Local attitudes and elephant spatial distribution in the Bénoué region, Cameroon: implications for human-elephant conflict and conservation

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Abstract

Local attitudes and elephant spatial distribution in the Bénoué region, Cameroon: implications for human-elephant conflict and conservation

Alys Granados

Increasing levels of human settlement and disturbance adjacent to protected areas have intensified human-wildlife conflict, and this is of special concern in developing nations where human livelihoods and species survival are strongly linked. Local attitudes, along with an understanding of how human disturbance affects species distribution must be considered in efforts to reduce conflict with wildlife. In this study, we evaluated the severity of human-elephant conflict (HEC) in the Bénoué Wildlife Conservation Area (BWCA), Cameroon by surveying locals adjacent to Bénoué National Park (BNP) and using GIS technology to study movement and occurrence of two female elephants relative to roads, villages, and a river. Fifty-eight percent of respondents were affected by elephant crop raiding in 2009, an 18% rise since 1997; likely due to increased immigration over the last decade. Although most villagers were positive towards the protected areas, 52% were negative towards elephants. Human disturbances affected elephant use of the BWCA, as occurrence near the highway and villages was infrequent, whereas occurrence relative to the river increased with proximity. Elephants spent most of their time outside BNP and despite low occurrence near the highway and villages, 95% Fixed Kernel home ranges overlapped with roads and villages, suggesting a high potential for HEC. Efforts to reduce conflict and habitat fragmentation in the long-term must include more efficient land use planning and continued work with locals to implement farm-based deterrents, thereby reducing crop damages and increasing tolerance for the species.

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TABLE OF CONTENTS

List of Figures

Figure 2.3: Percent of locations for each elephant (Doudjatou = closed circles; Oldiri= open circles) within 15 km of a) the highway, b) the Bénoué River, c) secondary roads, d) unpaved park roads, and e) villages, for overall locations, with the exception of Figure 2.3a and 2.3d, which depict Doudjatou and Oldiri's pooled dry season occurrence relative to the highway and unpaved park roads, respectively.

Figure 2.4: Mean seasonal distances (+1SE) to the highway, secondary roads, unpaved park roads, villages, and the Bénoué River for Doudjatou a) in 2007 and b) 2008, and for Oldiri in c) in 2007. Location data were not available for the 2008 dry season for Oldiri. Black bars = wet season; white bars= dry season.

List of Tables

15 km of the highway, secondary roads, unpaved park roads, villages, and the Bénoué River, respectively, within seasons. Chi-square (χ^2) statistics are given with *P*-values in brackets. Letter subscripts with *P*-values indicate the shape of the relationship observed between the number of locations and distance to the area being tested: p=positive (occurrence increases with proximity); n= negative (occurrence decreases with distance from area); q= quadratic relationship; c= cubic relationship. Symbols with *P*-values indicate the distance (km) at which the trend is significant: *= significant at > 2 km; **= significant at > 4 km; ⱡ= significant at < 13 km; ♦= significant at < 14 km. All other tests where $P<0.05$, were significant at ≤ 15 km relative to the area of interest. Df=1 for each test.

Table 2.3: Within season differences in the number of locations within 2 km and 1 km of different road types, for Doudjatou and Oldiri, respectively. Chi-square (χ^2) statistics are given with *P*-values in brackets. Wherever significant differences were found, areas near secondary roads where used more frequently. Df=1 for all.

Table 2.4: Seasonal differences in distance to the highway, secondary roads, unpaved park roads, villages, and the Bénoué River for 2007 and 2008, respectively, for Doudjatou and Oldiri. Kruskal-Wallis statistics (*H*) are given with *P*-values in brackets. Subscripts next to *P*-values indicate in which season (wet or dry) elephants were significantly closer to each area tested. Df= 1 for each test.

GENERAL INTRODUCTION

Protected areas, (e.g. national parks, wildlife and forest reserves) are threatened by human disturbance, including habitat fragmentation caused by the presence of roads and increasing human settlement, particularly in developing nations (Curran et al. 2004; Naughton-Treves et al. 2005). These disturbances have contributed to increased conflict between humans and wildlife, as both compete for resources and living space (Balmford et al. 2001; Naughton-Treves 1998). In Africa, human-wildlife conflict is common and may involve species causing injury or death to humans and livestock or damage to property and crops (Lamarque et al. 2009). Various species damage crops, including primates, birds, and insects (Endamana et al. 2006; Hill 1997; Naughton-Treves 1998), but farmers often report African savanna elephants *Loxodonta africana*, as the most problematic species (Weladji & Tchamba 2003) and conflict with humans has become a significant issue in elephant conservation over the past 30 years (Lamarque et al. 2009; Lee & Graham 2006; Parker et al. 2007).

Most elephant range occurs outside protected areas (Douglas-Hamilton et al. 2005). Growing settlement and expansion of crop land near national parks and wildlife reserves has intensified human-elephant conflict (HEC), negatively affecting human livelihoods (De Boer & Baquete 1998; Weladji & Tchamba 2003), as well as elephants, who are at risk of retaliatory killings by victims of crop damage (Martin et al. 2010). The presence of human settlements and roads may alter elephant behaviour and spatial distribution (Buij et al. 2007), and is of special concern in areas where elephant numbers are believed to be in decline (Blanc et al. 2007). Elephants are vulnerable to extinction (Blanc 2008), yet negative interactions with people can lead to local opposition of conservation efforts

(Barua et al. 2010; Taylor 1999). Reducing, or at least mitigating HEC is therefore central to elephant conservation efforts. In addition, community involvement and local support for conservation is crucial for coexistence between people and wildlife.

Numerous studies of HEC have been conducted in east and southern Africa (Chiyo et al. 2005; Jackson et al. 2008; O'Connell-Rodwell et al. 2000) but this issue has not received similar attention in Central Africa. The savanna elephant population in this region is thought to have declined by at least 76% over the last forty years (Bouché et al. 2011), though little is known about long-term trends in HEC there. In the present study, we assess the severity of HEC in the Bénoué Wildlife Conservation Area (BWCA), North Cameroon, an area that encompasses Bénoué National Park (BNP) and several surrounding hunting concessions, where thousands of people live, with most relying on agriculture as their principal livelihood.

In the first chapter of this thesis, we surveyed 129 people in three communities surrounding BNP regarding the incidence of crop raiding, and their attitudes towards elephants, the park, and hunting concessions. Data from previous work in this area (Weladji et al. 2003; Weladji & Tchamba 2003) allowed us to identify long-term changes in the incidence of crop raiding since 1997, along with changes in attitudes. In the second chapter, elephant movement and occurrence relative to a highway, secondary roads, unpaved park roads, villages, and the Bénoué River, were assessed for two female elephants in the BWCA from 2007 to 2009 using GIS technology. Knowledge of elephant spatial distribution, particularly relative to human activity centres, will assist in identifying areas at high risk of conflict with elephants. Overall, our aim is to improve the understanding of spatial and temporal patterns of HEC in northern Cameroon, to subsequently be directed towards developing more effective mitigation strategies and reduce conflict in the region.

Chapter 1:

Human-elephant conflict around Bénoué National Park, Cameroon: influence on local attitudes and implications for conservation

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ABSTRACT

Crop raiding by African savanna elephants threatens human food security and elephant survival, yet studies of long term changes in crop raiding and effects on attitudes are lacking. The scope of crop damage in three communities and local attitudes towards elephants, Bénoué National Park, and hunting concessions were surveyed using questionnaires in the Bénoué Wildlife Conservation Area, Cameroon in 2010. Temporal changes in attitudes and crop damage were estimated using previous work in this area. Responses from 2010 were analyzed using binomial and nominal logistic regression, and were compared to 1997 responses using chi-square contingency tests and Fisher's exact tests. The percent of households affected by elephant crop raiding increased since 1997 (58% versus 40%). Attitudes towards Bénoué National Park were positive (79% of respondents) and did not change over time, though today, people were more positive towards the hunting concessions (76% of respondents in 2010). Attitudes towards elephants were not predicted by whether respondents experienced crop damage by elephants, yet 52% reported no advantage to elephants being in the area. Investigation into farm-based deterrents and advance compensation schemes is warranted in this conservation area and may improve attitudes, while alleviating economic losses associated with crop damage. Recent increases in immigration likely contributed to increased reported elephant damages, hence better land use planning and the prevention of further encroachment are both central to reducing human-elephant conflict.

INTRODUCTION

Competition between humans and wildlife for natural resources and living space is a global and recurring problem, illustrated through livestock predation by carnivores in sub-Saharan Africa (Holmern et al. 2007; Van Bommel et al. 2007) as well in conflict with non-carnivores. For humans living adjacent to or near protected areas, crop raiding by the latter group is one of the most reported forms of human-wildlife conflict (O'Connell-Rodwell et al. 2000). Ungulates, primates (Naughton-Treves 1998) and birds (Endamana et al. 2006) raid crops throughout Africa. Such species are frequent crop raiders, but African savanna elephants *Loxodonta africana* typically receive the most attention due to the immense damage they can cause to cash and subsistence crops cultivated by people (Naughton-Treves 1998; Thouless 1994). This human-elephant conflict (HEC) is likely to intensify with growing settlement near protected areas, accompanied by the conversion of savanna habitat to agricultural land, leading to further encroachment on wildlife habitat (O'Connell-Rodwell et al. 2000; Okello 2005).

Although elephants are vulnerable to extinction (Blanc 2008), they may be killed by victims of crop damage in retaliation to eliminate “problem animals” (Martin 2010; Naughton et al. 1999). Humans are negatively affected through the immediate outcome of damaged crop fields. Elephants can potentially destroy an entire season’s yield in a single night and the area of damage from a single crop raiding event is typically greater than damage caused by other species (Naughton-Treves 1998). Understandably, complaints of crop raiding by elephants are often greater than that for other wildlife. Crop raiding by elephants additionally threatens the food security of the rural poor living adjacent to elephant habitat, especially when staple crops are concerned (Baririega et al. 2010). On average, families in Bhadra Tiger Reserve, India lost 11% of annual grain production as a result of elephant crop raids (Madhusudan 2003). Long-term effects of crop damage also include negative attitudes towards the species and can lead to reduced support for conservation, as well as increased poaching rates (Barirega et al. 2010; Barua et al. 2010; Okello 2005). Despite this, few studies have looked at the long term trends in crop raiding and the effects on local attitudes towards protected areas and species of interest.

Human-elephant conflict is one of the most important threats facing African savanna elephants (Hoare & Du Toit 1999; Tchamba 1996) and has been well documented across their east and southern range (Jackson et al. 2008; O'Connell-Rodwell et al. 2000; Parker & Osborn 2001). In spite of an increase in scientific papers published on human-wildlife conflict (Dickman 2010), few have focused on the Central African elephant population, which is believed to have declined by at least 76% over the last forty years and connectivity between populations appears to be poor (Bouché et al. 2011). In Cameroon, little information on population numbers are available, though major threats to their survival include habitat loss and poaching for ivory (Blanc 2008), and HEC is a real problem for people near protected areas, such as Bénoué National Park (BNP). Deforestation and poaching are ongoing problems in BNP (Endamana et al. 2007) and here, as in most places where HEC occurs, the problem lies in achieving conservation goals for elephants, yet preventing further conflict with people. Reducing or at least mitigating HEC is thus, central to elephant conservation efforts.

In the present study, we evaluate the extent of crop damage by elephants in the Bénoué Wildlife Conservation Area (BWCA), Cameroon and assess local attitudes towards elephants, BNP, and hunting concessions with the use of questionnaires across three communities in 2010. This study is unique in that communities previously studied by Weladji et al. (2003) and Weladji and Tchamba (2003) in 1997 were revisited to examine changes in attitudes and incidence of crop raiding events. We predicted that villages with the most severe crop damage would be more negative towards elephants, the national park, and hunting zones, as in Weladji et al. (2003). Local attitudes towards BNP were mostly positive in 1997, and we predicted 2010 respondents to be at least as positive as in 1997, due to the presence of non-governmental conservation organizations (NGOs) in the area since 1996, and in spite of ongoing conflict with wildlife (Ancrenaz et al. 2007; Arjunan et al. 2006; Sheppard et al. 2010). NGOs have helped implement education programs in the BWCA and employed locals in the past. We thus, also expected this NGO presence to lead to more positive attitudes among locals towards HC since 1997.

METHODS

Study area

Bénoué Wildlife Conservation Area (BWCA) consists of Bénoué National Park (BNP) (7.55°-8.40°N; 13.33°- 14.02°E) and eleven surrounding hunting concessions (HC) (Fig. 1.1). The park was designated as a national park in 1968 and covers 1800 km^2 of the conservation area's 8438 km^2. Nine of the HC border the park and are meant to act as transitional land between the protected area and crop fields. Regulated hunting is allowed in the HC, and while not legally permitted, settlement, as well as agricultural and forestry activities occur there as well. Hunting concessions are state owned, with the exception of the communities of Sakdje (HC 1 in Fig.1.1) and Bel Eland (HC 4 in Fig.1.1). These became community owned HC in 2002, in an effort by the government to reconcile rural development with conservation. Over 60,000 people live in villages throughout the HC, and agriculture is the principal or sole livelihood for most (Boum & Bene Bene 2008).

This region is classified as the East Sudanian Savanna Eco region. The wet season occurs from May to September whereas the dry season lasts from October to April. Major types of vegetation in BNP include *Isoberlinia* woodland, *Anogeissus* riparian forest, *Terminalia laxiflora* open savanna, *T. macroptera,* and *Burkea detarium* open savanna (Stark & Hudson 1985). Principal grass species include *Hyparrhenia, Andropogon* and *Loudetia* (Stark & Hudson 1985). Various wild animals are found here with the most recent elephant population estimate in BNP being around 540 (Blanc et al. 2007). Lion (*Panthera leo*), spotted hyena (*Crocuta crocuta*), warthog (*Phacochoerus aethiopicus*), African buffalo (*Syncerus caffer*), giraffe (*Giraffa camelopardalis*), and hippopotamus (*Hippopotamus amphibius*) also occur. Although a variety of species are blamed for causing crop damage, elephants were chosen as a species of interest, having previously been cited as a major cause of crop loss in Africa and Asia. Furthermore, as a charismatic and flagship species under threat, their protection can have ramifications for other species and their habitats (WWF 2007).

Data collection

Villages selected were part of a previous study of 114 households of crop damage and attitudes (Weladji et al. 2003; Weladji & Tchamba 2003), allowing for a temporal comparison of these parameters. We aimed to survey at least 20% of people from the communities of Mbaou, Gamba, and Na'ari, through the use of questionnaires, with each person representing a distinct household. The village of Doudja was included in the present study, due to its close proximity to Mbaou. Doudja, Mbaou, and Na'ari were 5 km, 7 km, and 11 km away, respectively from the BNP border, while Gamba shared 7 km of its border with the park. The total number of households in each village was determined from information provided by village chiefs and consisted of 20 in Doudja, 20 in Mbaou, 350 in Gamba, and 100 in Na'ari.

Interviews were conducted with the aid of an interpreter from each village in the native languages of Dourou, Fufulde, or in French. Questionnaires included open and closed ended questions (see appendix) and were formatted similar to Weladji et al. (2003) and Weladji and Tchamba (2003). People were questioned about the incidence of crop raiding by wildlife in the preceding year (i.e. 2009) and to estimate the percent of damage to their fields (0%, < 25%, 25-50%, or > 50%). Unless otherwise stated, crop depredation in this study refers to damage that occurred in 2009. This required participants to recall information from the preceding year and may have influenced the validity of the responses. We aimed to reduce this problem by interviewing as many distinct households as possible in each village, and whenever possible, having other household members present during the interview that could assist in recalling information.

Respondents were also surveyed on their present attitudes (in the 2010 year) towards elephants, BNP, and the HC. Here, we use the definition of attitudes in Ajzen and Fishbein (1980); with "attitude" being how favorable a person is to an object, area, or concept, etc. Possible responses included "good", "bad", "neutral", or "unsure", as in Weladji et al. (2003). In addition, if a participant answered for example, that they felt "good" about BNP or HC, they were then asked to explain this attitude by selecting one or more of the benefits provided by the park from a list, or they gave their own perceived benefit as their response. Likewise, if they felt bad towards elephants or the protected areas, they were asked also asked why. Participants were also asked whether they perceived the elephant population trend and the crop raiding trend as increasing, decreasing, stable, or whether they had no idea. Finally, villagers provided socioeconomic information on resource use and demographic variables.

Browne-Nuñez and Jonker (2008) noted a lack of consistency in methods used to measure attitudes, limiting the ability to make comparisons across study sites. Language and cultural barriers must also be considered, particularly in Africa, where various micro-nations and ethnic groups coexist, each with their own cultural norms and beliefs that may influence questionnaire responses. Furthermore, attitudinal studies in relation to human-wildlife conflict typically occur in hard to reach, rural areas with dispersed populations, yet locals must be interviewed face to face, due to impracticality of mail and phone surveys (Browne-Nuñez & Jonker 2008; Dickman 2010). We made efforts to take these issues into consideration and reduce sources of error and bias. Interviewer bias was reduced by hiring interpreters from each respective village. In addition to an interpreter, the interview team consisted of two French speaking assistants; at least one of whom also spoke the local language, allowing further ability to clarify questions or misunderstandings with the interpreter. Phrasing questionnaires similar to Weladji et al. (2003) and Weladji and Tchamba (2003) also allowed us to maintain equivalence in question meanings (Browne-Nuñez & Jonker 2008). Single-indicator attitude surveys may not fully convey all the beliefs that constitute an attitude (Browne-Nuñez & Jonker 2008), as perceptions and attitudes may also be influenced by cultural norms and societal experiences (Dickman 2010), which were not addressed in this study. We aimed to reduce this error by including more than one type of possible response (ie good, bad, neutral, etc) and allowing people to further explain their responses, wherever appropriate. Such open ended questions reduced the probability of loss of information (Browne-Nuñez & Jonker 2008).

Data analysis

Households from the villages of Doudja and Mbaou were combined and treated as a single unit for all analyses due to their close proximity to each other. Questionnaire responses were summarized and cross-tabulated for statistical analyses. Response variables were categorical, being either binomial (e.g. experienced crop damage vs did not experience crop damage) or multinomial (e.g. positive attitude, negative attitude, or neutral). Binary logistic regression analyses were used to identify whether demographic parameters (age, sex, education, residency length, and village) predicted positive or negative attitudes towards elephants, the national park, and HC, and was also used to determine whether village and/or the percent of damage to respondents' crop fields predicted crop damage by elephants. Where response variables had more than two categories, such as how respondents perceived the trend in crop raiding events and growth of the elephant population, as well as the percent of crop fields damaged, nominal logistic regression analyses were used to test their variation with demography. Nominal logistic regression was also used to identify the reported level of crop damage to fields resulting from wildlife crop raids.

A chi-square contingency test was used to detect differences between reported damages caused by elephants for young and intermediate crop growth stages combined, relative to the mature stage. Chi-square tests were also to identify how attitudes and the proportion of households affected by crop damages have changed since 1997, except where sample sizes and/or expected values were small, in which case; Fisher's exact test was used. "No idea" responses with respect to attitudes towards elephants, BNP, and HC were excluded from analyses. Inclusion of this response category in analyses did not change the results of patterns in attitudes presented. All statistical tests were performed with SAS version 9.2 (SAS Institute 2003) and a significance level of 5% was adopted.

RESULTS

Respondent demography

Twenty-four, 61, and 44 people from distinct households were interviewed in Doudja-Mbaou, Gamba, and Na'ari, respectively. This resulted in a total of 129 respondents. Households typically included the father as the male head of household, one or more wives, unmarried children, and often, other extended family members. Out of 129 questionnaire participants, most

(78.3%) were male due to the nature of the male-dominated society in north Cameroon and a greater willingness to participate in the research. The majority of all respondents were (47.3%) were under 40 years old, 36.4% were between 40 and 60 years old, and 16.3% were over 60 years of age. Mean respondent age was 43 and 54.3% were of Dourou ethnicity. Eighty-five percent of all respondents were grew crops for both subsistence and commercial use. Most (72%) agriculturalists claimed they had invested financially (i.e. herbicides, equipment, etc) into crop cultivation.

Crop damages

Eighty three percent of all respondents reported crop damage by wildlife, with variation among communities (χ^2=9.83, df=2, *P*=0.007). Indeed, significantly fewer households in Gamba (72.1%) reported crop damage relative to Doudja-Mbaou (95.8%) (χ^2=4.24, df=1, *P*=0.039) and to Na'ari (90.9%) (χ^2= 7.63, df=1, *P*=0.006), though the latter two villages did not differ from each other (χ^2= 2.10, df=1, *P*=0.156). There was no significant change in the proportion of households affected by wildlife crop raiding since 1997 (86.0%) (χ^2= 1.98; df=1, *P*=0.159)

Most respondents (49.0%) reported losing 25-50% of crop fields in 2009 while 10.7% lost <25% and 25.3% lost >50% of their fields. Villages did not differ in the level of damage to crop fields (χ^2=4.32, df= 2, *P*=0.115) but there was a difference from 1997, when most people (37.0%) reported losing <25% of their fields (Weladji & Tchamba 2003). Damages by wildlife were cited as the primary limit to crop production by 49.6% of all respondents, followed in importance by a lack of finances for labour and/or equipment (45.6%). This was significantly less than the percent who cited wildlife damages as the primary limit to agriculture in 1997 (χ^2=6.73, df=1, *P*=0.010).

Elephants were cited by the greatest proportion of respondents overall (58.1% of all households) as a species that damaged crops, followed by primates (57.0%) (Table 1.1). This represented a significant increase in households affected compared with 1997, which was 39.5% (χ^2=8.44, df=1, P=0.004) (Fig. 1.2). Villages varied in percent of households affected (χ^2= 49.67, df=2, P<0.001). Fewer households in Gamba (26.2%) reported damage by elephants than in Doudja-Mbaou (95.8%) (χ^2= 15.41, df=1, P<0.001) and Na'ari (81.8%) (χ^2= 29.03, df=1, P<0.001). Doudja-Mbaou also had more households affected than Na'ari (χ^2= 7.63, df=1, P=0.006). No respondents in Gamba reported damage by elephants in 1997, but the percent of affected households significantly increased in 2009 (χ^2=14.19, df=1, P<0.001). Differences over time within Doudja-Mbaou (Fisher's exact test, P=0.068) and Na'ari (χ^2=3.71, df=1, P=0.054) were not quite significant, but more households in Na'ari reported damages for 2009.

Nearly every type of crop cultivated in the BWCA was damaged by elephants at least once, including groundnuts, maize, millet, cotton, yam, beans, sweet potato, cassava, okra, soya, and onion. Staple crops (maize, millet, groundnuts) were most damaged by elephants (Table 1.2) and maize was the most damaged crop overall. Crops cultivated by most respondents (groundnut, maize, millet, beans, cotton, and yam) suffered more damages at maturation relative to younger crop growth stages, when damages at the young and intermediate growth stages were combined (χ^2=22.55, df=1, P<0.001). For all other crop types, damages were infrequent and almost equal, thus sample sizes and/or variation were not large enough to detect any significant differences. Villagers made repeated efforts to deter wildlife from their crops at this stage. The primary methods used to repel wildlife from crop fields were variations of animal scarring tactics. Noise tactics (i.e.

shouting, beating drums, fire crackers) were used by 53.3% of all crop damage victims, guarding and/or sleeping in crop fields was used by 19.7% of crop damage victims, and fire was used by 12.4%. When asked about their willingness to take part in future work to experiment with novel farm-based deterrents in the BWCA, 98.7% of past crop damage victims answered in the affirmative.

Local attitudes towards elephants, Bénoué National Park, and hunting concessions

Demographic variables did not predict any of the dependent variables (all P>0.05), except where noted. Fifty two percent of all respondents saw no advantage to the presence of elephants in the conservation area. Forty percent felt there was indeed an advantage, while the remaining 7.8% were unsure (Fig. 1.3). Positive and negative attitudes were not predicted by whether households had suffered crop damage by elephants (χ^2= 1.44, df=1, P=0.230). Most people (59.7%) believed that the elephant population had grown and this was also seen within villages (Table 1.3). Fifteen percent overall saw the trend as decreasing, and only 1.6% saw it as being stable, while 24% had no idea. Perceptions were not predicted by the level of crop damage to one's fields (χ^2= 0.01; df=1, P=0.907).

Most respondents were positive towards BNP, both overall (79.1%) and within villages (Fig. 1.4a, Table 1.3). Overall, 3.9% of respondents were negative towards the park, while 5.4% were neutral. Neutral respondents were all under 40 years of age and most were female. Twelve percent of respondents (all from Na'ari) were not aware of the existence of the park and 93.3% of these people had resided there for less than ten years. Percent of crop field damaged did not significantly predict positive or negative attitudes towards the park (χ^2= 0.24, df=3, P=0.970), similar to findings in 1997. Wildlife conservation was cited as the primary advantage of BNP by most (42.8%) positive respondents for all villages combined. We found no significant difference in overall attitudes towards BNP over time (χ^2= 0.44, df=1, P=0.508), as most respondents (84.2%) were also positive in 1997. There was also no difference detected within villages over time (Doudja-Mbaou: Fisher's exact test, P=0.498; Gamba: Fisher's exact test, P=0.168; Na'ari: Fisher's exact test, P=1.000).

People were generally positive towards the HC both overall and within villages (Fig. 1.4b, Table 1.3). Seventy-six percent of all respondents were positive towards the HC, 7.8% were negative, and 9.3% were neutral. Seven percent of respondents were unaware of their existence. Again, all were from Na'ari, and most (88.9%) had resided there for less than ten years. Similar to BNP, the most cited advantage of the HC was wildlife conservation, followed by employment (35.0% and 19.3% of respondents, respectively). Overall, a smaller percentage of people were negative than in 1997 (χ^2= 43.69, df= 1, P<0.001) and support for the HC increased over time within Doudja-Mbaou (χ^2= 20.25, df= 1, P<0.001) and Gamba (χ^2= 45.18, df= 1, P<0.001) but not in Na'ari (Fisher's exact test, P=0.709).

Out of 118 respondents, an equal proportion (approximately 46.7%) perceived an increasing trend in crop raiding events in recent years as those who thought it had declined, while 6.8% saw it as remaining stable. Most people (49.1%) who saw the trend as increasing attributed it to an increase in wildlife in the protected area, while the most cited explanation (23.6% of respondents) for its decline was a decrease in wild animals. Significantly more respondents in Na'ari viewed the trend as decreasing relative to Doudja-Mbaou (χ^2=11.55, df= 1, P= 0.007), where most respondents thought it had increased. Most people who saw the trend as declining had not attended school (χ^2= 10.93, df=1, P<0.001) and 90.1% of those people were from Na'ari (χ^2=30.01, df= 4, P<0.001). Responses varied over time, as fewer people overall in viewed the trend as increasing relative to 1997 (χ^2=16.51, df= 1, P< 0.001).

DISCUSSION

Factors influencing patterns in crop damage

Similar to findings elsewhere (Linkie et al. 2007; Naughton-Treves 1998; Sam et al. 2005), farms closer to the forest edge experienced more damage by wildlife in the BWCA, both in 2009 and in 1997. More households experienced crop raiding in Doudja-Mbaou and Na'ari, both of which are more remote than Gamba, surrounded by more continuous forest, and smaller in population. The greater perimeter to area ratio relative to larger communities also makes smaller villages more vulnerable to crop raiding (Madhusudan 2003). Fewer households in Gamba reported crop damages and the population here was the highest of the villages studied, with 95.1% of its respondents practicing sedentary agriculture. Weladji and Tchamba (2003) suggested that Gamba's close proximity to the highway on the western side of BNP contributed to the lack of elephant damages in 1997 resulting in a lower elephant population density. While a smaller percentage of people reported damages by elephants, most were still affected by several other species, and this was the only village where primates were reported as the most problematic species by the majority of people. Thus, in contrast to primates, elephants may prefer to avoid densely populated areas, as suggested by Newmark et al. (1994) who observed areas of high human density to experience more crop raiding by smaller species.

Incidence of crop damage by all wildlife did not change over time but a greater percentage of households reported damage by elephants. Human population growth, due to a government sponsored resettlement program in 2000, may have played an important role in this reported increase. Despite the project's official termination, the government has been unsuccessful in controlling further immigration to the Bénoué area, and migrants continue to arrive in waves each year (Endamana et al. 2007). The number of farmers, especially in Gamba and Na'ari, has thus increased (Endamana et al. 2007) since 1997 (Weladji & Tchamba 2003), resulting in more crop fields for wildlife to raid. A consequence of this increase in immigration is greater deforestation in the park (Endamana et al. 2007), as in Wolong Nature Reserve, China, where rates of habitat loss and fragmentation increased following a doubling of the human population in the protected area (Liu et al. 1999; 2001). Consequently, managing immigration is central in determining the future of BNP (Endamana et al. 2007). An expanding human population in this area may also contribute to the decline in elephant population here as Parker and Graham (1989) found an inverse relationship between human and elephant population density. This suggests that the increase in reported damages by elephants is due to growing encroachment on their habitat and/or more farms located on wildlife (i.e. elephant) corridors (Weladji 1998), rather than an increase in the elephant population, as most locals believed. The reported increase in damages found may also be attributed to the greater palatability of crops to elephants in comparison to the forage inside the park (Weladji 1998).

Damage at the mature crop growth stage

Crop damage at the mature crop growth stage has previously been reported in several species, including elephants (Jackson et al. 2008; Linkie et al. 2007; Sam et al. 2005) , and has been attributed to the higher nutritional quality of crops over grass during the wet season (Osborn 2004; Sukumar 1989). Damage at this growth stage is particularly harmful to human food security, with negative economic consequences for the largely rural poor of this area. Aside from time and labour, most people (72%) invested financially (i.e. herbicides, equipment, etc.) into crop cultivation, yet elephants can destroy their entire yield in a single night. Loss of income is also probable as most (85%) people around BNP grew crops for commercial as well as subsistence use. This was seen in Tanzania, where residents lost the equivalent of about two months' food supply because of crop raiding by large mammals, including elephants (Kaswamila et al. 2007).

Local attitudes towards elephants, BNP, and hunting concessions

People who rely on agriculture for their sole income and are at risk of experiencing crop damages by wildlife are also more likely to be negative towards wildlife (Dickman 2010). Level of crop damage can influence local attitudes towards wildlife and conservation (De Boer & Baquete 1998; Naughton-Treves 1998; Okello 2005) and may explain the present negative attitudes of villagers towards elephants, even though they recognized the importance of the park for wildlife conservation. Indeed, past negative experiences with an object typically foster negative attitudes towards that object, according to attitudes theory (Ajzen & Fishbein 1980). Thus, negative interactions with wildlife should contribute to negative attitudes towards the species in question. Elsewhere in northern Cameroon, over half of respondents reported no advantage to the presence of elephants due to crop raiding by the species (Tchamba 1996). In the Pantanal of Brazil however, Zimmerman et al. (2005) found that while jaguars predated on livestock, people still recognized the need for their conservation. Whether households had suffered crop losses did not predict attitudes towards elephants in the present study, yet the increase in affected households over time suggests this may have had some effect on the large proportion of negative respondents.

Research in Mozambique (De Boer & Baquete 1998), Nepal (Mehta & Heinen 2001), India (Arjunan et al. 2006) and even the Far North region of Cameroon (Bauer 2003) has found locals to be generally positive towards protected areas, in spite of conflict with wildlife. This was similar to our own findings, suggesting a mismatch between attitudes towards elephants and the protected area, as well as to conservation (Waylen et al. 2009). Contrary to our results, others (Arjunan et al. 2006; Mehta & Heinen 2001) found younger age classes and educated respondents to be more positive. Indeed, in 1997, attitudes towards the HC were predicted by residency length (Weladji 1998), but this was not the case in 2010.

People were more positive towards the HC in 2010. The presence of conservation NGOs [i.e. World Wildlife Fund (WWF), Netherlands Development Organization (SNV)] in the BWCA since 1996 and their work with locals through the development of education programs, may have contributed to this. Community education programs and campaigns can increase local tolerance for wildlife and awareness of conservation issues, especially where people receive direct benefits (Waylen et al. 2009). Employment in the BWCA resulting from safari hunting tourism may have also contributed to the more positive attitudes in 2010, as almost 20% of respondents cited employment as the primary benefit and similar results were found in Zambia (Lewis et al. 1990). Overall, in the BWCA, it seems that in 2010 more people believed they (or their relatives) were benefiting from the HC, in contrast to attitudes in 1997 (Weladji et al. 2003).

MANAGEMENT IMPLICATIONS

Given the high support for wildlife conservation, greater community involvement in this area is essential to reducing conflict as well as in improving local attitudes, and has had positive effects elsewhere in Africa (Kuriyan 2002; Sheppard et al. 2010). This is especially important in the Bénoué region, as reports of crop damage by elephants have increased over the last decade. Local involvement in the development of techniques to deter elephants from cultivated areas is also important in short-term efforts to reduce HEC. Given the willingness of locals around BNP to experiment with new farm-based deterrents, future work will test the effectiveness of novel methods that have shown promise elsewhere in Africa when used in combination with increased community vigilance (Osborn 2002; Parker & Osborn 2006; Sitati & Walpole 2006). We also recommend that NGOs working in the area develop and implement programs that further educate people on the potential damages they may incur with settlement in HEC areas, as net income associated with crop cultivation may decline with proximity to wildlife habitat (Elliot et al. 2008).

Although Lybbert et al. (2011) found that locals may not protect or conserve resources and/or species solely because of their greater economic or social value, it is still necessary to reduce the costs of living with wildlife to increase tolerance for the species. Programs that compensate farmers in advance and/or are conditional on wildlife abundance can serve as part of a larger management plan in the BWCA to increase tolerance for elephants and pay for crop losses that may occur (Nyhus et al. 2005; Schwerdtner & Gruber 2007). In contrast to the problems associated with programs that compensate farmers after crops have been damaged (Bulte & Rondeau 2005, 2007; Lamarque et al. 2009), the monetary amount given to farmers in advance payment systems is based on potential crop damage caused by elephants, and is suitable where conflict can be predicted spatially and temporally (Jackson et al. 2008; Schwerdtner & Gruber 2007) as in the BWCA. Payments would also serve the whole community if given in the form of lowered taxes, or for the construction of schools or clinics (Nyhus et al. 2005). Payment in advance and/or performance systems have shown promise in Germany (Schwerdtner & Gruber 2007) and Sweden (Swenson & Andrén 2005) and given severity of crop damage around BNP, future work to test their effectiveness here is warranted.

The consideration of past and present crop damage locations in land use planning and development is important in reducing conflict in the long-term, as well as in reducing pressure on natural resources caused by human encroachment on protected areas. It is recommended that future resettlement programs and other development projects not occur in areas frequented by elephants and/or where HEC is ongoing, as negative consequences are likely for both species (Newmark et al. 1994). Any plans to conserve elephants must consider the needs and attitudes of the people who share the same living space since increased conflict, as observed in the present study, can potentially lead to local opposition towards conservation efforts in the future (Barua et al. 2010). Continued work with locals to acquire a better understanding of HEC and develop strategies to reduce it must therefore become and remain part of long-term elephant conservation efforts.

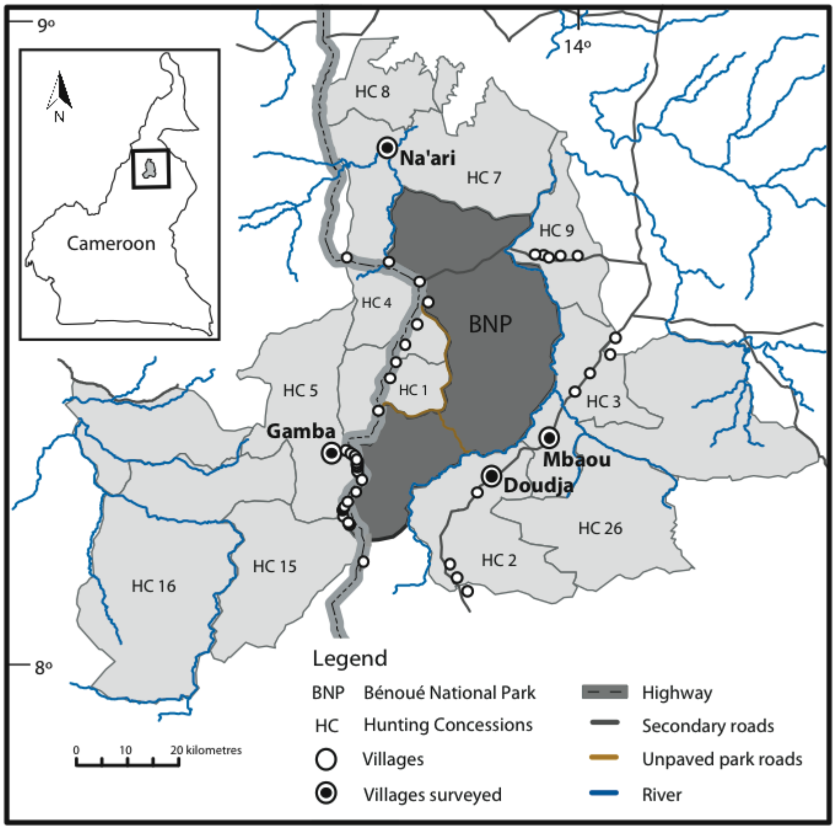

Figure 1.1: Bénoué Wildlife Conservation Area in north Cameroon, including Bénoué National Park and eleven surrounding hunting concessions, as well as villages surveyed, roads, and the Bénoué River. Inset shows the location of the study area within Cameroon.

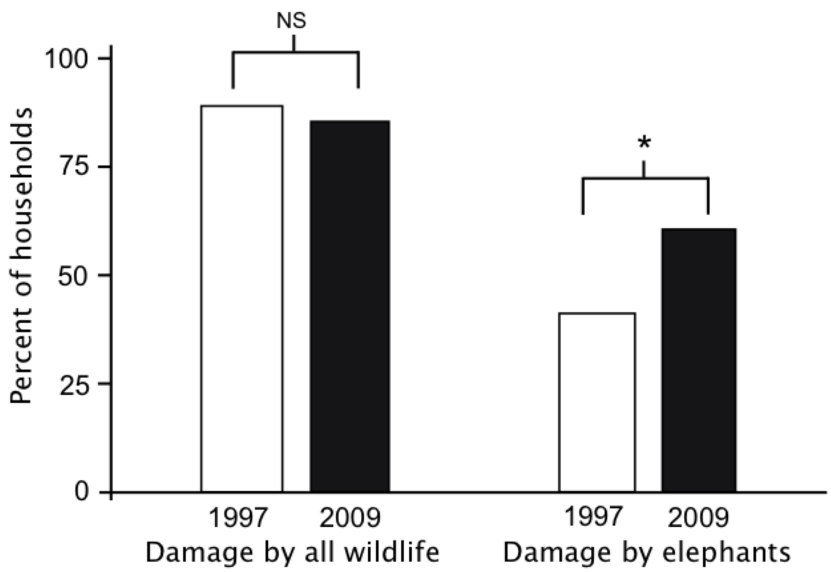

Figure 1.2: Overall percent of households reporting damage by all wildlife listed in Table 1.1 and by elephants in particular in 1997 and in 2009, respectively. NS= no significant difference between time periods; *= significant difference between time periods.

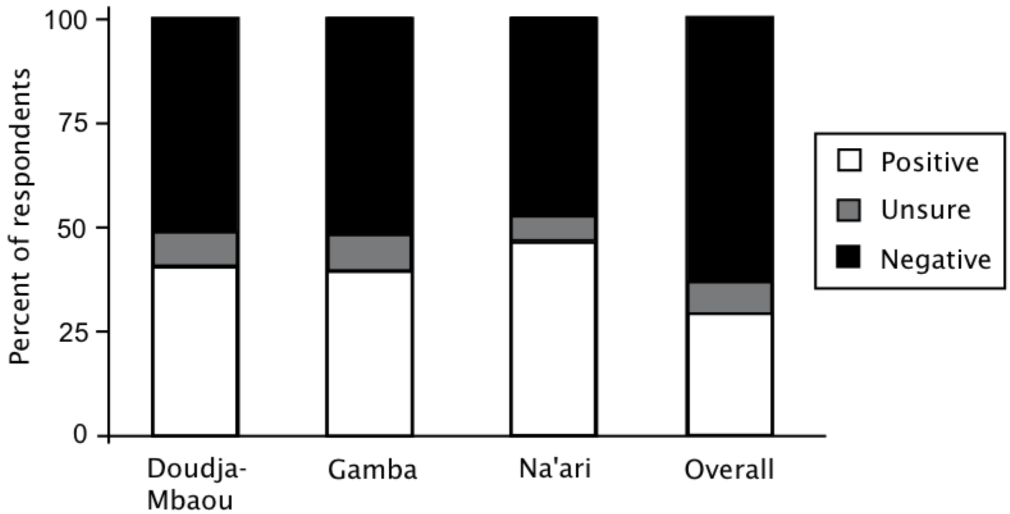

Figure 1.3: Percent of respondents who felt positive and negative towards elephants, as well as those that were unsure when asked "is there an advantage to having elephants present in the area?" within Doudja-Mbaou, Gamba, and Na'ari, and for all communities combined. Overall N=129.

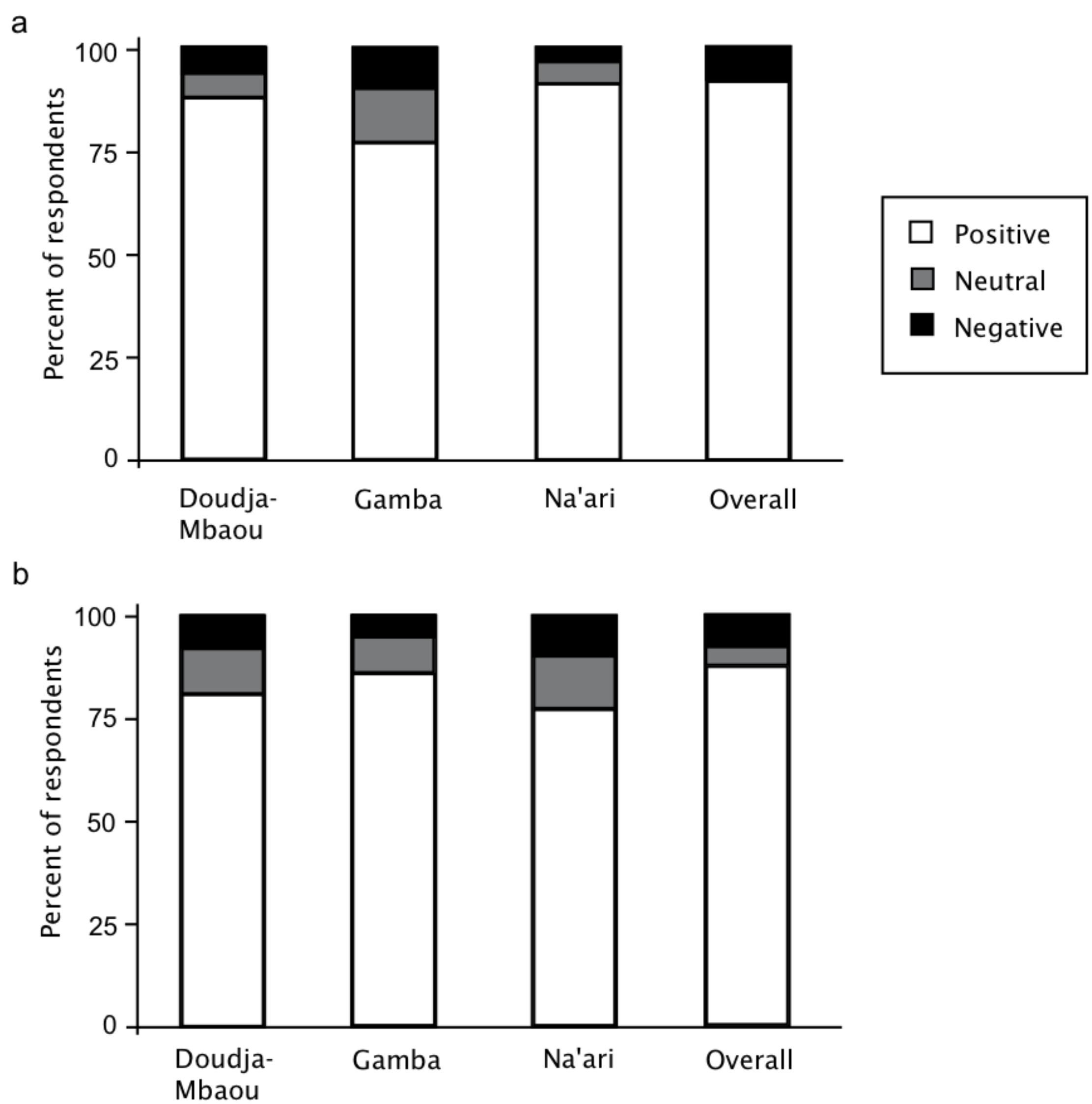

Figure 1.4: Percent of respondents in villages surveyed and for all communities combined who felt positive, neutral, and negative towards a) Bénoué National Park and towards b) the hunting concessions. Overall N=114 for Bénoué National Park and 120 for hunting concessions, respectively.

Table 1.1: Percent of households affected by crop damage by wildlife species in order of damage, reported within each community studied in the Bénoué Wildlife Conservation Area, as well as overall percent for all villages combined. Total percents add up to more than 100 as most households suffered damage by a number of species. Primate species include baboon (*Papio anubis*), ververt monkey (*Cercopithecus aethiops*), and patas monkey (*Erythrocebus patas*). Avian species include green parrot (*Poicephalus senegalus*) and weavers (*Ploceus* spp).

Wildlife type	Percent of households affected			
	Village			Overall
	Doudja-Mbaou	Gamba	Na'ari	
Elephant *Loxodonta africana*	96	26	82	58
Primate spp	79	61	11	47
Avian spp	38	23	18	24
Warthog *Phacocherus aethiopicus*	42	10	5	14
Porcupine *Atherurus africanus*	50	0	0	9
Buffon's kob *Kobus kob kob*	29	3	0	7
Rat *Cricetomys* spp.	4	5	9	6
Ground squirrel *Xerus erythropus*	0	3	14	6
Duiker *Cephalopinae spp*	8	0	2	2
African civet *Civettictis civetta*	4	2	0	2
Insect spp	8	0	0	2
Jackal *Canis* spp	0	2	0	1

Table 1.2: Percent of households within Doudja-Mbaou, Gamba, Na'ari, and for all villages combined that reported damage by elephants to various crop types in the Bénoué Wildlife Conservation Area in 2009. Percentages are out of crop raided households only.

Crop type	Percent of households reporting damage to crop			
	Village			Overall
	Doudja-Mbaou	Gamba	Na'ari	
Maize *Zea mays*	90	100	81	87
Groundnut *Archis hypogea*	90	69	36	59
Millet *Sorghum* spp.	90	44	11	41
Yam *Dioscorea rotundata*	35	25	0	15
Beans *Phaseolus vulgaris*	4	38	11	15
Cotton *Gossipium* spp.	9	6	14	11
Cassava *Manihot esculenta*	13	0	0	4
Sweet potato *Ipomea batatas*	4	6	3	4
Okra *Abelmoschus esculentas*	9	0	0	3
Onion *Allium cepa*	0	0	3	1
Soya *Glycine max*	0	0	3	0

Table 1.3: Overall and within village chi-square (χ^2) statistics for differences in attitudes towards Bénoué National Park, hunting concessions, and the elephant population trend. *P*-values are given in brackets. Df=1 for within village attitudes towards Bénoué National Park and hunting concessions, while overall Df=2 for attitudes towards these areas. Df= 2 for all elephant population trend tests.

	Village			Overall
	Doudja-Mbaou	Gamba	Na'ari	
Bénoué National Park	16.67 (<0.001)	54.07 (<0.001)	17.64 (<0.001)	161.74 (<0.001)
Hunting concessions	15.70 (<0.001)	31.72 (<0.001)	24.50 (<0.001)	126.00 (<0.001)
Elephant population trend	6.25 (0.012)	42.17 (<0.001)	35.37 (<0.001)	94.67 (<0.001)

Chapter 2:

Spatial distribution and occurrence of elephants in a human-dominated landscape, Bénoué Wildlife Conservation Area, Cameroon

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ABSTRACT

Increasing human settlement and disturbance adjacent to protected areas has intensified conflict between people and wildlife, resulting in competition for resources and living space. In northern Cameroon, over 60,000 people live in villages surrounding Bénoué National Park, leading to conflict with African savanna elephants which raid crops and may also damage homes and water or grain supplies. Using satellite-derived data from 2007 to 2009 for two female elephants, movement patterns were studied in relation to areas frequented by humans, such as a highway, secondary roads, unpaved park roads, and villages, in addition to the Bénoué River. Elephant occurrence was analyzed using log linear models while Kruskal-Wallis tests were used to detect seasonal differences in distance to the above areas. Elephants showed individual as well as seasonal differences in home range size and distribution within the protected area. Home ranges overlapped with several villages and roads, though occurrence within 1 km of the former area was infrequent. Elephants appeared to avoid the highway, suggesting it acts as a barrier to movement. In contrast, occurrence of elephants increased with proximity to secondary roads and to the Bénoué River. Our findings show that along with perennial water, human disturbances (i.e. the highway and villages) influence elephant spatial distribution in the Bénoué Wildlife Conservation Area and overlap of these areas with elephant home ranges suggest the potential for human-elephant conflict is high.

INTRODUCTION

Understanding the effects of human settlement and disturbance on wildlife distribution and movement is necessary for the effective management and conservation of threatened species (Kerley et al. 2002). With 80% of the range of African savanna elephants *Loxodonta africana* found outside protected areas (Hoare 2000), overlap with human settlement is inevitable, leading to conflict with humans through competition for land and resources (Balmford et al. 2001; Naughton-Treves 1998). Consequences include elephants causing human injury or death, destroying water and/or grain supplies, or competing with cattle for access to water (Thouless 1994). Elephants also damage crops when they leave the refuge of parks and/or wildlife reserves and travel through human communities, with growing settlement adjacent to these areas exacerbating the problem (Hoare 2000; Sitati et al. 2003). This can lead to illegal hunting by villagers in efforts to eliminate elephants thought to be recurring crop raiders (Martin et al. 2010; Naughton et al. 1999; Weladji & Tchamba 2003). Hunting is of special concern where elephant numbers are declining, such as in Central Africa (Blanc et al. 2007), as populations can be sensitive to even low increases in cow mortality (Thouless 1994). Human activity, particularly in unprotected areas may therefore determine elephant distribution and threaten the long-term viability of elephant populations (Buij et al. 2007).

The ability to identify and predict high-risk areas is important in reducing human-elephant conflict (HEC), as well as in preventing further elephant population decline in Central Africa. Despite poaching, habitat loss, and ongoing conflict with people, elephants in this region are not as well studied as elsewhere in Africa (Endamana et al. 2007) and may face greater pressure from anthropogenic disturbances than populations in east and southern Africa (Tchamba 1993). In addition, the Central African savanna elephant population is thought to have decreased by at least 76% within the last forty years, with more pronounced declines seen in the last decade (Bouché et al. 2011). Determining elephant spatial distribution both in and outside of protected areas and understanding the influence of ecological factors and of human presence, must therefore be considered in efforts to mitigate damage and reduce conflict (Douglas-Hamilton et al. 2005). In this study, we describe movement patterns of two female elephants in and around Bénoué National Park (BNP), Cameroon, and determine home range sizes and distribution in the protected area, along with elephant occurrence relative to roads, villages, and the Bénoué River with the use of satellite collars. This will be used to assess the potential for HEC in this area based on elephant spatial distribution.

During the dry season, elephants remain close to permanent water sources (Harris et al. 2008; Galanti et al. 2006; Stokke & Du Toit 2002). Hence, we predicted that elephants would have smaller home ranges in this season. We also expected them to exhibit shorter distances to the Bénoué River and that occurrence would increase with proximity to the river because of limited water availability during this time. In contrast, during the wet season, rainfall is high and water is readily available, so we anticipated that movement would not be restricted by efforts to remain close to permanent water sources, resulting in a larger home range size.

Human density influences elephant distribution, potentially more so than other ecological factors (Buij et al. 2007), and elephants may adjust their behaviour and distribution in response to disturbance, such as encroachment and habitat fragmentation (Barnes et al. 1991; Graham et al. 2009). We therefore expected elephant occurrence to decline near roads and villages. However, we predicted occurrence near villages to be greater in the wet season, the period of crop maturation, and when wildlife in West and Central Africa usually raid crops (Sam et al. 2005; Tchamba 1996). We anticipated that overall occurrence relative to roads would decline with proximity to road types with more traffic (the highway and secondary roads), as suggested by Jaeger et al. (2005). Similarly, we expected greater occurrence near roads during the wet season, due to their proximity to human settlements, and because elephants may travel beside roads to raid crops.

METHODS

Study Area

Bénoué Wildlife Conservation Area (BWCA) consists of Bénoué National Park (BNP) (7.55°-8.40°N; 13.33°- 14.02°E) and eleven surrounding hunting concessions (HC) (Fig. 2.1). BNP was designated as a national park in 1968 and covers 1800 km^2 of the conservation area's 8438 km^2. Nine of the HC border the park, acting as transitional land between the protected area and crop fields. Regulated hunting is allowed in the HC, and while not legally permitted, settlement, as well as agricultural and forestry activities occur there as well. Over 60,000 people (mostly agriculturalists) live in villages throughout the HC (Boum & Bene Bene 2008).

This region is classified as the East Sudanian Savanna Eco region. The wet season occurs from May to September while the dry season lasts from October to April. Major types of vegetation found in BNP include *Isoberlinia* woodland, *Anogeissus* riparian forest, which includes thick and impermeable vegetation, *Terminalia laxiflora* open savanna, *T. macroptera,* and *Burkea detarium* open savanna (Stark & Hudson 1985). Principal grass species in the park include *Hyparrhenia, Andropogon* and *Loudetia* (Stark & Hudson

1985). Various wild animals are found here with the most recent estimate of the elephant population in BNP being around 540 (Blanc et al. 2007). Lion (*Panthera leo*), spotted hyena (*Crocuta crocuta*), golden jackal (*Canis aureus*), warthog (*Phacochoerus aethiopicus*), water buck (*Kobus ellipsiprymnus*), African buffalo (*Syncerus caffer*), giraffe (*Giraffa camelopardalis*), and hippopotamus (*Hippopotamus amphibius*) also occur here.

Data collection

Two female elephants from different herds, Doudjatou and Oldiri, were collared in April 2007 and their movements were tracked using Argos satellite technology. Elephants live and travel in herds led by a matriarch, who is typically an older cow. Herds generally include several related females, their daughters and juvenile sons, with groups averaging around nine individuals (Moss 1988) and potentially having up to 20 adult cows; hence, locations of a single female are representative of the entire herd (Archie et al. 2006; Galanti et al. 2000; Wittemyer et al. 2005). Groups often join together to form larger herds, which in turn may fuse with others before breaking up again, characteristic of a fission-fusion society (Archie et al. 2006; Moss 1988).

Once located, elephants were immobilized by darting with 10 mg etorphine hydrochloride (Wildlife Pharmaceuticals, For Collins, CO, USA) and fitted with Argos satellite collars (Telonics, Mesa, AZ, USA). Collaring took place in the dry season, to facilitate better visibility for tracking. The Cameroon Ministry of Forestry and Wildlife (MINFOF) provided the permit for the capturing and collaring of elephants. Collars transmitted several locations each day starting April 17, 2007 and error was reduced by only using locations with class 2 (150 to 350 m) or 3 (<150 m) location class error margins. These locations were generally around 24 hours apart, though sometimes this increased to several days. Location data covered four seasons: the wet seasons of 2007 and 2008, and the dry seasons of 2007 and 2008. Data for Oldiri differed from that of Doudjatou, in that satellite data for the dry season of 2008 was unavailable due to collar malfunction. Weather data, including mean seasonal temperature and rainfall were obtained from the Division of Meteorology, Cameroon's Ministry of Transport. Mean temperatures for the 2007 wet season, 2007 dry season, 2008 wet season, and 2008 dry season were 28.24, 29.14, 27.50, and 30.07 ˚C, respectively. Mean rainfall for the 2007 wet season, 2007 dry season, 2008 wet season, and 2008 dry season were 143.92, 23.11, 230.58, and 13.03 mm, respectively.

Data analysis

Overall, 655 and 322 locations were used in data analyses for Doudjatou and Oldiri, respectively. Identical but separate analyses were performed for each elephant. Locations were mapped and analyses were performed in ArcGIS 9.3 (ESRI, Inc., Redlands, CA, USA). All statistical tests were done using SAS v. 9.2 (2003) and a significance level of 0.05 was adopted.

Home Range

Overall and seasonal home ranges were calculated using the Animal Movement Analysis extension (Hooge & Eichenlaub 2000). The Minimum Convex Polygon (MCP) method tends to overestimate home range size and was estimated only as an indicator of total potential habitat available to each animal (Graham et al. 2009). Home ranges were also estimated using Fixed Kernel (FK) methodology, believed to be a more robust method of estimating home range size. In contrast to the MCP method, the FK method considers the intensity of use in determining home range size and estimates the probability that an individual will be in any given part of its home range (Powell 2000). Home ranges were estimated for utilization distributions of 50% and 95%, the latter of which is most commonly used as the general home range size, and unless otherwise noted, home range results refer to the 95% FK utilization distribution home range. As in other home range studies (Blake et al. 2008; Kolowski et al. 2010) the 50% FK home range was considered to represent the animal's core area, and is the area used most frequently in the home range (Samuel et al. 1985). The 50% FK home ranges were used to determine the percent of elephant core areas found inside the park. The kernel bandwidth for the FK home range was selected using the Least Square Cross Validation method (Hooge & Eichenlaub 2000).

Elephant occurrence and distance relative to roads, villages, and the Bénoué River

Seasonal elephant occurrence relative to different areas in the BWCA was determined and included a national highway, secondary roads, unpaved roads inside BNP, villages, and the Bénoué River. The two-lane paved highway in the western region of the park is the principal route of travel between the towns of Garoua and Ngaoundéré and has a high volume of traffic. The unpaved roads in BNP are dirt or gravel paths, primarily used by safari hunters during the dry season or by park personnel year round. Secondary roads have an intermediate level of traffic and are mainly gravel roads.

Avoidance of human settlements and roads at distances within approximately 10 km has been reported in elephants (Barnes et al. 1991; Harris et al. 2008; Newmark et al. 1996) along with a greater use of areas within 10 km of water sources (Harris et al. 2008; Stokke and Du Toit 2002; Thouless 1995). As such, we chose to assess elephant occurrence within 15 km of the highway, secondary roads, unpaved park roads, villages, and the Bénoué River. This was done for all locations combined and within each season to identify patterns in number of elephant locations relative to their distance from a given area. Oldiri's occurrence relative to the highway was not analyzed, as few of her locations occurred within 15 km, and the closest she came to this road type was 12.7 km. Data for wet and dry seasons from different years were analyzed separately, unless otherwise indicated. Because the response variable, occurrence, was count type data, analyses were done using log linear models, and occurrence was analyzed at 1 km intervals up to and including 15 km.

To test whether elephants used places near high traffic roads more often than roads with less traffic, log linear models were also used to compare occurrence within 2 km and 1 km between road types. This was done within seasons, and because no year effect was found for occurrence within these distances for either elephant in wet (all $P>0.05$) or dry (all $P>0.05$) seasons, seasonal data were combined and analyzed as occurrence for all wet seasons and for all dry seasons, respectively. We additionally investigated seasonal differences in each elephant's distance to roads, villages, and the river. Data was highly skewed and not normally distributed, and any attempts to transform the data were unsuccessful. Accordingly, non-parametric Kruskal-Wallis tests were used to identify seasonal differences in distance to each area, within 2007 and within 2008. For Oldiri, this was done only for 2007, as location data were unavailable for the 2008 dry season.

RESULTS

Home range size and distribution

Doudjatou's dry season home ranges were larger than during the wet season, whereas Oldiri exhibited the opposite pattern (Table 2.1). The elephants also differed in their use of the park. Doudjatou showed a northward movement in the dry season from the southern region of the park in the preceding wet season, and a return south the following wet season (Fig. 2.2a-d). Oldiri displayed a more sedentary pattern, showing less movement overall and between seasons, and mostly remaining near the same eastern region of the park (Fig. 2.2e-g).

Less than half of each elephant's overall locations occurred inside BNP (Doudjatou: 45.2%; Oldiri: 35.7%; Table 2.1). In 2007, Doudjatou's occurrence in the park was greater in the wet season than in the dry season (χ^2=6.29, df= 1, P=0.012), while no seasonal difference was found in 2008 (χ^2=0.32, df= 1, P=0.570). Similarly, Oldiri's occurrence in the park did not differ between seasons in 2007 (χ^2=2.51, df= 1, P=0.113). Elephants also varied in the percent of their core areas that occurred inside BNP. Forty-one percent of Doudjatou's total core area occurred in the park, while for Oldiri, this was 22.8% (Table 2.1). Core areas always overlapped with the Bénoué River, regardless of season (Fig. 2.2).

Elephant occurrence relative to roads, villages, and the Bénoué River

As predicted, Doudjatou's occurrence declined with proximity to the highway, but only during the dry seasons and for locations under approximately 8 km (Fig 2.3a; Table 2.2), while Oldiri did not come within 11 km of the highway. Also as expected, elephant occurrence increased with proximity to the river (Fig. 2.3b; Table 2.2). Contrary to our initial predictions, a similar trend was observed for occurrence with respect to secondary roads (Fig. 2.3c; Table 2.2). Elephants showed different patterns in occurrence relative to unpaved park roads: within 10 km, Oldiri's overall occurrence was greater near these roads, whereas for Doudjatou, the opposite was found (Fig. 2.3d; Table 2.2). As predicted, occurrence declined with village proximity, though largely for locations within 6 to 8 km (Fig. 2.3e; Table 2.2). When all locations were considered, we additionally found that the relationship between occurrence and distance relative to villages was quadratic for Doudjatou ($\chi2$= 39.04, df=1, P<0.001) (Fig 2.3e) and cubic for Oldiri ($\chi2$= 6.93, df= 1, P=0.009) (Fig 2.3e), with locations peaking at approximately 7 km for both.

Overall and within season differences in occurrence near road types

No year effect for elephant occurrence within 2 km and 1 km of all road types was found between seasons (all P>0.5), hence seasons from different years were pooled for analyses. Areas near the highway were used significantly less than secondary roads (Table 2.3). Indeed, no elephant ever crossed the highway, and secondary roads were crossed more frequently by both elephants (Doudjatou: 13.6% of all movement paths; Oldiri: 21.8% of all paths). Unpaved park roads were crossed more frequently by Doudjatou (44.3% of all paths) than by Oldiri (15.0% of all paths). No difference was found between use of areas near the highway and unpaved park roads (Table 2.3).

Seasonal differences in distance to roads, villages, and the Bénoué River

On average, elephants were furthest from the highway, followed by unpaved park roads. Doudjatou and Oldiri stayed closer to secondary roads, and as expected, remained closest to the Bénoué River, with Oldiri being significantly closer in the dry season (Fig 2.4, Table 2.4). Both remained within 10 km of villages (Fig 2.4, Table 2.4). Doudjatou exhibited more seasonal variation in distance to areas tested. She maintained a shorter distance from the highway in the 2007 wet season and was closer to secondary roads and unpaved park roads in the dry season (Table 2.4). No significant differences in distance were found for Doudjatou in 2008 (all P>0.06). Despite an average distance of over 30 km from the highway, Oldiri was closer to the highway and to unpaved park roads in the wet season (Table 2.4).

DISCUSSION

Home ranges and distribution within the protected area

Previous research has found elephants to spend over half their time outside protected areas (Douglas-Hamilton et al. 2005) and in the present study, both herds behaved similarly in relation to BNP. Of the two elephants, Doudjatou spent more time inside the park (especially during the dry season), which may be a means of seeking refuge and avoiding humans (Galanti et al. 2006), since hunting is prohibited in the park but allowed in the HC during the dry season. Oldiri's home range largely occurred in the HC, potentially putting her and the herd at greater risk of mortality in addition to trauma associated with losing herd members (Bradshaw et al. 2005), emphasizing the importance of non-protected areas to elephant distribution and range (Douglas-Hamilton et al. 2005; Graham et al. 2009).

Animals may respond to hunting pressure by changing their movement patterns, i.e. avoiding open areas (Kilgo et al. 1998) and human activity centers (Dorrance et al. 1975; Rost & Bailey 1979), or by moving into more protected areas (Thouless 1994). Movement into new areas may further explain reports of crop raiding by elephants in the village of Gamba in the BWCA (Chapter 1), where there was previously none (Weladji & Tchamba 2003). In spite of greater deforestation outside the park and the potential dangers associated with leaving the protected area, occurrence inside declined over time. This suggests there is some benefit to being in high risk areas, such as the presence of preferred and/or higher quality forage outside BNP, representing a trade-off between better foraging and lower predation risk (Power & Compion 2009).

Doudjatou's long distance movements in the dry season were likely due to seasonal changes in resource availability and/or quality (Fryxell & Sinclair 1988), such as a decrease in high protein and energy forage (Meissner et al. 1990), while increased water availability and vegetation productivity contributed to smaller wet season home ranges (Young et al. 2009). The lack of long distance movements by Oldiri, may be indicative of her belonging to a more sedentary clan within BNP, while Doudjatou is part of a migratory clan, even if her northward movements were of relatively short distance. This may serve to reduce competition for water and forage in the park (Tchamba 1993). Regular long distance movement patterns by elephants were observed in Kenya (Thouless 1995) and Botswana (Verlinden & Gavor 1998), where herds showed regular seasonal movements, and in the latter case, migrated up to 200 km to reach water during drier conditions. This preference to be near water at this time may also be related to the presence of higher quality browse and shade near water (Smit et al. 2007).

Influence of the river on movement

Of all the areas considered in this study (roads, villages, and the river), on average, elephants maintained a closer distance to the river, as in Thomas et al. (2008). Similarly, in South Africa, herd density was highest within 1 km of water (Redfern et al. 2003). Oldiri's herd remained closer to water and had a smaller home range size in the dry season, supporting previous findings that home range size increases with water availability or with onset of the wet season (Stokke & Du Toit 2002). On the other hand, and contrary to our predictions, no seasonal difference in distance to water was found for Doudjatou, despite her longer distance movements.

The influence of perennial water on elephant distribution and the apparent nonrandom use of the protected area may indicate that elephants here are central place foragers, a strategy by which an animal returns to a common place between foraging

(Olsson et al. 2008; Schoener 1979), and has also been suggested for elephants in Mozambique (Ntumi et al. 2005). This is similar to hippopotamus whose distribution was found to be dependent on their distance to water (Lewison & Carter 2004). This dependence may also contribute to HEC in the dry season, when both species occur near water sources (Jackson et al. 2008; Thouless 1994). Indeed, distance to perennial water was the greatest predictor of crop raiding in Tsavo, Kenya whenever female elephants were involved (Smith & Kasiki 1999).

Elephant occurrence relative to road types

Disturbance caused by roads affects wildlife movement and behaviour (Forman & Alexander 1998), and road avoidance has been observed in large mammals, including cervids (Dyer et al. 2002; Forman & Alexander 1998; Rost & Bailey 1979), black bears (*Ursus americanus*) (Brody & Pelton 1989), wildebeest (*Connochaetes taurinus*) (Newmark et al. 1996), and elephants (Barnes et al. 1991). Roads can facilitate access to undeveloped areas for poachers (Trombulak & Frissell 2000) and may also act as barriers to movement, potentially disrupting migrations and fragmenting and/or isolating wildlife populations (Jaeger et al. 2005; Newmark 2008). Within 10 km of the highway, elephant occurrence in BNP decreased with proximity and few locations were found within 500 m, also seen with Doudjatou's occurrence relative to unpaved park roads. Elsewhere in Africa, similar trends were found. In Gabon, forest elephant abundance declined with road proximity (Laurance et al. 2006) and elephants remained at least 7 km from roads (Barnes et al. 1991). Likewise, herbivore abundance decreased within 600 m of a highway in Tanzania (Newmark et al. 1996).

Though the elephants in BNP crossed secondary roads, neither ever crossed the highway, and the highway's high volume of traffic may have contributed to this apparent avoidance (Jaeger et al. 2005). Traffic may be more important than road size in its impact on wildlife, and animal occurrence should decline as traffic volume increases (Jaeger et al. 2005). Contrary to this, secondary roads were used more than unpaved park roads, emphasizing the need for anti-poaching patrols along the former road type (Blom et al. 2005). Negative consequences associated with secondary roads include reduced cub survival among Amur tigers (Kerley et al. 2002); therefore, there is likely some trade-off or benefit for elephants to occur near such areas. The greater use of these roads in BNP may be related to their proximity to important resources (Gagnon et al. 2007), such as the Bénoué River and/or a preference for secondary forest near roads (Barnes et al. 1991; Olivier 1978). Several secondary roads occur near the river (Fig. 2.1), thus elephants may be trading off reduced predation risk for access to water and the forage found along rivers, particularly during the dry season. Indeed, distance to secondary roads was generally greatest in the late wet season and early dry season (following a period of high rainfall) and smallest near the end of the dry season (following a long period of little to no rainfall).

Movement relative to human settlements

Elephants, particularly females, avoid human settlements (Barnes et al. 1991; Blom et al. 2005; Galanti et al. 2006; Newmark et al. 1994; Parker & Graham 1989) and prefer areas with low human activity (Graham et al. 2009). Greater human settlement and disturbance may alter wildlife distribution (Ripple & Beschta 2004; Tchamba 1993) and the expansion of farmland around BNP may lead to more frequent interactions between people and elephants. Elephant occurrence generally declined within at least 7 km from villages, suggestive of avoidance behavior. However, village satellite locations represented village centers, and elephant occurrence relative to crop fields (data which were unavailable), may provide a better idea of HEC with respect to crop raiding in the BWCA. Animals may respond to humans similar to the manner in which they respond to the risk of predation (Frid & Dill 2002) and behavioural effects associated with proximity to human settlement include reduced foraging, increased agitation, and reduced resting behaviour (Kumar & Singh 2011; Ruggiero 1990). Such effects of intimidation may even be as important as direct mortality in their consequences on prey demography (Preisser et al. 2005).

Quadratic curves of occurrence relative to distance from villages were also found for elephants in the Nazinga game ranch, Burkina Faso (Hema et al. 2011), and could be representative of the region of the protected area where elephants preferred to spend their time. Peaks in occurrence on quadratic curves (generally around 9 km from villages) may indicate that elephants felt safer at this distance and/or that cover for refuge provided by dense vegetation was greater. Despite low elephant occurrence near villages, any presence near such areas represents potential HEC, particularly during the harvest season. In Tanzania, elephants avoided cultivated areas throughout the year, yet crop raiding was still a problem at the start of the harvest season (Galanti et al. 2006). Elephants are not frequent crop raiders, but can cause substantial damage to crop fields and to grain and water supplies in a single visit, threatening human food security (Naughton-Treves 1998; Okello 2005), with most crop raiders being matriarch-led family groups during the peak in the crop raiding season (Sitati et al. 2003, 2005; Thouless 1994).

MANAGEMENT IMPLICATIONS

Studies of elephant movement and distribution in places facing heavy encroachment are important for understanding HEC and identifying areas important to their survival (Graham et al. 2009). A large part of elephant range in the BWCA occurred outside the national park, thus, the importance of non-protected areas must be considered in elephant conservation strategies, in addition to the influence of perennial water on movement. To enable coexistence between species, any future conservation and/or management plans in this area must consider the needs of wildlife across park boundaries in addition to human interests, due to the influence of human activity centers on elephant spatial use (Galanti et al. 2006; Lee & Graham 2006).

Additional habitat fragmentation in the BWCA should be prevented through more effective land use planning (Graham et al. 2009) and preventing the further expansion of crop land plays a large role in this. While the HC were meant to serve as buffer zones between the national park and non-protected areas, the boundary between the concessions and park is immediate and requires a buffer zone in itself due to the area of disturbed habitat created by the presence of human settlement (Theobald et al. 1997). Disturbances within 300 m of large mammals may trigger a flight response (Freddy et al. 1986; Schultz & Bailey 1978). Knowledge of similar distances for elephants, where they are unlikely to take flight (Rodgers & Smith 1995; Theobald et al. 1997) or show altered behaviours (Kumar & Singh 2011; Ruggiero 1990), can be used to establish a set-back distance when creating buffers. For example, Burke (2005) found that elephant stress was reduced when tourists remained more than 50 m away from them in Pilanesberg National Park, South Africa. We thus recommend an additional buffer zone of at least 75 m around BNP, where additional settlement and agriculture are prohibited, in order to reduce conflict and allow species to adjust to being near hunting zones without immediately risking mortality (Burke 2005; Rodgers & Smith 2005).

Elephants in BNP avoided the highway, but frequented secondary roads, thus, wherever possible, we further recommend reduced or at least regulated access to these roads in areas where elephants are known to occur, particularly during the dry season. To our knowledge, movement of only one other elephant in BNP has been previously studied (Foguekem et al. 2007). Long-term monitoring, especially of additional herds in the BWCA, is thus required to determine home ranges of other elephant groups and whether their movement and distribution are similarly influenced by human disturbance. This should be considered in combination with data of fine scale land use and land cover in the protected area.

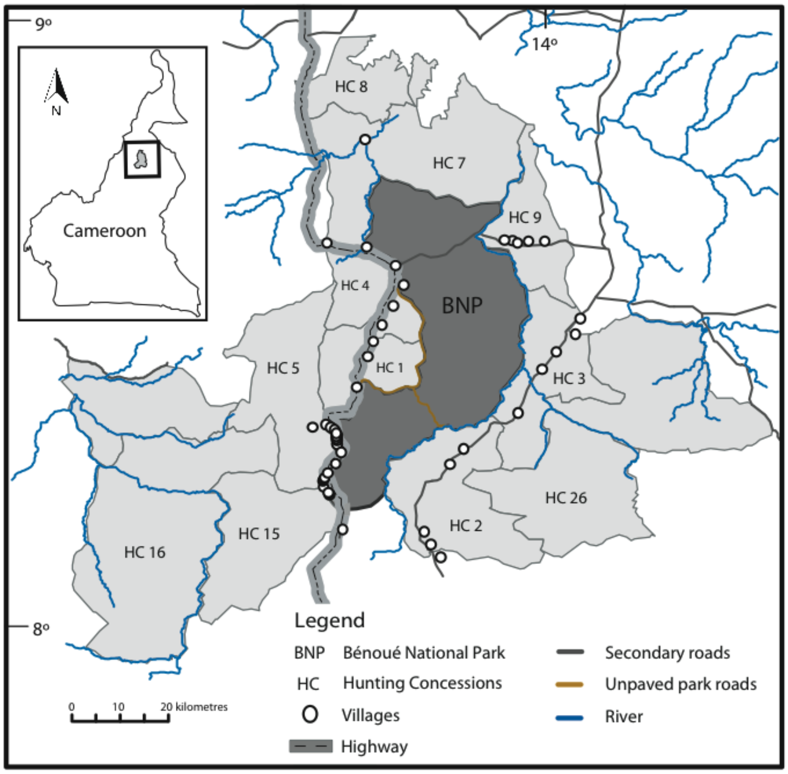

Figure 2.1: Bénoué Wildlife Conservation Area in north Cameroon, including Bénoué National Park and eleven surrounding hunting concessions, as well as villages, roads, and the Bénoué River. Inset shows the location of the study area within Cameroon.

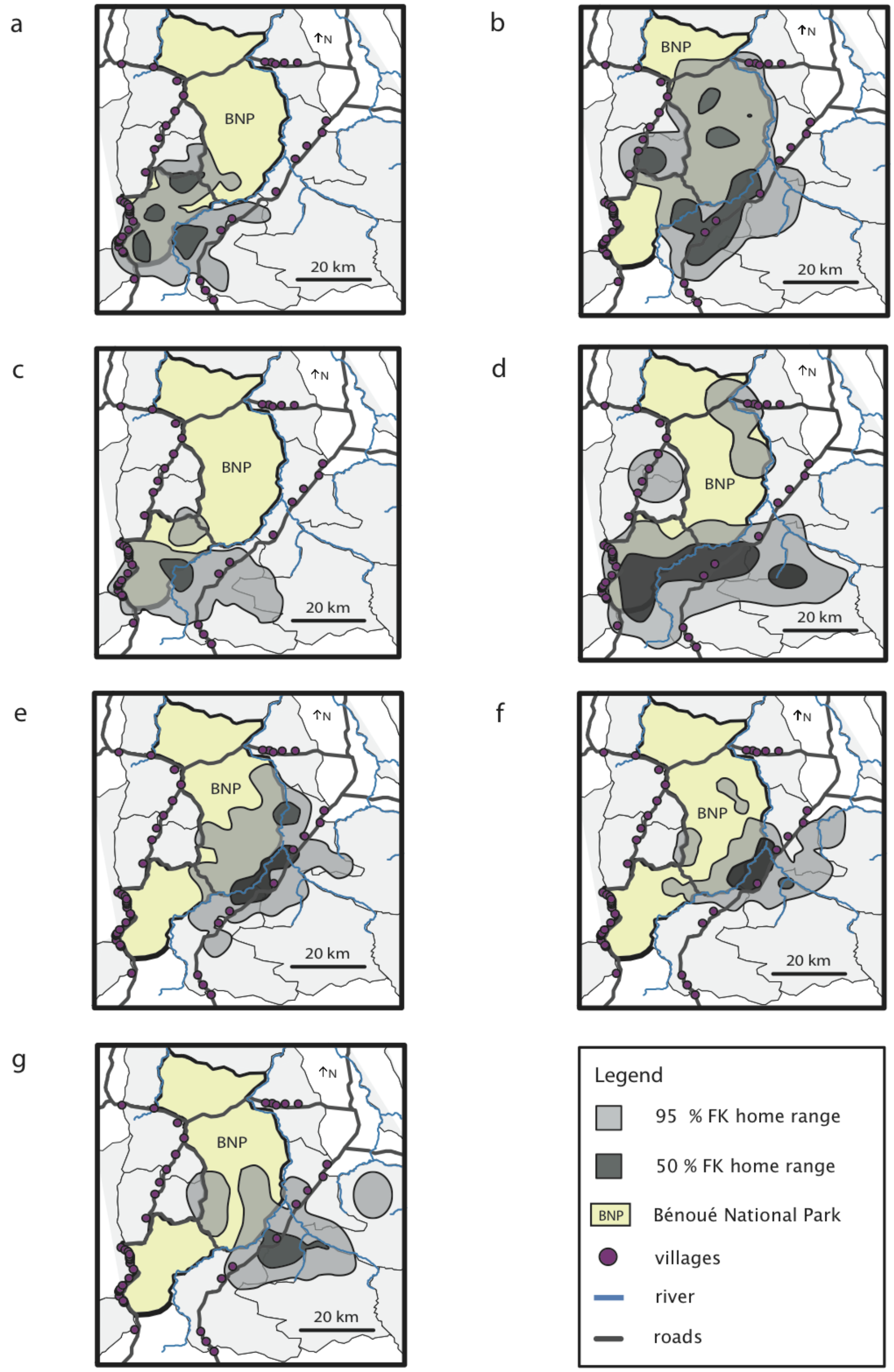

Figure 2.2: Seasonal and overall Fixed Kernel (FK) home ranges within the Bénoué Wildlife Conservation Area. a= 2007 wet season, b=2007 dry season, c= 2008 wet season, and d=2008 dry season, for Doudjatou. e= 2007 wet season, f= 2007 dry season, and g= 2008 wet season for Oldiri.

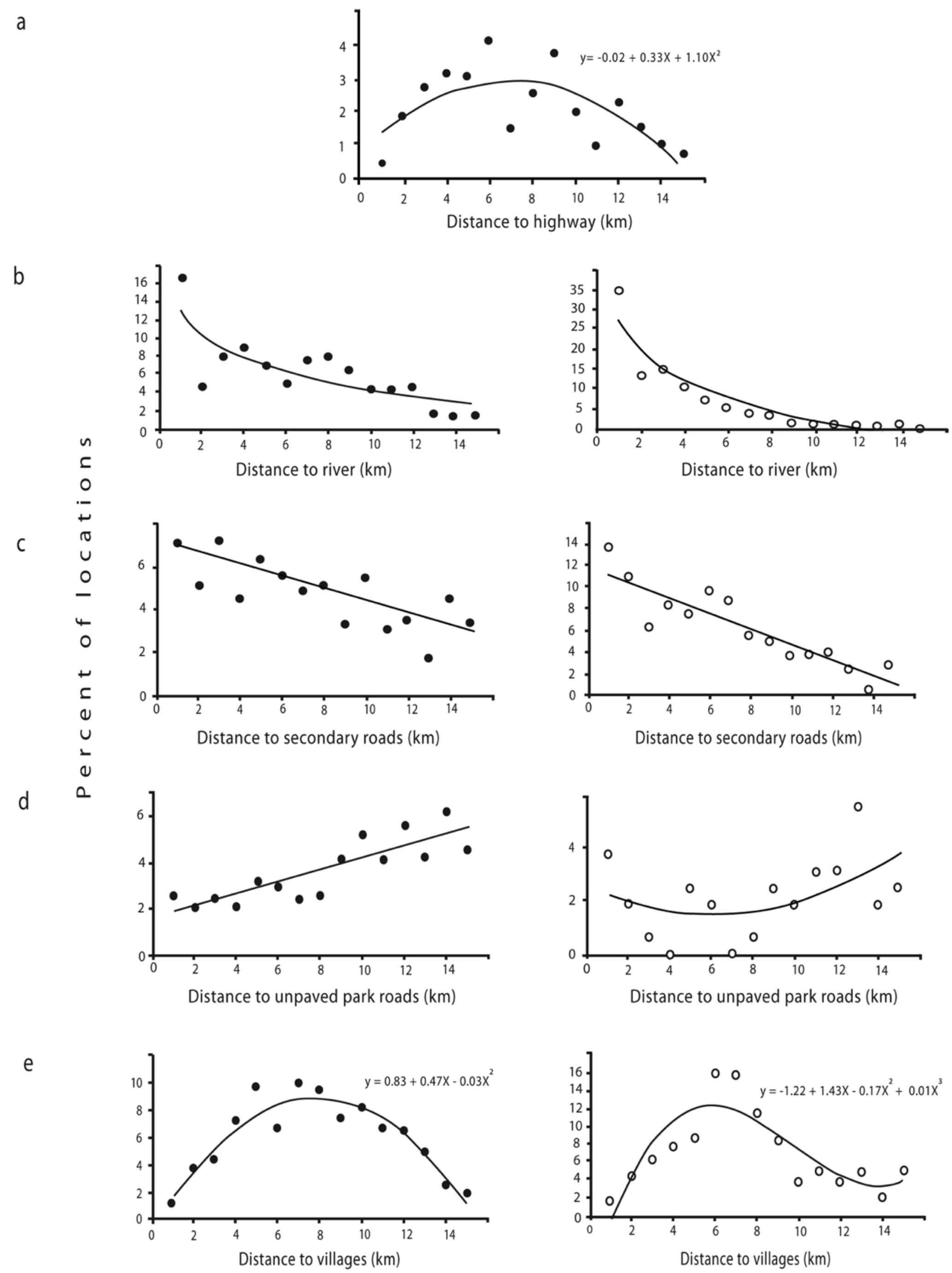

Figure 2.3: Percent of locations for each elephant (Doudjatou = closed circles; Oldiri= open circles) within 15 km of a) the highway, b) the Bénoué River, c) secondary roads, d) unpaved park roads, and e) villages, for overall locations, with the exception of Figure 2.3a and 2.3d, which depict Doudjatou and Oldiri's pooled dry season occurrence relative to the highway and unpaved park roads, respectively.

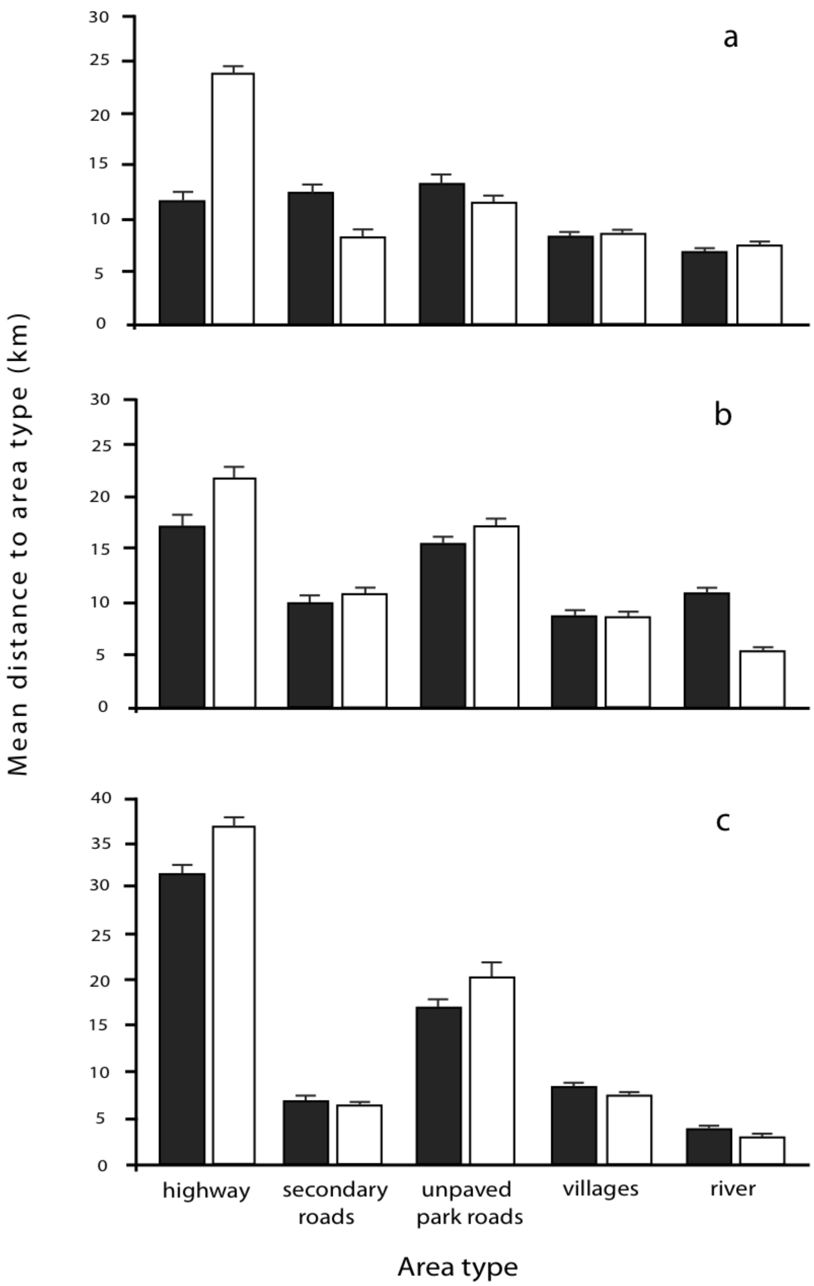

Figure 2.4: Mean seasonal distances (+1SE) to the highway, secondary roads, unpaved park roads, villages, and the Bénoué River for Doudjatou a) in 2007 and b) 2008, and for Oldiri c) in 2007. Location data was not available for the 2008 dry season for Oldiri. Black bars = wet season; white bars= dry season.

Table 2.1: Fixed Kernel (FK) and Minimum Convex Polygon (MCP) home range sizes, along with percent of locations and percent of core areas found inside Bénoué National Park for Doudjatou and Oldiri, within seasons and for all locations.

Year	2007		2008		Both years		All locations
Season	Wet	Dry	Wet	Dry	Wet	Dry	
Doudjatou							
95% FK	1132.08	2421.68	1093.77	2500.98	1433.47	3282.52	2808.38
50%	193.90	509.66	75.10	570.10	164.22	511.67	449.91
100% MCP	1081.47	1879.50	1020.20	2865.53	1260.00	2945.26	3171.57
Percent of locations	60.40	44.58	40.74	40.42	42.18	44.53	45.19
Percent of core area	60.57	33.37	45.56	38.82	28.83	37.00	41.25
N	101	166	136	218	237	384	655
Oldiri							
95% FK	1366.74	984.03	1239.61	-	1642.81	984.03	1193.58
50% FK	194.20	141.12	134.26	-	218.26	141.12	104.26
100% MCP	1239.82	1362.48	1074.06	-	1734.19	1362.48	2169.82
Percent of locations	46.08	36.25	22.73	-	39.04	36.25	35.71
Percent of core area	27.25	28.19	0.33	-	22.37	28.19	22.75
N	102	160	44	-	146	160	322

N= number of satellite-derived locations. Locations prior to the 2007 wet season and after the 2008 dry season were included in analyses for all locations. Thus, N for all locations is greater than the sum for all seasons.

Table 2.2: Relationship between the each elephants' number of locations and distance within 15 km of the highway, secondary roads, unpaved park roads, villages, and the Bénoué River, respectively, within seasons. Chi-square (χ^2) statistics are given with *P*-values in brackets. Letter subscripts with *P*-values indicate the shape of the relationship observed between the number of locations and distance to the area being tested: p=positive (occurrence increases with proximity); n= negative (occurrence decreases with distance from area); q= quadratic relationship; c= cubic relationship. Symbols with *P*-values indicate the distance (km) at which the trend is significant: *= significant at > 2 km; **= significant at > 4 km; †= significant at < 13 km; ♦= significant at < 14 km. All other tests where *P*<0.05, were significant at ≤ 15 km relative to the area of interest. Df=1 for each test.

Year	2007		2008		Both years		All locations
Season	Wet	Dry	Wet	Dry	Wet	Dry	
Doudjatou							
Highway	0.30	6.80	13.44	3.46	2.53	17.11	0.05
	(0.586)	(0.009^{q})	(<0.001^{p}*)	(0.063^{q})	(0.112)	(<0.001^{q})	(0.821)
Secondary	0.58	24.67	7.86	0.07	2.18	8.77	7.69
roads	(0.441)	(<0.001^{n})	(0.005^{n}**)	(0.791)	(0.140)	(0.003^{n})	(0.006^{n})
Unpaved park	12.72	4.97	30.38	7.13	11.49	9.34	10.78
roads	(<0.001^{q})	(0.026^{p}†)	(<0.001^{p})	(0.008^{p})	(<0.001^{p})	(0.002^{q})	(0.001^{p})
Villages	5.88	27.33	4.31	23.68	12.76	5.65	39.04
	(0.015^{p}♦)	(<0.001^{q})	(0.038^{p})	(<0.001^{q})	(<0.001^{q})	(0.018^{q})	(<0.001^{q})
River	6.25	12.89	21.39	20.05	15.13	30.17	42.24
	(0.012^{q})	(<0.001^{n})	(<0.001^{n})	(<0.001^{n})	(<0.001^{n})	(<0.001^{n})	(<0.001^{n})
Oldiri							
Secondary	19.61	19.81	1.89	-	8.49	19.81	17.59
roads	(<0.001^{n})	(<0.001^{n})	(0.170)	-	(0.004^{n})	(<0.001^{n})	(<0.001^{n})
Unpaved park	0.94	16.60	3.64	-	1.18	16.60	2.56
roads	(0.333)	(<0.001^{q})	(0.056^{q})	-	(0.277)	(<0.001^{q})	(0.110)
Villages	8.34	11.29	6.65	-	6.97	11.29	6.93
	(0.004^{q})	(<0.001^{q})	(0.001^{c})	-	(0.008^{q})	(<0.001^{q})	(0.009^{c})
River	65.62	126.65	11.92	-	42.33	126.05	75.64
	(<0.001^{n})	(<0.001^{n})	(<0.001^{n})	-	(<0.001^{n})	(<0.001^{n})	(<0.001^{n})

Table 2.3: Within season differences in the number of locations within 2 km and 1 km of different road types, for Doudjatou and Oldiri, respectively. Chi-square (χ^2) statistics are given with *P*-values in brackets. Wherever significant differences were found, areas near secondary roads where used more frequently. Df=1 for all.

	Season	Road type comparison		
		Highway vs secondary roads	Highway vs unpaved park roads	Secondary roads vs unpaved park roads
Doudjatou				
2km	Wet	0.60 (0.439)	0.02 (0.890)	0.40 (0.053)
	Dry	22.27 (<0.001)	0.54 (0.464)	12.96 (<0.001)
	Overall	13.86 (<0.001)	0.27 (0.602)	9.35 (0.022)
1km	Wet	0.05 (0.822)	0.81 (0.06)	0.21 (0.645)
	Dry	23.69 (<0.001)	2.15 (0.143)	9.48 (0.002)
	Overall	9.98 (0.002)	0.38 (0.540)	5.97 (0.015)
Oldiri				
2km	Wet	-	-	11.79 (<0.001)
	Dry	-	-	21.69 (<0.001)
	Overall	-	-	24.01 (<0.001)
1km	Wet	-	-	6.32 (0.012)
	Dry	-	-	55.55 (<0.001)
	Overall	-	-	15.14 (<0.001)

Table 2.4: Seasonal differences in distance to the highway, secondary roads, unpaved park roads, villages, and the Bénoué River for 2007 and 2008, respectively, for Doudjatou and Oldiri. Kruskal-Wallis statistics (*H*) are given with *P*-values in brackets. Subscripts next to *P*-values indicate in which season (wet or dry) elephants were significantly closer to each area tested. Df= 1 for each test.

	Highway	Secondary roads	Unpaved park roads	Villages	River
Doudjatou					
2007	74.26 ($<0.001^{w}$)	20.27 ($<0.001^{d}$)	3.60 (0.058^{d})	2.29 (0.130)	0.01 (0.904)
2008	3.44 (0.064^{w})	0.77 (0.381)	2.88 (0.090)	1.30 (0.255)	2.67 (0.102)
Oldiri					
2007	20.78 ($<0.001^{w}$)	0.61 (0.434)	4.17 (0.041^{w})	2.37 (0.124)	8.15 (0.004^{d})

GENERAL CONCLUSION

Increased human immigration and settlement can lead to protected area fragmentation and isolation (Curran et al. 2004) and has intensified HEC in the BWCA. Crop raiding by elephants was more severe in 2009 than in 1997 and was highest in the remote communities of Doudja and Mbaou, which were also the areas elephants spent most of their time in. In 2009, reports of elephant crop raiding increased in Gamba as well as in Na'ari since 1997. While damage did not affect attitudes towards elephants or the protected area, over half of respondents were negative towards the species, potentially leading to future opposition towards conservation efforts (Barua et al. 2010). In contrast, increased community involvement by NGOs since 1996 may have contributed to the more positive attitudes towards the HC over time. This was similar to other findings in Africa as well as Asia, where locals were positive towards protected areas in spite of conflict with wildlife (Bauer 2003; De Boer & Baquete 1998; Mehta & Heinen 2001), implying a mismatch in attitudes towards protected areas and wildlife (Waylen et al. 2009).

Similar to other findings (Douglas-Hamilton et al. 2005; Tchamba 1993), elephants in BNP spent most their time outside the park, putting themselves at greater risk of mortality by hunting and/or poaching, and stressing the importance of non-protected areas for elephant survival. Elephants generally avoid roads and villages (Barnes et al. 1991; Galanti et al. 2006; Graham et al. 2009; Parker & Graham 1989) and human disturbance altered the elephants' use of the protected area, with both spending little time near those areas. Elephants avoided the highway, while the proximity of secondary roads to perennial water may have contributed to them spending more time near that road type. This, along with high elephant occurrence outside the park suggests there may be a trade-off between the lower predation risks inside the park and/or farther from secondary roads, and access to water. Indeed, the Bénoué River largely influenced the elephants' use of the area, as occurrence increased with proximity to the river. Despite low occurrence near human activity centers, 95% FK home ranges showed overlap with these areas, highlighting the risk of HEC there.

Recommendations

HEC must be managed for the short as well as long-term if some level of coexistence between people and wildlife is to be achieved, and is necessary for the survival of the elephant population. Efforts to reduce HEC require the consideration of crop damage trends and local attitudes, in addition to elephant spatial distribution and occurrence in and around protected areas. Managing human disturbance and activity is central to managing HEC and given the findings of this study, we recommend:

1. Community involvement in the development of strategies to mitigate crop damage, including experimentation with farm-based deterrents that have shown promise elsewhere in Africa (e.g. Osborn 2002; Parker & Osborn 2006), especially in areas where damage was most severe.
2. Investigation into the effectiveness of advance payment programs in the BWCA to increase tolerance for elephants and alleviate some of the economic losses associated with crop damage.
3. No additional development or settlement in the BWCA, at least in HC 2 and 3, where HEC was most severe and elephants spent most of their time. In addition to this, we recommend that hunting, additional crop cultivation, and road construction be prohibited within at least 75 m of BNP boundaries.

4. Regulated and reduced access to secondary roads near the Bénoué River.
5. Collar and track additional elephants in BNP using GPS and/or satellite technology to obtain a more comprehensive picture of how other herds use the protected area.

REFERENCES

Ajzen, I., and M. Fishbein. 1980. Understanding attitudes and predicting social behavior. Prentice Hall, Englewood Cliffs, N.J.

Ancrenaz, M., C. Dabek, and S. O'Neil. 2007. The costs of exclusion: recognizing a role for local communities in biodiversity conservation. PLoS One **5:** 2443- 2448

Archie, E. A., C. J. Moss, and S. C. Alberts. 2006. The ties that bind: genetic relatedness predicts the fission and fusion of social groups in wild African elephants. Proceedings of the Royal Society B: Biological Sciences **273**:513-522.

Arjunan, M., C. Holmes, J. Puyravaud, and P. Davidar. 2006. Do developmental initiatives influence local attitudes toward conservation? A case study from the Kalakad-Mundanthurai Tiger Reserve, India. Journal of Environmental Management **79**:188-197.

Balmford, A., J. L. Moore, T. Brooks, N. Burgess, L. A. Hansen, P. Williams, and C. Rahbek. 2001. Conservation conflicts across Africa. Science **291**:2616-2619.

Bariregа, A., M. Buyinza, F. Kansiime, and G. Basuta-Isabirye. 2010. The effects of crop raiding on household food security in the Albertine Rift: a case study of Queen Elizabeth National Park, Western Uganda. Human Dimensions of Wildlife **15**:45-54.

Barnes, R., K. L. Barnes, M. P. T. Alers, and A. Blom. 1991. Man determines the distribution of elephants in the rain forests of northeastern Gabon. African Journal of Ecology **29**:54-63.

Barua, M., J. Tamuly, and R. A. Ahmed. 2010. Mutiny or clear sailing? Examining the role of the Asian elephant as a flagship species. Human Dimensions of Wildlife **15**:145-160.

Bauer, H. 2003. Local perceptions of Waza National Park, northern Cameroon. Environmental Conservation **30**:175-181.

Blake, S., S. L. Deem, S. Strindberg, F. Maisels, L. Momont, I. Isia, I. Douglas-Hamilton, W. B. Karesh, and M. D. Kock. 2008. Roadless wilderness area determines forest elephant movements in the Congo Basin. PLoS ONE **3**:1-9.

Blanc, J.J. 2008. *Loxodonta africana* (African Elephant). In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.1.< http://www.iucnredlist.org> Downloaded 22 November 2010.

Blanc, J. J., R. F. W. Barnes, G. C. Craig, H. T. Dublin, C. R. Thouless, I. Douglas-Hamilton, and J. A. Hart. 2007. African Elephant Status Report 2007: an update from the African Elephant Database. Occasional paper of the IUCN Species Survival Commission, No. 33. IUCN/ SSC African Elephant Specialist Group, Gland.

Blom, A., R. van Zalinge, I. M. A. Heitkonig, and H. H. T. Prins. 2005. Factors influencing the distribution of large mammals within a protected central African forest. Oryx **49**:381-388.

Bouché, P., I. Douglas-Hamilton, G. Wittemeyer, A.J. Nianogo, J.L. Doucet, P. Lejuene, and C. Vermeulen. 2011. Will elephants soon disappear from West African savannahs? PLoS ONE. **6 :** 1- 11.

Boum, R., and L. Bene Bene. 2008. Rapport de suivi des conflits populations- faune autour du Parc National de la Benoue. World Wildlife Fund, Garoua.

Bradshaw, G. A., A. N. Schore, J. L. Brown, J. H. Poole, and C. J. Moss. 2005. Elephant breakdown. Nature **433**:807-807.

Brody, A. J., and M. R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildlife Society Bulletin **17**:5-10.

Browne-Nuñez, C. and S.A. Jonker. 2008. Attitudes toward wildlife and conservation across Africa: a review of survey research. Human Dimensions of Wildlife **13*:*** 47-70.

Buij, R., W. J. McShea, P. Campbell, M. E. Lee, F. Dallmeier, S. Guimondou, L. Mackaga, and N. Guisseougou. 2007. Patch-occupancy models indicate human activity as major determinant of forest elephant *Loxodonta cyclotis* seasonal distribution in an industrial corridor in Gabon. Biological conservation **135**:189-201.

Bulte, E., and D. Rondeau. 2007. Compensation for wildlife damages: habitat conversion, species preservation and local welfare. Journal of Environmental Economics and Management **54**:311-322.

_____. 2005. Why compensating wildlife damages may be bad for conservation. Journal of Wildlife Management **69**:14-19.

Burke, T. 2005. The efect of human disturbance on elephant behaviour, movement dynamics and stress in a small reserve: Pilanesberg National Park. MSc. Thesis. University of KwaZulu-Natal, Durban.

Chiyo, P.I., E.P. Cochrane, L. Naughton, and G.I. Basuta. 2005. Temporal patterns of crop raiding by elephants: a response to changes in forage quality or crop availability? African Journal of Ecology **43**:48-55.

Curran, L.M., S.N. Trigg, A.K. McDonald, D. Astiani, Y. Hardiono, P. Siregar, I. Caniago, and E. Kasischke. 2004. Lowland forest loss in protected areas of Indonesian Borneo. Science **303**:1000.

De Boer, W. F., and D. S. Baquete. 1998. Natural resource use, crop damage and attitudes of rural people in the vicinity of the Maputo Elephant Reserve, Mozambique. Environmental Conservation **25**:208-218.

Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation **13**:458-466.

Dorrance, M. J., P. J. Savage, and D. E. Huff. 1975. Effects of snowmobiles on white-tailed deer. Journal of Wildlife Management **39**:563-569.

Douglas-Hamilton, I., T. Krink, and F. Vollrath. 2005. Movements and corridors of African elephants in relation to protected areas. Naturwissenschaften **92**:158-163.

Dyer, S. J., J. P. O'Neill, S. M. Wasel, and S. Boutin. 2002. Quantifying barrier effects of roads and seismic lines on movements of female woodland caribou in northeastern Alberta. Canadian Journal of Zoology **80**:839-845.

Elliot, W., R. Kube, and D. Montanye. 2008. Common ground: solutions for reducing the human, economic and conservation costs of human wildlife conflict. World Wildlife Fund, Gland.

Endamana, D., T. N. Francis, A. Gomse, and B. Boniface. 2006. Etude de base sur les conflits populations- faune autour du Parc National de la Benoue. World Wildlife Fund, Garoua.

Endamana, D., J. Sayer, G. Etoga, and L. Bene Bene. 2007. Conservation and development: The influence of accessibility, participatory management and immigration around the Bénoué National Park in Cameroon. Nature and Faune **22**:10- 20.

Foguekem, D., M. N. Tchamba, M. Macallister, P. Ngassam, and M. Loomis. 2007. Application of ArcView animal movement analysis extension as a tool for monitoring elephant movement: preliminary results from northern Cameroon. Pachyderm **43**:29-35.

Forman, R. T., and L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics **29**.

Freddy, D. J., W. M. Bronaugh, and M. C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin **14**:63-68.

Frid, A., and L. M. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology **6**:11.

Fryxell, J., and A. Sinclair. 1988. Causes and consequences of migration by large herbivores. Trends in Ecology and Evolution **3**:237-241.

Gagnon, J. W., T. C. Theimer, S. Boe, N. L. Dodd, and R. E. Schweinsburg. 2007. Traffic volume alters elk distribution and highway crossings in Arizona. Journal of Wildlife Management **71**:2318-2323.

Galanti, V., D. Preatoni, A. Martinoli, L. A. Wauters, and G. Tosi. 2006. Space and habitat use of the African elephant in the Tarangire–Manyara ecosystem, Tanzania: Implications for conservation. Mammalian Biology **71**:99-114.

Galanti, V., G. Tosi, R. Rossi, and C. Foley. 2000. The use of GPS radio-collars to track elephants (*Loxodonta africana*) in the Tarangire National Park (Tanzania). Hystrix **2**:27-37.

Graham, M. D., I. Douglas-Hamilton, W. M. Adams, and P. C. Lee. 2009. The movement of African elephants in a human-dominated land-use mosaic. Animal Conservation **12**:445-455.

Harris, G.M., G.J. Russell, R.I. van Aarde, and S.L. Pimm. 2008. Rules of habitat use by elephants *Loxodonta africana* in southern Africa: insights for regional management. Oryx **42:** 66- 75.

Hema, E.M., R.F.W. Barnes, and W. Guenda. 2011. Distribution of savannah elephants (*Loxodonta africana* Blumenback 1797) within Nazinga game ranch, Southern Burkina Faso. African Journal of Ecology **49**: 141- 149.

Hill, C.M. 1997. Crop-raiding by wild vertebrates: the farmer's perspective in an agricultural community in western Uganda. International Journal of Pest Management **43**:77-84.

Hoare, R.E. 2000. African elephants and humans in conflict: the outlook for co-existence. Oryx **34**:34-38.

Hoare, R. E., and J. T. Du Toit. 1999. Coexistence between people and elephants in African savannas. Conservation Biology **13**:633- 639.

Holmern, T., J. Nyahongo, and E. Røskaft. 2007. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. Biological Conservation **135**:518-526.

Hooge, P. N., and B. Eichenlaub. 2000. Animal movement extension to Arcview. Alaska Science Center - Biological Science Office, U.S. Geological Survey, Anchorage.

Jackson, T. P., S. Mosojane, S. M. Ferriera, and R. J. van Aarde. 2008. Solutions for elephant *Loxodonta africana* crop raiding in northern Botswana: moving away from symptomatic approaches. Oryx **42**:83-91.

Jaeger, J. A. G., J. Bowman, J. Brennan, L. Fahrig, D. Bert, J. Bouchard, N. Charbonneau, K. Frank, B. Gruber, and K. T. von Toschanowitz. 2005. Predicting when animal populations are at risk from roads: an interactive model of road avoidance behavior. Ecological Modelling **185**:329-348.

Kaswamila, A., S. Russell, and M. McGibbon. 2007. Impacts of wildlife on household food security and income in northeastern Tanzania. Human Dimensions of Wildlife **12**:391-404.

Kerley, L. L., J. M. Goodrich, D. G. Miquelle, E. N. Smirnov, H. B. Quigley, and M. G. Hornocker. 2002. Effects of roads and human disturbance on Amur tigers. Conservation Biology **16**:97-108.

Kilgo, J. C., R. F. Labisky, and D. E. Fritzen. 1998. Influences of hunting on the behavior of white tailed deer: implications for conservation of the Florida panther. Conservation Biology **12**:1359-1364.

Kolowski, J. M., S. Blake, M. D. Kock, M. E. Lee, A. Henderson, A. Honorez, and A. Alonso. 2010. Movements of four forest elephants in an oil concession in Gabon, Central Africa. African Journal of Ecology **48:** 1134- 1138.

Kumar, M. A., and M. Singh. 2011. Behavior of Asian elephant (*Elephas maximus*) in a land-use mosaic: conservation implications for human-elephant coexistence in the Anamalai hills, India. Wildlife Biology in Practice **6**:69- 80.

Kuriyan, R. 2002. Linking local perceptions of elephants and conservation: Samburu pastoralists in northern Kenya. Society and Natural Resources **15**:949- 957.

Lamarque, F., J. Anderson, R. Fergusson, M. Lagrange, Y. Osei-Owusu, and L. Bakker. 2009. Human-wildlife conflict in Africa. Food and Agricultural Organization of the United Nations (FAO), Rome.

Laurance, W. F., B. M. Croes, L. Tchignoumba, S. A. Lahm, A. Alonso, M. E. Lee, P. Campbell, and C. Ondzeano. 2006. Impacts of roads and hunting on central African rainforest mammals. Conservation Biology **20**:1251-1261.

Lee, P. C., and M. Graham. 2006. African elephants *Loxodonta africana* and human elephant interactions: implications for conservation. International Zoo Yearbook **40**:9-19.

Lewis, D., B. K. Gilson, and A. Mwenya. 1990. Wildlife conservation outside protected areas-lessons from an experiment in Zambia. Conservation Biology **4**:171-180.

Lewison, R. L., and J. Carter. 2004. Exploring behavior of an unusual megaherbivore: a spatially explicit foraging model of the hippopotamus. Ecological Modelling **171**:127-138.

Linkie, M., Y. Dinata, A. Nofrianto, and N. Leader-Williams. 2007. Patterns and perceptions of wildlife crop raiding in and around Kerinci Seblat National Park, Sumatra. Animal Conservation **10**:127-135.

Liu, J., M. Linderman, Z. Ouyang, L. An, J. Yang, and H. Zhang. 2001. Ecological degradation in protected areas: the case of Wolong Nature Reserve for giant pandas. Science **292**:98-101.

Liu, J., Z. Ouyang, W. W. Taylor, R. Groop, Y. Tan, and H. Zhang. 1999. A framework for evaluating the effects of human factors on wildlife habitat: the case of giant pandas. Conservation Biology **13**:1360-1370.

Lybbert, T.J., A. Aboudrare, D. Chaloud, N. Magnan, and M. Nash. 2011. Booming markets for Moroccan argan oil appear to beneft some rural households while threatening the endemic argan forest. PNAS **108:** 13963- 13968.

Madhusudan, M. D. 2003. Living amidst large wildlife: livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, South India. Environmental Management **31**: 466-0475.

Martin, E. 2010. Effective law enforcement in Ghana reduces elephant poaching and illegal ivory trade. Pachyderm **48**: 24-32.

Mehta, J. N., and J. T. Heinen. 2001. Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. Environmental Management **28**:165- 177.

Meissner, H., E. Spreeth, P. Villiers, E. Pietersen, T. Hugo, and B. Terblanche. 1990. Quality of food and voluntary intake by elephant as measured by lignin index. South African Journal of Wildlife Research **20**:104-110.

Moss, C. J. 1988. Elephant memories: thirteen years in the life of an elephant family. William Morrow, New York.

Naughton-Treves, L. 1998. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. Conservation Biology **12**:156-168.

Naughton-Treves, L., M. B. Holland, and K. Brandon. 2005. The role of protected areas in conserving biodiversity and sustaining local livelihoods. Annual Review of Environment and Resources **30**:219-252.

Naughton, L., R. Rose, and A. Treves. 1999. The social dimensions of human-elephant conflict in Africa: a literature review and case studies from Uganda and Cameroon. *Human-Elephant Conflict Task Force.* Gland, Switzerland: IUCN African Elephant Speclialist Group.

Newmark, W. D. 2008. Isolation of African protected areas. Frontiers in Ecology and the Environment **6**:321- 328.

Newmark, W. D., J. I. Boshe, H. I. Sariko, and G. K. Makumbule. 1996. Effects of a highway on large mammals in Mukumi National Park, Tanzania. African Journal of Ecology **34**:15- 31.

Newmark, W. D., D. N. Manyanza, D.-G. M. Gamassa, and H. I. Sariko. 1994. The conflict between wildlife and local people living adjacent to protected areas in Tanzania: human density as a predictor. Conservation Biology **8**:249-255.

Ntumi, C. O., R. J. van Aarde, N. Fairall , and W. F. De Boer. 2005. Use of space and habitat by elephants (*Loxodonta africana*) in the Maputo Elephant Reserve, Mozambique. South African Journal of Wildlife Research **35**:139- 146.

Nyhus, P. J., S. A. Osofsky, P. Ferraro, F. Madden, and H. Fischer. 2005. Bearing the costs of human-wildlife conflict: the challenges of compensation schemes. In: R. Woodroffe, S. Thirgood, and A. Rabinowitz (eds). People and wildlife: conflict or coexistence? Cambridge University Press, Cambridge.

O'Connell-Rodwell, C. E., T. Rodwell, M. Rice, and L. A. Hart. 2000. Living with the modern conservation paradigm: can agricultural communities co-exist with elephants? A five-year case study in East Caprivi, Namibia. Biological Conservation **93**:381-391.

Okello, M. M. 2005. Land use changes and human-wildlife conflicts in the Amboseli Area, Kenya. Human Dimensions of Wildlife **10**:19-28.

Olivier, R. 1978. On the ecology of the Asian elephant. Ph. D. Thesis. University of Cambridge, Unpublished, Cambridge.

Olsson, O., J. S. Brown, and K. L. Helf. 2008. A guide to central place effects in foraging. Theoretical population biology **74**:22-33.

Osborn, F. V. 2002. Capsicum oleoresin as an elephant repellent: field trials in the communal lands of Zimbabwe. Journal of Wildlife Management **66**:674- 677.

Osborn, F. V. 2004. Seasonal variation of feeding patterns and food selection by crop raiding elephants in Zimbabwe. African Journal of Ecology **42**:322-327.

Parker, I. S. C., and A. D. Graham. 1989. Men, elephants and competition. Symposia of the Zoological Society of London **61**:241- 252.

Parker, G. E. and F. V. Osborn. 2001. Dual season crop damage by elephants in the Eastern Zambezi Valley, Zimbabwe. Pachyderm **30**:49- 56.

Parker, G.E. and F.V. Osborn. 2006. Investigating the potential for chilli *Capsicum* spp. To reduce human-wildlife conflict in Zimbabwe. Oryx **40:** 343- 346.

Parker, G. E., F. V. Osborn, R. E. Hoare, and L. S. Niskanen. 2007. Human-elephant conflict mitigation: a training course for community-based approaches in Africa. Participant manual. Elephant Pepper Development Trust and IUCN Species Survival Commission, African Elephant Specialist Group, Human-Elephant Conflict Task Force, Livingstone, and Nairobi.

Powell, R. A. 2000. Animal home ranges and territories and home range estimators In: L. Boitani, and T. K. Fuller (eds). Research techniques in animal ecology. Columbia University Press, New York.

Power, R. J., and S. Compion. 2009. Lion predation on elephants in the Savuti, Chobe National Park, Botswana. African Zoology **44**:36-44.

Preisser, E. L., D. I. Bolnick, and M. F. Benard. 2005. Scared to death? The effects of intimidation and consumption in predator-prey interactions. Ecology **86**:501-509.

Redfern, J. V., R. Grant, H. Biggs, and W. M. Getz. 2003. Surface-water constraints on herbivore foraging in the Kruger National Park, South Africa. Ecology **84**:2092-2107.

Ripple, W. J., and R. L. Beschta. 2004. Wolves and the ecology of fear: can predation risk structure ecosystems? Bioscience **54**:755- 766.

Rodgers, J. A., and H. T. Smith. 1995. Set-back distances to protect nesting bird colonies from human disturbance in Florida. Conservation Biology **9**:89-99.

Rost, G. R., and J. A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management **43**:634-641.

Ruggiero, R. 1990. The effects of poaching disturbance on elephant behaviour. Pachyderm **13**:42-44.

Sam, M. K., E. Danquah, S. K. Oppong, and E. A. Ashie. 2005. Nature and extent of human-elephant conflict in Bia Conservation Area, Ghana. Pachyderm **38**:49- 58.

Samuel, M., D. Pierce, and E. Garton. 1985. Identifying areas of concentrated use within the home range. Journal of Animal Ecology **54**:711-719.

Schoener, T. W. 1979. Generality of the size-distance relation in models of optimal feeding. American Naturalist **114**:902-914.

Schultz, R. D., and J. A. Bailey. 1978. Responses of national park elk to human activity. Journal of Wildlife Management **42**:91-100.

Schwerdtner, K., and B. Gruber. 2007. A conceptual framework for damage compensation schemes. Biological Conservation **134**:354-360.

Sheppard, D. J., A. Moehrenschlager, J. M. McPherson, and J. J. Mason. 2010. Ten years of adaptive community-governed conservation: evaluating biodiversity protection and poverty alleviation in a West African hippopotamus reserve. Environmental Conservation **37**:270-282.

Sitati, N. W., and M. J. Walpole. 2006. Assessing farm-based measures for mitigating human-elephant conflict in Transmara District, Kenya. Oryx **40**:279-286.

Sitati, N. W., M. J. Walpole, and N. Leader-Williams. 2005. Factors affecting susceptibility of farms to crop raiding by African elephants: using a predictive model to mitigate conflict. Journal of Applied Ecology **42**:1175-1182.

Sitati, N. W., M. J. Walpole, R. J. Smith, and N. Leader-Williams. 2003. Predicting spatial aspects of human-elephant conflict. Journal of Applied Ecology **40**:667-677.

Smit, I., C. Grant, and I. Whyte. 2007. Landscape scale sexual segregation in the dry season distribution and resource utilization of elephants in Kruger National Park, South Africa. Diversity and Distributions **13**:225-236.

Smith, R., and S. Kasiki. 1999. A spatial analysis of human-elephant conflict in the Tsavo ecosystem. IUCN African Elephant Specialist Group Report, Gland.

Stark, M. A., and R. J. Hudson. 1985. Plant communities' structure in Bénoué National Park, Cameroon: a cluster association analysis. African Journal of Ecology **23**:21-27.

Stokke, S., and J. T. Du Toit. 2002. Sexual segregation in habitat use by elephants in Chobe National Park, Botswana. African Journal of Ecology **40**:360-371.

Sukumar, R. 1989. The Asian elephant: ecology and management. Cambridge University Press, Cambridge.

Swenson, J., and H. Andrén. 2005. A tale of two countries: large carnivore depredations and compensation schemes in Sweden and Norway. In: R. Woodroffe, S. Thirgood, and A. Rabinowitz (eds). People and wildlife: conflict or coexistence? Cambridge University Press, Cambridge.

Tchamba, M. N. 1993. Number and migration patterns of savanna elephants (*Loxodonta africana africana*) in Northern Cameroon. Pachyderm **16**:66-71.

Tchamba, M. N. 1996. History and present status of the human/elephant conflict in the Waza-Logone region, Cameroon, West Africa. Biological Conservation **75**:35-41.

Theobald, D. M., J. R. Miller, and N. T. Hobbs. 1997. Estimating the cumulative effects of development on wildlife habitat. Landscape and Urban Planning **39**:25-36.

Thomas, B., J. D. Holland, and E. O. Minot. 2008. Elephant (*Loxodonta africana*) home ranges in Sabi Sand Reserve and Kruger National Park: a five year satellite tracking study. PLoS ONE **3**:1-8.

Thouless, C. R. 1994. Conflict between humans and elephants on private land in northern Kenya. Oryx **28**:119-127.

Thouless, C. R. 1995. Long distance movements of elephants in northern Kenya. African Journal of Ecology **33**:321-334.

Trombulak, S. C., and C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology **14**:18-30.

Van Bommel, L., M. D. Bij De Vaate, W. F. De Boer, and H. H. De Iongh. 2007. Factors affecting livestock predation by lions in Cameroon. African Journal of Ecology **45**:490-498.

Verlinden, A., and I. Gavor. 1998. Satellite tracking of elephants in northern Botswana. African Journal of Ecology **36**:105-116.

Waylen, K. A., P. J. K. McGowan, and E. J. Milner-Gulland. 2009. Ecotourism positively affects awareness and attitudes but not conservation behaviours: a case study at Grande Riviere, Trinidad. Oryx **43**:343-351.

Weladji, R. B. 1998. Interactions Between People and Protected Areas: The case of the Bénoué Wildlife Conservation Area, North Cameroon. MSc. Thesis. Management of Natural Resources and Sustainable Agriculture. Agricultural University of Norway, Ås.

Weladji, R. B., S. R. Moe, and P. Vedeld. 2003. Stakeholder attitudes towards wildlife policy and the Bénoué Wildlife Conservation Area, North Cameroon. Environmental Conservation **30**:334-343.

Weladji, R. B., and M. N. Tchamba. 2003. Conflict between people and protected areas within the Bénoué Wildlife Conservation Area, North Cameroon. Oryx **37**:72-79.

Wittemyer, G., I. Douglas-Hamilton, and W. M. Getz. 2005. The socioecology of elephants analysis of the processes creating multitiered social structures. Animal Behaviour **69**:1357-1371.

World Wildlife Fund (WWF). 2007. Species fact sheet: African Elephant, Gland.

Young, K. D., S. M. Ferriera, and R. J. van Aarde. 2009. Elephant spatial use in wet and dry savannas of southern Africa. Journal of Zoology **278**:189-205.

Zimmermann, A., M. J. Walpole, and N. Leader-Williams. 2005. Cattle ranchers' attitudes to conflicts with jaguar *Panthera onca* in the Pantanal of Brazil. Oryx **39**:406-412.

Appendix – Household questionnaire

Human-elephant conflict in the Bénoué Wildlife Conservation Area, Cameroon

Granados, A. & R.B. Weladji

Household Questionnaire

Village______________________ Date___________ Name of respondent____________________________
Distance from house to field___________ Distance from field to hunting concession/park border__________
How long have you lived here? _________ Where did you live before?________________________________
Nationality _________________________

1. Respondent characteristics

Sex M/F	Age	Education level	
		01 primary school 03 secondary school	02 lower secondary 04 university

2. Agricultural production and income
List crop types by area cultivated and income/sale from each for last year (2009).

	Area (ha)	Crop types	Total Output (tons, bags, etc)	Area not cultivated (if any)	Inputs used (CFCA)	Sale (CFCA)
1						
2						
3						
4						

3 What do you consider to be the two most important problems limiting agricultural production? Please rank them.

01	02

4. Rank your activities in relation to the use of natural resources (1 to 6)

		Purpose (Y/N)	
Activities	Rank (1-6)	Subsistence?	Commercial?
01 Agriculture			
02 Livestock			
03 Forest use			
04 Fishing			
05 Hunting			
06 Others (specify)			

5. Attitudes towards Bénoué National Park

5.1 How do you perceive the park?

01 good	02 bad	03 neutral

5.2 What benefits do local people get from the PA? If more than 1, please rank.

	rank
01. Employment	
02. Recreation	
03. Tourism income	
04. Rural development	
05. Meat from culling/hunting	
06. Others, specify	
07. none	

5.3 If bad, why?

01 no local involvement	02 no benefit	03 takes all resources	04 no access	05 other, specify

6. Attitudes towards hunting concessions (HC)

6.1 How do you perceive the hunting concession?

01 good	02 bad	03 neutral

6.2 What benefits do local people get from the hunting concession? If more than 1, please rank.

	rank
01. Employment	
02. Tourism income	
04. Rural development	
05. Meat from culling/hunting	
06. Others, specify	
07. none	

6.3 If bad, why?

01 no local involvement in decision making	02 no benefit	03 other, specify

Conflicts and damages

7.1 Do you have any of the following problems because of wildlife?

	Y/N	
01 Crop damage		If yes→ 7.2
02 Predation		
03 Disease transmission (which species)		
04 Harassment (which species)		
05 Others (specify)		

7.2 What proportion of your field was damaged?

01 none
02 <25%
03 25-50%
04 >50%

7.3 What animals are the responsible for the most damage? Please rank them.

		Stage of growth		
Species	Type of crop damaged	Young	Intermediate	Mature
01				
02				
03				
04				
05				

7.4.1 Do you get any help to solve these problems? Y____ N____

7.4.2 If yes, from where do you get help?____

7.4.3 If you do receive help from the government, in which form?

01 compensation	02 culling by authorities	03 others (specify)

8. What is the tendency of the crop damage in BWCA?

01 increasing	02 decreasing	03 stable

9.1 Within the last 10 years, do you see the elephant population in the area as …

01 increasing?	02 decreasing?	03 stable?	04 unsure

9.2 Are there any benefits from having elephants in the area? Y___ N___ unsure____

9.3 If yes, please specify____

10. What are the methods you use to deter wildlife from causing crop damage?

01 ____

02 ____

03 ____

11.1 Are you aware of the use of chilli to deter elephants from raiding crops? Y___ N___ N/A___

11.2 In Zambia, Kenya, Zimbabwe, and Namibia farmers have started to plant chilies to deter elephants from raiding crops. The chili is mixed with elephant dung, sun dried, and then burned. This deters elephants as they do not like the smell or taste. Would you be willing to plant different or additional crops that may deter wildlife from crop raiding?

01 Yes	02 No	03 N/A

11.3 Would you be willing to have your farm serve as an experimental farm to test the efficiency of chilies in deterring elephants from raiding crops here in the BWCA?

01 Yes	02 No	03 N/A