Biological Conservation 189 (2015) 49–58

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Special Issue Article: Conservation Crime

Local perceptions of risk associated with poaching of wildlife implicated in human-wildlife conflicts in Namibia

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ARTICLE INFO

Article history:
Received 12 February 2014
Received in revised form 28 January 2015
Accepted 2 February 2015
Available online 25 February 2015

Keywords:
African buffalo
African elephants
Conservancies
Conservation criminology
Hippopotamus
Retaliation

ABSTRACT

Human-wildlife conflict (HWC) includes how people perceive risks associated with negative interactions with wildlife. Risk perceptions are important for conservationists to understand because perceptions can influence human behaviors in response to HWC, such as tolerance or poaching specific species. Our study site, the Zambezi region of Namibia, is renowned for diverse wildlife that come into conflict with humans and are vulnerable to poaching. Our study objectives were: (1) quantify local perceptions of risk associated with species-specific HWC and poaching, (2) examine the relationship between species-specific HWC and poaching risks, and (3) characterize economic costs, benefits and perceptions of the ecological values (e.g., disease vector) of the top four species implicated in HWCs and poaching. The species that were perceived to be at greatest risk from poaching were characterized as posing high ecological risks (e.g., disease vectors) and livelihood risks (e.g., crop damage) and were economically valuable for local subsistence and trade. Species perceived to pose high risk to livelihoods were moderately correlated with increasing perceived poaching vulnerability ($r = 0.53$, $p = 0.04$, df = 14). All but one of the top four species most vulnerable generated greater average annual revenue from legal hunting than average annual damage to crops. However, a majority of participants stated that conservancy benefits were not equitably distributed. Quantifying and characterizing how stakeholders perceive poaching-related risks can complement risk assessment data and result in more robust conservation planning. These findings have implications for risk communication, distribution of wildlife-related risks and benefits and more nuanced management of the most vulnerable species.

1. Introduction

Negative human-wildlife interactions [i.e., human-wildlife conflicts (HWCs)] pose risks to livelihoods and wildlife globally and have been the subject of numerous studies within the context of human tolerance for species involved in animal damage incidents (Kansky et al., 2014). Direct effects of HWC on human livelihoods range from nuisance behavior, such as reduced recreational opportunities (Messmer, 2009), to crop damage, livestock depredation (Ogra, 2008), fatal attacks on humans (Dunham et al., 2010), and zoonotic disease transmission to humans (Swift et al., 2007) or livestock (Michel and Bengis, 2012). HWC also has the potential to result in indirect effects that go uncompensated, are temporally delayed or can lead to negative psychological, health or social consequences (Barua et al., 2013) such as increased labor burdens, fear to leave home in search of livelihood resources (Ogra, 2008) or social conflict (Brashares et al., 2014). Additionally, poaching is one form of HWC that compromises the ability of local communities to legally use natural resources to support local livelihoods (Robinson and Bennett, 2004), threatens food security (Bowen-Jones et al., 2003) and reduces wildlife available for local economic development (e.g., ecotourism, trophy hunting) (Johannesen and Skonhoft, 2005). Poaching has wide-ranging implications for conservation efforts as well because it can undermine conservation investments, educational programs, public–private partnerships, and can involve extreme violence. Reducing risks from poaching is a high international policy priority (Nellemann et al., 2014).

Accordingly, local stakeholders' concerns about HWC can influence tolerance (Kansky et al., 2014) and help predict stakeholder actions toward wildlife that negatively affect the long-term chances of human-wildlife coexistence (Carter et al., 2012). One such human reaction that can compromise human-wildlife coexistence is lethal control, legal or illegal, of the offending

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http://dx.doi.org/10.1016/j.biocon.2015.02.001
0006-3207/

animal. Legal lethal control of animals involved in HWC is common in diverse African management contexts and is usually justified by threats to human health, safety, and economic well-being (Lamarque et al., 2009). When a problem-causing animal is killed it is generally done to maintain social accord rather than promote long-term resolution of on-going HWCs (Lamarque et al., 2009). However, illegal killing (i.e., poaching), threatens the conservation of some wildlife species (Liu et al., 2011) and carries with it a host of collateral social and ecological impacts. Wildlife populations subjected to poaching may suffer from reduction in population size, extirpation, or extinction (Woodroffe et al., 2005). For example, the retaliatory killing (legal and illegal) of large carnivores, such as the African lion (*Panthera leo*), has been found to be a major cause of their global decline (Ogada et al., 2003). Wildlife population reductions or loss from an area can result in ecosystem effects as well, such as the contemporary interruption of elephant-dependent seed dispersal in Democratic Republic of Congo due to the near extirpation of forest elephants (*Loxodonta cyclotis*) (Beaune et al., 2013).

Wildlife populations are not uniformly vulnerable to poaching (Kissui, 2008; Woodroffe et al., 2005); vulnerability may vary within and across taxa. For example, the vulnerability of Bolivian parrots (Family *Psittacidae*) to poaching for the pet trade is significantly higher for species found within 80 km of a city and animals from relatively more abundant populations (Pires and Clarke, 2011). Species biology (Kissui, 2008), distribution (Knapp et al., 2010) and interactions with human socio-economic systems vary their susceptibility to poaching risks (e.g., Liu et al., 2011). For example, retaliatory killing of carnivores in Tanzania has been found to be a function of both biological (e.g., nocturnal predation) and social factors (e.g., culture) (Kissui, 2008). Species vulnerability to poaching can also vary according to human motivations to poach. The motivations for poaching wildlife are diverse and it is likely that poachers have multiple motivations for their behavior (Kahler and Gore, 2012). Animals may be poached because of negative human attitudes about HWC (Kansky et al., 2014), avoidance of future HWCs (Sánchez-Mercado et al., 2008), or economics (Liu et al., 2011).

Reducing poaching-related risks requires understanding of ecological and sociocultural factors influencing species'-specific vulnerability (Kahler et al., 2013). Ideally, such understanding would be framed according to local perceptions of risk both to and from wildlife (Kahler et al., 2013) as well as knowledge about how species are valued within the larger economic, ecological and cultural context (Remis and Hardin, 2009). This is because when human and wildlife populations overlap, interactions will influence attitudes and behavior toward wildlife as well as perceptions of the risks and benefits of individual wildlife species (Baruch-Mordo et al., 2011). Risk perceptions (i.e., intuitive judgments as opposed to expert assessments) are relevant to multiple dimensions of wildlife conservation, including HWC, and offer insight about how individuals think and behave in response to risks (Gore et al., 2009). For example, perception of wildlife-related risk can be used to measure stakeholder support for lethal or non-lethal management actions (Gore et al., 2006) and aid in predicting responses to policy (Huang et al., 2010), such as compliance with new regulations. Understanding public perceptions of risk associated with HWC can inform interventions designed to influence human behavior and reduce HWC-related risks, inform the content and format of conservation messages, and improve risk communication by better anticipating how messages may be interpreted (Gore et al., 2006).

The diversity of factors influencing stakeholder perceptions of risk associated with HWC are well known (Gore et al., 2009). The extant literature clarifies stakeholder perceptions of impacts from HWC on human livelihoods (e.g., economics, health, safety) and how these perceptions influence acceptance of wildlife populations and their management (e.g., Schumann et al., 2012). Gaps in knowledge remain, however, in understanding factors that influence how stakeholders perceive HWC-related risks to wildlife populations and how these perceptions relate to HWC-risk perceptions to human livelihoods. This is problematic because understanding stakeholders' perceptions of HWC risks to wildlife, much like the perceptions of HWC-risks to livelihoods, could influence stakeholders' responses to HWC incidents and influence preferences for HWC policy and management. Further, perceptions of wildlife-related risks are not formed in isolation, where an individual independently assesses risk from each species. Rather, individuals are exposed to a suite of risks and benefits associated with multiple species at a time. Little research has examined wildlife-related risk perceptions of a wide assemblage of sympatric species that occupy diverse ecological niches (e.g., carnivores, herbivores). Lastly, assessments of poaching activities are known to be incomplete due to the illicit nature of these activities (Kahindi et al., 2009). Incorporating local stakeholder perceptions of the risks associated with poaching creates a more nuanced understanding about wildlife-related risks and enhances intelligence about human dimensions of wildlife conservation (Kahler et al., 2013).

Accordingly, we set the following objectives: (1) quantify local perceptions of risk associated with species-specific HWC and poaching, (2) examine the relationship between species-specific HWC and poaching risks, and (3) characterize economic costs, benefits and perceptions of the ecological values (e.g., disease vector) of the top four species implicated in HWCs and poaching. We used two community-based conservation areas (hereafter conservancies) in the Zambezi (formerly Caprivi) region of Namibia to achieve objectives. The conservancies in the Zambezi region were ideal for this case study because the region has the highest rates of HWC in Namibia (Jones and Barnes, 2006), and growing concern over wildlife poaching (Huang, 2014; Kahler et al., 2013). Additionally, conservancies maintain HWC and poaching incident records (Stuart-Hill et al., 2005) at the local level that include species-specific information. These data can be compared to residential perceptions of species implicated in HWC and poaching incidents.

1.1. HWC and poaching in Zambezi, Namibia

Namibia's Conservancy program, a community-based conservation program formed in 1996, aims to integrate communal-land residents into wildlife utilization and ecotourism development (Weaver and Skyer, 2005). Integration is enabled through devolved rights over wildlife to local communities (Barnes et al., 2002) and a legislated joint-venture management scheme between government agencies, national non-governmental organizations and rural communities (Stuart-Hill et al., 2005). The system includes a legislative basis for consumptive wildlife utilization through subsistence-based and commercial hunting and wildlife damage management and compensation procedures (Ministry of Environment & Tourism (MET), 2009). Theoretically, conservancy residents derive economic, ecological and cultural value from the consumptive use of wildlife (Barnes et al., 2002); thus Namibians living on conservancies have a vested interest to ensure that wildlife use is sustainable and maintains value.

Namibia's conservancies are widely considered successful community-based natural resource management (CBNRM) regimes in that they simultaneously conserve natural resources and provide for livelihood development (Hoole and Berkes, 2010). Literature on Namibia's conservancies often anecdotally assert that conservation success is, in large part, due to the positive effects of conservancies on local attitudes toward wildlife (e.g., Weaver and Skyer, 2005). Although many Namibian conservancies report increased abundance of wildlife populations (Nott and Jacobsohn, 2004), they also report increased frequencies and magnitudes of HWC (MET, 2009). In 2009, in response to increasing reports of HWC across the country, the federal government established a national policy for HWC management (MET, 2009). The legislation specified HWC management and financial compensation was the responsibility of the conservancies, outlined procedures for determining when problem-causing animals should be destroyed, and the delegation of authority to destroy said animals (MET, 2009).

Local livelihoods in our case study site of East Zambezi, one of Namibia's most impoverished and least developed regions, are largely supported by natural resources and subsistence agriculture (Suich, 2010). The environment is a mosaic of Kalahari grassland with mopane (*Colosphospermum mopane*) woodland and riverine floodplains and is managed under diverse forms of conservation approaches, having 13 communal conservancies, 7 community forests, and 3 state protected areas (Namibian Association of CBNRM Support Organizations (NACSO), 2014). These conservation areas are included and are geographically at the center of the Kavango-Zambezi Transfrontier Conservation Area (KZTCA), which includes conservation areas in Angola, Botswana, Namibia, Zambia, and Zimbabwe. The majority of the residents of this region live in rural areas (69%), in traditional dwellings (63%), and 39% are under the age of 15 years (Namibian Statistics Agency [NSA], 2011). Additionally, the Zambezi has high rates of HWC, a diverse assemblage of species including a large population of elephants (O'Connell-Rodwell et al., 2000), and a human population density nearly 2.5 times the national average (NSA, 2011). Numerous species are poached and involved in HWC in Zambezi (Supplement 1) and conservancy residents experiencing HWC in Zambezi sometimes engage in retaliatory poaching to remove problem-animals (Kahler et al., 2013; Kahler and Gore, 2012). However, not all human-caused wildlife mortality is from poaching, as lethal control is permitted under the National Policy on HWC Management (MET, 2009). The connections between poaching and HWC in conservancies are a local conservation concern because poaching steals wildlife revenue and resources from communities, which undermines communal conservation incentives and, communal development goals. Efforts to reduce risks to and from poaching will necessitate, in part, reducing HWC impacts on human livelihoods and economic development (Kahler and Gore, 2012).

2. Material and methods

2.1. Study area and research design

Research was conducted in two communal conservancies in East Zambezi, Dzoti and Wuparo. These adjacent conservancies are located between two national parks, share a boundary with the Kwando River, and were selected as research sites because they have comparable and representative habitat types, wildlife species composition, and presence of HWC. Additionally, these conservancies agreed to share archived records of HWC, poaching and legal hunting. However, these conservancies varied significantly in terms of area and population density with Wuparo (148 km^2; 14.3 people/km^2) being over 3 times as densely populated as Dzoti (245 km^2; 4.5 people/km^2) (NACSO, 2014).

An identical research protocol was implemented in each conservancy. Six local research assistants were hired based on the following criteria: (1) fluent in English, Lozi, and/or Sheyeyi; (2) completed secondary school; (3) were not members of the conservancy committees or traditional authority; and (4) agreed to work the entire duration of research activities. All research assistants participated in a day-long training session before data collection commenced and survey instruments were collaboratively translated by three research assistants to improve data quality (Gore and Kahler, in press).

2.2. Sampling

Study participants and were chosen independently from each of the village zones (i.e., distinct residential areas) using a cluster sampling technique with probability proportionate to size (Bernard, 2006). However, there were no reliable lists (e.g., property tax records) of residents in the conservancies so the technique entailed identifying population clusters (i.e., village zones), using population estimates from the conservancy, and assigning a given number of interviews to each cluster based on their population size relative to other clusters (Bernard, 2006). Because the likelihood of HWC varies across the conservancy landscape (e.g., Kendall, 2011), all village zones within each conservancy were sampled to ensure that the opinions of residents with the highest and lowest likelihood of interacting with wildlife were represented. Within each village zone we used a stratified street intercept-sampling frame (Bernard, 2006). This entailed entering a village zone and approaching participants as we intercepted them in their homes, in their fields, or in shared public spaces. To further reduce self-reporting bias (Gavin et al., 2010) during street intercept sampling, only one participant per household was permitted to participate. Alternating between approaching men and women to participate at the household level maintained gender parity, reduced biases and stratified our sample. Research was conducted during one of the least active times on the agricultural calendar in order to minimize response burden. Conservancy residents eligible to participate were any permanent residents of the respective conservancies who were 18 years of age or older. Existing data were acquired with permission from Dzoti and Wuparo Conservancy Offices.

2.3. Data collection

Data collection occurred via three sources: existing conservancy data, focus groups, and semi-structured interviews. Existing conservancy data included Problem Animal Incident cards, Poaching Event cards, and Legal Hunting cards in the conservancy Event Books (EB) from 2003 to 2008. All existing data were handwritten and stored in conservancy offices. Digital photographs of EB cards were taken at both conservancies and the 2009 price list for Wuparo hunting permits was recorded. Dzoti did not have a legal hunting concession at the time of data collection and Legal Hunting cards for 2005 in Wuparo were missing. Problem Animal Incident cards included information on incident date, damage type (crops, livestock, human attack), specific crop or livestock type, number of livestock or humans affected (if applicable), wildlife species implicated, descriptive notes and location within a 2 km x 2 km grid cell. Poaching Event cards included information on date, species impacted (if applicable), number of animals involved in the incident, type of incident (firearm, snare, traditional), number of incidents, descriptive notes and geographic information. Legal Hunting cards included information on type of legal hunt (personal, trophy), date, species harvested, number harvested, sex of harvested animal, whether meat was distributed and which stakeholder group received distributed meat (camp workers, conservancy households, Ministry ranger, traditional authority).

Focus groups were used to elicit information about perceived frequency, severity, motivations and wildlife species affected by poaching. In each conservancy a two-day focus group, comprised of local conservancy residents and local environmental decision makers (conservancy committee members, traditional village authority), was held to conduct participatory risk ranking and scoring (PRRS) activities (Tschakert, 2007) and risk description activities. Focus group participants were divided into three parallel groups of male residents, female residents, and local environmental decision-makers to promote a nonthreatening environment for dialogue (Tschakert, 2007). During the four-step PRRS process, participants first individually free-listed risks associated with a target (people, wildlife). Second, participants assigned ordinal values to rank the importance of each risk. Third, participants rated the severity of each risk on a five-point scale (1 = not severe, 5 = life threatening). Fourth, within their groups, participants shared and discussed their results. The PRRS process was completed independently for two risk targets: local livelihoods and conservancy wildlife. Lastly, they created HWC risk description posters, which included a ranked list of species involved in a particular HWC risk. Species were initially free-listed and then ranked by the group from the most to the least threatening/ threatened in relation to the specific HWC event. They provided qualitative data (e.g., poaching method, motivations) in relation to specific species.

Semi-structured interviews were conducted with conservancy residents in order to capture HWC-related risk perceptions. Interviews measured participant demographic characteristics and perceptions of the severity and frequency of risks to local people and to wildlife from HWC. Wildlife was defined as non-domesticated vertebrate animals, which included birds, mammals, and reptiles but excluded fish. Closed-ended questions were measured using four-point visual scales (0 = no risk, 1 = low, 2 = medium, 3 = high), which were developed to reduce response burden and aid in interpretation in situations of low literacy (Gore and Kahler, in press). Close-ended questions were asked in regards to perceptions of wildlife disease and to get opinions regarding the equity of benefit sharing (e.g., meat, revenue). Open-ended questions and elaboration by participants on quantitative questions provided qualitative data regarding perceptions of HWC.

3. Analysis

Descriptive statistics were used to analyze data from EB with incidents being pooled across the conservancies ($n = 2$) and years ($n = 6$). Species-specific EB information was compared against PRRS data. Average annual damage to agricultural crops was calculated using prices set by the Human Wildlife Self Reliance Scheme (MET, 2009). Estimating the total economic damage done by herbivores was problematic due to a lack in reporting of an approximate area damaged in each incident. Low economic estimates are based on one-quarter hectare of damage and high estimates based on one hectare of damage per incident. These low and high estimates are based on Namibia's agricultural compensation scheme, where one-quarter of a hectare is the minimum amount of crop damage compensated (MET, 2009), and not on data related to estimations of actual crop damage. The result is that for some species (e.g., elephants) the high estimate is likely appropriate or may underestimate the damage and for others (e.g., kudu) it may be an overestimate of each incident. Trophy hunting values are based on the 2009 price list in Wuparo.

Our results should be interpreted with care. The validity and reliability of surveys within the context of cross-cultural (Browne-Nuñez and Jonker, 2008), HWC (Ogra, 2008), and poaching (Solomon et al., 2007) related studies have been questioned. In regards to the cross-cultural nature of the research we increased research reliability by using appropriate sampling techniques, interview training, multiple methods, and were attentive to cross-cultural issues (e.g., obtained permission to conduct research from local traditional authorities) (Browne-Nuñez and Jonker, 2008). Further, the sampling protocol for focus groups and interviews facilitated inferential statistical analysis that could be generalized to all residents of the study conservancies. However, results herein should not be generalized to the regional or national conservancy level. Specifically, the focus groups were used to explore diversity of opinions, gain understanding, and in some circumstances have participants come to an agreement (e.g., ranking of species) within a very specific environmental, management, and socio-cultural context. Therefore, one cannot generalize these results (e.g., species x is most vulnerable due to y or z reason) outside of the specific context in which they were gathered. However, the results from this case study can inform theory building (e.g., HWC risk perceptions affect poaching vulnerability) and implore further research in varying contexts.

An iterative process guided coding and analysis of individual participants' free-listed, ranked and scored risks generated during the PRRS activity. First, we reviewed all text produced during the free-listing stage to generate a wide range of response categories (Saldaña, 2009). Next, we compared responses within categories and created a coding protocol to systematically transcribe each risk into an exclusive categorical variable (Bernard, 2006). Then, we coded all risks according to the protocol, revised protocol rules where appropriate, and conducted a final iteration of review coding to validate findings (Saldaña, 2009). Qualitative data associated with species-specific poaching risk were recorded (poaching method, animal-parts used) and was coded using the aforementioned iterative process (Saldaña, 2009).

Following Tschakert's (2007) methods for PRRS analysis, we calculated an incidence (I), importance (Pj), and joint risk index (Rj) for each HWC-related risk and species implicated pooling data from both conservancies. The incident index (I) ranges from 0 to 1 and is the proportion of subgroups ($n = 6$) that identified a particular species associated with a particular risk. Participants created species lists for 5 types of HWC in the area; the incident index was calculated then as proportion of times each species was implicated in these 5 types of HWC across the 6 subgroups. The importance index (Pj), ranges from 0 to 1 (0 = not important, 1 = most important) and reflects the ordinal rank that participants assigned to a particular species in relation to the total number of species they listed. The joint risk index represents the most acute risk and is a function of a species' average incident index (Ij) and average importance index score (Pj); it ranges from 0 to 1 (1 = most critical) and is calculated as $\mathrm{Rj} = \mathrm{Ij}/(2 - \mathrm{Pj})$ (Tschakert, 2007). Index scores were initially developed for HWC-related risks (e.g., crop damage, poaching) and then for species implicated in each risk for comparison to EB data (Tschakert, 2007).

We calculated a Spearman's Rho for the perceived HWC risk to livelihoods by species (Rj) and the percentage of total recorded animal damage incidents that species was implicated in by EBs to assess the correlation between participants perceptions and available records. We also calculated a Pearson's r based on the perceived poaching risk to species (Rj) and the recorded animal damage incidents (%). Lastly, we assessed correlations between perceived HWC risks to livelihoods (Rj) and the perceived poaching risk (Rj) by calculating a Pearson's r correlation. We ran a linear regression with a Gaussian distribution to inspect the residual plots for normality of the error distribution in all cases to ensure we used the appropriate tests. We ran these tests on the species with the top 15 highest poaching vulnerability joint risk scores, which resulted in analysis of 16 species due to species with equivalent scores.

Responses to interview questions were recoded from four-point scales (0 = "not at all," 1 = "a little," 2 = "somewhat," and 3 = "greatly") into dichotomous variables (0 = low, 1 = high). We cross-tabulated the variables to assess the percentage of "high" responses. Interview data were reviewed and quotes were selected according to previously defined coding protocol to aid interpretation of quantitative results within a qualitative context.

4. Results

EBs reported 1192 problem animal incidents and 53 discrete poaching incidents. Fifty local stakeholders (Dzoti = 20; Wuparo = 30) participated in the focus groups. All focus group participants completed PRRS activities focused on HWC risks to wildlife and 48 completed PRRS activities focused on poaching risks to wildlife. Focus group participants ranged from 18–63 years of age and all were involved in some form of subsistence-based agriculture or rural industry (e.g., artisanal fisheries). A total of 76 interviews were completed (Dzoti = 41; Wuparo = 35). Interview participants ranged in age from 18 to 88 (mean = 43 years) and 98% (n = 40) of Dzoti and 89% (n = 31) of Wuparo residents reported agriculture as their primary livelihood strategy. The majority of participants interviewed in these conservancies were of Mayeyi (93%, n = 71) ethic origin, with Totela (4%, n = 3), Mafwe (1%, n = 1) and Kwanyama (1%, n = 1) peoples represented as well.

4.1. Recorded incidents and risk perceptions associated with poaching and HWC

Our first objective was to quantify perceptions of risk associated with poaching and HWC. The EBs detailed 53 discrete poaching events of which 22 (42%) reported species-specific impacts such as wildlife mortality, injury or trapping. Discrete poaching events were defined as one entry in the EB, which may have included multiple snares collected, detected on the same day and within the same spatial proximity (2 km × 2 km grid cell). The EBs recorded 11 species that were poached from 2003 to 2008 (2005 data was missing) (Table 1). PRRS participants generated a list of 25 species vulnerable to poaching; we reported the top 16 (Table 1). Poaching of six species appeared congruently in the EB and PRRS activity (Table 1).

Animal damage events were recorded in EBs (57% crop damage, 42% livestock loss, 0.9% human fatality, 0.1% property damage. All focus group participants in both conservancies listed crop damage, being attacked, and livestock depredation as a risk to local livelihoods from wildlife (see Appendix S1 in Kahler et al., 2013 for more information) Focus group participants provided a larger list of species implicated in animal damage incidents than did EBs (focus groups = 31; EB = 18).

4.2. Correlation between HWC risks to livelihoods and vulnerability to poaching

Our second objective was to examine the relationship between HWC-related risks and poaching. There was a strong positive correlation between the perceived HWC risks to livelihoods by species and the recorded incidents of HWC by species (rho = 0.86, $p < 0.001$). This means that there was significant agreement between the local perceptions of which species are involved and their relative importance in HWC risks to livelihoods to the actual recorded incidents of HWC in the Event Books (Fig. 1a). There was not a significant correlation between perceived poaching risks to species and the percentage of recorded animal damage incidents by species (r = 0.24, p = 0.37, df = 14). There was a moderate positive correlation between the perceived HWC risks to livelihoods by species and the perceived poaching risk to species (r = 0.53, p = 0.04, df = 14) (Fig. 1b). Overall, increases with perceived severity of HWC risks posed to livelihoods by species were correlated with higher perceptions of their vulnerability to poaching.

4.3. Ecological and economic values

We used semi-structured interviews, focus groups and EBs to understand perceptions and situations surrounding our third objective: characterize local perceptions of economic costs and benefits and ecological values associated with wildlife. The intent here was not to assess the accuracy of participant's knowledge about ecological processes, but rather to capture and characterize impressions. In the focus groups, ecological values of wildlife species were dominated by negative perceptions of wildlife species as vectors of zoonotic disease or sources of physical damage to natural resources such as water (Table 2). Elephants in particular were singled out as both a source of disease (e.g., anthrax) and physical damage (e.g., water resources) (Table 2). One participant noted, "Only elephants are killing the bush, [they] are clearing a lot of bush [sic] (P36)."

When asking interview participants about disease risks, most were highly concerned about livestock contracting diseases from wildlife (86%; n = 65) and not very concerned about wildlife contracting diseases from livestock (64%; n = 49). For example, one interview participant noted, "In all cases livestock [get] foot n'

Table 1
Comparison of perceived versus assessed risk of poaching to species[a] in two Namibian conservancies. Perceived risks are listed according to species, incidence index, perceived importance of poaching, and overall rank calculated as a function of importance and incident index scores; data was collected via focus groups in 2009 (n = 50 participants). Reported poaching events are listed according to species, method of take, and total number of recorded poaching incidents; data was collected via Event Books from Wuparo and Dzoti conservancies (2003–2008). Species identified in both perceived and assessed poaching risks are boldfaced.

Perceived (Focus Group, 2009)				Reported (Event Book, 2003–2008)		
Species	Incidents Index	Importance Index	Overall Rank	Species	Method of take	Total # incidents
Buffalo	0.88	0.84	1	**Hippopotamus**	Firearm	4
Kudu	1.00	0.45	2	**Duiker**	Firearm	3
Elephant	0.88	0.60	3	Wildebeest	Firearm	3
Hippopotamus	0.88	0.56	4	**Buffalo**	Firearm	2
Warthog	0.75	0.50	5	**Elephant**	Firearm	2
Guineafowl	0.63	0.63	6	Partridge	Snares	2
Zebra	0.50	0.37	7	**Warthog**	Traditional	2
Springhare	0.25	1.00	8	Bird	Firearm	1
Duiker	0.38	0.44	9	Quail	Snares	1
Hyena	0.38	0.38	10	Snake	Snares	1
Lion	0.25	0.56	11	**Pangolin**	Traditional	1
Pangolin	0.25	0.50	11			
Porcupine	0.25	0.44	12			
Impala	0.25	0.35	13			
Aardvark	0.25	0.20	14			
Leopard	0.25	0.20	14			

[a] Please refer to Supplement 1 for species scientific names and IUCN Red List conservation status.

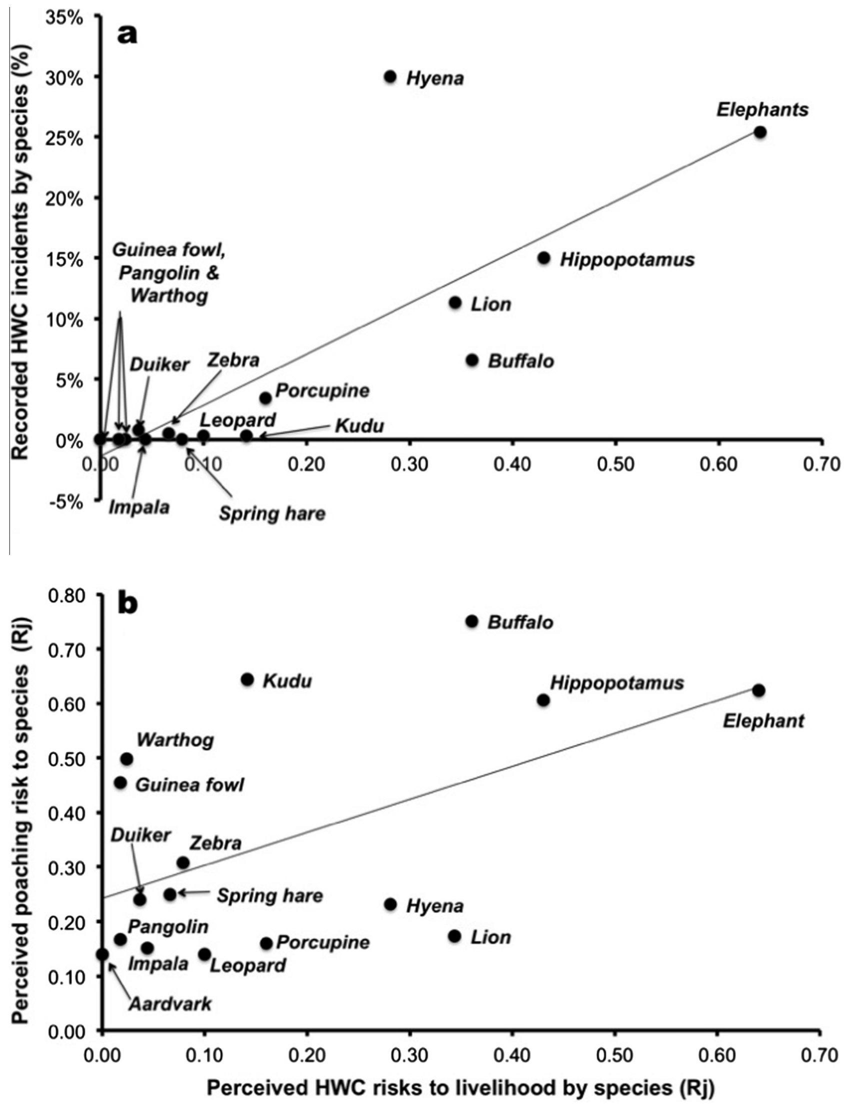

Fig. 1. The correlation between Event Book (2003–2008)-recorded HWC incidents (crop damage, livestock depredation, human fatalities) and perceptions of HWC and poaching related risks by species from focus groups in two conservancies (2009, $n = 50$), Zambezi Namibia. (a) Spearman's rho between perceived severity of HWC risks to livelihoods using the joint risk score (Rj) and percentage of the Event Book HWC records by species. (b) Pearson's r correlation between perceived severity of HWC risks to livelihoods (Rj) and perceived poaching vulnerability (Rj) by species.

mouth from buffalos [because they are] not as strong as wildlife [sic] (P58)." The opinion that wildlife, in particular buffalo, spread disease to livestock appeared consistent with the high concern over wildlife health (75%; $n = 57$) by interview participants.

Participants in both interviews and focus groups discussed positive and negative economic values of wildlife. Negative values were dominated by crop damage and livestock depredation (Table 2) Positive economic values from hunting revenues were also noted. Reviewing data from Wuparo EBs, we found a total of 60 legal hunting licenses issued (personal = 11; trophy = 49) (Table 3). Two species, buffalo (50%) and elephant (22%), accounted for over 70% of the legal hunting take. For the years surveyed these two species are responsible for a combined average annual income for the conservancy of $54,765 USD, which is over 11 times the high estimated value of their combined economic costs through crop damage (Table 2).

Interview participants were asked to discuss the distribution of the benefits (e.g., meat after a legal hunt) and risks associated with conservancy wildlife. Species differ in the amount of meat they provide (Table 2). According to EB records, the meat from personal and trophy hunting was distributed 77% of the time a successful hunt occurred (Table 3). Conservancy households were recipients of meat 26% of the time, while the traditional authorities (i.e., chief and sub-chiefs) received 70% of meat. Importantly, 17% of traditional authority's meat was used for the traditional festival where all households are welcome to participate (Table 3). When interview participants were asked whether the benefits from wildlife hunting were dispersed equally 75% ($n = 56$) said "no." However, when asked whether the risks from wildlife damage were dispersed equally a majority (66%, $n = 50$) said "yes." They also expressed views that wildlife was or could be economically valuable. For example, P17 stated, "When we take care of wildlife we can sell them to other people and we benefit," and P63 said, "To conserve wildlife is a better idea, [it] leads to wealth in future generations [sic]." There was an overwhelmingly high level of worry (91%; $n = 69$) about the loss of wildlife as a resource for economic development.

5. Discussion

Reducing risks from poaching to wildlife and human populations is an increasingly important international policy priority

Table 2
Positive and negative economic values (USD), ecological values and description of poaching activities related to the top four species implicated in human wildlife conflict (HWC) and poaching vulnerability as perceived by local conservancy stakeholders (2009, $n = 50$) and Event Books (2001–2008) in two conservancies, East Zambezi Namibia.

	Buffalo	Elephant	Greater Kudu	Hippopotamus
Perceptions of HWC and poaching related risks [a]				
HWC Rank	3	1	10	2
Ecological interactions	Crop damage, disease vector, threatens and attacks people	Crop damage, disease vector, damages waterways and forests, threatens and kills people	Crop damage	Crop damage, disease vector, threatens and kills people
Poaching Rank	1	3	2	4
Poaching motivation [b]	Trophy males, meat, disease prevention	Trophy males, ivory, meat	Meat, hide, head mount	Hide, meat
Event book records of HWC and poaching [b]				
% of HWC incidents (total)	7% (79)	25% (303)	0.3% (4)	15% (179)
People killed	0	8	0	2
Poaching incidents	2	2	0	4
Estimated average annual crop damage (range from ¼ to 1 ha) [b,c]				
Crop damage (USD)	\$244–\$974	\$897–\$3727	\$12–\$49	\$543–\$2193
Estimated economic and subsistence benefits from legal hunting [b,d]				
Trophy hunting prices	\$4331	\$11,069	\$241	\$1925
Average annual trophy income	\$25,987	\$28,778	\$96	\$1925
% of total harvest in legal hunts	50	22	3	8
Meat potential (kg) [e]	500–900	3600–6000	120–315	1300–4500

[a] Data from focus groups ($n = 50$; 2009).
[b] Event Books from Dzoti and Wuparo (2004–2008).
[c] Calculated using prices from Namibia's Human-Wildlife Self Reliance Scheme (MET, 2009).
[d] Trophy hunting prices are based on 2009 prices in Wuparo; all hunting records are for Wuparo only.
[e] Mass from Animal Diversity Web, University of Michigan (www.animaldiversity.umich.edu).

(Nellemann et al., 2014). Beyond negative impacts on ecosystems, wildlife declines can be both a cause and a consequence of social disorder (Brashares et al., 2014). Quantifying and characterizing how local stakeholders perceive poaching-related risks can complement risk assessment data and result in more robust conservation planning. Below, we discuss the most important implications from our exploration of poaching and HWC-related risks.

Although it is somewhat unsurprising that we found discrepancies between perceptions and assessments of risk associated with wildlife poaching and HWC, the nature of the difference is highly relevant for conservation planning. Further, there were some instances where there were no discrepancies between data sources, such as both EBs and PRRS noting warthogs as being poaching targets. Discrepancies between documented incidents and perceived vulnerability were prevalent. For example, greater kudu (*Tragelaphus strepsiceros*) were never identified during eight years of poaching incident monitoring in EBs and yet were perceived as the second most vulnerable species to poaching. However, the participants' identification of kudu as a desirable species due to the meat and trophy is consistent with their perception that food and money are the most prevalent motivations for poaching in their conservancies (Kahler and Gore, 2012). Another example, common wildebeest (*Connochaetes taurinus*) poaching, was reported on three occasions in Dzoti conservancy yet stakeholders in the focus group activities, including environmental decision makers, did not mention the species as being vulnerable to poaching.

Table 3
Characterization of legal hunting, frequency of meat distribution, and recipients of meat distributed in Wuparo Conservancy from 2003 to 2008.

Legal hunting by type	Frequency	Percent
Personal use/consumption	11	18
Trophy	49	82
Total	60	100
Frequency of meat distribution for all hunting types		
No	14	23
Yes	46	77
Total	60	100
Recipients of meat distribution through all hunting types		
Camp workers	1	2
Conservancy households	12	26
Ministry of Environment & Tourism ranger	1	2
Traditional Authority (TA)	32	70
General (unspecified)	5	11
Festivals	8	17
Meetings	2	4
Households	17	37
Total	46	100

There are multiple sources of potential biases in regards to data discrepancies that can be considered when interpreting data. Some of the discrepancies may reflect differences in the temporal scale of the data. For example, participants when asked to provide the species at risk from poaching during the focus group activities may have been reporting knowledge of the contemporary trends while the EBs are historical records reporting past incidents. Or, focus group participants may have limited recall. Additionally, the EB poaching incident cards do not record enforcement efforts in regards to time expenditures or area coverage (Kahler et al., 2013); Gavin et al. (2010) noted enforcement records may be biased toward readily apparent violations, including activities closer to enforcement headquarters. This may be problematic as wildlife species are not evenly distributed across the geographic space of conservancies and poaching of some species may be harder to detect than others. Regardless of these limitations, results add to research indicating the strength of combining methods and data sources when investigating wildlife crime (e.g., Kahindi et al., 2009) and inspire opportunities for additional research evaluating their efficacy.

Three species emerged as having both high perceptions and assessments of poaching and HWC-related risks: buffalo *(Syncerus caffer),* elephant *(Loxodonta africana)*, and hippopotamus *(Hippopotamus amphibius).* Study participants considered buffalo most vulnerable to poaching and the species was ranked third-most vulnerable by EBs. Participants revealed buffalo poaching in study conservancies was driven by fear of attack and injury, the high value meat and trophy, and prevention of crop damage and spread of foot and mouth disease (FMD) to cattle. The Zambezi is located in a "designated veterinary restriction zone" due to the presence of diseases that impact livestock and wildlife, such as FMD and bovine tuberculosis (bTB), which hampers livestock exports and the viable market of wild meat (e.g., disease-free buffalo) within Namibia (Weaver and Skyer, 2005). Community members commonly view buffalos as the primary vector of livestock diseases, particularly FMD, which has had major economic ramifications through periodic closure of meat export markets. Buffalo have been implicated in the maintenance and transmission of FMD and bTB to domestic livestock elsewhere (Michel and Bengis, 2012); this risk has been found to be temporally and spatially related to shared grazing and watering areas in the dry season (Miguel et al., 2013). Although FMD does not appear to compromise the health and survival of buffalo populations, it does compromise their positive economic value to communities through ecotourism (Michel and Bengis, 2012). The extent to which conservationists can improve FMD risk management by targeting high-risk areas and seasons (Miguel et al., 2013) may determine overall community tolerance, and thus this species' vulnerability within the Zambezi ecosystem.

Elephants were less vulnerable to poaching according to both the focus group participants and EBs; however, this species was characterized by positive economic and negative ecological values in these conservancies. Elephants were implicated in the second highest number of HWC incidents by EBs and were one of two species implicated in the trifecta of HWC-related risks including crop damage, livestock loss, and human death. Local stakeholders considered elephants the most threatening to local livelihoods and described negative ecological and economic values associated with elephants. Economically, according to our estimates, elephants are theoretically able to generate enough revenue through hunting to cover compensation for average annual crop and livestock damage. However, given the number of HWC incidents in which elephants are implicated, a positive economic value may be limited by the extent to which the individual risk associated with elephants is compensated for by communal benefits (O'Connell-Rodwell et al., 2000). Our research indicates perceptions of risk, specifically fear for personal and familial safety and increased labor burdens, may play as prominent a role in shaping the elephant's vulnerability to poaching. Although local farmers may not engage in direct poaching of elephants, they may be permissive in allowing outsiders to poach this high impact species (e.g., Liu et al., 2011).

Hippopotamuses are vulnerable throughout their range largely due to habitat loss or conversion and poaching (Lewison, 2007). Our research participants ranked hippopotamuses as the fourth-most likely to be poached and the second-most implicated in HWCs. These perceptions aligned with EB records of HWCs, in which hippopotamuses are responsible for 15% of the total animal damage incidents, but not poaching records where they were the most common target of past poaching incidents. The hippopotamus was also the only top three HWC-implicated species that failed to generate greater average annual revenue than estimated crop damage in the conservancies. Participants also expressed that hippopotamuses had negative ecological values as they were listed as a disease vector. Although the participants did not specify the disease, hippopotamuses were deemed responsible for the 2004/2005 outbreak of anthrax in Queen Elizabeth and Lake Mburo National Parks in Uganda (Wafula et al., 2007). This outbreak required a multi-sectoral response that included containment, carcass disposal, livestock vaccination, community sensitization, and surveillance programs (Wafula et al., 2007). Additionally, hippopotamuses were responsible for one quarter of human deaths in these two conservancies, including a husband and wife killed in their courtyard. Human-hippopotamus conflict is known to incite retaliatory killing and culling across their range (Kendall, 2011). In our study sites hippopotamuses pose high ecological risks, in the form of potential zoonotic disease outbreaks, have caused violent and traumatic human mortality, and high economic costs. However, the distribution of agricultural and livelihood risks from hippopotamuses vary by distance to rivers and river access points (Kendall, 2011). The distribution of conservancy benefits from wildlife species, in the form of income from hunting and meat distribution, warrant scrutiny as well. In relation to meat distribution, in Wuparo Conservancy over 75% of the time the meat was distributed but conservancy households were recipients a minority of the time. Prior to the 2009 enactment of the Human-Wildlife Self Reliance Scheme, which stipulates payment for elephant and hippopotamus crop damage (MET, 2009), the distribution of benefits versus the risks of hippopotamus-conflict would have been unlikely to encourage coexistence.

Our research illustrates that species perceived as being most vulnerable to poaching are those with positive economic or subsistence values. Further, in understanding how communities value wildlife species we need to be attentive to ecological interactions in addition to economic ones. For example, the extent to which the perceived negative ecological value of buffalos (e.g., FMD vector) may undermine tolerance despite their overall positive contribution to the economy of the conservancies is unknown. Conversely, we know that a species' positive ecological interactions with local communities may increase tolerance of conflict (e.g., Schumann et al., 2012). For example, Namibian commercial farmers were found to be more favorable of carnivores and less likely to desire removal when they had greater understanding of ecological roles that carnivores play in the ecosystem (Schumann et al., 2012). Quantifying the tipping point for ecological and economic values would be useful for conservation planning and policy evaluation.

5.1. Managing poaching-related risks

We found that with increases in the perceived severity of HWC risks posed to livelihoods by a species there was a moderately higher perception of poaching risk for that species. Understanding people's perception of wildlife-related risk is crucial for improving risk communication, designing effective HWC mitigation policies, and evaluating interventions (Gore et al., 2008) designed to reduce species' vulnerability to poaching. Because perception of wildlife-related risks is of interest partly for its relationship to conservation and development policies (Huang et al., 2010), there is a great potential for crafting more effective policy through understanding local people's perception about managing wildlife-related risks. Such understanding may help explain and predict human behavior in response to conservation policy and help improve efficacy of policy and management.

When considering perceptions related to HWC and poaching, rather than questioning the veracity of stakeholder perceptions, these data indicate using participatory approaches in combination with official records of poaching can be advantageous, particularly in community-based conservation areas, in overcoming the inevitable information gaps that exist in formal monitoring of illicit activities (Kahindi et al., 2009; Kahler et al., 2013). Participatory methods strive to take advantage of local knowledge and promote adoption of applied research findings by involving key local stakeholders in the process of conducting research (Siemer et al., 2001).

Understanding how communities in these community-based conservation areas valued wildlife species is useful in thinking about prioritizing interventions and risk communication efforts to the most vulnerable species. The degree to which professionals can improve wildlife management processes and outcomes depends in part on their ability to integrate knowledge from multiple disciplines, including those that detail how people interpret and respond to wildlife-related risks.

Interventions targeting economic values associated with wildlife are common, from wildlife damage compensation schemes to legal hunting concessions that generate income, and are generally meant to increase social acceptability of wildlife species and promote conservation (e.g., MET, 2009). However, compensation techniques have been critiqued from both a conservation and livelihood perspective and may not induce wildlife conservation or protect vulnerable local people from losses (Bulte and Rondeau, 2007). This research is one example of this critique in that it demonstrates challenges associated with equitable distribution of benefits and species that had a net negative economic value (e.g., hippopotamus). Much less attention has been paid to developing interventions that target negative ecological values attached to wildlife. Insights from persuasive risk communication have proven effective at promoting conservation behavior in other contexts and may prove relevant here. Persuasion is not ethically problematic in conditions allowing message recipients to make informed choices minimizing the possibility that persuasion leads to inadvertent harm. Practically, this indicates that conservationists strive to create fair messages that fully inform recipients and help them avoid harm (Rossi and Yudell, 2012). When conducted ethically, persuasion is an effective tool to promote behavioral change of people (Dillard and Shen, 2013), especially when compared to knowledge-transfer only programs that aim to correct a perceived "information deficit" among local people. Ultimately, the extent to which interventions effectively target ecological, in addition to economic values, is an empirical question. The literature on communication intervention evaluation in conservation is small but growing; authors such as Baruch-Mordo et al. (2011) and Gore et al. (2008) demonstrate both the need to evaluate communication interventions in conservation as well as the diversity of evaluation methods available to conservationists in doing so.

Acknowledgements

We acknowledge: Dzoti and Wuparo conservancies, M. Chris, S. Hasken, N. Lasken, E. Liswaniso, F. Lizumo, R. Makanyi, C. Mutabani, and O. Tama. This research was funded by the Department of Fisheries and Wildlife and School of Criminal Justice at Michigan State University.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2015.02.001.

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