CANADIAN WILDLIFE BIOLOGY & MANAGEMENT

CWBM 2018: Volume 7, Number 1 *ISSN: 1929–3100*

Original Research

A Meta-analysis of Animal Survival Following Translocation: Comparisons Between Conflict and Conservation Efforts

Blake STUPARYK[1,2], Collin J. HORN[1,2] Sofia KARABATSOS[1,2], and Josue ARTEAGA TORRES[1,2]

[1] Equal Contributors.

[2] University of Alberta, Department of Biological Sciences, 11455 Saskatchewan Drive, CW 405, Biological Sciences Building Edmonton, Alberta, T6G 2E9, Canada.

Abstract

Wildlife management balances conservation goals with meeting societal objectives. It incorporates scientific disciplines such as ecology, animal behaviour, geography, and sociology to determine management practices and make policy recommendations. Two major areas of contemporary management are conservation (protecting animals in at risk environments) and conflict management (mitigating human-animal conflict). Translocation, the targeted movement of animals to a new location, is a method that can be used for conservation or conflict management. When dealing with conflict animals, translocation offers several advantages over culling. It can allow for the survival of the animal, a particular concern with threatened species, and has relatively low impact on its non-problem conspecifics. However, there is ambivalent evidence regarding the effectiveness of translocations. We conducted a series of categorical and continuous model meta-analyses to assess the effect of translocation on the survival of terrestrial vertebrates. For all cases combined, translocation reduced mean percent survival relative to rates observed in reference populations. Overall, animals moved for conflict purposes had significantly reduced mean percent survival, while animals moved for conservation purposes did not. Large mammal mean survival is significantly reduced by translocation, but small mammals did not experience this reduction. Although translocation has been implemented for several decades, improvements over time have only been made in conservation efforts. Based on our review, we discuss opportunities and challenges in the management of problem animals through translocation.

Correspondence: Collin J. Horn, University of Alberta, Department of Biological Sciences, 11455 Saskatchewan Drive, CW 405, Biological Sciences Building, Edmonton, Alberta, T6G 2E9, Canada. Email: chorn@ualberta.ca

Key Words: Conservation, Human-wildlife Conflict, Mitigation, Nuisance Animal Problem Animal, Translocation.

INTRODUCTION

Wildlife management balances conservation goals with societal interests. It incorporates scientific disciplines such as ecology, animal behaviour, geography, and sociology to determine management practices and make policy recommendations (Bowyer *et al.* 1997; Gilchrist *et al.* 2005). It is applied in conservation, pest control, park operations, and hunting management.

As human activity encroaches into undisturbed areas and animal habitats, conflicts between humans and animals become more prevalent (Massei *et al.* 2010; Pyne *et al.* 2010). Animals involved in such conflicts, hereafter called problem animals, can cause damage to people, property, and themselves (Bradley *et al.* 2005; Massei *et al.* 2010; Fernando *et al.* 2012). A wide variety of animals can become involved in conflicts which are resolved by translocation, ranging from cheetahs (*Acinonyx jubatus*) to squirrels (*Sciurus* spp.) (Adams *et al.* 2004; Boast *et al.* 2016).

Mitigating conflicts is a major focus of contemporary wildlife management (Fernando *et al.* 2012; Swan *et al.* 2017). Ostensibly, the goal of conflict management is to minimize the harm caused to both persons and animals; however, human interests have usually been prioritized over conservation (Kellert 1985). This prioritization of human interests has been particularly strong in the management of mammalian predators, which tend to elicit fear in the public and can have a significant economic impact on the agriculture sector (Kellert 1985; Andersone and Ozolinš 2004). For example, the near extinction of North American grey wolves (*Canis lupus*) in the 20th century resulted largely from management strategies that eradicated predators for the protection of livestock and game species (Paquet and Carbyn 2003). Top predators, more so than other trophic groups, tend to receive rapid and extreme responses from managing bodies − responses which are not always justified, well researched, or scientifically sound (Fontúrbel and Simonetti 2011).

Recent work has focused on preventing conflict by eliminating circumstances that give rise to human-wildlife conflicts and deploying strategies that reduce the impact of human-animal interactions, often called damage abatement (Soulsbury and White 2015). When conflict does occur, managers have primarily resolved it by 1 of 2 methods: destruction (culling or increased hunting) or translocation (Fernando *et al.* 2010; Swan *et al.* 2017). Both methods can eliminate the immediate threat to people and property. However, public perception of both methods has changed over time. Although destruction was a standard response in North America during the early 20th century, the method is increasingly disapproved of by the public, policy makers, and experts (Paquet and Carbyn 2003; Massei et al 2010). Due to increased ecological awareness, there is increasing pressure from the public and animal protection groups to avoid the destruction of wildlife (Fontúrbel and Simonetti 2011; Swan *et al.* 2017). This is especially true for threatened species. In the ideal outcome, translocation avoids the unpopular alternative of killing a problem animal by relocating it to a new environment where it is no longer in conflict (Swan *et al.* 2017). For example, efforts to resolve conflicts between cheetah (*Acinonyx jubatus*) and farmers via translocation could avoid the destruction of this vulnerable species (Boast *et al.* 2016). This method also has the advantage of being targetable; specific problem animals can be relocated with minimal impact on their conspecifics (Swan *et al.* 2017).

Translocation is also used in conservation, both for the reintroduction of animals to their former native range and to rescue populations in habitats at risk (Seddon *et al.* 2007). In this meta-analysis, we differentiate conflict translocations (to eliminate negative human-animal interactions) from conservation translocations (to protect, establish, or bolster populations). Although translocation can be used for both objectives, the success of the technique may differ between applications. Differences may result from the biology of the animals, the nature of the human-animal interactions, and the methods used. Comparing the efficacies, in terms of animal survival, of conservation and conflict translocations may reveal strategies to better manage human-animal conflicts. Scientifically rigorous translocations reported better outcomes in the conservation translocations reviewed by Germano *et al.* (2015). Since conservation projects place a strong emphasis on the survival of study animals, more research on the ecology of the species may be conducted during these projects to improve the odds of success (Germano *et al.* 2015). We, therefore, hypothesize that animals translocated to alleviate conflict will have lower mean percent survival than animals moved for conservation purposes.

Ideally, translocation can protect human interests without the destruction of problem animals. However, there is ambivalent evidence regarding the survival rates of translocated animals (Fontúrbel and Simonetti 2011). Published results vary greatly; some studies have reported improved survival rates following translocation (Molony *et al.* 2006), whereas others reported ~100% mortality rates (Fontúrbel and Simonetti 2011) or increased aggressiveness among translocated individuals (Athreya *et al.* 2011). We propose that a quantitative review is needed to assess patterns in the outcome of conflict translocations, and to determine the sources of variance in animal survival.

We collected 104 studies of conflict and conservation translocations of terrestrial vertebrates for a meta-analysis of translocation success. To assess success, we calculated an effect size (Hedges' *d*) of translocation on the mean percent survival of the translocated group (Gurevitch and Hedges 2001). Because species respond differently to translocation (Germano *et al.* 2015), we hypothesize that variance in mean survival exists based on the taxon of the translocated animal. If mean survival rate is related to taxonomic affinity, we expect that Hedges' *d* will differ significantly among cases of translocation grouped by the taxon of the problem animal.

Beyond variance based on evolutionary relatedness, we expect there to be commonalities amongst animals sharing similar niches and of similar body sizes. In particular, we expect trophic guilds (viz. carnivores, herbivores, omnivores) to respond similarly. Trophic guild affects the resource exploitation of animals and how managers handle them, both of these effects can influence their mean survival post-translocation (Fontúrbel and Simonetti 2011). Because managers may be pressured to move problem predators rapidly, we hypothesize that survival will be worse for predators than other trophic guilds. In formal terms, we predict the effect size of translocation on mean percent survival in predators will be larger than in the other trophic groups.

We explicitly compare survival outcomes of conflict and conservation translocations, which, to the best of our knowledge, no previous meta-analysis has done. The goals of our analysis are to: 1) identify trends in the research of conflict translocation; and 2) assist practitioners in determining which problem animals might respond best to translocation and when translocations are most likely to fail. We then make suggestions for future research based on our findings.

METHODS

Data collection

Our dataset was sourced from primary scientific articles, and published reports from government departments or park/wildlife managers. We retrieved most of the papers used in analysis with the online databases: Web of Science, Scopus, and Google Scholar. Because key words and their definitions were not consistent across similar studies, we expanded our search terms to incorporate synonyms and combinations of all reported keywords in our initial searches. Examples of these keywords include: "mitigation translocation", "human-wildlife conflict", "problem animal", "animal relocation", and "conservation translocation" (full list in Appendix). In the cases of review articles, we examined citation lists to find additional primary sources. Our initial searches were highly inclusive; sources were not screened by quality, only topic. Broad selection criteria allowed us to make note of trends and discrepancies within the literature during the data acquisition process. The acquisition process garnered 104 studies of translocations for both conflict (n=41) and conservation purposes (n=63). Within these meta-analyses, we used "observation" to refer to the survival rate of a specific population relative to a reference, while "study" referred to the source document.

Following collection, we filtered retrieved papers based on their statistical methods. To be usable in our meta-analysis, a study had to report an empirical measurement of survival over a discrete time period for specific translocated animals; this requirement reduced the data set to 66 studies. Multiple observations were retrieved from a single study if data were reported for the translocation of several non-overlapping animal groups (e.g., age classes, gender, cohort size, etc.). When a study reported survival rates of translocated animals at multiple points in time, we only used the final rate reported to avoid duplication and non-independence of data.

Our target metrics were "mean percent survival of study animals per year" and standard deviation. If an annual rate was not reported, we converted available survival metrics to per-year rates. For the sake of comparable effect size calculations, we assumed constant survivorship throughout the time reported and not reported by studies. While this ignores the specific ecology of each observation, our dataset varied heavily on the reported time period to define post-release survival. Reported variances of survival rates were converted to standard deviations (Gurevitch and Hedges 2001). If a study reported percent mortality per year instead, survival rate was calculated as its reciprocal. Several studies only reported whether the animals survived or perished after a given success time period or framed their results around individual animals and their survival status. When pooled survival rates were not reported but the results of discrete individuals who lived or died after a stated success period were, we pooled these results and calculated mean percent survival and standard deviation. Our meta-analyses required measurement of mean annual percent survival for a reference or control group that was not translocated; this reduced our sample to 30 studies. From these studies, a total of 43 observations were collected; 28 observations of conflict translocation and 15 observations of conservation translocation. Studies analyzed were published between 1985 and 2016 and had no geographic restrictions.

Effect size calculations

Effect sizes (*d*) were calculated using a Hedges' *d* estimation for each observation in our data pool (translocated relative to reference). This calculation requires a mean, standard deviation, and sample size for the experimental (translocated) and control groups. The Hedges' *d* method accounts for unequal sample sizes (Gurevitch and Hedges 2001), as often occurred in studies of conflict translocation where a small group of problem animals were moved and compared with a larger reference population. Hedges' *d* provides a weighted estimation of the absolute difference in effect magnitude, regardless of directionality, for each unique observation (Gurevitch and Hedges 2001). Compared to the mean percent survival of the reference population, *d* of 0 represents a null effect on the translocated animals, a positive *d* represents increased survival, and a negative *d* represents decreased survival. We assessed the significance of effect sizes using 95% confidence intervals, such that if the interval included 0, the effect size was deemed insignificant. After checking for outliers at this stage, we decided to remove 2 observations. We removed 1 observation due to methodological decisions in the study which resulted in an extremely large negative effect size (Calvete and Estrada 2004). The second removed observation related to a study of sea turtle (*Caretta caretta*) hatchlings and followed a reference population of 9,000 eggs (Ahles and Milton 2016). These outlying measurements would have skewed the cumulative effect sizes, and by extension our interpretations. Thus, the final data set included 28 studies (see Appendix) which yielded 41 unique observations. Of these 41 observations, 27 were conflict translocations, and 14 were conservation translocations. Despite strict selection criteria, our initial collection included enough studies such that our final dataset maintains a large breadth of taxonomic examples with sufficient statistical rigor. For this reason, we believe our dataset to be a representative (but not exhaustive) sample of available translocation literature and appropriate to address our objectives.

Using MetaWin version 2.1 (Rosenberg *et al.* 2000), we performed an unstructured random-effects meta-analysis model to determine the weighted average magnitude of effect (E++) that translocations had on annual mean percent survival, and the total heterogeneity (Q_T) between observations. In calculating a weighted cumulative effect size, observations are assigned a weight based on the reciprocal of its sampling variance. The procedure then adds the aforementioned effect sizes and weights of each observation together and divides this total by the cumulative sum of weights across our dataset. Similarly, variance of the weighted average effect is the reciprocal of the sum of weights. Weighting the observations was necessary to control for the unequal sample sizes between observations, and for differences in variance due to those sample sizes (Gurevitch and Hedges 2001). Using a random-effect model allowed us to account for random stochastic variables and events that influence animal survival, beyond simple sampling error which is often seen in fixed-effects models (Rosenthal 1994). Heterogeneity (Q) represents how significantly different a mean effect is from another, which we can statistically test by comparing against a chi-square distribution, with degrees of freedom *n*-1. We used a significance level of α=0.05. The null hypothesis of this chi-square comparison is that all effect sizes are equal. A significant Q value of a categorical meta-analysis indicates the variance around the mean effect sizes are larger than can be expected by sampling error. Heterogeneity can refer to the difference between observations overall (Q_T), between cumulative group means (Q_B), and the amount of difference between individual observation effect sizes within the groups cumulatively (Q_W).

In addition to the above meta-analysis, we carried out a series of categorical mixed-effect model meta-analyses to determine weighted group effect sizes and heterogeneity among and between these categories. Cumulative effect sizes were interpreted similar to individual observation effect sizes, where the cumulative *d* represents the impact translocation had on survival of 1 group of animals compared to a reference population of the same demographic. Bootstrapped 95% confidence intervals were calculated around each categorical effect size to evaluate significance.

To determine if translocation impacts have changed significantly over time, we conducted a series of continuous random-effect meta-analysis between survival impact and year of publication. We determined the slope using a weighted least squares regression (Hedges and Olkin 1985). We conducted these analyses on translocations overall, and for conflict and conservations separately. Calculating standard error for this slope was done by finding the reciprocal value of the square rooted denominator of our least squares regression expression (Hedges and Olkin 1985). By dividing the slope by the standard error, we determined the Z-score of the slope, and its statistical significance based on an alpha value of 0.05. Heterogeneity within continuous meta-analysis models (Q_M) are compared against a chi-square distribution to explain the amount and significance level of any heterogeneity captured by the regression model. In this way we can examine the amount of heterogeneity explained by the independent variable, that is year.

After consolidating all recorded observations together, we grouped them based on trophic guild, taxon, and, for mammals, large or small body size. This mammalian-focused group was created to highlight translocation effect on predators and their prey, both of whom are often the target of managerial decisions. Within conflict translocation studies, we had observations of carnivorous animals such as cougars (*Puma concolor*), wolves, hognose snakes (*Heterodon platirhinos*), and rattlesnakes (Subfamily: Crotalinae). Carnivorous animals within conservation studies included river otters (*Lontra canadensis*), weasels (*Mustela* spp.), leopards (*Panthera pardus*), and Hawaiian monk seals (*Neomonachus schauinslandi*). Herbivorous problem animals included white-tailed deer (*Odocoileus virginianus*) and elephants (*Elephas maximus*), while conservation studies included black-tailed deer (*O. hemionus*), oribi (*Ourebia ourebi*), and European hares (*Lepus europaeus*). Omnivorous conflict translocated animals were grizzly (*Ursus arctos*) and black bears (*U. americanus*), squirrels (Family: Sciuridae), and hedgehogs (Subfamily: Erinaceinae). Conservation-translocated omnivorous animals included black bears, western gorillas (*Gorilla gorilla*), prairie dogs (*Cynomys* spp.), and Cabot's tragopan (*Tragopan caboti*). We grouped mammalian observations based on the relative size of the animal they referred to. To be large, a species had to be larger in body size than a brown hare (average mass >3.8kg). Finally, we used natural groupings in the data pool to group animals by taxonomic classifications. Raw data input and organization was conducted using Microsoft Excel version 14.0 (Microsoft Corporation 2010). All effect size calculations and weighted meta-analyses were conducted using MetaWin version 2.1 (Rosenberg *et al.* 2000) and visualized using KaleidaGraph (Synergy Software 2013).

RESULTS

For all cases combined, annual mean percent survival of animals is significantly reduced by translocation (E++= -.6238; df=40; +CI(95%)= -0.3110; -CI(95%= -1.0013). We observed moderate, but insignificant heterogeneity overall amongst our 41 observations (Q_T=45.5358; df=40, *P*=0.2526). Overall, there was a small insignificant positive increase in effect size over the time period we analyzed (1985-2016) (slope=0.0162, *P*=0.283). Heterogeneity within the data was not explained by the advancement of time (Q_M=0.4707, *P*=0.4927).

The cumulative effect of conflict translocation on animal survival was significantly negative while conservation

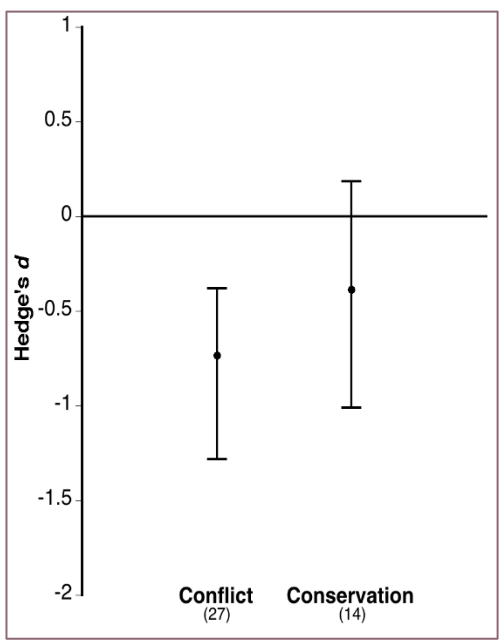

Figure 1. Average effect sizes (Hedges' *d* and bootstrapped 95% confidence intervals) of conflict or conservation translocations on annual wildlife survival rates. Individual effect sizes (Hedges' *d*) were calculated for 41 observations of wildlife translocations, obtained from 28 empirical scientific or managerial reports. The number of observations included in each category is indicated in parentheses. Average effect sizes calculated using a weighted average, based on category.

translocations had a statistically insignificant negative effect on animal survival overall (Figure 1). The cumulative mean effect sizes of conflict and conservation translocations were not significantly different than each other (Figure 1). This insignificance between mean effect sizes was reflected in the small and insignificant heterogeneity between group means, while there exists a moderate but insignificant heterogeneity of observations within group means (Q_B=0.7585, df=1, *P*=0.3838; Q_W =43.8927, df=39, *P*=0.2719). Conservation translocations trended significantly towards increasingly positive effect sizes over the 31-year span of observations (slope=0.0658, *P*=0.0201). This was further supported by the statistically significant captured heterogeneity value (Q_M=7.3015, *P*=0.0069). Conversely, conflict translocation effect sizes did not change meaningfully over our 25-year period of observations (slope=-0.0099, *P*=0.396), while the regression model failed to significantly explain the heterogeneity found throughout the 25-year span of conflict observations (Q_M=0.1122, *P*=0.7377). Among conflict translocations, annual survival of translocated animals ranged from 3% to 90%, while survival ranged from 0% to 93% in conservation translocations.

Conflict translocations had the largest negative effect on carnivore survival, while exhibiting similarly significant detrimental effects on omnivores and herbivores (Figure 2a). However, these 3 groups effect sizes were not significantly different from one another (Figure 2a). Heterogeneity between trophic guilds was small but significant, while within guild heterogeneity was larger but insignificant (Q_B= -7.2110, df=2, *P*=0.0100; Q_W= 32.4998, df=24, *P*=0.1151). Large mammals were significantly affected by conflict translocations, while small mammals were insignificantly affected overall (Figure 2c). Heterogeneity within mammalian size categories was higher than between size category means, but both were insignificant (Qw=20.9818, df=22, *P*=0.5219; Q_B=1.2848, df=1, *P*=0.2610). Feline carnivores experienced the greatest reduction in survival followed by snakes (Figure 2e). Amongst our taxonomic groups, hedgehogs fared best after conflict translocation, displaying a positive, but statistically insignificant, change in survival rate (Figure 2e). Heterogeneity between and within each grouping was small but not significant (Q_B=9.7133, df=5, *P*=0.1310; Qw=21.4925, df=19, *P*=0.3102).

Translocations performed for conservation did not significantly reduce the mean survival of any trophic guild significantly, while the guild means were not significantly different from each other (Figure 2b). Observation effect sizes within trophic guilds had significant, larger heterogeneity than the statistically insignificant heterogeneity between guild means (Q_W=22.8924, df=11, *P*=0.0183; Q_B=0.1460, df=2, *P*=0.9296). Conservation translocations significantly reduced large mammal survival, while insignificantly reducing the average small mammals survival (Figure 2d). Heterogeneity within body size observation groups was larger and significant, than the small and insignificant heterogeneity between the cumulative group means (Qw=21.1262, df=11, *P*=0.0321; Q_B=0.6506, df=1, *P*=0.4199). Separate from other small mammals, rodent survival is significantly reduced by conservation translocation, more so than the other taxa (Figure 2f). Among herbivores, ungulate survival was significantly reduced by conservation translocation, but the survival of hares was not (Figure 2f). Bear survival was significantly reduced by conservation translocations as well as conflict translocations (Figure 2f). These mixed average responses are reflected in the significant heterogeneity between the cumulative effect sizes of animal taxa (Q_B=17.5230, df=4, *P*=0.0015). The observation effect sizes within each animal taxon had smaller, insignificant heterogeneity overall (Q_W=8.1732, df=6, *P*=0.2257).

DISCUSSION

Carnivores had, on average, negative responses to conflict translocations but not conservation translocations (Figure 2a, b). We predicted this pattern based on the priorities of management organizations when responding to human-animal conflicts. Rightly or wrongly, the public perceives predator species as dangerous, and as such, managers may experience more pressure to intervene quickly (Kellert 1985; Andersone and Ozolinš 2004). Additionally, the destruction of livestock by predators, perceived or real, often creates a strong financial motivation to remove predators rapidly (Musiani *et al.* 2003). Urgency may lead to translocations with less prior surveying and research, reducing the mean survival of the translocated animals. Germano *et al.* (2015) found that translocation programs that integrated ecological and biological knowledge of the target species had higher survival rates. If predators are uniquely vulnerable to translocation in general, we would predict a negative effect following conservation translocations as well. However, predators, along with herbivores and omnivores, did not experience a significant decrease in mean survival rates in response to conservation translocations (Figure 2a, b).

Omnivores experienced significantly better outcomes relative to predators following conflict translocations, but still had a significantly negative response (Figure 2a). This may be a result of omnivores generally having broader niches than predators leading to an ability to exploit at least one resource in the new territory following translocation (Krivan and Diehl 2005). However, if resource exploitation

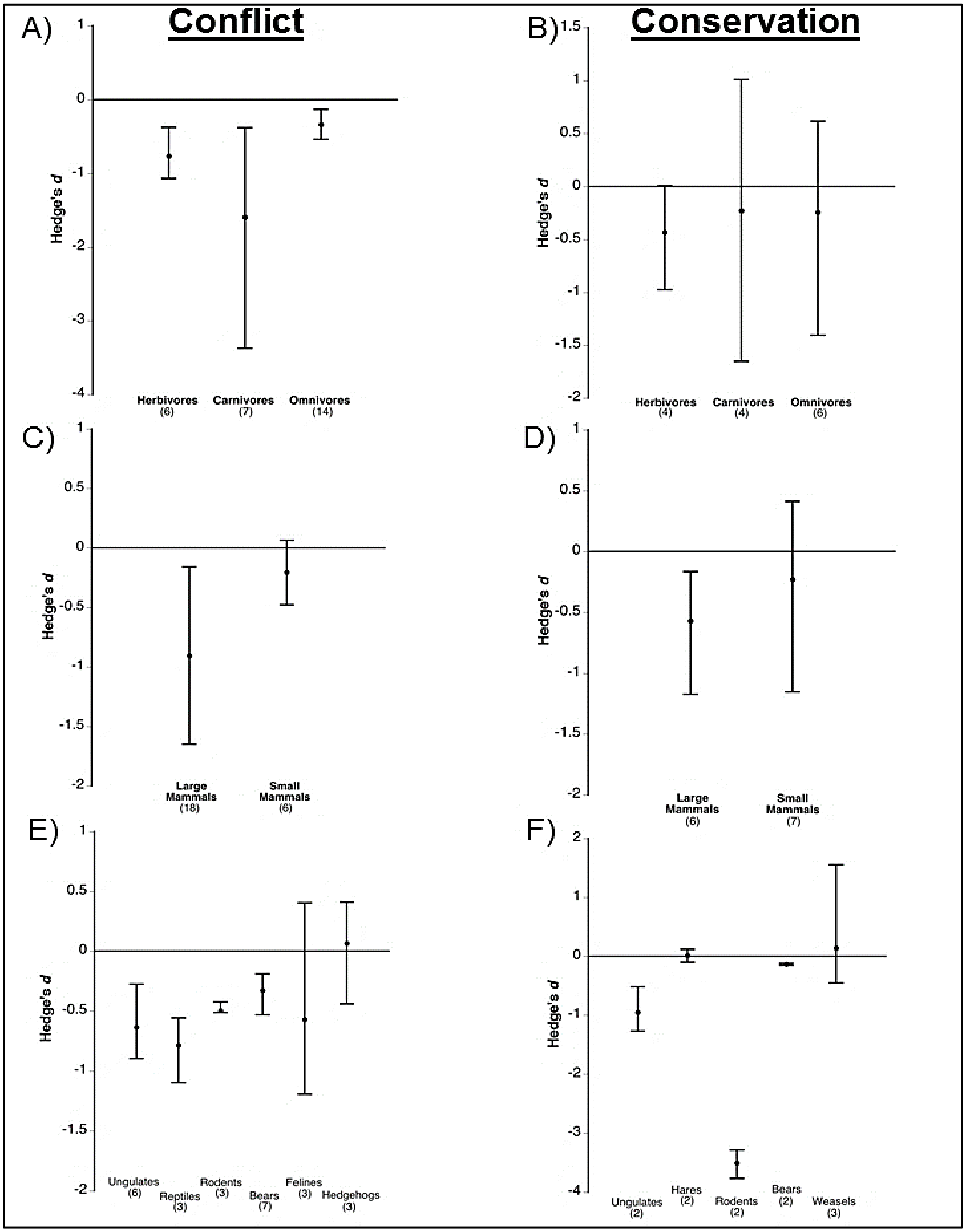

Figure 2. Average categorical effect sizes (Hedges' *d* and bootstrapped 95% confidence intervals) of translocations on animal survival based on trophic guild (A, B), mammalian body size (C, D), and animal group (E, F). Individual effect sizes (Hedges' *d*) were calculated for 41 observations of wildlife translocations, obtained from 28 empirical scientific or managerial reports. The number of observations included in each category is indicated in parentheses. Observations were omitted if the size of the category was smaller than 2 or did not fit into the categorical groups. Average effect sizes calculated using a weighted average.

was the sole difference, then we would expect omnivores to also outperform predators following conservation translocations – however, that is not the case (Figure 2b). Comparison of the methods used in carnivore and omnivore translocations following conflict may suggest ways to improve predator survival.

Herbivores experienced overall negative outcomes following conflict translocations but not conservation translocations (Figure 2a, b). Herbivores are the most likely to be exposed to novel predators that they are not adapted to avoid (Cox and Lima 2006). These novel predators may lead to an increased mortality rate following translocation (Cox and Lima 2006). Second, novel locations may have unusable or suboptimal plant resources, leading to reduced feeding and possible starvation (Bright and Morris 1994). Due to differences in urgency, it is more likely that conservation projects have accounted for these predator and resource considerations, and as such explaining the difference observed.

Large mammals experienced reduced mean survival rates following translocation, while small mammals did not have reduced survival (Figure 2c, d). This trend held for both conflict and conservation translocations (Figure 2c, d). We propose 3 non-mutually exclusive hypotheses for this trend. First, small mammals tend to have lower caloric requirements than large mammals (Paine 1966; Demment and Van Soest 1985). Therefore, if a mammal is relocated to a random environment, the environment is more likely to support a small mammal than a larger mammal. Small animals, therefore, have better survival odds if the new environment is of lower quality than the original (Paine 1966; Demment and Van Soest 1985). Alternatively, managers may feel less urgency to translocate small animals, as they are perceived as less dangerous. This reduced urgency may lead to more time with which to design rigorous translocation plans (Germano *et al.* 2015). Lastly, defensive strategies associated with small animals (e.g., hiding) may also be adaptive at surviving when transferred to a novel environment (Cooper and Stankowich 2010). Consequently, small animals may have greater odds of avoiding novel threats than larger mammals, which are more likely to use fight or flight strategies (Cooper and Stankowich 2010).

Translocation can result in high levels of mortality amongst animals. For example, over 95% mortality has been observed in studies of translocated eastern grey squirrels (*Sciurus carolinensis*, Adams *et al.* 2004). However, the effect of translocation differs significantly based on species (Figure 2e). Bears, ungulates, and rodents had significantly negative survival rates (Figure 2e). Survival rates of hedgehogs, weasels, felines, and hares did not change significantly (Figure 2e); notably, these are predominately small animals (Figure 2c, d). We observed that social animals, such as ungulates, had poorer survival after translocations, but other sources of mortality are common in ungulates such as capture myopathy (Beringer *et al.* 1996).

Translocation itself is often a source of mortality (Beringer *et al.* 1996). Physiological stresses resulting from capture, anesthesia, holding, and novel environment can lead to increased risk of death (Dickens *et al.* 2010). When a translocated group is compared to a baseline rate, the effects of capture myopathy are not accounted for. This is a particularly challenging problem when testing new capture methods or release strategies (Beringer *et al.* 1996). The study of translocation to manage conflict animals is held back by a reliance on previously published baselines instead of study specific data.

Animals experienced different outcomes when translocated for conservation or conflict management purposes (Figure 1). Conflict translocation had a significantly negative effect on annual mean percent survival, as well as each trophic guild individually (Figures 1, 2a). In stark contrast, conservation translocations did not have a significant impact on average, or on any individual trophic guild (Figures 1, 2b). Thus, differences between the methods used in conservation and conflict translocations may be a significant predictor of animal survival. We hypothesize that urgency and priorities of the managers may influence the outcome for animals. This explanation is consistent with the observation that conservation translocation reduces survival less than conflict translocation regardless of animal type (Figure 1). If urgency, leading to more rapid translocation, affects the outcome for animals, then establishing translocation protocols in advance may make the method more effective when conflict occurs. Since the assumed goal of conservation projects is to establish populations that can persist, there may be a greater impetus to understand the ecology of the translocated species (Germano *et al.* 2015). On the other hand, if a problem animal is successfully removed from the area of conflict, there may be less interest in determining if it survived and for how long (Paquet and Carbyn 2003). Such differences create difficulties in interpreting and comparing translocation goals. Ideally, researchers could be involved in these conflict translocations and provide follow-up.

The studies analyzed in this project occurred between 1985 and 2016. Over these 3 decades, there have been substantial cultural, governmental, and scientific changes. During this time, translocation became increasingly popular as a management tool (Seddon *et al.* 2007). Initially, we expected that translocation, for both conflict and conservation, would improve and accordingly survival rates of translocated animals would increase with time. Improvements in capture technology could reduce the risk of capture myopathy (Beringer *et al.* 1996); while increased ecological understanding could improve the survival rates of animals post-translocation (Germano *et al.* 2015). However, there was no significant increase in the overall mean percent survival over time; for that reason, we considered the possibility that conservation and conflict translocations have not improved equally. Indeed, conservation translocations have trended towards improved mean mortality rates, while conflict translocations have not changed significantly. It is possible that recent research into animal behaviour and ecology has been integrated into conservation work, but not conflict-mitigation work. This explanation is congruent with the motivations behind conflict and conservation translocations.

There are understandable difficulties in conducting research on problem animals and their management. Funding may be more available for action, but not to follow up on the translocated species (Paquet and Carbyn 2003). Beyond animal welfare concerns normally associated with research, individual animals that have had dangerous interactions with people warrant special attention (Athreya *et al.* 2011). Experimental translocation can pose a safety risk to workers and the public. One study testing the efficacy of translocation in reducing conflicts between leopards (*P. p. fusca*) and people observed an increase in attacks following translocation (Athreya *et al.* 2011). Translocation is regularly deployed by governments and parks, and in such situations researchers ought to engage as participants to evaluate and improve practices. Ethical research in conflict management should deploy rigorous study designs to avoid animal suffering/risk that does not contribute to better understanding. If translocating non-problem animals as a control is not viable, it may be to collaborate with conservation projects in the same area on the species of interest to generate relevant reference data instead of relying on previously reported baseline rates.

The use by studies of previously published baseline mortalities instead of true controls created problems when analyzing the effectiveness of translocation. Of the 65 papers we found that reported a survival rate for translocated group, only 31 had a usable control/reference group. A similar result was reported by Germano *et al.* (2015) who reviewed the scientific rigor of translocations that removed animals from habitats that were going to be destroyed. They found that most projects did not adequately report their methods and results for replication (Germano *et al.* 2015). Temporal variation in animal fitness results from seasonal effects, multi-year cycles, and long-term changes in climate and habitat (Fuentes *et al.* 2016). This variation makes comparisons between a study population in a given year/season, and a previously measured baseline unreliable.

We urge caution when trying to apply these results to deciding the management policy of a specific species. The conflicting reporting standards and often incomplete data in the literature led to a smaller than ideal sample size. In fact, fewer than half the studies found in our search had sufficiently robust data reporting to be included in this meta-analysis, but we do argue that the studies analyzed are representative of the literature as a whole due to our broad selection criteria. In order to use much of the data collected, we had to compute a per annum mean percent survival; this assumption does not always represent the true survivorship of the species accurately, but it was necessary for comparisons such as those performed here (Gurevitch and Hedges 2001). As such, computed effect sizes should not be interpreted as indicative of the survivorships. Furthermore, we found large variance even within categories with a strong overall trend. Thus, as with any management policy, it is vital to consider the biology of the particular species under consideration (Germano *et al.* 2015). We contend the conclusions of this meta-analysis suggest areas for future research and improvement, not as definitive suggestions for particular cases.

Given the limitations of working with inconsistent data in a developing field, our recommendations are largely focused on improving research and follow-up: translocated animals should be followed for at least 1 year post translocation; control animals should be used as a comparison of survival, not reference rates; and standardized metrics and reporting would ease future comparisons. Specific to management, we recommend reassessing the methods used in conflict translocations, in particular for predators. Since predators are not intrinsically vulnerable to translocation, as shown by their overall robust response to conservation translocation, it could be possible to improve their outcomes in conflict translocation.

Translocations are potentially a valuable tool in the management of conflict animals. However, current efforts at mitigating conflicts using translocations negatively impacts survival, particularly for predators. Our analysis shows a need to identify differences between conservation and conflict management, and why better outcomes are consistently achieved in conservation programs. Over the last 3 decades, conflict translocation projects have shown no increase in animal survival rates. On the other hand, conservation translocations have achieved greater success over time. This stagnation is both a concern and a potential opportunity, as it suggests there is potential to improve conflict management by putting recent scientific progress into practice.

ACKNOWLEDGEMENTS

Cindy Paszkowski provided editorial guidance. Carolyn M[c]Kinnon proofread the manuscript. We would like to thank 2 anonymous reviewers who provided substantial and constructive comments.

LITERATURE CITED

Adams, L. W., J. Hadidian, and V. Flyger. 2004. Movement and mortality of translocated urban-suburban grey squirrels. Animal Welfare 13: 45–50.

Ahles, N., and S. L. Milton. 2016. Mid-incubation relocation and embryonic survival in loggerhead sea turtle eggs. Journal of Wildlife Management 80: 430–437.

Andersone, Z., and J. Ozolinš. 2004. Public perception of large carnivores in Latvia. Ursus 15: 181–187.

Athreya, V., M. Odden, J. D. C. Linnell, and K. U. Karanth. 2011. Translocation as a tool for mitigating conflict with leopards in human-dominated landscapes of India. Conservation Biology 25: 133–141.

Beringer, J., L. P. Hansen, W. Wilding, J. Fischer, and S. L. Sheriff. 1996. Factors affecting capture myopathy in white-tailed deer. Journal of Wildlife Management 60: 373–380.

Boast, L. K., K. Good, and R. Klein. 2016. Translocation of problem predators: is it an effective way to mitigate conflict between farmers and cheetahs *Acinonyx jubatus* in Botswana? Oryx 50: 537–544.

Bowyer, R. T., V. Van Ballenberghe, and J. G. Kie. 1997. The role of moose in landscape processes: effects of biogeography, population dynamics, and predation. Pages 265–287 *in* J. A. Bissonette, editor. Wildlife and Landscape Ecology. Springer, New York City, USA.

Bradley, E. H., D. H. Pletscher, E. E. Bangs, K. E. Kunkel, D. W. Smith, C. M. Mack, T. J. Meier, J. A. Fontaine, C. C. Niemeyer, and M. D. Jimenez. 2005. Evaluating wolf translocation as a nonlethal method to reduce livestock conflicts in the Northwestern United States. Conservation Biology 19: 1498–1508.

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

Calvete, C., and R. Estrada. 2004. Short-term survival and dispersal of translocated European wild rabbits. Improving the release protocol. Biological Conservation 120: 507–516.

Cooper, W. E., and T. Stankowich. 2010. Prey or predator? Body size of an approaching animal affects decisions to attack or escape. Behavioral Ecology 21: 1278–1284,

Cox, J. G., and S. L. Lima. 2006. Naiveté and an aquatic-terrestrial dichotomy in the effects of introduced predators. Trends in Ecology & Evolution 21: 674–680.

Demment, M. W., and P. J. Van Soest. 1985. A nutritional explanation for body-size patterns of ruminant and nonruminant herbivores. The American Naturalist 125: 641–672.

Dickens, M. J., D. J. Delehanty, and L. M. Romero. 2010. Stress: an inevitable component of animal translocation. Biological Conservation 143: 1329–1341.

Fernando, P., P. Leimgruber, T. Prasad, and J. Pastorini. 2012. Problem-elephant translocation: translocating the problem and the elephant? PLoS ONE 7: e50917.

Fontúrbel, F. E., and J. A. Simonetti. 2011. Translocations and human-carnivore conflicts: problem solving or problem creating? Wildlife Biology 17: 217–224.

Fuentes, M., S. Delean, J. Grayson, S. Lavender, M. Logan, and H. Marsh. 2016. Spatial and temporal variation in the effects of climatic variables on dugong calf production. PLoS ONE 11: e0155675.

Germano, J. M., K. J. Field, R. A. Griffiths, S. Clulow, J. Foster, G. Harding, and R. R. Swaisgood. 2015. Mitigation-driven translocations: are we moving wildlife in the right direction? Frontiers in Ecology and the Environment 13: 100–105.

Gilchrist, G., M. Mallory, and F. Merkel. 2005. Can local ecological knowledge contribute to wildlife management? Case studies of migratory birds. Ecology and Society 10: 20.

Gurevitch, J. and L. V. Hedges. 2001. Meta-analysis: combining the results of independent experiments. Pages 347–369 *in* S. M. Scheiner and J. Gurevitch, editors. Design and Analysis of Ecological Experiments, 2nd edition. Oxford University Press, Oxford, UK.

Hedges L. V., and I. Olkin. 1985. Statistical methods for meta-analysis. Academic Press, New York, USA.

Kellert, S. R. 1985. Public perceptions of predators, particularly the wolf and coyote. Biological Conservation 31: 167-189.

Krivan, V., and S. Diehl. 2005. Adaptive omnivory and species coexistence in tri-trophic food webs. Theoretical Population Biology 67: 85– 99.

Massei, G., R. J. Quy, J. Gurney, and D. P. Cowan. 2010. Can translocations be used to mitigate human–wildlife conflicts? Wildlife Research 37: 428–439.

Microsoft Corporation. 2010. Microsoft Excel. Version 14.0. Microsoft Corporation. Redmond, Washington, USA.

Molony, S. E., C. V. Dowding, P. J. Baker, I. C. Cuthill, and S. Harris. 2006. The effect of translocation and temporary captivity on wildlife rehabilitation success: an experimental study using European hedgehogs (*Erinaceus europaeus*). Biological Conservation 130: 530–537.

Musiani, M., C. Mamo, L. Boitani, C. Callaghan, C. C. Gates, L. Mattei, E. Visalberghi, S. Breck, and G. Volpi. 2003. Wolf depredation trends and the use of fladry barriers to protect livestock in Western North America. Conservation Biology 17: 1538–1547.

Paine, R.T. 1966. Food web complexity and species diversity. The American Naturalist 100: 65–75.

Paquet, P. C., and L. N. Carbyn. 2003. Gray wolf. Pages 482–510 *in* B. C. Thompson, G. A. Feldhamer and J. A. Chapman, editors. Wild Mammals of North America: biology, management, and conservation. John Hopkins University Press, Maryland, USA.

Pyne, M. I., K. M. Byrne, K. A. Holfelder, L. Mcmanus, M. Buhnerkempe, N. Burch, E. Childers, S. Hamilton, G. Schroeder, and P. F. Doherty. 2010. Survival and breeding transitions for a reintroduced bison population: a multistate approach. Journal of Wildlife Management 74: 1463–1471.

Rosenberg, M.S., D.C. Adams, and J. Gurevitch. 2000. MetaWin: Statistical software for meta-analysis. Version 2.1. Sinauer Associates, Sunderland, Massachusetts, USA.

Rosenthal, R. 1994. Parametric measures of effect size. Pages 231–244 *in* H. Cooper and L. V. Hedges, editors. The Handbook of Research Synthesis. Russell Sage Foundation, New York, New York, USA.

Seddon, P. J., D. P. Armstrong, and R. F. Maloney. 2007. Developing the science of reintroduction biology. Conservation Biology 21: 303–312.

Soulsbury, C. D., and P. C. L. White. 2015. Human-wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. Wildlife Research 42: 541–553.

Swan, G. J. F., S. M. Redpath, S. Bearhop, and R. A. Mcdonald. 2017. Ecology of problem individuals and the efficacy of selective wildlife management. Trends in Ecology and Evolution 32: 518–530.

ABOUT THE AUTHORS

Blake Stuparyk, is a graduate student in ecology at the University of Alberta. Blake completed his BSc at the University of Alberta and studies environmental stressors on aquatic alpine communities.

Collin J. Horn, Collin is a graduate student in ecology at the University of Alberta. He also completed his undergraduate degree at the University of Alberta; he now studies parasitology and disease ecology.

Sofia Karabatsos is a graduate student in ecology at the University of Alberta. Sofia completed her BSc at the University of Ottawa and now works on conservation biology.

Josue Arteaga Torres is a graduate student in ecology at the University of Alberta. Josue completed his BSc in Ecuador before joining the University of Alberta where he studies conservation and ecology.

Received 7 January 2018 – Accepted 29 March 2018

APPENDIX

List of keywords used in literature search

"mitigation", "translocation", "human-wildlife conflict", "conflict", "problem animal", "animal relocation", "conservation translocation", "conflict", "conservation", "nuisance", "nuisance animal".

References of studies found during the literature search phase

I: included in the study. NI: not included in the study. Relocation purpose: Conflict − Cf or Conservation − Cn.

1. **Alldredge, M. W., D. P. Walsh, L. L. Sweanor, R. B. Davies, and A. Trujillo. 2015.** Evaluation of translocation of black bears involved in human-bear conflicts in south-central Colorado. Wildlife Society Bulletin 39: 334–340. **I/Cf**
2. **Beringer, J., L. P. Hansen, J. A. Demand, J. Sartwell, M. Wallendorf, and R. Mange. 1973.** Efficacy of translocation to control urban deer in Missouri: Costs, efficiency, and outcome. Wildlife Society Bulletin 30: 767–774. **I/Cf**
3. **Blanchard, B. M., and R. R. Knight. 1995.** Biological consequences of relocating grizzly bears in the Yellowstone ecosystem. The Journal of Wildlife Management 59: 560–565. **I/Cf**
4. **Bosson, C. O., R. Palme, and R. Boonstra. 2013**. Assessing the impact of live-capture, confinement, and translocation on stress and fate in eastern gray squirrels. Journal of Mammalogy 94: 1401–1411. **I/Cf**
5. **Bradley, E. H., D. H. Pletscher, E. E. Bangs, K. E. Kunkel, D. W. Smith, C. M. Mack, T. J. Meier, J. A. Fontaine, C. C. Niemeyer, and M. D. Jimenez. 2005.** Evaluating wolf translocation as a nonlethal method to reduce livestock conflicts in the northwestern United States. Conservation Biology 19: 1498–1508. **I/Cf**
6. **Brown, J. R., C. A. Bishop, and R. J. Brooks. 2009.** Effectiveness of short-distance translocation and its effects on western rattlesnakes. Journal of Wildlife Management 73: 419–425. **I/Cf**
7. **Cromwell, J. A., R. J. Warren, and D. W. Henderson. 1999.** Live-capture and small-scale relocation of urban deer on Hilton Head Island, South Carolina. Wildlife Society Bulletin 27: 1025–1031. **I/Cf**
8. **Dullum, J. A. L. D., K. R. Foresman, and M. R. Matchett. 2005.** Efficacy of translocations for restoring populations of black-tailed prairie dogs. Wildlife Society Bulletin 33: 842–850. **I/Cn**
9. **Fernando, P., P. Leimgruber, T. Prasad, and J. Pastorini. 2012.** Problem-elephant translocation: translocating the problem and the elephant? PLoS ONE 7: e50917. **I/Cf**
10. **Foley, A., B. Pierce, D. G. Hewitt, R. W. DeYoung, T. A. Campbell, M. W. Hellickson, J. Field, S. Mitchell, M. A. Lockwood, and K. V. Miller. 2008.** Survival and movements of translocated white-tailed deer in south Texas. Proceedings of the annual conference / Southeastern Association of Fish and Wildlife Agencies: 25–30. **I/Cf**
11. **Grey-Ross, R., C. T. Downs, and K. Kirkman. 2009.** Reintroduction failure of captive-bred oribi (*Ourebia ourebi*). South African Journal of Wildlife Research 39: 34–38. **I/Cn**
12. **Hellstedt, P., and E. R. Kallio. 2005.** Survival and behaviour of captive-born weasels (*Mustela nivalis nivalis*) released in nature. Journal of Zoology 266: 37–44. **I/Cn**
13. **Johnson, S. A., and K. A. Berkley. 1999.** Restoring river otters in Indiana. Wildlife Society Bulletin 27: 419–427. **I/Cn**
14. **Jones, J. M., and J. H. Witham. 1990.** Post-translocation survival and movements of metropolitan white-tailed deer. Wildlife Society Bulletin 18: 434–441. **I/Cf**
15. **Liu, B., L. Li, H. Lloyd, C. Xia, Y. Zhang, and G. Zheng. 2016.** Comparing post-release survival and habitat use by captive-bred cabot's tragopan (*Tragopan caboti*) in an experimental test of soft-release reintroduction strategies. Avian Research 7: 1–9. **I/Cn**
16. **Misiorowska, M., and M. Wasilewski. 2008.** Spatial organisation and mortality of released hares − preliminary results. Annales Zoologici Fennici 2450: 286–290. **I/Cn**
17. **Misiorowska, M., and M. Wasilewski. 2012**. Survival and causes of death among released brown hares (*Lepus europaeus* Pallas, 1778) in Central Poland. Acta Theriologica 57: 305–312. **I/Cn**
18. **Molony, S. E., C. V. Dowding, P. J. Baker, I. C. Cuthill, and S. Harris. 2006.** The effect of translocation and temporary captivity on wildlife rehabilitation success: an experimental study using European hedgehogs (*Erinaceus europaeus*). Biological Conservation 130: 530–537. **I/Cf**
19. **Norris, T. A., C. L. Littnan, and F. M. D. Gulland. 2011.** Evaluation of the captive care and post-release behavior and survival of seven juvenile female Hawaiian monk seals (*Monachus schauinslandi*). Aquatic Mammals 37: 342–353. **I/Cn**
20. **O'Bryan, M. K., and D. R. McCullough. 1985**. Survival of black-tailed deer following relocation in California. The Journal of Wildlife Management 49: 115–119. **I/Cn**
21. **Pearson, L., P. Aczel, S. Mahé, A. Courage, and T. King. 2007.** Gorilla reintroduction to the Batéké Plateau National Park, Gabon. Projet Protection des Gorilles (PPG), The Aspinall Foundation. Franceville, Gabon. **I/Cn**
22. **Plummer, M. V, and N. E. Mills. 2000.** Spatial ecology and survivorship of resident and translocated hognose snake. Journal of Herpetology 34: 565–575. **I/Cf**
23. **Reinert, H. K., R. R. Rupert, and R. R. Rupert Jr. 1999.** Impacts of translocation on behavior and survival of timber rattlesnakes, *Crotalus horridus*. Journal of Herpetology 33: 45–61. **I/Cf**
24. **Ruth, T. K., K. A. Logan, L. L. Sweanor, M. G. Hornocker, and L. J. Temple. 1998.** Evaluating cougar translocation in New Mexico. The Journal of Wildlife Management 62: 1264–1275. **I/Cf**
25. **Spinola, R. M., T. L. Serfass, and R. P. Brooks. 2017.** Survival and post-release movements of river otters translocated to western New York. Northeastern Naturalist 15: 13–24. **I/Cn**

26. **Van Vuren, D., A. Kuenzi, I. Loredo, A. Leider, and M. Morrison. 2016.** Translocation as a nonlethal alternative for managing California ground squirrels. Journal of Wildlife Management 61: 351–359. **I/Cf**
27. **Wear, B. J., R. Eastridge, and J. D. Clark. 2005.** Factors affecting settling, survival, and viability of black bears reintroduced to Felsenthal National Wildlife Refuge, Arkansas. Wildlife Society Bulletin 33: 1363–1374. **I/Cn**
28. **Weise, F. J., J. Lemeris Jr, K. J. Stratford, R. J. Van Vuuren, S. J. Munro, S. J. Crawford, L. L. Marker, and A. B. Stein. 2015.** A home away from home: insights from successful leopard (*Panthera pardus*) translocations. Biodiversity and Conservation 24: 1755-1774. **I/Cf**
29. **Adams, L. W., Hadidan, J., and V. Flyger. 2004**. Movement and mortality of translocated urban-suburban grey squirrels. Animal Welfare 13: 45-50. **NI/Cf**
30. **Ahles, N., and S. L. Milton. 2015.** Mid-incubation relocation and embryonic survival in loggerhead sea turtle eggs. Journal of Wildlife Management 80: 430-437. **NI/Cf**
31. **Almberg, E. S., Cross, P. C., Dobson, A. P., Smith, D. W., and P. J. Hudson. 2012.** Parasite invasion following host reintroduction: a case study of Yellowstone's wolves. Philosophical Transactions of the Royal Society B: Biological Sciences 367: 2840-2851. **NI/Cn**
32. **Anderson, D., J. Arnold, R. Higgins, B. Jeffress, B. McQuivey, and M. Stirland. 1990.** Proceedings of the Nevada wildlife/mining workshop. Nevada Mining Association, Reno, Nevada. **NI/Cf**
33. **Athreya, V., M. Odden, J. D. Linnell, and K. U. Karanth. 2010.** Translocation as a tool for mitigating conflict with leopards in human-dominated landscapes of India. Conservation Biology 25: 133-141. **NI/Cf**
34. **Ausband, D. E., and K. R. Foresman. 2006.** Dispersal, survival, and reproduction of wild-born, yearling swift foxes in a reintroduced population. Canadian Journal of Zoology 85: 185-189. **NI/Cn**
35. **Bade, S. R., A. Jimenez, A. K. Poole, and G. A. Feldhamer. 2012.** Prevalence of *Baylisascaris procyonis* and implications for reintroduced woodrat populations in southern Illinois. Transactions of the Illinois State Academy of Science 105: 33-39. **NI/Cn**
36. **Barding, E. E., and M. J. Lacki. 2014.** Demographic and reproductive characteristics of reintroduced northern river otters in Kentucky: implications for population growth. American Midland Naturalist 172: 338-347. **NI/Cn**
37. **Belant, J. L. 1997**. Gulls in urban enviroments: landscape-level management to reduce conflict. Landscape and Urban Planning 38: 245-258. **NI/Cf**
38. **Boast, L. K., K. Good, and R. Klein. 2016.** Translocation of problem predators: is it an effective way to mitigate conflict between farmers and cheetahs *Acinonyx jubatus* in Botswana? Oryx 50: 537-544. **NI/Cf**
39. **Bocci, A., S. Menapace, S. Alemanno, and S. Lovari. 2016.** Conservation introduction of the threatened Apennine chamois (*Rupicapra pyrenaica ornata*): Post-release dispersal differs between wild-caught and captive founders. Oryx 50: 128-133. **NI/Cn**
40. **Beringer, J., L. Hansen, W. Wilding, J. Fischer, and S. L. Sheriff. 1996.** Factors affecting capture myopathy in white-tailed deer. Journal of Wildlife Management 60: 373-380. **NI/Cn**
41. **Butler, H., B. Malone, and N. Clemann. 2005.** The effects of translocation on the spatial ecology of tiger snakes (*Notechis scutatus*) in a suburban landscape. Wildlife Research 32: 165-171. **NI/Cf**
42. **Calvete, C., and R. Estrada. 2004.** Short-term survival and dispersal of translocated European wild rabbits. Improving the release protocol. Biological Conservation 120: 507-516. **NI/Cn**
43. **Calvete, C., E. Angulo, R. Estrada, S. Moreno, and R. Villafuerte. 2005.** Quarantine length and survival of translocated European wild rabbits. Journal of Wildlife Management 69: 1063-1072. **NI/Cn**
44. **Cannella, E. G., and J. Henry. 2017**. A case of homing after translocation of chuditch, *Dasyurus geoffroii* (Marsupialia : Dasyuridae). Austalian Mammology 39: 118-120. **NI/Cn**
45. **Crouch, S., C. Paquette, and D. Vilas. 2002.** Relocation of a large black-crowned night heron colony in southern California. Waterbirds 25: 474-478. **NI/Cf**
46. **Davidson, A. D., M. T. Friggens, K. T. Shoemaker, C. L. Hayes, J. Erz, and R. Duran. 2014**. Population dynamics of reintroduced Gunnison's Prairie dogs in the southern portion of their range. Journal of Wildlife Management 78: 429-439. **NI/Cn**
47. **Devan-Song, A., P. Martelli, D. Dudgeon, P. Crow, G. Ades, and N. E. Karraker. 2016.** Is long-distance translocation an effective mitigation tool for white-lipped pit vipers (*Trimeresurus albolabris*) in south China? Biological Conservation 204: 212-220. **NI/Cf**
48. **Dickens, M. J., D. J. Delehanty, and L. M. Romero 2010**. Stress: an inevitable component of animal translocation. Biological Conservation 143: 1329-1341. **NI/Cn**
49. **Diefenbach, D., L. Hansen, J. Bohling, and C. Miller-Butterworth. 2015**. Population and genetic outcomes 20 years after reintroducing bobcats (*Lynx rufus*) to Cumberland Island, Georgia USA. Ecology and Evolution 5: 4885-4895. **NI/Cn**
50. **Fontúrbel, F., and J. A. Simonetti. 2011**. Translocations and human-carnivore conflicts: problem solving or problem creating? Wildlife Biology 17: 217-224. **NI/Cf**
51. **Gilbert, T., and T. Woodfine. 2008.** The reintroduction of scimitar-horned oryx (*Oryx dammah*) to Dghoumes National Park, Tunisia. European Endagered Species Programme, Marwell Preservation Trust. Dghoumes National Park, Tunisia. **NI/Cn**
52. **Germano, J. M., and P. J. Bishop. 2007.** Suitability of amphibians and reptiles for translocation. Conservation Biology 23: 7-15. **NI/Cn**
53. **Germano, J. M., M. G. Nafus, J. A. Perry, D. B. Hall, and R. R. Swaisgood. 2017.** Predicting translocation outcomes with personality for desert tortoises. Behavioral Ecology 28: 1075-1084. **NI/Cn**
54. **Guerrant, T. L., C. K. Pullins, S. F. Beckerman, and B. E. Washburn. 2013**. Managing Raptors to Reduce Wildlife Strikes at Chicago’s O’Hare International Airport. Wildlife

Damage Management Conferences Proceedings 15: 63-68. **NI/Cf**

55. **Hale, S. L., J. L. Koprowski, and H. Hicks. 2013.** Review of black-tailed prairie dog reintroduction strategies and site selection: Arizona reintroduction. USDA Forest Service Proceedings 67: 310-315. **NI/Cn**
56. **Hall, T. C., and P. Groninger. 2002.** The effectiveness of a long-term Canada goose relocation program in Nevada. Proceedings of the 20th Vertebrate Pest Conference: 180-186. **NI/Cf**
57. **Hamilton, L. P., P. A. Kellly, D. F. Williams, D. A. Kelt, and H. U. Wittmer. 2010.** Factors associated with survival of reintroduced riparian brush rabbits in California. Biological Conservation 143: 999-1007. **NI/Cn**
58. **Han, S., C. Lee, J. W. Mjelde, and T. Kim. 2010**. Choice-experiment valuation of management alternatives for reintroduction of the endangered mountain goral in Woraksan National Park, South Korea. Scandinavian Journal of Forest Research 25: 534-543. **NI/Cn**
59. **Hardman, B., and D. Moro. 2006**. Optimizing reintroduciton success by delayed dispersal: is the release protocol important for hare-wallabies? Biological Conservation 128: 403-411. **NI/Cn**
60. **Hayward, M. W., A. S. L. Poh, J. Cathcart, C. Churcher, J. Bentley, K. Herman, L. Kemp, N. Riessen, P. Scully, C. H. Diong, S. Legge, A. Carter, H. Gibb, and J. A. Friend. 2015.** Numbat nirvana: conservation ecology of the endangered numbat (*Myrmecobius fasciatus*) (Marsupialia: Myrmecobiidae) reintroduced to Scotia and Yookamurra Sanctuaries, Australia. Austrialian Journal of Zoology 63: 258-269. **NI/Cn**
61. **Hodder, K. H., and J. M. Bullock. 1997**. Translocations of native species in the UK: implications for biodiversity. Journal of Applied Ecology 34: 547-565. **NI/Cn**
62. **Hopkins, J. B., and S. T. Kalinowski. 2013.** The fate of transported American black bears in Yosemite National Park. Ursus 24: 120-126. **NI/Cf**
63. **Jachowski, D. S., R. A. Gitzen, M. B. Grenier, B. Holmes, and J. J. Millspaugh. 2011.** The importance of thinking big: large-scale prey conservation drives black-footed ferret reintroduction success. Biological Conservation 144: 1560-1566. **NI/Cn**
64. **Jenni, J., N. Keller, B. Almasi, J. Duplain, B. Homberger, M. Lanz, F. Korner-Nievergelt, M. Schaub, and S. Jenni-Eiermann. 2015.** Transport and release procedures in reintroduction programs: stress and survival in grey partridges. Animal Conservation 18: 62-72. **NI/Cn**
65. **Jones, D. N., and T. Nealson. 2003.** Management of aggressive Australian magpies by translocation. Wildlife Research 30: 167-177. **NI/Cf**
66. **Kidjo, N., G. Feracci, E. Bideau, G. Gonzalez, C. Mattei, B. Marchand, and S. Aulaginer. 2007.** Extirpation and reintroduction of the Corsican red deer *Cervus elaphus corsicanus* in Corsica. Oryx 41: 488-494. **NI/Cn**
67. **Kingsley, L., A. Goldizen, and D. O. Fisher. 2012.** Establishment of an Endangered species on a private nature refuge: what can we learn from reintroductions of the bridled nailtail wallaby *Onychogalea fraenata*? Oryx 46: 240-248.. **NI/Cn**
68. **Korablev, N., Y. Puzachenko, N. Zavyalov, and A. Zheltukhin. 2011.** Long term dynamics and morphological peculiarities of reintroduced beaver population in the Upper Volga basin. Baltic Forestry 17: 136-146. **NI/Cn**
69. **Laubscher, L. L., N. E. Pitts, J. P. Raath, and L. C. Hoffman. 2015.** Non-chemical techniques used for the capture and relocation of wildlife in South Africa. African Journal of Wildlife Research 45: 275-286. **NI/Cn**
70. **Lehrer, E. W., R. L. Schooley, J. M. Nevis, R. J. Kilgour, P. J. Wolff, and S. B. Magle. 2016.** Happily ever after? Fates of translocated nuisance woodchucks in the Chicago metropolitan area. Urban Ecosystems 19: 1389-1403. **NI/Cf**
71. **Massei, G., R. J. Quy, J. Gurney, and D. P. Cowan. 2010.** Can translocations be used to mitigate human-wildlife conflicts? Wildlife Research 37: 428-439. **NI/Cf**
72. **McArthur., K. L. 1981.** Factors contributing to effectiveness of black bear transplants. Journal of Wildlife Management 45: 102-110. **NI/Cf**
73. **Milliano, J., J. D. Stefano, P. Courtney, P. Temple-Smith, and G. Coulson. 2016.** Soft-release versus hard-release for reintroduction of an endangered species: an experimental comparison using eastern barred bandicoots (*Perameles gunnii*). Wildlife Research 43: 1-12. **NI/Cn**
74. **Mosillo, M., E. J. Heske, and J. D. Thompson. 1999.** Survival and movements of translocated raccoons in northcentral Illinois. Journal of Wildlife Management 63: 278-286. **NI/Cf**
75. **Mukesh, L. K. Sharma, S. A. Charoo, and S. Sathyakumar. 2015.** Conflict bear translocation: Investigating population genetics and fate of bear translocation in Dachigam National Park, Jammu and Kashmir, India. PLoS ONE 10: 1-17. **NI/Cf**
76. **Normande, I. C., F. D. O. Luna, A. C. M. Malhado, J. C. G. Borges, P. C. Viana Jr., F. L. N. Attademo, and R. J. Ladle. 2015.** Eighteen years of Antillean manatee *Trichechus manatus* manatus releases in Brazil: lessons learnt. Oryx 49: 338-344. **NI/Cn**
77. **Northrup, J. M., G. B. Stenhouse, and M. S. Boyce. 2012.** Agricultural lands as ecological traps for grizzly bears. Animal Conservation 15: 369-377. **NI/Cf**
78. **Pedersen, G. 2009.** Habitat use and diet selection of reintroduced white rhinoceros (*Ceratotherium simum*) in Pafuri, Kruger National Park. Unpublished MSc thesis, Stellenbosch University, Stellenbosch, South Africa. **NI/Cn**
79. **Peignot, P., M. J. E. Charpentier, N. Bout, and O. Bourry, U. Massima, O. Dosimont, R. Terramorsi, and E. J. Wickings. 2008**. Learning from the first release project of captive-bred mandrills *Mandrillus sphinx* in Gabon. Oryx 42: 122-131. **NI/Cn**
80. **Pinter-Wollman, N., L. A. Isbell, and L. A. Hart. 2009.** Assessing translocation outcome: comparing behavioral and physiological aspects of translocated and resident African elephants (*Loxodonta africana*). Biological Conservation 142: 1116-1124. **NI/Cn**
81. **Poole, A. K., B. A. Novosak, A. C. Gooley, D. M. Ing, R. D. Bluett, T. C. Carter, and G. A. Feldhamer. 2013.**

Reintroduction of the eastern woodrat (*Neotoma floridana*) in southern Illinois. Southeastern Naturalist 12: 1–10. **NI/Cn**

82. **Powell, R. A., R. C. Swiers, A. N. Facka, S. Matthews, and D. Clifford. 2014.** Understanding a fisher reintroduction in northern California from 2 perspectives. Report, United States Fish and Wildlife Service, Yreka, California. **NI/Cn**
83. **Pyne, M. I., K. M. Byrne, K. A. Holfelder, L. McManus, M. Buhnerkempe, N. Burch, E. Childers, S. Hamilton, G. Schroeder, and P. F. Doherty Jr. 2010**. Survival and breeding transitions for a reintroduced bison population: a multistate approach. Journal of Wildlife Management 74: 1463-1471. **NI/Cn**
84. **Robbins, C. T., C. C. Schwartz, and L. A. Felicetti. 2004.** Nutritional ecology of ursids: a review of newer methods and management implications. Ursus 15: 161-171. **NI/Cn**
85. **Rosatte, R., J. Hamr. J. Young, I. Filion, and H. Smith. 2007.** The restoration of elk (*Cervus elaphus*) in Ontario, Canada: 1998–2005. Restoration Ecology 15: 34-43. **NI/Cn**
86. **Ross, P. I., and M. G. Jalkotzy. 1995.** Fates of translocated cougars, *Felis concolor*, in Alberta. Canadian Field-Naturalist 109: 475-476. **NI/Cf**
87. **Sankar, K., Q. Qureshi, P. Nigam, P. K. Malik, P. R. Sinha, R. N. Mehrotra, R. Gopal, S. Bhattacharjee, K. Mondal, and S. Gupta. 2010.** Monitoring of reintroduced tigers in Sariska Tiger Reserve, western India: preliminary findings on home range, prey selection and food habits. Tropical Conservation Science 3: 301-318. **NI/Cn**
88. **Schmidt, J. H., J. W. Burch, and M. C. MacCluskie. 2017.** Effects of control on the dynamics of an adjacent protected wolf population in interior Alaska. Wildlife Management 198: 1-30. **NI/Cn**
89. **Schneider, J., D. S. Maehr, K. J. Alexy, J. J. Cox, J. L. Larkin, and B. C. Reeder. 2006.** Food habits of reintroduced elk in southeastern Kentucky. Southeastern Naturalist 5: 535-546. **NI/Cn**
90. **Schutz, K. E., E. Agren, M. Amundin, B. Roken, R. Palme, and T. Morner. 2006.** Behavioral and physiological responses of trap-induced stress in European badgers. Journal of Wildlife Management 70: 884-891. **NI/Cf**
91. **Sjoasen, T. 1997.** Movements and establishment of reintroduced European otters *Lutra lutra*. Journal of Applied Ecology 34: 1070-1080. **NI/Cn**
92. **Sullivan, B. K., E. M. Nowak, and M. A. Kwiatkowski. 2014.** Problems with mitigation translocation of herpetofauna. Conservation Biology 29: 12-18. **NI/Cf**
93. **Swan, G. J. F., S. M. Redpath, S. Bearhop, and R. A. McDonald. 2017**. Ecology of problem individuals and the efficacy of selective wildlife management. Trends in Ecology & Evolution 32: 518-530. **NI/Cn**
94. **Tatin, L., S. R. B. King, B. Munkhtuya, A. J. M. Hewison, and C. Feh. 2008.** Demography of a socially natural herd of Przewalski's horses: an example of a small, closed population. Journal of Zoology 277: 134-140. **NI/Cn**
95. **Vonholdt, B. M., D. R. Stahler, D. W. Smith, D. A. Earl, J. P. Pollinger, and R. K. Wayne. 2007.** The genealogy and genetic viability of reintroduced Yellowstone grey wolves. Molecular Ecology 17: 252-274. **NI/Cn**
96. **Whiting, J. C., K. M. Stewart, R. T. Bowyer, and J. T. Flinders. 2010.** Reintroduced bighorn sheep: do females adjust maternal care to compensate for late-born young? European Journal of Wildlife Research 56: 349-357. **NI/Cn**
97. **Whiting, J. C., D. D. Olson, J.M. Shannon, T. Bowyer, R. W. Klaver, and J. T. Flinders. 2012.** Timing and synchrony of births in bighorn sheep: implications for reintroduction and conservation. Wildlife Research 39: 565-572. **NI/Cn**
98. **Vilasenor, N. R., M. A. H. Escobar, and C. F. Estades. 2012.** There is no place like home: high homing rate and increased mortality after translocation of a small mammal. European Journal of Wildlife Research 59: 749-760. **NI/Cf**
99. **Weise, F. J., I. Wiesel, J. Lemeris Jr., and R. J. Van Vuuren. 2015.** Evaluation of a conflict-related brown hyaena translocation in central Namibia. African Journal of Wildlife Research 45: 178-186. **NI/Cf**
100. **Wolf, M. C., B. Griffith, C. Reed, and S. A. Temple. 1996.** Avian and mammalian translocations: Update and Reanalysis of 1987 Survey Data. Conservation Biology 10: 1142-1154. **NI/Cn**
101. **Wolf, C. M., T. Garland Jr, and B. Griffith. 1998.** Predictors of avian and mammalian translocation success: reanalysis with phylogenetically independent contrasts. Biological Conservation 86: 243-255. **NI/Cn**
102. **Xia, C., J. Cao, H. Zhang, X. Gao, W. Yang, and D. Blank. 2014.** Reintroduction of Przewalski's horse (*Equus ferus przewalskii*) in Xinjiang, China: the status and experience. Biological Conservation 177: 142-147. **NI/Cn**
103. **Yan., Z., C. Li, L. Zhang, Z. Zhong, and Z. Jiang. 2015.** No correlation between neonatal fitness and heterozygosity in a reintroduced population of Père David's deer. Current Zoology 59: 249-256. **NI/Cn**
104. **Zidon, R., D. Saltz, L. S. Shore, and U. Motro. 2009.** Behavioral changes, stress, and survival following reintroduction of Persian fallow deer from two breeding facilities. Conservation Biology 23: 1026-1035. **NI/Cn**