



Desert-adapted lions on communal land: Surveying the costs incurred by, and perspectives of, communal-area livestock owners in northwest Namibia

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ABSTRACT

Though subsistence pastoralism is the primary land-use throughout much of Africa, lions (*Panthera leo*) living outside protected areas are largely overlooked in discussions of pan-African lion conservation. In northwest Namibia, a unique population of desert-adapted lions has grown by > 400% over the past twenty years. This growth has primarily taken place upon communal conservancy land. Human-caused lion mortality following human-lion conflict (HLC) is now the primary direct threat to the persistence of these lions. HLC exacerbates challenges faced by pastoralists from an ongoing drought. Our survey is the first-ever attempt to quantitatively and qualitatively examine local pastoralists' perceptions of the desert-adapted lions and the impacts of living with lions in northwest Namibia. Results show that losses, due to drought and lions, are differentiated by livestock species and that the magnitude of livestock losses during the drought has been exacerbated by predation. Respondents in different conservancies reported different levels of hostility towards lions. Across all conservancies, though 83.9% do not benefit from living with lions, 75.9% state that it is important to continue to share communal land with lions. We discuss the cultural and livelihood effects of livestock losses as well as the implications of balancing the costs and benefits of living with lions for lion conservation.

1. Introduction

In the past twenty-plus years African lions (*Panthera Leo*) have decreased by 43% (Bauer et al., 2016). Recent studies emphasize the importance of Protected Areas (PAs) as the “backbone of conserved landscapes” (Bauer et al., 2015b; P. A. Lindsey et al., 2018, p. E10793). Reviewing lion population densities and population trends across 42 sites in 11 countries, Packer et al. (2013) conclude that lion populations within fenced reserves are closer to estimated carrying capacity than unfenced populations. However, PAs are a partial solution to the challenges facing Africa's lions: only 1/3rd of PAs maintain lions at 50% carrying capacity (Jacobson and Riggio, 2018). Furthermore, PAs have been challenged by social justice advocates and researchers for being dispossessive, exclusionary, and for entrenching economic inequalities (Brockington, 2002; Dieckmann, 2007; Neumann, 1998). Government instability, corruption, and funding shortfalls have already put many of Africa's PAs in peril. Viable alternatives to PAs are an important part of ensuring the future for lions in Africa.

Subsistence pastoralism is the primary land-use throughout much of arid and semi-arid Africa, and continued human population growth will

likely increase pressure on rangelands across the continent. If lions and subsistence pastoralists are unable to coexist, it is likely that lion range will continue to disappear. A growing body of research examines the potentials of conserving lions within landscapes shared by subsistence pastoralists (e.g. Románach et al., 2007; Hazzah et al., 2014; Dickman et al., 2014). Among the key threats to lions in places where their range overlaps with humans and livestock are retaliatory killings following human-lion conflict (HLC) incidents (Jacobson and Riggio, 2018; P. Lindsey et al., 2018). Better understanding the drivers of HLC and implementing mitigation measures to combat HLC have been shown to reduce lion killings by subsistence pastoralists (Hazzah et al., 2014).

Northwest Namibia is one of the few places where lion numbers have increased on communal land during the past twenty years (Bauer et al., 2015b; Stander, 2018). Here, a unique population of desert-adapted lions has grown from a low of approximately 20 individuals in 1997 to an estimated 180 in 2015 (GRN, 2016; Stander, 2019). Whereas by the late 1990s, regional lion range had contracted to approximately 7000 km², these lions now range across > 40,000 km² (GRN, 2016) (Fig. A.1). This almost 400% population increase has primarily taken place upon unfenced communal conservancy land; a unique

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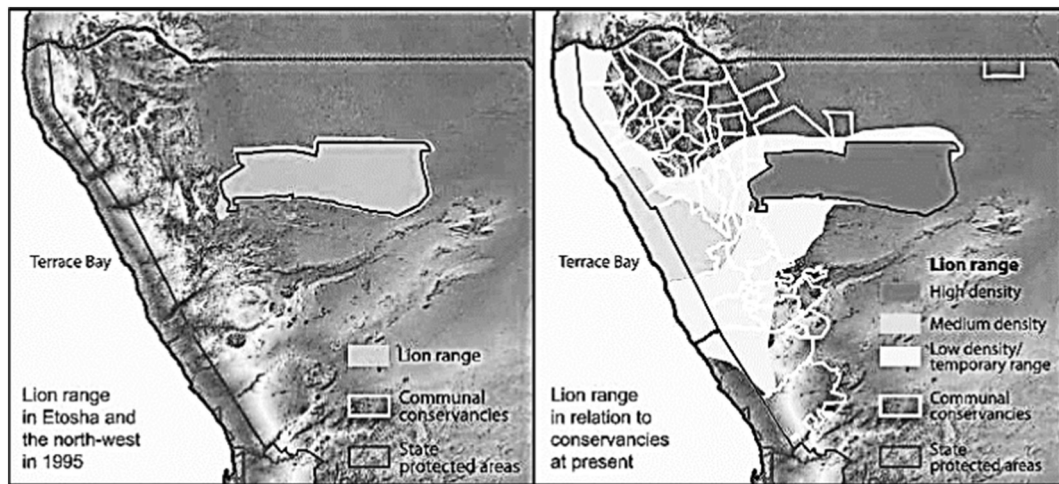


Fig. A.1. Lion range expansion in Northwest Namibia, 1995–2015. Reprinted from NACSO, 2016, 40.

community-based natural resource management (CBNRM) success story (Jones, 2010; Owen-Smith, 2010). However, this success has been accompanied by HLC. Since 2000, human-caused mortalities have accounted for 80% of adult lion mortalities, and 100% of sub-adult (non-cub) lion mortalities, with the knock-on effect that HLC mortalities disproportionately target males, skewing the population's sex-ratio to 5.4 females per male (Stander, 2018). As the number one cause of lion mortality, such preventative and retaliatory killings are an important challenge facing this population.

Data in the form of 'Event Books' (Stuart-Hill et al., 2005) gives an overview of HLC incidents at a conservancy-wide level, though these data do not measure the household-level impacts of HLC, nor examine farmer tolerance for living with lions. In 2017, Namibia's Ministry of Environment and Tourism (MET) implemented the *Human Lion Conflict Management Plan for North West Namibia* (GRN, 2016); our survey is an outcome of that plan. This survey of farmers living in core lion-range conservancies was designed and implemented as part of an active, evidence-based approach to mitigate and ultimately prevent HLC. Our survey also examines how drought-related livestock losses are compounded by HLC in these conservancies. Northwest Namibia has been gripped by a region-wide drought, broadly considered to have begun in 2011/12. Early estimates (2012–2013) indicate a 45.8% drop in rainfall (Schneegg and Bollig, 2016, p. 66). Since the beginning of the drought, indicator species have substantially declined (Fig. B.1). Among conservation practitioners in the region, the drought is thought to have drastically constrained livelihoods and limited farmer tolerance for HLC.

This survey is a quantitative and qualitative first step towards better understanding the impacts of desert-adapted lions on rural livelihoods in light of drought conditions and the willingness of rural community members to live with lions in core lion-range conservancies. The costs and benefits of living with lions were assessed. Costs were assessed in terms of livestock losses and benefits were assessed in terms of perceived intrinsic and instrumental value that lions provide to respondents. The survey was designed and implemented to meet the following objectives:

1. Record the effect of the recent drought on households by quantifying livestock losses.
2. Record the effect of predation on livestock over the same period.
3. Estimate the value of livestock lost to all causes, all predators, and lions in particular.
4. Record household-head perceptions of the benefits received from living with lions.

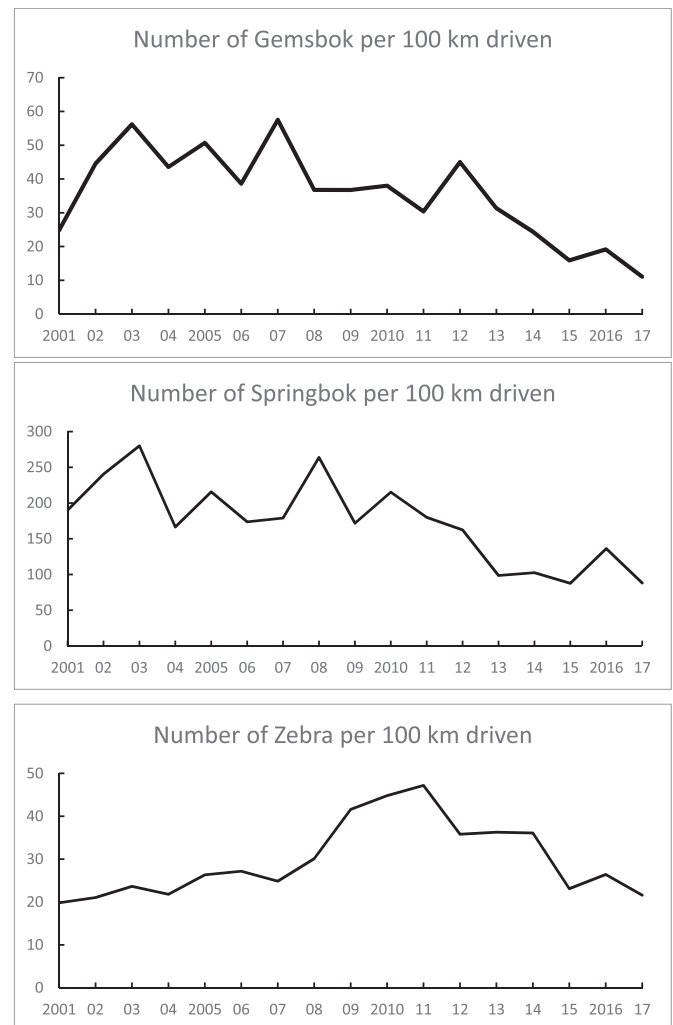


Fig. B.1. Estimated populations of three indicator species, based upon north-west road-based game count.

5. Assess household-level willingness to share communal conservancies with lions going forward.

1.1. Background

The desert-adapted lion population inhabits the Skeleton Coast National Park (SCNP) and communal conservancies within and bordering the northern Namib desert. Because the SCNP and communal conservancies remain entirely unfenced, desert-adapted lions move relatively freely through the landscape. Historically, lions occurred throughout northern and central Namibia (Shortridge, 1934). By the 1970s persecution on commercial (white) farmland coupled with increasing availability of firearms within the ‘homelands’ (Owen-Smith, 2010) meant that as many as 90% of Namibia’s lions were confined to Etosha National Park (Joubert and Mostert, 1975). This remained the case throughout the 1980s and 1990s: what few lions persisted in the northwest outside of Etosha lived a marginal existence, hunting and scavenging along the Skeleton Coast (Bridgeford, 1985); in one case even resorting to preying upon people (Reardon, 1986). At its lowest ebb the northwest population may have been entirely confined to one mountainous area in the Sesfontein Conservancy (Stander, 2018).

Following Independence in 1990, the Nature Conservation Amendment Act (No. 5 of 1996) empowered communities inhabiting communal land to form communal conservancies: officially-registered, legally-recognized entities to manage natural resources within a defined, community-agreed-upon, jurisdiction. Each conservancy must pass a constitution for governing environmental affairs and outlining how benefits from wildlife will flow to members (NACSO, 2015). Communal conservancies are based upon four pillars of CBNRM: sustainable use as a conservation paradigm, market-based valuing of resources (economic instrumentalism), locals empowered with decision-making rights (devolutionism), and local, community level ownership of resources (collective proprietorship) (Jones and Murphree, 2004). There are currently 83 registered conservancies in Namibia, covering 163,017 km², and > 189,000 residents. About the same time the first conservancies were registered, an Etosha National Park ranger, Philip Stander, moved permanently to the northwest to study the local lions.

1.2. Study area

Lions now range across many of northwest Namibia’s 36 communal conservancies, with varying HLC effects. Using more than nineteen years of satellite and VHF collaring data, in 2017 MET identified four core lion-range conservancies where HLC is critical (GRN, 2016). Three conservancies, Anabeb, Puros, and Sesfontein, assented to have farmer surveys implemented (Fig. C.1, Table A.1). Typical of conservancies in northwest Namibia, these three areas are characterized by vast, rugged landscapes, limited population, and erratic rainfall. All three conservancies border other communal conservancies as well as land set-aside for non-consumptive tourism. Anabeb and Sesfontein conservancies border the Palmwag Concession – an area set-aside for wildlife tourism. SCNP makes up the western border of both Puros and Sesfontein conservancies. Livestock and hunting are prohibited in Palmwag and SCNP. Each of the three conservancies have contracts for trophy and own-use hunting. In late 2016, because of concern over falling wildlife numbers due to the ongoing drought, MET placed a moratorium on shoot-and-sell hunting, prohibiting conservancies from shooting game to sell the resulting meat.

Anabeb, Puros, and Sesfontein are among the wealthiest conservancies in northwest Namibia, as measured by annual conservancy income from all sources (NACSO, 2018), and all three fall within the Sesfontein constituency, where 40% of the population live on ≤US\$1/day and 23% live on < US\$0.73/day (GRN, 2012). Nomadic pastoralism is the primary source of income, but all three conservancies are north of a country-wide veterinary fence, colloquially known as the “Red Line,” that prohibits the exportation of livestock to the country’s

premier markets in central and southern Namibia (Bollig and Olwage, 2016; Miescher, 2012). Livelihoods are limited by a marginal economy that developed during more than a century of German and South African rule (Bollig, 1998; Owen-Smith, 2010; Rizzo, 2012). The conservancies are largely composed of Herero/Himba people, who migrated from central Africa between the 10th and 18th centuries (Borg and Jacobsohn, 2013), and Damaras who have lived in northwest Namibia even longer (Lau, 1987).

2. Materials and methods

A growing body of literature examines the effects of conflict on local perceptions of carnivores and livelihoods within rural African communities. Following Dickman et al. (2014) and Hazzah (2006) with feedback from the Save the Rhino Trust – Namibia, Lion Guardians (Tanzania and Kenya), and Integrated Rural Development and Nature Conservation (IRDNC) staff, data were collected using semi-structured surveys applying techniques of rapid and participatory rural appraisal (Chambers, 1994). Responses cover six main areas: (i) demographic and background data; (ii) coarse-grain employment and income-source data to assess the role of livestock husbandry in household livelihoods; (iii) household livestock data focusing on four species: cattle, sheep, goats, and donkeys, including perceived value of livestock and recent livestock losses to all causes, including predation; (iv) perceptions of where lion problems occur, how they can be prevented, and effectiveness of mediation programs; (v) lion-specific livestock losses and lion conflict issues; (vi) benefits resulting from and attitudes towards lions. The semi-structured surveys sought both quantitative and qualitative information, with respondents encouraged to provide relevant details. Where appropriate, specific quantitative responses were sought. However, if respondents were uncertain about numbers – e.g. the number of cattle they had three years ago – they were asked to estimate. Attitudes towards lions were surveyed using a series of Likert-scale responses adapted from a recent Save the Rhino Trust – Namibia survey of regional farmers and herders (Unpublished Survey: Rhino Reporting Final Survey, Farmers and Herders, 2016).

Surveys were conducted with the assistance of conservancy-employed environmental resource monitors known as Conservancy Game Guards, who were requested to identify every livestock-owning household within the conservancy. Sampling was limited to one response per household. Surveys of household heads were performed in situ in each of the three conservancies at a variety of locations. In each case we asked for the household representative most familiar with the household’s livestock – this was almost uniformly the senior member of the household, and always the senior male when present, in keeping with local custom. Though we did not manage complete coverage – some household heads were absent – these surveys cover > 80% of livestock-owning households within the three conservancies. No one refused to participate – respondents generally answered every question, though in some instances a few questions were missed. Surveys were administered in the preferred language of the respondent, including English, Afrikaans, Otjiherero, and Damara and generally took 35–45 min. All translations were done by JT. We recognize the difficulty of perfectly rendering survey questions across numerous language barriers and worked carefully to ensure question and response fidelity. All responses were recorded on standardized survey forms by JH, and all surveys were audio recorded on an audio recorder in mp3 format. Data were entered by JH into Microsoft Excel. Statistical analysis was performed by JH and CP in Microsoft Excel and using Vassar Stats statistical computation website (VassarStats, 2018).

To assess livestock losses during the ongoing drought we asked respondents to compare current livestock numbers to numbers three years earlier. We recognize that losses in a clearly defined three-year window are difficult to quantify; the general impression was that respondents were comparing current numbers to pre-drought livestock numbers. The fluidity of time-scale is not considered problematic: we sought to

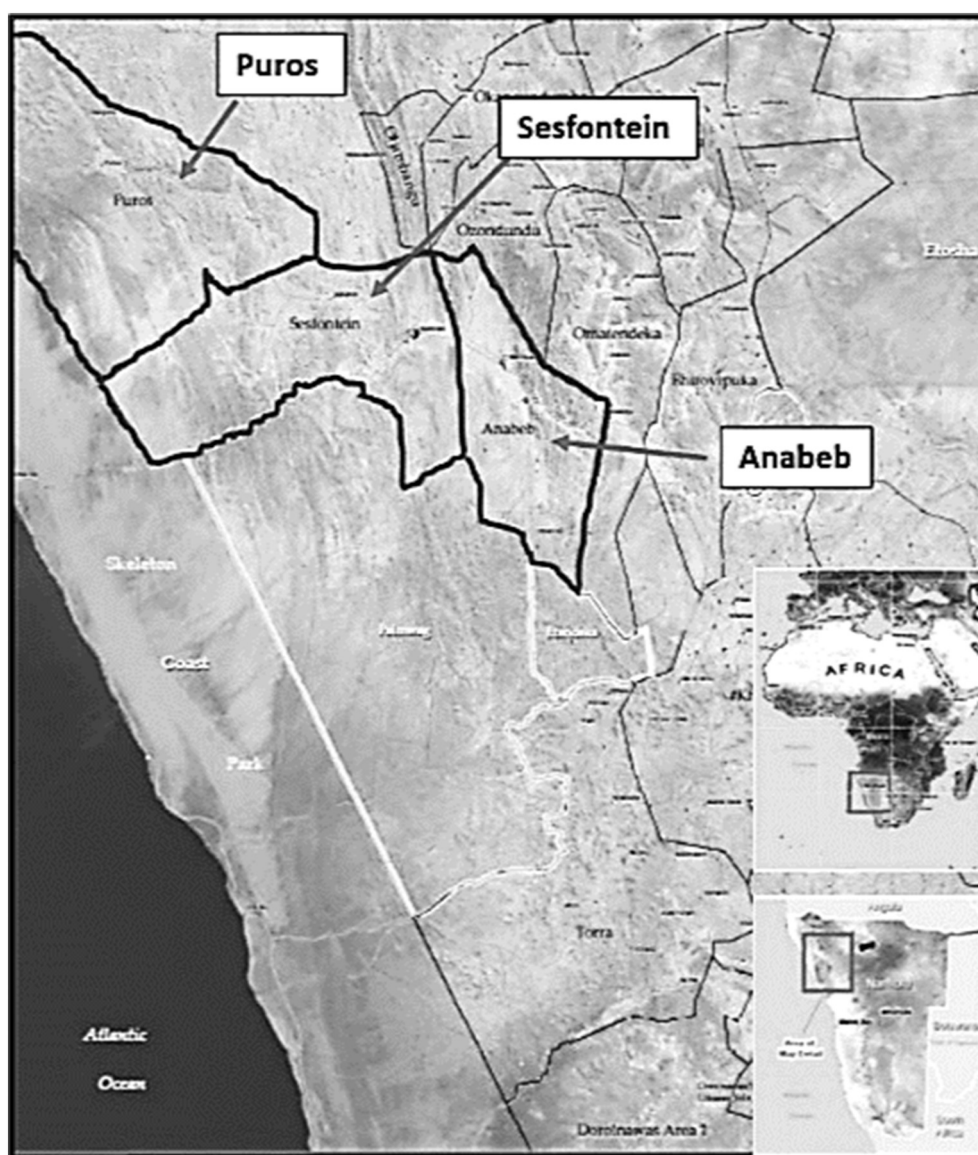


Fig. C.1. Core lion-range conservancies surveyed.

Table A.1
Surveyed conservancy background information.

Conservancy	Date gazzatted	Population	Area (km ²)	Density	Annual rainfall (mm)
Anabeb	2003	1402	1570	0.893	150–250
Puros	2000	641	3562	0.18	50–150
Sesfontein	2003	1491	2465	0.605	50–150

capture trends related to the recent drought; everyone agreed that the region had been suffering from drought. Respondents were asked to estimate the value of four livestock species – cow, goat, sheep, and donkey – on the basis of an average-size adult female. The estimated value of livestock lost over the past three years, was derived by multiplying the number lost by the value given by each respondent for that species. Though this means values were not standardized across households, we feel this method better conveys the *perceived* economic loss. This approach is also necessitated by the lack of access to livestock markets among farmers in the area, which is part of the ongoing legacy of colonialism and apartheid (Bollig, 1998; Miescher, 2012; Wolputte, 2013). When a set list of possible responses was available – e.g. “how

common are lion in your conservancy:” a) very common; b) common; c) rare; or, d) not present – respondents were given the chance to answer freely. Where responses to questions contained discrete answers – e.g. “how would you describe the problems you have with lions: none, low, moderate, or serious?” – these levels were not defined. Surveys allowed ample space for follow-up discussions and comments. Whenever possible, comments were noted and used to clarify responses.

3. Results

3.1. Demographics

85 respondents representing 36 different farming areas were interviewed; two respondents provided apparently fantastical responses that could not be verified and were therefore dropped from analysis. 77.1% of respondents identified as Herero/Himba and 18% identified as Damara. The rest were either Owambo or Nama. 78.3% of respondents were male, and 21.7% were female. When the respondent's age was known, the mean age given was 50 years old. Of the ten respondents who did not know their age, nine stated they were over 60 – because they were receiving government pensions. Among known ages,

Table B.1

Summary of household-level livestock ownership among survey respondents, comparing livestock ownership in 2017 (October to December) to livestock ownership three years prior. μ , mean number of specific type of livestock owned; med, median number of specific type of livestock owned; skew, Pearson's second skewness coefficient, positive value indicates rightward skew among responses; min, minimum number of specific type of livestock owned; max, maximum number of specific type of livestock owned; total, total number of specific type of livestock owned across all respondents; n responses; number of respondents for each specific type of livestock. 2 Summary of percentage of remaining livestock, compared to three years earlier.

1		μ	μ '17	med	med '17	skew	skew '17	mizn	min '17	max	max '17	total	total '17	n response
Stock ownership, three years prior & 2017 household-level	cattle	48.2	10.3	25	4	0.870	0.940	0	0	500	140	4003	854	83
	sheep	28.7	11.0	20	5	0.769	0.865	0	0	200	150	2381	911	83
	goats	143.0	71.0	100	50	0.937	0.920	0	0	600	300	11867	5894	83
	donkeys	5.1	1.6	4	1	0.606	0.769	0	0	25	11	415	129	82
2														
Percentage Remain per Species, by household	cattle		32.1%		16.7%		0.92							77
	sheep		43.6%		36.2%		0.53							68
	goats		91.1%		50%		0.793							81
	donkeys		39.5%		27.6%		0.684							63

respondents ranged from 19 to 83 years. 45.8% of respondents reported having no formal schooling, though 27.7% had advanced to grade nine or above. Respondents had lived in their conservancy, or what became their conservancy, for a mean of 36.6 years. For religious affiliation, 68.7% of respondents identified as Christian, 8.4% identified as practicing a traditional religion, while 22.9% stated no religious practice.

All respondents reported keeping livestock for personal consumption, 77.1% also sold livestock. 15.7% of respondents reported livestock as their only source of income. 32.5% receive government pensions; the same amount receive government assistance for their children (not mutually exclusive). 37.3% receive at least one salary, primarily as a conservancy Game Guard or from a nearby tourism operation. 19.3% have one source of income, 44.6% have two, and 31.3% have three.

3.2. Livestock

Livestock ownership was unevenly distributed and skewed rightwards for all species, both currently and in the past (Table B.1). The drought appears to have exacerbated inequalities in livestock ownership: the measure of skewness (Pearson's second skewness coefficient) reveals that inequality in livestock ownership has increased across three of the four types of livestock – inequality of goat ownership is somewhat decreased, though still right-skewed.

Concentration of livestock among the wealthiest stock-owners has risen (Fig. D.1). In many cases, those households among the top five in cattle ownership are also among the top five in ownership among other stock species. The heads of such households, particularly those predominating in cattle, occupy central places in each of the conservancies and their wealth is well-known in the region.

The drought has greatly affected livestock ownership in the corelion range conservancies. The mean size of household cattle, sheep, and donkey herds has greatly decreased (Table B.1). Other predatory species (spotted hyenas, leopards, cheetahs) and lions did not account for the majority of livestock losses (Table C). Nevertheless, the toll on cattle and donkey herds by lions in particular has exacerbated losses due to drought (Table D).

To gauge the value of lost livestock, we asked respondents to estimate the monetary cost (in Namibian dollars) of an average-sized adult female for each species. The average value given for a cow was US \$468.21 ($n = 77$), US\$86.37 for a sheep ($n = 75$), US\$109.14 for a goat ($n = 79$), and US\$70.76 for a donkey ($n = 74$) (Table E.1). As with livestock numbers, the values of lost livestock are skewed rightwards, indicating that the economic losses during the drought were not evenly distributed.

The mean number of cattle lost per household to all predators over the past three years was 7.7 (median 4.5; skew 1.036; total: 575). The mean number of sheep lost to all predators was 14.65 (median 6; skew 1.19; total: 923). The mean number of goats lost to all predators was

34.8 (median 19.5; skew 0.983; total 2784). The mean number of donkeys lost to all predators was 3.34 (median 3; skew 0.253; total 197). The estimated values of these lost livestock are given in Table E.2.

The mean number of cattle lost to lions over the past three years was 4.32 (median 2; skew 0.895; total 324). The mean number of sheep lost to lions was 0.2 (median 0; skew 0.405; total 13). The mean number of goats lost to lions was 1.89 (median 0; skew 0.721; total: 153). The mean number of donkeys lost to all lions was 2.267 (median 1; skew 0.986; total: 136). The estimated value of livestock lost to lions is given in Table E.3.

3.3. Perceptions of lions

Responses varied by conservancy as to how common lions are within a respondents' conservancy (Table F.1). No respondents stated that lions were absent in their conservancy; one was unsure. Though respondents were not asked to define what was meant by "very common," "common," etc., recent killings of problem lions in Puros Conservancy in 2016/17 (Stander, 2017) suggest lion prevalence was considered relative to past prevalence.

86.7% stated that lions are a serious problem in their conservancy. There was a weak, though significant correlation between the presence of lions ("very common," "common," or "rare") and the extent to which respondents felt lions were a serious problem ($R^2 = 0.3227$, $F(1, 83) = 3.0877$, $p < 0.01$).

When asked, "do you benefit from lions in your conservancy" 84.3% responded "no." However, when asked "is it important to continue to have lions in your conservancy," 75.9% of respondents stated "yes." There was no significant correlation between benefiting from lions and feeling they are important to have in the conservancy. When asked why lions are important, respondents gave varying answers. Categorized according to intrinsic versus instrumental value of lions, 33.3% stated that it was important to have lions for their potential instrumental value – primarily because they *could* provide the conservancy with benefits through hunting or tourism. In contrast, 61.9% stated lions were important for primarily non-instrumental reasons – e.g. so their children could see lions, or because lions have intrinsic value.

The percentage of cattle lost to lions has a significant effect on whether or not respondents felt it is important to continue to have lions in their conservancy (Mann-Whitney Z score = 5.66105, $n_1 = n_2 = 71$, $p < 0.001$, two-tailed). There was likewise a significant relationship between the percentage of goats (Mann-Whitney Z score = 7.97561, $n_1 = n_2 = 79$, $p < 0.001$, two-tailed) and donkeys (Mann-Whitney Z score = 5.14006, $n_1 = n_2 = 59$, $p < 0.001$, two-tailed) lost to lions and whether or not respondents felt it is important to continue to have lions. In all three cases higher losses are associated with more negative perceptions of lions within the conservancy. There were insufficient incidents to test for effects of sheep losses.

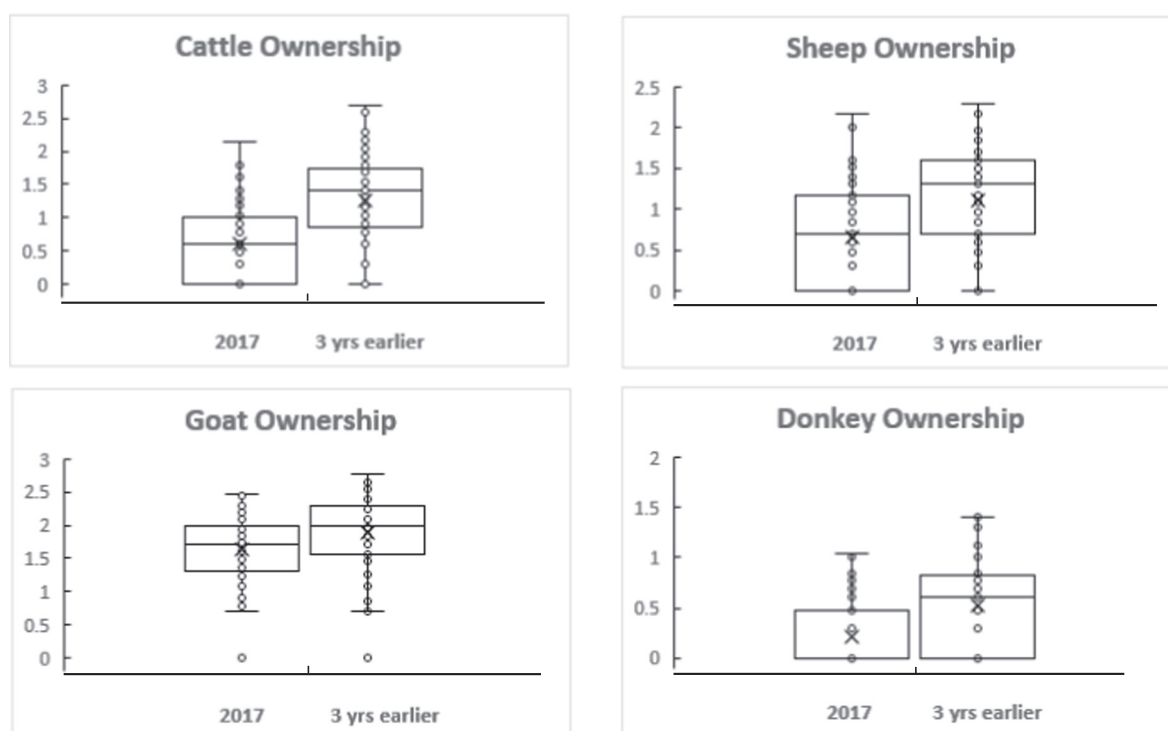


Fig. D.1. Boxplots display self-reported household-level livestock ownership for each individual species, comparing 2017 ownership to three years earlier. Data has been log10 transformed. This visualization demonstrates that livestock ownership is unequally distributed – concentrated within a few relatively wealthy households – and the recent livestock losses experienced have somewhat exacerbated this concentration. Currently the top five cattle owners possess 43% of the cattle (367 of 854), compared to 38.7% three years ago (1500 of 4003). The top five sheep owners hold 39.3% (358 of 911), compared to 27% (644 of 2381). The top five donkey owners have 31.8% (41 of 129), compared to 23.9% (99 of 415). In contrast, the top five goat owners keep 19.9% (1170 of 5894), compared to 20.3% (2410 of 11,867). Currently 31.1% of respondents own no cattle, while 34.9% own no sheep, and 48.7% own no donkeys. In contrast, three years ago, only 7% owned no cattle, while 18% owned no sheep, and 23.2% owned no donkeys. Ownership of goats is relatively unchanged (1.2% currently not owning goats versus 2.4% three years ago). Moderate correlation for relative livestock ownership between current and three years ago exists for each species. Cattle: $R^2 = 0.439$, $F(1, 83) = 4.391$, $p < 0.001$. Sheep: $R^2 = 0.702$, $F(1, 83) = 8.882$, $p < 0.001$. Goats: $R^2 = 0.633$, $F(1, 83) = 7.36$, $p < 0.001$. Donkeys: $R^2 = 0.565$, $F(1, 83) = 6.157$, $p < 0.001$. This indicates that household position regarding one another in terms of livestock ownership is mostly unchanged.

Table C

Summary of number of livestock lost. 1 Losses directly due to all predators. 2 Losses directly due to lions. Column headings: μ , mean number of losses due to predators per species; med, median number of losses due to predators per species; skew, Pearson's second skewness coefficient. For 1, values are mixed by species: losses of cattle, goats, and sheep are relatively skewed rightwards while donkey losses are relatively uniformly distributed. For 2, values for cattle, goats, and donkeys indicate that losses are relatively concentrated among particular respondents, while sheep-loss data come from only a single event.

		μ	Med	Skew	Total lost
1					
Number	Cattle	7.7	4.5	1.036	575
Lost per species to predators, by household	Sheep	14.65	6	1.19	923
	Goats	34.8	19.5	0.983	2784
	Donkeys	3.34	3	0.253	197
2					
Number	Cattle	4.32	2	0.895	324
Lost per species to lions, by household	Sheep	0.2	0	0.405	13
	Goats	1.89	0	0.721	153
	Donkeys	2.27	1	0.986	136

When asked, if a lion kills some of your livestock tomorrow, what will you do, 39.7% stated they would “kill it” or try to kill it. However, the relationships between percentage losses of cattle and donkey and a response of “kill it” were not statistically significant; for goats the relationship was significantly negative (Mann-Whitney Z score = -3.7695 , $n_1 = n_2 = 78$, $p < 0.001$, two-tailed).

When asked, if a lion kills some of your livestock tomorrow, what

Table D

Summary of percentage of livestock losses. 1 Losses directly due to all predators. 2 Losses directly due to lions. Column headings: μ , mean percentage of losses per species; med, median percentage of losses per species; skew, Pearson's second skewness coefficient. For 1, values are mixed by species, indicating losses of goats and sheep are relatively uniformly distributed while cattle losses skew slightly rightwards, and donkey losses skew greatly leftwards. For 2, values for cattle, goats, and donkeys indicate that losses are concentrated among particular respondents.

		μ	Med	Skew	n response
1					
Percentage	Cattle	28.9%	24.5%	0.464	70
Lost per species to predators, by household	Sheep	58.2%	60%	-0.134	55
	Goats	40.1%	38.8%	0.097	78
	Donkeys	62.7%	75%	-0.879	53
2					
Percentage	Cattle	18.4%	5%	1.412	77
Lost per species to lions, by household	Sheep	3%	0	0.436	58
	Goats	2.3%	0	0.715	78
	Donkeys	38%	25%	0.951	53

will you do, those respondents stating they do not benefit from having lions were not significantly more likely to say they will kill or try to kill the offending lion (Mann-Whitney Z score = -2.67899 , $n_1 = n_2 = 83$, $p < 0.01$, two-tailed). Among variables tested (whether respondents benefit from lions, whether they consider lions a serious problem, respondent's ethnicity, respondent's conservancy) only specific conservancy residence showed a significant correlation with a respondent's

Table E

Summary of household-level livestock value lost over the past three years. 1 Losses from all causes, including all predators during previous three years. 2 Losses from all predators during the same period. 3 Losses from lions during the same period. Column headings: μ , mean reported value lost per species; med, median reported value lost per species; skew, Pearson's second skewness coefficient, positive value reveals rightward skew among responses, indicating value lost by species is unevenly distributed; min, minimum value lost per species; max, maximum value lost per species; total, total reported value lost per species; n response; number of respondents assigning value for each specific type of livestock. Respondents never possessing a particular species were not questioned as to the value of that species, and could not have suffered losses to predators/lions.

		μ	Med	Skew	Min	Max	Total	n response
1								
Estimated value	Cattle	\$21,115	\$8000	0.878	\$0	\$274,400	\$1,562,556	74
Lost per species, US\$	Sheep	\$1712	\$704	1.157	\$0	\$17,280	\$121,606	71
	Goats	\$10,426	\$4800	1.298	\$0	\$67,680	\$719,428	69
	Donkeys	\$275	\$116	1.032	\$0	\$3360	\$18,987	72
2								
Estimated value	Cattle	\$4117	\$2400	0.93	\$0	\$32,000	\$288,240	70
Lost to predators per species, US\$	Sheep	\$1463	\$520	1.102	\$0	\$17,280	\$86,372	59
	Goats	\$4342	\$1728	1.275	\$0	\$28,800	\$334,400	77
	Donkeys	\$229	\$142	0.973	\$0	\$1120	\$12,392	54
3								
Estimated value	Cattle	\$2572	\$800	1.03	\$0	\$30,400	\$177,488	69
Lost to lions per species, US\$	Sheep	\$23	0	0.444	\$0	\$1200	\$1360	59
	Goats	\$228	0	0.688	\$0	\$6720	\$17,384	76
	Donkeys	\$162	\$54	1.284	\$0	\$960	\$8752	54

Table F.1

Summary of response to how common lions are in conservancies. Column headings: vcommon, percentage of respondents stating lions are very common in their conservancy; common, percentage of respondents stating lions are common in their conservancy; rare, percentage of respondents stating lions are rare in their conservancy; n response; number of respondents. (No respondents stated that lions were absent in their conservancy; one was unsure.)

		Vcommon	Common	Rare	n response
Percentage response	Anabeb	26.2%	42.3%	26.2%	42
lion commonness,	Puros	0	46.2%	53.8%	13
by household	Sesfontein	38.4%	53.8%	7.7%	26
	Overall	27%	48%	24.7%	82

stated likelihood of killing lions, though the strength of this correlation was moderate ($R^2 = 0.2561$, $F(1, 82) = 3.742$, $p < 0.01$). The motivation to kill lions was greatest in Puros Conservancy.

When asked which predators are most dangerous to people, 85.5% responded lions; the second most feared predator was the leopard (*Panthera pardus*), 53%.

4. Discussion

A 2012–2014 survey examining the effects of drought in northwest Namibia reported cattle losses between 10% and 40% (Schnegg and Bollig, 2016); our study indicates that the drought has continued to kill livestock: mean losses of cattle approaching two-thirds can seriously constrain farmers' livelihood. In a region where 40% of inhabitants live on less than US\$1/day, median cattle losses exceeding \$8000 can be life- and community-altering across generations: day-to-day needs are compromised and funds to cope with emergencies are limited. Most household's herds suffered from the combined, and related, effects of drought and predation. However, though this has not been universal: a few households were able to maintain, even grow their herds during the drought years. In addition to the monetary losses, cattle have long been an essential component of Herero/Himba identity (Crandall, 1998; Jacobsohn, 1995). Our results suggest that during drought, cattle may have been replaced by goats, as goats eat less and are seen to be more drought-resistant. But even when the economic value of a lost cow is matched by five or six goats, the cultural impacts remain.

The effects of predators on livestock ownership are differentiated by livestock species. A maxim in northwest Namibia is that donkeys do not

die from drought: though donkey numbers have decreased by 69%, at least two-thirds of this loss was positively attributed to predators, primarily to lions. In contrast, though total cattle numbers have decreased by 79%, only 29% of this loss was attributed to predators – primarily to lions and spotted hyena (*Crocuta crocuta*). While losses to all predators are differently distributed among respondents, the skewness of cattle and donkey losses indicate percent losses of livestock to lions are particularly concentrated among certain households.

Conservation of the desert-adapted lions poses a unique challenge. Across northwest Namibia in 2016, lions were destroyed at a higher rate (approximately 4%) following conflict incidents than any other species, despite causing relatively few losses (Fig. E) – suggesting that lions are either easier to dispatch (Kissui, 2008) or are killed for reasons beyond the damage they cause. Most respondents feel lions pose a particular risk to people. It is worth noting that, in contrast to areas in East Africa (Packer et al., 2011), lion attacks on people are exceedingly rare in northwest Namibia. The last confirmed lion-caused human fatality in northwest Namibia occurred in 1982. Nevertheless, a common refrain among respondents was that lions attack people and that child herders are particularly vulnerable. Historically lion attacks on people in northwest Namibia were thought to be widespread; it may only have been with increasing access to firearms in the last half-century that lion attacks abated (Andersson, 1861; Owen-Smith, 2010).

Because no significant correlation exists between benefiting from lions and feeling they are important to the conservancy, our results suggest that limiting the costs of living with lions would more effectively enhance attitudes towards lions than would increasing benefits. We found considerable tolerance for sharing communal land with lions, but the percentage of cattle, goats, and donkeys lost out of total herd size negatively affected the perceived importance of having lions within a conservancy. This suggests that assisting farmers with smaller herds may have an outsize effect on increasing tolerance for living with lions: two cattle lost out of five is a greater proportional loss than two cattle out of fifty.

We tested a variety of likely variables to better understand why certain respondents stated they will try to kill lions that kill their livestock. Only conservancy residency was sufficiently explanatory: respondents from the Puros Conservancy are more likely to try and kill lions that take livestock than are respondents from other conservancies. Why this is the case is uncertain. Recent history of Puros provides a possible explanation: in 2016/17 one Puros farming area suffered a series of high-profile HLC incidents during which five sub-adult male

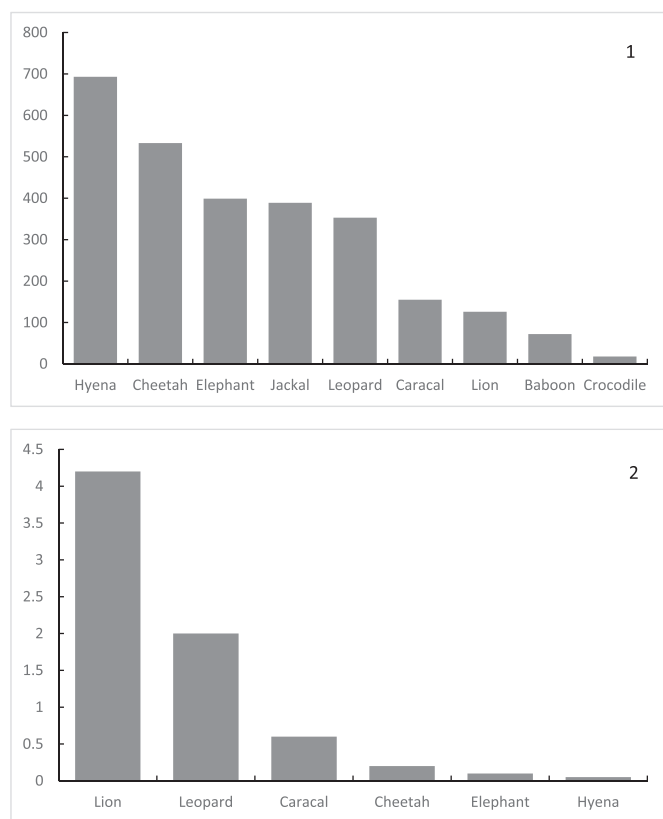


Fig. E. Recorded human-wildlife conflict in northwest Namibia, 2016. 1. Number of incidents involving each species across the region. 2. Percentage of Conflict Incidents leading to species destruction. Reprinted from [NACSO, 2016](#), 41.

lions were killed; most Puros respondents stated that lions, though formerly common, were now less common in the conservancy and pointed to these high-profile lion killings as the reason why lions have become less common. Because of these recent incidents, Puros residents, more so than residents of other conservancies, may view lion-killing as an effective measure to addressing HLC. Further research is needed to understand why certain respondents evince different levels of willingness to kill lions.

Respondents often viewed living with lions as a balancing act between costs and benefits. Linkages with local tourist operators are ongoing, but the extent to which communities receive direct benefits from these agreements is unquantified. New programs linking lions to payments for ecosystem services and for conservancy conservation performance are being developed ([Braat and de Groot, 2012](#); [Kuchelmeister and Lindeque, 2018](#)). An Early-Warning System to alert communities in high conflict areas about relevant lion movements, is being pioneered by a team of government and NGO stakeholders (*“First early-warning tower erected”*, 2018). Additionally, a group of community ‘Lion Rangers’ are being trained and deployed to monitor lions, provide communities with relevant and up-to-date lion information, and respond to conflict incidents (*“Lion Rangers”*, 2018). This program is adapted from the Lion Guardians program in Kenya and Tanzania, which has achieved positive lion conservation outcomes ([Hazzah et al., 2014](#)).

While 83.9% of respondents report that they do not benefit from having lions in their conservancy, 75.9% state that it is important to have lions. This tolerance for living with lions, even without direct (instrumental) benefits, appears to be a recent development among communities in northwest Namibia. Garth Owen-Smith, a long-serving conservationist in the region, notes that, prior to independence, the communities would not tolerate living with certain carnivores – chiefly

lions ([Owen-Smith, 2018](#)). How non-use value affects environmental decision-making is a productive yet challenging frontier in environmental economics and conservation ([Chan et al., 2012](#)). Interactions between lions and people are strongly mediated by cultural ([Ikanda and Packer, 2008](#)) and economic ([Kissui, 2008](#)) considerations. As noted by [Parks and Gowdy \(2013\)](#), human ‘values’ are not fully captured in traditional welfare economics. Our study is merely a first step towards better understanding how farmers value lions within northwest Namibia conservancies. Future research, along the lines of [Romañach et al. \(2007\)](#), should be specifically tailored to the environment and culture of northwest Namibia to foster greater tolerance for living with lions.

Socially-focused innovations may be of little use without cooperation from the region's ecological systems. As long as prey populations remain depressed, livestock depredation is likely to remain a challenge to rural pastoralists and conservationists. Relatively plentiful rainfall between 2000 and 2010 may help explain the increase in lion numbers before the drought, but the recent lack of rainfall is compromising livelihoods and threatens to undercut the efficacy of the CBNRM approach. Global climate change raises the possibility that droughts in northwest Namibia will increase, emphasizing the importance of providing benefits and early-warning of lion movements to rural residents. [Bauer et al. \(2015a, 2015b\)](#) noted that lions in unfenced areas fare best in areas with very low human population densities. Population growth in northwest Namibia may also affect HLC in northwest Namibia in the future.

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Conflict of interest

The authors declare no conflicts of interest.

References

- Andersson, C.J., 1861. Lake Ngami, or, Explorations and Discoveries during Four years' Wanderings in the Wilds of Southwestern Africa. Harper and Brothers, New York, NY.
- Bauer, H., Chapron, G., Nowell, K., Henschel, P., Funston, P., Hunter, L.T.B., Macdonald, D.W., Dloniak, S.M., Packer, C., 2015a. Reply to Riggio et al.: ongoing lion declines across most of Africa warrant urgent action. *Proc. Natl. Acad. Sci.* 113, 201522741.
- Bauer, H., Chapron, G., Nowell, K., Henschel, P., Funston, P., Hunter, L.T.B., Macdonald, D.W., Packer, C., 2015b. Lion (*Panthera leo*) populations are declining rapidly across Africa, except in intensively managed areas. *Proc. Natl. Acad. Sci. U. S. A.* 112,

- 14894–14899.
- Bauer, H., Packer, C., Funston, P.J., Henschel, P., Nowell, K., 2016. *Panthera Leo*. The IUCN Red List of Threatened Species 2016.
- Bollig, M., 1998. The colonial encapsulation of the North-Western Namibian pastoral economy. *Africa J. Int. African Inst.* 68, 506–536.
- Bollig, M., Olwage, E., 2016. The political ecology of hunting in Namibia's Kaokoveld: from Dorsland Trekkers' elephant hunts to trophy-hunting in contemporary conservancies. *J. Contemp. Afr. Stud.* 34, 1–19.
- Borg, G., Jacobsohn, M., 2013. Ladies in Red – Mining and Use of Red Pigment by Himba Women in Northwestern Namibia. 10. Tangungen Des Landesmuseums Fur Vorgeschichte Halle, pp. 43–51.
- Braat, L.C., de Groot, R., 2012. The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosyst. Serv.* 1, 4–15.
- Bridgeford, P.A., 1985. Unusual diet of the lion *Panthera leo* in the Skeleton Coast Park. *Madoqua* 14 (2), 187–188.
- Brockington, D., 2002. *Fortress Conservation*. Oxford University Press, Oxford, UK.
- Chambers, R., 1994. The origins and practice of participatory rural appraisal. *World Dev.* 22, 953–969.
- Chan, K., Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. *Ecol. Econ.* 74, 8–18.
- Crandall, D.P., 1998. The role of time in Himba valuations of cattle. *J. R. Anthropol. Inst.* 4, 101–114.
- Dickman, A.J., Hazzah, L.N., Carbone, C., Durant, S.M., 2014. Carnivores, culture and “contagious conflict”: multiple factors influence perceived problems with carnivores in Tanzania's Ruaha landscape. *Biol. Conserv.* 178, 19–27.
- Dieckmann, U., 2007. Hai|om in the Etosha region: a history of colonial settlement, ethnicity and nature conservation. In: *Basler Afrika Bibliographien*. Basel, Switzerland.
- First early-warning tower erected. In: *Kunene Conserv. Res.* URL: <http://kuneneconservation.dash.umn.edu/lion-rangers/27-april-2018-first-early-warning-tower-erected/>, Accessed date: 29 June 2018.
- GRN, 2012. *Namibia Poverty Mapping*. Windhoek, Namibia.
- GRN, 2016. *Human-lion Conflict Management Plan for North West Namibia (Draft December, 2016)*. Windhoek, Namibia. <http://www.the-eis.com/data/literature/NW%20Lion%20Management%20Plan%2020161222.V1.pdf>.
- Hazzah, L.N., 2006. Living among Lions (*Panthera Leo*): Coexistence or Killing? Community Attitudes Towards Conservation Initiatives and the Motivations Behind Lion Killing in Kenyan Maasailand. University of Wisconsin-Madison.
- Hazzah, L.N., Dolrenry, S., Naughton, L., Edwards, C.T.T., Mwebi, O., Kearney, F., Frank, L., 2014. Efficacy of two lion conservation programs in Maasailand, Kenya. *Conserv. Biol.* 28, 851–860.
- Ikanda, D., Packer, C., 2008. Ritual vs. retaliatory killing of African lions in the Ngorongoro conservation area, Tanzania. *Endanger. Species Res.* 6, 67–74.
- Jacobsohn, M., 1995. Negotiating Meaning and Change in Space and Material Culture: An Ethno-archaeological Study among Semi-Nomadic Himba and Herero Herders in North-Western Namibia. University of Cape Town.
- Jacobson, A., Riggio, J., 2018. Big Cats in Africa: Status Update on the African Lion, Cheetah and Leopard, with Recommendations for Effective Big Cat Conservation Funding.
- Jones, B.T.B., 2010. The evolution of Namibia's communal conservancies. In: Nelson, F. (Ed.), *Community Rights, Conservation and Contested Land*. Earthscan, London, pp. 106–120.
- Jones, B.T.B., Murphree, M.W., 2004. Community-based natural resource management as a conservation mechanism: lessons and directions. In: *Parks in Transition: Biodiversity, Rural Development, and the Bottom Line*, pp. 63–103.
- Joubert, E., Mostert, P.K.N., 1975. Distribution patterns and status of some mammals in South West Africa. *Madoqua* 9, 5–44.
- Kissui, B.M., 2008. Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai steppe, Tanzania. *Anim. Conserv.* 11, 422–432.
- Kuchelmeister, G., Lindeque, P., 2018. German Financial Cooperation with Namibia Community Conservation Fund Namibia Project on Poverty-oriented Support to Community Conservation in Namibia Feasibility Study. (Illertissen and Windhoek).
- Lau, B., 1987. *Namibia in Jonker Afrikaner's Time*. Windhoek Archives Publication Series, Windhoek, Namibia.
- Lindsey, P.A., Miller, J.R.B., Petracca, L.S., Coad, L., Dickman, A.J., Fitzgerald, K.H., Flyman, M.V., Funston, P.J., Henschel, P., Kasiki, S., Knights, K., Loveridge, A.J., Macdonald, D.W., Mandisodza-Chikerema, R.L., Nazerali, S., Plumptre, A.J., Stevens, R., Van Zyl, H.W., Hunter, L.T.B., 2018. More than \$1 billion needed annually to secure Africa's protected areas with lions. *Proc. Natl. Acad. Sci.* 115, E10788–E10796.
- Lindsey, P., Miller, J.R.B., Petracca, L.S., Coad, L., Dickman, A.J., Fitzgerald, K.H., Flyman, M.V., Funston, P.J., Henschel, P., Knights, K., Loveridge, A.J., Macdonald, D.W., Roseline, L., Nazerali, S., Plumptre, A.J., Stevens, R., Van, H.W., Hunter, L., 2018. Supplementary information - more than \$1 billion needed annually to secure Africa's protected areas with lions. *Proc. Natl. Acad. Sci.* 115, 1–21.
- Lion Rangers, 2018. *Kunene Conserv. Res.* URL: <http://kuneneconservation.dash.umn.edu/lion-rangers/>, Accessed date: 29 June 2018.
- Miescher, G., 2012. *Namibia's Red Line: The History of a Veterinary and Settlement Border*. Palgrave Macmillan, New York, NY.
- NACSO, 2015. *The State of Community Conservation in Namibia - a Review of Communal Conservancies, Community Forests and Other CBNRM Initiatives*. (Windhoek, Namibia).
- NACSO, 2016. *The State of Community Conservation in Namibia: A Review of Communal Conservancies, Community Forests and Other CBNRM Initiatives; Annual Report 2016*. (Windhoek, Namibia).
- NACSO, 2018. *Registered Conservancy Statistics*. URL: <http://www.nacso.org.na/conservancies#statistics> (accessed 6.10.18).
- Neumann, R.P., 1998. *Imposing Wilderness: Struggles of Livelihood and Nature Preservation in Africa*. University of California Press, Berkeley, California.
- Owen-Smith, G., 2010. *An Arid Eden: A Personal Account of Conservation in the Kaokoveld*. Jonathan Ball, Johannesburg and Cape Town.
- Owen-Smith, G., 2018. (Personal Communication).
- Packer, C., Swanson, A., Ikanda, D., Kushnir, H., 2011. Fear of darkness, the full moon and the nocturnal ecology of African lions. *PLoS One* 6, 4–7.
- Packer, C., Loveridge, A., Canney, S., Caro, T., Garnett, S.T., Pfeifer, M., Zander, K.K., Swanson, A., MacNulty, D., Balme, G., Bauer, H., Begg, C.M., Begg, K.S., Bhalla, S., Bissett, C., Bodasing, T., Brink, H., Burger, A., Burton, A.C., Clegg, B., Dell, S., Delsink, A., Dickerson, T., Dloniak, S.M., Druce, D., Frank, L., Funston, P., Gichohi, N., Groom, R., Hanekom, C., Heath, B., Hunter, L., Deiongh, H.H., Joubert, C.J., Kasiki, S.M., Kissui, B., Knocker, W., Leathem, B., Lindsey, P.A., MacLennan, S.D., McNutt, J.W., Miller, S.M., Naylor, S., Nel, P., Ng'weno, C., Nicholls, K., Ogutu, J.O., Okot-Omoya, E., Patterson, B.D., Plumptre, A., Salerno, J., Skinner, K., Slotow, R., Sogbohossou, E.A., Stratford, K.J., Winterbach, C., Winterbach, H., Polasky, S., 2013. Conserving large carnivores: dollars and fence. *Ecol. Lett.* 16, 635–641.
- Parks, S., Gowdy, J., 2013. What have economists learned about valuing nature? A review essay. *Ecosyst. Serv.* 3, e1–e10.
- Reardon, M., 1986. *The Besieged Desert: War, Drought, Poaching in the Namib Desert*. William Collins Sons, London.
- Rizzo, L., 2012. *Gender and Colonialism: A History of Kaoko in North-western Namibia, 1870s–1950s*. Basler Afrika Bibliographien, Switzerland.
- Romañach, S.S., Lindsey, P.A., Woodroffe, R., 2007. Determinants of attitudes towards predators in central Kenya and suggestions for increasing tolerance in livestock dominated landscapes. *Oryx* 41, 185–195.
- Schnegg, M., Bollig, M., 2016. Institutions put to the test: community-based water management in Namibia during a drought. *J. Arid Environ.* 124, 62–71.
- Shortridge, G.C., 1934. *The Mammals of South West Africa*. Heinemann, London.
- Stander, P.E., 2017. *XPL-93 and HWC in Perspective*. Desertlion.info. <http://desertlion.info/news.html>, Accessed date: 3 July 2017.
- Stander, P.E., 2018. *Vanishing Kings: Lions of the Namib Desert*. HPH Publishing, Johannesburg, South Africa.
- Stander, P.E., 2019. *Lions (Panthera leo) specialising on a marine diet in the Skeleton Coast National Park, Namibia*. *Namibian J. Environ.* 3, 1–10.
- Stuart-Hill, G., Diggle, R., Munali, B., Tagg, J., Ward, D., 2005. The event book system: a community-based natural resource monitoring system from Namibia. *Biodivers. Conserv.* 14, 2611–2631.
- VassarStats: Website for Statistical Computation, 2018. URL: <http://vassarstats.net/> (accessed 6.29.18).
- Wolputte, S. Van, 2013. Vicious vets and lazy locals: experimentation, politics and CBPP in north-west Namibia, 1925–1980. *J. Namibian Stud.* 13, 79–100.