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# Exploring perceptions of subsistence farmers in northwestern Zimbabwe towards the African lion (Panthera leo) in the context of local conservation actions

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| **Abstract:** | We explored the perceptions and attitudes held by subsistence farmers (living in communal lands within the CAMPFIRE programme area in northwestern Zimbabwe) towards the African lion ( Panthera leo ) and related conservation and management interventions undertaken by management authorities. We used a structured, face to face interview format to collect data across three different farming communities bordering Hwange and Zambezi National Parks. Ordinal regression models were used to analyse the data. Our results illustrate that farmers' attitudes towards lions are strongly negative and appear to be influenced by the geographic location in which the farmer lives as well as the farmer's ethnic group.Further, we found that attitudes towards lions are not associated with specific livestock losses or to the potential benefits farmers receive from wildlife conservation, e.g., school classroom blocks or road improvements. Instead, we suggest that the fear of lions and perceived risk to livestock or human wellbeing may play a stronger role in shaping farmers' attitudes compared to actual livestock losses. Moreover, we suggest that sharing information across farmer social networks within a community area, along with the potential for media attention over sensational events, may also influence perceptions and attitudes towards lions. Our results contribute a baseline dataset for future applied research in this area, and provide insight into developing locally-meaningful conservation interventions, including the type of information to be shared, channels for communication, and the benefits derived from participating in wildlife conservation. |

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# Exploring perceptions of subsistence farmers in northwestern Zimbabwe towards the African lion (*Panthera leo*) in the context of local conservation actions

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## ABSTRACT

We explored the perceptions held by subsistence farmers (living in communal lands within the CAMPFIRE programme area in northwestern Zimbabwe) towards the African lion (*Panthera leo*) and related conservation interventions undertaken by management authorities. Conceptually guided by the cognitive hierarchy, we used a semi-structured, face-to-face interview format to collect data across three different farming communities bordering Hwange and Zambezi National Parks. Ordinal regression models were used to analyse the data. Our results illustrate that farmers' perceptions towards lions were strongly negative and appeared to be associated with the geographic location in which the farmer lived, as well as the farmer's ethnic group. We also found that perceptions towards lions were not associated with specific livestock losses or to the potential benefits farmers received from wildlife conservation, e.g., school classroom blocks or road improvements. Instead, we suggest that fear of lions and perceived risk to livestock or human wellbeing may play a stronger role in shaping farmers' perceptions compared to actual livestock losses. Moreover, we suggest that sharing information across farmer social networks within a community area, along with the potential for media attention over sensational events, may also influence perceptions towards lions. Our results contribute a baseline dataset for future applied research in this area, and provide insight into developing locally-meaningful conservation interventions, including the type of information to be shared, channels for communication, and the benefits derived from participating in wildlife conservation.


*Keywords***:** human-lion conflict, livestock depredation, *Panthera leo*, subsistence farmers, Zimbabwe

# INTRODUCTION

Worldwide, large carnivore populations are declining (Inskip & Zimmermann, 2009). This decline can be attributed to the increase in human population growth and associated resource use resulting in a reduction of natural prey, habitat fragmentation or loss, and the over-exploitation of certain species (Ripple et al., 2014). Given that the world's human population is predicted to continue to increase (Gerland et al., 2014), especially in areas next to protected areas (Wittemyer, Elsen, Bean, Burton, & Brashares, 2008), a further decline in large carnivore populations can be expected, unless human-carnivore coexistence can be improved (Woodroffe, 2000).

A species struggling with the consequences of human population growth is the African lion (*Panthera leo*) (Bauer, Packer, Funston, Henschel, & Nowell, 2016). With fewer than 30,000 individuals remaining in fragmented populations, lions have been extirpated from 85% of their historic range, with an overall population decline of 43% over the last two decades (Bauer et al., 2016). One of the few areas in Africa with a sizable lion population is the Hwange-Matetsi Protected Area Complex (HMPAC) in Zimbabwe (IUCN, 2016). This area supports *ca*.700 lions and is part of the wider Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA) population: one of only six remaining areas that support over 2,000 lions (IUCN, 2016). In the HMPAC, lions are commonly killed by local subsistence farmers (hereafter: *farmers*) in retaliation for livestock loss (Loveridge, Hemson, Davidson, & Macdonald, 2010a). For example, between 2009 and 2017 more than 50 lions, most of which were females and dispersing young males, were killed in conflict-related incidents and many more from trophy hunting (Loveridge et al., 2017). Loveridge et al. (2010a) demonstrated that anthropogenic mortality, conflict with farmers included, accounts for up to 42% of the total lion mortality in this area, which is unsustainable.

To safeguard the future of lion populations, governments and conservation organisations in lion-range countries need to develop effective coexistence strategies (IUCN SSC Cat Specialist Group, 2018). However, fundamental to developing coexistence strategies is understanding the perceptions and actions of the local people that share the landscape with lions (Gebresenbet, Bauer, Vadjunec, & Papeş, 2018; Hill, 2015). As such, our study draws conceptual insights from the cognitive hierarchy framework (Fulton, Manfredo, & Lipscomb, 1996) as well as other relevant literature (Ajzen, 2001; Amit & Jacobson, 2017; Bennett, 2016). Within this conceptual framework we first explore perceptions (or beliefs), defined as how a person observes, interprets and evaluates an experience, object, action or other social entity (Pickens, 2005). Perceptions can change over time, and can be influenced by various external factors (e.g., age, gender, education), the collective sharing of information, as well as normative behaviours (Bennett, 2016). However, perceptions are context-specific and therefore cultural, social, economic and environmental factors must be considered (Woodford et al., 2016).

Examining local perceptions can be helpful in conservation policy, in terms of understanding peoples' views on wildlife species or the role of different governance arrangements and their impact on livelihoods and conservation objectives (Bennett, 2016). Specifically, risk perceptions can be very important to understanding human relations with lions, as well as the practices they adopt or enact (Amit & Jacobson, 2017). Moreover, perceptions of governance arrangements to conserve lions or other wild species can be useful to identify issues of legitimacy, appropriateness, or inclusivity (Bennett et al., 2017). Perceptions "represent a facet of the truth" (Bennett 2016, p. 588), and can influence how an individual assesses the value of a wildlife species or conservation action (Bennett, 2016). Additionally, perceptions (including changing perceptions) can influence the actions or behaviours that individuals choose to enact (Manfredo & Dayer, 2004).

While several studies [e.g. Dickman (2005); Mkonyi, Estes, Msuha, Lichtenfeld, and Durant (2017); Parry and Campbell (2009)] have assessed perceptions towards lions and other carnivores in African countries, this information is lacking for Zimbabwe's HMPAC. As such, in preparation for the introduction of a human-lion conflict intervention programme, we conducted semi-structured interviews to explore farmers' perceptions and actions towards lions and conservation authorities and management interventions. Specifically, we explored:

a) the perceptions, and factors influencing perceptions, of local farmers towards lions;
b) current practises or actions that farmers use to mitigate conflict with lions; and,
c) farmers' perceptions towards conservation actions.

Additionally, given that the lion is not the only species that comes into conflict with local farmers in this area (Loveridge et al., 2017), we also gathered perception data on other wildlife species that have the potential to cause negative livelihood impacts, and compared these to perceptions of lions. The other species included the elephant (*Loxodonta africana*) and spotted hyaena (*Crocuta crocuta*). We hypothesised that the risks and costs from living with lions and other potentially damage-causing wild animals would negatively affect a farmer's perception towards lions and conservation authorities, while benefits derived from conservation activities will have a positive effect on perceptions. More specifically, we predicted that perceptions towards different damage-causing species are associated with the extent of damage (e.g., costs) and level of human safety threat. Taken together, we suggest that understanding perceptions and actions of farmers towards lions and conservation authorities will help develop relevant coexistence strategies with farmers, as well as provide baseline data that can be used to gauge community support for lion conservation in the area and across other lion range countries (Amit & Jacobson, 2017; Gebresenbet, Baraki, Yirga, Sillero-Zubiri, & Bauer, 2017).

# METHODS

## Study Area

This study was conducted in three rural communal land sites located alongside the boundaries of protected areas in northwestern Zimbabwe, and were selected based on their (a) proximity to protected areas; (b) differences in ethnic groups; (c) financial losses to depredation; and (d) the benefits from Communal Areas Management Programme For Indigenous Resources (CAMPFIRE). Other site characteristics are summarized in **Table 1**. Of the three rural communities, two border the Hwange National Park: Tsholotsho (Matupula and Siphoso Chieftainships: 2,171 $km^2$) and Mabale (Nelukoba Dingani Chieftainship: 480 $km^2$), while Victoria Falls (Mvuthu and Shana Chieftainships: 655 $km^2$) was the third site and borders the Zambezi National Park (Fig. 1). All three rural communities and the mentioned protected areas are part of the wider KAZA TFCA.

All three rural communities are also part of CAMPFIRE. CAMPFIRE's objectives are to devolve natural resource management to the local community level and provide direct benefits to rural communities living with wildlife (Frost & Bond, 2008). CAMPFIRE generates revenue through trophy hunting, ecotourism, and land leasing fees (Frost & Bond, 2008). Fifty-five percent of the total revenue from CAMPFIRE is intended for distribution across the local communities by the Rural District Councils (RDCs) for community development projects (CAMPFIRE, 2016). Management of wildlife across communal lands is jointly shared by the Zimbabwe Parks and Wildlife Management Authority (ZPWMA) and the RDCs, with lethal control as the most commonly used intervention regarding damage-causing wildlife species, including lions (Karidozo, La Grange, & Osborn, 2016).

Ecologically, the area is semi-arid (average rainfall: 550-600 mm) with three distinguishable seasons, a cold dry season (May-August), a hot dry season (September-November), and a wet season (December-April). Livestock rearing and crop farming are the

primary livelihood sources with cattle (*Bos taurus*), donkey (*Equus asinus*), sheep (*Ovis aries*) and goats (*Capra hircus*) as the main livestock, and maize (*Zea mays*), millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) the main crops (Kuiper et al., 2015). Livestock depredation of high-value livestock, such as cattle and donkeys, is commonly done by lions and spotted hyaenas, with leopards (*Panthera pardus*), African wild dogs (*Lycaon pictus*), cheetahs (*Acinonyx jubatus)* and black-backed jackals (*Canis mesomelas*) occasionally preying on small lower-value stock such as sheep and goats (Rasmussen, 1997). Previous studies have shown that poor livestock herding practices (e.g., not corralling at night) and seasonality can influence livestock attacks (Kuiper et al., 2015). During the wet season farmers herd their livestock in areas closer to the national park, further away from the human communities, exposing livestock to high depredation risk (Kuiper et al., 2015).

Tsholotsho has experienced the highest financial losses due to livestock depredation followed by Victoria Falls, while Mabale has the lowest (Loveridge et al., 2017). Also, farmers in Tsholotsho reportedly receive more financial benefits from wildlife, through the RDCs, than farmers in Victoria Falls or Mabale (CAMPFIRE, 2016). However, Victoria Falls rural community close to the major regional tourism hub of Victoria Falls and where farmers from these villages have the opportunity to receive more benefits from tourism activities (e.g., village tours) (L. Sibanda, pers. obs., 2012). Regardless, livestock rearing is particularly important across the study area, with culturally-embedded values for livestock, as a source of food, income, and cultural identity (Moyo & Swanepoel, 2010). These livestock roles may play a role in influencing perceptions towards lions, as well as perceptions of conservation authorities and organizations, particularly given historical views of pastoralism as environmentally destructive (Dickman, 2008). Given that livestock losses to lions can be relatively high, coupled with perceived risk or reality of personal injury or death, perceptions towards lions can be negative (Kushnir & Packer, 2019). Such negative perceptions have the

potential to negatively impact conservation efforts and can incite emotional responses related to fear of lions and livestock losses (Johansson, Ferreira, Støen, Frank, & Flykt, 2016).

*[Insert Fig. 1: A map of the study area in Zimbabwe*]

*[Insert Table 1: Population size, residential density and ethnic groups at our study sites*]

**Data collection**

Data were collected using a semi-structured interview format, informed by Dickman (2008), consisting of closed and open-ended questions organized into five sections: (a) demographics (e.g., age, number of people per farmstead, primary livelihood sources); (b) perceptions (Likert-based) towards lions, and in comparison to other damage-causing species; (c) livestock husbandry practices or actions taken towards lions (i.e., farmer actions); (d) actual livestock losses to lions, and (e) perceptions towards the conservation authorities of the HMPAC and CAMPFIRE and their management actions.

We tested the interview questions with 20 farmers of varying age and gender, selected randomly from Mabale, and included their responses in the final analysis. Mabale was chosen because it is the most central of the three study sites. After testing the interview, we used a systematic sampling approach to select every fifth farmstead in each village across the three study sites, interviewing only one adult male or female (i.e., self-identified 'head' of farmstead) in each home. We attempted to interview males and females (> 18 years) as equally as possible. Recognizing the importance of human ethics in conservation activities, we fully explained the purpose of the study before commencing with each interview, with all respondents giving verbal free and informed consent to voluntarily participate (Brittain et al., 2019). To help minimise response bias (e.g., social desirability) we did not provide monetary compensation to participate. Each interview was conducted in the farmer's preferred language (*isi*Ndebele, *chi*Nambya or Tonga) and the responses were recorded in English. Each session lasted ± 90 minutes including the time taken to verify kill sites in the grazing

193 area. To validate livestock losses to wildlife, we only considered losses ≤12 months prior to
194 the interview and used a two-point validation system. First, we compiled a separate incident
195 report and interviewed the farmer to establish which carnivore species was responsible. To
196 assess the farmer's accuracy in carnivore identification, we showed each farmer pictures of
197 different carnivores and their paw prints, which they were asked to identify. Next, we
198 recorded whether the attacks were officially reported to the local authorities (e.g., village
199 head, ZPWMA, RDC), and confirmed all losses with the village head who, as part of his civil
200 duties, keeps a register of all conflict reports in their village.
201 Perceptions towards lions were determined by asking: "How much do you like or
202 dislike lions and why?" and respondents selected a response from a five-point Likert-based
203 response: "strongly like", "like", "neither like nor dislike", "dislike" and "strongly dislike".
204 To determine perceptions towards the desired the lion population change we asked: "What
205 would you like to see happening to the current lion population, around your village, in the
206 future and why?" The respondents selected a response from: "increase", "decrease" and "stay
207 the same". To determine farmer actions taken towards lions we asked: "What do you do to
208 protect your livestock and why?". Perceptions towards conservation authorities and
209 management actions were determined by various questions like: (a) "Are you aware of the
210 HMPAC and what do you think of it and why?" and respondents selected a response from a
211 five-point Likert-based response: "strongly like", "like", "neither like nor dislike", "dislike"
212 and "strongly dislike"; (b) "How important do you think it is to protect wildlife in Hwange/
213 Zambezi NP?" and the respondent also selected a response from a five-point Likert-based
214 response: "very important", "quite important", "neither important or unimportant", "quite
215 unimportant" and "very unimportant"; (c) "How important do you think it is to protect
216 wildlife in the communal lands?" and the respondent selected a response from a five-point
217 Likert-based response: "very important", "quite important", "neither important or

unimportant", "quite unimportant" and "very unimportant"; (d) Are you aware of the CAMPFIRE programme and have you ever benefited from this scheme?".

**Data analysis**

To determine whether or not our sample size was adequate to detect meaningful effect sizes we performed a post-hoc statistical power analysis for sample size estimation using an online sample size calculator (www.surveysystem.com/sscalc.htm#one) with the following parameters: Confidence Levels = 95%; Confidence Interval = 4, Population (rounded off to the nearest thousand) = 8,000. We used descriptive statistics (mean ± *SD*) to summarise farmers' demographic information. Factors influencing perceptions towards the lion (listed in **Table 2**) were analysed using Generalised Linear Mixed Models (GLMMs) with a binomial error structure and logit-link function in R-statistical software (R Core Team, 2019). We fitted cumulative-link models to the ordinal response using the '*clmm*' function in 'ordinal' package (Christensen, 2015). The response variable (perceptions) was generated using a 1-5 scale, where 1 represents 'strongly dislike' and 5 represents 'strongly like'. Collinearity between categorical predictors was assessed using contingency tables, whereas collinearity between continuous predictors was assessed using the function '*corr'* in R. Linear models (with function '*lm'* in R Statistical Software) were used to assess correlation between categorical and continuous predictors, with the continuous predictor as a response. Two variables with $R^2$ greater than .50 were considered substantially correlated, therefore, one of the two variables was excluded from the final model (see Supplementary tables 1 & 2 for correlations). To determine which of the two to exclude, we calculated the variance-inflation factor (VIF) using the '*vif*' function in '*car'* package (Fox & Weisberg, 2019) and excluded a variable with a VIF greater than 10 (James, Witten, Hastie, & Tibshirani, 2014). For example, the variable 'age' was highly correlated with the number of years a farmer had been in an area (residence) ($R^2$ = .54, $p < .001$), so we excluded the variable 'age' (*vif*=12.04) from

the final model to reduce redundancy. The following variables were included as fixed effects in the candidate models: (a) demographic variables (farmstead size, level of education ethnic group, position in the farmstead); (b) socio-economic variables (residence, area, self-reported benefits from national parks, self-reported benefits from CAMPFIRE); and (c) personal losses to lions (livestock lost to lions within 12 months preceding the interview). We controlled for possible clustering of similar responses between study villages by adding the variable 'village' as a random effect to the model. We used the package '*MuMIn*' (Bartoń, 2019) for model averaging and ranking of the candidate models using the Akaike Information Criterion (AIC) value (Burnham & Anderson, 2002). Given that several models had similar levels of support, we used model-averaging, considering all models up to a cumulative Akaike weight of .95. Possible non-linear effects in the ordinal and continuous predictors were explored graphically using the package '*sure'* (Liu & Zhang, 2018). To support our analysis, we also include key quotes from interviewees to highlight farmer perceptions. To explore how perceptions towards lions compare with several other damage-causing species, we first performed a Friedman's Rank-Sum test and then used Wilcoxon Signed-Ranks tests to determine pairwise differences between the lion, elephant, leopard, African wild dog, black-backed jackal and spotted hyaena given the potential for these species to cause similar negative livelihood impacts.

## RESULTS

### General farmstead characteristics

Results from the post hoc power analysis indicate the projected sample size needed for this study was approximately $n$ = 558 interviews, which is less than the 632 interviews that we collected in total. We therefore conclude that our sample size was more than sufficient to achieve adequate power to detect meaningful effect sizes. The 632 farmers (men = 48%, women = 52%; response rate = 100%), where from Mabale ($n$ = 124), Tsholotsho ($n$ = 234)

and Victoria Falls ($n$ = 274), which is a sample size proportionate to the total farmer population in each site. The average age was 52.15 ± *SD* = 16.08 years (median: 53 years; range: 18-92 years), and the average time a farmer had been a resident in their respective village was 33.75 ± *SD* = 19.39 years (median: 34 years; range: <1-83 years). The average farmstead size combined for all three study sites was 6.41 ± *SD* = 2.96 people (median: 6; range: 1-21). The majority of the farmers (89%) had at least attained primary education. Crop farming (95%) and livestock rearing (63%) were the main sources of livelihoods, both for direct consumption and income generation.

**Perceptions towards lions**

Across the three communities, self-reported perceptions towards lions were strongly negative (mean: 1.3 ± *SD* = .72; median: 1), with the majority (93%) disliking lions and indicating they wanted a decrease in the lion population (86%). Perceived livestock loss from lion depredation was a commonly stated reason for negative perceptions (82%) even by farmers who experienced no livestock losses to lions in the 12 months preceding the interview (71%). For example, one male farmer (32 years old) who owned no livestock mentioned: "Lions kill our livestock! I don't own cattle myself [but] I depend on my neighbour's cows to plough my fields. So, if a lion killed my neighbour's cows, I also suffer [from] their loss"[2]. In another example, one female farmer (47 years old) from Tsholotsho indicated she had not witnessed lions killing livestock directly but had learned of these events from others in her village:

> "Lions killed cows belonging to one old lady from Mlevu village [in Tsholotsho], and she was left nursing a young calf after the mother died. The old lady was left with nothing, her kraal become a source of wood for fire after all her cows were killed by lions. She was made poor to this day".

[2] The interviews were conducted in local language and the quotes were translated by L. Sibanda (2020)

In contrast, a small proportion of farmers held either neutral (3%) or positive perceptions (4%), though these farmers indicated they would still like to see a decline in the lion population in future (36%), as stated by one female farmer (57 years old): "Too much of anything can be a problem, we don't want the lion numbers [in the area surrounding their village] to increase because they might end up eating us [humans] and our livestock". Despite the perceived risk of livestock loss from lions, we found no evidence that farmer perceptions towards lions were associated with actual livestock losses, nor did we find an association between perceptions and demographics (e.g., position) or socio-economic factors (e.g., residence, farmstead size, benefits received from HMPAC or CAMPFIRE) (**Table 3**). Further, our results indicate significant variations in perceptions regarding lions across the study sites (**Table 3**) (see also supplementary fig. 1). The farmers in Victoria Falls had the most negative perceptions (mean = 1.2 ± *SD* = .44; median: 1), followed by Tsholotsho (mean = 1.4 ± *SD* = .77; median: 1), and Mabale (mean = 1.6 ± *SD* = 1.00; median: 1). For example, one farmer (female, 44 years old) from Victoria Falls mentioned: "I strongly dislike lions, a few weeks back lions attacked a male relative while herding livestock and [the lion] started feeding on him after he fell unconscious, such is unheard of". We also found a significant difference in perceptions towards lions amongst ethnic groups, which are intermixed across all villages (**Table 3**) (see also **Supplementary Fig. 2**). The farmers who identify with the Nambya ethnic group had the most negative self-reported perceptions towards the lion, followed by the Ndebele and the Tonga ethnic group with the least negative perceptions.

[*Insert Table 3: Summary of model-averaged coefficients calculated using the MuMIn*]

**Perceptions towards other damage-causing species**

We found that perceptions towards lions were significantly more negative compared to perceptions towards other damage-causing wildlife species, including elephants despite crop-

raiding being listed as a higher threat to livelihoods than livestock depredation (**Fig. 2**). For example, one male farmer (39 years) compared perceived benefits from elephants to those from lions:

> "Elephants only come in this village during the cropping season but lions come here more frequently…even though elephants raid my crops, when an elephant is shot, I get meat that I sell and get money to buy mealie-meal to feed my family. But when a lion is killed what do I get? I don't eat lion meat".

While, another farmer (female, 51 years old) mentioned that they disliked lions, cited the risk that a lion poses to humans especially children: "A lion is dangerous and scary especially [for] young children but adults too, but other predators like the jackal are not scary instead they are scared of humans".

[*Insert Fig. 2: Farmers perceptions towards different damage-casing wild*)]

**Farmer actions towards lions**

To protect livestock against wild carnivores, 45% of the farmers reported they herd their livestock during the day; 54% mentioned they enclose their livestock in protective enclosures or corrals at night; whilst 1% mentioned they use deterrents (e.g., fire and scarecrows) (1%), to protect livestock against wild carnivores. A male farmer (47 years old) stated "We [him and his family] herd our livestock during the day and pen then at night, otherwise if we don't, we may lose all our livestock to wild predators".

**Reported livestock losses**

A total of 393 livestock were reportedly killed by carnivores, with the spotted hyaena cited as the main culprit followed by the lion. During the same period, more livestock were reported to have died of disease ($n$ = 467), yet disease was rarely mentioned as a threat to livelihoods (2%). Reports of lion attacks on humans were very low, with only one farmer from Chief Shana area in Victoria Falls reportedly attacked by a lion in August 2012. Farmers did not

perceive livestock depredation to be the greatest livelihood threat. Instead, farmers reported elephant crop raiding, followed by economic circumstances (e.g. unemployment and poverty) as greater threats (**Table 4**).

**Perceptions towards conservation actions**

Farmers in Victoria Falls held more positive perceptions towards the HMPAC (4.0 ± *SD* = 1.13, median: 4), compared to farmers from Tsholotsho (mean = 3.4 ± *SD* = 1.38, median: 3) and Mabale (3.8 ± *SD* = 1.41, median: 4) (Table 5). Farmers mentioned the assistance received from the authorities in managing negative wildlife impacts (32%) and the role the HMPAC plays in safeguarding wildlife resources for future generations (27%) as reasons to feel positive towards the HMPAC. However, 78% of the farmers disagreed that protecting wildlife, including lions, was important in the communal lands of the HMPAC, which contrasts the with 77% who indicated they thought it was important to protect wildlife in Hwange or Zambezi National Parks. For instance, one farmer (female, 34 years) who held negative perceptions towards wildlife conservation in the communal lands said:

> "We like wild animals, especially lions, only when they are in the park where they belong. But the opposite can be said when they come to village lands. This is because wild animals such as lions are dangerous to my livestock as well as my children and therefore when a lion comes to my village it should be killed because it will call other lions here".

With regard to the CAMPFIRE programme, only 18% of farmers perceived the programme as directly beneficial, with benefits including the construction of a local clinic and school classroom block (10%), provisioning of water sources (7%), and meat from elephant hunts (1%). The remaining (82%) indicated they would like the CAMPFIRE programme to discontinue, citing the damage from wild animals and lack of direct benefits at the farmstead level as reasons. For instance, a male farmer (53 year old) mentioned: "The problem with

CAMPFIRE is that their wild animals destroy our crops and livestock and I do not benefit anything in return…CAMPFIRE ought to be completely discontinued".

One male farmer (83 years), responded to the same question and gave a similar answer though from a different angle:

> "When CAMPFIRE started we used to get dividends per farmstead but today that no longer exists. CAMPFIRE is of no benefit at all yet their wild animals destroy our crops and kill our livestock. We don't want CAMPFIRE, we are better off without CAMPFIRE".

Overall, 70% of the farmers blamed the ZPWMA and CAMPFIRE for livestock depredation. One male farmer (40 years old) mentioned that: "If my neighbour's cow ate my crops I blame the owner…If a wild predator killed my livestock, I blame the [national] parks and CAMPFIRE, who are the owners of wild animals". Proposed solutions in response to depredation and other damages caused by wild animals included direct compensation [financial compensation (74%), food aid (20%)], and wildlife management-related activities [e.g., translocation (5%), lethal removal of problem animals (54%), fencing the HMPAC (26%), more research (13%)]. A combined 8% of farmers had no opinion on proposed solutions.

## DISCUSSION

Farmers' perceptions towards lions were largely negative, with perceived livestock depredation as their most commonly stated reason. Most farmers, including those with neutral or positive perceptions, indicated they wanted to see a decrease in the future lion population. This is not unexpected considering that lions can pose serious risks to human livelihoods and safety (Mulder et al., 2019). This is also consistent with other recent research on human-lion relations and conservation activities in the HMPAC (Western, Macdonald, Loveridge, & Dickman, 2019). We expected perceptions towards lions to be associated with

costs and benefits derived from the species. However, we found no evidence that actual livestock loss, impacts on personal income, or benefits received from CAMPFIRE were factors influencing farmers' perceptions towards lions. For example, there was no significant difference between the perceptions of farmers that did lose livestock to lions in the 12 months preceding interviews to those that did not. Both groups indicated they strongly disliked lions regardless of actual depredation. We also found that farmers in Victoria Falls held the most negative perceptions towards lions. This sentiment may have been caused by a lion attack on a local farmer during our study period.

Our findings appear to be in accordance to Dickman et al., (2014) who found that farmers adjacent to Ruaha National Park in Tanzania disliked lions despite having no direct experience of livestock depredation, a phenomenon they referred to as 'contagious conflict'. This contagious conflict, or what we suggest as being contagious negative perceptions towards lions, is conceivably exacerbated by rare and tragic events compared to the accumulated effects of more common incidences (Naughton-Treves, Treves, Woodroffe, Thirgood, & Rabinowitz, 2005). Infrequent though sensational carnivore attacks on humans, coupled with stories told through social interactions or media depictions, has been found to influence peoples' perceptions of risk (Gore, Siemer, Shanahan, Schuefele, & Decker, 2005; Sabatier & Huveneers, 2018). We suggest that if sensational information like the risks posed by lions is communicated through trusted sources, such as community or village leaders, other well-respected farmers, or popular news media, this information can influence farmers' perceptions and ultimately, attitudes (Putnam, 1993; Rose, Keating, & Morris, 2018). Certainly, trust along with social norms (i.e., sociological guidelines for accepted thought and action), are important aspects of social capital, and social capital demonstrably influences conservation outcomes (Davenport & Hassan, 2019). We suggest that future research could explore both the risk categories that farmers ascribe to living with lions (Amit & Jacobsen,

2017), and the social capital and networks of information flows amongst farmers, government, and non-governmental organisations. This would enable a better understanding of what factors, whether emotional, cognitive or experiential, might influence farmer perceptions and actions towards lions as well as what and how information flows across farmer networks (Amit & Jacobson, 2017). In turn, conservationists would be well advised to craft effective communication tools to share accurate human-lion coexistence strategies. That said, we also suggest future study could explore farmers' value orientations towards different wildlife species more broadly, to better develop a broader array of human-wildlife coexistence strategies based on fundamental beliefs and goals (Dietsch, Teel, & Manfredo, 2016; Manfredo & Dayer, 2004). Likewise, future study could utilize the Theory of Planned Behaviour (Ajzen & Fishbein, 1980) to better understand the rational planned choices behind different human behaviour (Amit & Jacobson, 2017) in the context of lion conservation.

We also found that farmers' perceptions towards lions are related to a farmer's ethnic group. The Tonga ethnic group had the least negative perceptions towards lions. This is possibly because traditional beliefs amongst the Tonga identify the lion as having an important cultural value as a spirit of the rain-maker '*Mpande'* (L. Sibanda, pers. obs., 2012). Such cultural beliefs are common in most African cultures, for example, the San people from the Kalahari consider lions as their brothers and therefore tolerate their coexistence (Thomas, 2003). As demonstrated elsewhere, understanding and incorporating cultural beliefs and values in conservation programmes is important to gain support for lion conservation efforts (Infield, Entwistle, Anthem, Mugisha, & Phillips, 2017). For example, Kenya's Lion Guardians programme (www.lionguardians.org) in Amboseli has successfully shifted cultural values that promote killing lions amongst young Maasai men to monitoring and guarding lions, and protecting their village by utilising predator-proof livestock enclosures (Hazzah et al., 2014). In addition, Mulder et al. (2019) suggests that shifting lion-killing culture can

occur through the use of locally-developed and culturally-relevant village bylaws, drawing on local institutions and leadership to shift otherwise negative perceptions and detrimental behaviours or actions. However, caution is urged if or when suggesting that certain cultural beliefs are misconceived or wrong, given issues related to ethical quandaries of imposing new belief systems (Manfredo et al., 2017; Pooley et al., 2017).

When comparing farmers' perceptions towards lions with other damage-causing wild animals, we found perceptions to lions were more negative. This remained consistent even when compared to elephants, despite crop-raiding reportedly imposing a higher negative livelihood impact than livestock depredation. We suggest this may be influenced by the association of perceived benefits from elephants outweighing the potential risks they pose (Bel, Stansfield, Grange, & Taylor, 2013; Naughton-Treves et al., 2005). Farmers were also found to hold stronger negative perceptions towards lions, followed by spotted hyaenas, in comparison to leopards, jackals, or African wild dogs. As with elephants, these species may be perceived as less risky to human livelihoods or wellbeing, in this case because they were reported to predate on lower-value livestock (e.g. sheep and goats) and are considered to generally be more easily deterred. We also consider that, as with other studies, the ease which a damage-causing animal is deterred can influence peoples' perceptions towards them (Hill, 2004). It follows then that lions are assessed to pose a greater risk, both for livestock depredation and human injury or death, and in turn influence more negative perceptions amongst farmers (Goldman, Roque De Pinho, & Perry, 2010). Certainly, other studies have shown that perceptions towards wild animals, and particularly those with which farmers experience conflict, are influenced by the risks and costs imposed, along with the potential benefits derived from, living with these animals (Barua, Bhagwat, & Jadhav, 2013; Parry & Campbell, 2009). However, we also consider this phenomenon may also be explained by cognitive polyphasia, a concept in social psychology which suggests multiple different and

sometimes contradictory ways of thinking and reasoning can be held simultaneously about an object or subject (Buijs et al., 2012; Hovardas & Korfiatis, 2012). This might explain how and why farmers have constructed their perceptions towards different damage-causing species relative to the conflict and risk (whether real or perceived) they experience (Hovardas, 2018). It would be informative for future research to explore the social constructions and representations farmers hold for lions and other wildlife species, as findings can help craft locally-relevant conservation actions (Buijs et al., 2012; Figari & Skogen, 2011).

With regard to farmers' perceptions of conservation actions, i.e., what needs to happen in the event of livestock depredation (or crop raiding), the majority of farmers indicated they would like the authorities to provide financial compensation. Currently in this area there is no compensation programme despite being a widely utilised strategy elsewhere, with demonstrated positive outcomes for carnivore species in some areas (Bauer, Müller, Van Der Goes, & Sillero-Zubiri, 2015). Arguably though, compensation schemes require significant and sustainable funding resources, usually from the government, and most ultimately fail because of lack of resources, monitoring, poor administration and moral hazard (i.e., when pay-outs unintentionally encourage lax herding by farmers) (Dickman, Macdonald, & Macdonald, 2011). Given the numerous difficulties associated with compensation schemes, we suggest this is not currently an appropriate solution in northwestern Zimbabwe. Rather, we recommend that conservation authorities prioritise damage prevention through educational outreach and working with farmers, over compensation. Using the data collected from this study, we suggest coexistence strategies can be designed that help address the knowledge gaps or misinformation as well as develop outreach efforts that in turn foster useful skills for farmers in mitigating lion conflict. Farmers also indicated they would support the translocation of problem lions as another management

491 action. However, given the numerous difficulties associated with the capture and movement
492 of problem animals, including financial, logistical, biological, and ethical, as well as homing
493 behaviour where translocated animals move back to the original site, we suggest this is not a
494 promising solution (Loveridge, Wang, Frank, & Seidensticker, 2010b). Instead, we advocate
495 minimising contact between lions and livestock through improved livestock herding (e.g.,
496 constant presence of herders, use of guard dogs) and livestock protection (e.g., fortified
497 enclosures, night-time penning). We also suggest a lion early-warning system may be
498 beneficial to proactively mitigating conflict while simultaneously addressing risk perceptions.
499 In regards to perceptions related to conservation activities at the program level, we
500 found that farmers generally held positive perceptions towards the HMPAC. Specifically,
501 farmers indicated that the assistance received from government authorities in managing the
502 impacts from wildlife (e.g. shooting problem elephants), combined with HMPAC protecting
503 wildlife species and habitat for future generations, were important factors influencing their
504 perceptions. More specifically, farmers from Victoria Falls held stronger positive perceptions
505 towards HMPAC than farmers from Mabale and Tsholotsho. This may be related to the fact
506 that farmers in Victoria Falls enjoyed greater direct benefits through increased tourism and
507 employment opportunities compared to the other two communities (L. Sibanda, pers. obs.).
508 However, we found no evidence to suggest farmers' perceptions towards lions were
509 influenced by the benefits provided from CAMPFIRE, whether income generated from
510 wildlife activities (tourism, trophy hunting), construction of classroom blocks, medical
511 clinics, water boreholes, or road repairs. In fact, districts who reportedly received the highest
512 financial benefits from CAMPFIRE (Tsholotsho US$50,452 annually, versus Mabale and
513 Victoria Falls US$11,862 combined) (CAMPFIRE, 2016) did not hold positive perceptions
514 towards lions. Moreover, even when CAMPFIRE benefits were received, the majority of
515 farmers indicated they wanted the programme to discontinue. This is in line with other

research which has identified the shortcomings of CAMPFIRE (Frost & Bond, 2008; Taylor, 2009). In part, we suggest these negative perceptions may be influenced by the relatively paltry revenue received from CAMPFIRE, when compared to mean annual financial losses to predators over this period of time [Tsholotsho $34 882, Mabale $13 054, Victoria Falls $31 413, (Loveridge et al., 2017)]. Additionally, benefits are distributed at the ward level rather than to the individual farmer, despite the individual farmer directly experiencing livestock loss, suffering economically or risking personal injury or worse. While other studies have demonstrated that direct benefits accrued from wildlife conservation activities can improve perceptions towards carnivores and coexistence, and influence the adoption of desired conservation practices (Dickman et al., 2011), this appears to hold true only when the benefits are accrued at a local or proximate level and reflect the needs and values of the people expected to live with wildlife (Romañach, Lindsey, & Woodroffe, 2007). Indeed, successful benefits schemes are characterised by the enthusiastic participation of local people, including the development of what constitutes a benefit, clear guidelines and expectations as to what conservation actions must be taken in order to receive benefits, reasonable consequences for failure to honour agreements, and acceptable criteria for the distribution of benefits (Archabald & Naughton-Treves, 2002; Bulte & Rondeau, 2005). We suggest future work with local leaders is needed to develop contextually-relevant benefits schemes, and ensure that conservation benefits are delivered at an appropriate scale and are appropriate to human values, livelihoods and wellbeing. In working with community to solicit their perceptions, values and needs, it is our hope that we can also encourage and nurture positive perceptions towards lions, and ultimately influence positive coexistence (Fiallo & Jacobson, 2009; Newmark & Leonard, 1993).

## CONCLUSION

We explored the perceptions and actions towards lions and conservation activities in northwestern Zimbabwe between 2010-2012. Our findings provide insight into human-lion relations in the area, and a valuable baseline for future conservation monitoring and for developing locally-meaningful conservation interventions. Self-reported perceptions towards lions were strongly negative and were not directly related to either a farmer's actual livestock loss, personal income, or direct benefits received from the CAMPFIRE programme. Further, we found that despite the potential for livestock depredation, economic loss or personal safety risks, perceptions towards lions were more negative compared to perceptions towards other damage-causing wildlife species (i.e., elephants, hyaenas, leopards, jackals, African wild dogs). This is despite the fact that elephant crop-raiding was reported as a higher livelihood threat than livestock depredation. Overall, we found that perceived depredation and safety risk, along with geographic location and ethnic group, appear to play a stronger role in influencing farmers' lion perceptions. This suggests that understanding the cultural context and peoples' proximity to protected areas, coupled with developing locally-relevant benefits, are important factors to consider when designing lion conservation interventions.

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## REFERENCES

Ajzen, I. (2001). Nature and operation of attitudes. *Annual Review of Psychology, 52*, 27-58. doi:10.1146/annurev.psych.52.1.27

Amit, R., & Jacobson, S. K. (2017). Understanding rancher coexistence with jaguars and pumas: a typology for conservation practice. *Biodiversity and Conservation, 26*(6), 1353-1374. doi:10.1007/s10531-017-1304-1

Archabald, K., & Naughton-Treves, L. (2002). Tourism revenue-sharing around national parks in Western Uganda: early efforts to identify and reward local communities. *Environmental Conservation, 28*(02). doi:10.1017/s0376892901000145

Bartoń, K. (2019). Multi-Model Inference. Retrieved from https://CRAN.R-project.org/package=MuMIn

Barua, M., Bhagwat, S. A., & Jadhav, S. (2013). The hidden dimensions of human–wildlife conflict: Health impacts, opportunity and transaction costs. *Biological Conservation, 157*, 309-316. doi:10.1016/j.biocon.2012.07.014

Bauer, H., Müller, L., Van Der Goes, D., & Sillero-Zubiri, C. (2015). Financial compensation for damage to livestock by lions Panthera leo on community rangelands in Kenya. *Oryx, 51*(01), 106-114. doi:10.1017/s003060531500068x

Bauer, H., Packer, C., Funston, P. F., Henschel, P., & Nowell, K. (2016). Panthera leo: The IUCN Red List of Threatened Species (T15951A115130419) (Publication no. 10.2305/IUCN.UK.2016-3.RLTS.T15951A107265605.en).

Bel, S. L., Stansfield, F., Grange, M. L., & Taylor, R. (2013). Managing local overabundance of elephants through the supply of game meat: The case of Savé Valley Conservancy, Zimbabwe. *South African Journal of Wildlife Research, 43*(2), 103-119. doi:10.3957/056.043.0201

Bennett, N. J. (2016). Using perceptions as evidence to improve conservation and environmental management. *Conserv Biol, 30*(3), 582-592. doi:10.1111/cobi.12681

Bennett, N. J., Roth, R., Klain, S. C., Chan, K., Christie, P., Clark, D. A., . . . Wyborn, C. (2017). Conservation social science: Understanding and integrating human

dimensions to improve conservation. *Biological Conservation, 205*, 93-108. doi:10.1016/j.biocon.2016.10.006

Buijs, A., Hovardas, T., Figari, H., Castro, P., Devine-Wright, P., Fischer, A., . . . Selge, S. (2012). Understanding people's Ideas on natural resource management: Research on social representations of nature. *Society & Natural Resources, 25*(11), 1167-1181. doi:10.1080/08941920.2012.670369

Bulte, E. H., & Rondeau, D. (2005). Why compensating wildlife damages may be bad for conservation. *Journal of Wildlife Management, 69*(1), 14-19. doi:10.2193/0022-541X(2005)069<0014:WCWDMB>2.0

Burnham, K. P., & Anderson, D. (2002). Model Selection and Inference: A Practical Information-Theoretic Approach. 2nd Edition, Springer-Verlag, New York. .

CAMPFIRE. (2016). Community benefits summary. Retrieved from http://www.campfirezimbabwe.org/article/community-benefits-summary

Christensen, R. H. B. (2015). Ordinal Regression Models for Ordinal Data. *R package version 2015.6-28.* Retrieved from http://www.cran.r-project.org/package=ordinal

Davenport, M., & Hassan, R. M. (2019). Social capital and self-organised collective action: Lessons and insights from a South African community project. *Development Southern Africa,* 1-15. doi:10.1080/0376835x.2019.1628708

Dickman, A. J. (2005). *An assessment of pastoralist attitudes and wildlife conflict in the Rungwa-Ruaha region, Tanzania, with particular reference to large carnivores.* (Master of Science Thesis). University of Oxford, United Kingdom.

Dickman, A. J., Macdonald, E. A., & Macdonald, D. W. (2011). A review of financial instruments to pay for predator conservation and encourage human-carnivore coexistence. *Proc Natl Acad Sci U S A, 108*(34), 13937-13944. doi:10.1073/pnas.1012972108

Dietsch, A. M., Teel, T. L., & Manfredo, M. J. (2016). Social values and biodiversity conservation in a dynamic world. *Conservation Biology, 30*(6), 1212-1221. doi:10.1111/cobi.12742

Fiallo, E. A., & Jacobson, S. K. (2009). Local Communities and Protected Areas: Attitudes of Rural Residents Towards Conservation and Machalilla National Park, Ecuador. *Environmental Conservation, 22*(03). doi:10.1017/s037689290001064x

Figari, H., & Skogen, K. (2011). Social representations of the wolf. *Acta Sociologica, 54*(4), 317-332. doi:10.1177/0001699311422090

629 Fox, J., & Weisberg, S. (2019). An R Companion to Applied Regression. Retrieved from
630 https://socialsciences.mcmaster.ca/jfox/Books/Companion/
631 Frost, P. G. H., & Bond, I. (2008). The CAMPFIRE programme in Zimbabwe: Payments for
632 wildlife services. *Ecological Economics, 65*(4), 776-787.
633 doi:10.1016/j.ecolecon.2007.09.018
634 Fulton, D. C., Manfredo, M. J., & Lipscomb, J. (1996). Wildlife value orientations: A
635 conceptual and measurement approach. *Human Dimensions of Wildlife, 1*(2), 24-47.
636 doi:10.1080/10871209609359060
637 Gebresenbet, F., Baraki, B., Yirga, G., Sillero-Zubiri, C., & Bauer, H. (2017). A culture of
638 tolerance: coexisting with large carnivores in the Kafa Highlands, Ethiopia. *Oryx*, 1-
639 10. doi:10.1017/s0030605316001356
640 Gebresenbet, F., Bauer, H., Vadjunec, J. M., & Papeş, M. (2018). Beyond the numbers:
641 Human attitudes and conflict with lions (Panthera leo) in and around Gambella
642 National Park, Ethiopia. *PLoS One, 13*(9), e0204320.
643 doi:10.1371/journal.pone.0204320
644 Gerland, P., Raftery, A. E., Ševčíková, H., Li, N., Gu, D., Spoorenberg, T., . . . Wilmoth, J.
645 (2014). World population stabilization unlikely this century. *Science, 346*(6206), 234-
646 237. doi:10.1126/science.1257469
647 Goldman, M. J., Roque De Pinho, J., & Perry, J. (2010). Maintaining Complex Relations
648 with Large Cats: Maasai and Lions in Kenya and Tanzania. *Human Dimensions of*
649 *Wildlife, 15*(5), 332-346. doi:10.1080/10871209.2010.506671
650 Gore, M. L., Siemer, W. E., Shanahan, J. E., Schuefele, D., & Decker, D. J. (2005). Effects
651 on risk perception of media coverage of a black bear-related human fatality. *Human*
652 *Dimensions, 33*(2), 507-516.
653 Hazzah, L., Dolrenry, S., Naughton-Treves, L., Edwards, C. T., Mwebi, O., Kearney, F., &
654 Frank, L. (2014). Efficacy of two lion conservation programs in Maasailand, Kenya.
655 *Conserv Biol, 28*(3), 851-860. doi:10.1111/cobi.12244
656 Hill, C. M. (2004). Farmers' Perspectives of Conflict at the Wildlife–Agriculture Boundary:
657 Some Lessons Learned from African Subsistence Farmers. *Human Dimensions of*
658 *Wildlife, 9*(4), 279-286. doi:10.1080/10871200490505710
659 Hill, C. M. (2015). Perspectives of "Conflict" at the Wildlife–Agriculture Boundary: 10
660 Years On. *Human Dimensions of Wildlife, 20*(4), 296-301.
661 doi:10.1080/10871209.2015.1004143

662 Hovardas, T. (2018). *Large Carnivore Conservation and Management: Human Dimensions*:
663 Routledge.
664 Hovardas, T., & Korfiatis, K. J. (2012). Adolescents' Beliefs about the Wolf: Investigating
665 the Potential of Human–Wolf Coexistence in the European South. *Society & Natural*
666 *Resources, 25*(12), 1277-1292. doi:10.1080/08941920.2012.677942
667 Infield, M., Entwistle, A., Anthem, H., Mugisha, A., & Phillips, K. (2017). Reflections on
668 cultural values approaches to conservation: lessons from 20 years of implementation.
669 *Oryx, 52*(2), 220-230. doi:10.1017/s0030605317000928
670 Inskip, C., & Zimmermann, A. (2009). Human-felid conflict: a review of patterns and
671 priorities worldwide. *Oryx, 43*(01). doi:10.1017/s003060530899030x
672 IUCN. (2016). The IUCN Red List of Threatened Species 2016. Retrieved from
673 https://www.iucnredlist.org/species/15951/115130419. Retrieved 12 February 2019
674 https://www.iucnredlist.org/species/15951/115130419
675 IUCN SSC Cat Specialist Group. (2018). *Guidelines for the Conservation of Lions in Africa.*
676 *Version 1.0*. Retrieved from
677 James, G., Witten, D., Hastie, T., & Tibshirani, R. (2014). An Introduction to Statistical
678 Learning: With Applications in R. Springer Publishing Company, Incorporated.
679 Johansson, M., Ferreira, I. A., Støen, O.-G., Frank, J., & Flykt, A. (2016). Targeting human
680 fear of large carnivores — Many ideas but few known effects. *Biological*
681 *Conservation, 201*, 261-269. doi:10.1016/j.biocon.2016.07.010
682 Karidozo, M., La Grange, M., & Osborn, F. V. (2016). *Assessment of the human wildlife*
683 *conflict mitigation measures being implemented by the Kavango-Zambezi*
684 *Transfrontier Conservation Area (KAZA TFCA) partner countries. Report to the*
685 *KAZA TFCA Secretariat (BMZ No.: 2009 66 788 and BMZ No.: 2006 65 646)*.
686 Retrieved from Kasane, Botswana:
687 Kuiper, T. R., Loveridge, A. J., Parker, D. M., Johnson, P. J., Hunt, J. E., Stapelkamp, B., . . .
688 Macdonald, D. W. (2015). Seasonal herding practices influence predation on
689 domestic stock by African lions along a protected area boundary. *Biological*
690 *Conservation, 191*, 546-554. doi:10.1016/j.biocon.2015.08.012
691 Kushnir, H., & Packer, C. (2019). Perceptions of Risk From Man-Eating Lions in
692 Southeastern Tanzania. *Frontiers in Ecology and Evolution, 7*.
693 doi:10.3389/fevo.2019.00047

694 Liu, D., & Zhang, H. (2018). Residuals and Diagnostics for Ordinal Regression Models: A
695 Surrogate Approach. *J Am Stat Assoc*, *113*(522), 845-854.
696 doi:10.1080/01621459.2017.1292915
697 Loveridge, A. J., Hemson, G., Davidson, Z., & Macdonald, D. W. (2010a). African lions on
698 the edge: reserve boundaries as attractive sinks. In D. W. Macdonald & A. J.
699 Loveridge (Eds.), *Biology and conservation of wild felids* (pp. 283-314). Oxford:
700 Oxford Univeristy Press.
701 Loveridge, A. J., Kuiper, T., Parry, R. H., Sibanda, L., Hunt, J. H., Stapelkamp, B., . . .
702 Macdonald, D. W. (2017). Bells, bomas and beefsteak: complex patterns of human-
703 predator conflict at the wildlife-agropastoral interface in Zimbabwe. *PeerJ, 5*, e2898.
704 doi:10.7717/peerj.2898
705 Loveridge, A. J., Wang, S. W., Frank, L. G., & Seidensticker, J. (2010b). People and wild
706 felids: conservation of cats and management of conflicts. In D. W. Macdonald & A. J.
707 Loveridge (Eds.), *Biology and Conservation of Wild Felids* (pp. 161-195). Oxford
708 Oxford University Press.
709 Manfredo, M. J., Bruskotter, J. T., Teel, T. L., Fulton, D., Schwartz, S. H., Arlinghaus, R., . .
710 . Sullivan, L. (2017). Why social values cannot be changed for the sake of
711 conservation. *Conserv Biol, 31*(4), 772-780. doi:10.1111/cobi.12855
712 Manfredo, M. J., & Dayer, A. A. (2004). Concepts for Exploring the Social Aspects of
713 Human–Wildlife Conflict in a Global Context. *Human Dimensions of Wildlife, 9*(4),
714 1-20. doi:10.1080/10871200490505765
715 Mkonyi, F. J., Estes, A. B., Msuha, M. J., Lichtenfeld, L. L., & Durant, S. M. (2017). Local
716 Attitudes and Perceptions Toward Large Carnivores in a Human-Dominated
717 Landscape of Northern Tanzania. *Human Dimensions of Wildlife, 22*(4), 314-330.
718 doi:10.1080/10871209.2017.1323356
719 Moyo, S., & Swanepoel, F. J. C. (2010). Multifuncionality of livestock in developing
720 communities. In A. S. a. S. M. Frans Swanepoel (Ed.), *The Role of Livestock in*
721 *Developing Communities: Enhancing Multifunctionality*. South Africa: Co- published
722 by The Technical Centre for Agricultural and Rural Cooperation (CTA) and
723 University of the Free State.
724 Mulder, M. B., Kwiyega, J. L., Beccaria, S., Bwasama, S. S., Fitzherbert, E., Genda, P., &
725 Caro, T. (2019). Lions, Bylaws, and Conservation Metrics. *BioScience*.
726 doi:10.1093/biosci/biz114

727 Naughton-Treves, L., Treves, A., Woodroffe, R., Thirgood, S., & Rabinowitz, A. (2005).
728 Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants
729 and other wildlife in Africa. In *People and Wildlife* (pp. 252-277).
730 Newmark, W. D., & Leonard, N. L. (1993). Conservation attitudes of local people living
731 adjacent to five protected areas in Tanzania. *Biological Conservation, 63*, 177-183.
732 Parry, D., & Campbell, B. (2009). Attitudes of Rural Communities to Animal Wildlife and Its
733 Utilization in Chobe Enclave and Mababe Depression, Botswana. *Environmental*
734 *Conservation, 19*(03). doi:10.1017/s0376892900031040
735 Pickens, J. (2005). Attitudes and perceptions. In N. Borkowski (Ed.), *Organizational*
736 *behavior in health care* (2nd ed., pp. 43-69). Boston, NY: Jones and Barlettt
737 Publisher.
738 Pooley, S., Barua, M., Beinart, W., Dickman, A., Holmes, G., Lorimer, J., . . . Milner-
739 Gulland, E. J. (2017). An interdisciplinary review of current and future approaches to
740 improving human-predator relations. *Conserv Biol, 31*(3), 513-523.
741 doi:10.1111/cobi.12859
742 Putnam, R. D. (1993). The prosperous community. *The American Prospect, 4*, 35-42.
743 R Core Team. (2019). R: A language and environment for statistical computing (Version
744 3.5.2). Vienna, Austria: R Foundation for Statistical Computing. Retrieved from
745 https://www.r-project.org
746 Rasmussen, G. S. A. (1997). Livestock predation by the painted hunting dog Lycaon pictus in
747 a cattle ranching region of Zimbabwe: a case study. *Biological Conservation,*
748 *88*(1999), 133-139.
749 Ripple, W. J., Estes, J. A., Beschta, R. L., Wilmers, C. C., Ritchie, E. G., Hebblewhite, M., . .
750 . Wirsing, A. J. (2014). Status and ecological effects of the world's largest carnivores.
751 *Science, 343*(6167), 1241484. doi:10.1126/science.1241484
752 Romañach, S. S., Lindsey, P. A., & Woodroffe, R. (2007). Determinants of attitudes towards
753 predators in central Kenya and suggestions for increasing tolerance in livestock
754 dominated landscapes. *Oryx, 41*(02). doi:10.1017/s0030605307001779
755 Rose, D. C., Keating, C., & Morris, C. (2018). *Understanding how to influence farmers'*
756 *decision-making behaviour: a social science literature review.* Retrieved from
757 Sabatier, E., & Huveneers, C. (2018). Changes in Media Portrayal of Human-wildlife
758 Conflict During Successive Fatal Shark Bites. *Conservation and Society, 16*(3).
759 doi:10.4103/cs.cs_18_5

760 Taylor, R. (2009). Community based natural resource management in Zimbabwe: the
761 experience of CAMPFIRE. *Biodiversity and Conservation, 18*(10), 2563-2583.
762 Thomas, E. M. (2003). The lion-bushman relationship in the Nyae Nyae in the 1950s: a
763 relationship crafted in the old way. *Anthropologica, 45*(1), 73-78. Retrieved from
764 https://www.jstor.org/stable/25606114
765 Western, G., Macdonald, D. W., Loveridge, A. J., & Dickman, A. J. (2019). Creating
766 Landscapes of Coexistence- Do Conservation Interventions Promote Tolerance of
767 Lions in Human-dominated Landscapes? *Conservation and Society, 12*(2), 214-217.
768 doi:10.4103/cs.cs_18_29
769 Wittemyer, G., Elsen, P., Bean, W. T., Burton, A. C. O., & Brashares, J. S. (2008).
770 Accelerated Human Population Growth at Protected Area Edges. *Science, 321*(5885),
771 123-126. doi:10.1126/science.1158900
772 Woodford, D. J., Richardson, D. M., MacIsaac, H. J., Mandrak, N. E., van Wilgen, B. W.,
773 Wilson, J. R. U., & Weyl, O. L. F. (2016). Confronting the wicked problem of
774 managing biological invasions. *NeoBiota, 31*, 63-86. doi:10.3897/neobiota.31.10038
775 Woodroffe, R. (2000). Predators and people: using human densities to interpret declines of
776 large carnivores. *Animal Conservation, 3*(2), 165-173.
777 doi:10.1017/S136794300000086X
778

779 **LIST OF TABLES**

780 **Table 1**: Population size, residential density and ethnic groups of our study sites (Tsholotsho,
781 Mabale and Victoria Falls) in northwestern Zimbabwe

| Parameters | Tsholotsho | Mabale | Victoria Falls |
|---|---|---|---|
| Area ($km^2$) | 2,171 | 480 | 655 |
| Density (buildings/ $km^2$) | 1.8 | 6.2 | 6.1 |
| Ethnic Groups /(%) | | | |
| - Ndebele | 99 | 48 | 57 |
| - Tonga | 0 | 20 | 14 |
| - Nambya | 1 | 32 | 29 |
| Depredation costs/ farmstead[a] | US$8.93 | US$4.34 | US$7.79 |

782 [a] Source: Loveridge et al., (2017)

783 **Table 2**: Full list of predictor variables used to predict perceptions of subsistence farmers
784 towards the lion in northwestern Zimbabwe. * means there is no evidence of any non-linear
785 effects.

| Predictor variable | Explanations | Variable type |
|---|---|---|
| (a) Ethnic group | Which ethnic group does the respondent belong to, as indicated by first language. | Categorical: 1=Tonga, 2= Nambya, 3= Ndebele 4= Other |
| (b) Education | The respondent's level of formal education and assuming this predictor serves as a proxy for knowledge | Ordinal*: 0= None, 1= Primary, 2= Secondary & above |
| (c) Age | Respondent's age (in years)? | Numeric: (18-92) |
| (d) Proportion of livestock lost to lion | Livestock losses to lion in the preceding 12 months, expressed as a proportion of livestock owned | Continuous: 0-1 |
| (e) Benefits from wildlife | Perceived benefits from National Park or the CAMPFIRE programme | Binary: 0= No, 1= Yes |
| (f) Village | Name of village | 68 different villages |
| (g) Permanence | Number of years the farmer had been present in the area? | Numeric: (<1-83) |
| (h) Area | Which study site is the farmer from? | Nominal: 1= Mabale 2= Tsholotsho, 3= Victoria Falls |
| (i) Income | Did the farmer list livestock-rearing as a major source of income? | Binary*: 1=Yes; 0= No |
| (j) Position in the farmstead | What is the role of the farmer in the farmstead? | Binary*: 0= Dependant; 1= Head of farmstead |
| (k) Farmstead size | How many people live in the farmstead, together with the respondent? | Continuous: (possible range from 1-21) |
| Perceptions towards lions | Using a scale 1-5, where 1 represents 'strongly dislike' and 5 represents 'strongly like', how much do you like lions, and why? | Ordinal: 1= Strongly dislike,2= Dislike, 3= Neither like nor dislike, 4= Like, 5= Strongly like |

786

787 **Table 3**: Summary of model-averaged coefficients calculated using the *MuMIn* package in R.
788 The results below show a significant 'Area' and 'Ethnic group' effect.

| | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| *Area (reference area = Mabale)* | | | | |
| Tsholotsho | -.45 | .48 | .94 | .35 |
| Victoria Falls | -1.68 | .51 | 3.27 | < .001* |
| *Ethnic group (reference ethnic group = Nambya)* | | | | |
| Ndebele | .59 | .43 | 1.40 | .16 |
| Tonga | 2.34 | .77 | 3.02 | < .001* |
| *Benefits from:* | | | | |
| Hwange /Zambezi NPs | -.43 | .38 | 1.12 | .26 |
| CAMPFIRE | .22 | .29 | .76 | .45 |
| *Proportion lost to lions* | | | | |
| Donkeys | -.69 | .70 | .99 | .32 |
| Cattle | -.36 | .35 | 1.02 | .31 |
| *Socioeconomic variables* | | | | |
| Education | -.17 | .19 | .90 | .37 |
| Residence status | -.01 | .01 | .63 | .53 |
| Farmstead size | .03 | .04 | .65 | .52 |
| Livestock income | -.13 | .31 | .42 | .67 |

789
790 *Statistically significant

791 **Table 4**: Perceived threats to the farmer's livelihood, presented per study site and as total
792 percentage of farmers who listed this threat. Rank is based on the total percentage of farmers
793 who mentioned the threat based on all sites combined. Seven farmers were excluded from
794 this particular analysis because they did not have any clear responses.

| No. | Threat | Mabale (*n* = 124) | Tsholotsho (*n* = 228) | Vic Falls (*n* = 273) | All sites combined (*n* = 625) | Rank |
|---|---|---|---|---|---|---|
| 1 | Crop raiding | 60 | 25 | 27 | 33 | 1 |
| 2 | Economic circumstances | 4 | 15 | 28 | 18 | 2 |
| 3 | Livestock depredation | 18 | 18 | 12 | 15 | 3 |
| 4 | Drought and natural disasters | 6 | 8 | 21 | 13 | 4 |
| 5 | Disease in family | 2 | 11 | 7 | 7 | 5 |
| 6 | Lack of government assistance | 4 | 6 | 1 | 3 | 6 |
| 7 | Inadequate water sources | 3 | 8 | 0 | 3 | 6 |
| 8 | Malnutrition | 1 | 4 | 3 | 2 | 8 |
| 9 | Disease in livestock | 2 | 4 | 2 | 2 | 8 |
| 10 | Lack of agricultural inputs | 2 | 2 | 1 | <1 | 10 |
| 11 | Stock theft | 1 | <1 | 1 | <1 | 11 |
| 12 | Accidental death in livestock | 0 | <1 | 1 | <1 | 12 |

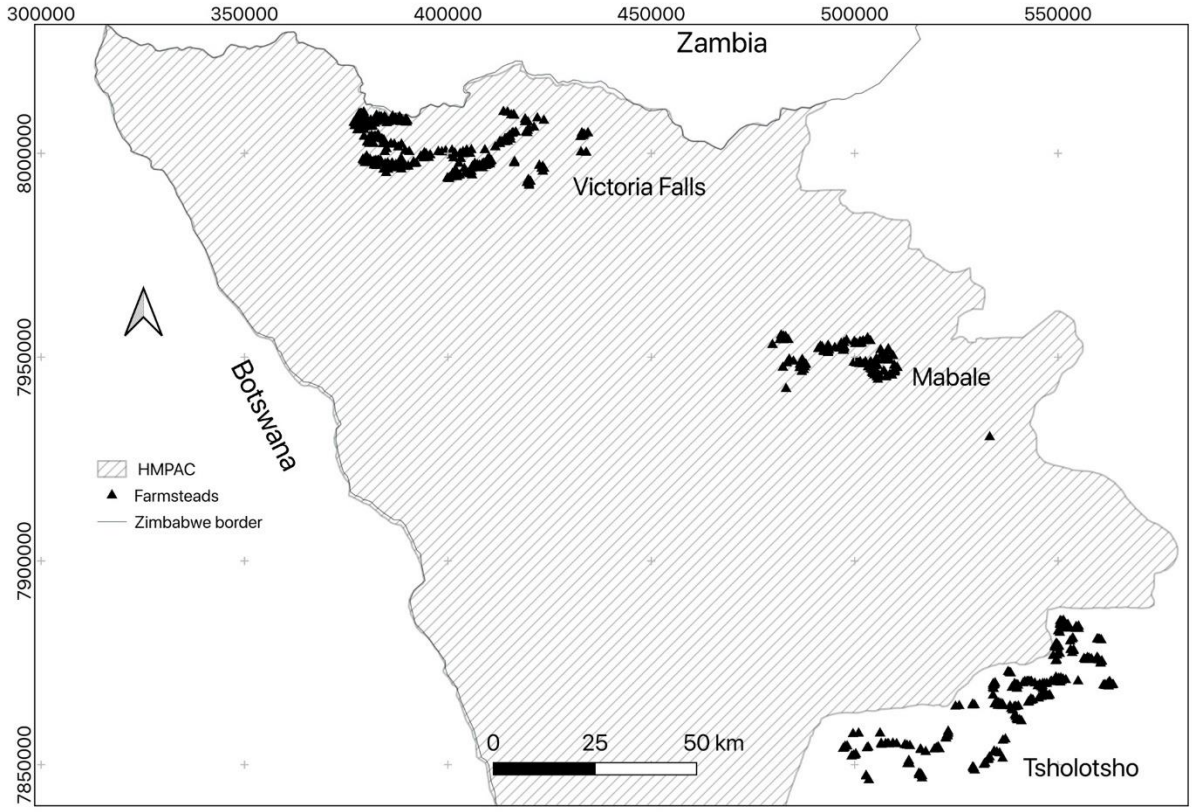
795

796 **Table 5**: Perceptions towards the HMPAC and reasons to like or dislike the HMPAC. The
797 value in the table below represents the percentage of farmers who mentioned the
798 corresponding response. Seven farmers were excluded from this particular analysis because
799 they did not have clear responses.

| Attribute | Mabale (*n* = 124) | Tsholotsho (*n* = 228) | Vic. Falls (*n* = 273) | Combined for all sites (*n* = 625) |
|---|---|---|---|---|
| *Perceptions towards the HMPAC* | | | | |
| Very negative | 7 | 6 | 13 | 9 |
| Negative | 9 | 20 | 3 | 10 |
| Neither | 4 | 14 | 12 | 11 |
| Positive | 57 | 50 | 13 | 36 |
| Very positive | 23 | 10 | 59 | 34 |
| *Reasons for positive perceptions towards the* HMPAC | | | | |
| Provision of resources for people, e.g., meat | 16 | 11 | 10 | 11 |
| Management of wildlife impacts | 15 | 22 | 48 | 32 |
| Protection of wildlife and habitats for future generations | 42 | 32 | 17 | 27 |
| *Reasons for negative perceptions towards the* HMPAC | | | | |
| Wildlife has a negative impact on lives and livelihoods | 9 | 8 | 5 | 7 |
| Protected areas do not provide benefits | 18 | 28 | 22 | 23 |

800

801 **LIST OF FIGURES**

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803

804 **Fig. 1**: Our study sites (Tsholotsho, Mabale and Victoria Falls) within the Hwange-Matetsi
805 Protected Area Complex (HMPAC) in northwestern Zimbabwe, where 632 semi-structured
806 interviews were conducted to explore perceptions of subsistence farmers towards lions
807 (*Panthera leo*).

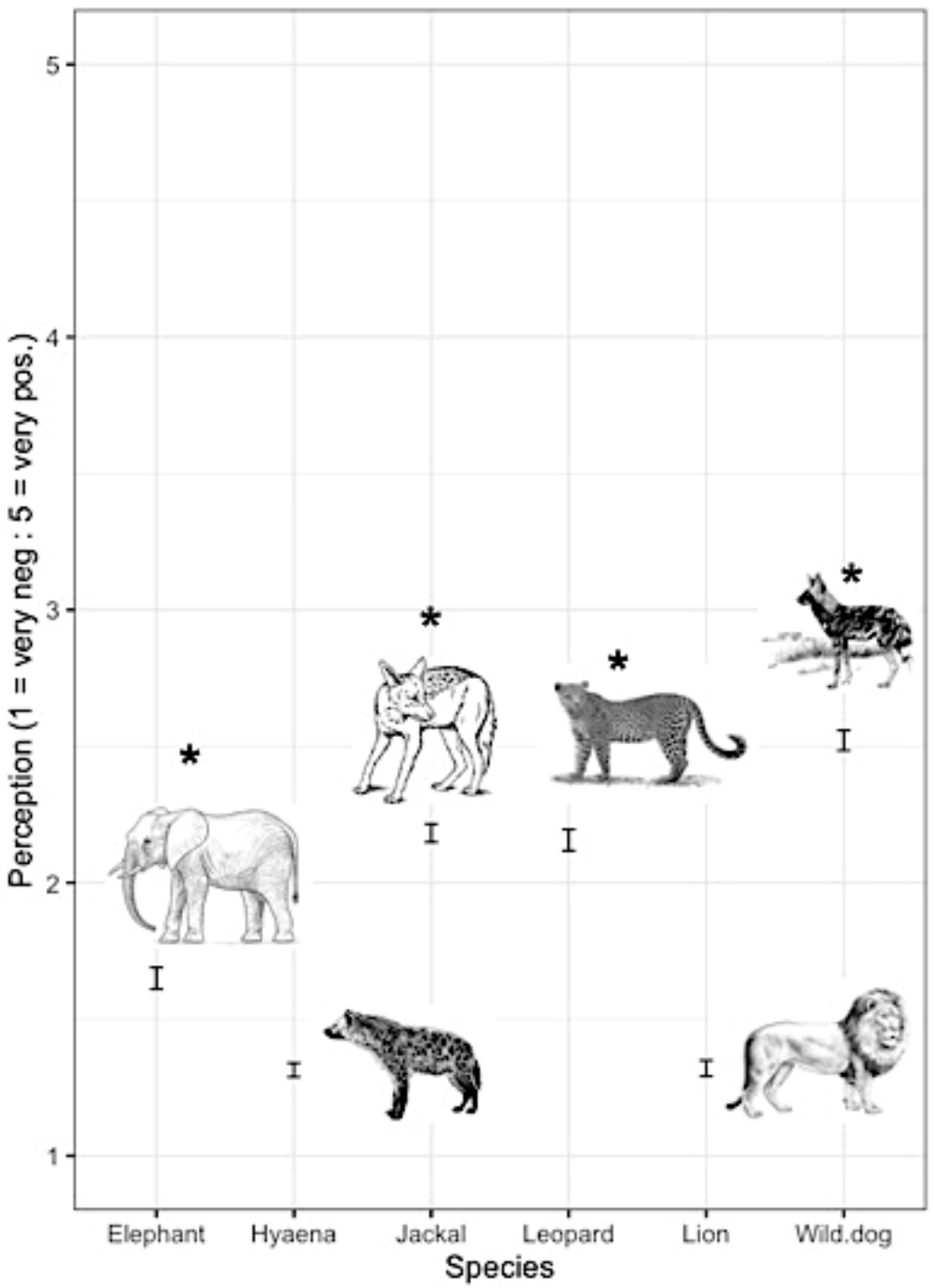


**Fig. 2**: Perceptions of subsistence farmers towards different damage-causing wild animals. The error bars represent the standard error (SE). The asterisk (*) means the perception score is significantly different to that held towards lions.