Notornis, 2013, Vol. 60: 63-69
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Translocations of North Island tomtits (*Petroica macrocephala toitoi*) and North Island robins (*P. longipes*) to Zealandia-Karori Sanctuary, an urban sanctuary. What have we learned?

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Abstract Transfers of North Island robin (*Petroica longipes*) and North Island tomtit (*P. macrocephala toitoi*) were undertaken from various sites around the Wellington region to within the mammal-proof fence at the Zealandia-Karori Sanctuary from 2001-2004. Differing methodologies were trialled to test translocation protocols for these species. Robin translocations (34 males and 42 females from Kapiti I translocated in 2000 and 2001) were straightforward and robins established in the sanctuary despite the fence not being a physical barrier to dispersal. They bred from the first season and numbers have since increased rapidly. Tomtits were transferred from 2 source populations (Kapiti I and Akatarawas; 39 males and 12 females over 4 years from 2001-2004) but failed to establish. To hold tomtits in an aviary and avoid aggression it was necessary to keep sexes apart. Although successful tomtit breeding was observed both within and outside the sanctuary, predation pressure was higher outside the sanctuary. A progressive move of tomtit territories out of the sanctuary may have been a response to increasing aggression from the expanding robin population.

Empson, R.; Fastier, D. 2013. Translocations of North Island tomtits (*Petroica macrocephala toitoi*) and North Island robins (*P. longipes*) to Zealandia-Karori Sanctuary, an urban sanctuary. What have we learned? *Notornis 60(1):* 63-69.

Keywords North Island robin; *Petroica longipes*; North Island tomtit; *Petroica macrocephala toitoi*; Zealandia-Karori Sanctuary; translocation methods

INTRODUCTION

Zealandia-Karori Sanctuary (41˚18′S, 174˚44′E ; 225 ha) is located at the head of a steep-sided stream catchment adjacent to Wellington City at the southern end of the North I, New Zealand (Fig. 1). Formerly a part of a lowland forest ecosystem that would have extended over the lower North I, the valley today is a relatively isolated patch of regenerating lowland forest adjacent to city suburbs, farmland and regenerating shrublands. It is recovering from a history of burning and farming as well as the introduction of exotic plants and animals. The stream is also highly modified, being dammed in 2 locations to previously supply water to Wellington City for almost 100 years.

The sanctuary has a goal to restore the valley as far as possible to its pre-human state. In 1999, an 8.6 km mammal-proof fence was built around the perimeter of the reserve that has successfully excluded all mammalian pests except mice (*Mus musculus*). It was the first of its kind, and the same year a successful eradication operation removed 14 species of introduced mammals. While the removal

Received 26 Nov 2012; accepted 19 Feb 2013
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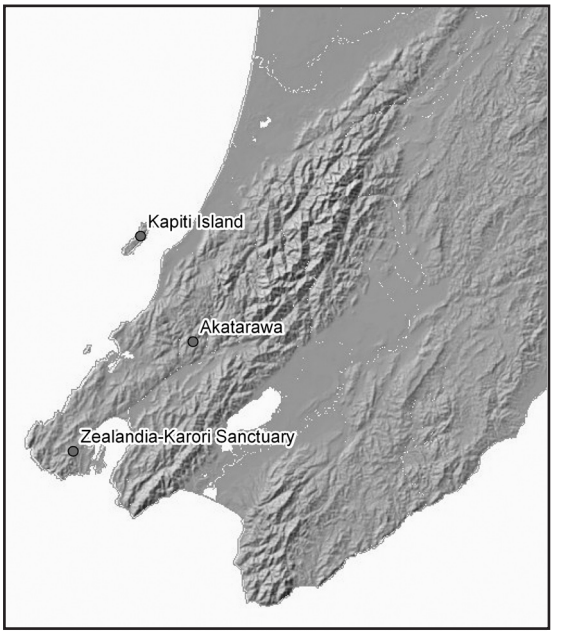

Fig. 1. Map showing location of capture and release sites for robin and tomtit translocations to Zealandia-Karori Sanctuary.

and exclusion of pest mammals benefitted resident species such as tui (*Prosthemadera novaeseelandiae)*, many species were locally extinct and have had to be reintroduced. Since 2000, 14 species of birds have been released into the sanctuary. The translocations of little spotted kiwi (*Apteryx owenii*), tieke/North Island saddleback (*Philesturnus rufusater*), and the hihi/stitchbird (*Notiomystis cincta*) have established these species on the mainland for the first time in over 100 years. The latest additions are a pair of the South Island takahe (*Porphyrio hochstetteri*), the first birds transferred as an analogue for a nationally extinct species (North Island takahe, *P. mantelli).*

There are a number of questions associated with the translocation of any species: is the release site safe and suitable for the species? What is a suitable source population? What is the appropriate number of founders and transfer methodology (*i.e.*, a single large transfer or multiple transfers)? What order should transfers occur where several species are involved? And what monitoring and post-release management should be undertaken to determine if the transfer has been a success (Armstrong & Seddon 2008; Tracy *et al.* 2011)? All transfers are necessarily experimental in nature, and this has been particularly so for Zealandia-Karori Sanctuary. As the first mainland site with a perimeter fence that is a barrier only to dispersal of flightless species, it was well placed to test the efficacy of translocating not only birds surviving on the mainland, but also more vulnerable species. Intensive monitoring has been undertaken following all transfers to determine if the population increases following successful breeding and recruitment and to identify techniques and management actions that might improve transfer success and recruitment. Some transfers have been more successful than others and, in common with other isolated sites including offshore islands, long-term population viability may be a challenge for many species. In this paper we examine the methodology and outcomes of transfers of North Island robins (*Petroica longipes)* and North Island tomtits (*P. macrocephala toitoi*) to Zealandia-Karori Sanctuary.

METHODS

In 2001 and 2002, North Island robins were captured from Kapiti I (40˚50′S, 174˚55′E; 40˚51′S, 174˚55′E and 40˚53′S, 174˚53′E; Fig. 1), which is the closest population to Zealandia. Robins were caught using clap traps baited with mealworms (*Tenebrio monitor*), or caught in mistnets. Each bird was measured and banded with unique combinations of a numbered metal band and colour bands, and placed into cardboard transfer boxes with a perch, dish of water and mealworms following protocols already established for robin transfers elsewhere (Armstrong 1995). In 2002, waxmoth larvae (*Galleria mellonella*) were also provided. All birds were transferred and released into a central location in the sanctuary (41˚18′S, 174˚44′E) within 30 hours of capture. During 2001, the probable sex of transferred birds was determined by tarsus length from notch. In 2002, sex was determined by tarsus length and wing lengths (Armstrong 2001). Sex was later confirmed through post-release behavioural observations and breeding data. The outcome of these transfers was monitored for 2 breeding seasons as part of a M.Sc. study (Small 2004) and by volunteers for a further 2 breeding seasons (until 2005).

The first transfer of North Island tomtits to the sanctuary was undertaken in 2001 (n = 2), with later transfers in 2002 (n = 20), 2003 (n = 19) and 2004 (n = 10). This was the first attempted transfer of this subspecies of the tomtit, with transfers of Chatham Island tomtit (*P. m. chathamensis*) having been undertaken successfully from Rangatira I to Mangere I in 1987, 1988, and 1989 and unsuccessfully from Rangatira I to Chatham I in 1998 (Powlesland *et al.* 2001). All birds were attracted to and caught in mistnets using taped calls and squeakers (polystyrene rubbed on a bottle), measured, sexed (based on plumage), and banded with unique combinations of coloured bands. The time between capture and release was varied to determine the best methodology for successfully transferring tomtits and several techniques were trialled. Because of the

variability in capture time and transportation times, birds were not systematically assigned random treatments.

Three release strategies were trialled including same day release (n = 23), holding overnight in transfer boxes for early release the next day (n = 17), and holding in aviaries before transfer (n = 15) with some variation in configuration of holding. Birds were monitored for signs of aggression and other changes in behaviour.

Tomtits were caught in 2 locations on Kapiti I (40°51′S, 174°55′E, and 40°49′S, 174°56′E) and all but 2 were held temporarily in aviaries on the island before transfer to the sanctuary. The first 2 birds captured (both males) were transferred from Kapiti I in Aug 2001 and released the same day as caught. In subsequent transfers from Kapiti I (May 2002 and Jun 2003) all but 1 female were held in small aviaries on Kapiti I for 1-2 days before transfer and release; 1 female was held for 4 days. Various holding configurations were used including male and female birds together, male and female birds individually, and multiple males and multiple females together.

Three different aviaries were used for holding tomtits on Kapiti I: a 1 m x 2 m x 2 m aviary lined with shadecloth, a small 1 m x 2 m x 0.5 m tent, and a partitioned shadecloth-lined section of the main aviary measuring 1.8 m x 2.9 m x 2.45 m. The aviaries and tent were equipped with rotten logs, leafy branches, and perches. Leaf litter baited with active invertebrates and a dish of water were placed on the floor. Birds were fed daily with a variety of invertebrates including: mealworms, waxmoth larvae, maggots (*Musca* spp.), flour beetles (*Trilobium* spp.), fruit flies *(Drosophila* spp.) and whiteworms (*Enchaetaeus albidus*). A mix of jam and honey was also provided in the aviaries during 2003 but since there was no evidence that tomtits fed on this mixture it was not provided in 2004.

Tomtits were transported from Kapiti I to the sanctuary by boat and car while being held in modified cardboard cat boxes. Each box held 1 bird and was equipped with perches, small-leaved branches of vegetation secured inside to provide cover and possibly insects, a mix of litter and compost material containing active invertebrates and a dish of water which was removed prior to transportation to avoid spillage. A similar variety of live invertebrates which were provided to tomtits in the aviaries were also placed into the transfer boxes.

Between 2002 and 2004 tomtits were also caught in the Akatarawas, all within 6 km of 41° 03′S 175° 02′E (see Fig. 1). These birds were placed into specially constructed wooden transfer boxes (325 mm x 450 mm x 410 mm) with a maximum of 1 female or 2 males per box (due to known compatability of males and greater potential sensitivity of females). Each box was equipped and provisioned in a similar way to the transfer boxes used in tomtit transfers from Kapiti I. Birds were transported by 4WD to the sanctuary and released the same day they were caught or held overnight in their transfer boxes and released early the next day. In 2002 (all tomtits) and 2003 (2 males caught in May and 1 female caught in Jul), birds were released in the sanctuary the same day they were caught. In subsequent transfers (from Jul 2003 to Jul 2004) all tomtits were held in their transfer boxes overnight and released the next day. The birds released the same day as capture were released at least 2 hours before dark so they had time to forage; those held overnight had more time to forage before nightfall in their new environment.

To determine the success of the transfers, tomtit survival and breeding were monitored by volunteers and staff between 2002 and 2007 using similar survey and nest monitoring techniques as earlier studies (Knegtmans & Powlesland 1999).

RESULTS

In May 2001, 38 clap-trapped robins (20 males, 18 females) were transferred to the sanctuary by helicopter, 2 female robins caught in mist nets were transferred by boat and car in Aug 2001 and another 36 robins (14 males, 22 females) were transferred from Kapiti I by boat and car in May 2002 (Small 2004). Despite the mammal-proof fence not preventing dispersal, high retention rates resulted, with at least 84% (2001) and 77% (2002) of robins being confirmed within the sanctuary fence in Sep, 4 months after transfer (Small 2004). This compares with 73% survival for 5 months after transfer of 44 robins to Tiritiri Matangi I in Apr 1992 (Armstrong 1995).

In 2008, 7 years after the first transfer, robins were surveyed in a 37 ha study area within the sanctuary that had previously been monitored from 2002 to 2005. Density had increased from *c.* 0.7 robins/ha in 2003 to *c.* 2.5 robins/ha in 2008, with an associated reduction in territory size (McGavin 2009).

Fifty one tomtits (39 males, 12 females) were released at the sanctuary between Aug 2001 and Jul 2004. This consisted of 12 males and 3 females from Kapiti I transferred over a period of 4 years, and 27 males and 9 females transferred from the Akatarawas over 3 years. The 2 source sites, one an offshore island and one a mainland site, necessitated differing approaches to the transfers. In 2002, the 1 m x 2 m x 2 m aviary was used with mixed success – a female died one day after being placed in this aviary with a single male, despite no aggression being observed. A second female was also found dead a day after capture when placed in this aviary

Table 1. The effect of release strategy on percentage of tomtits sighted at least 2 months after release.

	Kapiti Island		Akatarawas	
	Male	Female	Male	Female
Same day release	50% (n = 2)	-	7% (n = 13)	17% (n = 6)
Next day release	40% (n = 5)	-	14% (n = 14)	33% (n = 3)
Release ≥2 days after capture	40% (n = 5)	0 (n = 3)	-	-
Overall	42% (n = 12)	0 (n = 3)	11% (n = 27)	22% (n = 9)

with 3 males. However, a female was successfully held alone for 2 days in 2002 after the 3 males had been moved out of the aviary. This same aviary was used successfully again in 2003 for 3 males and the 1 m x 2 m x 0.5 m high tent was used in 2002 to house 4 males before transfer. The partitioned section of the main aviary on Kapiti I housed 1 female for 2 days in 2003 until a second female was caught and placed in the same aviary for 2 additional days before both birds were transferred.

There was a significant difference between source of males and whether or not they were sighted within the sanctuary post-release (χ^2 = 4.76; df = 1; P < 0.05) with 42% of Kapiti I males sighted compared with only 11% of Akatarawa males (Table 1). There was no significant difference between Akatarawa females and release day (χ^2 = 0.32; df = 1; P = 0.57), with 17% of same-day release females sighted compared with 33% for next-day release females, but with a total of 9 females, only extreme differences between release days would be detectable. Fifty percent of males transferred in Jun and 50% of females transferred in Jul were re-sighted after release (Table 2).

Successful breeding of tomtits at the sanctuary was confirmed for the first time when a pair was found with 2 unbanded fledglings in Nov 2003. This pair was released at different times in 2003 (male in May, female in Jul), but both were released the same day they were caught in the Akatarawas. An active nest for this pair was located in Jan 2004 and 4 banded nestlings successfully fledged. Evidence of more successful breeding was found with 10 juveniles being caught and banded in May 2004, and at least 1 other unbanded tomtit seen subsequently. Some of these may have been produced by the only other pair of tomtits seen during the breeding season, a female tomtit from the Akatarawas and a Kapiti I male, both released in 2003, although no nests were found.

Seven locally bred tomtits (67% of the banded females, (n = 6) and 36% of the banded males (n = 8)), plus a male released Jun 2004 were recruited into the breeding population in the 2004/5 breeding season. Five pairs were identified (Table 3), 3 with territories inside the sanctuary fence and 2 with territories predominantly outside the fence (Empson & Parker 2005).

Predation of eggs occurred at 1 nest outside the fence, and the loss of a single chick in a nest within the fence occurred during a storm (2 other clutches with 2 and 4 chicks survived this event). Twenty three nestlings were banded (9 males, 14 females determined from plumage) but an unbanded male and 4 unbanded females were also observed, bringing the total number of tomtits known to have fledged to 28 (10 males, 18 females) compared with 8 males and 6 females fledged the previous season. Nests in 2004/5 produced a mean of 3.3 fledglings per brood (n = 9).

At least 5 locally bred tomtits that fledged in 2004/5 (20% of the males and 17% of the females) were recruited into the breeding population along with a male transferred from Kapiti I in 2001 that had not bred since release. One breeding female was never identified but her lack of response to observers offering mealworms suggests she was also a new recruit (Cross 2006).

Eighteen nestlings (6 males, 12 females) were banded in 2005/6, a mean of 3.6 fledglings/brood raised (n = 5). Two of these (1 male, 1 female) bred successfully in 2006/7, the only breeding pair found inside the fence; however, a second pair (female unidentified) bred successfully, probably outside the sanctuary, because a banded male (WB-GM) was seen with an unbanded female fledgling on 15 Dec 2006. Despite much searching, only 1 nest was found and 1 nestling banded and fledged. The last tomtit seen in the valley was an unbanded female in May 2007. No tomtits have been seen since (to Jan 2013) and the translocation has thus failed.

DISCUSSION

Robins established at the sanctuary following transfer from Kapiti I in 2001 and 2002, increasing by 2008 to a density of *c*. 2.5 robins/ha, which is higher than other mainland sites (McGavin 2009). This success is likely due to the effectiveness of the mammal-proof fence. By 2007, the population had met our *a prioiri* definition of success and was able to be the source for a transfer of robins out of the sanctuary to Matiu-Somes I (41°16′ S, 174°52′E; 26 ha).

As with robins, the tomtits translocated to the sanctuary bred soon after release. This was a

Table 2. The effect of transfer timing on percentage of tomtits sighted at least 2 months after release.

	Kapiti Island		Akatarawas		Overall	
Release month	Male	Female	Male	Female	Male	Female
May	14% (*n* = 7)	0 (*n* = 1)	50% (*n* = 2)	-	22% (*n* = 9)	0 (*n* = 1)
June	100% (*n* = 3)	0 (*n* = 2)	20% (*n* = 5)	0 (*n* = 1)	50% (*n* = 8)	0 (*n* = 3)
July	-	-	13% (*n* = 8)	50% (*n* = 2)	13% (*n* = 8)	50% (*n* = 2)
August	50% (*n* = 2)	-	0 (*n* = 10)	20% (*n* = 5)	8% (*n* = 12)	20% (*n* = 5)
September	-	-	0 (*n* = 3)	0 (*n* = 1)	0 (*n* = 3)	0 (*n* = 1)

significant achievement given a 2004 transfer of 32 tomtits to Tiritiri Matangi I failed and revealed that tomtits have strong and capable homing instincts, with one adult male flying at least 56 km to return to its territory in the Hunua Ranges (Parker *et al.* 2004). However, despite this initial success, tomtits did not persist and the translocation eventually failed.

The significant difference in number of sightings of male tomtits transferred from Kapiti I compared with the Akatarawas (Table 1) could reflect the fact that tomtits are sympatric with robins on Kapiti I and accustomed to foraging in the presence of the larger, closely-related robin, but not in the Akatarawas where robins are absent. The transfer of robin-naïve tomtits to Tiritiri Matangi I, where robins were present, and the subsequent dispersal away from the island of at least some of the tomtits suggests some merit to this argument. We also note that no Akatarawa tomtits were held in aviaries prior to release and another reason could be that male tomtits were less inclined to disperse after time in an aviary compared with same day or next day release straight from a transfer box.

It was difficult to determine the best time to transfer tomtits due to small sample size and the effect of source or transfer strategy on outcomes (Table 1). Nevertheless, as no tomtits transferred in Sep were seen again (Table 2), and only 10% of males transferred in Jul/ Aug were resighted, compared with 40% males transferred in May/Jun, it would appear that May/Jun may be the best time to transfer male tomtits. Of the 2/12 females known to have survived at the sanctuary, one was released on 3 July and the other 1 Aug, suggesting Jul might be a more appropriate time to transfer female tomtits. However, more work needs to be done to test the effect of season on translocation success and whether this might vary between the sexes.

Female tomtits had high mortality when held with males in aviaries; all (*n* = 2) died overnight when held with 1 and 3 males in an aviary whereas 2 females survived for up to 4 days when held together. We recommend that future transfers only hold birds in single sex aviaries. Females also survived being held singly in transfer boxes overnight. There were no losses of male tomtits that were held prior to release and up to 3 were successfully housed together in small aviaries for up to 2 days and 2 were held together overnight in a wooden transfer box.

Tomtit breeding at the sanctuary between 2003 and 2006 was similar to that at other North I sites with modal clutch size (4 eggs), and the mean number of 3.3 fledglings/brood in the sanctuary (*n* = 18) similar to that reported at Pureora Forest Park (Knegtmans & Powlesland 1999). Mean clutch size for nests inside the sanctuary was larger than for nests outside the fence (Table 3), though difficult to assess statistically due to small sample size. This may be due to increased food supply inside the fence, although the tomtits that nested inside near the fence also foraged outside. Nesting success in both years was better "inside" the fence (Table 3), and overall (74%, *n* =19), was similar to other mainland sites such as Tahae (67%, *n* = 6) and Waimanoa (80%, *n* = 5) where possums and rats had been reduced by poison operations, and was much greater than Kaharoa (7.7%, *n* = 26) where predation was the main cause of nesting failure (Knegtmans & Powlesland 1999). Based on plumage, 63% of nestlings banded in 14 nests were female (*n* = 46). It is unknown how this compares with other sites and whether or not this sex ratio is related to maternal condition (Robertson et al 2006) but, given a surplus of males were transferred and several survived, at least for several years, this was a desirable outcome to maximise potential recruitment.

In 2004/5, 3 of the 5 tomtit pairs nested inside the fence, but 2 of these pairs foraged outside the fence as their territories straddled the fence. In 2005/6, the "inside" territory used in 2003/4 and 2004/5 was abandoned and all tomtit pairs observed occupied territories that straddled the fence or were outside. Again most nests in territories that straddled the fence were found inside the fence but foraging occurred outside as well. Female tomtits that nested outside the fence were at greater risk of predation and nest failure; 3 of 4 females that nested outside the fence during 2004/5 & 2005/6 breeding seasons disappeared after their first clutch compared with 1 out of 6 pairs that nested inside the fence. A total

Table 3. Tomtit breeding success "inside" and "outside" the sanctuary. * excludes pairs where birds disappeared during the breeding season.

Breeding season	Nest location	No. pairs	No. nests/ pair *	Mean clutch size ±S.D. (*n* = no. nests)	Breeding success (% eggs fledged)	Nesting success (% nests that fledged)
2004/5	Inside fence	3	3 (*n* = 2)	3.9 ± 0.69 (*n* = 7)	81	86
2004/5	Outside fence	2	3 (*n* = 1)	3.3 ± 0.96 (*n* = 4)	62	75
2004/5	All	5	3 (*n* = 3)	3.6 ± 0.81 (*n* = 11)	75	82
2005/6	Inside fence	5	3 (*n* = 1)	3.8 ± 0.75 (*n* = 6)	65	67
2005/6	Outside fence	2	-	3.5 ± 0.71 (*n* = 2)	43	50
2005/6	All	7	3 (*n* = 1)	3.75 ± 0.71 (*n* = 8)	60	63

of 43% (*n* = 7) of active nests outside failed due to predation compared with 8% of nests inside (*n* = 12) (1 nest with infertile eggs and 1 with single chick that died during storm were excluded).

The small number of tomtit founders (6 minimum) meant that the genetic diversity of the population was limited, with most single males that held territories for a year or 2 after release having disappeared by 2004, 3 years after first release. Nevertheless, productivity was good, at least in the early years (≥15 fledglings in 2003/4, ≥28 in 2004/5 and ≥20 in 2005/6) and since genetic issues were unlikely to have an impact so early in the establishment phase, this does not explain the sudden decline of the tomtit population in 2006.

Using the same basis for calculating robin numbers as McGavin (2009; *i.e.,* total number individuals seen minus half the individuals whose territories bordered the study area), robin density at the beginning of the 2004/5 breeding season was 1.1 robins/ha (KST, *unpub. data*). Robins continued to expand throughout the sanctuary following their release and this may have contributed to the decline in tomtits. Robins are dominant over tomtits, and the rapid increase in robins inside the sanctuary, may have increased interspecific competition. By 2006, interactions were observed more often between the 2 species, with robins harassing tomtits taking food to their nestlings (Cross 2006), and this coincided with the shift in tomtit territories towards and over the fence where robins were only rarely seen (RAE, *pers. obs*). Consequently, the shift of tomtits beyond the mammal-proof fence to areas surrounding the sanctuary put them at increased risk of predation and this is likely to have been responsible for the sudden decline of tomtits inside the fence in 2006, and their local extinction in 2007.

CONCLUSION

Our study confirms that North Island tomtits can be caught and transferred successfully to new locations, but establishing them in locations with resident robins appears to be problematic, and this is possibly the case on islands as well as the mainland. Tomtits that are familiar with robins may have a better competitive ability to local robin populations, and should be selected for future translocations over tomtits naïve to robins. Transfers to mainland sites with contiguous habitat outside the protected area may be more prone to failure due to the dispersal options for tomtits. More research is required to develop successful transfer techniques for tomtits.

ACKNOWLEDGEMENTS

The transfers were funded by the R&D Evans Charitable Trust (2001), the Kinsky family (2002-2004) and the Karori Sanctuary Trust. Many staff and volunteers were involved in the capture & transfer of the robins and tomtits but special thanks to members of the local 4WD club who helped with 4WD and mistnetting support in the Akatarawas. Matu Booth, Ron Goudswaard, Mark Kearney and Matt Robertson led capture trips into the Akatarawas between 2003 and 2004. KST staff and volunteers assisted Delia Small with monitoring the robins after release, but particularly Annette Harvey, Frances Gazley and Faye Schaef who went on to undertake the followup monitoring of robins in the "study area" until 2005. Graham Parker, Rob Cross and Ron Goudswaard were very involved in the monitoring of tomtits in the sanctuary assisted by other staff and volunteers. Judi Lapsley Miller provided statistical advice. Lynn Adams, Monica Awasthy, and 2 anonymous referees provided helpful comments that improved the paper.

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