OPEN ACCESS Freely available online

PLOS ONE

Financial Costs of Large Carnivore Translocations – Accounting for Conservation

Florian J. Weise[1]*, Ken J. Stratford[2], Rudolf J. van Vuuren[1]

1 Research Department, N/a'an ku sê Research Programme, Windhoek, Khomas, Namibia, **2** Research Department, Ongava Research Centre, Outjo, Kunene, Namibia

Abstract

Human-carnivore conflict continues to present a major conservation challenge around the world. Translocation of large carnivores is widely implemented but remains strongly debated, in part because of a lack of cost transparency. We report detailed translocation costs for three large carnivore species in Namibia and across different translocation scenarios. We consider the effect of various parameters and factors on costs and translocation success. Total translocation cost for 30 individuals in 22 events was $80,681 (US Dollars). Median translocation cost per individual was $2,393, and $2,669 per event. Median cost per cheetah was $2,760 ($n = 23$), and $2,108 per leopard ($n = 6$). One hyaena was translocated at a cost of $1,672. Tracking technology was the single biggest cost element (56%), followed by captive holding and feeding. Soft releases, prolonged captivity and orphaned individuals also increased case-specific costs. A substantial proportion (65.4%) of the total translocation cost was successfully recovered from public interest groups. Less than half the translocations were confirmed successes (44.4%, 3 unknown) with a strong species bias. Four leopards (66.7%) were successfully translocated but only eight of the 20 cheetahs (40.0%) with known outcome met these strict criteria. None of the five habituated cheetahs was translocated successfully, nor was the hyaena. We introduce the concept of Individual Conservation Cost (ICC) and define it as the cost of one successfully translocated individual adjusted by costs of unsuccessful events of the same species. The median ICC for cheetah was $6,898 and $3,140 for leopard. Translocations are costly, but we demonstrate that they are not inherently more expensive than other strategies currently employed in non-lethal carnivore conflict management. We conclude that translocation should be one available option for conserving large carnivores, but needs to be critically evaluated on a case-by-case basis.

Citation: Weise FJ, Stratford KJ, van Vuuren RJ (2014) Financial Costs of Large Carnivore Translocations – Accounting for Conservation. PLoS ONE 9(8): e105042. doi:10.1371/journal.pone.0105042

Editor: Elissa Z. Cameron, University of Tasmania, Australia

Received September 24, 2013; **Accepted** July 19, 2014; **Published** August 15, 2014

Copyright: © 2014 Weise et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Funding: This study was supported by grants (either financially or in-kind) from the National Geographic Big Cats Initiative (grant number: B10-11), Land Rover South Africa, Chester Zoo, Colchester Zoo, Sea World and Busch Gardens, Idea Wild, Sirtrack as well as SPOTS Foundation. Carnivore research at Ongava Research Center is funded by charitable donations from The Namibian Wildlife Conservation Trust (UK), West Midland Safari Park, the directors of Ongava Game Reserve, and the Zoological Society of Philadelphia. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: As part of this study the authors received in-kind support (2 research vehicles) from Land Rover South Africa and (tracking technology) from Sirtrack. Moreover, the authors received financial support (payments of tracking collars and GPS collar data fees) from Sea World and Busch Gardens. The authors explicitly declare that this does not alter the authors' adherence to PLOS ONE policies on sharing data and materials. External support agencies had absolutely no role in the design, analysis or interpretation of the study, nor did they in any way influence the preparation of the manuscript or any statements made by the authors. Co-author Dr Ken Stratford is the founding Director of Ongava Research Centre. As part of this study, he did not receive any funding towards his salary or his services. Dr Stratford's involvement in this study is entirely academic and had no commercial component. None of the three authors have competing commercial interests pertaining to this manuscript.

* Email: florian.weise@gmail.com

Introduction

The translocation of endangered animals, or those involved in human-wildlife conflicts, is a frequently used tool in conservation management. Translocation describes the deliberate movement of an organism from its source site to a recipient site that may either be within its extant or historic range (adapted from [1,2]) or a novel but suitable environment. The objectives of translocations differ but commonly include population augmentation, introduction and re-introduction [3], or transfers into permanent captivity and population control. These interventions usually require substantial funding. Total costs for structured large carnivore re-introductions that involve translocations, for example, can be as high as hundreds of thousands [4] or millions of US Dollars (USD) [5,6].

The use of translocation in the mitigation of human-carnivore conflicts and carnivore conservation in general has been viewed with skepticism [1,7–15]. The strategy, though non-lethal and therefore publicly appealing [9–11], is controversial. Different concerns have been examined extensively and include large post-release movements [13,15], reduced survivorship [10,13,16], possible creation of conflict at the recipient site [16] and quickly recurring conflict at the source site [8,14]. Some translocations have in fact exacerbated human-carnivore conflicts, resulting in increased human mortality [7]. In addition to these problems, criticism points to a serious lack of cost transparency [1]. One assessment [17] found that only 3% of 180 animal translocation studies contained any cost data. Although only few attempts at cost reporting have been published thus far (e.g. [4,18–21]), translocations are generally regarded as an "expensive" tool [2,10,22,23]. From the little evidence available, it has been estimated that felids are amongst the most expensive large carnivores to translocate, with figures ranging up to $4,000 per animal [1]. Case-specific costs may even be higher in cases of long-term rehabilitation

[19,20]. This is highly relevant when considering that 71% of all translocated conflict carnivores are felids and that funding is usually very restricted [1].

In Namibia, landowner conflicts with large carnivores remain one of the major conservation challenges because the main conflict species, i.e. endangered cheetah (*Acinonyx jubatus*) and leopard (*Panthera pardus*), occur in large numbers outside of formally protected areas on livestock production ranches [24–27]. Because of persistent conflict with these species, Namibian farmers frequently request removal of individual predators (FJW unpublished data). Landowner attitudes towards and tolerance of large carnivores are unlikely to change if conflicts are not properly addressed.

The question arises whether translocation is an efficient use of conservation and management funding [10] because economic considerations play an important role in wildlife management and prioritization of restricted financial resources for species protection is paramount [28–31]. Thus, researchers and managers are responsible for providing decision-makers with transparent and accurate costing of their activities to enable comprehensive evaluations. However, it is the general omission of costing that still impedes adequate assessment of translocation as a contemporary conservation management tool [17]. Moreover, it often seems unclear to whom translocation costs should be attributed when a variety of different public and private stakeholders are involved in the process and have an interest in its successful outcome [11].

Here we report the financial cost of large carnivore translocations in Namibia across three species and comprising different translocation scenarios. The objectives of translocations in this study were to return perceived conflict predators into free-ranging environments with minimum potential for post-release conflict, and to enable their contribution to the wild gene pool. To our knowledge this is the first detailed documentation of case-specific large carnivore translocation costs. We identify the factors that influence translocation costs. Because of its public appeal (especially for charismatic large carnivores), we document which proportion of translocation costs we were able to raise from public support and did not accrue to the translocating agency. We assess translocation success and use this to derive a measure of conservation expenditure that we define as Individual Conservation Cost (ICC). This study neither argues for nor against large carnivore translocations – its' intention lies in the objective and transparent documentation of costs for consideration by wildlife managers.

Methods

Cost data comprise information from translocations involving large carnivores that had been trapped under different circumstances on freehold properties in Namibia and that were perceived or confirmed as conflict predators. These animals were moved from the source site into a government-approved temporary captive facility with the purpose of subsequent release into free-range systems on private and public reserves. In some cases (when government permission could be obtained immediately) the animals were moved from source to recipient site without temporary holding. During temporary captivity the animals were maintained in enclosures that reflected their natural habitat and were in compliance with the national guidelines for the keeping of large carnivores in captivity [32]. Enclosures often had to be tailor-built for specific animals and necessitated electric fencing as well as reinforced materials for their safekeeping. Carnivores were kept with minimum human contact to avoid habituation to human presence and loss of natural fear. The animals were fed with horse, donkey or game meat. The length of temporary captivity varied considerably and was dependent on case-specific circumstances such as the sourcing of suitable recipient sites, manufacture of tracking devices, physical fitness, presence of dependent offspring, or the issuing of relevant permit documents. As a general rule, time in captivity was minimized as much as was practicable. Research was approved by the Ministry of Environment and Tourism in Namibia (permit number 1459/2008 with subsequent renewals), and all efforts were made to minimize stress and disturbance of study animals. Public and private landowners allowed access to their properties for research purposes.

Prior to translocation for release, carnivores were immobilized with combinations of Tiletamine and Zolazepam or Ketamine and α2-agonists to carry out intensive health assessments and permanent marking, as well as fitting of monitoring technology. During immobilization, standard body measurements were recorded and biological samples collected. We fitted animals with Very High Frequency (VHF) radio transmitters or Global Positioning System (GPS) satellite transmitters at a ratio of $<$ 1.5% of their body weight to enable intensive post-release monitoring. Suitable transmitters were purchased from Advanced Telemetry Systems (Insanti, USA), Africa Wildlife Tracking (Pretoria, SA) and Sirtrack (Hastings, NZ). Immobilizations were reversed with appropriate antagonists (Atipamezole or Yohimbine).

We define transportation distance as the total linear distance from source to temporary captivity site and from there to the recipient site, or from source site directly to recipient site. We translocated carnivores at varying distances that were chosen to prevent homing to the original conflict site. Transportation distances were also influenced by the case- and species-specific availability of suitable recipient sites. During transportation the carnivores were not under the influence of any immobilizing agents and animals were moved in wooden or metal transport crates that allowed safe transportation whilst limiting the possibility of injury to the individuals.

In this study, candidate recipient areas had to meet the following criteria: i) be within extant range of the species; ii) contain appropriately documented and suitable predator guild and prey composition; and iii) present land uses with minimum potential for post-release conflict. Releases were carried out to resemble events of natural immigration of disperser animals into existing populations, i.e. animals were released as individuals or, in the case of cheetah, in small natural coalitions. Subsequent translocations into the same area were carried out at intervals of several months or years as opposed to continuous mass relocations (see [7]). At the recipient sites, carnivores were either hard released at permanent water sources (i.e. directly from the transport crate), or through the process of a soft release (after acclimatization to the local environment in a suitable enclosure) lasting from ten days to five months.

Reasons for translocations differ, and so do the definitions of desired outcomes and success (*cf*. [16,21,22,33]). We define success by individual based on the following conditions: i) survival for 12 months post-release, ii) no significant livestock conflict ($>$5 units per year – the amount determined agreeable for compensation directly outside of release reserves), and iii) no homing to the source site. In contrast with others [15,34], we do not consider site fidelity as a prerequisite for translocation success because carnivores were released into environments without predator-proof fencing, thus permitting free choice of movement. Similarly, reproductive success was not a condition for translocation success because despite intensive monitoring it is impractical to ascertain this with confidence for some individuals, especially males. We define Individual Conservation Cost (ICC) as the cost of successfully translocating an individual adjusted by the costs for unsuccessful translocations. We calculated ICCs by dividing the median cost for different translocation categories (i.e. individuals, each species and each release mode) by their respective success rates, thereby ensuring that both successful and unsuccessful cases contributed to the results.

We recorded translocation costs as true costs at the time when expenses occurred. All original costs were converted from South African Rand (ZAR) into USD to permit international comparisons. Conversions were made on the 15^{th} of every month during which costs occurred. Conversion rates ranged from $1.00 USD/9.86 ZAR to $1.00 USD/14.67 ZAR during the study. All values in this article are reported in USD unless otherwise is indicated. Any expenses contributing to the total cost were classified into one of the following distinct categories: i) government permits; ii) tracking (monitoring technology such as VHF and GPS transmitters as well as GPS data retrieval for the first 12 months); iii) veterinary expenses (salary, immobilization, identification tags, disease screening, health assessments, biological samples); iv) transport (travel from source site to temporary captivity site and subsequently to recipient site (or directly to release site) including fuel and standard vehicle wear-and-tear rates); v) captive holding (enclosure facilities); vi) captive feeding; and vii) staff salary. Although substantial, we exclude the cost of follow-up field monitoring of translocated carnivores from this analysis (although it was carried out) because its intensity, and consequently its cost, is highly biased towards the specific scientific objectives of the translocating agency and thus not representative of other translocation operations. Moreover, most carnivores in this study were fitted with GPS transmitters and could therefore be monitored remotely without significant extra costs other than the purchase of the tracking units.

We analyzed data using package 'stats' in R v. 3.1.0 [35]. Because cost data were not distributed normally and restricted to sample sizes of 30 or less, we utilized non-parametric statistics including a two-tailed Mann-Whitney U-Test (W) with a 95% confidence level for comparisons and Spearman's rank correlation coefficient (rs) to test associations between data sets. Results are presented as medians unless where comparisons are made with other studies. We recorded which cost elements were successfully funded externally through effective fundraising and we calculated overall proportions of total costs that could be reclaimed from public support. We assessed the effect of species, release mode, type of tracking technology, time spent in temporary captivity, degree of habituation, transportation distance and year of capture and release on translocation costs. We provide case-specific cost data in as much detail as possible (Table S1). Following others [36–39] we explored the data to look for associations between translocation factors and success. These included species, sex, age class, capture reason, captive time, transportation distance, post-release conflict, release mode, degree of habituation and cost. We initially used binary logistic regression to explore the data, and then more sophisticated non-parametric modelling approaches, including Bayesian Networks [38,39], K-means cluster analysis [40] and Random Forests [41].

Results

Cost and outcome data were recorded from 22 translocation events for a total of 30 animals −23 cheetahs, six leopards and one brown hyaena (*Hyaena brunnea*). Of these, nine cheetahs, all leopards and the hyaena were translocated as individuals, while the remaining 14 cheetahs were captured and released in groups (two groups of three, four groups of two). The animals had been trapped indiscriminately or deliberately on free-hold commercial farms in Namibia as suspected or confirmed livestock raiders during routine carnivore control operations by private landowners, or had been orphaned during these operations. One leopard had been confiscated from illegal captivity by the local wildlife authorities. The animals in this sample were trapped and translocated in the period 2008–2012 (see Table 1). We excluded the individual costs for 10 dependent sub-adult cheetahs that were translocated together with their mothers because the presence of offspring did not significantly increase case-specific costs for these females (cheetahs 07, 56, 58 and 59 in Table 1 respectively).

Carnivores were held for periods between 1-1,138 days, corresponding respectively to immediate release and the rearing of orphaned cubs. Transportation distances (collection - holding - release, or collection - release) were dependent on source site location and recipient site selection, but ranged from 63–842 km. Both hard ($n = 19$) and soft ($n = 11$) release modes were employed. Where possible GPS transmitters were deployed ($n = 18$) but for group releases of animals expected to remain together (only for cheetahs), we deployed a single GPS transmitter and then deployed VHF transmitters on the other animals. If GPS transmitters were not available within 3 months of capture, we also deployed VHF units for releases of individuals ($n = 11$ total VHF tracking units), but only in situations when an on-site post-release monitoring team was present at the recipient site. One identification collar was deployed on a cheetah female as part of a group release (Table 1).

There was a wide range of total cost across animals, with the most expensive ($7,559) relating to an orphaned cheetah cub (held until old enough to release at 4 years, translocated 348 km and soft released with a GPS transmitter) and the cheapest ($269) associated with the immediate hard release of an adult cheetah translocated 71 km with a VHF transmitter (animals 40 and 65 respectively in Tables 1 and S1). The translocation of these 30 animals cost a total of $80,680.91, at a median cost per animal of $2,392.88, or $2,668.23 per translocation event (Table 2). The distribution of these costs into categories is shown in Figure 1a. Since the cost of equipment and expenses for GPS data retrievals comprises more than half of the total cost ($44,906.05, 56%), we also present a distribution of the costs without tracking in Figure 1a and Table 2. Each cost category showed a wide range of associated costs, although their magnitudes were very different. Permit costs were the cheapest ($1.27–$4.12), followed by staff ($13.77–$203.84), veterinary ($23.76–$756.22) and feeding ($0–$889.43) costs. Tracking ($27.00–$3,694.00) and holding ($0–$3,656.83) costs were the biggest factors in determining the total cost for an individual animal.

Total translocation cost and time spent in captivity were strongly correlated ($rs = 0.654$, $p < 0.001$), but we found no correlation between total cost and transportation distance ($rs = 0.199$, $p = 0.294$), year of capture ($rs = 0.203$, $p = 0.281$) or year of release ($rs = 0.280$, $p = 0.135$). There was no significant difference in costs when analyzed by species, sex, age class and capture reason, although maximum individual costs were considerably higher for cheetah ($7,558.86; $4,275.83 without tracking costs) than for leopard ($4,145.27; $1,641.81 without tracking costs). We found a significant difference between costs by release method ($W = 147.0$, $p = < 0.02$, $n = 19$ for hard release, $n = 11$ for soft release) and also found that, when tracking costs were removed, orphans ($n = 6$) cost significantly more than non-orphans ($n = 24$) ($W = 147.0$, $p = 0.001$).

We were able to evaluate translocation success for 27 of the 30 animals (Fig. 2). The GPS collars failed on three cheetahs

Table 1. Biological and technical details for 30 translocated large carnivores, 2008–2012.

Specimen	Age (years)	Sex	Year	Reason of Capture	Captivity (days)	Transportation Distance (km)	Tag Type	Habituation	Release Mode	Success	Total Cost (USD)	Comment
Aju001	2–3	F	2008	Indiscriminate	10	530	VHF	Wild	Hard – group	Yes	636.52	---
Aju002	2–3	F	2008	Indiscriminate	10	530	ID	Wild	Hard – group	Yes	443.52	Reproduced
Aju003	2–3	M	2008	Indiscriminate	10	530	VHF	Wild	Hard – group	No	636.52	Natural death
Pp006	4–5	M	2008	Livestock raider	16	372	VHF	Wild	Hard – single	Yes	867.97	Observed courtship
Aju007	7–9	F	2008	Livestock raider	61	461	VHF	Wild	Hard – single[a]	No	1,117.44	Recaptured
Pp015	4–6	F	2009	Confiscation	168	741	GPS	Wild	Hard – single	Yes	4,145.27	Reproduced
Aju017	5–7	M	2009	Livestock raider	175	493	GPS	Wild	Hard – single	Yes	3,980.34	Observed courtship
Aju018	5–7	F	2009	Livestock raider	157	473	GPS	Wild	Hard – single	No	3,994.94	Death from heat shock
Aju019	3–5	M	2009	Indiscriminate	62	314	VHF	Wild	Hard – group	No	829.78	Killed by hyaena
Aju020	6–8	F	2009	Indiscriminate	37	444	GPS	Wild	Hard – group	Unknown	4,228.91	Collar failure
Aju026	3–5	M	2009	Indiscriminate	12	184	GPS	Wild	Hard – single	Unknown	1,748.82	Collar failure
Pp027	2	F	2009	Orphan	639	316	GPS	Wild	Hard – single	Yes	3,027.05	Reproduced
Aju029	2–3	F	2010	Orphan	596	485	VHF	Semi-habituated	Soft – group	Yes	1,478.02	Reproduced
Aju030	2–3	M	2010	Orphan	446	467	GPS	Semi-habituated	Soft – group	Unknown	2,965.06	Collar failure
Aju034	3–4	M	2010	Indiscriminate	47	141	VHF	Wild	Hard – single	Yes	512.92	---
Aju038	3–4	M	2011	Indiscriminate	153	265	GPS	Wild	Soft – single	Yes	7,433.32	Observed courtship
Aju040	3–4	F	2012	Indiscriminate	1,184	348	GPS	Habituated	Soft – group	No	7,558.86	Killed by hyaena
Aju041	3–4	F	2012	Indiscriminate	1,184	348	VHF	Habituated	Soft – group	No	4,466.08	Shot
Aju042	3–4	M	2011	Orphan	1,055	824	VHF	Habituated	Soft – group	No	2,828.41	Shot
Aju043	3–4	M	2011	Orphan	1,106	842	GPS	Habituated	Soft – group	No	6,180.96	Shot
Aju044	3–4	M	2011	Orphan	1,055	824	VHF	Habituated	Soft – group	No	2,858.16	Shot
Pp045	2–4	M	2011	Livestock raider	206	764	GPS	Wild	Hard – single	No	2,005.67	Conflict behaviour - observed courtship
Pp047	2–4	M	2012	Livestock raider	183	400	GPS	Wild	Soft – single	Yes	2,208.40	---
Hbr055	1–2	F	2012	Livestock raider	3	63	GPS	Wild	Hard – single	No	1,671.82	Killed in vehicle accident
Aju056	5–7	F	2012	Indiscriminate	169	403	GPS	Wild	Hard – single[b]	Yes	3,848.38	Reproduced
Pp057	3–4	F	2012	Livestock raider	4	71	GPS	Wild	Hard – single	No	1,744.09	Killed in vehicle accident
Aju058	5–7	F	2012	Indiscriminate	260	411	GPS	Semi-habituated	Soft – single[a]	Yes	2,759.10	Reproduced
Aju059	4–6	F	2012	Indiscriminate	272	801	GPS	Semi-habituated	Soft – single[b]	No	2,577.36	Killed in gin trap
Aju065	6–7	M	2012	Indiscriminate	1	71	VHF	Wild	Hard – group	No	268.81	Homed to capture site
Aju066	6–7	M	2012	Indiscriminate	2	71	GPS	Wild	Hard – group	No	1,658.41	Homed to capture site

Aju indicates cheetah; Pp indicates leopard; Hbr indicates brown hyaena. Year is year of release. Indiscriminate captures include animals that predated on valuable game species. Semi-habituated = tolerance of human proximity only during feeding events before release. Habituated = tolerance of human proximity beyond feeding events before release. Group releases represent coalitions and not presence of offspring. Observed courtship = males seen in presence of wild females and displaying obvious courtship behaviour.

[a]translocated with 2 dependant offspring.

[b]translocated with 3 dependant offspring.

doi:10.1371/journal.pone.0105042.t001

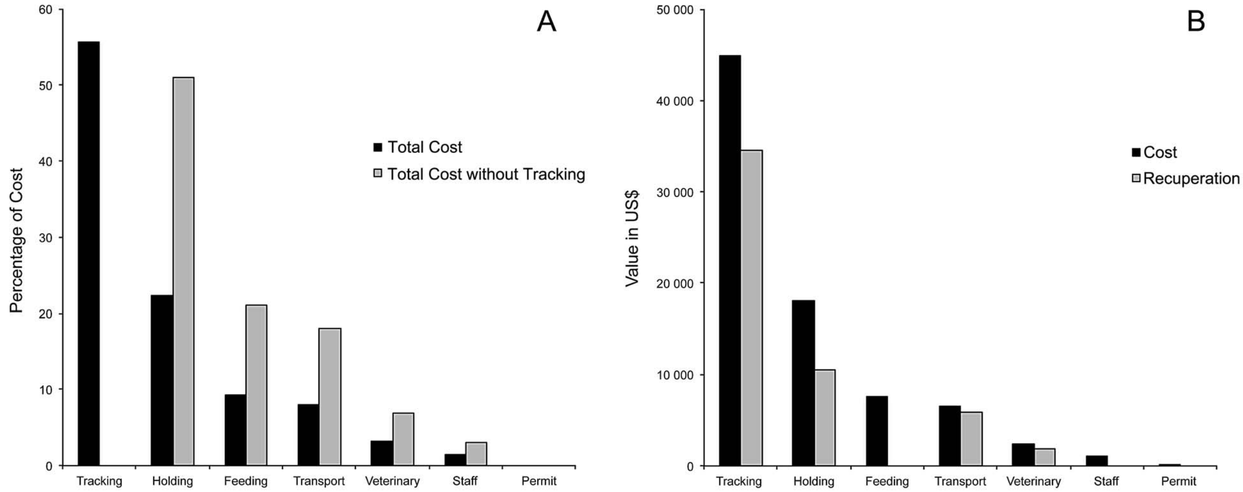

Figure 1. Analysis of large carnivore translocation costs. Panel A displays the distribution of total cost by category (black bars), demonstrating the impact of tracking technology (grey bars). Panel B compares cost and the amount recuperated from public interest groups in each category.
doi:10.1371/journal.pone.0105042.g001

(numbers 20, 26 and 30 in Table 1) before 12-months had elapsed. Four of the six leopards (67%) were classed as successful translocations, as were eight of the 20 cheetahs with known outcome (40%, see Tables 1 and 2). This gives an overall success rate of 44.4%. The ICC for cheetah was more than double that for leopard (Table 2). Of the 15 confirmed unsuccessful translocations, 11 died in their first year post-release (one leopard, nine cheetahs and the brown hyaena), two cheetahs homed back to the capture site (numbers 65 and 66), one cheetah was recaptured (number 07), and the remaining leopard (number 45) was reported to raid livestock.

Translocation success was significantly associated with degree of habituation ($p = 0.023$, Chi-2), as all five fully-habituated cheetahs were killed within 12 months of their release (Fig. 2). Four individuals were shot by landowners whilst the fifth was killed by a spotted hyaena (*Crocuta crocuta*). While we found no significant association between release mode and translocation success ($p = 0.498$, Chi-2), the five habituated cheetahs were all released from acclimatization bomas, significantly impacting on the soft release success rate. Translocation success was also not significantly associated with sex, age class or capture reason. Despite extensive exploration of the data set, we were unable to find any statistically significant multivariable models that described associations between costs, translocation success and the various translocation factors. Neither Generalized linear models (in our case binary logistic regression) nor more complex modelling approaches (see Methods) provided significant results. Figure 2 shows translocation success statistics by different categories and factors.

In this study we were able to recuperate costs from external funding sources for expenses in four categories – tracking, veterinary, transport and holding (see Fig. 1b and Table S1). In the case of tracking costs, the most costly category at 56% of total costs, external funding fully covered the costs of 20 of 29 transmitters deployed (15 of 18 GPS transmitters, five of 11 VHF transmitters) making a total recuperation of $34,517.62 (77%). Similarly we were able to recuperate 76% of veterinary costs, 91% of transport costs, and 58% of holding costs (Fig. 1b). The total amount recuperated from external sources was $52,791.58, equivalent to 65.4% of the total cost of all translocations. This figure decreases to 51.1% if tracking costs are removed. Total recuperation equates to an average of $1,762.45 per animal ($0–$6,270.42), or 65.5% of the average cost. Percentage of total costs recuperated per year significantly increased during the study and almost doubled from 2008 (45.2%) to 2012 (80.4%) as did our effort to source translocation funding – moving from eight proposals in 2008 to 15 proposals in 2012 (Fig. 3).

Discussion

Conservation of large carnivores depends on the availability and most efficient allocation of financial resources. Carnivore managers in both the public and private sectors rely on using different approaches to deal with the manifold challenges of human-carnivore interactions – including compensation [42–47], translocation [16,21,33,34,48,49], improved stock husbandry [50–62] and lethal control [49]. Translocation is a much implemented, yet largely under-studied strategy, especially with regard to its financial implications. We present the first report of detailed cost information with outcomes for translocations of three carnivore species in Namibia. We also introduce the concept of Individual Conservation Cost (ICC), which facilitates a simple and replicable evaluation of the cost-effectiveness of conservation effort.

In our study, translocation costs – across species, individuals and translocation scenarios – were highly variable (Tables 1 and S1) and success rates differed by species (Table 2). This variability reflects case-specific translocation circumstances (Fig. 2). Four leopards and eight cheetahs were translocated successfully without causing post-release conflict and effectively alleviating concern at the source sites for longer than 12 months. Our overall translocation success (44.4%) was very similar to that for other reported animal translocations (*cf.* [1,17]). However, the translocation of leopards was nearly twice as successful as that of cheetahs whilst less than half as expensive - the ICC for the translocation of a leopard was $3,140 and that of a cheetah $6,898. Our cheetah translocation success was strongly influenced by the failed soft releases of five habituated individuals (animals 40–44). Therefore, the least successful translocations also involved the most expensive specimens (Tables 1 and S1), inflating the ICC for this species. We primarily attribute failure of these cheetahs to naivety resulting from habituation to humans during prolonged captivity [63]. Pre-release behavioural training has been shown to mitigate this

Table 2. Success rates and costs of large carnivore translocations in USD, including estimated Individual Conservation Cost (ICC) for each category.

		A – Total Cost				B – Total Cost without Tracking			
Total		**80,680.91**				**35,774.86**			
Category	*Translocation Success Rate**	*Min*	*Median*	*Max*	*Estimated Cost per ICC*	*Min*	*Median*	*Max*	*Estimated Cost per ICC*
All individuals ($n = 30$)	0.44	268.81	2,392.88	7,558.86	**5,982.20**	75.03	627.31	4,275.83	**1,568.28**
All events ($n = 22$)	---	512.92	2,668.23	12,024.94	---	88.44	799.89	8,534.69	---
Cheetah ($n = 23$)	0.40	268.81	2,759.10	7,558.86	**6,897.75**	75.03	606.65	4,275.83	**1,516.63**
Leopard ($n = 6$)	0.67	867.97	2,107.03	4,145.27	**3,139.47**	160.71	675.16	1,641.81	**1,005.99**
Brown hyaena ($n = 1$)	0.00	1,671.82	---	1,671.82	---	88.44	---	88.44	---
Hard release ($n = 19$)	0.47	268.81	1,671.82	4,228.91	**3,557.06**	75.03	496.27	1,641.81	**1,055.89**
Soft release ($n = 11$)	0.40	1,478.02	2,858.16	7,558.86	**7,145.40**	905.07	2,638.16	4,275.83	**6,595.40**

A – Total cost for translocation study by category. B – Total cost without post-release tracking technology and expenses. *Individuals with unknown translocation outcome ($n = 3$) were removed from success rate calculations. An Individual Conservation Cost (ICC) is defined as the successful translocation in each category and accounts for failed attempts. Cost per ICC was estimated as the median cost/translocation success in each category, except for events because cheetah group releases resulted in both successful and unsuccessful translocations.

doi:10.1371/journal.pone.0105042.t002

vulnerability [19]. Long captive periods also had a strong effect on translocation cost - holding and feeding accounted for about 67% of the total cost of all translocations even after the primary cost factor (tracking technology) was removed (Fig. 1a). Our high costs for rehabilitations correspond with those for other long-term care cases of the same species [19,20]. The limited release success of captive carnivores [2,19,63,64] coupled with high costs for these subjects suggests that their use in translocations should generally be avoided.

Overall, tracking technology exerted the strongest influence on translocation costs (Fig. 1a). The deployment of tracking technology was considered important in this study, and carried out to enable intensive post-release monitoring for several reasons. Firstly, very little translocation-related ecological information was available for our focal species during the study period and existing records are based on small sample sizes [8,15,22,48,49,65]. Secondly, the need for intensive post-translocation monitoring has been strongly emphasized in previous reviews of the strategy [2,9–11,17]. Lastly, we attempted to improve accountability of these translocations for local government and landowners. However, since tracking is not a biological prerequisite for translocation success, we argue that translocation costs could potentially be reduced by over 50% (Fig. 1a) or a significant proportion of these monitoring costs can be reclaimed from public support (Fig. 1b).

The use of soft releases for cheetahs resulted in case-specific costs exceeding $5,000 (Table 1). Despite higher costs (here resulting from the necessity to build large enclosures in remote semi-desert areas), soft release is reported to improve translocation outcomes for carnivores [10,11,16,19,37,66]. Our pooled results show little beneficial effect of the technique in comparison with hard releases (Fig. 2) but our soft release success would increase to 80% if the five habituated cheetahs were excluded. Year of translocation showed no significant effect on total cost, indicating that inflation and currency conversions were not important factors in this study. We caution that the relative contribution of specific cost elements to the total (Fig. 1a) may be different in other parts of the world.

Public interest in and support of non-lethal carnivore management is indisputably growing and was an important component in this study. It cannot be denied that the charisma of large carnivores attracts substantial public funding support [67]. In Asia, international donor expenditures towards wild tiger conservation were estimated in excess of 40 million USD in less than one decade [68]. We successfully reclaimed a large amount of the total translocation cost from national and international non-governmental organizations, institutions and/or individuals (Fig. 1b). Support was also sourced through avenues such as in-kind donations of veterinary services and vehicles, direct funding of tracking technology (including data retrieval fees) and transport costs, logistical assistance at the recipient sites (e.g. soft release enclosures) and supportive tourism and volunteering enterprises. The proportion of costs we were able to reclaim increased during the study period (Fig. 3) but was directly linked to increasing efforts to source funding and thus resulted in considerable administrative efforts that need to be borne in mind by managers.

Although cost accounting has improved in recent years, direct comparison of our study with other non-lethal conflict mitigation alternatives remains difficult since there is no standardized methodology for reporting costs. Nonetheless, and even when considering ICCs for cheetah and leopard, translocations for conflict reduction or rehabilitation (*cf.* [19,20]) were not more expensive than other conservation measures (Table 3) and should therefore not be rejected solely on cost grounds. Livestock

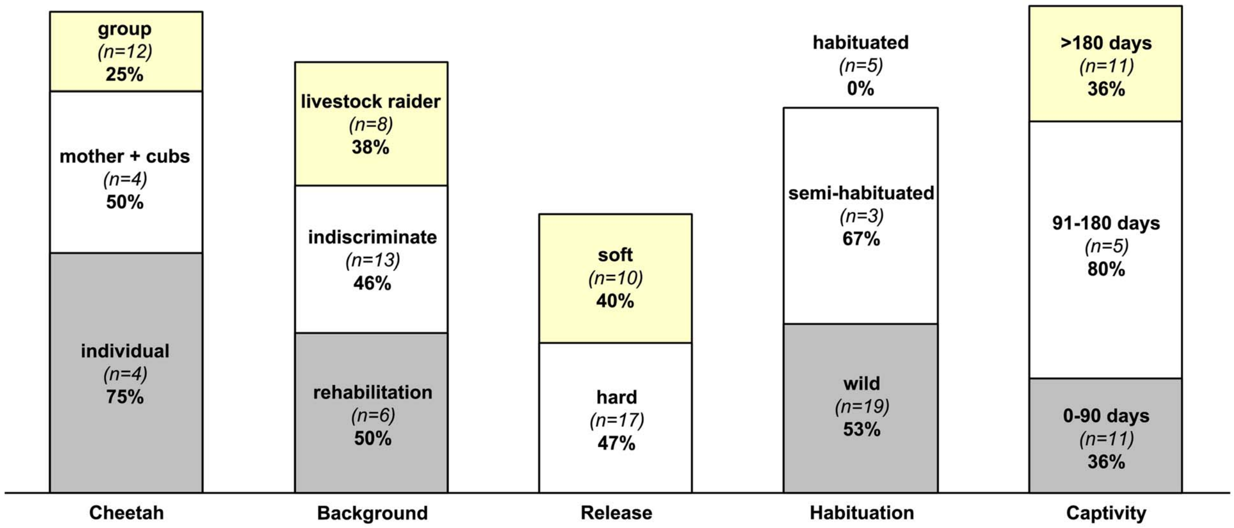

Figure 2. Large carnivore translocation success rates. Each column represents an analysis of all translocations for which outcome could be assessed ($n = 27$, for Cheetah $n = 20$) by different categories. Sub-categories show translocation success percentage, and are also scaled by the same factor. Rehabilitation in category Background includes confiscated leopard female Pp015.
doi:10.1371/journal.pone.0105042.g002

compensation schemes, which provide an alternative symptomatic approach, frequently necessitate payments of hundreds of thousands or millions USD if they are implemented at large scales [42,46,69]. From a conservation perspective, investment into conflict prevention should take priority over symptomatic mitigation of damage [56,57,62]. For example, Namibian cheetahs can successfully be excluded from areas with valuable game species using cost-effective non-lethal swing gates [70]. Guard donkeys, guard dogs and thorn bomas have also been utilized to prevent livestock depredation by cheetahs and leopards [54–57]. The

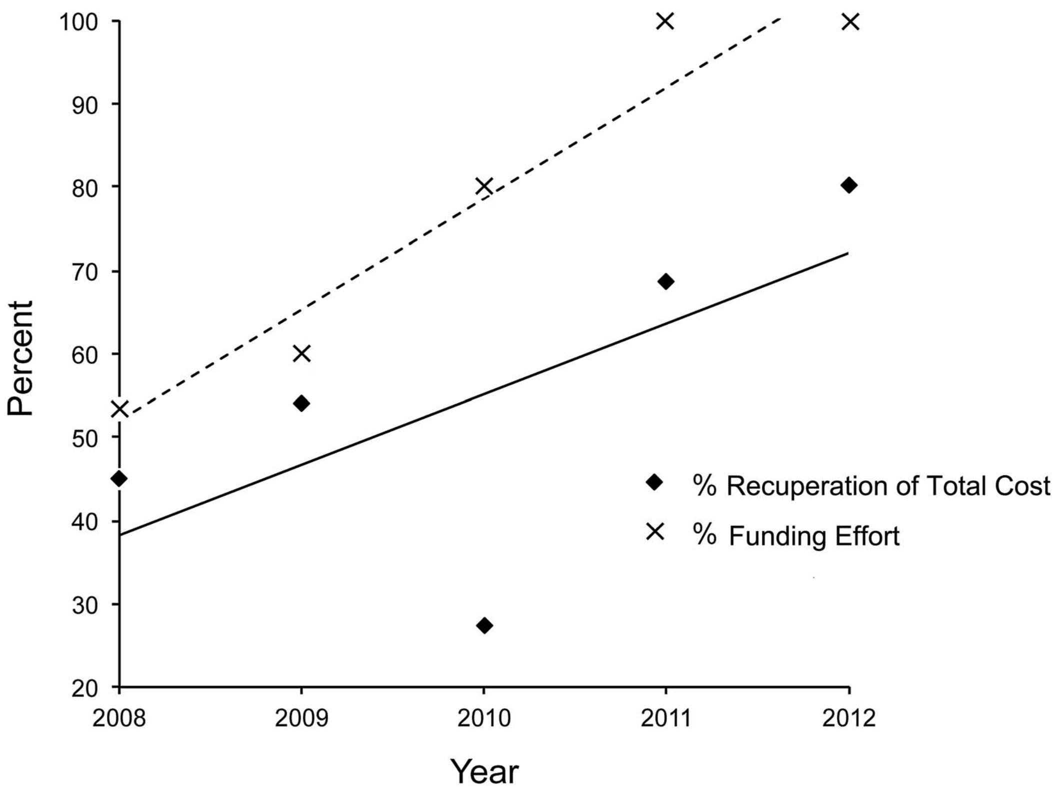

Figure 3. Percentage recuperation of total large carnivore translocation costs and funding effort across the study period. Year indicates year of release. Lines show best regression fits. The low recuperated value in 2010 was associated with a small sample of released individuals ($n = 3$) for which cost recuperation was less successful (see Table S1).
doi:10.1371/journal.pone.0105042.g003

Table 3. Reported cost per carnivore (in USD) of different non-lethal carnivore conflict management options.

Country	Focal Carnivore	Method	Cost per Individual	Comment	Source
USA	Bear	Translocation	1,038	Cost estimate excluded staff salaries and administrative costs	Riley et al. 1994 [21]
Zimbabwe	Cheetah	Translocation	1,730	Removal of perceived conflict predator + re-introduction into protected area	Purchase 1998 [22]
n/a	Bears	Translocation	3,981	Mean value from translocation review	Fontúrbel and Simonetti 2011 [1]
n/a	Large felids	Translocation	3,941	Mean value from translocation review	Fontúrbel and Simonetti 2011 [1]
n/a	Canids	Translocation	2,875	Mean value from translocation review	Fontúrbel and Simonetti 2011 [1]
Namibia	Leopard	Translocation	2,334	Removal of perceived conflict predator	This study
Namibia	Brown hyaena	Translocation	1,672	Removal of perceived conflict predator	This study
Namibia	Cheetah	Translocation	2,827	Removal of perceived conflict predator	This study
South Africa	Cheetah	Translocation + Compensation	1,094[a]	Source landowner receives payment for not killing offending cheetah – recipient pays 50% of cost	Buk and Marnewick 2010 [18]
Italy	Wolf	Compensation	6,765[a]/year	Mitigation of livestock losses	Boitani et al. 2010 [43]
Russia	Leopard	Compensation	960[b]/year	Mitigation of livestock losses	Hötte and Bereznuk 2001 [44]
Kenya	Lion	Compensation	3,400/year	Mitigation of livestock losses	Maclennan et al. 2009 [45]
Sweden	Lynx/Wolverine	Performance payment	29,000	Payment per confirmed offspring to tolerant community to off-set expected lifetime damage	Zabel and Holm-Müller 2008 [47]

All values are rounded to the nearest US$. For comparison, all values are reported as means. We consulted a total of 57 publications that mentioned costs of non-lethal mitigation strategies. Here we report only those studies that measured cost using similar methodologies to our study.
[a]Where necessary, original values where converted from other currencies into USD on 16 April 2013.
[b]Annual cost extrapolated from monthly cost.
doi:10.1371/journal.pone.0105042.t003

combined cost for acquisition and one year's maintenance of suitable guardian animals is consistently reported at less than $1,000 [50,52,53,55,58,60,61] and their use may decrease livestock losses by several thousands of USD per property per year [51,56,58,59]. Furthermore, small-scale tourism ventures involving conflict carnivores have the potential to substantially outweigh financial losses from livestock depredation and significantly contribute to rural income generation. Monies earned from tracking conflict leopards exceeded losses twelve-fold [14]. Even though livestock protection is considerably more cost-effective than predator persecution [56], the availability of different conflict mitigation techniques has not stopped Namibian landowners from indiscriminately or purposefully trapping several hundred large carnivores every year (FJW unpublished data). Most of these animals, if not attended to by local wildlife authorities or non-governmental organizations, are still destroyed, resulting in large annual losses.

The significant ICC for translocations shows that this strategy should only be attempted in selected situations when the value of few individuals justifies such expenses (e.g. endangered species) and when these individuals enhance the population status of that species (*see* [4,37]) by contributing to the free-ranging gene pool. High ICCs may only be justifiable in scenarios where the live-removal of individuals reduces landowner motivation to continue persecution and increases tolerance towards other free-ranging conspecifics. Appropriate candidate selection should therefore be the primary concern to maximize conservation output per translocation dollar spent.

Supporting Information

Table S1 Detailed cost breakdown per category for 30 translocated large carnivores (23 cheetahs, six leopards, one brown hyaena) in Namibia. The table also indicates the amount of translocation cost recuperated from external funding sources. Data show a high degree of case-specific variability in terms of total cost per individual and cost recuperation.
(DOC)

Acknowledgments

We thank the Ministry of Environment and Tourism in Namibia for issuing permits to conduct this research and for logistical support in several cases. We also thank the staff and management of NamibRand Nature Reserve, Kulala Wilderness Reserve and Sandfontein Private Nature and Game Reserve. We explicitly thank the following people: W. and R. Agenbach, A. Araldi, S. Bachran, I. Baines, L. Baum, M. Beckingham, B. Beytell, C. Brain, J. Brand, A. Brückner, C. Heunis, S. Hirn, A. Keding, S. Munro, N. Odendaal, M. and A. Scott, C. Thiel, J. Vaatz, M. van Vuuren, C. Venter, J. and T. Verburg and P. Woolfe for their considerable assistance with logistics, implementation and monitoring of translocations. We thank colleagues for comments on earlier versions of this manuscript, especially J. Hollyer and L. Cobden for assistance with statistics and D. Barrett for management of accounts. M. Gusset and one anonymous reviewer improved the quality and clarity of this article.

Author Contributions

Conceived and designed the experiments: FJW RJvV. Performed the experiments: FJW RJvV. Analyzed the data: FJW KJS. Contributed reagents/materials/analysis tools: FJW KJS RJvV. Wrote the paper: FJW KJS RJvV.

References

1. Fontúrbel FE, Simonetti JA (2011) Translocations and human-carnivore conflicts: problem solving or problem creating? Wildlife Biol 17: 217–224.
2. Miller B, Ralls K, Reading RP, Scott JM, Estes J (1999) Biological and technical considerations of carnivore translocation: a review. Anim Conserv 2: 59–68.
3. Wolf CM, Griffith B, Reed C, Temple SA (1996) Avian and Mammalian Translocations: Update and Reanalysis of 1987 Survey Data. Conserv Biol 10: 1142–1154.
4. Lindsey PA, Alexander R, Du Toit JT, Mills MGL (2005) The Cost Efficiency of Wild Dog Conservation in South Africa. Conserv Biol 19: 1205–1214.
5. Bangs EE, Fritts SH (1996) Reintroducing the Gray Wolf to Central Idaho and Yellowstone National Park. Wildl Soc Bull 24: 402–413.
6. Metrick A, Weitzman ML (1996) Patterns of Behavior in Endangered Species Preservation. Land Econ 72: 1–16.
7. Athreya V, Odden M, Linnell JDC, Karanth KU (2011) Translocation as a Tool for Mitigating Conflict with Leopards in Human-Dominated Landscapes of India. Conserv Biol 25: 133–141.
8. Cobb S (1981) The leopard - problems of an overabundant, threatened, terrestrial carnivore. In: Jewell PA, Holt S, Problems in Management of Locally Abundant Wild Mammals. London: London Academic Press. pp. 181–192.
9. Craven S, Barnes T, Kania G (1998) Toward a Professional Position on the Translocation of Problem Wildlife. Wildl Soc Bull 26: 171–177.
10. Linnell JDC, Aanes R, Swenson JE, Odden J, Smith ME (1997) Translocation of carnivores as a method for managing problem animals: a review. Biodivers Conserv 6: 1245–1257.
11. Massei G, Quy RJ, Gurney J, Cowan DP (2010) Can translocations be used to mitigate human-wildlife conflicts? Wildlife Res 37: 428–439.
12. Rabinowitz AR (1986) Jaguar Predation on Domestic Livestock in Belize. Wildl Soc Bull 14: 170–174.
13. Ruth TK, Logan KA, Sweanor LL, Hornocker MG, Temple LJ (1998) Evaluating Cougar Translocation in New Mexico. J Wildl Manage 62: 1264–1275.
14. Stander PE, //au K, |ui N, Dabe T, Debe D (1997) Non-consumptive Utilisation of Leopards: Community Conservation and Ecotourism in Practice. Proceedings of a Symposium on Lions and Leopards as Game Ranch Animals. Onderstepoort, South Africa.
15. Weilenmann M, Gusset M, Mills DR, Gabanapelo T, Schiess-Meier M (2010) Is translocation of stock-raiding leopards into a protected area with resident conspecifics an effective management tool? Wildlife Res 37: 702–707.
16. Bradley EH, Pletscher DH, Bangs EE, Kunkel KE, Smith DW, et al. (2005) Evaluating Wolf Translocation as a Nonlethal Method to Reduce Livestock Conflicts in the Northwestern United States. Conserv Biol 19: 1498–1508.
17. Fischer J, Lindenmayer DB (2000) An assessment of the published results of animal relocations. Biol Conserv 96: 1–11.
18. Buk K, Marnewick K (2010) Cheetah conservation in South Africa. Afr Insight 39: 212–224.
19. Houser AM, Gusset M, Bragg CJ, Boast LK, Somers MJ (2011) Pre-release hunting training and post-release monitoring are key components in the rehabilitation of orphaned large felids. S Afr J Wildl Res 41: 11–20.
20. Marnewick K, Hayward MW, Cilliers D, Somers MJ (2009). Survival of Cheetahs Relocated from Ranchland to Fenced Protected Areas in South Africa. In: Hayward MW, Somers M, Reintroduction of Top-Order Predators. London: Wiley-Blackwell. pp. 282–306.
21. Riley SJ, Aune K, Mace RD, Madel MJ (1994) Translocation of Nuisance Grizzly Bears in Northwestern Montana. Ursus 9: 567–573.
22. Purchase G (1998) An Assessment of the Success of a Cheetah Re-Introduction Project in Matusadona National Park. MSc Thesis. Harare: University of Zimbabwe. 118 p.
23. Woodroffe R, Ginsberg JR, Macdonald DW, the IUCN/SSC Canid Specialist Group (1997) The African Wild Dog – Status Survey and Conservation Action Plan. Gland: IUCN. 167 p.
24. Lindsey PA, Havemann CP, Lines R, Palazy L, Price AE, et al. (2013) Determinants of Persistence and Tolerance of Large Carnivores on Namibian Ranches: Implications for Conservation on Southern African Private Lands. PlosOne 8(1): e52458. doi:10.1371/journal.pone.0052458.
25. Marker LL (2002) Aspects of Cheetah (*Acinonyx jubatus*) Biology, Ecology and Conservation Strategies on Namibian Farmlands. PhD Thesis. Oxford: University of Oxford. 459 p.
26. Marker LL, Dickman AJ (2005) Factors affecting leopard (*Panthera pardus*) spatial ecology, with particular reference to Namibian farmlands. S Afr J Wildl Res 35: 105–115.
27. Marker-Kraus L, Kraus D (1994) The Namibian Free-ranging Cheetah. Environ Conserv 21: 369–370.
28. Dickman AJ, Macdonald EA, Macdonald DW (2011) A review of financial instruments to pay for predator conservation and encourage human-carnivore coexistence. PNAS 108: 13937–13944.
29. Marsh H, Dennis A, Hines H, Kutt A, McDonald K, et al. (2007) Optimizing Allocation of Management Resources for Wildlife. Conserv Biol 21: 387–399.
30. Martn-López B, Montes C, Benayas J (2008) Economic Valuation of Biodiversity Conservation: the Meaning of Numbers. Conserv Biol 22: 624–635.
31. Shogren JF, Tschirhart J, Anderson T, Writhenour Ando A, Beissinger SR, et al. (1999) Why Economics Matters for Endangered Species Protection. Conserv Biol 13: 1257–1261.
32. MET (2012) Regulations for Large Carnivores in Captivity: Nature Conservation Ordinance, 1975. Government Gazette of the Republic of Namibia No. 4911. Windhoek: Ministry of Environment and Tourism in Namibia.
33. Goodrich JM, Miquelle DG (2005) Translocation of problem Amur tigers *Panthera tigris altaica* to alleviate tiger-human conflicts. Oryx 39: 1–4.
34. Hamilton PH (1981) The Leopard *Panthera pardus* and the Cheetah *Acinonyx jubatus* in Kenya. Report for the U.S. Fish & Wildlife Service and The Government of Kenya. 137 p.
35. R Core Team (2014) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
36. Gusset M (2009) A Framework for Evaluating Reintroduction Success in Carnivores: Lessons from African Wild Dogs. In: Hayward MW, Somers M, Reintroduction of Top-Order Predators. London: Wiley-Blackwell. pp.307–320.
37. Gusset M, Ryan SJ, Hofmeyr M, van Dyk G, Davies-Mostert HT, et al. (2008) Efforts going to the dogs? Evaluating attempts to re-introduce endangered wild dogs in South Africa. J Appl Ecol 45: 100–108.
38. Johnson S, Mengersen K, de Waal A, Marnewick K, Cilliers D, et al. (2010) Modelling cheetah relocation success in southern Africa using Iterative Bayesian Network Development Cycle. Ecol Model 221: 641–651.
39. Linklater WL, Adcock A, du Preez P, Swaisgood RR, Law PR, et al. (2011) Guidelines for large herbivore translocation simplified: black rhinoceros case study. J Appl Ecol 48: 493–502.
40. Sparks DN (1973) Euclidean cluster analysis. J R Stat Soc Ser C: Appl Stat 22: 126–130.
41. Brieman L (2001) Random forests. J Machine Learn Res 45: 5–32.
42. Agarwala M, Kumar S, Treves A, Naughton-Treves L (2010) Paying for wolves in Solapur, India and Wisconsin, USA: Comparing compensation rules and practice to understand the goals and politics of wolf conservation. Biol Conserv 143: 2945–2955.
43. Boitani L, Ciucci P, Raganella-Pelliccioni E (2010) Ex-post compensation payments for wolf predation on livestock in Italy: a tool for conservation? Wildlife Res 37: 722–730.
44. Hötte M, Bereznuk S (2001) Compensation for livestock kills by tigers and leopards in Russia. Carnivore Damage Prevention News 3: 6–7.
45. Maclennan SD, Groom RJ, Macdonald DW, Frank LG (2009) Evaluation of a compensation scheme to bring about pastoralist tolerance of lions. Biol Conserv 142: 2419–2427.
46. Naughton-Treves L, Grossberg R, Treves A (2003) Paying for Tolerance: Rural Citizens' Attitudes toward Wolf Depredation and Compensation. Conserv Biol 17: 1500–1511.
47. Zabel A, Holm-Müller K (2008) Conservation Performance Payments for Carnivore Conservation in Sweden. Conserv Biol 22: 247–251.
48. Skinner JD, van Aarde RJ (1987) Range use by brown hyaenas *Hyaena brunnea* relocated in an agricultural area of the Transvaal. J Zool 212: 350–352.
49. Stander PE (1990) A suggested management strategy for stock-raiding lions in Namibia. S Afr J Wildl Res 20: 37–42.
50. Andelt WF (1984) Livestock Guarding Dogs Protect Domestic Sheep from Coyote Predation in Kansas. Great Plains Wildlife Damage Control Proceedings, Paper 297. Available: http://digitalcommons.unl.edu/gpwdcwp/297. Accessed 2013 February 20.
51. Andelt WF, Hopper SN (2000) Livestock guard dogs reduce predation on domestic sheep in Colorado. J Range Manage 53: 259–267.
52. Corff S (2005) Livestock Guardian Dogs Protect Sheep in the Alberta Foothills, Canada. Carnivore Damage Prevention News 9: 24–26.
53. Green JS (1989) Donkeys for Predation Control. Fourth Eastern Wildlife Damage Control Conference, 1989, Paper 19. Available: http://digitalcommons.unl.edu/ewdcc4/19. Accessed: 2013 February 20.
54. Marker L (2000) Donkeys protecting livestock in Namibia. Carnivore Damage Prevention News 2: 7–8.
55. Marker L, Dickman A, Schumann M (2005) Using Livestock Guarding Dogs as a Conflict Resolution Strategy on Namibian Farms. Carnivore Damage Prevention News 8: 28–31.
56. McManus JS, Dickman AJ, Gaynor D, Smuts BH, Macdonald DW (2014) Dead or alive? Comparing costs and benefits of lethal and non-lethal human–wildlife conflict mitigation on livestock farms. Oryx, 9 p. Available: http://dx.doi.org/10.1017/S0030605313001610. Accessed: 2014 May 7.
57. Ogada MO, Woodroffe R, Oguge NO, Frank LG (2003). Limiting Depredation by African Carnivores: the Role of Livestock Husbandry. Conserv Biol 17: 1521–1530.
58. Ribeiro S, Petrucci-Fonseca F (2005) The Use of Livestock Guardian Dogs in Portugal. Carnivore Damage Prevention News 9: 27–33.
59. Rust NA, Whitehouse-Tedd KM, Macmillan DC (2012) Predator-Friendly Farming: Perceived Efficacy of Livestock Guarding Dogs in South Africa. Available: http://www.bioecon-network.org/pages/14th_2012/Rust.pdf. Accessed: 2013 May 4.
60. Stoynov E (2005) Providing Livestock Guarding Dogs and Compensation of Livestock Losses Caused by Large Carnivores in Bulgaria. Carnivore Damage Prevention News 9: 19–23.

61. Walton MT, Feild CA (1989) Use of Donkeys to Guard Sheep and Goats in Texas. Fourth Eastern Wildlife Damage Control Conference, 1989, Paper 43. Available: http://digitalcommons.unl.edu/ewdcc4/43. Accessed: 2013 February 20.
62. Woodroffe R, Frank LG, Lindsey PA, ole Ranah SMK, Romañach S (2007) Livestock husbandry as a tool for carnivore conservation in Africa's community rangelands: a case–control study. Biodivers Conserv 16: 1245–1260.
63. Jule KR, Leaver LA, Lea SEG (2008) The effects of captive experience on reintroduction survival in carnivores: A review and analysis. Biol Conserv 141: 355–363.
64. Hunter L, Rabinowitz A (2009) Felid reintroductions using captive founders: poor science and worst practices. Cat News 51: 28–29.
65. Hayward MW, Adendorff J, Moolman L, Hayward GJ, Kerley GIH (2006) The successful reintroduction of leopard *Panthera pardus* to the Addo Elephant National Park. Afr J Ecol 45: 103–104.
66. Belden RC, Hagedorn BW (1993) Feasibility of Translocating Panthers into Northern Florida. J Wildl Manage 57: 388–397.
67. Nelson F (2009) Developing Payments for Ecosystem Services Approaches to Carnivore Conservation. Human Dimensions of Wildlife 14: 381–392.
68. Linkie M, Christie S (2007) The value of wild tiger conservation. Oryx 41: 415–416.
69. Linnell JDC, Brøseth H (2003) Compensation for large carnivore depredation of domestic sheep 1994–2001. Carnivore Damage Prevention News 6: 11–13.
70. Schumann M, Schumann B, Dickman A, Watson LH, Marker L (2006) Assessing the use of swing gates in game fences as a potential non-lethal predator exclusion technique. S Afr J Wildl Res 36: 173–181.