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REVIEW

# Translocation tactics: a framework to support the IUCN Guidelines for wildlife translocations and improve the quality of applied methods

**William G. Batson[1]*, Iain J. Gordon[1,2], Donald B. Fletcher[3] and Adrian D. Manning[1]**

[1]*The Fenner School of Environment and Society, The Australian National University, Canberra, ACT 2601, Australia;* [2]*James Hutton Institute, Invergowrie, Dundee DD2 5DA, UK; and* [3]*Environment and Planning Directorate, ACT Government, Canberra, ACT 2601, Australia*

## Summary

**1.** Translocation is a popular conservation tool, but the outcomes are variable. Many tactics can be used to improve the probability of success, but a comprehensive summary of these does not exist. This increases the risk that valuable tactics will be overlooked, and inhibits effective communication.

**2.** We assess the diversity of 'translocation tactics' used in mammal and bird translocations, by reviewing the IUCN/SSC Guidelines for Reintroduction and other Conservation Translocations, 195 peer-reviewed articles and 73 case studies from the IUCN/SSC Global Reintroduction Perspectives Series.

**3.** We recorded descriptions of every technique used to influence the post-release performance of translocated wildlife. We developed the Translocation Tactics Classification System (TTCS) which defines a collection of 30 tactics and organize them into an ecologically relevant framework. We also assess the occurrence of tactics within the Guidelines, the primary literature and the case studies to evaluate how tactics are communicated within these mediums.

**4.** Our results indicate that the Guidelines are a valuable resource, but do not exhaustively cover tactics, and that detailed methodological accounts are rarely made publicly accessible. This highlights the need to develop context-specific resources to support the Guidelines, and to develop and exploit mediums that facilitate recording of methodological detail, the tactical rationale behind the design and evaluations of effectiveness. Although some forms of grey literature address this issue, the general lack of information limits the ability to investigate the relationship between tactics and translocation success.

**5.** *Synthesis and applications*. The Translocation Tactics Classification System (TTCS) provides a checklist which ensures that the full diversity of tactics is considered when developing translocation processes. Standardizing the communication of tactics, and encouraging detailed accounts of applied methodologies to be recorded, along with the tactical reasoning behind the design, will provide operational models and the data required to conduct broad-scale meta-analyses.

**Key-words:** assisted colonization, conservation, processes, protocols, reintroduction, restocking, strategy, supplementation

## Introduction

> Strategy without tactics is the slowest route to victory. Tactics without strategy is the noise before defeat.Sun Tzu, The Art of War (c.500 BC).

'Conservation translocations' (hereafter referred to as 'translocations') describe the deliberate movement of wildlife for the purposes of conservation (Seddon 2010; IUCN/SSC 2013). Despite the growing popularity of translocations as a conservation tool, the outcomes remain variable due to the myriad of factors that can affect translocated populations (Griffith *et al.* 1989; Wolf *et al.* 1996; Fischer & Lindenmayer 2000). Translocations

*Correspondence author. E-mail: william.batson@anu.edu.au

inherently fail from a population perspective when the effects of mortality, dispersal and disrupted reproduction cannot be mitigated (Soorae 2008, 2010, 2011, 2013). The probability of success can be improved by using 'tactics' which are techniques capable of influencing post-release individual performance or population persistence. The selection and design of tactics should be founded on 'strategy' which are clearly defined objectives (e.g. minimizing dispersal) that guide the selection of tactics which maximize the probability of success, whilst maintaining the efficiency and feasibility of the overall project. Many tactics are commonly applied during translocations, including controlling the number of individuals released, selecting suitable areas of habitat and incorporating a confinement period prior to release (Miller *et al.* 1999; Armstrong & Seddon 2008; Parker *et al.* 2012; Batson, Abbott & Richardson 2015). However, a comprehensive summary of the diversity of tactics is not currently available, which reduces the standardization of terminology and increases the risk that potentially valuable tactics could be overlooked in translocation design, especially given the specific needs of different translocations.

Although tactics can improve the probability of success, they are unlikely to be effective unless they are integrated into an appropriately designed process. We use the terms strategy and tactics deliberately to highlight the need to consider the design of translocation processes within the context of these concepts. Ideally, translocations are designed by interdisciplinary groups making evidence-based decisions (IUCN/SSC 2013), but many decisions appear to be founded upon personal knowledge, opinions and experience (Parker *et al.* 2012). This reliance on human cognizance may affect the quality of translocation processes due to variability in the knowledge of tactics. The potential for variability in the implementation of translocations is compounded by the complexity of translocations and the unpredictability of biological and behavioural responses to different methods (Miller *et al.* 1999; Seddon, Strauss & Innes 2012; Moseby, Hill & Lavery 2014). Therefore, increasing the conceptual and theoretical understanding of tactics could help to improve conservation outcomes by increasing the general quality of translocation processes.

The IUCN Reintroduction Specialist Group (RSG) was established in 1988 in response to the proliferation of poorly managed translocations (Seddon, Armstrong & Maloney 2007). Since inception, the RSG has advocated universal standards for translocation by publishing the Guidelines for Reintroduction (1998) and the Guidelines for Reintroduction and other Conservation Translocations (2013). The purpose of these Guidelines is to 'provide guidance on the justification, design and implementation of any conservation translocation' and the content is 'based on principle rather than example' (IUCN/SSC 2013 p. 1). The Guidelines are widely accepted by the conservation community, who generally adhere to the recommended standards (Soorae 2008, 2010, 2011, 2013). However, the necessary broad scope and non-taxon-specific nature of the Guidelines restrict the depth of information regarding specific aspects of translocation practice. This suggests that there is a need to support the Guidelines with resources with a specific focus. In recognition of the benefits associated with recording practical information, the IUCN/SSC produced the Global Reintroduction Perspectives Series (Soorae 2008, 2010, 2011, 2013). This series presents reintroduction case studies with a focus on application, key learnings and ultimate outcomes.

Here, we present a tactics-focused resource to complement the Guidelines. Our objective is to identify, define and organize the diversity of tactics used to improve the outcomes of bird and mammal translocations. These taxonomic groups were selected because they are involved in a significant proportion of translocation projects and are over-represented in the translocation-related literature (Fischer & Lindenmayer 2000; Seddon, Soorae & Launay 2005; Bajomi *et al.* 2010). To achieve this, we reviewed the content of the 2013 edition of the Guidelines, a collection of 195 articles from the primary literature and 73 case studies from the Global Reintroduction Perspectives Series (Soorae 2008, 2010, 2011). From this review, we developed the Translocation Tactics Classification System (TTCS) which supports the Guidelines by placing the diversity of tactics into a logical and ecologically relevant framework. The purpose of the TTCS is to ensure that conservation groups are fully aware of the range of tactics available when designing translocations. We also evaluate the communication of tactics within all three media and provide recommendations to improve the standard of communication in the future.

## Materials and methods

We reviewed the content of the Guidelines and recorded descriptions of every technique that fulfilled our criteria for a tactic. To maintain a specific focus, we excluded techniques associated with species selection, monitoring, capture, handling and transportation because these are often taxon specific and have also been reviewed elsewhere (Kleiman 1989; Letty, Marchandeau & Aubineau 2007; Parker *et al.* 2012). We also excluded techniques associated with non-ecological or biological aspects of translocation (e.g. economic, social and political), and those stated as being associated with translocations not involving birds or mammals. We then repeated this process on a collection of 195 articles accessed using the ISI Web of Science data base in January 2013. We identified articles using the search terms Translocat* OR Reestabl* OR Re-establ* OR Reintroduc* OR Re-introduc*, Introduc* OR Relocat* OR Re-locat* entered in 'Topic', with the 'Research Area' restricted to 'Biological Conservation' which produced 1499 hits. This was reduced to 195 articles using the following criteria: (i) a full pdf. version of the article was accessible using the Find Full Text function in Endnote X6, (ii) the article focused on mammal or bird translocation(s) (including simulation models and reviews), and (iii) the article included a description of at least one tactic. We used the same criteria to select 73 case studies published in the mammal and bird sections

of Global Reintroduction Perspectives Series (Soorae 2008, 2010, 2011).

We recorded a description of each technique that was indicated as being implemented or excluded to improve post-release performance or persistence (e.g. survival or reproduction), induce a desirable behavioural response (e.g. settlement) or to avoid/mitigate a potential threat (e.g. mortality or genetic viability). We also recorded descriptions of techniques that were recommended to be used in subsequent projects, and those suggested as being beneficial in reviews and modelling articles. We excluded techniques associated with capture, handling and transportation on the assumption that these are predominantly taxon specific. We developed definitions of tactics using the descriptions, ensuring that every technique described was accounted for within a definition. We grouped tactics according to operative similarities into a hierarchical framework to produce the TTCS. We also recorded presence or absence of each tactic within the Guidelines, articles and case studies to allow the communication of tactics to be compared between mediums.

## Results

We identified and defined a total of 30 tactics during the review process (Table 1). Each tactic was identified in the collection of case studies, 29 were detected within the collection of articles, and 24 were detected in the Guidelines (Table 1). The tactics were organized into the TTCS based on operational similarities. The uppermost tier of the framework is the *tactical pool* which represents the entire collection of tactics. The tactical pool is divided to form the *tactical focus groups* which differentiate between *animal-focused tactics* and *environment-focused tactics* based on the aspect of the translocation process in which they operate. The tactical focus groups are further subdivided into *tactical groups* by differentiating between tactics that operate according to the principles of *selection, preconditioning, release design* or *post-release management*. Each tactical group is subdivided into specific *tactics* (Fig 1). The detection rates of the tactical groups and tactics in the three media are presented in Table 1.

## Discussion

The abundance and diversity of the tactics indicate the compositional complexity of translocations. This complexity presumably increases the likelihood that the knowledge of tactics will vary among conservation groups involved in translocation projects. The TTCS provides a framework that can improve the ability to identify, select and design tactics which help to achieve defined strategies. The TTCS also outlines the fundamental theory behind the operation of each tactic. The TTCS complements the Guidelines by placing key recommendations within a logical framework, and will ultimately improve the ability to identify and counter potential threats to translocation success. Using the TTCS as a checklist will also encourage and facilitate standardized and systematic design processes to be adopted. The TTCS will also improve the ability to interpret and communicate tactics among people from various disciplines by providing a standardized set of definitions.

The 2013 version of the Guidelines presents a broader range of recommendations compared to the previous version. As a majority of tactics identified in the primary literature also featured in the Guidelines, we conclude that the 2013 version of the Guidelines presents a comprehensive, but not exhaustive, record of the tactics used in bird and mammal translocations. It appears that the absence of the missing tactics can attributed to their rare use, as indicated by the relatively low detection rates in articles and case studies, whereas the absence of post-release threat control can be attributed to the Guidelines not differentiating between threat control measures that occur pre- and post-release. Despite the substantial coverage of tactics in the Guidelines, we believe that the distribution of these references among different sections of the document reduces the ease with which they can be accessed and interpreted by the reader highlighting the benefit of the TTCS as a supportive framework. The extensive coverage of tactics within the Guidelines validates the breadth of information presented, and the process used to develop the resource. The extent of coverage of tactics in the Guidelines is encouraging given the prominent role the Guidelines have in advocating responsible translocation standards. Conversely, the absence of some tactics highlights the need to develop concept-specific resources to complement the Guidelines.

As the TTCS is based on subjective interpretations of applied techniques, its structure and definitions may appear arbitrary in places. However, any debate surrounding its validity is unlikely to reduce its effectiveness as a resource for practitioners as long as the operational basis of each tactic is understood. It is also inevitable that there will be additional tactics that do not appear within the TTCS due to the method used to develop this framework. It is also important to recognize that despite the focus on bird and mammal translocations in this study, many of the tactics presented will also be relevant to other taxa. In the future, we would encourage the expansion of the TTCS to encompass additional tactics, those that related to non-biological and non-ecological elements, and those associated with other taxa. Expanding the framework will ultimately improve the conceptual understanding of the translocation process in its entirety.

The broad scope of the Guidelines and the TTCS make general recommendations regarding the design or implementation of tactics for translocations within specific characteristics inappropriate. However, these types of recommendations have been presented elsewhere. For example, Jones & Merton (2012) advocate, predominantly supported by experimental evidence, the use of immediate releases for translocating wild birds, and delayed releases for those involving captive birds (Mitchell *et al.* 2011; Richardson *et al.* 2015). However, sweeping recommendations are relatively uncommon in the translocation literature due to the complexity of an animal's response to

**Table 1.** The definition of the tactical options presented in the Translocation Tactics Classification System. Each definition is supported with examples of how a tactical option can be implemented in a translocation, and relevant references (max. 3). The two right-hand columns indicate whether a tactical option was detected in the IUCN/SSC Guidelines for Reintroductions and Other Conservation Translocations (2013), and the detection rates in the collection of 195 articles and 73 case studies assessed during this study. Where possible, the references provided present both a theoretical and an applied account of the respective tactic

| Tactical option | Definition | Example | References | Detected in Guidelines | Detection rate in articles (%) | Detection rate in case studies (%) |
|---|---|---|---|---|---|---|
| Animal Selection | The deliberate selection of an individual or source population based on the relative prevalence for a discernible trait | | | | 34 | 40 |
| Behavioural Selection | The deliberate selection of individuals or groups from multiple candidates based on a behavioural trait | Selection for or against behavioural boldness, shyness or wildness | Miller *et al.* (1999), Bremner-Harrison, Prodohl & Elwood (2004), Le Gouar, Mihoub & Sarrazin (2012) | Y | 3 | 7 |
| Demographic Selection | The deliberate selection of individuals or groups from multiple candidates based on a demographic trait | Selection for or against sex, age, reproductive or social status | Miller *et al.* (1999), Sarrazin & Legendre (2000), Aaltonen *et al.* (2009) | Y | 16 | 29 |
| Genetic Selection | The deliberate selection of individuals or groups from multiple candidates based on the prevalence for a genetic trait | Selection for or against heterozygosity or level of genetic differentiation | Elliott, Merton & Jansen (2001), Letty, Marchandeau & Aubineau (2007), Jamieson & Lacy (2012) | Y | 7 | 1 |
| Physiological Selection | The deliberate selection of individuals or groups from multiple candidates based on the prevalence for a physiological trait | Selection for or against body mass or body condition | Calvete *et al.* (2005), Letty, Marchandeau & Aubineau (2007) | Y | 3 | 4 |
| Health Selection | The deliberate selection of individuals or groups from multiple candidates based on the prevalence for a health trait | Selection for or against immunology, pathogen or parasite load or injury (often involves health screening) | Mathews *et al.* (2006), Faria, van Oosterhout & Cable (2010), Ewen *et al.* (2012) | Y | 8 | 15 |
| Experiential Selection | The deliberate selection of individuals or groups from multiple candidates based on pre-release experiences | Selection for or against source type (wild vs. captive), raising conditions (hand-reared vs. cross-fostered) or predator experience | Jule, Leaver & Lea (2008), Zidon *et al.* (2009), Parlato & Armstrong (2013) | Y | 10 | 4 |
| Animal Preconditioning | The deliberate alteration of a trait within an individual or group prior to release | | | | 29 | 41 |
| Behavioural Preconditioning | The deliberate alteration of a behavioural trait within individuals or group prior to release | Preconditioning through predator avoidance or resource acquisition training | Shier & Owings (2006), Alonso *et al.* (2011), White *et al.* (2012) | Y | 6 | 3 |
| Genetic Preconditioning | The deliberate alteration of genetic | | Frankham (1995), Christie (2009) | N | 3 | 1 |

(continued)

**Table 1.** (continued)

| Tactical option | Definition | Example | References | Detected in Guidelines | Detection rate in articles (%) | Detection rate in case studies (%) |
|---|---|---|---|---|---|---|
| | traits within an individual or group prior to release | Preconditioning through controlled breeding in captivity | | | | |
| Physiological Preconditioning | The deliberate alteration of physiological traits within individuals prior to release | Preconditioning through wing clipping or improved body condition | Combreau & Smith (1998), Calvete *et al.* (2005), Letty, Marchandeau & Aubineau (2007) | N | 4 | 1 |
| Social Preconditioning | The deliberate alteration of social relationships between individuals prior to release | Preconditioning through communally housing of individuals to establish social networks | Tear & Ables (1999), Gusset, Slotow & Somers (2006) | Y | 4 | 10 |
| Experiential Preconditioning | The deliberate alteration of environmental characteristics of the source environment prior to release | Preconditioning through the provision of wild environmental features whilst in captivity | Shepherdson (1994), Biggins *et al.* (1999), Letty, Marchandeau & Aubineau (2007) | Y | 12 | 26 |
| Health Preconditioning | The deliberate alteration of health characteristics of individuals prior to release | Preconditioning through immunization or the treatment of pre-existing conditions | Mathews *et al.* (2006), Faria, van Oosterhout & Cable (2010), Ewen *et al.* (2012) | Y | 6 | 12 |
| Reproductive Preconditioning | The deliberate alteration or control of the reproductive status of individuals prior to release | Preconditioning through the removal of pouch young from marsupials | Andrews, Bigwood & Barlow (2010) | N | 0 | 1 |
| Animal Release Design | The deliberate control of the size or composition of a founder population | | | | 38 | 40 |
| Population Size | The deliberate selection of the number of individuals included in a translocated cohort | Deliberately maximizing the size of a cohort, or releasing a predetermined number of individuals | Komers & Curman (2000), Tracy *et al.* (2011), Batson *et al.* (2015) | Y | 26 | 21 |
| Genetic Composition | The deliberate control of the genetic make-up of a translocated cohort | Deliberately maximizing genetic diversity within cohort, or mimicking the genetic make-up of a wild population | Robert *et al.* (2004), Biebach & Keller (2012), Batson *et al.* (2015) | Y | 5 | 11 |
| Demographic Composition | The deliberate control of the demographic make-up of a translocated population or cohort | Deliberately designed sex bias, age bias or wild-like demographic structure in a translocated population | Komers & Curman (2000), Jamieson & Lacy (2012), Batson *et al.* (2015) | Y | 12 | 16 |
| Social Composition | The deliberate control of the social make-up of a translocated population or cohort | Deliberately designed social composition established by translocating multiple members of an established social group | Bennett *et al.* (2012), Shier & Swaisgood (2012), Batson *et al.* (2015) | Y | 9 | 16 |

(continued)

**Table 1.** (continued)

| Tactical option | Definition | Example | References | Detected in Guidelines | Detection rate in articles (%) | Detection rate in case studies (%) |
|---|---|---|---|---|---|---|
| Post-release Animal Management | Management actions undertaken on translocated individuals post-release | | | | 10 | 16 |
| Intervention | Actions undertaken in order to mitigate issues based on post-release observations | The treatment of an injury or the removal of problem of individuals based on post-release observations | Elliott, Merton & Jansen (2001), Mathews *et al.* (2006), Ewen *et al.* (2012) | Y | 6 | 8 |
| Manipulated Reproduction | Actions undertaken to influence the reproductive cycles or offspring of translocated individuals | The removal of offspring from translocated adults to hand raise or cross foster | Elliott, Merton & Jansen (2001) | N | 3 | 3 |
| Managed Dispersal | Action undertaken to establish and maintain meta-population dynamics | The translocation of individuals among translocated subpopulations | Davies-Mostert, Mills & Macdonald (2009), Gusset *et al.* (2009), Jamieson & Lacy (2012) | N | 3 | 5 |
| Environmental Selection | The selection of a source or recipient environment based on the relative prevalence for a discernible trait | | | | 42 | 62 |
| Suitability Selection | The deliberate selection of an environment from multiple candidates based on the level of suitability to the translocated wildlife | Selection based on resource availability, threat abundance suitability or climatic suitability | Miller *et al.* (1999), Osborne & Seddon (2012), White *et al.* (2012) | Y | 38 | 62 |
| Similarity Selection | The deliberate selection of an environment from multiple candidates based on the level of similarity between the source and recipient environments | Selection based on resource availability, threat abundance suitability, or climatic similarity | Letty, Marchandeau & Aubineau (2007), Osborne & Seddon (2012), Parlato & Armstrong (2013) | Y | 8 | 3 |
| Environmental Preconditioning | The deliberate alteration of a trait within a recipient environment | | | | 17 | 25 |
| Pre-release Resource Augmentation | The deliberate augmentation of resources within the recipient environment pre-release | Environmental preconditioning through habitat restoration, artificial resources or biological markers (e.g. broadcasting con-specific scat) | Veitch (1995), Manning, Lindenmayer & Fischer (2006), Osborne & Seddon (2012) | Y | 8 | 16 |
| Pre-release Threat Control | The deliberate control of threats within the recipient environment pre-release | Environmental preconditioning through fencing and predator control | Moseby *et al.* (2011), Burns, Innes & Day (2012), Osborne & Seddon (2012) | Y | 9 | 10 |

(continued)

**Table 1.** (continued)

| Tactical option | Definition | Example | References | Detected in Guidelines | Detection rate in articles (%) | Detection rate in case studies (%) |
|---|---|---|---|---|---|---|
| Environmental Release Design | The control of the spatial or temporal dynamics of releases | | | | 44 | 67 |
| Spatial Configuration | The deliberate control of the number and configuration of release sites | Deliberately designing the number of release sites, distance between release sites or distance between source and recipient sites | Saltz (1998), Rout, Hauser & Possingham (2009), Berger-Tal, Bar-David & Saltz (2012) | Y | 9 | 12 |
| Temporal Configuration | The deliberate control of the number and configuration of release events | Deliberately designing the number of release events or the period between release events | Gusset *et al.* (2009), Faria, van Oosterhout & Cable (2010), Batson *et al.* (2015) | Y | 14 | 19 |
| Release Timing | The deliberate control of the timing of a release event(s) | Deliberately designing the timing of a release event according to seasonal, behavioural or biological cycles | Bright & Morris (1994), Tavecchia *et al.* (2009), Batson *et al.* (2015) | Y | 11 | 23 |
| Delayed or Immediate Release | The deliberate inclusion, exclusion and design of a holding period immediately preceding release | Deliberately including or excluding a temporary confinement period immediately preceding release | Letty, Marchandeau & Aubineau (2007), Batson *et al.* (2015), Richardson *et al.* (2015) | Y | 25 | 45 |
| Post-release Environmental Management | Management actions undertaken on recipient environment post-release | | | | 24 | 45 |
| Post-release Resource Augmentation | The deliberate augmentation of resources within the recipient environment post-release | Post-release management through ecological restoration, artificial resources or biological markers | Swaisgood (2010), Bradley *et al.* (2011), Chauvenet *et al.* (2012) | Y | 17 | 30 |
| Post-release Threat Control | The deliberate control of threats within the recipient environment post-release | Post-release management through predator or pathogen control | Short *et al.* (1992), Armstrong *et al.* (2006), Moseby *et al.* (2011) | N | 10 | 21 |

different methods (Parker *et al.* 2012). Therefore, the design of translocation processes needs to be considered on a project-by-project basis (IUCN/SSC 2013), and be conducted within adaptive and experimental frameworks to constantly improve the quality of translocation practices (Seddon, Armstrong & Maloney 2007; McCarthy, Armstrong & Runge 2012). One of the primary functions of the TTCS is to encourage each tactic to be carefully evaluated, and decisions founded on empirical evidence and previous experience where possible. Adopting this systematic design process will ultimately improve the general quality of translocation methods (meaning the probability that the process will achieve the ultimate objectives of the project) and avoid the implementation of poorly planned projects.

The primary literature is important for communicating translocation-related information (IUCN/SSC 2013). However, it is apparent that scientific articles rarely present detailed accounts of translocation methods. This was recognized by Sutherland *et al.* (2010) who outline how the lack of detail description of methodology impacts on the ability to interpret methods, draw comparisons among projects and conduct broad-scale systematic meta-analyses. There are many factors responsible for the lack of methodological detail in the primary literature including publication constraints (e.g. word limits), and the concise focus of scientific articles (Armstrong & McCarthy 2007). The level of detail is further restricted by other factors including the lack of involvement by scientists in many projects, the limited resource available to produce scientific articles, personal motivations and the required scientific rigour (e.g. sample size) needed to publish in many scientific journals. These factors provide substantial barriers to the reporting in the primary literature and can often shift the focus of articles that are produced away from the methodological concepts (Armstrong &

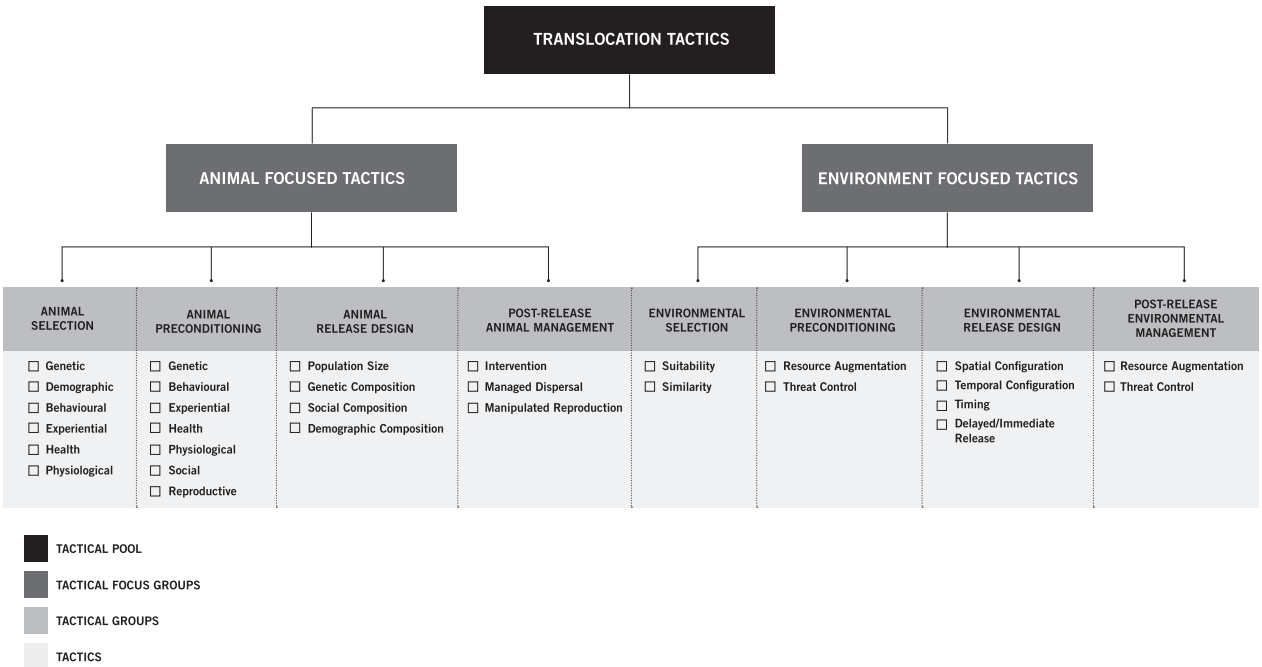


**Fig. 1.** The Translocation Tactics Classification System. This framework represents a hierarchical organization of the tactical options identified from the literature review. The groupings are created according to operational similarities.

McCarthy 2007; Seddon, Armstrong & Maloney 2007; Sutherland *et al.* 2010).

The need for increased reporting and access to practical information motivated the IUCN/SSC to produce the Global Reintroduction Perspectives Series. This series is specifically designed to record practical information without many of the barriers associated with the primary literature. The central focus of this series encompasses the design, application, key learnings and the ultimate outcomes of reintroductions. The higher detection rates of tactics in the case studies compared to the articles assessed in this study suggest a greater level of methodological detail is being provided in the case studies. However, it can be assumed that only a small number of reintroduction projects are reported in this series which presents a potential loss of valuable information.

It was apparent, in both the articles and case studies, that the description of many techniques that could be considered tactics were overlooked because they were not supported by the tactical rationale behind their design. We argue that this information should be reported whenever possible because it allows the factors that influence methodological design to be interpreted and be used to guide the design of other projects. For example, it is beneficial to understand whether the number of individuals released was predominantly determined by restricted availability or as a tactic to ensure genetic viability. The limited volume of methodological information currently available also restricts the opportunity to investigate the effects of specific tactics on translocation success to only the most commonly described tactics (e.g. Fischer & Lindenmayer 2000) and the most commonly translocated taxa (e.g. Wolf *et al.* 1996). This restriction may lead to a perception that the most commonly described tactics are the most critical components of a translocation process, but the validity of this assumption remains to be tested. The ability to record full methodological accounts, and the tactical rationale of their design, is likely to require the creation of a new medium (e.g. a centralized data base) which is specifically designed to serve this purpose. Ultimately, the design and structure of any future resource would be founded on the TTCS framework. The value of developing such a resource would be the accumulation of information that could be used to conduct broad meta-analyses to assess the effectiveness various approaches, within specific translocation contexts. More detailed accounts would also provide conservation practitioners with operational models to help guide the design of translocation processes, and avoid mistakes being repeated.

The outcomes of translocations are strongly influenced by the ability to select and design appropriate tactics. As translocation methods are predominately shaped by the knowledge of the people involved in the project, those people need to be fully aware of the tactical options available. When faced with uncertainty, practitioners should make use of evidence-based recommendations accessed through various media including the primary literature, case studies and personal communication. Accessing this information will help to ensure that justifiable decisions are made and decrease the chances of making mistakes. The role of conservation biology is to develop the theoretical understanding of the factors that can influence conservation outcomes. However, striving for scientific

novelty may cause fundamental components to be under-appreciated and under-represented in the scientific literature. To remedy this problem, conservationists should be encouraged to record and communicate their practical experiences, as well quantitative results to increase awareness across the community. Although, there is immense value provided by general Guidelines as produced by the IUCN/SSC, these need to be supported by context-specific resources and practical case studies which provide insight regarding application and design. Here, we provide a supporting resource that can be used by all members of the conservation community whatever their disciplinary background which will help to improve the tactical and strategic strength of translocation processes.

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## Data accessibility

Data used to calculate the detection rates of tactics within each article, case study and the Guidelines are accessible at Dryad Digital Repository doi: 10.5061/dryad.gm6mc (Batson *et al.* 2015).

## References

Aaltonen, K., Bryant, A.A., Hostetler, J.A. & Oli, M.K. (2009) Reintroducing endangered Vancouver Island marmots: survival and cause-specific mortality rates of captive-born versus wild-born individuals. *Biological Conservation*, **142**, 2181–2190.

Alonso, R., Orejas, P., Lopes, F. & Sanz, C. (2011) Pre-release training of juvenile little owls *Athene noctua* to avoid predation. *Animal Biodiversity and Conservation*, **34**, 389–393.

Andrews, L., Bigwood, S. & Barlow, S. (2010) The re-introduction of yellow-footed rock-wallaby to the northern Flinders Ranges, South Australia. *Global re-Introduction Perspectives: Additional Case-Studies From Around the Globe* (ed. P.S. Soorae), pp. 215–219. IUCN/SSC Re-introduction Specialist Group & Environment Agency-Abu Dhabi, Abu Dhabi, UAE.

Armstrong, D.P. & McCarthy, M.A. (2007) Big decisions and sparse data: adapting scientific publishing to the needs of practical conservation. *Avian Conservation and Ecology*, **2**, article 14.

Armstrong, D.P. & Seddon, P.J. (2008) Directions in reintroduction biology. *Trends in Ecology & Evolution*, **23**, 20–25.

Armstrong, D.P., Raeburn, E.H., Lewis, R.M. & Ravine, D. (2006) Estimating the viability of a reintroduced New Zealand robin population as a function of predator control. *Journal of Wildlife Management*, **70**, 1020–1027.

Bajomi, B., Pullin, A.S., Stewart, G.B. & Takacs-Santa, A. (2010) Bias and dispersal in the animal reintroduction literature. *Oryx*, **44**, 358–365.

Batson, W., Abbott, R. & Richardson, K.M. (2015) Release strategies for fauna reintroductions: theory and tests. *Advances in Reintroduction Biology of Australian and New Zealand Fauna* (eds D.P. Armstrong, M.W. Hayward, D. Moro & P.J. Seddon), pp. 7–16. CSIRO Publishing, Collingwood, Australia.

Batson, W.G., Gordon, I.J., Fletcher, D.B. & Manning, A.D. (2015) Data from: translocation tactics: a framework to support the IUCN Guidelines for wildlife translocations and improve the quality of applied methods. *Dryad Digital Repository*, doi:10.5061/dryad.gm6mc.

Bennett, V.A., Doerr, V.A.J., Doerr, E.D., Manning, A.D. & Lindenmayer, D.B. (2012) The anatomy of a failed reintroduction: a case study with the brown treecreeper. *Emu*, **112**, 298–312.

Berger-Tal, O., Bar-David, S. & Saltz, D. (2012) Effectiveness of multiple release sites in reintroduction of Persian fallow deer. *Conservation Biology*, **26**, 107–115.

Biebach, I. & Keller, L.F. (2012) Genetic variation depends more on admixture than number of founders in reintroduced alpine ibex populations. *Biological Conservation*, **147**, 197–203.

Biggins, D.E., Vargas, A., Godbey, J.L. & Anderson, S.H. (1999) Influence of prerelease experience on reintroduced black-footed ferrets (*Mustela nigripes*). *Biological Conservation*, **89**, 121–129.

Bradley, D.W., Ninnes, C.E., Valderrama, S.V. & Waas, J.R. (2011) Does 'acoustic anchoring' reduce post-translocation dispersal of North Island robins? *Wildlife Research*, **38**, 69–76.

Bremner-Harrison, S., Prodohl, P.A. & Elwood, R.W. (2004) Behavioural trait assessment as a release criterion: boldness predicts early death in a reintroduction programme of captive-bred swift fox (*Vulpes velox*). *Animal Conservation*, **7**, 313–320.

Bright, P.W. & Morris, P.A. (1994) Animal translocation for conservation: performance of dormice in relation to release methods, origin and season. *Journal of Applied Ecology*, **31**, 699–708.

Burns, B., Innes, J. & Day, T. (2012) The use and potential of pest-proof fencing for ecosystem restoration and fauna conservation in New Zealand. *Fencing for Conservation* (eds M.J. Somers & M.W. Hayward), pp. 65–90. Springer-US, New York City, New York, USA.

Calvete, C., Angulo, E., Estrada, R., Moreno, S. & Villafuerte, R. (2005) Quarantine length and survival of translocated European wild rabbits. *Journal of Wildlife Management*, **69**, 1063–1072.

Chauvenet, A.L.M., Ewen, J.G., Armstrong, D.P., Coulson, T., Blackburn, T.M., Adams, L., Walker, L.K. & Pettorelli, N. (2012) Does supplemental feeding affect the viability of translocated populations? The example of the hihi. *Animal Conservation*, **15**, 337–350.

Christie, S. (2009) Breeding far eastern leopards for reintroduction: the zoo programme perspective. *Reintroduction of Top-Order Predators* (eds M.W. Hayward & M. Somers), pp. 388–410. Wiley-Blackwell, Hoboken, New Jersey, USA.

Combreau, O. & Smith, T.R. (1998) Release techniques and predation in the introduction of houbara bustards in Saudi Arabia. *Biological Conservation*, **84**, 147–155.

Davies-Mostert, H.T., Mills, M.G.L. & Macdonald, D. (2009) A critical assessment of South Africa's managed metapopulation recovery strategy for African wild dogs. *Reintroduction of Top-Order Predators* (eds M.W. Hayward & M.J. Somers), pp. 10–42. Blackwell Publishing, Oxford, UK.

Elliott, G.P., Merton, D.V. & Jansen, P.W. (2001) Intensive management of a critically endangered species: the kakapo. *Biological Conservation*, **99**, 121–133.

Ewen, J.G., Acevedo-Whitehouse, K., Alley, M.R., Carraro, C., Sainsbury, A.W., Swinnerton, K. & Woodroffe, R. (2012) Empirical consideration of parasites and health in reintroduction. *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 290–335. Blackwell Publishing Ltd., Oxford, UK.

Faria, P.J., van Oosterhout, C. & Cable, J. (2010) Optimal release strategies for captive-bred animals in reintroduction programs: experimental infections using the guppy as a model organism. *Biological Conservation*, **143**, 35–41.

Fischer, J. & Lindenmayer, D.B. (2000) An assessment of the published results of animal relocations. *Biological Conservation*, **96**, 1–11.

Frankham, R. (1995) Genetic management of captive populations for reintroduction. *Reintroduction Biology of Australian and New Zealand Fauna* (ed. M. Serena), pp. 31–34. Surrey Beatty and Sons, New South Wales, Australia.

Griffith, B., Scott, J.M., Carpenter, J.W. & Reed, C. (1989) Translocation as a species conservation tool – status and strategy. *Science*, **245**, 477–480.

Gusset, M., Slotow, R. & Somers, M.J. (2006) Divided we fail: the importance of social integration for the re-introduction of endangered African wild dogs (*Lycaon pictus*). *Journal of Zoology*, **270**, 502–511.

Gusset, M., Jakoby, O., Muller, M.S., Somers, M.J., Slotow, R. & Grimm, V. (2009) Dogs on the catwalk: modelling re-introduction and translocation of endangered wild dogs in South Africa. *Biological Conservation*, **142**, 2774–2781.

IUCN/SSC (1998) *Guidelines for Re-Introductions*. IUCN Species Survival Commission, Gland, Switzerland and Cambridge, UK.

IUCN/SSC (2013) *Guidelines for Reintroductions and Other Conservation Translocations*. IUCN Species Survival Commission, Gland, Switzerland.

Jamieson, I.G. & Lacy, R.C. (2012) Managing genetic issues in reintroduction biology *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 441–475. Blackwell Publishing Ltd., Oxford, UK.

Jones, C.G. & Merton, D.V. (2012) A tale of two islands: The rescue and recovery of endemic birds in New Zealand and Mauritius. *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 33–72. Wiley-Blackwell, Oxford, UK.

Jule, K.R., Leaver, L.A. & Lea, S.E.G. (2008) The effects of captive experience on reintroduction survival in carnivores: a review and analysis. *Biological Conservation*, **141**, 355–363.

Kleiman, D.G. (1989) Reintroduction of captive mammals for conservation. *BioScience*, **39**, 152–161.

Komers, P.E. & Curman, G.P. (2000) The effect of demographic characteristics on the success of ungulate re-introductions. *Biological Conservation*, **93**, 187–193.

Le Gouar, P., Mihoub, J. & Sarrazin, F. (2012) Dispersal and habitat selection: Behavioral and spatial constraints for animal translocations. *Reintroduction Biology: Integrating Science and Management* (eds J. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 138–164. Wiley-Blackwell Publishing Ltd., Oxford, UK.

Letty, J., Marchandeau, S. & Aubineau, J. (2007) Problems encountered by individuals in animal translocations: lessons from field studies. *Ecoscience*, **14**, 420–431.

Manning, A.D., Lindenmayer, D.B. & Fischer, J. (2006) Stretch goals and backcasting: approaches for overcoming barriers to large-scale ecological restoration. *Restoration Ecology*, **14**, 487–492.

Mathews, F., Moro, D., Strachan, R., Gelling, M. & Buller, N. (2006) Health surveillance in wildlife reintroductions. *Biological Conservation*, **131**, 338–347.

McCarthy, M.A., Armstrong, D.P. & Runge, M.C. (2012) Adaptive Management of Reintroduction. *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 256–289. Blackwell Publishing Ltd., Oxford, UK.

Miller, B., Ralls, K., Reading, R.P., Scott, J.M. & Estes, J. (1999) Biological and technical considerations of carnivore translocation: a review. *Animal Conservation*, **2**, 59–68.

Mitchell, A.M., Wellicome, T.I., Brodie, D. & Cheng, K.M. (2011) Captive-reared burrowing owls show higher site-affinity, survival, and reproductive performance when reintroduced using a soft-release. *Biological Conservation*, **144**, 1382–1391.

Moseby, K.E., Hill, B.M. & Lavery, T.H. (2014) Tailoring release protocols to individual species and sites: one size does not fit all. *PLoS ONE*, **9**, 1–12.

Moseby, K.E., Read, J.L., Paton, D.C., Copley, P., Hill, B.M. & Crisp, H.A. (2011) Predation determines the outcome of 10 reintroduction attempts in arid South Australia. *Biological Conservation*, **144**, 2863–2872.

Osborne, P.E. & Seddon, P.J. (2012) Selecting suitable habitats of reintroductions: Variation, change and the role of species distribution modelling. *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 73–104. Wiley-Blackwell Publishing Ltd., Oxford, UK.

Parker, K.A., Dickens, M.J., Clarke, R.H. & Lovegrove, T.G. (2012) The theory and practice of catching, holding, moving and releasing animals. *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 105–137. Wiley-Blackwell Publishing Ltd., Oxford, UK.

Parlato, E.H. & Armstrong, D.P. (2013) Predicting post-release establishment using data from multiple reintroductions. *Biological Conservation*, **160**, 97–104.

Richardson, K., Castro, I.C., Brunton, D.H. & Armstrong, D.P. (2015) Not so soft? Delayed release reduces long-term survival in a passerine reintroduction. *Oryx*, **49**, 535–541.

Robert, A., Sarrazin, F., Couvet, D. & Legendre, S. (2004) Releasing adults versus young in reintroductions: Interactions between demography and genetics. *Conservation Biology*, **18**, 1078–1087.

Rout, T.M., Hauser, C.E. & Possingham, H.P. (2009) Optimal adaptive management for the translocation of a threatened species. *Ecological Applications*, **19**, 515–526.

Saltz, D. (1998) A long-term systematic approach to planning reintroductions: the Persian fallow deer and the Arabian oryx in Israel. *Animal Conservation*, **1**, 245–252.

Sarrazin, F. & Legendre, S. (2000) Demographic approach to releasing adults versus young in reintroductions. *Conservation Biology*, **14**, 488–500.

Seddon, P.J. (2010) From reintroduction to assisted colonization: moving along the conservation translocation spectrum. *Restoration Ecology*, **18**, 796–802.

Seddon, P.J., Armstrong, D.P. & Maloney, R.F. (2007) Developing the science of reintroduction biology. *Conservation Biology*, **21**, 303–312.

Seddon, P.J., Soorae, P.S. & Launay, F. (2005) Taxonomic bias in reintroduction projects. *Animal Conservation*, **8**, 51–58.

Seddon, P.J., Strauss, W.M. & Innes, J. (2012) Animal Translocations: What are they and why do we do them? *Reintroduction Biology: Integrating Science and Management* (eds J.G. Ewen, D.P. Armstrong, K.A. Parker & P.J. Seddon), pp. 1–32. Wiley-Blackwell Publishing Ltd., Oxford, UK.

Shepherdson, D. (1994) The role of environmental enrichment in the captive breeding and reintroduction of endangered species. *Creative Conservation: Interactive Management of Wild and Captive Animals* (eds P.J.S. Olney, G.M. Mace & A.T.C. Feistner), pp. 167–177. Chapman and Hall, London.

Shier, D.M. & Owings, D.H. (2006) Effects of predator training on behavior and post-release survival of captive prairie dogs (*Cynomys ludovicianus*). *Biological Conservation*, **132**, 126–135.

Shier, D.M. & Swaisgood, R.R. (2012) Fitness costs of neighborhood disruption in translocations of a solitary mammal. *Conservation Biology*, **26**, 116–123.

Short, J., Bradshaw, S.D., Giles, J., Prince, R.I.T. & Wilson, G.R. (1992) Reintroduction of macropods (marsupialia, macropodoidea) in Australia – a review. *Biological Conservation*, **62**, 189–204.

Soorae, P.S. (2008) *Global Re-Introduction Perspectives: Re-Introduction Case-Studies From Around the Globe*. IUCN/SSC Re-introduction Specialist Group, Abu Dhabi, UAE.

Soorae, P.S. (2010) *Global Re-Introduction Perspectives: Additional Case-Studies From Around the Globe*. IUCN/SSC Re-introduction Specialist Group, Abu Dhabi, UAE.

Soorae, P.S. (2011) *Global Re-Introduction Perspectives: 2011. More Case Studies From Around the Globe*. IUCN/SSC Re-introduction Specialist Group, Gland, Switzerland and Environment Agency-Abu Dhabi, Abu Dhabi, UAE.

Soorae, P.S. (2013) *Global Re-Introduction Perspectives: 2013 Further Case-Studies From Around the Globe*. IUCN/SSC Re-introduction Specialist Group, Gland, Switzerland and Environment Agency-Abu Dhabi, Abu Dhabi, UAE.

Sutherland, W.J., Armstrong, D., Butchart, S.H.M., Earnhardt, J.M., Ewen, J., Jamieson, I. *et al.* (2010) Standards for documenting and monitoring bird reintroduction projects. *Conservation Letters*, **3**, 229–235.

Swaisgood, R.R. (2010) The conservation-welfare nexus in reintroduction programmes: a role for sensory ecology. *Animal Welfare*, **19**, 125–137.

Tavecchia, G., Viedma, C., Martinez-Abrain, A., Bartolome, M.A., Gomez, J.A. & Oro, D. (2009) Maximizing re-introduction success: assessing the immediate cost of release in a threatened waterfowl. *Biological Conservation*, **142**, 3005–3012.

Tear, T.H. & Ables, E.D. (1999) Social system development and variability in a reintroduced Arabian oryx population. *Biological Conservation*, **89**, 199–207.

Tracy, L.N., Wallis, G.P., Efford, M.G. & Jamieson, I.G. (2011) Preserving genetic diversity in threatened species reintroductions: how many individuals should be released? *Animal Conservation*, **14**, 439–446.

Veitch, C.R. (1995) Habitat repair: A necessary prerequisite to translocation of threatened birds. *Reintroduction Biology of Australian and New Zealand Fauna* (ed. M. Serena), 97–104. Surrey Beatty and Sons, New South Wales, Australia.

White, T.H., Collar, N.J., Moorhouse, R.J., Sanz, V., Stolen, E.D. & Brightsmith, D.J. (2012) Psittacine reintroductions: common denominators of success. *Biological Conservation*, **148**, 106–115.

Wolf, C.M., Griffith, B., Reed, C. & Temple, S.A. (1996) Avian and mammalian translocations: update and reanalysis of 1987 survey data. *Conservation Biology*, **10**, 1142–1154.

Zidon, R., Saltz, D., Shore, L.S. & Motro, U. (2009) Behavioral Changes, stress, and survival following reintroduction of Persian fallow deer from two breeding facilities. *Conservation Biology*, **23**, 1026–1035.

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