

CONSERVATION EVIDENCE: ASSESSING TRANSLOCATIONS AND
REINTRODUCTIONS OF TERRESTRIAL CARNIVORES

by

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Executive Summary

Around the world terrestrial carnivores are facing rapid declines in population size from threats including habitat loss, poaching, disease, insufficient prey, highways and inbreeding. To prevent the extinction of carnivores effective conservation practices must be established, however the appropriate intervention for specific situations is not always obvious.

One of the greatest challenges to conservation is providing environmental managers with information regarding what interventions have been done elsewhere and their results. Part of the growing demand for evidence-based actions, Conservation Evidence (CE) works to collect, summarize, and distribute quantitative evidence of conservation efforts in a succinct, user-friendly program that is freely accessible to the public.

This report, focused on translocations and reintroductions of felids, represents a portion of the forthcoming CE synopsis on terrestrial carnivores, defines and assesses success of these practices, observes cause of death and discusses management challenges for these actions.

The translocation and reintroduction of terrestrial carnivores are widely used conservation interventions to maintain or reestablish healthy populations in areas experiencing declining numbers or local extinction. The variety of capture, release, and monitoring methods seen throughout practices influence the outcome of these interventions. Animal mortalities following release illuminate ongoing stressors in supplemented populations. These practices are typically considered 'successful' if individuals establish home ranges or reproduce, however there is no standard threshold value.

This report first examines papers within the Conservation Evidence database regarding translocations and reintroduction of felid (cat) species. It identifies articles with quantitative results of practices that are appropriate for summarizing via Conservation Evidence protocol. Completed summaries of the 25 suitable papers are not included within this report, but will be made available online at <http://www.conservationevidence.com>.

It then sets a sensible definition of "success" within translocations and reintroductions based upon the reproduction and home range establishment of moved animals. This definition indicated the vast majority of the studies (18 out of 25) as successful interventions. Compiled by species the number of reported offspring varied greatly due to differences in life histories, fecundity rates and behavior. The same factors influence the number of animals to establish home ranges, which differed noticeably by species and gender.

Next it assesses reported cause of death in supplemented populations after a translocation or reintroduction, which is predominantly unknown. Major non-human threats reported were infectious and non-infectious diseases, aggressive encounters, prey interactions, trauma and starvation or dietary issues. Deaths related to human activities include vehicular collisions, illegal killings and legal or managed killings.

Lastly, the challenges for translocations and reintroduction practices are discussed. These include, but are not limited to, cause of initial local extinction, presence of existing population, social group composition, source population and captive-bred stock, prey availability, and local economics.

Translocations and reintroductions are reactive conservation practices taken after significant damage has already been inflicted on struggling or eliminated populations. Without interventions that address maintaining healthy populations large carnivore species could vanish. While these interventions are being done, people managing them often do not have access to research and data from previous efforts. Conservation Evidence is working to remedy the lack of such a resource, as research not communicated is research not completed.

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Abstract

Around the world terrestrial carnivores are facing rapid declines in population size. Larger species are especially vulnerable to declines as they typically have solitary social structures, low population densities and low fecundity. In order to prevent extinctions effective conservation practices need to be established. Conservation Evidence, a project begun at Cambridge University, is designed to gather quantitative scientific evidence for various conservation interventions into a succinct and user-friendly program that is freely accessible to the public. This report, focused on translocations and reintroductions of felids, represents a portion of the forthcoming synopsis on terrestrial carnivores. This project also shows that the 'success' of translocations and reintroductions is difficult to define. An intervention is typically viewed as 'successful' if individuals establish home ranges or reproduce, however there is no standard threshold value.

Introduction

Carnivores are experiencing declining populations. These declines are a result of a high number of threats that include, but are certainly not limited to, poaching, insufficient prey populations, disease, habitat loss, inbreeding and even highways. These threats are present around the world, with interventions to mitigate them ranging from paying ranchers not to kill problematic carnivores eating their livestock to building wildlife overpasses to translocations and reintroductions of species. Each of these interventions is intended for a specific threat in a specific ecological context. Therefore, when putting these interventions into practice they must be tailored to the appropriate context and needs of the target species.

Order Carnivora

Incredibly diverse, the order Carnivora includes animals that can be found across the world. The range of sizes, from the least weasel (*Mustela nivalis*) of 35 g to the southern elephant seal (*Mirounga leonis*) of more than 3,600 kg, illustrates the variety of adaptations developed for survival (EOL 2012a). The presence of carnivores on every continent and in every ocean means that there is a broad assortment of life histories and ecosystem niches. Consequently, they are presented with a variety of threats requiring a variety of conservation practices.

Family Felidae

Typically divided into big cats and small cats, the family Felidae is generally characterized by animals with swimming and climbing skills, solitary habits, and almost exclusive reliance on food they kill themselves (EOL 2012b). Native cats are present on nearly every large landmass. Even with invasive movements, cats are not found on polar icecaps or treeless tundra habitats.

Evidence-Based Conservation

The appropriate intervention for a particular situation is not always obvious. One of the greatest challenges to conservation is providing environmental managers with information regarding what interventions have been done elsewhere and their results. This information is typically found one of three ways: (1) reading scientific literature, (2) asking a scientist, or (3) reading literature reviews (Dicks 2010). Many conservationists do not have sufficient funds to pay for access to scientific papers or access through academic institutions, making the first option difficult. Even with access, sifting through publications is time consuming and can be slowed by managers not knowing the scientific terminology. The second option is rarely possible, as a manager can only ask a scientist if they know a scientist in the desired field. In addition, a scientist may provide biased advice based on personal experiences. The most unbiased and practical is the third option, but few comprehensive reviews on carnivore conservation are available.

The Conservation Evidence (CE) project is part of the growing demand for evidence-based conservation. Conceived by Professor William Sutherland at the University of Cambridge, CE works to collect and distribute quantitative evidence of conservation efforts. Conservation Evidence has three components: (1) an online journal which publishes original studies that quantitatively assess various conservation interventions, (2) a series of published synopses of available evidence for a specific type of ecosystem, issue or taxa, and (3) an online searchable database of concise summaries of previously existing studies (found at <http://www.conservationevidence.com>).

Terrestrial Carnivore Synopsis

This project is a contribution for the forthcoming CE synopsis on terrestrial carnivores. To date eight synopses have been published. They assemble summaries of all evidence available on interventions used to conserve their specified taxa, issue, or ecosystem. Published animal taxa synopses include amphibians (Smith and Sutherland 2014), bats (Berthinussen, Richardson et al. 2014), bees (Dicks, Showler et al. 2010) and birds (Williams, Pople et al. 2013). These synopses, along with any regarding farmland conservation (Dicks, Ashpole et al. 2013) have been published

as books and are available online as PDFs

(<http://www.conservationevidence.com/synopsis/index>). Synopses for natural pest control (Wright, Ashpole et al. 2013), soil fertility (Key, Whitfield et al. 2013) and sustainable aquaculture (Jones, Mead et al. 2013) are currently only available online as PDFs. The intention of CE is for these synopses to aid conservationists interested in a specific taxon, habitat or issue in their decision of what interventions if most appropriate for their unique situation. The synopses are designed to thoroughly review the literature while being as concise as possible. They objectively state the evidence without giving a recommendation.

The terrestrial carnivore synopsis will encompass all rationally applied interventions for members of order Carnivora with terrestrial habitats. This project contributes to the synopsis sections that address translocations and reintroductions while focusing on family Felidae. These practices are important for carnivore populations with low numbers due to inbreeding, disease, poaching and habitat loss.

Ecological Importance of Carnivores

The protection of terrestrial carnivores is critical, not only for the survival of the species, but for the overall health of the ecosystem they inhabit. The loss of apex predators from an area can result in trophic cascading, where the entire system experiences sweeping consequences (Estes and Terborgh 2010). The change in a single trophic level radiates through the rest of the trophic web. As an apex predator is removed the species it preys upon experience less pressure, allowing their populations to rapidly increase to unsustainable numbers. The high herbivore populations have the ability to devastate the vegetation they rely upon, eventually resulting in a reduction in an area's overall biodiversity. In this way, apex predators perform the critical role in their ecosystems by controlling herbivore populations to prevent them from overharvesting vegetation.

Trophic cascades can also occur at intermediate trophic levels and even cross over ecosystem boundaries. In cases where the trophic web comprises of species with complex life histories cascades have been known to cross between and impacts both aquatic and terrestrial systems (Knight, McCoy et al. 2005). A species that lives part of their life cycle in water and other parts on land can carry effects of a trophic cascade across the different ecosystems, allowing the cascade to influence areas beyond the exact ecosystem where the original predator disappeared. The loss of an apex predator has the potential for extensive impacts within both the area they originally inhabited and adjacent ecosystems.

Translocations and Reintroductions

Typically one of the last efforts used, the reintroduction of a species into part of their former range can be used for conservation in an area where they have been locally eliminated. Properly monitored reintroductions can provide insight into reasons for the initial loss of a species in an area (Sankar, Qureshi et al. 2010). Reintroduction practices may also provide conservationists and environmental manager insight into the causes of a species' decline in areas they previously inhabited. Translocations are very similar to reintroductions in practice, but maintain one distinct difference: the placement of additional individual animals into an already existing population. Carnivore populations subject to translocation practices are typically subject to rapidly decreasing populations, thus actions are taken in an attempt to prevent their disappearance in a specific area.

Practices of translocation and reintroduction are generally considered successful if they eventually result in a self-sustaining population (Griffith, Scott et al. 1989). Unfortunately, monitoring efforts are rarely maintained long enough to definitively observe establishment of self-sustainability.

Objectives

The objectives of this project are:

1. To assess, summarize and compare literature with quantitative data of felid translocations and reintroductions following CE guidelines.
2. To contribute article summaries to CE as a portion of the pending carnivore synopsis so they may be made available to any interested parties
3. To indicate success for various species and predominant cause of death in supplemented populations.
4. Discuss management challenges of felid translocation and reintroduction practices.

Methods

This project was conducted in two parts:

Part 1

A database of conservation interventions that provide qualitative data was compiled by the Big Cats Initiative (BCI) intern group at Duke University in the fall of 2011. More recent literature was added via journal trawling. The database is comprised of published scientific papers, review

papers, professional reports and grey literature. Despite having access to journals through Duke University Libraries, 14 papers were difficult to access. To retrieve these I went through other academic institutions, specifically Virginia Commonwealth University and George Mason University.

Papers addressing translocations and reintroductions performed on felid species were identified. Each article was summarized according to the CE format (Appendix I). First, a form is filled out to identify the intervention, species, region, habitat and major findings of each article. This information is added to the online CE database, making it possible to find the summary based on key words. Second, the study is summarized into a single, succinct paragraph to be part of the final synopsis.

Part 2

To assess the success of translocations and reintroductions two criteria were examined: reproduction by moved individuals and establishment of home ranges. There is no established threshold value within the conservation community for either of these metrics. For this study evidence of successful breeding included visual observations (typically of a female with young) and animals without tags seen alive or found dead (Vandel, Stahl et al. 2006; Van Houtan, Halley et al. 2009). Reported observations of reproduction were compiled by species and compared to the total number of moved individuals of the same species. The establishment of a home range was deemed successful if individuals remained in an area, using it for predation and rest (Hayward, Hayward et al. 2009). Home ranges were compiled by species and gender, and compared to the total number to relocated individuals of the same species and gender.

Cause of death was recorded for observed carcasses. Mortality causes were differentiated into ten categories: vehicular collisions, infectious disease, non-infectious disease, illegal killing, legal or managed killing, trauma, aggressive encounter, prey interaction, starvation and dietary issues, and unknown. Illegal killing includes poaching, trapping and poisoning, and negative human interactions. Legal killing includes shootings by local management officials and permitted hunting. Trauma covers drowning and unfortunate events where clear physical damage was induced but cause could not be determined. Aggressive encounters were both interspecific and intraspecific. Starvation and dietary issues includes malnutrition, emaciation, and obstipation. Animals found in poor health and given veterinary care were not counted as mortalities, despite the high likelihood of them dying without assistance.

Results

As of March 2013 the database consisted of 455 papers meeting the CE criteria. Of these, 108 studies address translocations or reintroductions of terrestrial carnivores and of those, 30 directly concerned felid species (Figure 1 & Figure 2).

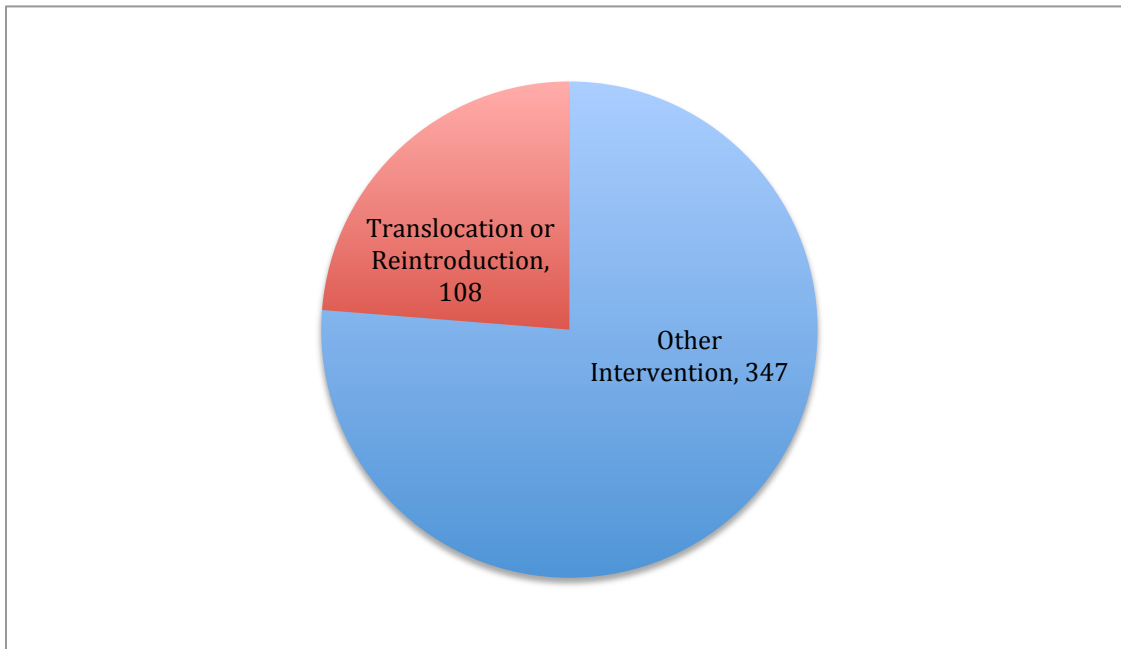


Figure 1. Distribution of intervention type for studies from CE database, as of March 2013.

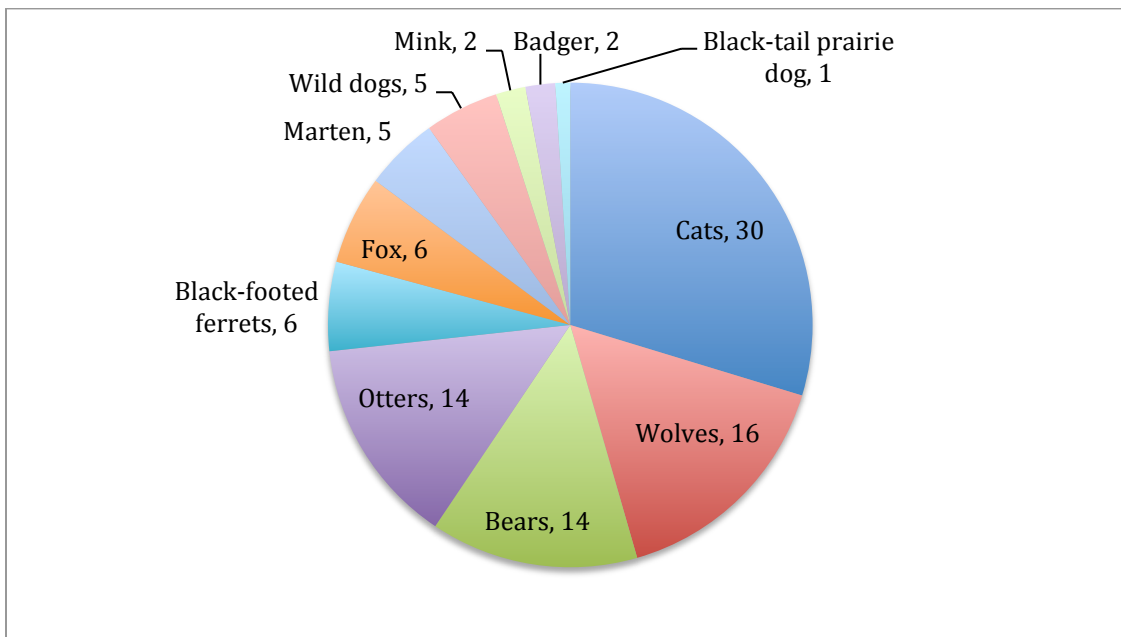


Figure 2. Number of papers per carnivore family in CE database regarding a translocation or reintroduction.

Twenty-five papers were suitable for summaries. Of these, five examine more than one species (Table 1). These studies focus on a wide array of felid species, locations and time frames, making direct comparisons difficult. Five papers are not summarized due to them being correlative studies, repetitive of other CE studies or already being on the CE website. The summaries of these 25 interventions will contribute to the final carnivore synopsis. Each study will be summarized in a single paragraph that comprises the most significant information.

Table 1. Felid species studies regarding translocation or reintroduction. Several studies addressed more than one species.

Target Species	Number of Studies	Percentage of Total Papers
Lion	9	36%
Leopard	7	28%
Lynx	6	24%
Cheetah	4	16%
Bobcat	2	8%
Cougar	2	8%
Jaguar	1	4%
Serval	1	4%
Tiger	1	4%

The majority of the studies (72%) found their actions to be successful. Of the remaining studies 24% were inconclusive and 4% was decisively unsuccessful (Table 2). Analysis of their basic data indicates where gaps exist in currently available research.

Table 2. Basic data pulled from the 25 studies on felid translocations and reintroductions in the CE database. (Diefenbach et al. 1989; Belden and McCowan 1996; Breitenmoser et al. 1998; Cop and Frkovic 1998; Hunter 1998; Ruth et al. 1998; Schmidt-Posthaus et al. 2002; Kilian and Bothma 2003; Druce et al. 2004; Steury and Murray 2004; Diefenbach et al. 2006; Vandell et al. 2006; Hayward et al. 2006; Hayward et al. 2007(a); Hayward et al. 2007(b); Trinkel et al. 2008; Hayward et al. 2009; Devineau et al. 2010; Isasi-Catala 2010; Sankar et al. 2010; Weilenmann et al. 2010; Athreya et al. 2011; Houser et al. 2011; Hunter et al. 2012; Miller et al. 2013)

Study	Species	Action	Research Design	Success?	Measure
Athreya et al. 2011	Leopard	Translocation	Study	Inconclusive	
Belden & McCowan 1996	Cougar	Translocation	Before-and-after trial	Yes	Home Range, Reproduction
Breitenmoser et al. 1998	Lynx	Reintroduction	Before-and-after trial	Yes	Home Range
Cop & Frkovic 1998	Lynx	Reintroduction	Before-and-after trial	Yes	Reproduction
Devineau et al. 2010	Lynx	Reintroduction	Before-and-after trial	Yes	Home Range

Diefenbach et al. 1989	Bobcat	Reintroduction	Before-and-after trial	Yes	Home Range, Reproduction
Diefenbach et al. 2006	Bobcat	Reintroduction	Before-and-after trial	Yes	Home Range, Reproduction
Druce et al. 2004	Lion	Translocation	Before-and-after trial	Yes	Home Range, Reproduction
Hayward et al. 2006	Leopard	Reintroduction	Before-and-after trial	Yes	Home Range
Hayward et al. 2007(a)	Lion, Leopard, Cheetah, Serval	Reintroduction	Review	Yes	Reproduction
Hayward et al. 2007(b)	Lion, Leopard, Cheetah	Reintroduction	Before-and-after trial	Yes	Reproduction
Hayward et al. 2009	Lion, Leopard	Translocation	Before-and-after trial	Yes	Home Range
Houser et al. 2011	Cheetah, Leopard	Translocation	Before-and-after trial	Inconclusive	Home Range
Hunter 1998	Lion, Cheetah	Translocation	Before-and-after trial	Yes	Home Range
Hunter et al. 2012	Lion	Translocation	Correlative	Inconclusive	
Isasi-Catala 2010	Jaguar	Translocation	Systematic Review	Inconclusive	
Kilian & Bothma 2003	Lion	Translocation	Before-and-after trial	Yes	Home Range, Reproduction
Miller et al. 2013	Lion	Reintroduction	Correlative	Inconclusive	
Ruth et al. 1998	Cougar	Translocation	Before-and-after trial	Yes	Home Range
Sankar et al. 2010	Tiger	Reintroduction	Before-and-after trial	Yes	Home Range
Schmidt-Posthaus et al. 2002	Lynx	Reintroduction	Correlative	Yes	Reproduction
Steury & Murray 2004	Lynx	Reintroduction	Correlative	Inconclusive	
Trinkel et al. 2008	Lion	Translocation	Before-and-after trial	Yes	Home Range, Reproduction
Vandel et al. 2006	Lynx	Reintroduction	Before-and-after trial, Replicated	Yes	Home Range, Reproduction
Weilenmann et al. 2010	Leopard	Translocation	Before-and-after trial	Unsuccessful	Home Range

Reproduction in supplemented populations was reported in 8 papers (Figure 3). High numbers of offspring were reported for lions (134) and Eurasian lynx (61). Reported offspring for bobcats and cheetahs was 24 and 23 respectively. A single leopard offspring was verified.

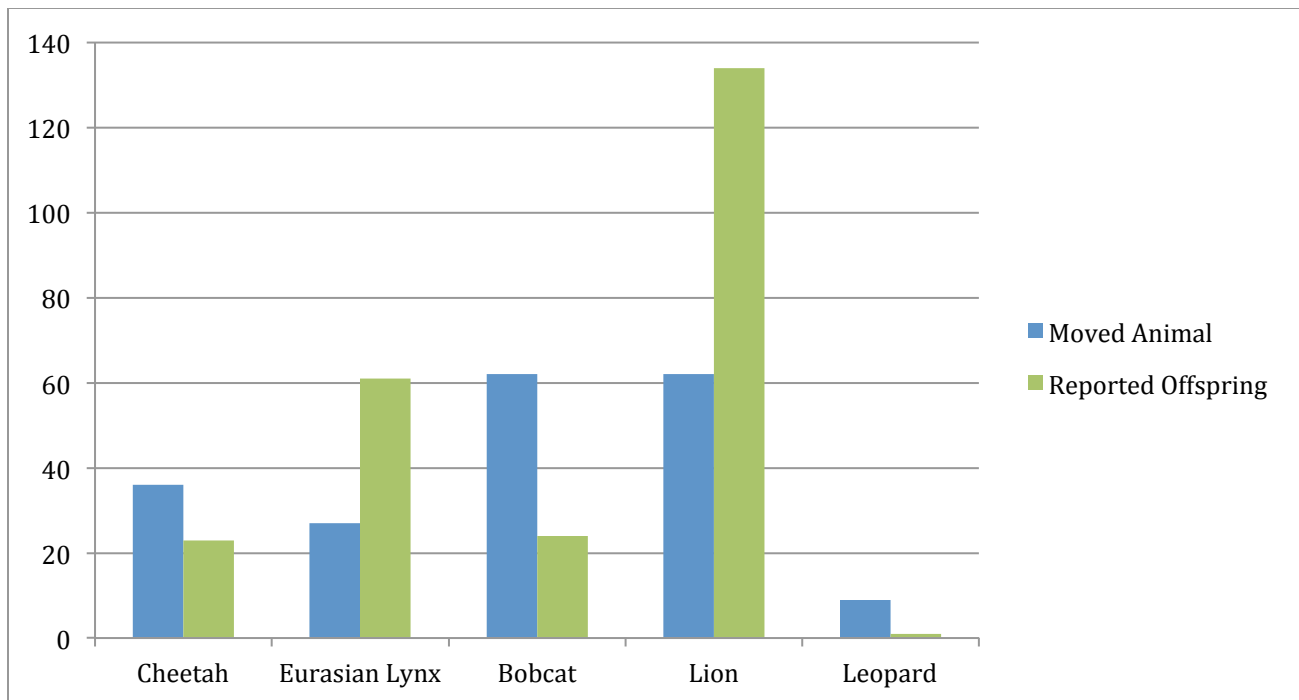


Figure 3: Observed offspring in supplemented populations by species. (Diefenbach et al. 1989; Cop and Frkovic 1998; Kilian and Bothma 2003; Druce et al. 2004; Diefenbach et al. 2006; Vandell et al. 2006; Hayward et al. 2007(b); Trinkel et al. 2008)

Establishment of home ranges was predominantly successful (Figure 4). The highest number of successful home range establishment for both genders was observed in bobcats and lions (14 of 15 male and 15 of 15 female bobcats and 14 of 15 male and 17 of 20 female lions). Reported successful ranges for cougars were slightly above majority of known released individuals (8 of 13 males and 12 of 20 females). Successful tiger establishment was similar to cougars, though smaller in number (1 of 2 males and 2 of 3 females). Leopards showed establishment by one male and one female (1 of 4 males and 1 of 2 females). The single known male cheetah successfully established a home range while the two known females did not. The Eurasian lynx reported lowest number of reported home ranges in comparison to known individuals (1 of 15 males and 0 of 12 females).

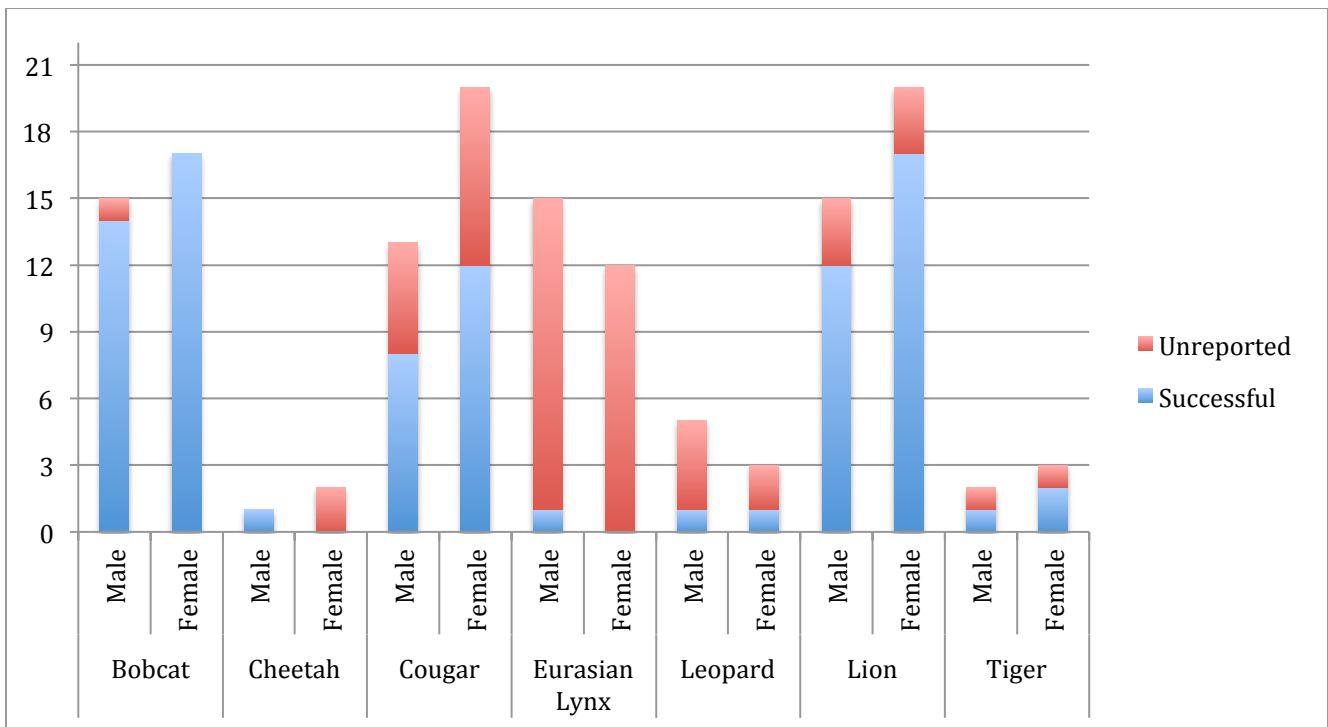


Figure 4. Interventions reported as successful via home range establishment by species and known gender. (Belden and McCowan 1996; Kilian and Bothma 2003; Druce et al. 2004; Diefenbach et al 2006; Vandell et al. 2006; Trinkel et al. 2008; Hayward et al. 2009; Sankar et al. 2010; Weilenmann et al. 2010; Houser et al. 2011)

Cause of death varied greatly across felid species (Figure 5). For observed carcasses the predominant cause of death was legal or managed killings, with 234 reported cases. Incidents of illegal killing were confirmed for 47 animals. The second most frequent cause of death is unknown (82 observed carcasses). Infectious disease was observed in 25 carcasses, while non-infectious disease claimed 51 animals. Vehicular collisions claimed 46 individuals. An additional 15 cases of trauma not related to vehicle collision were observed. Aggressive encounters and prey interactions were the cause of death for 3 and 8 individuals, respectively. Eighteen animals died due to starvation or other dietary issues.

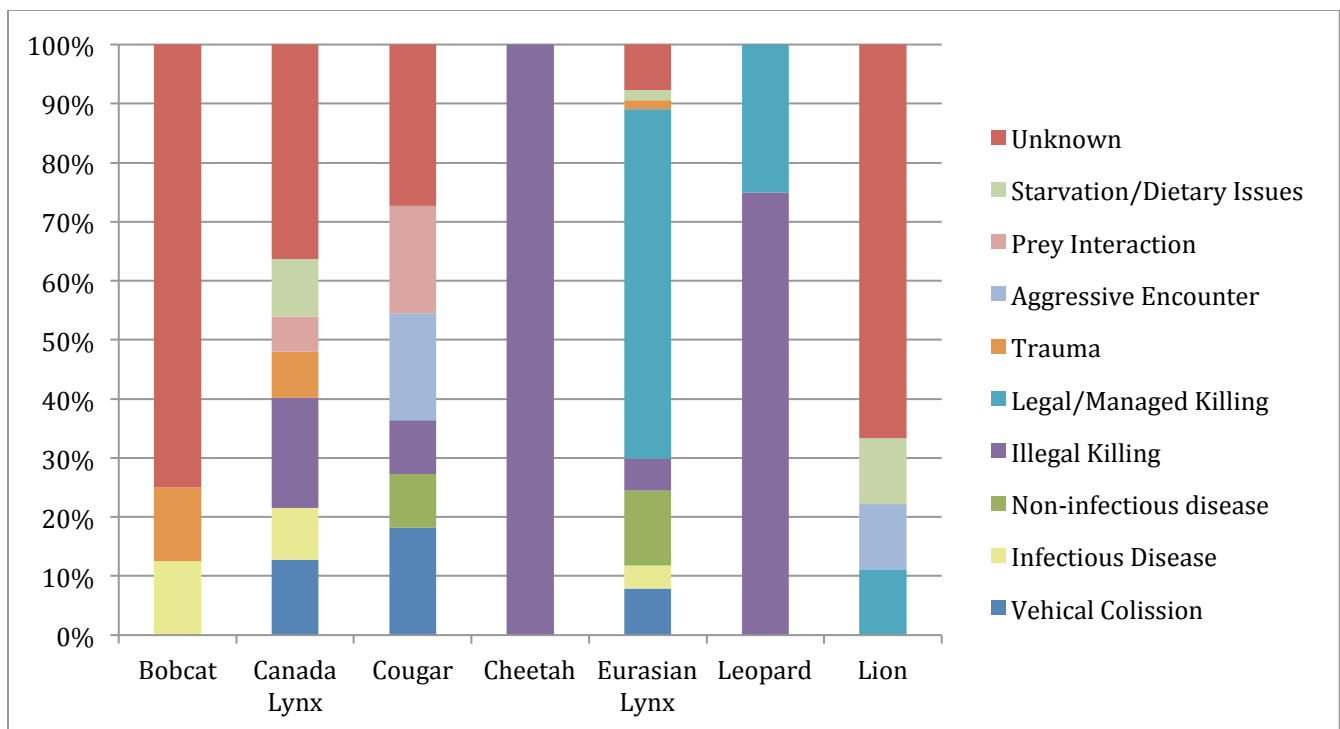


Figure 5. Recorded cause of death for observed carcasses. (Diefenbach et al. 1989; Belden and McCowan 1996; Cop and Frkovic 1998; Ruth et al. 1998; Schmidt-Posthaus et al. 2002; Druce et al. 2004; Diefenbach et al. 2006; Vandiel et al. 2006; Trinkel et al. 2008; Devineau et al. 2010; Weilenmann et al. 2010; Houser et al. 2011)

Discussion

From a variety of sources over more than 4 decades, a large number of articles met the criteria set for CE; they were quantitative and held practical value. The number of articles relating to carnivores is promising, especially since several (24%) relate to translocations and reintroductions and the most represented carnivore family is Felidae (27%). However, the number of studies is not representative of all interventions of this type being performed. Translocations and reintroductions are well known practices, sometimes performed without any records kept. Furthermore, studies on carnivores and practices implemented at a landscape-scale are challenging to monitor.

Conservation Evidence Summaries

An encouraging outcome of this analysis is that the vast majority of the studies were determined to have successful interventions. The studies deemed inconclusive were done so due to lack of quantitative data regarding home range establishment or reproduction. The one unsuccessful study clearly stated that the animals were killed before they were able to settle and mate. These results suggest that, despite different methods being used in almost every article,

researchers recognize the importance of recording reproduction and establishment of home ranges.

This analysis reiterates that there is a lack of a standard measurement for success in translocation and reintroduction practices. The standardization of methods and record keeping would be highly beneficial for future assessments. Assessing the current literature further will aid in formulating suggestions for more standardized practices, but more research needs to be done. Due to the variety of life histories across species it is implausible that a single standard will ever be reached.

Measurement of Success

Reproduction

The number of reported offspring varied greatly between species. This is due to differences in life histories, fecundity rates and behavior. These distinctions further complicate defining success across translocation and reintroduction practices. Lions are known to rebound quickly from population drops, supporting the high number of offspring (Hunter, White et al. 2012). The number of reported young can't be compared across time due to all CE articles covering different time frames, varying from 3 months to 30 years.

The confirmation of a single leopard may have been due to their elusive behaviors. As such, the lack of confirmed young does not mean they do not exist. Future studies of leopards may invest in improved monitoring techniques. For example, setting camera traps near known established home ranges could provide additional reports of offspring, allowing for a better understanding for reproductive rates in new populations.

Establishment of a Home Range

The number of individuals reported as establishing home ranges was noticeably varied across species and gender. These variations have several contributing factors, however two are of particular importance: release location and monitoring methods. Selection of release sites is limited, causing less than ideal areas to be used. The placement of radio collars on moved individuals is effective for determining if individuals establish home ranges, but leaves much data lacking. In several instances monitoring equipment was defective or stopped transmitting in the field.

Excluding cheetahs and Eurasian lynx, all species reported more home ranges for females than males. Most species had more females release to start with, making it logical that more females establish home ranges. Large dispersal distances of 50 to 100 km have been reported for

carnivores, with males typically traveling further than females (Noss, Quigley et al. 1996). However, the large size of carnivores makes large areas of suitable habitat vital for their success. In practices where sufficient area is unavailable, animals wander further and create home ranges after a longer period of time. Studies with short monitoring periods potentially miss the later settlements, making the intervention appear that it did not work. In some instances, the two female cheetahs for example, individuals suffer mortalities before they are able to settle in (Houser, Gusset et al. 2011). Future practices may consider setting radio collars to send locations half as often, allowing longer data sets to be generated.

Range establishment is well reported for lions, bobcats, cougars and tigers. As charismatic megafauna, these species are typically carefully monitored and documented. Cheetahs and leopards are more challenging to monitor, making the reported number of reported home ranges lower. Almost none of Eurasian lynx indicated home range foundation. It is unlikely they merely did not settle, as long term monitoring of a reintroduction indicated clear success and population growth (Schmidt-Posthaus, Breitenmoser-Würsten et al. 2002). The lack of reported home ranges does not mean they did not happen. For all species monitoring methods can be improved and perhaps even more standardized.

Mortality

Major non-human threats in relocated felid populations are infectious and non-infectious diseases. Without veterinary interventions there is no way to eliminate this threat. The presence of diseases in a release area and local populations should be well studied prior to release. Knowing what is present allows managers to loosely estimate how strong an effect the disease will have on the success of a translocation effort. The frequency of starvation and dietary issues suggests that not all release sites were suitable. Conversely, managers may have released too many individuals, increasing competition for resources and inadvertently causing starvation or malnutrition and aggressive encounters.

Illegal killings are a concern across all species. Not all species explicitly report them, but they are still a possibility. Translocations and reintroduction conducted in areas near human populations resistant to the intervention tend to have a higher number of illegal killings. Species that are viewed as having high monetary value or as hunting prizes have a greater risk for illegal killings. Furthermore, killings due to negative interactions, such as attacks on humans or predation on farm animals, are important factors in the success of movement practices.

Relative distance between release areas and human settlements are significant, along with the presence of roads and rails for transportation. Several studies have found that road density is a practical measure for large carnivore habitat suitability; increases in road density increases habitat suitability decreases (Thiel 1985; McLellan and Shackleton 1988). Not only do they permit collisions and subsequent deaths, they enable illegal killings by making remote wildlife areas more accessible.

Legal killings are significantly higher in Eurasian lynx reintroductions. Despite these typically being reintroductions, their history in one release area was well documented, giving a slight insight into the potential result of the practice. As such, local laws in the release area were structured for permitted hunting and trapping of lynx (Cop and Frkovic 1998; Schmidt-Posthaus, Breitenmoser-Würsten et al. 2002). Subsequently, the data tracking and population monitoring is better than most areas, allowing the practice to continue effectively. Long-term efficacy of translocation and reintroduction interventions is rarely known. Though not feasible for all species, creating a take allowance or a participatory management structure within local communities may support the success of reintroductions and translocations.

Unknown deaths will always be reported in mortality studies. Monitoring every individual via monitoring tags once a week is already expensive, attaching video would be economically unfeasible regardless of local support.

Management Challenges

The amount of basic knowledge on large carnivores is lacking. Not only do carnivores have nocturnal and elusive tendencies, they have the potential for harming researchers, making them difficult to study (Karanth and Chellam 2009). As a result, translocations and reintroduction are often reactive conservation practices taken after significant damage has already been inflicted on struggling or eliminated populations. In order for translocations and reintroductions to be successful several factors must be taken into consideration during the planning process.

Cause of Initial Local Extinction

Every population decline has factors driving it. The elimination of the causes for the initial population decline must be accomplished in order for the conservation intervention to succeed (Kleiman 1989). Not knowing the cause of a problem makes solving it significantly more difficult. When the cause is identified, managers have crucial information that allows them to tailor their initial approach and final decisions. If populations have declined due to negative human-wildlife

interactions managers may eliminate, or at least minimize, the threat by relocating individuals to an area further away from human activities.

Prey Availability

A well-chosen release site requires sufficient prey availability. In translocation and reintroduction efforts where sufficient prey is available but vegetation of the area is not the normal habitat for a species, there is still a chance for success (Karanth, Nichols et al. 2004). When prey is insufficient individuals are likely to roam instead of establishing home ranges. Furthermore, if prey is insufficient animals are unlikely to reproduce, while some have been observed using less-than-ideal habitat for mating and raising young where food supply is more bountiful (Bertram 1975). The loss or alteration of critical habitat is the driving force for population declines in most species. For large carnivores decreased prey availability is of higher consequence.

Presence of Existing Population

The key difference between translocations and reintroductions is the presence of an existing population in the release area. Post-release behavior can be influenced by competition with resident animals, whether they are of the same or a different species. An existing population can result in either an increased attraction to it or an avoidance of it by moved individuals (Kilian and Bothma 2003). More reclusive species, such as the leopard, are deterred by existing populations, causing them to wander greater distances in order to establish home ranges and avoid intraspecies aggression. Conversely, the social structure of lions allows for additions to existing prides, drawing moved individuals, females especially, to settle faster. Several reintroduction programs attribute their failure to the presence of an existing population (Griffith, Scott et al. 1989). The intricacies of this factor are extensive and may never be fully understood.

Social Group Composition

Appropriately mixing individuals into a social group is imperative. Considerations must include species behavioral habits, existing populations and their demographics, cause of initial extinction, and size of the release area. Social predators, such as lions, have shown resiliency to interacting with unfamiliar and unrelated individuals (Caro and Riggio 2014). Individual female bobcats have been able to share large areas of their home ranges but do not directly interact with other introduced animals (Diefenbach, Hansen et al. 2006). Special attention should be paid to the gender ratio within the existing population.

Captive-Bred Stock

Some species do not have wild populations suitable for use as a source population in translocations and reintroductions. This has led to the release of captive-bred animals. Introducing captive-bred animals is largely ineffective due to insufficient survival training techniques and genetic differences (Houser, Gusset et al. 2011; Kleiman 1989). Documented maladaptive behaviors in captive prides intended for release include high mortality in cubs, cubs being killed by females, and males killing females with no explanation (Hunter, White et al. 2013). Captive-bred animals also lack local adaptations and can potentially introduce pathogens that would decimate wild populations (Daszak, Cunningham et al. 2000). As a last resort captive-bred animals could be used in reintroductions, but should be avoided in translocation practices.

Economics

The monetary cost of translocations and reintroductions are very costly. High costs can hinder these practices but can also be a driving factor in areas where healthy carnivore populations have economic value. Typically, such areas have tourism reliant upon large carnivore survival and conservation of their habitats, along with other charismatic species. Consequently, local managers are well practiced in translocation making it less expensive to fund and safer for the animals involved (Hayward 2005). Where these interventions are routinely practiced it is easy to argue for the ecological benefits they can provide. Where the practice is a new attempt for a local population it can be difficult to find investors and people qualified to perform the intervention. Managers in both areas should consider the level of investment by the local human population and determine the appropriate amount to spend.

Fences

Most reserves are a result of fragmentation, small areas set within larger disturbed areas. The presence or non-presence of fencing can greatly influence the outcome of translocation or reintroduction interventions. Poorly planned conservation areas can become over populated. This can lead to smaller home ranges, failure to establish home ranges and increased aggressive interactions (Druce, Genis et al. 2004). Well-placed fences can greatly decrease negative human-wildlife interactions and promote confident ownership of wildlife areas, leading to more actively invested participation. Fencing also aids in the reduction of encroachment and unwanted species (Saunders, Hobbs et al. 1991). Considering the ecology and behavior of species in, or even intended to be in, a reserve is critical when determining fence placement.

Conclusion

The conservation of carnivores is challenging due to the high number of threats populations face in the modern world. Felids are particularly susceptible to decreased habitat area, declining populations, inbreeding, disease, insufficient prey, and negative human interactions. Without interventions that address maintaining healthy populations, translocations and reintroductions, charismatic species could vanish. While these interventions are being done, people managing them often do not have access to research and data from previous efforts. The high monetary cost of these actions requires their justification through a body of evidence showing their efficacy. Conservation Evidence is working to remedy the lack of such a resource, as research not communicated is research not completed.

It is clear that the amount of literature available on the translocation and reintroduction of felids is insufficient. Their study needs to be continued more in depth in order to understand what factors have higher influence on their success. While reproduction and home range establishment are decent measures of success, several other factors need to be better understood and additional standardization in data reporting should be established. Hopefully Conservation Evidence's synopsis on terrestrial carnivores will inspire more studies on felid translocations and reintroductions so that managers can have a strong database to rely upon.

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Appendix I: Summary Template (CE)

Unique ID	#
Citation	Refer to p. 7-8 in writing guide
Research Design	Site comparison, Replicated, Controlled, Paired Sites, Randomized, Before-and-after trial, Review, or Systematic review. Some papers might be rejected study types. If so, write the reject category here and leave the rest blank.
Year(s) (and season/month if available) study took place	If a review article, state when review was conducted and when the reviewed data were collected if available.
Number of sites	#
Habitat type	Use IUCN categories. Can be more than one.
Location	Region, country, lat/long if available
Species	Common name <i>Latin name</i>
Non-Target Species	Any herbivores or non-terrestrial carnivores also studied
Action Type	Use IUCN categories. Can be more than one. If a study measures results for more than one type of intervention make separate tables for each action type
Threat Type	Use IUCN categories. Can be more than one.
Main results	Unless specifically stated otherwise, results should reflect statistical tests performed on the results, i.e. only state that there was a difference if it was a significant difference, or state that there was no significant difference. No need to include p values.
List additional results	•
Methodology	Short description of methods used including specifics about when certain actions were taken, how many individuals were included, and how many sites were involved.
URL	Closest link the actual publication without requiring a subscription. If the publication is freely available online, link directly to the pdf. If it is in a subscriber only journal, link to the abstract, preferably using the paper's DOI.

*If anything in this table is not explicitly stated in the paper, write that it is unspecified. For example, “unspecified number of sites” or “released otters using unspecified release methods”.

Summary paragraph template

A [TYPE OF STUDY] in [YEAR and SEASON] in [HOW MANY SITES] of {HABITAT} in [REGION and COUNTRY] [REFERENCE] found that [SPECIES] subject to [INTERVENTION] were [MAIN RESULT]. In addition, [EXTRA RESULTS and CONFLICTING RESULTS]. The [DETAILS OF TECHNIQUES or SAMPLING METHODS].