remain off unless birds began moving away from the core management area. The times of playback and release events are shown in Table 1.

Radio-tracking

All radio-tracking was performed using a Telonics TR-4® receiver (Telonics, Inc.; Mesa, AZ, USA) and 3-element folding Yagi antenna (Sirtrack Ltd.; Havelock North). Birds were tracked daily on 22–24 Jul, 28 Jul - 12 Aug, and 14-18 Aug 2005. On all but 2 days (12, 18 Aug) birds were tracked twice daily, once beginning at dawn and again in the late afternoon. Left and right fade points for each signal were recorded along with an estimate of signal strength for exceptionally strong or weak signals. Bearings were taken from several points for each bird during radio-tracking sessions. When clear triangulation was not possible (because birds moved or were in awkward terrain) locations were estimated based on bearings, lines of sight, and signal strength. This method may over-represent use of ridges, as ridges were typically the farthest (most conservative) line of sight location within the expected range of a detected transmitter. However, it is still likely that most such locations were on upper slopes or ridgelines, as valleys between the receiver and the ridge were not in line of sight.

After 18 Aug, radio tracking was less frequent. Birds were tracked on: (2005) 7–8, 15–16, 21–23 Sep; 4, 12, 18–19, 26–27 Oct; 1–3, 7–11, 14–18 Nov; 14 Dec; (2006) 11 Jan; 7–10 Mar; 13 Apr.

Nest monitoring

For 3 territorial pairs, at least 1 bird carried an active transmitter. Nests for these pairs were found by tracking an adult to the general area of the nest. For 2 pairs where neither member carried a working transmitter, playback was used to attract 1 or both adults, and then the birds were followed back to the general area of the nest. Once the general area was known, the nest tree was located by careful observation.

Most (5) nests were checked daily to determine that they were still active, and a 6th nest was checked weekly. Nest checks were non-invasive and based on observations of adult activity (incubation times, visitation rates). If neither adult visited the nest after *c.*1 h of observation during a check, adults were located using either radio-tracking or playback.

RESULTS

Post-release monitoring

One female bird's transmitter failed on the day of release (21 Jul), so she was never tracked, nor was she sighted subsequently. However, on 3 Aug (13 days post-release) several distinctive kokako vocalizations ("mews") were heard on 2 different occasions within 200 m of the release site; in both instances, no transmitter signal could be detected in the area, so it is likely that the vocalizations were made by this female. Most birds' transmitters were detected at least once during all or nearly all radio-tracking sessions between 22 Jul and 18 Aug. All radio-tracking data placed birds within the core management area, with a single exception: a male was located just outside the boundary on 1 morning, but he had returned to the management area by the afternoon. Fig. 2 shows approximate locations of birds for all radio-tracking sessions between release and 18 Aug.

There was no evidence of aggression among released individuals or attraction of predators as a

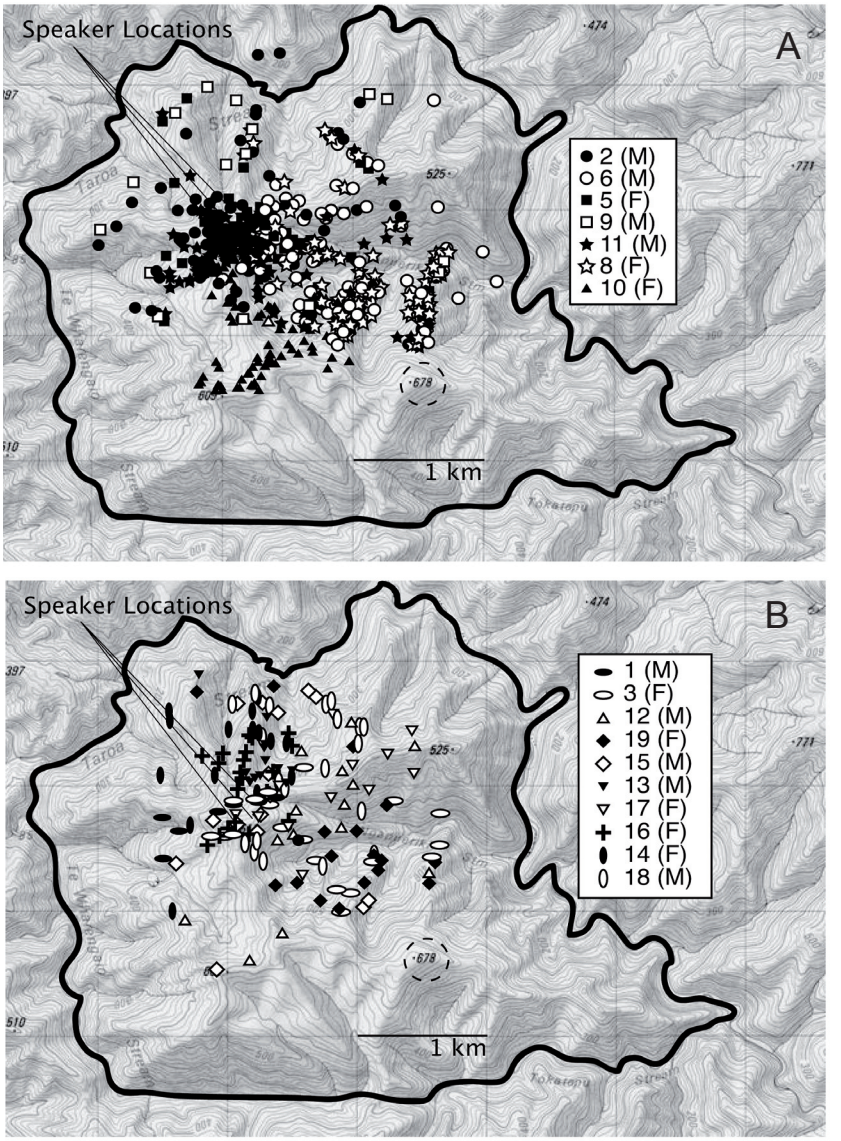

Fig. 2 Estimated locations based on radio-tracking of all birds from release date until 18 Aug: **A**, birds released on 21 Jul (tracking data 22 Jul - 18 Aug); **B**, 2nd group of birds released, on 13 Aug (tracking data 14-18 Aug). Map legends show symbols used for individual birds. Area high point ("678") indicated by dashed circle; speaker locations indicated by lines: playback not running for entire period. Some ridgeline locations may represent birds on upper slopes rather than ridgelines; when triangulation was not possible ridgeline locations were assigned based on the farthest reasonable line of sight location for a signal.

result of the playback. Observations and tracking suggested that released birds were not repelled by the playback. Tracking data showed that 6 of the 7 trackable birds released on 21 Jul visited the anchor area (approached to within 50 m of a speaker) at least once between release and 18 Aug. Seven of 10 birds released on 13 Aug had also visited the anchor area by 18 Aug, despite being tracked for a relatively short period.

Tracking data showed at least 40 visits by released birds to the acoustic anchor area during the 13 mornings when playback was running. At least 1 bird was heard vocalizing or sighted within 100 m of an anchor speaker on most days, and all sightings were during or shortly after morning radio-tracking runs. Birds were seen or heard on 12 of 13 tracking days with anchor playback, and 7 of 11 tracking days without anchor playback. Male 11 was the most conspicuous and vocal of the released birds, but at least 9 different individuals were seen or heard (5♂♂, 4♀♀). When visiting the anchor area, birds would often counter-sing (Bradbury & Vehrencamp 1998) with the playback, sometimes approaching to within a few metres of a speaker. On some mornings three or four different individuals were seen or heard in the anchor area; when this occurred birds would often respond to one another vocally or follow one another around.

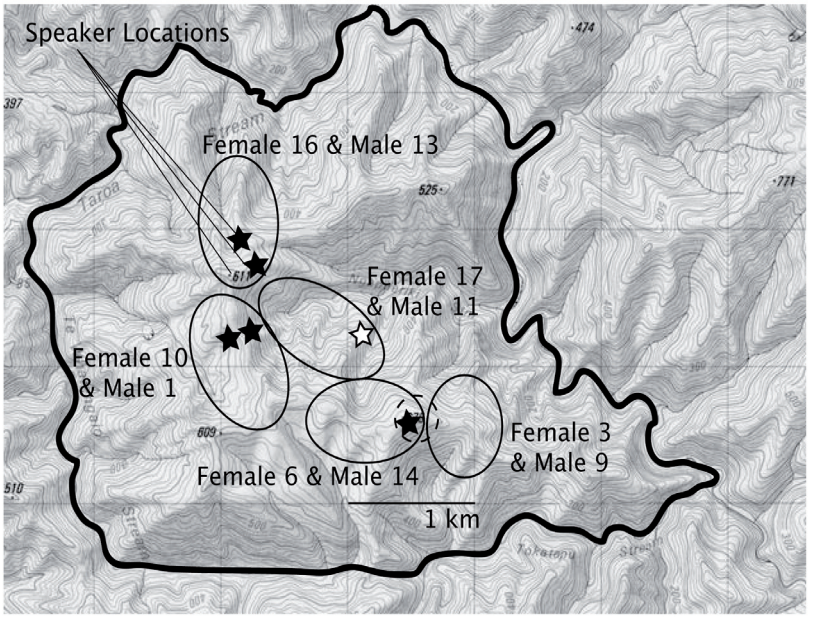

Fig. 3 Estimated territorial boundaries for 5 North Is kokako pairs established at Ngapukeriki, between release dates and 13 Apr 2006. Stars, known nests; black stars unsuccessful nests; white star successful nest. Other conventions as in Fig. 2. Playback not run after 23 Aug.

On one occasion Male 11, who was counter-singing with a speaker, stopped singing and glided across a valley towards a mew from a female (Female 8 or 10) who was 300-500m away.

Released birds rarely came within 100 m of the aviary. The paucity of visits was probably not because the released birds were unaware of the aviary birds; the aviary birds could be heard singing from the acoustic anchor area during radio-tracking sessions on 11 mornings between 21 Jul and 13 Aug. Aviary birds regularly counter-sang with the anchor playback and probably vocalized more often than was detected during the radio-tracking sessions. Tracking data showed only 6 visits by released birds to the vicinity of the aviary before the aviary birds were released. Three of these visits involved Male 6. Male 6 was also heard vocalizing ("mews") near the aviary on 10 Aug; this visit was not during a radio-tracking session, and it was the only occasion when a released bird was seen or heard in the aviary area. The aviary pair responded to male 6's vocalizations with ''mews'' and 2 full song themes. Male 6 also visited the aviary area once after the release of the aviary pair.

Pair formation, territory establishment, and breeding

As of 13 Apr 2006, 5 pairs had formed. Six nests were found, at least 4 of which contained chicks. At least 1 chick fledged successfully from 1 of the 4 nests. Two failed nests were accessible, but there was no evidence as to the cause of failure; the nests were empty with no clear signs of predation. Inaccessible nests were presumed to have failed when parental attendance ended before sufficient time had passed to allow young to fledge, and when no young were sighted subsequently on the territory. Estimated home ranges of territory-holding pairs (based on sightings and radio-tracking data) and nests are shown in (Fig. 3).

Male 6 and Female 14 held a territory centred on Trig 678 (Fig. 3), and nested near this point, the highest in the management area. This nest was confirmed to contain chicks, but they did not fledge successfully.

Male 9 and Female 3 held an adjoining territory to the west of Trig 678. It is not known if this pair attempted to breed. Male 1 and Female 10 held a territory area centered on a ridge, south of the anchor. They built their first nest to the east of this ridge but we did not confirm the presence of chicks. The chicks in their 2nd nest, just to the west of the same ridge, did not fledge.

Male 11 and Female 17 held a territory west of birds 1 and 10 in the Ngapukeriki Valley, where their nest was located, from which they successfully fledged at least 1 chick.

Male 13 and Female 16 held a territory that encompassed much of the area around the acoustic anchor and the hut and aviary. They built 2 nests, the 1st of which failed or was abandoned quickly. Their 2nd nest contained chicks that did not fledge. The territory included the site of 1 anchor speaker, but playback ended >2 months before the pair began nesting.

Last known locations of birds

Fig. 4 shows the approximate locations during the breeding season of birds whose pairing status we were not able to confirm and who apparently did not attempt to breed.

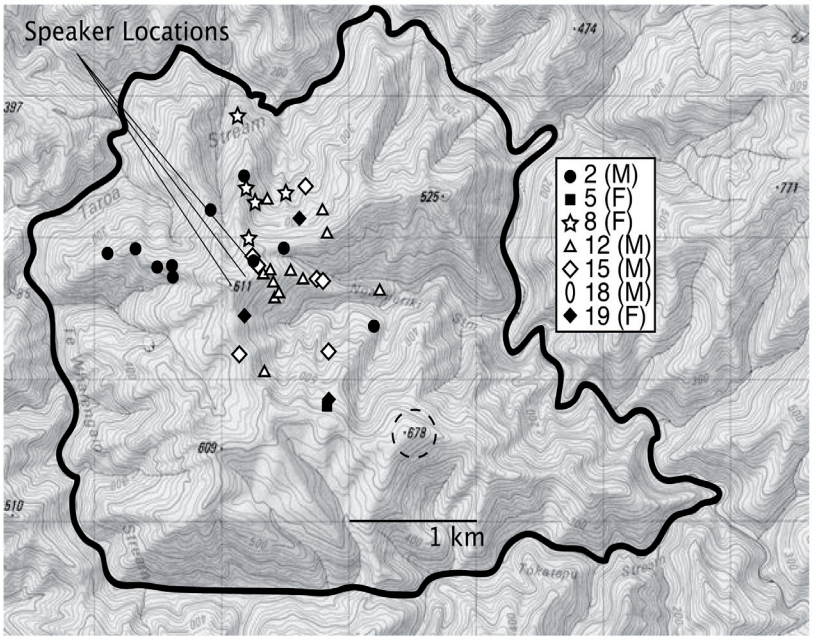

Fig. 4 Locations of non-breeding North Is kokako at Ngapukeriki, during radio-tracking 12 Oct 2005 – 13 Apr 2006. Other conventions as in Fig. 2. Playback not run after 23 Aug at the latest.

By 13 Apr 2006, 10 of 18 transmitters had either failed or fallen off (including the transmitter that failed at the time of release). Four birds whose transmitters failed were positively identified by band combinations after the failure or loss of their transmitters, which suggests that a failure to detect signals at this stage was probably because the transmitter had been lost or had failed rather than because the bird had left the study area.

DISCUSSION

One of the challenges in many animal translocations is to prevent released individuals from leaving the release site: such dispersal may slow or reduce the likelihood of population establishment (Meek *et al.* 2003; Moehrenschlager & Macdonald 2003; Tweed *et al.* 2003; Armstrong & Seddon 2008). In instances where a relatively small portion of the available habitat is "safe" for released animals, it is crucial to prevent this dispersal. Even where it is not vital to the success of the translocation, dispersal can make the success of the translocation difficult or impossible to gauge, because the fates of released animals will be unknown. A greater propensity to disperse is a typical, hormonally-mediated response to stress across vertebrate taxa (Wingfield *et al.* 1997). The procedures involved in translocations are presumably highly stressful for the individuals moved, so the animals are likely to wander widely after release.

Dispersal is also likely to result from released animals seeking food, shelter, and conspecifics in their new habitat, or from homing behaviour. Whatever the cause, post-release dispersal is commonly observed after translocation (Armstrong 1995; Armstrong & Craig 1995; Clarke & Schedvin 1997; Armstrong *et al*. 1999). Kokako naturally disperse substantial distances as juveniles (mean net distance between natal site and established territory, 1.5 km [maximum 5.4 km], Innes *et al*. 1996; Innes & Flux 1999; Grant Jones, Jeff Hudson, *unpubl. data*); even territorial adults may wander outside their home ranges occasionally (LEM, *unpubl. data*). Despite their limited flight abilities, kokako can move long distances following translocation.

Many potential causes of dispersal can be managed. Stress, for example, can be minimised by careful handling and husbandry of translocated individuals. Release sites can be chosen that contain adequate food and shelter, or supplementary food or nest boxes can be provided. Although social attractants are rarely considered in translocations of terrestrial birds, some translocation reports note that released birds appear to be attracted to, and interact with, either resident birds or other releasees (Armstrong & Craig 1995; Armstrong *et al*. 1999; Tweed *et al.* 2003). These results mirror results of work on some northern temperate migratory species, in which individuals preferentially select territories and nest sites near conspecifics, or even "simulated" conspecifics (Ward & Schlossberg 2004; Ahlering & Faaborg 2006). A similar phenomenon in seabirds has been exploited to good effect in several species, where artificial visual and acoustic "lures" have helped attract birds to potential colony sites (Gummer 2003). Models of conspecifics

or playback of calls have had some success in attracting individuals of various penguin, albatross, petrel, storm petrel, tern, shearwater, and puffin species to target areas, sometimes even eliciting aggressive displays or courtship feeding from wild birds (Gummer 2003).

Despite evidence from such studies showing that cues involving conspecifics are attractive, it is still somewhat surprising that dispossessed and presumably stressed individuals would choose to approach playback of territorial song. Kokako song clearly serves in territory demarcation and defence (Molles *et al*. 2006; Molles & Waas 2006), and studies in other songbird species have shown that playback alone can deter individuals from invading otherwise unoccupied habitat (Krebs *et al*. 1978; Falls 1988). However, speaker-replacement studies such as these typically involve removal of territorial birds from established neighbourhoods. Invading individuals are resident or "floating" in the area before the removals, so it is possible that they are attracted to areas they know to have been newly vacated as much as they are repelled by areas that continue to appear to be occupied.

The social situation in a species reintroduction is very different; translocated individuals do not know where conspecifics, territorial or otherwise, might be. They can determine the identities and territorial boundaries of residents only by approaching apparent singers. In a sense, translocated birds are placed in the position of a dispersing juvenile searching for a territorial vacancy or a potential mate. Either resource can be located only by exploration, and the 1st place to explore may simply be an area where other birds are known to be present.

In the Ngapukeriki reintroduction, tracking of kokako in the 1st few weeks after release strongly suggested that birds were attracted to playback of conspecifics' songs of their own dialect. Evidence for this was threefold: at least 13 of 18 released birds visited the area "occupied" by the playback speakers; some birds made multiple visits to the speakers during playback; and birds approached and counter-sang with playback speakers.

Whether the attraction was necessary to retain the birds in the area, or affected the positions of their final settlement, is unknown, in part, because there was no "control" release without acoustic anchoring. Most of the ridgeline areas where birds were located by radio-tracking were within earshot of anchor playback sounds. Additionally, the release at Ngapukeriki differed in several ways from previous releases (see Appendix). Eighteen birds were released within a short time (23 days). This contrasts sharply with earlier releases to non-isolated mainland areas (3-4 individuals translocated, see Appendix) and was likely an important factor in the programme's success. Animal introductions and re-introductions involving larger numbers of individuals are more likely to succeed (Wolf *et al*. 1996; Fischer & Lindenmayer 2000; but see Taylor *et al*. 2005). Even in translocations involving more modest numbers, more may be better: of 180 reintroduction or supplementation projects analysed by Fischer & Lindenmayer (2000), 40% of attempts involving < 10 individuals definitely failed, whereas only 20% of attempts involving 11-20 individuals definitely failed. In small releases success could be limited by stochastic, demographic, or social barriers to population establishment, but spatial constraints on dispersal (such as translocation to an island) may mitigate these problems (Taylor *et al*. 2005). The use of social attractants to limit dispersal could similarly enhance small releases in large release areas.

In each of the 3 previous attempts to translocate kokako to non-isolated areas (Trounson; Pikiariki; Hunua Ranges), only 3 or 4 individuals were released; none attempted to breed, and most left their release areas (Appendix). The birds released in Trounson and Pikiariki were not tracked; birds released to the Hunua Ranges travelled widely and interacted with one another and with already-resident birds (Overdyck 1999). Although it is plausible that the Ngapukeriki birds could have found one another and interacted without song playback, observations of birds' behaviour during song playback suggest that speakers did increase the frequency of social interactions. For example, birds often met after approaching speakers, and birds vocalising in response to speakers were more conspicuous than they would otherwise have been. The *combination* of multiple released birds and acoustic anchor playback may have been a significant factor in the success of the translocation. An important aim in future work will be to determine whether a few birds, or even single birds, can be induced to stay in a target area by playback of kokako song.

Although the Ngapukeriki release did not unequivocally establish that acoustic anchoring is effective in large-block translocations, it did show that playback attracts released birds. In particular, the trial illustrated that song playback is more attractive than live birds held in aviaries: most released birds visited playback speakers, but only 1 was detected near the captive aviary pair. Behaviour of released kokako in isolated forest habitats at Pukaha/Mt Bruce and Boundary Stream had suggested that aviary birds might be attractive to translocated individuals (Appendix). The results of this study show that captive birds are not necessary, and will allow future translocations to eliminate the cost and risk of holding kokako in aviaries during re-introduction programmes. The proximity of the aviary to the hut may have deterred some birds from approaching the captive birds, but the observed interactions with the speakers and the success of the

translocation suggest that the presence of captive birds was not essential.

Future translocations will provide opportunities to explore the importance of dialect in attracting released kokako, the effectiveness of acoustic anchoring when small numbers of individuals are initially released into an area, and the behaviour of kokako released into an area with no playback at all. This series of experiments should allow us to determine whether acoustic anchoring improves translocation success, and perhaps gain some insight into why translocated kokako find playback attractive. Acoustic anchoring is also worth investigating with respect to translocations of other terrestrial species, particularly those that rely heavily on vocal communication. Because conspecific attraction appears to be a common phenomenon in territorial species (Ahlering & Faaborg 2006; Bourque & Desrochers 2006), simulation of resident birds may be a useful technique for many of New Zealand's year-round territorial songbirds. Even among species, such as honeyeaters, that use song to defend patchy resources, playback of vocalisations of conspecifics may prove attractive to translocated birds that are unfamiliar with the spatial distribution of food resources within their new habitats. Many studies have found that birds often choose to forage in areas where they can see others feeding (Galef & Giraldeau 2001) and perhaps vocalisations also provide hungry birds with useful cues. Similarly, translocated parrots may be better able to locate important resources when calls in familiar dialects are used. Playback of such calls to flying flocks can attract conspecifics to land, approach, and vocally interact with playback (Vehrencamp *et al*. 2003), so could potentially be used to attract wandering parrots to natural or artificial food sources.

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APPENDIX

Results of previous kokako translocations

Translocations to islands and "mainland islands"

Kokako translocations serve several purposes. In some instances, kokako have been translocated to predator-free offshore islands to create "insurance" populations and to preserve the genetic heritage of populations whose mainland habitat was threatened with destruction. Some offshore island and mainland translocations were aimed at supplementing numbers or increasing genetic diversity in small, inbred populations. Translocations on the mainland have been focused increasingly on returning kokako to areas of their former range from which they have been extirpated. Usually, kokako translocations have been successful. Most target areas have been isolated tracts of forest (restricting released birds' ability to leave the managed area. Effective predator control programmes in recipient areas have ensured high productivity once the released birds have settled, paired, and begun breeding.

Kokako have been translocated successfully to 4 offshore islands: Hauturu/Little Barrier I; Kapiti I; Tiritiri Matangi I, and Mauimua/Lady Alice I.

Hauturu/Little Barrier I was the 1st to receive kokako. Between 1981 and 1988, 32 birds were moved from remnant populations in the Waikato and Rotorua regions (Innes & Flux 1999; Brown *et al*. 2004). Although body measurements taken at capture suggest that perhaps only 6 of the originally released birds were female, the population expanded rapidly in the absence of introduced mammalian predators (Innes & Flux 1999) and was estimated to include at least 100 breeding pairs in 2006 (Kokako Recovery Group 2006).

Twenty-nine kokako from several sources were moved to Kapiti I between 1991 and 1997. Many of the birds came from remnant populations (Te Rauamoa, Waikato; Manawahe, Bay of Plenty; Makino, Taranaki). Others were brought from Hauturu/Little Barrier I, Mapara Wildlife Reserve, and the captive breeding facility at Mt Bruce National Wildlife Centre (Brown *et al*. 2004). Many of the birds released were probably older male birds, and the skewed sex ratio may have contributed to low productivity in the population. In 1997 there were only 18 kokako on the island (Brown et al 2004). Another factor in the initial low productivity may have been the inclusion of birds from different sources. Females preferentially selected mates from their own area of origin, and same-origin pairs formed much more quickly than different-origin pairs. However, offspring of parents from all sources interbred readily (Rowe 2001). The population has continued to grow slowly and in 2006 there were at least 14 pairs on the island, concentrated in 200 ha of forest (Erica Cammack, *pers. comm*..).

In 1997 a wild-caught pair of kokako from Mapara Wildlife Reserve and 1 captive-reared male from the Mt Bruce National Wildlife Centre were liberated on Tiritiri Matangi I. Four additional captive-reared males were moved there from Mt Bruce in 1998. All Mt Bruce birds were offspring of the same parents (a female offspring of 2 wild-caught parents from Otorohanga, and a male wild-caught in the Waikato region; Hazel Speed, *pers. comm*.). The population on Tiritiri Matangi I had increased to 22 birds in 2006, but inbreeding is an increasing concern (Tamara Henry & Hazel Speed, *pers. comm*.).

One of the 2 last remaining males from Puketi in Northland was caught and translocated to Mauimua/Lady Alice I in 2005, where 2 females were released in 2004. The females had been caught as nestlings in Kaharoa and hand-reared, with exposure to recordings of Puketi song (Steve McManus, *pers. comm*.). The small population had not bred by 2006, but numbers were to be augmented by captive-reared offspring of birds from Puketi.

Two successful translocations to mainland sites have been to tracts of forest embedded in farmland. In both instances, captive breeding programmes on-site provided many of the birds released into the management areas.

In 2004, 6 birds caught at Mangatutu were released at Pukaha, a forest tract adjoining the Mt Bruce National Wildlife Centre. One pair formed from released birds raised 2 chicks in the 1st breeding season after release. In 2004, 2 more wild-caught birds from Mangatutu were released (1 died within 3 weeks), as well as 5 birds from the Wildlife Centre's own captive-breeding program. Although wild juvenile birds, and in 1 instance a juvenile accompanied by an adult, visited the area near the aviaries at the Wildlife Centre, most former captives have not been resighted. Seven wild-caught birds from Mapara Wildlife Reserve were translocated to Pukaha in 2005. One of these birds died within 1 week of release, but the others settled quickly; 5 young fledged in the breeding season following release (Tony Silbery, *pers. comm*.).

Three non-breeding pairs from the captive breeding program at Boundary Stream Mainland Island were released there in Feb 2004. They all remained in the area. Three female chicks from the captive breeding program were released in May 2004, and the remaining 2 captive breeding pairs in the following Aug. Two released birds died after an unusually heavy snowfall, but others have survived, paired, and bred successfully. In the 2004/2005 breeding season, after the release, 3 pairs nested and a total of 8 chicks fledged. Five chicks were fledged successfully in the 2005/2006 season. Boundary Stream's captive birds came originally from Otamatuna, and an additional release of 10 Otamatuna birds was planned for 2007 to increase genetic diversity (Kahori Nakagawa, *pers. comm.*).

Translocations to sites with contiguous forest

In at least 3 instances, kokako have been translocated to mainland sites that were not isolated and from which kokako could easily leave the target/management area. One bird settled permanently in its release area, but the fates of most released birds are unknown. However, most translocated birds remained at least temporarily in the release areas, and the outcomes of the translocations may have been quite different with larger numbers of birds.

Four kokako were translocated to Trounson Park, 2 in 1996/1997 and 2 in 1998/1999. One bird died shortly after release. Two birds left the release area after *c.*2 weeks, but 1 remained in the area for at least a year before disappearing (Ian Flux, *pers. comm.*).

An attempt was made to supplement a remnant population of 3-4 males in Pikiariki (Pureora Forest, central North I). Of 3 birds (2♀♀, 1♂) released, only the male appeared to establish a territory. The 2 females released moved through pine forest and across a large road gap to a nearby native forest block with a large resident kokako population (Ian Flux, *pers. comm*.; Hazel Speed, *pers. comm*).

A remnant population of kokako persists in the Hunua Ranges, southeast of Auckland. In 1998, 4 females were moved from Mapara Wildlife Reserve to the Hunua Ranges to supplement both numbers and genetic diversity. The females remained near the resident birds (within vocal range) for at least 100 days after release, but eventually disappeared. During the time they were tracked, they moved through territories of pairs and single birds, and 2 of the released birds moved significant distances together. One of the released birds formed a pair bond with a resident male, but was killed by a stoat before it bred. A 2nd female was seen with a resident male 315 days after release, but disappeared later (Overdyck 1999).