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Farm management and economic analyses of leopard conservation in north-central Namibia

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Abstract

We investigated the livestock farms surrounding the Waterberg Plateau Park in north-central Namibia to assess farmer attitudes, management techniques, financial impacts, as well as the potential benefits of tourism and trophy hunting, with respect to leopard *Panthera pardus* conservation. Farmers were asked about their use of six livestock husbandry techniques and farmers who employed at least one had 85% less reported conflict than farmers not employing any. Livestock farmers lost on average 3.8% of their calves to depredation annually (US$1370 per farm per year) but were willing to lose 3.3%, a difference of only US$180 per farm or US$3064 regionally. Where losses were higher than stated tolerance, we found that potential benefits from tourism and trophy hunting could offset losses. Surveys with tourists and professional hunters in the region strengthened this conclusion.

Introduction

Many large carnivore populations have been drastically reduced across their ranges (Weber & Rabinowitz, 1996; Woodroffe, 2000; Ray, Hunter & Zigouris, 2005), primarily because of conflicts with livestock farmers (Nowell & Jackson, 1996) outside or on the boundaries of protected areas (Newmark *et al*., 1994; Woodroffe & Ginsberg, 1998; Weladji & Tchamba, 2003). Therefore, the conservation of large carnivores is dependent, in large part, on the attitudes and management activities of farmers on private lands (Treves & Karanth, 2003; Lindsey *et al*., 2005).

Farmer attitudes and perceptions can have a strong influence on farmers' actions, and education programs can change the perceptions of farmers and potentially the management systems that they employ (Linnell, Swenson & Andersen, 2001; Marker, Mills & Macdonald, 2003*b*). An assessment of the balance between the costs and the potential benefits of maintaining wildlife can be useful when creating a comprehensive management strategy (Bade & Parkin, 2002; Shwiff & Sterner, 2002; Hughey, Cullen & Moran, 2003), and researchers have studied the potential benefits gained through tourism and trophy hunting for a variety of species throughout Africa (Grobler, 1997; Lewis & Alpert 1997; Wilkie & Carpenter 1999*a*,*b*; Gossling 2000; Lindsey *et al*., 2006, 2007*a*,*b*; Lindsey, Roulet & Romanach, 2007*c*).

Because balancing wildlife utilization and biodiversity conservation in Namibia (Richardson, 1998), and elsewhere, is difficult, we assessed the attitudes, tolerances to livestock loss and management systems of commercial livestock farms within north-central Namibia surrounding the Waterberg Plateau Park (WPP) as a case study for a multi-land use system along the border of a protected area. We focused on the leopard *Panthera pardus* as a widely distributed species of conflict that has not been intensively studied previously in the area (Mizutani, 1999; Marker *et al*., 2003*a*,*b*; Ray *et al*., 2005). We also assessed the potential costs and benefits of maintaining leopards on commercial farms in north-central Namibia, and thus paid attention to farm management, tourism and trophy hunting. We compare economic strategies between the north-east and south-west portions of the study region to highlight differences in culture and management strategies. Finally, we include findings from two small surveys carried out among tourists and trophy hunters in north-central Namibia. We assess the amount of money tourists would be willing to pay for varying likelihoods of seeing leopards, and the average fee trophy hunters are willing to pay farmers to have access to their land for a leopard hunt.

Study area

We studied farms in 2368 km^2 surrounding the 470-km^2 WPP (Fig. 1), located in north-central Namibia (20.46133°S,

Figure 1 Individual farms of north-central Namibia surrounding the Waterberg Plateau Park (medium gray), with the north-east (light gray) and south-west (dark gray) regional farms highlighted.

17.20812°E) and established in the 1970's for the protection of native and other endangered large mammal species (Schneider, 1998). In the south-west, the plateau is characterized by 200-m-high sandstone cliffs; to the north-east, the plateau levels off with surrounding farmland.

Surrounding farms are managed for livestock production, but support populations of wildlife for game farming, trophy hunting and conservation. A combination of large herbivore removal, increased livestock pressure and drought conditions has given rise to thick *Acacia* shrubland and woodland (Kaufman *et al.*, 2007) characterized as the thornveld biome (Barnard, 1998; Schneider, 1998). Mean annual rainfall is about 450 mm (Mendelsohn *et al.*, 2002), but ground water is often pumped to the surface for livestock and used by wildlife.

Lions *Panthera leo*, spotted hyenas *Crocuta crocuta* and African wild dogs *Lycaon pictus* once occurred throughout the region but were essentially eliminated by the 1980s; they are rarely seen and are usually immediately lethally removed and so we did not address their management in this analysis (Stein, Fuller & Marker, 2008). Besides leopards, other carnivores in the area that are of concern to farmers are jackals *Canis mesomelas*, brown hyenas *Hyaena brunnea*, caracals *Felis caracal* and cheetahs *Acinonyx jubatus*.

About half of the south-west commercial livestock farmlands border the WPP escarpment and all are cooperatively managed for natural resource conservation through the Waterberg Conservancy. They support a density of livestock (432/100 km^2) that is nearly half the reported density of wild herbivores (781/100 km^2) in the region (Stein, 2008). The south-west farmers are primarily from a German cultural background and have been farming in the region for several generations (Stein, 2008).

The north-east farms bordering the WPP all have a >3-m-high boundary fence with >10 wire strands to keep most wildlife species (but not leopards) within the Park. Cattle density (651/100 km^2) and wild herbivore density (709/100 km^2) are similar. Most farmers are members of the Platveld Farmer's Association, a group that regularly discusses issues of farm production and security. A few members are also affiliated with the Ngorogombe Conservancy, similar in focus to the Waterberg Conservancy in the south-west. The north-east farmers are primarily from the Afrikaans culture, with the exception of two German and two local African landowners.

Methods

In order to assess farmer attitudes and economic effects of depredation on livestock, we surveyed farmers between July 2005 and November 2006. We administered semi-structured questionnaires in face-to-face interviews (Mitchell & Carson, 1989) with farmers who managed land adjacent to, or within 100 km of, the WPP ($n = 23$). Each survey was administered either during a farmers' meeting after a brief introduction, or during a scheduled meeting between the farmer and the interviewer. In cases where the farmer did not speak adequate English, an interpreter familiar with the project was employed to collect the information.

For our analyses, we only included farmers who derived $>50\%$ of their annual income from livestock production ($n = 19$ or 83% of respondents), because the sample sizes for the remaining game and tourist farms were too low for comparison. These 19 farmers managed 75% of the land in the study area.

Farmers were asked to estimate the amount of livestock on their farm, and the average annual calf loss they experienced to predators. Because income can be a sensitive topic, we asked farmers to state the percentage of their annual income derived from different initiatives; therefore, minimum annual earnings were not estimated. Farmer tolerance for livestock losses was measured using contingent valuation to determine what per cent of their calves they were 'willing to lose' (WTL) annually to predators before actively pursuing the culprit (Romanach, Lindsey & Woodroffe, 2007). One farmer who stated a seemingly unbelievably high tolerance (i.e. would accept 30% loss of calves) was removed as an outlier. All values are reported as US$ based on the mean exchange rate between 2004 and 2006 (US$1:N$6.4).

Although it is difficult to assess, we believe that most farmers were responding to the best of their knowledge. Farmers were not able to truly confirm the cause of death of many of their livestock because they were not herded; their responses, however, are valuable because management decisions are based on their perceived reasons for cattle loss. In other sites, farmers may exaggerate losses in order to increase compensation or pressure government into actively pursuing a more active problem animal control policy

(Gusset *et al.*, 2008), but compensation is illegal in Namibia and farmers are able to legally remove predators if they contact the Ministry of Environment and Tourism within a short period after the removal takes place; thus, there would be no benefit to inflating losses for this survey. Lastly, farmer tolerance appeared consistent with reported removal rates of perceived problem animals.

Farm management

Livestock farmers were asked to rank all native predators according to their presence and their status as a problem (0 – not present/no problem and 5 – very common/large problem). Specific management questions pertaining to the presence, problems and removal rates of leopards were asked to assess attitudes and the impact of attitudes on local leopard populations. Removal rates were reported as an annual rate of removed leopards through translocation, problem animal shooting or trophy hunting over the past 5 years.

Tolerance was examined as the dependent variable in a backwards stepwise logistical regression (Mendenhall, Beaver & Beaver, 2006) while controlling for the backgrounds of the farmers. The analysis included factors such as education, farming experience, age and ethnicity presented as categorical variables, mean annual per cent cattle loss to predators, per cent of husbandry techniques used, removal rates of leopards and tolerance as measured by their WTL. We further tested the individual relationship between tolerance and each of these factors using a Pearson's coefficient test.

Financial analysis

The benefit–cost model is a simple representation of the cost, as measured by losses reported by farmers to predators, compared with the reported tolerance, and potential benefits through tourism and trophy hunting of leopards. Farmer tolerance was analyzed as the per cent of calves they would be willing to lose to predators annually. This percentage was converted to US$ based on the total number of calves for that farm (at US$391 per calf; J. Britz, pers. comm.). The 'benefit need' was calculated based on the amount of money needed to mitigate the discrepancy between the actual livestock loss with the reported tolerance if losses exceed tolerance. Based on a mean price tourists were willing to pay (described below), we calculated the number of tourists required to cover the benefit need. Similarly, the minimum number of trophy hunts necessary to cover the benefit need was calculated, tempered by the calculated sustainable off-take of leopards determined from population estimates and calculated population growth rates (Stein, 2008).

Tourist and trophy hunter surveys

In 2006, we assessed tourist interest in predators and their willingness to pay (White, Bennett & Hayes, 2001) for leopard-based activities using a survey administered to tourists at the Cheetah Conservation Fund visitor's center outside Otjiwarongo, Namibia. The tourists were approached by an interviewer, briefed on the research, and asked if they would participate in the survey. Because 89% of those approached agreed to participate, we believe the effect of non-response bias is small. Other potential biases related to 'pleasing the interviewer' were not assessed, although they may have had an influence (Carson, 2000). Each tourist was asked what they were most interested in seeing among a variety of tourist experiences, including mammal viewing, scenery viewing, cultural tourism, flora, the 'Big 5' (i.e. the former hunting classification of the most dangerous wildlife to hunt, including lions, leopards, elephants *Loxodonta africana*, rhinoceroses *Ceratotherium simum*, *Diceros bicornis* and Cape buffalo *Syncerus caffer*), predators and birding, on a scale from 0–5 (not interested to very interested). A list of 18 large mammals was provided and tourists were asked to express their preferences for seeing each animal on the same scaling system. Using contingent valuation, tourists could choose one of several US$ amounts (0, 25, 50, 75 and 100) based on their willingness to pay for specific tourist experiences, including the viewing of leopards in captivity and at a baiting station with various likelihoods of success.

For questions pertaining to captive facilities, only tourists who traveled in large tour groups ($n > 20$) were analyzed because the Cheetah Conservation Fund visitors center is known as a captive cheetah facility. Smaller tourist groups to the Cheetah Conservation Fund most likely target that destination to view captive cheetahs, whereas tourists within a large tour group had a set itinerary including visits to national parks, etc., and therefore would most likely represent a less biased cross-section of visitors. We did not ask farmers to discuss tourist volumes, so potential income from leopard-based tourism could not be derived from farmer surveys.

Professional hunters were identified through contact with farmers associations, hunters associations, conservation organizations and colleagues. Many individuals and organizations were unwilling to share information due to unfavorable relations with specific regional conservation organizations. A semi-structured interview explored the hunters' personal experience and involvement with various associations and organizations. Because of obvious response bias, results presented here are for illustrative purposes, and are not intended to represent the views of the entire cross-section of professional hunters. Hunters were asked what they were willing to pay (WTP) farmers for access to hunt leopards. Trophy fees for leopards were estimated from the average fees listed on websites of trophy hunting operations throughout Namibia (http://www.dmoz.org/Regional/Africa/Namibia/Recreation_and_Sports/Hunting).

Results

Farm management

In the area surrounding the WPP, we interviewed all 23 farm owners or managers (no refusals), a heterogeneous population with respect to culture, age and education (Stein, 2008).

Game fencing was present on a portion of only 39% of the farms (mean area = 103 km^2; range = 32–400 km^2), and none of the farms maintained electric fencing aside from enclosures used for captive predators. A total of 55% of the respondents claimed that >90% of their household income was derived from livestock related activities, while only 23% received 50% or less of their income from livestock farming. Other sources of income included trophy hunting, which was conducted on 55% of the farms and contributed between 5 and 50% of the yearly household income for those farms. In addition, tourism provided income for 36% of the farms (range = 1–100%). One farm, run by a non-government organization, received 97% of its income from private donations. Game farming was considered a small income source for 18% of the farms (range = 1–20%). Although some farmers have invested in game farming, only two stated that >5% of their income came from game.

The three highest reported causes of livestock losses were consistent between the cattle and small stock farms. Carnivore depredation was the most commonly reported cause of cattle loss (mean annual % loss of cattle = 3.8, SD = 3.9%, range = 0–14, $n = 19$) with disease (mean = 3.4%, SD = 3.2, range = 0–10, $n = 15$) and theft (mean = 1.3%, SD = 3.4, range = 0–13, $n = 14$) listed as the next highest causes respectively. Farmers stated that small stock mortality was primarily due to carnivore depredation (mean = 5.7%, SD = 6.2, range = 0–15, $n = 13$) followed by disease (mean-5.7%, SD = 8.8, range = 0–30, $n = 11$) and theft (mean-3.3%, SD = 5.1, range = 0–15, $n = 11$). Poisonous plants were listed as a substantial source of small stock loss (mean-2.1%, SD = 2.5, range = 0–8, $n = 9$). The remaining sources of livestock loss, including poison, dystocia or birthing difficulties, snake bites and poor nutrition, were not considered primary sources of loss. Farmers thought that jackals *C. mesomelas* were both the most common predator on their farms and had the highest status as a problem, and leopards and cheetahs were the next most common and problematic (Table 1).

Livestock farmers employed a variety of techniques to manage their livestock and protect them from predators, disease and stock theft (Table 2). Of the livestock farmers interviewed, 67% of all farmers implemented a calving season (focused effort to have livestock give birth in the same season); the least common technique used was livestock kraaled near (<30 m from) a house (32%). More than half of the farmers employed three to six techniques; seven farmers employed only one or no husbandry techniques. Those farmers employing at least one husbandry technique have reduced (~85% less) livestock losses ($n = 14$) compared with farmers using no husbandry, yet we detected no differences among farmers using one or more techniques, nor among different combinations of techniques used.

Over 90% of the respondents believed that leopards were present on their farms, yet only 55% believed them to be a problem. The majority of farmers (53%) believed that the leopard population was stable, while 41% perceived it to be increasing and 6% believed the population was decreasing.

Nearly 45% of regional farmers stated that they would only remove a leopard after losses have occurred while 40% of farmers stated that they would not remove leopards even after losses. However, 15% of the farmers responded that they would remove leopards at the first sign of their presence, regardless of losses. When conflicts occurred, 60% of farmers would attempt to shoot the problem animal, but 45% would also trap animals either to shoot, translocate or release them, 35% would call the Ministry of Environment and Tourism or a conservation organization to seek advice or animal translocation after capture (trapped leopards were translocated from 29% of the farms), 18% of farmers 'trophy hunted' problem animals, 17% set poison and 12% called the 'predator hotline' to organize a trophy hunt.

Over the past 5 years, an average of 11 leopards has been removed (killed or translocated) annually, as reported by regional commercial farmers. This removal rate represents about 14% of the adult leopard population, as extrapolated from intensive camera-trapping survey estimates (Stein, 2008).

Livestock farmers were willing to lose 3.3% (range 0–10%) of their calves annually (Table 3). When comparing the current level of livestock loss reported by individual livestock farmers with the per cent they are willing to lose,

Table 1 Predator occurrence and conflict rankings between farms near the Waterberg Plateau Park in north-central Namibia

	Jackal		Leopard		Cheetah		Brown hyena		Caracal		Wild dogs	
Area	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
South-west (n = 9)												
Occurrence	4.6	0.7	3.7	1.1	2.3	1.8	2.4	1.1	2.3	1.7	1.1	1.5
Problem	2.8	1.9	3.7	2.2	2.1	1.9	1.3	1.7	1.6	1.6	1.2	2.2
North-east (n = 10)												
Occurrence	5.0	0	1.8	1.3	2.4	1.3	1.8	1.6	1.3	1.3	0.3	0.7
Problem	3.5	1.6	2.2	1.6	3.4	1.5	0.1	0.3	0.7	1.1	0.2	0.6
Overall (n = 19)												
Occurrence	4.6	0.5	2.7	1.5	2.4	1.4	2.2	1.5	1.8	1.5	0.7	1.1
Problem	3.2	1.7	2.9	2.0	2.8	1.7	0.6	1.2	1.2	1.3	0.7	1.6

Farmers stated on a scale from 0 to 5 (not present/problem to very common/high conflict).
The mean represents the average response of the livestock farmers within the stated region.

Table 2 Per cent of cattle operations near the Waterberg Plateau Park in north-central Namibia that used various livestock husbandry techniques

Area	Calving season	Separated during calving	Kraaled	Livestock near house[a]	Guard animals	Herder
South-west ($n=8$)	63	63	50	33	33	25
North-east ($n=10$)	70	30	30	30	20	40
Total ($n=18$)	67	44	39	32	26	33

[a]Livestock kraaled within 30 m of a house.

Table 3 Characteristics of farms for the two subregions around the Waterberg Plateau Park, Namibia

		Farm size (km^2)		Total number of calves		Per cent of calves killed by predators		Per cent WTL[a]		Cost (US$) of lost calves/100 km^2	
Area	n[b]	Mean	SD	Mean	SD	n	Per cent	n	Per cent	n	Cost
North-east	9	62.1	20.8	88	39.3	7	6.4	6	4.0	7	0.50
South-west	8	129.4	114.7	96	62.9	8	1.7	6	2.8	8	0.05
Total	17	93.7	84.6	92	50.4	15	3.8	13	3.3	15	0.15

[a]Per cent of calves willing to be lost (WTL) to predators.

[b]Not all questions were answered by all farmers so 'n' represents the number of respondents for that question.

over 64% of the livestock farmers tolerate their current level of livestock loss ($n = 14$). There were no significant correlations among farmer background, farm size or location, losses to predators, husbandry practices or removal rates.

Financial analysis

On commercial livestock farms, regional farmers reported owning a total of 8839 animals, of which 1567 were calves valued at US$612 697. Regional livestock farms maintained a mean of 92.2 calves (SD = 50, range 30–180), of which an estimated 3.8% (3.5/farm, or 59.5 total) were reported lost to predators each year (no adult livestock were killed by predators). This total monetary loss (US$23 283) equals US$1370 per farm. However, farmers reported an average WTL 3.3% of their calves (3.0/farm, or 51.7 total) to predators, an average of about US$1189/farm (Table 3). Thus, the discrepancy between the amount that farmers lost and what they were willing to lose was approximately US$180/farm (US$3064 for the region).

The per cent losses attributed to predators were significantly higher ($P = 0.003$) for north-eastern farms (mean = 6.4, $n = 7$) compared with south-western farms (mean = 1.7, $n = 8$; Table 3). However, mean farmer tolerance on farms of the north-eastern region (%WTL = 4.0, $n = 6$) was also slightly higher than for farms in the south-western region (%WTL = 2.8, $n = 6$). Still, all north-eastern farmers received more loss than they reported they would tolerate ($n = 5$) and all south-western farmers incurred less loss than they reported tolerating ($n = 6$). Income sources for farmers were not significantly different between areas (Table 4).

Although the overall cost of lost calves per unit area averaged about US$0.15/100 km^2 (Table 4), there was an order of magnitude difference in cost between farms in the north-east (US$0.50/100 km^2) versus those in the south-west (US$0.05/100 km^2). This is because farms in the north-eastern region were smaller (mean = 62 km^2) than the farms of the south-western region (mean = 129 km^2), and though farms in the north-east had nearly the same number of calves per farm (88 vs. 96), the per cent of calves lost was almost four times higher (Table 3), possibly a result of the higher livestock densities in the north-eastern region.

A total of 83 useable questionnaires identified tourists from nine countries, primarily in Europe; 71% were from large tour groups and therefore were incorporated into the captive viewing analysis. Tourists showed the highest preference for viewing mammals and scenery, as well as predators and the 'Big 5,' and appeared somewhat less interested in culture, flora and birds as part of their experience. When asked about specific mammal species, leopards, lions and cheetahs ranked the highest, nearly universally valued as the most preferred species for viewing; elephants, rhinos and giraffes *Giraffa camelopardalis* also were highly preferred (Stein, 2008, p. 163). In general, wild herbivores, hyenas and jackals were moderately preferred, and caracals, African wild dogs and Cape buffalo were least preferred.

Many tourists were willing to pay for the opportunity to view leopards, depending on the likelihood of seeing one (Fig. 2). With a 25% likelihood of viewing a leopard at a bait station, 52% of respondents were unwilling to pay, while 36% were willing to pay between US$25 and US$50 and 12% were willing to pay US$50 or more. If the likelihood of viewing a leopard was increased to 50%, fewer respondents were unwilling to pay and more were willing to pay at each cost level. Even though captive facilities would provide a 100% chance of viewing a leopard, tourists were less willing to pay in comparison with a 75% viewing chance in the wild, and would pay about the same as a 50% viewing chance in the wild (Fig. 2). Those respondents willing to pay to visit a captive facility cited interests in either the conservation or educational aspects of the facility.

Professional trophy hunters receive payment for a variety of charges and fees, among which is a species-specific trophy

Table 4 Per cent of annual income derived from various sources for livestock farmers around the Waterberg Plateau Park, Namibia

Area	Income source	Mean	SD	Minimum	Maximum
North-east	Livestock	83	25	40	100
	Trophy hunting	13	21	0	50
	Tourism	2	6	0	20
	Game farming	2	6	0	20
South-west	Livestock	80	14	60	100
	Trophy hunting	10	13	0	35
	Tourism	5	8	0	20
	Game farming	2	2	0	5
Total	Livestock	81	21	40	100
	Trophy hunting	13	18	0	50
	Tourism	3	7	0	20
	Game farming	2	5	0	20

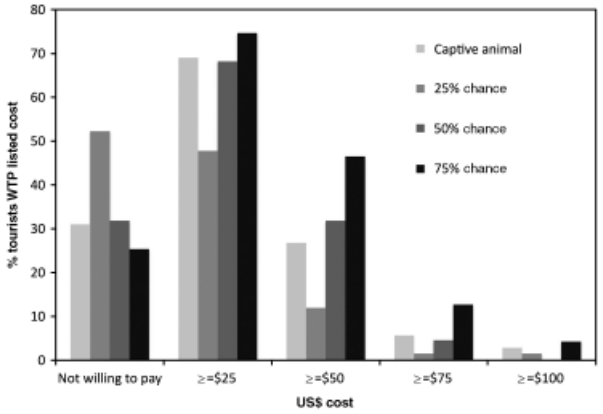

Figure 2 The willing to pay (WTP) of tourists for viewing leopards in captivity and varying likelihood of viewing wild leopards at bait stations.

fee based on species abundance and required hunting effort. For leopards, interviewed trophy hunters ($n = 11$) were willing to pay farmers 50–60% of their trophy fees (mean-US$3363; SD = US$776, range = US$1900–4250) for the opportunity to hunt a leopard on a commercial farm. Given a payment to farmers of 50% of an average reported trophy fee (about US$1682) that does not include fees for lodging, staff assistance, etc., that some farmers may collect, and an average of 11 leopards removed from farms in the study area each year, the potential annual remittance to farmers is perhaps US$18 497. Currently, four to five of the removed leopards are actually reported as 'trophy hunted,' but the current rate of remittance to farmers for these hunted leopards could not be determined. Interestingly, problem animal control records obtained from the Ministry of Environment and Tourism (MET) showed a total of 11 problem animal control permits within the study area between 2000 and 2005 or 1.8 problem animal control removals per year (MET, unpubl. data) as opposed to the 33 leopards killed and 55 removals reported by survey respondents.

Discussion

Livestock management, and in particular, use of various livestock husbandry techniques (e.g. Ogada *et al.*, 2003; Marker, Dickman & Macdonald, 2005), is an essential part of farm management oriented to biodiversity conservation. Even so, the financial discrepancy between the reported losses and tolerated losses for all of the farms in the study area was *c.* US$3064/year, and thus the system is not financially viable based solely on calf losses and farmer tolerance (Bade & Parkin, 2002). The question, then, is whether additional income could be generated to cover this discrepancy. This is important because otherwise, farmers will likely conclude that their best management option is to reduce depredation in the coming years by killing leopards.

Tourism may offer an additional source of income for those farmers with the infrastructure to house tourists without additional investment. Tourists were not only interested in wildlife viewing as a primary reason for visiting Namibia, but were willing to contribute directly to wildlife conservation and community welfare through tourist initiatives (Barnes, Schier & van Rooy, 1999). Also, our surveys, as well as those in protected areas in South Africa and Zimbabwe also found that 'big cats' were species tourists wanted to see most (Lindsey *et al.*, 2007*a*). Some leopard-based tourism initiatives will not work on the regional farms studied because of the closed habitat and reclusiveness of local leopards; only 33% (seven of 21) of all regional farmers stated that they see leopards on a at least a monthly basis, while 61% stated that they see leopards on a yearly basis. (Stein, 2008). Therefore, leopard viewing requires the development of a technique for increased likelihood of viewing leopards. If baiting could provide a 100% chance of viewing a leopard, our survey indicates that a tourist lodge could conservatively charge a minimum of US$25 for the opportunity to view a leopard, and thus 123 tourist visits/observations would earn US$3075 over the entire area, an amount that would off-set the region-wide discrepancy in actual and tolerated losses from calf predators (but see Rondeau & Bulte, 2007). Most importantly, 35% of regional farms already derive a portion of their income (range = 1–100%)

from tourism and recent figures show that tourism in Namibia is increasing in recent years (Suich, 2001).

Trophy hunting of leopards offers another option for farmers to off-set their livestock losses by sustainably removing 'problem animals.' At US$1682/trophy, only two additional leopard trophy hunts would mitigate the 'benefit need' created by predator depredation on calves. The hunting of 'problem animals' is not a new concept in Namibia, and indeed farmers can contact professional hunters through the Namibian Professional Hunter's Association's 'Hunter's Hotline.' However, only 12% of the surveyed farmers stated that they would call the hotline and these particular farms conduct their own trophy hunts, as well. Many farmers felt that it was easier to remove animals on their own with a problem animal control permit, which can be issued after a problem animal is killed as a threat to life or livelihood, without the logistical difficulties associated with trophy hunting. Alternatively, farmers could coordinate hunting hotlines within their local conservancies and farmer's associations. The advantage of coordinating hunting initiatives at the local level is that when a problem animal is identified, a professional hunter would be immediately available on the neighboring farm, thereby removing the need to contact farmers from throughout the country. Results from other studies suggest that clients would pay more for the opportunity to hunt a 'problem animal' (Lindsey *et al.*, 2006), though we did not see evidence of this in our area. There is also concern that trophy hunting of large carnivores, in general, needs to be monitored closely to avoid population declines (Packer *et al.*, 2009).

Population estimates show that most of the leopard population in the region exists outside of the WPP, which is the only local protected area (Stein, 2008). Therefore, farmers have a key role in the fate of the regional leopard population and conservation initiatives should involve farmers and their needs and concerns when addressing the continued persistence of predators. Ignoring the needs of farmers could increase the number of predator removals causing populations to decline. Currently, some individual farmers receive benefits from trophy hunting and tourism, while the region as a whole receives more loss from predators than they tolerate. For those farmers bearing losses greater than their stated tolerance, benefit distribution, through tourism and trophy hunting, could be done collectively among those affected farmers to maintain positive attitudes towards wildlife and their advocates (Gillingham & Lee, 1999; Archabald & Naughton-Treves, 2001). A potential solution to mitigate the cost of high livestock losses could be to further facilitate trophy hunting of 'problem animals' and place 20% of each trophy fee from nine leopard trophy hunts into a communal fund overseen by the local MET office, farmer's association, or conservancy leadership. These funds could be used towards community projects such as radio towers, anti-poaching guards or a self-insurance fund that could pay out claims to farmers who have received losses after employing a minimum required set of livestock husbandry criteria (Mishra *et al.*, 2003; Bulte & Rondeau, 2005).

A cooperative approach would also allow farmers to focus on one particular aspect of a regional multidimensional initiative. Similar initiatives have developed in Quebec, where the responsibilities of fish and wildlife co-management have been shared among several stakeholders called Zones d'Exploitation Controlee (ZEC; Pearse & Wilson, 1999). Benefit distribution and decision making abilities within these ZECs are incorporated into the management structure with the goal that natural resource management include the objective of financial self-sufficiency. In Namibia, regional collaboration could create ZECs where particular incompatible initiatives, such as bait stations for leopard viewing and trophy hunting, are not conducted in adjacent areas. With coordination, however, farmers could develop an improved multi-use system in which livestock farming, tourism and trophy hunting could be conducted concurrently.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Farmer survey.
Appendix S2. Tourist survey.
Appendix S3. Professional Hunter Survey.

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