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Post-release monitoring of bird translocations: why is it important and how do we do it?

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Abstract Translocation is an important tool for the conservation management of birds in New Zealand. Early translocations marooned endangered species in predator-free environments, typically remote islands. However, modern integrated pest control, coupled with a proliferation of community-based restoration projects, has led to increased opportunities for translocations, particularly to mainland sites. Effective post-release monitoring of bird translocations is vital for improving overall translocation success. Here, we discuss why post-release monitoring is important and how it can be achieved, and suggest methods for documenting and monitoring translocation projects for birds. Key suggestions include: specifying the characteristics of each translocation, including how many birds are released, demographic composition and transfer processes; conducting post-release monitoring using discreet surveys and consistent sensible methodologies; individually marking birds; distinguishing immediate post-release effects from long-term site-related effects; and documenting the results in an accessible format such as a web-based database or published paper. We advocate a strategic approach whereby the intensity of post-release monitoring is directly related to the need and subsequent use of the data collected.

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INTRODUCTION

New Zealand ecosystems were radically altered following human colonisation, and many species either became extinct or were reduced to remnant populations (Caughley 1989; Holdaway 1989). Subsequently, modern conservation practice in New Zealand has had to develop methods for recovering and maintaining threatened and endangered species. Conservation translocations, the intentional movement of organisms from one place to another for conservation purposes (Seddon *et al.* 2012), have played a critical role in managing many New Zealand species. Some of the first conservation translocations were conducted in the late 1800s by Richard Henry in an attempt

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to establish populations of kākāpō (*Strigops habroptilus*) and kiwi (*Apteryx* spp.) on Resolution I in Fiordland (Hill & Hill 1987). Richard Henry's translocations ultimately failed because mustelids (*Mustela* spp.) invaded Resolution I (Hill & Hill 1987). However, conservation translocations were adopted by the New Zealand Wildlife Service from the early 1960s (and by the New Zealand Department of Conservation from 1987), and translocation has been essential for the conservation management of species such as the Chatham Island black robin (*Petroica traversi*)(Butler & Merton 1992), kākāpō (Powlesland *et al.* 2006) and the North and South Island saddlebacks (*Philesturnus rufusater* and *P. carunculatus*)(Lovegrove 1996). The ongoing management of these and many other threatened species is facilitated by the judicious use of translocations (see Miskelly & Powlesland 2013).

Modern New Zealand translocation practice has evolved from one of marooning critically endangered species on pest-free islands, to releases on islands and into mainland sites following pest eradications (Parker 2013). Species in lesser threat categories are also being translocated as part of ecological restoration programmes and increasingly translocations are conducted by community-based groups rather than being the sole domain of conservation professionals (Parker 2013). An average of 33 translocations per year were approved by the New Zealand Department of Conservation between 2002 and 2010 (Cromarty & Alderson 2013). In 2002, ~16% of these translocations were initiated by community-based restoration groups, whereas by 2010, 70% of approved translocations were by such groups (Cromarty& Alderson 2013). Many of these translocations are to pest-free mainland sites rather than to pest-free offshore islands. This is a critical point because of the greater dispersal opportunities for translocated species to move from protected mainland sites into surrounding unprotected habitats. There is also a higher probability of reinvasion by mammalian predators at protected mainland sites. In contrast, dispersal of translocated species from islands, and reinvasion by mammalian predators, is typically negligible due to water barriers.

Dispersal (Le Gouar *et al.* 2012), along with factors such as predation, competition, releases into unsuitable habitat (Osborne & Seddon 2012), genetic factors (Jamieson & Lacy 2012; Keller *et al.* 2012) and disease (Ewen *et al.* 2012b) can prevent the establishment and persistence of a translocated population. Considerable time, money and effort go into planning and conducting translocations, along with ethical considerations for the translocated animals themselves (Parker *et al.* 2012). Therefore, it is essential that we carefully plan translocation protocols to maximise initial success (Parker *et al.* 2012) and that we develop suitable post-release monitoring protocols for determining population establishment and persistence (McCarthy *et al.* 2012; Nichols & Armstrong 2012). Indeed, a feature of the translocation literature has been a sustained call for more effective post-release monitoring (see Sutherland *et al*. 2010, Ewen *et al.* 2012a and references therein). Here we discuss why post-release monitoring is important and outline what should be recorded for every translocation attempt. We then advocate a strategic approach whereby the intensity of post-release monitoring is directly related to the need and subsequent use of the data collected (Ewen & Armstrong 2007; McCarthy *et al.* 2012; Nichols & Armstrong 2012) and suggest several alternative methods for post-release monitoring of translocated birds. Finally, we join others in recommending that translocation outcomes be documented in an accessible format such as a published paper or web-based database (Sutherland *et al.* 2010).

Why is post-release monitoring important?

There are several possible outcomes following the release of translocated birds (Fig. 1). Ideally, there will be high post-release survival, successful breeding and recruitment, and a high probability of long-term persistence of the translocated population. Alternatively, a translocation may fail for a variety of reasons including the stress associated with the translocation process (capture, holding, moving and releasing animals)(Parker *et al.* 2012), dispersal from the release site into unprotected areas (Le Gouar *et al.* 2012), predation, disease (Ewen *et al.* 2012b), a lack of suitable habitat (Osborne & Seddon 2012), environmental and demographic stochasticity, or competition with other species. Depending on the life history traits of the translocated species these effects will typically occur over relatively short periods (immediately post-release through the first few breeding seasons for small forest passerines). However, a population might also fail in the long term (decades to hundreds of years) if, for example, the founders were insufficiently genetically diverse and the population becomes prone to the problems associated with genetic bottlenecks, inbreeding and drift (Jamieson & Lacy 2012; Keller *et al.* 2012). Clearly, we need to know what happens following a translocation and when. If a translocation is successful (*i.e.,* establishment is followed by reasonable population growth and long-term persistence), then further management intervention may not be required, although future monitoring may reveal unexpected problems. Meeting success criteria might also indicate that translocations of other species could reasonably be attempted at the same site. Alternatively, if monitoring reveals low

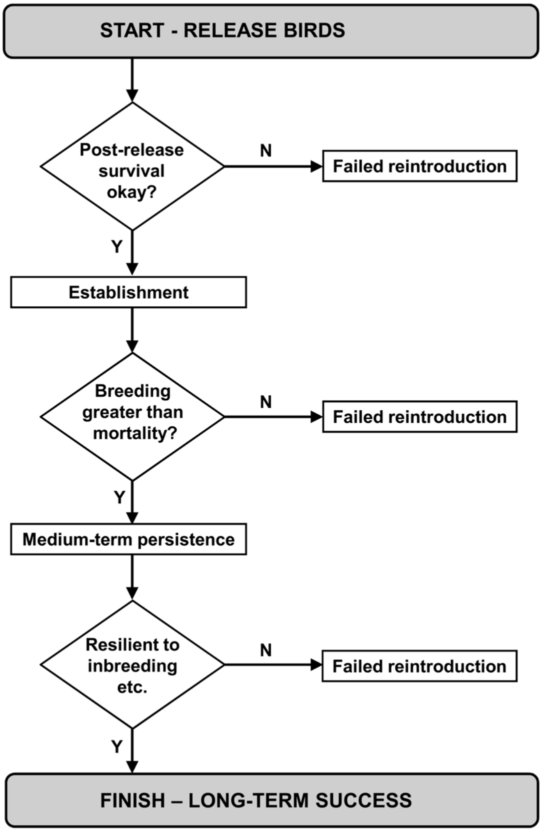

Fig. 1. Possible short-, medium- and long-term outcomes following a translocation. Outcomes should be assessed against specific *a priori* criteria in determining what level of survival indicates a successful translocation.

post-release survival and low population growth, further management will be required to achieve establishment and long-term persistence. This might include refining translocation techniques and release-site selection, supplementary translocations for behavioural or long-term (decades to hundreds of years) genetic management, and release-site support such as the provision of supplementary food, shelter or nest sites. Finally, if a translocation fails, knowing when and why it failed is essential in deciding whether further translocations should be attempted and what might be done to increase the likelihood of success. Translocation failure for any particular species can also be useful in deciding whether it is sensible to attempt translocations of other species to the same site.

Strategic post-release monitoring

At the most basic level there must be a record of every translocation even before any post-release monitoring takes place (Sutherland *et al.* 2010). This will include information on the species, the number of individuals translocated, the source, the age and sex ratio, the timing of the translocation, the method and period of confinement, husbandry details, health screening and quarantine protocols, release methods (*i.e.*, immediate or delayed release), any supportive management post-release (*e.g.*, food provision), and release-site management (Sutherland *et al.* 2010). Without this information it is difficult for future translocation practitioners to research past efforts to draw on information to improve translocation planning. Reporting translocation failures is also necessary to maintain transparency and refine translocation practices.

In designing methodologies for post-release monitoring we advocate a strategic approach whereby the data collected are directly relevant to the needs of the project and the species being translocated (Ewen & Armstrong 2007; McCarthy *et al.* 2012; Nichols & Armstrong 2012). In other words, the critical questions are what will these data be used for? How much certainty of translocation success do we have? Do we need to know what the immediate outcome of this translocation is? Do we need information to guide future management of this or other populations? How intense does the monitoring need to be to meet the needs of this particular project and what is the trade-off between the cost of monitoring and the quality of the data collected? Is there a research project associated with this translocation? While they might not be explicitly stated, translocation practitioners typically have a series of similar questions about the methods they are using for any particular translocation and the suitability of the release site. These questions should be formalised, particularly where uncertainty exists, to target monitoring and improve outcomes. Many questions will be answered in the planning stages, particularly for well understood systems or species (*e.g.*, island sites and robins), but for others considerable uncertainty will exist with a concomitant need for targeted monitoring.

The answers to these questions will be directly related to the species and site being considered for a translocation (*i.e.*, has the target species been translocated to a similar site before, how frequently has it been translocated and what were the outcomes?). For example, translocation protocols for North Island (NI) saddlebacks are well established and where translocation sites are free of mammalian predators translocations to offshore islands have been very successful (Lovegrove 1996; Hooson & Jamieson 2003). Therefore, there is a high likelihood of success when NI saddlebacks are translocated to islands and our post-release monitoring needs are likely to be minimal, such as only conducting a pre- and post- breeding survey of marked birds in the year following release. Alternatively, if

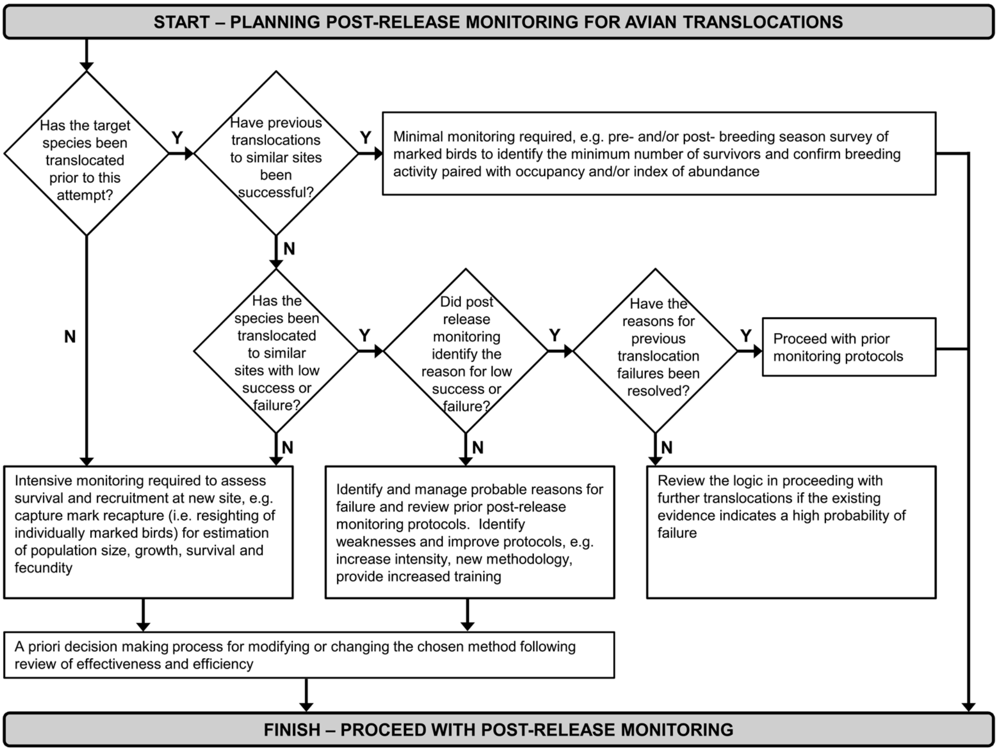

Fig. 2. Flow chart for assessing the need and intensity of post-release monitoring. We advocate an evidence based approach where possible, *i.e.* the outcomes from previous translocations are crucial in deciding appropriate post-release monitoring protocols.

NI saddlebacks were translocated to a protected mainland site within a larger unprotected contiguous habitat, post-release monitoring would have to be much more intense, *e.g.*, capture-mark-recapture methods (note that "recapture" is achieved through resighting of individually marked birds), because there is potential both for dispersal of translocated birds out of the protected area and for reinvasion of mammalian predators. There is less certainty about the success of a NI saddleback translocation to a mainland site because NI saddlebacks are highly vulnerable to mammalian predation (Higgins *et al.* 2006) and post-release monitoring would need to demonstrate whether the birds stayed within the protected area and if predator control was sufficient. Similarly, whiteheads (*Mohoua albicilla*) have been successfully translocated to several islands and discreet mainland sites (peninsulas or isolated habitat remnants), but translocations to mainland sites within larger contiguous unprotected habitats have been much less successful (K.A. Parker, *unpub. data*). Species that have never been translocated, such as the long-tailed cuckoo (*Eudynamys taitensis*), or that have never been successfully translocated, such as bellbirds (*Anthornis melanura*), will require greater post-release monitoring than those that have been translocated with some success.

Clearly, the first step in planning a translocation and deciding on post-release monitoring protocols is researching the outcomes of previous translocations of the same or comparable species via scientific literature, translocation reports and discussion with colleagues who have translocated the target species (*e.g.*, the Oceania Reintroduction Specialist Group http://rsg-oceania.squarespace.com/ provides contacts for many translocations of New Zealand species). With this information at hand, we suggest working through a simple flow chart (Fig. 2) to direct decisions on the type and intensity of post-release monitoring required. The use of data from prior translocations is central to structured decision making and adaptive management decision making processes that are particularly valuable for the overall translocation planning, which includes post-release monitoring as an integral part (McCarthy *et al.* 2012; Nichols & Armstrong 2012). We assume that any research project associated with a translocation, regardless of species or site, will devise post-release monitoring protocols appropriate to the specific research needs (see Armstrong *et al.* 1994; Armstrong

Table 1. Methods for post-release monitoring of translocated birds.

Approach*	Advantages	Disadvantages	References
1. Occupancy	Cheap and easy; good for abundant/spreading organisms	Not good for large organisms in small places; not a measure of abundance	(McKenzie *et al.* 2005)
2. Index of abundance	Cheap and easy	Need to understand the relationship between the index and N; poor precision	(Thompson *et al.* 1998)
3. Observational estimation of N (e.g. distance sampling)	Unbiased absolute estimate if assumptions are met; no marking of birds required	Less precise estimate of growth	(Buckland *et al.* 2001)
4. CMR estimation of N	Higher precision and better if observational assumptions of 3 are not met	More expensive	(White & Burnham 1999)
5. CMR estimation of λ, s and f	More precise estimate of λ and can be combined with 4	More problematic than 4 for estimating N	(White & Burnham 1999)
6. CMR of s, monitor reproductive success of individual pairs/females, λ a derived parameter	Greater precision of λ estimates, partitioning of reproductive versus juvenile survival, age effects and pedigrees for estimating inbreeding depression	Expensive	(White & Burnham 1999)
7. Quick site visit/expert opinion	Suitable for practitioners with large egos or…	…who are going to court.	
8. Throw up hands in despair	Alternative for practitioners with smaller egos		

*N = population size, CMR = capture mark recapture but note that individually marked birds are resighted rather than recaptured, λ = finite rate of population increase, s = survival and f= fecundity

& McLean 1995; Sarrazin & Barbault 1996; Ewen & Armstrong 2007; Seddon *et al.* 2007; Armstrong & Seddon 2008 and references therein for discussion of translocations and experimentation).

Post-release monitoring methods

The single most useful tool for post-release monitoring is to ensure that all released birds are individually marked thus allowing recognition of birds post-release (Sutherland *et al*. 2010). For many species (*e.g.,* passerines, waders, waterfowl, parrots, rails) this is typically achieved with a unique combination of colour leg bands. For species that might be recaptured during post-release monitoring, such as kiwi (*Apteryx* spp.) and burrowing seabirds, a single metal band or even a microchip might be sufficient. Where radio transmitters are used, each individual will be allocated unique signal characteristics, also taking into account other monitored species within the dispersal range of the translocated individuals. Some form of long-term visible marking, such as a band, is also recommended as transmitters will eventually fail or fall off.

There is a great range of methodologies available for post-release monitoring and we present only a few options here (Table 1 plus http://www.doc.govt.nz/biodiversitymonitoring provide useful starting points). Research into methodologies used in previous translocations is important when choosing a method that meets your needs; when possible workers should seek advice. However, regardless of the method used it must be applied in a well-designed and consistent manner, that is both repeatable and logical (Sutherland *et al.* 2010). The surveys must also be undertaken by adequately skilled personal. This is critical because as any good field worker knows, finding birds after release can be very challenging. Therefore, those conducting surveys should be familiar with the target species, be comfortable in the field and possess the requisite skills, such as being adept at reading colour bands, experienced with telemetry equipment, or competent at catching and handling the target species. Accurate, clearly interpretable records of surveys are essential, as the people collecting field data might not be those who analyse it. For the same reason, it is essential that the data are checked as soon as possible by the people who will be analysing it, as there are inevitably errors or points of confusion that need to be clarified. We also note that while a particular group might not have the resources to analyse data using a particular methodology (*e.g.,* capture-mark-recapture models), they will often have the ability to collect accurate data suitable for analysis.

Many restoration projects have existing monitoring protocols for resident bird populations as a means of assessing the effectiveness of restoration and pest control, typically an index of abundance (Table 1, approach 2) such as 5-minute bird counts. Such protocols can be used to monitor translocated species, but the information obtained, at least in the short- and medium-term, is often too coarse to allow interpretation beyond confirming that at least some individuals are present. In particular, it is difficult to determine anything about population size with such methods. However, for species with high post-release survival and productivity, such as NI saddlebacks to an island, an index of abundance might indicate long-term population increases - although we suggest coupling this with a pre- and post-breeding survey of banded birds and offspring in the first year following release. Observational estimation of population size, such as through distance sampling (Table 1 approach 3), is also used at some restoration sites and might be useful for initial post-release monitoring. However, the effort required to obtain the number of detections needed to generate population estimates might be better applied in an alternative method such as occupancy or capture-mark-recapture methods. Capture-mark-recapture methods (Table 1, approach 4-6) can provide robust estimates of survival and population size, but also require investment in time, skill and resources, and as a result can be expensive. We suggest they are most appropriate for translocations where there is a low certainty of outcome and a high need for the information, or if there is a research project associated with the translocation. The time frame over which inferences are required will also be a key issue. Intensive methods provide maximum information in a small amount of time (1-5 years) whereas less intensive methods such as distance sampling might provide similar information over much longer time frames (10-30 years). Site visits by experts on the translocated species can provide useful information but are not a substitute for formal surveys of marked birds (Table 1, approach 7-8).

The cost of post-release monitoring tends to increase with the intensity of the monitoring. This can sometimes be circumvented through the use of dedicated volunteers or with research collaborations, but the cost needs to be kept in context. Post-release monitoring is simply a part of any translocation and the overall cost is likely to be low relative to that of maintaining a release site, particularly on the mainland, and the cost of everything up to the point of actually releasing birds. Therefore, post-release monitoring by skilled field workers is an investment in the species and the site to which it is translocated, aids decisions about future translocations to the site, and contributes to overall efforts for both the species and for other restoration sites. The key to determining the required monitoring investment is to balance these benefits against the costs of monitoring. For example, in Table 2 we have recommended the greatest investment in monitoring for situations where the greatest long-term benefit is anticipated. An impediment to getting this balance right is that the majority of the return on any monitoring investment might occur through future projects, so taking a short-term view inevitably leads to under-monitoring.

Documenting translocation outcomes

Many projects focus on establishing a species at a particular site. This is understandable but a broader perspective is also required for coordinated restoration over a wide area, *e.g.* the Hauraki Gulf, the North I or even the whole of New Zealand, to improve translocation practice and clearly document what works and what does not. The Department of Conservation requires translocation outcomes to be reported back to the Department. However, we, along with others (Sutherland *et al.* 2010; Ewen *et al.* 2012a) urge translocation outcomes be reported also to a wider audience. The obvious repository for translocations in the New Zealand and Oceania region is the Oceania Reintroduction Specialist Group website (http://rsg-oceania.squarespace.com). International websites such as the Avian Reintroduction and Translocation Database (www.lpzoosites.org/artd) are also useful, as is publication in scientific journals such as *Notornis* (*e.g.*, Miskelly *et al.* 2012). The open-access online journal *Conservation Evidence* (www.ConservationEvidence.com) provides a particularly relevant and accessible model for documenting translocation outcomes (*e.g.*, see Parker & Laurence 2008 or Ewen *et al.* 2011).

CONCLUSIONS

Post-release monitoring is often viewed as being difficult and expensive, and even optional. However, the cost is small relative to other restoration activities (*e.g.*, developing and maintaining a suitable release site) and the benefits are large (*e.g.*, will this translocation work and if not why?). Therefore, acceptance of post-release monitoring as a natural and integral component of any translocation is essential to improve outcomes, to maintain high welfare standards and ethical practices throughout the translocation process and to maintain and improve effective use of scarce conservation dollars. We do not advocate undirected post-release monitoring, but rather urge rational monitoring effort for maximum gain of useful knowledge. Single translocations will be limited in their ability to improve translocation practise but meta-analyses of multiple translocations can provide critical insight (Seddon *et al.* 2007). Needless repetition of failed techniques is financially and ethically unsupportable (Parker *et al.* 2012). Effective post-release monitoring is the only way our methods can be robustly tested and our management refined (Parker *et al.* 2012).

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