

# Socioeconomic drivers of illegal bushmeat hunting in a Southern African Savanna

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## ABSTRACT

### Keywords:

Bushmeat  
Illegal hunting  
Law enforcement  
Poaching  
Protected areas

Illegal bushmeat hunting of economically and ecologically valuable wildlife populations is emerging as a threat across African savannas. Due to the cryptic nature of illegal hunting, little information exists on the drivers of the bushmeat industry. Here we report on the socioeconomic drivers identified in a broader investigation into illegal bushmeat hunting in rural villages around a southern African savanna ecosystem, the Okavango Delta, Botswana. We conducted interviews with bushmeat hunters and heads of rural households about hunting activities, rural livelihoods, attitudes towards wildlife, and market characteristics of illegal bushmeat. Using generalized linear models, we identified and investigated a set of independent variables that characterize illegal-hunter households. Results revealed that compared to non-hunter households, illegal hunter households ( $n = 119$ , 25% of the sample) lived in closer proximity to wildlife, were more likely to farm crops, and more often received income from formal employment by at least one household member. Bushmeat hunting was positively correlated with livestock wealth but not associated with household income. Only 11.4% ( $n = 44$ ) of non-hunter households reported purchasing bushmeat. Most households (84%) reported incurring costs associated with living near wildlife (e.g., damages to crops or livestock), with no difference between hunter and non-hunter households. Hunters were more likely to say they valued wildlife. We conclude that bushmeat hunting in Botswana is generally supplemental to household core income sources rather than essential for subsistence. We propose two interventions to counter the negative impacts of illegal hunting on the region's lucrative wildlife-based economy: 1) more effective law enforcement that imposes costs for hunting illegally, and 2) development of alternative wildlife-based revenue streams that motivate communities to conserve wildlife.

## 1. Introduction

Bushmeat hunting has driven many species and ecosystems to the brink of extinction or collapse (Galetti and Dirzo, 2013; Ripple et al., 2016). Bushmeat hunting, or the hunting of wild animals for the primary purpose of consuming the meat or selling the meat for consumption, has long been a focus of socioecological research in the forests of Central and West Africa (Fa et al., 2002; Fa and Brown, 2009; Abernethy et al., 2013). More recently, bushmeat hunting has emerged as a severe threat to wildlife in the savannas of East and Southern Africa (Lindsey et al., 2013; van Velden et al., 2018). Wildlife are declining as a result (Hilborn et al., 2006; Hayward, 2009; Lindsey et al., 2011a; Lindsey et al., 2015; Rogan et al., 2017). Amidst growing concern for the conservation implications of bushmeat hunting, our under-

standing of the drivers and socioeconomic implications of bushmeat hunting in savannas remains limited, particularly across Southern African ecosystems.

Findings from the few savanna ecosystems that have been studied are generally complex and contradictory (van Velden et al., 2018). Further, we cannot assume that the lessons learned from studying bushmeat hunting in the forest biome will hold true for savanna systems. Large vertebrate communities are more productive in mesic savannas than forests, increasing potential bushmeat harvests (Robinson and Bennett, 2004), while the prevalence of pastoral communities expands the scope for human-wildlife conflict in savannas. Wildlife-based industries such as trophy hunting and photographic tourism are also more prominent in savannas. These industries contribute billions of dollars to regional economies (Makochekanwa, 2013) and depend on effective strategies to control illegal and unsustainable bushmeat hunting.

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Most bushmeat hunting in savannas is illegal (Lindsey et al., 2013). This complicates research. Data collection on illegal activities is challenging and underreporting is common (Knapp et al., 2010). Yet two general perceptions emerge from the literature: illegal hunting is 1) a subsistence activity practiced primarily by poor households for consumption, or 2) a commercial practice done for financial gain (Duffy and St. John, 2013). The truth is more complex (Duffy et al., 2016). The relationships between illegal bushmeat hunting and poverty or wealth vary, both within and among communities, in response to diverse regulatory and socioeconomic conditions (Brashares et al., 2011; van Velden et al., 2018).

In the simplest terms, consuming bushmeat and selling it for cash are the two most direct benefits hunters derive (Muth and Bowe Jr., 1998; Nielsen et al., 2017). Most bushmeat hunting globally is for home consumption (Nielsen et al., 2017). However, some hunters earn substantial income from selling bushmeat (Loibooki et al., 2002; Damania et al., 2005; Kümpel et al., 2010; Lindsey et al., 2011b; Rentsch and Damon, 2013; Nielsen and Meilby, 2015).

Bushmeat hunting is frequently presumed to stem from community-level poverty (Adams et al., 2004). Hunters are often unemployed (Knapp, 2007; Lindsey et al., 2011b) and, in some areas, own fewer livestock than non-hunters (Loibooki et al., 2002). Hunting is sometimes associated with responses to human-wildlife conflict (Alexander et al., 2014; Kahler et al., 2013). Bushmeat is typically an inexpensive alternative protein source in rural areas where it originates (Ndibalema and Songorwa, 2008; Rentsch and Damon, 2013; Lindsey et al., 2011b), but in some contexts the poorest households may lack the resources required for hunting (Coad et al., 2010) even in the face of food insecurity (Brashares et al., 2011). In these cases, rural households that hunt are wealthy relative to their communities (Coad et al., 2010; Mgawe et al., 2012). Wealthier urban households create commercial demand and intercontinental markets (Chaber et al., 2010) underpinned by premium prices (Bennett, 2002; van Vliet and Mbazza, 2011).

Social issues also motivate bushmeat hunting. Empirical studies have found that local hunting rates in Africa vary with ethnic group (Ceppi and Nielsen, 2014). Elevated social status obtained through hunting is a key motivator (Brown and Marks, 2007; Lindsey et al., 2013). People seek bushmeat because they prefer the taste or wish to add variety to their diet (Wilkie et al., 2005; Lindsey et al., 2011b). Some perceive bushmeat as healthier than meat from livestock (van Vliet and Mbazza, 2011). Where it is illegal, hunting can be an expression of personal or traditional rights, or an act of defiance against the state or landowner (Muth and Bowe Jr., 1998; Harrison et al., 2015). Illegal hunting is not purely a product of circumstance. Individual attitude, behavior, and decision-making are critical motivators (Duffy et al., 2016).

We explored the motivations for illegal bushmeat hunting in the Okavango Delta of Botswana, a World Heritage site renowned for its rich wildlife community. The Delta is the cornerstone of Botswana's lucrative wildlife tourism industry, which contributed 11% of national GDP in 2016 (WTTC, 2017). The economic benefits deriving from the tourism sector are vital to the region but are unevenly distributed geographically (Mbaiwa, 2005). In 2009–2010, 28% and 47% of residents in the Ngamiland East and Ngamiland West census districts lived below the poverty line (Statistics Botswana, 2014).

Botswana traditionally permitted limited bushmeat and trophy hunting on designated public lands. In January, 2014, the government stopped issuing permits to hunt mammals due to concerns about declines in wildlife populations (Mbaiwa, 2017a). All subsequent bushmeat hunting has been illegal with the exception of regulated hunting of game birds. Illegal bushmeat hunting is pervasive in and around the Delta, although illegal hunting has generally been overlooked as a criti-

cal conservation issue (Rogan et al., 2015). Rogan et al. (2017) estimated that nearly 2000 illegal hunters operate in the Delta, extracting >500,000 kg of meat per annum. The scale and intensity of illegal hunting is likely unsustainable, reducing the capacity of the Delta to support large carnivore populations and compromising the growing wildlife-tourism industry (Rogan et al., 2017). Due to the severity of these threats, mitigating illegal bushmeat hunting is one of the most critical conservation challenges in northern Botswana.

We interviewed bushmeat hunters and heads of households in 13 villages in the region; we used these data to compare the socioeconomic characteristics of hunter households to non-hunter households and to describe patterns in livelihoods, bushmeat hunting and consumption, and attitudes towards wildlife. We investigated several hypotheses: that most bushmeat hunters would 1) lack formal employment (Lindsey et al., 2011b), 2) identify with certain ethnic groups (Ceppi and Nielsen, 2014; Kiffner et al., 2015), and 3) have direct access to protected areas where wildlife was accessible (Brashares et al., 2011; Ceppi and Nielsen, 2014). We aim to provide conservationists and policy makers with insights into illegal hunting in African savannas. We further offer recommendations for policy interventions tailored to the Delta but relevant across savanna ecosystems.

## 2. Methods

### 2.1. Study area

The Okavango Delta is a ~20,000 km<sup>2</sup> inland freshwater delta, savanna, and woodland ecosystem in northern Botswana that hosts a rich community of large vertebrates (McNutt, 1996). The Delta's network of protected areas consists of the Moremi Game Reserve (MGR) surrounded by 18 Wildlife Management Areas (WMAs), land concessions that the government leases to private companies or community trusts for the purpose of wildlife-based tourism (Fig. 1). Boundaries between WMAs and areas designated primarily for human land use (hereafter "residential concessions") are delineated by semi-permeable veterinary fences designed to inhibit the spread of disease from wildlife to livestock. Although they are intended to separate livestock and wildlife to prevent disease transmission, animals routinely cross the fence lines, with cattle entering protected areas (Rich et al., 2016) and wildlife widely distributed on community grazing lands (EWB 2010).

Enforcement of wildlife laws varies among concessions in the Delta. All concession lease holders are required to conduct monitoring as part of their management agreements, but they are not obligated to conduct anti-poaching. Some WMA leaseholders employ private anti-poaching teams, and the Department of Wildlife and National Parks and the Botswana Defence Force conduct anti-poaching patrols throughout the region, with an emphasis on high-value poaching for ivory and rhinoceros horn. Wildlife crimes are investigated by the Botswana Police Service.

We surveyed households in 13 villages in the Okavango Delta. All were located within 35 km of WMAs, a reasonable distance for hunters travelling on horseback or spending multiple nights on hunting expeditions (Loibooki et al., 2002). Villages were geographically, economically, and ethnically diverse (see Rogan et al., 2017 for a more detailed description of study villages). Eleven study villages consisted of a core residential area surrounded by cattle posts, semi-permanent outposts used primarily for accessing remote crop fields or grazing livestock. Two of the villages consisted entirely of cattle posts. We concentrated efforts to interview bushmeat hunters in six villages along the western edge of the Delta's protected areas. We selected this region because bushmeat hunting was well-documented and because these villages exhibited variation in village economies and land use policies which were representative of the Delta as a whole.

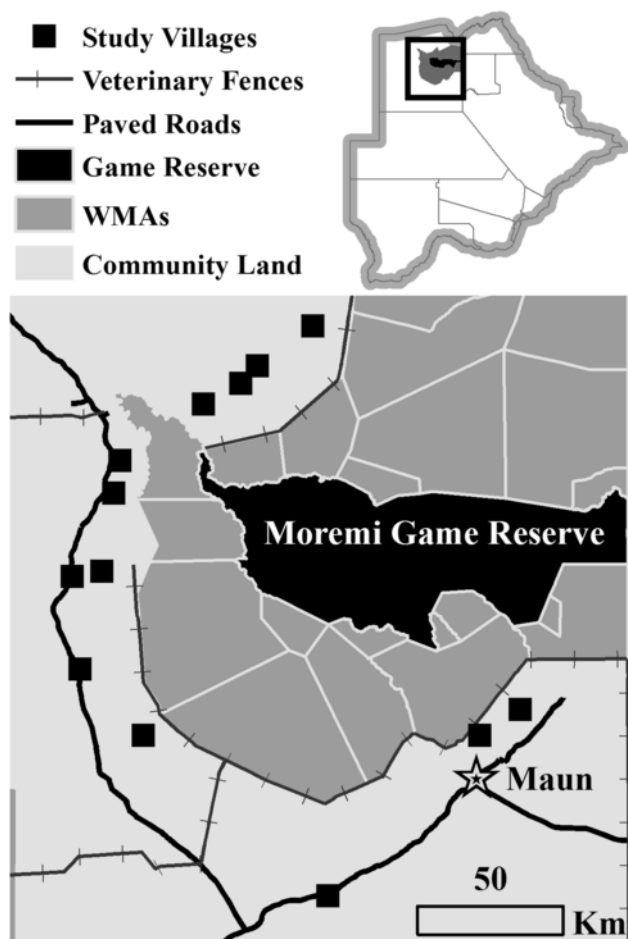


Fig. 1. Map of study villages and the Okavango Delta, Botswana. Wildlife Management Areas (WMAs) are tracts of public land that are leased to private companies or community trusts for photographic tourism.

## 2.2. Interviews

Semi-structured interviews with heads of households and bushmeat hunters in villages were conducted in the study area from August 2014, to March, 2015, under research permit EWT 8/36/4 xxvii (25). Interviewers came from communities in the Delta. They were trained as research assistants in interview techniques before conducting interviews, and all had prior experience conducting interviews. Additionally, research assistants were selected based on their knowledge of study villages, local languages, and bushmeat hunting. Interviews were conducted in Setswana, Hambukushu, Herero, Mbanderu, or Seyei languages depending on the respondents' preferences.

Respondents were asked open-ended interview questions adapted from Lindsey et al., 2011b. Questions covered topics including demographics, income, employment, dietary habits, perceptions of wildlife, and knowledge of bushmeat hunting and trade (see Rogan et al., 2017 SI 1–2). No identifying information was collected in order to maintain the anonymity of participants.

Bushmeat hunters were identified using three methods: 1) a random sample of heads of households within villages, 2) a non-random sample of heads of households at selected cattle posts, and 3) snowball sampling (Goodman, 1961; see Rogan et al., 2017 for details of the sampling protocols). Based on village size and prevalence of bushmeat hunting, researchers interviewed people from 30 to 72 households in each village and associated cattle posts, with a minimum of 25 ran-

domly-sampled households from each village (following the survey scales of Ceppi and Nielsen, 2014 and Mgawe et al., 2012).

Interview surveys of bushmeat hunters are among the foremost approaches for investigating bushmeat hunting in savanna ecosystems (van Velden et al., 2018). Where bushmeat hunting is illegal, however, we would expect some individuals not to report this activity (Knapp, 2007). Nevertheless, we are reasonably confident our sample of hunters is representative for three reasons. First, the hunters that we interviewed exhibited little concern for keeping their activity secret because bushmeat laws were rarely enforced. Second, our sample of hunters exhibited wide variation in hunting practices (e.g., hunting methods, hunting intensity, species targeted), age, geographic location, and other variables, which suggests our sample covers the full range of hunting behaviors. Variation in hunting is not the same as variation among hunters, but it suggests a lack of bias in the sample towards particular behaviors. Lastly, the hunting rates we detected via interviews were consistent with hunting rates estimated using an alternative approach based on conviction rates rather than self-reporting (see Rogan et al., 2017 for a description of variation in bushmeat hunting and multi-method estimates of hunting rates). We conclude that any underreporting that did occur was insufficient to systematically bias the socioeconomic characteristics of our sample.

## 2.3. Court cases

The risks and penalties associated with being convicted of a crime likely influence the decision making of potential illegal hunters (Keane et al., 2008; Knapp, 2012). Therefore, we acquired records of every court case in Ngamiland that related to wildlife crime that opened after 1 January, 2009, and concluded prior to 31 December, 2014. We recorded the species involved and the case outcomes.

## 2.4. Analysis

We analyzed socioeconomic patterns among hunters and non-hunters using generalized linear models (GLMs) and Kolmogorov-Smirnov tests. We identified the factors associated with whether a household hunted bushmeat using GLMs with a binomial distribution and a logit link function (Ceppi and Nielsen, 2014; Kiffner et al., 2015). The binomial response (1 or 0) represented hunting or not hunting bushmeat, respectively. We omitted interviews with missing data from GLM analyses ( $n = 55$  or 11%).

We included four variables as indicators of economic status, three variables as indicators of impoverishment and food security, two variables as indicators of access to bushmeat, and one cultural variable. To measure economic status, we included variables representing employment, income, livestock wealth, and financial assistance from the government. We grouped households into four categories of formal employment: no employment (represented as the intercept in models); year-round part-time employment, seasonal or temporary employment; and year-round full-time employment. We grouped respondents by income level (split into five evenly-divided numerical groups; hereafter “income”) based on cumulative income from five distinct sources: formal employment, crop harvests, livestock sales, government assistance programs, and other sources, but excluding income from hunting bushmeat. We estimated each household’s livestock wealth (household ownership of cattle, goats, sheep, horses, donkeys, and chickens) at local market rates. Lastly, we included a binary variable indicating whether households receive economic assistance from the government through direct subsidies such as pension schemes, agricultural support programs, and poverty alleviation programs (hereafter “government assistance”).

To measure impoverishment and food security, we included variables for 1) the number of meals that respondents reported skipping

annually because their household did not have enough money for food (hereafter “skipped meals”); 2) whether a household received income through two poverty alleviation programs for “destitute” families (hereafter “poverty assistance”); and 3) whether a household farmed crops. The skipped meals variable was calculated based on respondents reporting whether they skip meals daily, weekly, monthly, a few times per year, or never, while taking into account seasonal differences. We measured accessibility to wildlife using 1) the distance to wildlife as reported by representatives of each household; and 2) the distance to the nearest protected area, calculated as the Euclidean distance from a respondent’s village or cattle post to the nearest WMA (using concession boundaries acquired from the Botswana Department of Surveys and Mapping). Although respondents’ perceptions of distance are subjective, this measure was necessary to capture the unmonitored movement of wildlife outside protected areas and because we expect perceptions of wildlife accessibility to be a motivating factor for hunters. We represented cultural background using a household’s ethnicity, with ethnic groups uncommon in the delta region (i.e., accounting for <1% of randomly-sampled households) aggregated into a single group (represented as the intercept in the models).

We conducted all statistical analyses using R 3.4.1 (R Core Development Team, 2017). We included predictor variables in GLMs based on a two-part selection process. First, we generated univariate GLMs to examine which variables were strongly associated with bushmeat hunting and selected variables with statistically significant relationships ( $p \leq 0.05$ ). Second, to avoid collinearity among variables in the model, we calculated Spearman’s correlation coefficients for pairs of variables and included variables with low correlations ( $r_s \leq 0.6$ ). We included the remaining variables in multivariate global models, which we used to generate and rank models with all combinations of predictor variables based on Akaike’s Information Criterion (AIC; Burnham and Anderson, 2002) using the ‘MuMIN’ package in R (Bartoń, 2017). We checked the top models for multicollinearity among variables by assessing Variance Inflation Factors (VIF) using the ‘car’ package (Fox and Weisberg, 2011). We tested whether respondent village was significant as a random effect using package ‘lme4’ (Bates et al., 2015) and applied ANOVA to compare mixed effects and fixed effects models. Finally, we tested for model goodness of fit using the Hosmer-Lemeshow test with the ‘ResourceSelection’ package (Lele et al., 2017), and by assessing accuracy when the cumulative true positive and true negative rates were maximized. For each predictor variable, we calculated the average marginal effect (AME) in the ‘margins’ package (Leeper, 2018) with standard errors estimated using “heteroscedasticity and autocorrelation consistent” estimators in package ‘sandwich’ (Zeileis, 2004, 2006).

### 3. Results

Interviews were conducted with 523 households, including 137 households that described participation in bushmeat hunting activities (hereafter ‘hunter households’). Ninety-one participants identified via snowball sampling described themselves as hunters. Forty-six respondents in the head-of-household survey reported that other members of their household were hunters but elected not to identify them. Forty-nine percent of respondents were female, but hunters were predominantly male, with only one identified female hunter. Hunters ranged in age from 18 to 87 years, with a median of 32 years. A small proportion of households ( $n = 40$ , or 8.5%) reported consuming bushmeat that they purchased or received as gifts, but did not hunt themselves. <3% of households refused to participate in the survey, suggesting that refusal rates were too low to bias results (Lindner et al., 2001).

#### 3.1. Factors associated with bushmeat hunting

Univariate GLMs revealed eight variables that were significantly associated with hunting. Households with some form of formal employment were 1.6 times more likely to hunt than unemployed households (CI: 1.0–2.4,  $p = 0.025$ ), however both groups exhibited similar rates of year-round employment (35% and 30%, respectively). Seasonal employment had the strongest correlation with the likelihood of hunting ( $z = 3.47$ ,  $p < 0.001$ ), followed by full-time employment ( $z = 1.69$ ,  $p = 0.09$ ).

Despite exhibiting higher overall rates of employment, hunter households received less average income from formal employment than non-hunter households. Yet median income from all livelihoods was 35% greater among hunter households than in non-hunter households and hunting rates increased with income, from 14% of households in the poorest quintile to 34% of households in the wealthiest quintile ( $z = 3.17$ ,  $p = 0.001$ ). Median livestock wealth among hunter households was more than four times greater compared to non-hunter households ( $z = 4.88$ ,  $p < 0.001$ ). The revenue that the average hunter household earned from livestock explains the discrepancy in income between hunter and non-hunter households (Fig. 2). Hunting was twice as common among crop farmers (37% versus 18%;  $z = 4.50$ ,  $p < 0.001$ ) and nearly 50% more common among households receiving government assistance (31% vs. 22%;  $z = 2.22$ ,  $p = 0.026$ ). In contrast to economic status, rates of poverty assistance did not differ significantly between hunter and non-hunter households ( $z = 1.2$ ;  $p = 0.229$ ). Hunter households were less likely to skip meals ( $z = -2.94$ ,  $p = 0.002$ ). They lived in closer proximity to wildlife ( $z = -4.69$ ,  $p < 0.001$ ), but did not live demonstrably closer to protected areas ( $z = -1.7$ ;  $p = 0.081$ ) than non-hunter households. Hunting rates were lower among households from ethnic groups that were not indigenous to the delta region ( $z = -2.33$ ,  $-1.975$ ;  $p = 0.020$ ,  $0.048$ , respectively). Due to their insignificant relationships to bushmeat hunting, poverty assistance and distance to protected areas were excluded from multivariate GLMs ( $\alpha = 0.05$ ). The remaining eight variables retained for multivariate GLMs did not show evidence of collinearity ( $r_s < 0.6$  for all pairs).

The best performing multivariate hunter model (AIC = 454.2) included all predictor variables except income and meals skipped (Table 1). A more parsimonious model that also excluded government assistance performed similarly ( $\Delta AIC = 0.85$ ). All predictor variables under both models exhibited generalized VIF values <2.0. Due to the low p-value of the Hosmer-Lemeshow goodness-of-fit test for the model ex-

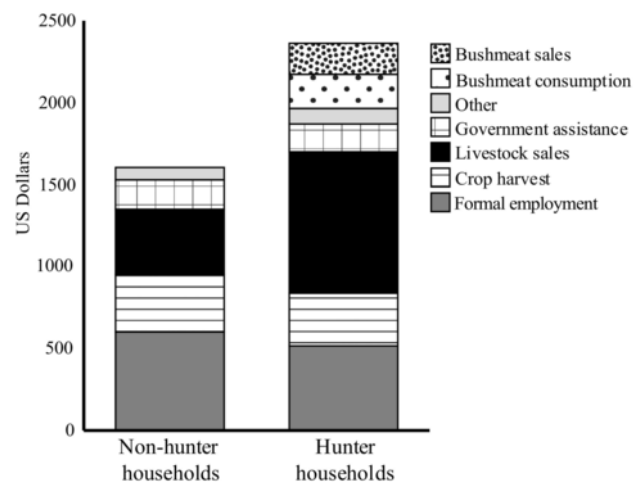


Fig. 2. Average household income from livelihood activities.

**Table 1**Results from nested GLMs with  $\Delta AIC < 3$ , indicating the characteristics associated with whether a household hunts bushmeat in the Okavango Delta, Botswana.

AIC rank	Model	Degrees of freedom	$\Delta AIC$
1	Crops + distance + employment + ethnicity + assistance + livestock	12	0
2	Crops + distance + employment + ethnicity + livestock	11	0.85
3	Crops + distance + employment + ethnicity + assistance + livestock + meals	13	1.45
4	Crops + distance + employment + ethnicity + assistance + livestock + income	13	1.91
5	Crops + distance + employment + assistance + livestock	8	2.30
6	Crops + distance + employment + ethnicity + livestock + meals	12	2.46
7	Crops + distance + employment + ethnicity + livestock + income	12	2.85

cluding government assistance ( $p = 0.047$ ), we rejected the more parsimonious model and accepted the lowest AIC model as the best supported ( $p = 0.095$ ). True positive and true negative rates were 76% and 79%. Including village as a random effect had little influence on the model (variance = 0.25, SD = 0.50, ANOVA p-value = 0.35).

Seasonal employment and crop farming exhibited the strongest marginal effects ( $20.1 \pm 6.7\%$  and  $11.9 \pm 4.2\%$  respectively) among categorical variables. An increase in household wealth of 10 cattle (or equivalent values of other livestock) was associated with a 1% (interquartile range: 0.6–1.7%) increase in the probability of hunting. Each additional kilometer between a household and the nearest wildlife populations was correlated with a 1.5–2% (interquartile range: 0.9–2.6%) reduction in the probability of hunting (Table 2).

### 3.1.1. Motivations for hunting

Thirty percent ( $n = 91$ ) of interviewed hunters acknowledged selling bushmeat illegally. On average, these commercial hunters earned US\$604 (BWP 6043 at 31 March 2015, exchange rates; www.x-rates.com) from bushmeat sales in the previous year. Three quarters of commercial hunters earned <40% of total household income from selling bushmeat (range: 4–71%). Mean income from bushmeat (US\$389), including both sales and the value of meat consumed at home, amounted to 17% of the average hunter's household income.

Half of all hunters listed bushmeat among their households' three most frequent protein sources. Ten percent reported bushmeat as their most frequent source. Thirty-eight percent of hunters described bushmeat as critical to their food security, because they were unable to afford legally acquired meat or required bushmeat to obtain sufficient food. However, these same households also exhibited high livestock

**Table 2**

Parameters of the best performing GLM by AIC and Hosmer-Lemeshow test for estimating the probability of a household engaging in illegal hunting in the Okavango Delta, Botswana.

Variable	Z-value	P-value	AME <sup>a</sup> (SE)
Intercept <sup>b</sup>	-2.36	0.018	
Ethnicity 1	-1.64	0.100	-14.0 (9.0)
Ethnicity 2	-0.90	0.371	-8.7 (10.1)
Ethnicity 3	0.52	0.604	5.6 (10.5)
Ethnicity 4	-0.12	0.902	-1.1 (9.1)
Part-time employment	0.07	0.945	0.4 (5.3)
Seasonal employment	3.31	<0.001	20.6 (6.7)
Full-time employment	1.28	0.202	5.5 (4.5)
Crop farming	2.98	0.003	11.9 (4.2)
Government assistance	1.69	0.091	6.3 (3.8)
Livestock wealth <sup>c</sup>	3.58	<0.001	1.1 (0.4)
Distance to wildlife <sup>d</sup>	-4.63	<0.001	-1.8 (0.4)

<sup>a</sup> Average marginal effect, measured as percent gain, of a unit-increase in each variable.

<sup>b</sup> Signifies unemployed households that do not farm crops, do not own livestock, do not receive government assistance, live in the immediate vicinity of wildlife, and come from an ethnic group uncommon in the Delta.

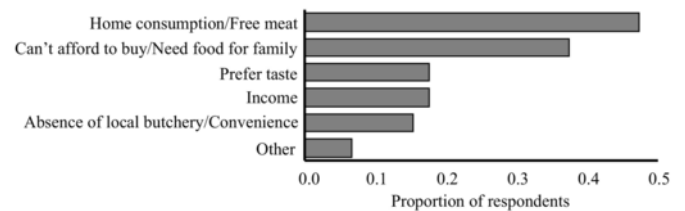
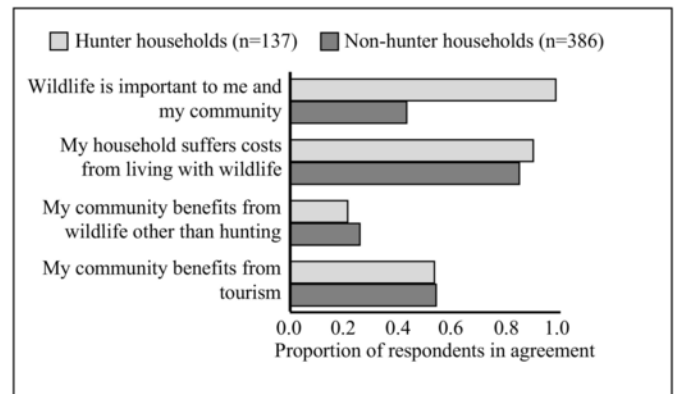
<sup>c</sup> Measured in units equivalent to 10 cattle (~US\$2000 or 20,000 BWP).

<sup>d</sup> Measured in kilometers.

wealth consistent with hunter households in general (KS test,  $p = 0.61$ ). This suggests that hunter households, including those who described bushmeat as fundamental to feeding their families, were typically more secure economically than non-hunter households, and were choosing bushmeat in lieu of consuming their own livestock. Other commonly-cited reasons for hunting included free meat, additional income, and taste preference (Fig. 3).

### 3.2. Perceptions about wildlife

Perceptions about wildlife were generally consistent between hunters and non-hunters. >80% of respondents reported costs associated with living close to wildlife, primarily in the form of livestock and crop losses, but also through damage to fences and boreholes. Half of respondents reported that their community benefits from tourism, but only a quarter reported that their community benefits from Botswana's wildlife, indicating that hunters did not associate wildlife with employment or tourism-related economic benefits. The only issue that revealed a notable difference in perceptions of wildlife between hunter and non-hunter households was related to whether respondents felt wildlife was important to themselves and their community: nearly all hunters, compared to only 42% of non-hunters, said that they consider wildlife to be important (Fig. 4).

**Fig. 3.** Motivations underlying illegal bushmeat hunting in the Okavango Delta, Botswana.**Fig. 4.** Percent of respondents that agreed with statements regarding perceptions about wildlife.

### 3.3. Law enforcement

Two of the 91 interviewed hunters (2%) reported that they had been convicted of wildlife crimes in the previous five years. We additionally collected records of 40 cases from two Ngamiland courts involving 100 defendants. Fifty-five percent of the cases involved species other than elephant, with high geographic variation: only one of the 15 cases at the Gumare court (western Delta) related to elephants, compared to 17 of 25 at the Maun Court (central, southern, and eastern Delta). Eighty-three percent of cases resulted in a conviction of at least one defendant. Thirty-two percent of defendants were convicted of crimes relating to species commonly hunted for bushmeat (i.e., including all ungulates and excluding elephants, lion, and pythons). Twenty-nine percent were fined in lieu of a jail sentence (which they must serve if they cannot pay the fine), with fines ranging from US\$50–500 per offense (median = US\$100, or 30% of the average rural household's monthly disposable income; Statistics Botswana, 2014). Six percent of those convicted were sentenced to jail terms that were suspended on the condition they not repeat the crime. Three of those individuals received no fine and thus suffered no penalty. Only one was sentenced to serve jail time. Eight received lashes in addition to fines.

## 4. Discussion

Illegal bushmeat hunting is widespread in the Okavango Delta, Botswana (Rogan et al., 2017). In contrast to bushmeat hunting in some African savanna ecosystems (Fusari and Carpaneto, 2006; Nielsen, 2006; Lindsey et al., 2011b), we found little evidence that household poverty and food insecurity were the primary drivers of hunting. Hunter households' combination of higher livestock wealth, higher rates of employment, and greater income than non-hunter households suggests that most hunter households are comparatively secure financially relative to their communities (cf. Coad et al., 2010; Kümpel et al., 2010; Nielsen et al., 2017). Delta wildlife experts tend to have split perceptions of bushmeat hunting in the Delta as either predominantly for subsistence or for a commercial black market (Rogan et al., 2015). Yet in truth, most hunters occupy a middle ground, taking advantage of a profitable and low-cost resource that they neither depend on for their subsistence nor as a primary source of income.

Exceptions exist. A few hunters reported selling more than a ton of meat (Rogan et al., 2017) and earning 70% of their income from these sales. Other households reported occasionally skipping meals because they could not afford food, or receiving support through “destitute” welfare programs. Furthermore, while we have shown that hunter households are typically better off than others in their communities, the communities that we surveyed are impoverished in general relative to both the national and district average (Statistics Botswana, 2014). Bushmeat hunting might alleviate this poverty. Alternatively, the poorest households might face prohibitive barriers to harvesting bushmeat and other natural resources (de Merode et al., 2004; Angelsen et al., 2014). Diversifying livelihood activities also mitigates risk (Wright et al., 2016), especially in the drought- and disease-prone livestock industry of the western Delta. Some hunters might rely more on bushmeat when income is depressed (Rentsch and Damon, 2013). Families relying on intermittent livestock sales or seasonal employment and crop harvests earn income inconsistently. In this study, however, such households were not the norm. The typical hunter household owned sufficient livestock to be food-secure even when incomes were depressed. Most hunters reporting ‘a need for bushmeat’ to feed families also reported owning sufficient livestock to meet their needs. These hunters routinely chose to hunt bushmeat instead of harvesting their own livestock for food.

We acknowledge that respondents' memories of livestock sales can introduce inaccuracies (de Nicola and Giné, 2014) and, accordingly, the estimates of income from sales of livestock and crops are likely imprecise. However, the data are unlikely to be biased between hunter and non-hunters, and, in the case of livestock sales, are consistent with patterns of livestock ownership. We conclude that most hunters have sufficient income from livestock sales, employment, crop farming, and government assistance to sustain their families. In such cases, hunters are motivated by self-interest, not need.

Thus, we conclude that rather than need, the availability of wildlife and opportunity to hunt are major drivers of bushmeat hunting (cf. Ceppi and Nielsen, 2014). It is practiced primarily by rural agriculturalists living close to wildlife. Families living in small villages or based primarily at cattle posts generally lived closer to wildlife populations than to the nearest formal meat shop. Proximity to wildlife translates into access and reduces the time needed for hunting (Brashares et al., 2011), which lowers the risk of being caught (Lindsey et al., 2011a).

The economic opportunity in bushmeat hunting stems from low costs rather than a highly lucrative market. Bushmeat did not enjoy a price premium over livestock meat. All commercial hunters reported selling the meat directly to consumers rather than to bushmeat traders. Most hunting was for domestic consumption and commercial hunting generally contributed little to household incomes, a pattern typical of many bushmeat industries (Fusari and Carpaneto, 2006; Nielsen, 2006; Kümpel et al., 2010; Nielsen et al., 2017). Few non-hunting households reported buying bushmeat; in many villages, those who desire bushmeat hunt it themselves instead of paying others to do so. Bushmeat hunters take advantage of an inexpensive source of protein that either increases their household's purchasing power of other goods (Coad et al., 2010) or allows households to conserve livestock resources (Barnett, 2000), and likely contributes to hunter households' disproportionate livestock wealth.

The low costs of illegal hunting result from the low risks of being caught. Among those who are caught, few are convicted of wildlife crimes. Some that are convicted suffer no penalty. In most other cases, fines for bushmeat hunting are equivalent to the value of hunting a single kudu, one of the most commonly hunted species. Thus the probability and severity of being fined is insufficient to deter hunters.

Although financial incentives for hunting appear to be important, they do not fully explain the prevalence of illegal hunting or who engages in the activity. Not all community members have the desire, opportunity, physical ability, skills, or means to hunt. Taste preferences (Brown and Marks, 2007), perceptions of health and nutrition (Ndibalema and Songorwa, 2008), and access to legal meat in remote communities also influence demand for bushmeat. Research elsewhere in the region suggests people hunt illegally because it is a traditional practice and because they are excluded from tourism enterprises (Mbaiwa, 2011, 2017b). Although we detected anecdotal evidence of these sentiments, more rigorous investigation of these socio-political issues is needed. Hunters' desire for local ownership of wildlife resources, however, is consistent with another of our findings: bushmeat hunters overwhelmingly attached greater value to wildlife than did their communities at large.

Interventions designed primarily to boost prosperity in communities might mitigate the financial motivations for hunting, but they will not necessarily address socio-political drivers relating to disenfranchised citizens. Furthermore, prosperity can have conflicting effects on demand for bushmeat. In some cases, a rise in purchasing power raises demand (Brashares et al., 2011; Rentsch and Damon, 2013). In other cases, prosperity is associated with less illegal hunting (Wilfred and MacColl, 2010; Harrison et al., 2015). In the Okavango Delta, however, communities, and bushmeat hunters in particular, exhibit greater food security than many rural African populations where bushmeat hunting is common (e.g., Lindsey et al., 2011b). A reduction in illegal hunting

due to increased prosperity is likely to be limited. Additional strategies are needed to address the financial and the socio-political issues related to local community involvement in the conservation of Botswana's natural capital (Snyman, 2012; Oldekop et al., 2016).

#### 4.1. Comparison of legal and illegal uses of wildlife

It is important to contextualize the benefits from illegal hunting relative to benefits from legal wildlife-based land uses. Snyman (2012) quantified the income one community conservancy in the Delta generated from photographic tourism. Income from employment in lodges was an order of magnitude greater than the income generated from bushmeat hunting in the same communities. Yet, hunting jeopardizes tourism (Rogan et al., 2017). More broadly, tourism continues to grow at an estimated 6.8% annually and created approximately 68,000 jobs in Botswana in 2016 (WTTC, 2017), mainly in the two northern districts. Compared to the economic contribution of the tourism industry at the district level, it is evident that low-value hunting of limited wildlife resources is not in the economic development interests of Ngamiland.

#### 4.2. Law enforcement

Improving anti-poaching law enforcement to impose costs for illegal hunting has been criticized as "green militarization" (Duffy, 2014; Lunstrum, 2014). We contend, however, that the rule of law is critical to maintaining national democratic values, developing the economy, and generating income (Rigobon and Rodrik, 2005), and can contribute to effective conservation (Hilborn et al., 2006; Ceppi and Nielsen, 2014; Lotter and Clark, 2014). Bushmeat is sufficiently high-value that it is tempting for some individuals to hunt illegally even in contexts where communities benefit significantly via legal means from wildlife, further emphasising the importance of law enforcement (Lindsey et al., 2013).

Increasing budgets to improve anti-poaching efforts in WMAs is a sound investment. Protecting and enhancing Botswana's wildlife tourism harnesses the country's natural capital and can drive economic growth (Makochekanwa, 2013). Botswana is reported to be the least corrupt country in Africa (Transparency International, 2017), has greater capacity for wildlife management than many African countries, and ranks among the world's best stewards of mammals (Lindsey et al., 2017). However, the vastness of its wildlife estate means that the available resources for anti-poaching are thinly spread. Cost sharing by all WMA concession holders in the region would demonstrate greater commitment to the wildlife tourism industry's social and environmental responsibilities and would contribute to ecosystem health and resilience.

Law enforcement can reduce illegal hunting in the short term, but long-term solutions require working with communities to address the motivations to hunt and the disincentives to conserve wildlife (Challender and MacMillan, 2014; Cawthorn and Hoffman, 2015). Interventions based on intrinsic motivations generate better outcomes than solutions based purely on external pressure (Cetas and Yasué, 2017). Policy makers should aim to make conservation valuable to Delta communities.

#### 4.3. Conservation incentives

Facilitating intrinsic motivations should come from two types of interventions, efforts to reduce the costs of living with wildlife and programs to increase the benefits (Biggs et al., 2017; Cooney et al., 2017). Alternative livelihoods are likely to produce the most positive conservation outcomes when targeted at individuals, such as hunters, most reliant on access to natural resources (Wright et al., 2016). A wildlife guardian program that harnesses hunters' skillset to reduce human-

wildlife conflict and improve wildlife management would give hunters a stake in conservation (Pienaar et al., 2013).

A comprehensive strategy also demands interventions at the community level. Tourism is a boon to the regional economy, but its benefits are not distributed equally among communities and households in the Delta (Mbaiwa, 2005). Remote, rural communities often benefit the least from tourism (Mbaiwa, 2017b). Although CBNRM policy has produced mixed outcomes in Botswana (Lindsey, 2010; Mbaiwa, 2011), it can improve wildlife management as part of a comprehensive strategy for reducing illegal hunting (Hilborn et al., 2006). There is opportunity in the region to expand tourism around the periphery of the Delta, precisely where bushmeat hunters are concentrated (Winterbach et al., 2015).

Finally, Botswana has an existing legal framework for sales of legal bushmeat from private ranches, but no efforts currently exist to provide consumers in rural areas of the Delta access to these products. A legal supply in rural areas would make the industry more equitable and is the most direct way to address the demand for bushmeat stemming from personal preference or health concerns.

#### 4.4. Conclusions

Our findings suggest that illegal bushmeat hunting in the Okavango region of Botswana is not driven by subsistence or food security demands, but rather by opportunistic and profitable enterprise conducted among the region's more affluent community members. Although the evidence presented here indicates a low level of commercial marketing, the bushmeat hunting in Botswana represents an inefficient use of wildlife resources (Chardonnet et al., 2002; Lindsey et al., 2015). These results can inform policy interventions that directly address the key motivators for illegal hunters. We identify a suite of interventions and we are optimistic that a comprehensive approach to managing wildlife and reducing hunting can improve outcomes for both the Okavango Delta's human communities and its wildlife.

#### Uncited references

Baxter et al., 2004  
Brashares et al., 2004  
Koerner et al., 2016  
Nielsen et al., 2016

#### Acknowledgements

The Food and Agriculture Organization of the United Nations provided the majority of funding for this research under Technical Cooperation Programme project TCP/BOT/3501. The study was also supported by Panthera and the Botswana Predator Conservation Trust. JRBM was supported in part by National Science Foundation Coupled Human and Natural Systems Grant 115057. We appreciate the assistance of the Botswana Ministry of Environment, Wildlife, and Tourism; the Department of Wildlife and National Parks; and the Magistrate Courts of Ngamiland. Special thanks are due to the research assistants, Kentse Madise, Ikatametseng Pro Seboifeng, Ernest Tjihumino, Keone Samxhose, and Anna Shaw. We thank an anonymous reviewer for comments on the manuscript.

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