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Costs and Benefits of the Presence of Leopards to the Sport-Hunting Industry and Local Communities in Niassa National Reserve, Mozambique

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Abstract: *Sport hunting is often proposed as a tool to support the conservation of large carnivores. However, it is challenging to provide tangible economic benefits from this activity as an incentive for local people to conserve carnivores. We assessed economic gains from sport hunting and poaching of leopards (Panthera pardus), costs of leopard depredation of livestock, and attitudes of people toward leopards in Niassa National Reserve, Mozambique. We sent questionnaires to hunting concessionaires (n = 8) to investigate the economic value of and the relative importance of leopards relative to other key trophy-hunted species. We asked villagers (n = 158) the number of and prices for leopards poached in the reserve and the number of goats depredated by leopard. Leopards were the mainstay of the hunting industry; a single animal was worth approximately U.S.$24,000. Most safari revenues are retained at national and international levels, but poached leopard are illegally traded locally for small amounts ($83). Leopards depredated 11 goats over 2 years in 2 of 4 surveyed villages resulting in losses of $440 to 6 households. People in these households had negative attitudes toward leopards. Although leopard sport hunting generates larger gross revenues than poaching, illegal hunting provides higher economic benefits for households involved in the activity. Sport-hunting revenues did not compensate for the economic losses of livestock at the household level. On the basis of our results, we propose that poaching be reduced by increasing the costs of apprehension and that the economic benefits from leopard sport hunting be used to improve community livelihoods and provide incentives not to poach.*

Keywords: livestock depredation, *Panthera pardus*, payments to encourage coexistence, poaching

Costos y Beneficios de la Presencia de Leopardos para la Industria de la Caza Deportiva y las Comunidades Locales en Niassa, Reserva Nacional, Mozambique

Resumen: *La caza deportiva se propone frecuentemente como una herramienta para apoyar a la conservación de grandes carnívoros pero es un reto proporcionar beneficios económicos tangibles a partir de esta actividad como un incentivo para que la población local conserve a los animales. Estudiamos las ganancias económicas de la caza deportiva y la caza furtiva de leopardos (Panthera pardus), los costos de la depredación de ganado por leopardos y la actitud de las personas hacia los leopardos en la Reserva Nacional Niassa, Mozambique. Enviamos cuestionarios a concesionarias de caza (n = 8) para investigar el valor económico y la importancia relativa de los leopardos con respecto a otras especies-trofeo de importancia. Preguntamos a los aldeanos (n = 158) el número de leopardos y el precio de especímenes capturados mediante caza furtiva en la reserva y el número de cabras depredadas por leopardos. Los leopardos fueron el pilar de la industria de la caza ya que un solo animal valía aproximadamente U.S.$24,000. La mayoría de las ganancias de los safaris se retienen en niveles nacionales e internacionales pero los leopardos capturados por medio de la caza furtiva*

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son intercambiados localmente y de manera ilegal por cantidades pequeñas ($83). Los leopardos depredaron 11 cabras, a lo largo de 2 años, en 2 de las 4 aldeas encuestadas y esto resultó en pérdidas de $440 en 6 casas. Las personas en estas casas tenían actitudes negativas hacia los leopardos. Aunque la caza deportiva de leopardos genera ganancias brutas mayores a las de la caza furtiva, la caza ilegal proporciona beneficios económicos mayores para las familias involucradas en la actividad. Las ganancias de la caza deportiva no compensaron las pérdidas económicas a nivel de familias. Con base en nuestros resultados, proponemos que la caza furtiva sea reducida incrementando los costos de captura y que los beneficios económicos de la caza deportiva de leopardos se usen para mejorar las viviendas comunitarias y proporcionar incentivos para evitar la caza furtiva.

Palabras Clave: caza furtiva, depredación de ganado, pagos para alentar la coexistencia, *Panthera pardus*

Introduction

Conservation of large carnivores is a costly activity and often competes with other societal priorities (MacDonald & Sillero-Zubiri 2002). The probability that carnivore conservation will succeed may be increased with incentive-driven strategies that encourage people to support conservation of these species (Hutton & Leader-Williams 2003). These strategies could be financed through the transfer of funds from the beneficiaries of carnivore presence to villagers who are negatively affected by their presence (MacDonald & Sillero-Zubiri 2002). The strategies must have the potential to contribute to conservation and to contribute to poverty alleviation (Abensperg-Traun 2009).

Conservation practitioners, the general public, and governments at national and international levels have to choose between regulated consumptive and nonconsumptive-use conservation strategies (Novelli et al. 2006). Some countries, such as Kenya, have adopted an exclusively nonconsumptive-use policy whereas others, such as South Africa and Namibia, combine nonconsumption and regulated consumption strategies (Lindsey et al. 2006). With either course, the challenge is to generate revenues sufficient to maintain and protect large carnivores that are competitive with other land uses.

The potential for economic data to inform such conservation strategies is clear (Naidoo et al. 2006). Economic analyses are useful for determining the value of sport hunting of large carnivores to stakeholders (Leader-Williams 2009). Proponents of sport hunting argue that well-managed sport hunting can have positive economic and ecological effects on community livelihoods and wildlife conservation (Lindsey et al. 2007). Sport hunting can be a conservation tool when local communities tolerate populations of large predators in exchange for revenues from the harvest of some proportion of the population (Leader-Williams 2009). Sport hunting can also be a conservation tool when a considerable proportion of the revenues earned are invested in species conservation (Balme et al. 2010). Despite these benefits, an assessment of the effects of sport hunting on conservation in many parts of Africa is hampered by a lack of data on the economic effects of the activity (Lindsey et al. 2006) and an objective assessment of whether sport hunting is improving in situ community livelihoods and wildlife conservation.

In Mozambique many protected areas have little funding and few meet their conservation goals of protecting species, habitats, and ecosystems for present and future generations (MITUR 2003). However, in Niassa National Reserve (NNR) conservation activities are funded considerably through revenues from sport hunting (SGDRN 2007). The NNR is one of the major hunting destinations in Mozambique and supports a growing human population of 35,000 people (INE 2008*a*, 2008*b*). Legally, 20% of the revenues from trophy and concession fees must accrue to villages within NNR, ostensibly as an incentive for tolerating wildlife in the reserve (DNFFB 1999). Whether these revenues provide adequate economic compensation for the costs of living with wildlife or improve community livelihoods has yet to be determined.

Assessing the contribution of sport hunting to economic development in Mozambique is constrained by the paucity of data (Magane et al. 2009). We sought to partially fill this gap by studying the economic aspects of leopard hunting as an example. The hunting of other large carnivores, such as lions (*Panthera leo*) and spotted hyaenas (*Crocuta crocuta*), is also permitted in NNR (DNFFB 1999). We focused on leopards because they are economically important for both photographic- and sport-hunting operations (Lindsey et al. 2006) and are the main source of human–carnivore conflict in NNR (Begg et al. 2007). Leopard are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) because their abundance is declining in response to habitat loss, fragmentation, and hunting for trade and predator control (Packer et al. 2009). We considered the economic gains involved in leopard hunting and poaching, the costs of leopard depredation of livestock to local communities, and the attitudes of communities toward leopards. Based on this information, we propose ways in which the benefits from leopard sport hunting can be used to improve community livelihoods and provide incentives for sustainable species conservation.

Methods

Study Area

Located on the border with Tanzania along the Rovuma River (Supporting Information), NNR is Mozambique's largest protected area (42,000 km^2). A large proportion of Mozambique's remaining wildlife populations are supported in NNR (AGRECO 2008). The reserve was originally proclaimed by the colonial government as a game reserve in 1954, and from 2000 to 2012 it was managed by Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa (SGDRN), a partnership between the government and a private company (Investimentos Niassa). The NNR has designated concessions for hunting (9 units), photographic tourism (6 units), and resource conservation (2 units). At present none of the photographic tourism units are active, although one photographic tourism camp is operational in a sport-hunting concession. For this camp we collected only employment data because no additional benefits accrued to villages from the ecotourism activities. We focused mostly on revenues generated by sport-hunting units because one of SGDRN's goals was to finance management activities in NNR through revenues from hunting and photographic tourism operations.

Census data suggest relatively high rates of human population growth and the expansion of the 40 settlements in NNR from 1997 to 2007 (INE 2008*a*, 2008*b*), although detailed data are unavailable. In NNR, the poverty level of communities is high, food security is low, infrastructure and social services are poor, and levels of human–wildlife conflict are high, particularly with African elephants (*Loxodonta africana*) and large carnivores (Cunliffe et al. 2009). Subsistence slash-and-burn farming is the principal livelihood activity (Cunliffe et al. 2009). Use of natural resources, including bushmeat hunting and shifting cultivation, tend to act in direct opposition to the stated conservation goals of the reserve (Cunliffe et al. 2009). Cattle are absent in NNR because of the presence of the tsetse fly (*Glossina* spp.), but goats, chickens, and domestic dogs and cats are present in the villages. The overall estimated income generated from fishing, livestock, trading, and agriculture ranges from $5 to $1532 per household per year (Cunliffe et al. 2009). (All monetary units are in U.S. dollars.)

Stakeholders and Revenue from Sport Hunting

In 2011 we identified the key stakeholders in the NNR hunting industry and estimated the amounts earned by each stakeholder from client and operator expenditures on different components of sport hunting in general and of leopard safaris during the 2010 hunting season (as per Booth 2009). We calculated revenues of stakeholders on the basis of client expenditure on hunting packages, travel, accommodation, and trophy export and taxidermy.

From government offices, we obtained the costs of licenses for client and professional hunters, export permits, firearm licenses, visas, and salary taxes. We extracted daily safari rates, trophy fees, and benefits (e.g., employment, meat, money) allocated to local communities from annual hunting reports of operators. From SGDRN records we extracted the number and nationalities of clients and their observers (family members or friends accompanying hunters), the amounts for trophy royalty and concession fees, the type of safari and its duration, and animal off-takes. Private sector entities were contacted to provide typical prices for services demanded by NNR hunting clients.

We used the client payments for trophy fees and daily rates to calculate the gross revenue for hunting operators. We based estimates of government revenues on payments by clients and operators to the Ministry of Tourism for client and professional hunter licenses, trophy licenses, and trophy-ownership certificates; Ministry of Interior for firearm and ammunition licenses and visas; Ministry of Agriculture for CITES and non-CITES export and veterinary permits; and Ministry of Finances for taxes on salaries of concessionaire workers from villages. We based SGDRN revenues on operator payments for concession and trophy-royalty fees.

We calculated the economic benefits for stakeholders in the private sector on the basis of typical client payments to travel agencies (international and domestic flights before and after the hunt), private customs agents (temporary importation of hunting rifles and ammunitions), hotels (accommodation before and after the hunt), air-charter companies (transport from Niassa, Cabo Delgado, or Lilongwe to and from the hunting destination in NNR), trophy-export companies (trophy documentation and processing), and taxidermists (trophy mounting). We based revenues for petrol stations on the amounts paid by the hunting operators for fuel for the safari operations.

Surveys and Interviews

In February 2011, we sent questionnaires in English via email (Supporting Information) to the NNR commercial ($n = 7$) and noncommercial hunting operators ($n = 1$) to assess the perceived economic value of leopards and the relative importance of leopard safaris relative to buffalo (*Syncerus caffer*), lion, and elephant safaris during the 2010 hunting season.

Between September and December 2010, we interviewed members of Mbamba ($n = 24$), Mussoma ($n = 52$), Macalange ($n = 32$), and Lissongole–Cuchiranga ($n = 50$) villages to assess the perceived economic and cultural value of leopards and the costs from leopard predation on goats. These villages are inside NNR, and we chose them because data on human–carnivore conflict in these

villages exist and were collected by Management Orientated Monitoring System (MOMS) agents from 2007 onward. There was also evidence of illegal hunting of carnivores, such as snared animals, reported by tourism operators and villagers from these villages. The MOMS is a community-based system within which data on human–wildlife conflict are collected. Sample sizes were uneven because the villages differed in size and different numbers of people were available for interviews across the villages.

Although there are economic benefits to leopard poaching, it is unlawful in Mozambique (DNFFB 1999) and people generally do not want to discuss the practice. To determine the number of and prices for leopard skins illegally traded in NNR with which we could assess the accuracy of the structured interview responses, we first interviewed a former poacher. This individual was a local resident in Mbamba in NNR and was employed by a conservation organization to assess lion and leopard mortalities in snares. He provided us with an estimate of the number of leopard skins traded in Mbamba village in 2010 and the market price for these skins.

Prior to interviewing villagers with the assistance of MOMS agents (Supporting Information), we held one meeting in every village to present the objectives of the interviews and explain the importance of participation to the community and local leaders. We tried to make it clear that the objective was not to assess illegal activity but to understand the benefits and costs of leopards to the community. We conducted the surveys in collaboration with the resident MOMS agent. These agents are familiar with data collection as part of their MOMS duties and translated the structured interview questions into the local languages, Cyao, Cmakua, or Swahili, when necessary. We asked villagers to estimate the number and values of leopards killed in their villages during that year.

During the interview of villagers, we extrapolated the economic cost of leopard depredation on goats on the basis of the number of goats reported killed by leopards in NNR per year. We used MOMS records of goats attacked from 2009 to 2010 to verify the reports of livestock killed by leopards in the 4 villages. The cost of goat depredation was calculated on the basis of market value of a goat in the villages (A.J., personal observation). We did not determine economic losses due to human injuries from leopards or due to the loss of other domestic animals (e.g., chickens) because these were not frequent or the costs were low. From the interviews, we determined livestock husbandry techniques and compared the attitudes among villagers toward leopards and their perceptions of the importance of leopards. We conducted chi-square tests to assess villagers' attitudes regarding the proposed methods to protect goats in the villages.

By law 20% of the payments to MITUR for trophy fees and 20% of SGDRN royalty and concession fees are paid to local communities (DNFFB 1999). To estimate the economic benefits accruing to each village from the 20% of sport-hunting revenues and the amounts paid to communities through employment and products obtained by operators in the village, we divided the community-hunting benefits by the number of villages (40) in NNR. Data on the number of households in a village were only available for Mbamba. For this village, we divided the total village benefit by the 420 households to provide an example of the economic benefit provided by sport hunting to each household.

Results

We identified sport-hunting clients, hunting concessionaires, local communities, the management entity of NNR, government, and the private sector as the most relevant stakeholders in the NNR hunting industry in 2010 (Table 1). Seventy clients (55% from the United States and 13% from France), accompanied by 26 observers, spent $3,285,967 over 1070 hunting days while sport hunting in 9 concessions in NNR in 2010 (Table 1). The client expenditure was predominantly for hunting packages (47%), accommodation and travel (23%), trophy shipping and mounting (19%), and government and SGDRN hunting fees (11%) (Fig. 1). Earnings by SGDRN ($481,934) from trophy and concession fees were invested in antipoaching and management activities in NNR and covered 30% of the annual operational costs of the reserve. Communities received revenues from the sport-hunting industry through employment ($130,763, 41%), received 20% of the trophy and concession fees ($122,568, 38%), and received payments from concessionaires for local materials for construction (e.g., thatch and bamboo) ($67,347, 21%) (Table 1).

Of the 19 safaris that included leopard hunting (27%) in 2010, leopards were the main trophy in 16 safaris, whereas in 3 safaris leopards were hunted with other key species such as lions or elephants. Sixteen hunters (69% United States, 13% Italy, 6% each Germany, Mexico, and Portugal) spent $927,353 over 225 hunting days on leopard hunting and operators spent an additional $30,710 (Fig. 2). The mean length of each safari was 14 days (0.9 SE), and the mean daily expenditure was $2,587 for government taxes and licenses, accommodation, safari expenses, trophy handling and packing, and air charter. The overall direct expenditure on leopard safari packages ($431,888) was 28% of expenditure on all hunting packages.

Of the 8 operators involved in the survey, only 1 (noncommercial hunting concessionaire) did not return the questionnaire. According to the hunting operators, the mean economic value for a leopard trophy (daily rate plus trophy fee) was $23,878 (SE 1,375) and the range was $20,000–30,000, depending on the operator. Most of the revenues from leopard hunting were retained by

Table 1. Distribution of expenditures from sport-hunting clients and hunting operators for stakeholders from all hunting safaris and leopard safaris and the equivalent distribution of revenues from leopard poaching in 1 year (2010).

Stakeholder and source of revenue[a]	*Expenditure (U.S.$) from all hunting safaris (n = 70)*[b]		*Expenditure (U.S.$) from leopard safaris (n = 16)*		*Revenue from leopard poaching (n = 8)*[c]
	clients	*operators*	*clients*	*operators*	
MITUR[d], trophy fee	130,907	0	21,168	0	0
MITUR, PH[e] and client licenses	3117	721	515	0	0
MITUR, export permits	483	0	133	0	0
MINT[f], firearm licenses	15,088	3500	3142	2000	0
MINT, work and tourist visas	28,580	16,935	2295	8085	0
MINAG[g], export permits	3380	0	2523	0	0
MINF[b], salary taxes	0	8,095	0	0	0
Government	181,555	29,251	29,776	10,085	0
Trophy fee	575,257	0	184,308	0	0
Daily rate[i]	965,622	0	247,580	0	0
Operators	1,540,879	0	431,888	0	0
Royalty fee	186,727	0	32,081	0	0
Concession fee	0	295,207	0	0	0
SGDRN[j]	186,727	295,207	32,081	0	0
Trophy fee	0	63,527	0	10,650	0
Concession fee	0	59,041	0	0	0
Employment[k]	0	130,763	0	0	0
Meat[l]	0	51,347	0	0	0
Construction materials	0	16,000	0	0	0
Local hunter(s)	0	0	0	0	670
Communities	0	320,678	0	10,650	670
Air charter companies	205,100	0	61,700	0	0
Hotels	37,800	0	9100	0	0
Travel agencies	515,000	0	121,500	0	0
Clients and observers hunting trips	515,000	0	121,500	0	0
Private custom agents	2501	0	493	0	0
Trophy shipment companies	41,175	0	14,535	0	0
Taxidermists	575,230	0	226,280	0	0
Petrol stations	0	252,112	0	9975	0
Private sector	1,376,806	252,112	433,608	9975	0
Total	3,285,967	897,248	927,353	30,710	670

[a]*Stakeholders and source of revenues for which expenditure distribution could not be quantified: Ministry of Finance, taxes from client and operator expenditures on the purchase of goods in Mozambique; operators, expenditures on salaries for senior staff, marketing trips, purchase of hunting equipment (clothes, rifles, ammunitions, etc.), antipoaching equipment, construction equipment (vehicle, tractors, etc.), food and beverage, office consumables, and marketing materials; private sector, revenues accrued to outside trader from the sale of poached leopard(s).*
[b]*Amount generated from trophy hunting of 360 animals of 26 species on quota in 2010: buffalo (*Syncerus caffer*), common duiker (*Sylvicapra grimmia*), suni (*Neotragus moschatus*), red duiker (*Cephalophus natalensis*), blue duiker (*C. monticola*), oribi (*Ourebia ourebi*), steenbok (*Raphicerus campestris*), reedbuck (*Redunca arundinum*), wildebeest (*Connochaetes taurinus*), nile crocodile (*Crocodylus niloticus*), kudu (*Tragelaphus strepsiceros*), eland (*Taurotragus oryx*), elephant (*Loxodonta africana*), warthog (*Phacochoerus africanus*), hartbeest (*Alcelaphus lichtensteinii*), spotted hyena (*Crocuta crocuta*), hippo (*Hippopotamus amphibious*), bushbuck (*Tragelafus scriptus*), impala (*Aepyceros melampus*), waterbuck (*Kobus ellipsiprymnus*), lion (*Panthera leo*), leopard (*P. pardus*), yellow baboon (*Papio cynocephalus*), sable (*Hippotragus niger*), bushpig (*Potamochoerus larvatus*), and zebra (*Equus quagga*).*
[c]*Calculated from numbers of and prices for leopards poached. Data from our baseline study in Mbamba village (*n*, total number of villages surveyed).*
[d]*Ministry of Tourism.*
[e]*Professional hunter.*
[f]*Ministry of Interior.*
[g]*Ministry of Agriculture.*
[b]*Ministry of Finances.*
[i]*Daily rate charged to clients in hunting camps during leopard safaris.*
[j]*Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa (Society for Management and Development of Niassa Reserve).*
[k]*Salaries paid to approximately 400 temporary and seasonal local workers.*
[l]*Market value of approximately 4500 kg of meat distributed as rations to concession workers and to the villages and money paid to communities to purchase buffalos from community quota.*

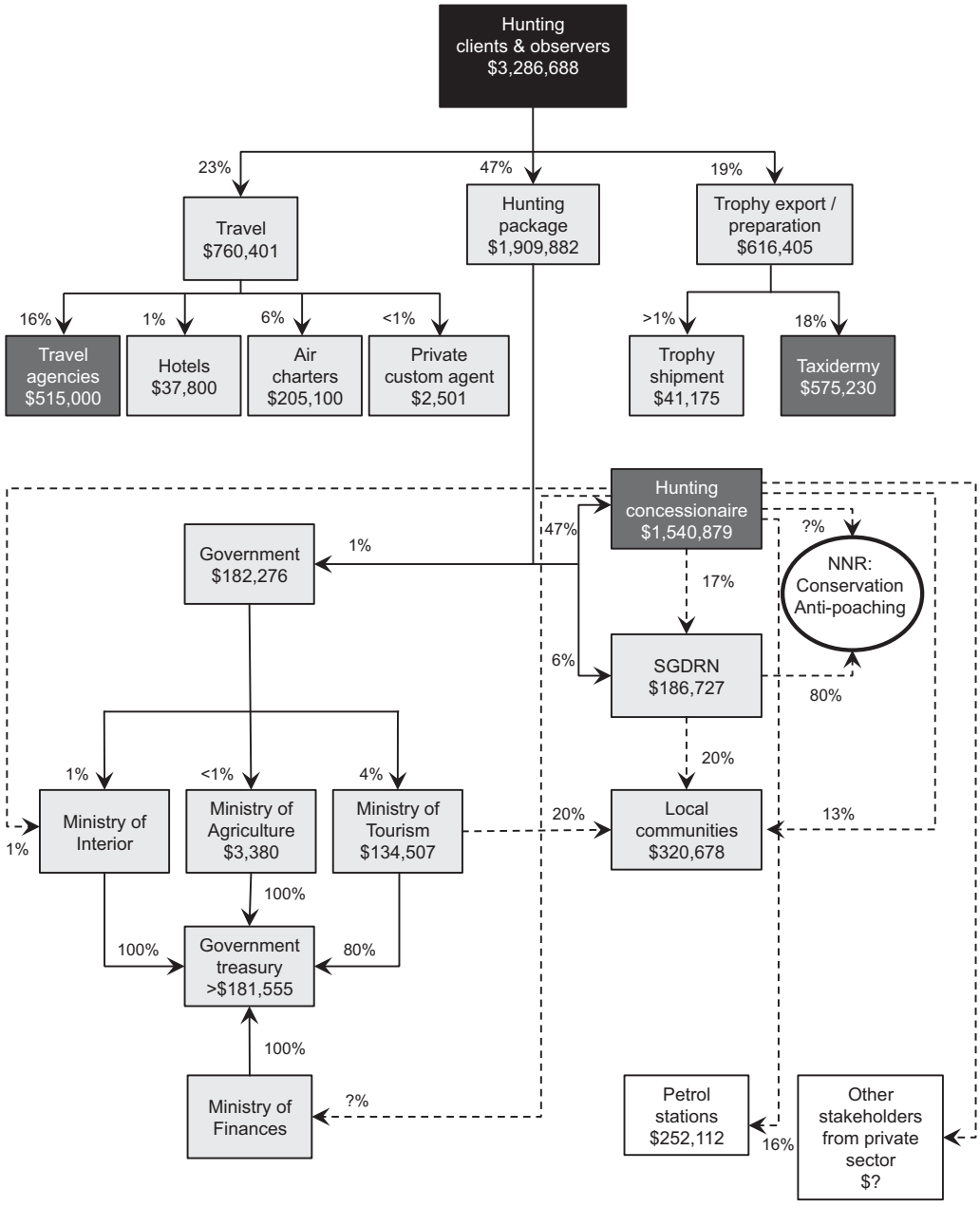

Figure 1. Distribution of expenditures (U.S.$) from sport-hunting clients and operators to stakeholders in the Niassa National Reserve (NNR) hunting industry in 2010 (SGDRN, Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa [Society for Management and Development of Niassa Reserve]; solid lines, client expenditure; dark gray, >10% of $3,286,688; light gray, <10% of $3,286,688; dotted lines, expenditure by operators and SGDRN).

hunting operators (47%), taxidermists (24%), and travel agencies (13%) (Fig. 2). All operators derived a larger proportion of revenue from the daily rate ($17,200–$25,000) than from the trophy fee ($4,100–6,000). Although client expenditure for leopard hunting ($25,997) was less than that for elephants ($47,067) or lions ($65,255), more leopard safaris ($n = 16$) were conducted than lion ($n = 4$) or elephant ($n = 2$) safaris, and thus, leopard hunting contributed to higher gross revenues for concessionaires (Fig. 3a). In concessionaires, where human population density was relatively high and wildlife abundance relatively low, leopard safaris contributed 33% of the total operators' ($n = 4$) revenues ($712,597). Where human population density was relatively low and wildlife abundance was relatively high, leopard safaris were the second highest contributor (23%) to the operators' ($n = 3$) gross revenues ($806,273); revenues from buffalo hunting were the highest.

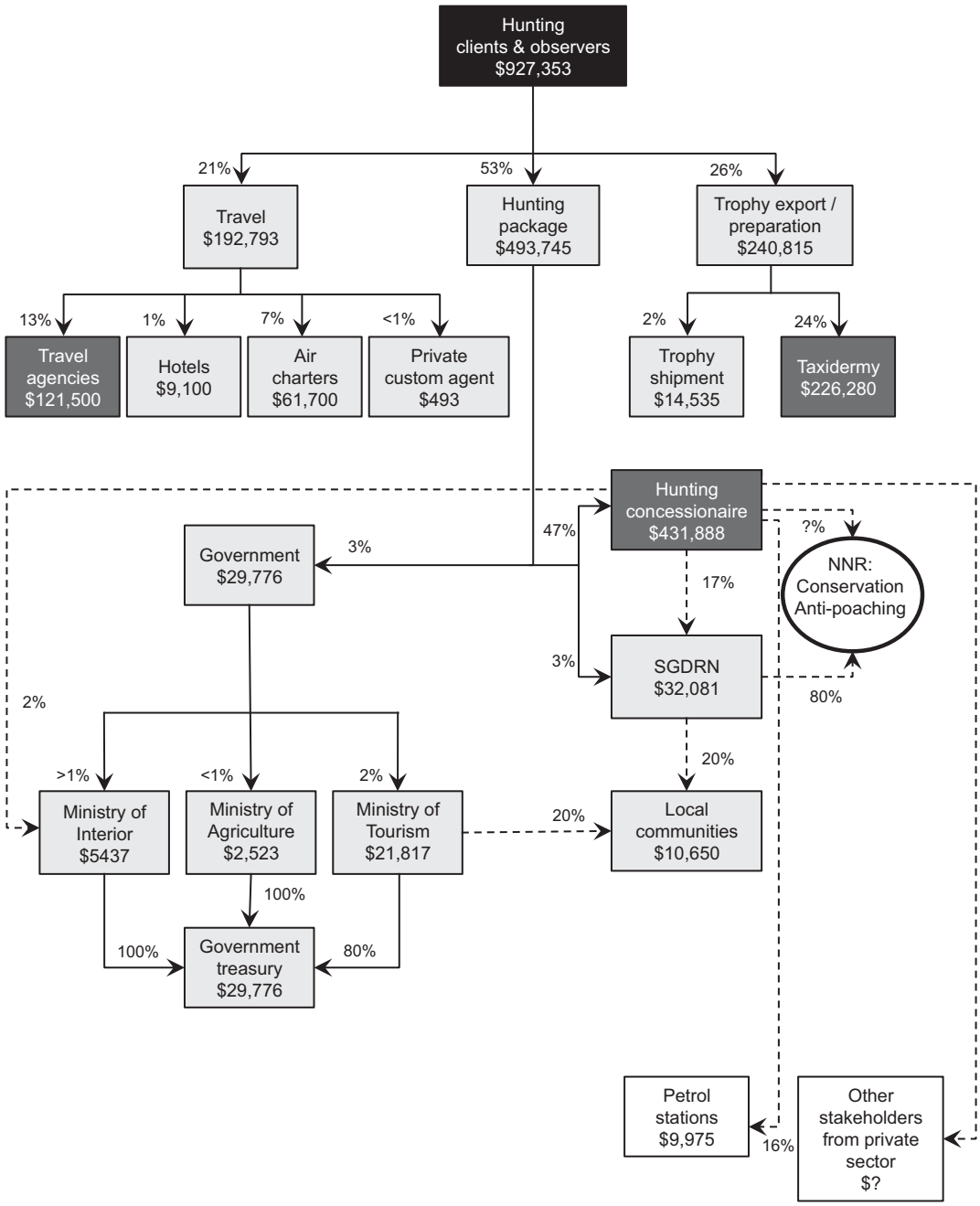

Figure 2. Distribution of expenditures (U.S.$) from leopard hunting (n = 16) in Niassa National Reserve (NNR) in 2010 (acronyms defined in legend of Fig. 1; solid lines, client expenditure; dark gray, >10% of $927,353; light gray, <10% of $927,353; dotted lines, expenditure by operators and SGDRN).

Leopards were generally perceived by 4 concessionaires as the second most important species, after elephants, for the hunting business (Fig. 3b). Only one operator, with no previous experience in NNR, ranked leopards as the least important species. The total revenue from leopard safaris was equivalent to 90% of the operators' annual costs of salaries for local workers, government taxes, fuel, and concession fees ($435,326) (Table 1).

There was a large difference between the estimated revenue generated from leopard sport hunting and that generated from leopard poaching (Table 1). In 2010, at least 2 leopard skins were reported by a former poacher to have been traded out of Mbamba village; each was sold for approximately $83 to an outside trader or traders. Predictably, many respondents (82%, $n = 130$ interviews) provided no estimation of the numbers of leopards killed in their villages. People from 2 of the 4 surveyed villages

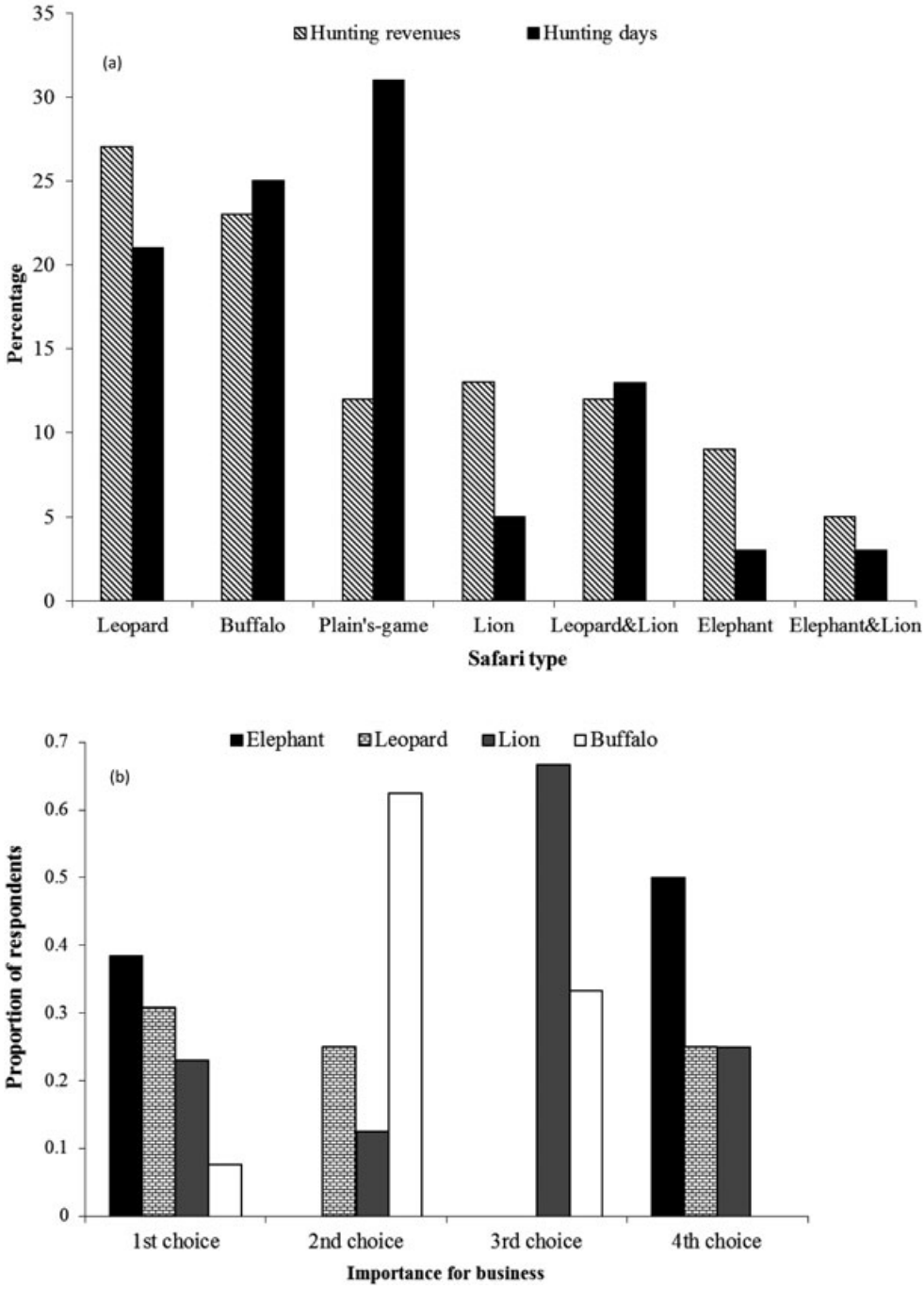

Figure 3. (a) Percentage of revenue to the operators gained from trophy fees and the percentage of hunting days from safaris during lion, leopard, buffalo, elephant, and plain's game hunts in Niassa National Reserve (NNR) in 2010 and (b) importance of trophies for particular hunting businesses as ranked by operators (n = 7) in NNR. Operators were able to select more than one animal for each category.

(28 respondents) provided an estimate of up to 4 leopards poached during the past year. This is likely an underestimate because in the same year in Mbamba village alone, 3 radio-collared female leopards were found dead in snares (C.B., personal observation). Of the respondents that provided estimates for the economic value of a leopard skin (63%, $n = 106$), 30% ($n = 48$) estimated the value as <$100, 27% ($n = 42$) indicated a skin was worth $100–$200, and a minority (10%, $n = 16$) provided estimates of >$200.

Six livestock owners (23% of 26 owners surveyed) reported losses of goats to leopards in 2009 and 2010. For these 6 households the monetary cost of depredation totaled $440 in 2 years; approximately $73 was lost by

Table 2. Number of goats owned and depredated by leopards and the attitude of people toward leopards in 4 villages surveyed in Lissongole–Cushiranga, Macalange, Mbamba, and Mussoma in 2010

			Attitude toward leopard		
Village	*Goats owned*[*]	*Goats depredated*	*like (%)*	*dislike (%)*	*indifferent (%)*
Lissongole–Cushiranga	1 (50)	1	26	68	6
Macalange	0 (32)	0	75	25	0
Mbamba	0 (24)	0	79	8	13
Mussoma	51 (52)	10	33	62	4
Total	52	11			

[*]*Number of people surveyed is in parentheses.*

each household. Despite the low occurrence of leopard attacks on goats, the loss was high for individual households when it occurred because average monthly household income was <$100 for employed people in the villages surveyed. More people from villages where leopards killed goats reported negative attitudes toward leopard than people from villages with no recent records of leopard attacks (Table 2). Twenty-seven percent of villagers stated that they did not know how to prevent leopard attacks. Others stated that goats should be kept in corrals at night (58%), leopards should be removed from NNR (9%), and domestic dogs should be used to protect goats (7%). People with positive attitudes toward leopards (61%, $n = 56$) were more likely to propose corralling to protect the animals than those with negative attitudes ($\chi^2 = 42.41$, df $= 2$, $p < 0.01$). All individuals who proposed drastic measures such as removal of leopards from the reserve to prevent attacks on goats were indifferent ($n = 1$) or disliked leopard ($n = 13$). Eighty-five percent of goat owners ($n = 22$) reported the use of corrals. The rest reported keeping goats in unfenced yards. Of the goats killed by leopards, 7 were inside corrals and 4 were in unfenced yards.

Villagers valued leopards mainly for bringing hunting and photographic tourists (58%, $n = 91$) to the area, for preying on crop-raiding wild animals (15%, $n = 24$), for skin (10%, $n = 16$), and for the usefulness of body parts for medicinal purposes (3%, $n = 4$). Some villagers claimed to not know the importance of leopards (13%, $n = 21$) or considered leopards unimportant (1%, $n = 2$). The potential economic benefits accruing to individual households in Mbamba from leopard hunting (<$1) and sport hunting in general ($19) were much less than losses from goat depredation ($73) and benefits from poaching ($83).

Discussion

Our study represents the first assessment of the contribution of sport-hunting revenues to socioeconomic development at local and national levels in Mozambique. As in South Africa (Balme et al. 2010), leopards were one of the most important species in the NNR sport-hunting industry. Although data reflect only the revenues generated from sport hunting, the estimated daily expenditure per leopard hunter ($2587), who stayed for an average of 14 days, was 6 times higher ($440) than that spent by photographic tourism clients, who stayed for an average of 2.5 days at the single operational ecotourism camp in NNR (SGDRN, unpublished data).

The overall revenues to stakeholders from the legal hunting of one leopard ($33,783) greatly exceeded the revenue from poaching ($83) of one leopard. However, the illegal hunting of each leopard would still generate more money for an individual villager compared with the annual 20% benefit share from sport hunting of one leopard (<$ 0.1). If a minimum of 2–4 leopards were killed in each of the 40 villages in NNR each year, the illegal off-take of leopards would be much higher than the legal off-take of 20–25 total leopards per year for the whole reserve (SGDRN, unpublished data). The revenues provided from sport hunting of leopards for conservation in NNR and for protected areas nationally were substantial ($181,555); poaching provided no revenue for conservation activities.

The low level of human–leopard conflict and relatively few livestock depredated in NNR suggest leopards are generally poached because of the economic value of their skins rather than in retaliation for livestock depredation. The estimated numbers of poached leopards obtained from interviews are an underestimation; nonetheless, our estimates and the data from the snaring of radio-collared leopards and turnover rates of individual leopards (A.J., unpublished data) confirm a considerable illegal trade in leopard skins in the NNR. Application of a randomized response technique (as per St. John et al. 2010) will be critical to advancing current knowledge of poaching of leopards in NNR.

Regardless of the actual number of leopards poached, a single leopard skin provides approximately a month's salary ($83) (SGDRN, unpublished data) in NNR at almost no cost to poachers. Although this is much less than the average revenue generated from the sale of ivory from a single poached elephant ($2500) (SGDRN, unpublished data), poaching of a leopard would constitute a large

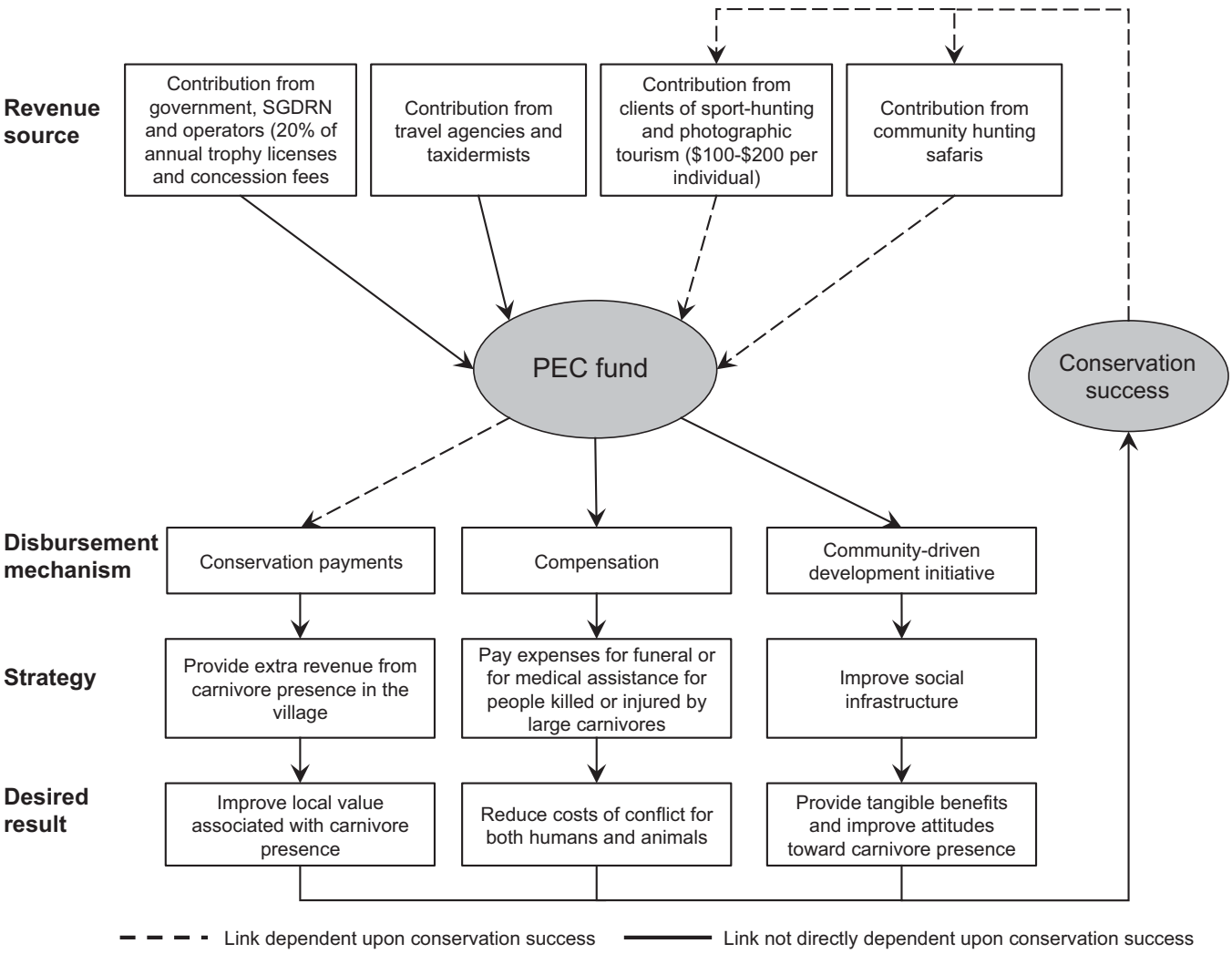

Figure 4. Payments to encourage coexistence (PEC) with different strategies combined under a single scheme to encourage carnivore conservation in Niassa National Reserve. Modified from Dickman et al. (2011) with permission.

source of income for a local hunter (Kühl et al. 2009). Because, poachers can seldom afford to pay the minimum fine for leopard poaching ($453) (DNFFB 1999), increasing the opportunity costs through more effective antipoaching measures (Messer 2000) and providing alternative sources of income may help reduce poaching (Kühl et al. 2009).

Despite the low occurrence of livestock depredation in NNR, people from affected villages had negative attitudes toward leopards. The failure of corrals to protect livestock was most likely due to poor design and construction, as reported elsewhere (Oli et al. 1994; Ogada et al. 2003; Namgail et al. 2007), where corrals are built to enclose goats rather than exclude predators (Namgail et al. 2007). The depredation of livestock by carnivores can be effectively reduced by improving enclosures (Begg & Begg 2011) and by providing incentives to the communities to protect their livestock (Namgail et al. 2007).

The high value of leopards to trophy hunters compared with the low value of leopards to communities poses a serious challenge for leopard conservation (Dickman et al. 2011), particularly in light of continued human population growth and related threats to populations of large carnivores in NNR (INE 2008*a*, 2008*b*). It is therefore critical to practice incentive-driven conservation in areas where people share land with large carnivores (Hutton & Leader-Williams 2003). Although the proportions of hunting revenues accrued to NNR communities (20%) were higher than those allocated to villages in Zambia (12%) (Lindsey et al. 2007) and Cameroon (10%) (Yasuda 2011), there is still a need to increase the revenues and improve benefit sharing among the communities within the reserve. To encourage coexistence with large carnivores

and to alter people's negative perception of leopards, communities should get higher revenues from sustainable sport hunting. These revenues should be awarded to individuals in the villages to compensate for the costs imposed by the presence of predators (Packer et al. 2009). For instance, carnivore populations in communal lands in Namibia are increasing, mainly because people receive substantial revenues from sport hunting and consequently value these hunted carnivores (Frank 2010). By contrast, expanding human populations and the associated problems in sport-hunting management has led to a decline of lion and leopard populations in some areas in Tanzania (Packer et al. 2011).

Recently, Dickman et al. (2011) proposed that payments to encourage coexistence (PEC) be made. Such payments have the potential to meet both social and ecological objectives for carnivore conservation. We believe that through coordinated efforts of stakeholders in the NNR hunting industry, a PEC scheme could be implemented that would improve local livelihoods and foster conservation of large carnivores (Fig. 4). By giving user rights to NNR communities, they could operate leopard safaris in partnership with local operators and retain most of the safari revenue for the fund (V. Booth, personal communication). The revenue loss for the hunting operators would be minimal compared with the economic gain for local communities. Thus, communities become engaged in the sport-hunting business and incentives to poach leopards are reduced (Bunnefeld et al. 2011). A similar approach was proposed for losses of livestock to predation by leopards in Namibia (Stein et al. 2010), and this strategy has been key to the conservation of jaguar (*Panthera onca palustris*) in human-dominated landscapes in Mexico (Rosas-Rosas & Valdez 2010).

Furthermore, through agreements with NNR operators, reputable taxidermists and travel agencies in the United States and Europe could be granted exclusive rights to provide services to NNR clients in return for contributing a certain percentage of their profits to the PEC scheme. Hunting clients are prepared to support conservation initiatives (Lindsey et al. 2006); therefore, an additional fee ($100–200 per client) could be charged to finance the PEC scheme. Economic incentives proposed for local communities participating in PEC schemes, directly linked to the presence of large carnivores, encourages people to conserve them (Salafsky & Wollenberg 2000). The difficulty will be to determine an accurate indicator of carnivore presence that can be reliably measured and can be directly linked to conservation performance (i.e., a decrease in illegal off-take or retaliatory killing) and does not simply reflect natural cycles in the carnivore population (Sachedina & Nelson 2010).

High levels of illegal hunting pose a serious risk to the long-term sustainability of sport hunting of large carnivores. The sport hunting of leopards is critical to the ongoing economic sustainability of all sport-hunting operations in NNR. Sport hunting inside the protected area generates substantial revenue for the operators and substantial funds for conservation in NNR through concession and trophy fees. However, because revenue accruing to communities from leopard hunting and sport hunting in general is so low and because there is no direct link between leopard conservation and these revenues, sport hunting is currently not providing a positive incentive for leopard conservation by communities in NNR.

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Supporting Information

A map of the study area (Appendix S1) and the verbal (Appendix S2) and written questionnaires (Appendix S3) are available online. The authors are responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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