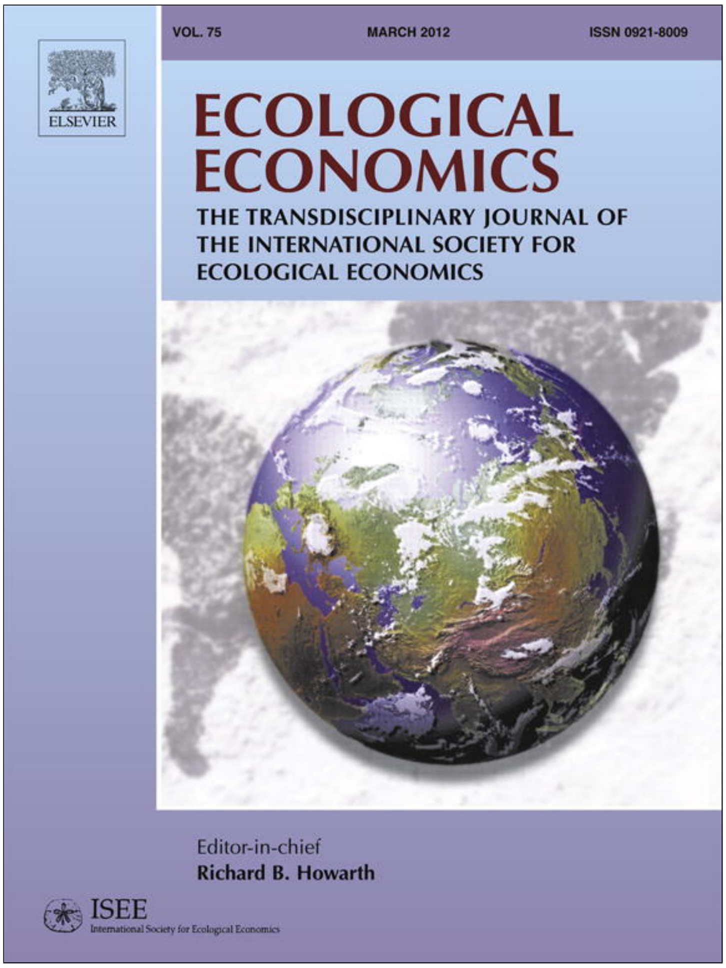
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Analysis

Elephants in the garden: Financial and social costs of crop raiding

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ABSTRACT

Residents near protected areas disproportionately bear conservation costs, in part due to crop raiding by protected animals when protected areas are situated within an agricultural landscape. These costs increase as conservation efforts lead to recovery of animal populations, and human population growth increases the proportion of land outside the parks used for agriculture. Financial and social costs associated with crop raiding were studied in 25 villages around Kibale National Park, Uganda. Perceptions about crop raiding were collected using focus groups and household surveys, while damage was evaluated based on physical monitoring of crop raiding incidents. The average financial loss for farmers around the park over six months was US$74 (1.5% of median household capital asset wealth) and damage was particularly high within 0.5 km of the park boundary. Households experiencing crop raiding were more prone to food insecurity, and higher rates of self-reported human and livestock diseases, while children from villages bordering the park tended to have poorer scholastic achievement. Compensation is not affordable for the wildlife authority, nor is it sustainable as crop raiding is escalating. To mitigate costs for local communities, funding has been justified for the implementation of crop raiding defenses.

1. Introduction

When people live next to protected areas (PAs) there will be conflict between people and wildlife. People argue wild animals trespass on their lands (Laudati, 2010; Sifuna, 2005), while conservationists highlight that ever-growing human population encroaches upon wild animal habitat (Sitati et al., 2005; Thouless and Sakwa, 1995). Close to PAs surrounded by rural agriculture, crop damage by park-protected animals is a significant risk for farmers. Oerke et al. (1994) estimated that farmers in Africa typically loose 16.7% of their crop production to animal pests, including insects, birds, and small mammals, a loss comparable to disease (15.6%), and weeds (16.6%). However, farmers near PAs also loose crops to larger, more destructive mammals. Studies in Tanzania and Uganda found 86–88% of farmers living adjacent to PAs reported raiding by park-protected animals (Naughton-Treves, 1997; Newmark et al., 1994; Weber et al., 2007). As a result, communities can retaliate, killing animals or aiding poachers (Nyhus et al., 2005; Sifuna, 2005). Human-wildlife conflict creates barriers to cooperation between communities and conservation authorities (Tweheyo et al., 2005), while deteriorating support for conservation (Naughton-Treves, 1998; Tchamba, 1996).

Near PAs the traditional defense of killing raiding animals is restricted by conservation policy (Laudati, 2010; Naughton-Treves, 1997; Weber et al., 2007). Farmers in Africa are typically not compensated for losses caused by protected animals (Naughton-Treves, 1997), however, some countries, do have partial compensations programs (Jackson et al., 2008). Although smaller losses may be tolerated, loss of an entire season's crop in one night can be devastating (Naughton-Treves, 1998). This economic injustice at the boundary of PAs has lead to calls for compensation programs (Laudati, 2010; Naughton-Treves, 1998; Tchamba, 1996); but most conservation authorities lack the revenues to finance such programs without external support (Tchamba, 1996). Others believe compensation simply will not work (Bulte and Rondeau, 2005; Warren et al., 2007), recommending funds be directed toward crop raiding defenses to mitigate losses (Sitati and Walpole, 2006; Thouless and Sakwa, 1995; Warren et al., 2007).

Farmers do try to protect their crops. Human guarding, chili rope, trenches, and dogs are effective against crop raiders (Newmark et al., 1994; Sitati and Walpole, 2006; Sitati et al., 2005), while non-electrified fences and live traps are generally ineffective (Sitati et al., 2005; Weber et al., 2007). Passive solutions like fences and trenches need to be maintained to remain effective, as raiding animals learn to destroy or move around them (Osborn and Parker, 2003; Thouless and Sakwa, 1995). Guarding is labor intensive, often restricting the household from participating in income-generating activities (Hill, 2000; Naughton-Treves, 1998; Osborn and Parker, 2003), or keeping children from school to guard crops (Haule et al., 2002; Kagoro-Rugunda, 2004). Therefore crop raiding has negative implications for development, resulting in poor childhood education

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(Haule et al., 2002), food insecurity (Hill, 1997), and physical injury from raiding animals (Sifuna, 2005).

This research describes and values protected animal crop raiding losses incurred by farmers around Kibale National Park in Uganda. These costs are used to justify additional investment in crop raiding defenses. We also assessed the perceived social costs of crop raiding, as reported in focus groups, by testing perceived costs against household survey and scholastic achievement data to determine whether perceived social costs were generally realized around the park.

2. Methods

2.1. Study Site

Kibale National Park (KNP), located in southwest Uganda (Fig. 1), is a 795 km^2 mixed forest and savanna PA providing habitat for 13 primate species (Chapman and Lambert, 2000), of which baboon (*Papio cynocephalus*), redtail monkey (*Cercopithecus ascanius*), vervet monkey (*Cercopithecus aethiops*), colobus (*Colobus guereza*), L'hoesti monkey (*Cercopithecus lhoesti*), and chimpanzees (*Pan troglodytes*) have been documented to raid neighboring crops (Naughton-Treves, 1998). Other identified crop raiding species in KNP (Chiyo et al., 2005; Naughton-Treves, 1998) include elephant (*Loxodonta africana*), bushpig (*Potamochoerus procus*), civet (*Civettictis civetta*), porcupine (*Hystrix africae-australis*), duiker (*Cephalophus* spp.) and bushbuck (*Tragelaphus scriptus*).

In 1992, Naughton-Treves (1998) found redtail monkey and baboon were the most frequent raiding species around KNP, with primates in general responsible for 71% of crop raiding events and 48% of crop damage. In 1999 a follow-up study found redtail monkeys and baboons remained the most frequent raiders, but baboons had usurped the red-tail monkey as the species that damaged the greatest number of farms (Naughton-Treves and Treves, 2005). Proximity to the forest was the strongest predictor of damage (Naughton-Treves and Treves, 2005), with 90% of damage located within 160 m (1992–94) and 200 m (1999) of the park respectively. Farmers lost on average 4–7% of their crops to wild animals in 1992–94 and 6–9.4% in 1999 (Naughton-Treves and Treves, 2005).

Neighbors provide compensation if livestock damage crops; however, the Ugandan government does not compensate for wild animal raiding (Naughton-Treves, 1997), although the Uganda Wildlife Statute (1996) does provide for 20% of park entrance fees to be shared with local communities for development projects (Archibald and Naughton-Treves, 2001). Most communities want this money for crop raiding defenses (MacKenzie, in press). Some communities have used this money to construct elephant trenches (3 m deep by 2–3 m wide), along portions of the boundary (Fig. 1). Additional trenches have been funded by the Uganda Wildlife Authority (UWA), Face the Future Foundation, and the International Union for Conservation of Nature (IUCN). IUCN also funded Mauritius thorn planting (*Caesalpinia decapetala*) to deter animals from exiting the park (Chhetri et al., 2004).

2.2. Data Collection

A combination of interview-based surveys and physical verification of damage by trained field assistants was used to collect crop raiding data, as recommended by prior studies (Hill, 1997; Kagoro-Rugunda, 2004; Naughton-Treves, 1998; Sitati and Walpole, 2006; Tchamba, 1996). Focus groups provided data about the perceived problems caused by crop raiding. Since livestock can account for up to 36% of raiding losses (Naughton-Treves, 1998; Warren et al., 2007; Weber et al., 2007), livestock damage was recorded and then removed from all data in this study.

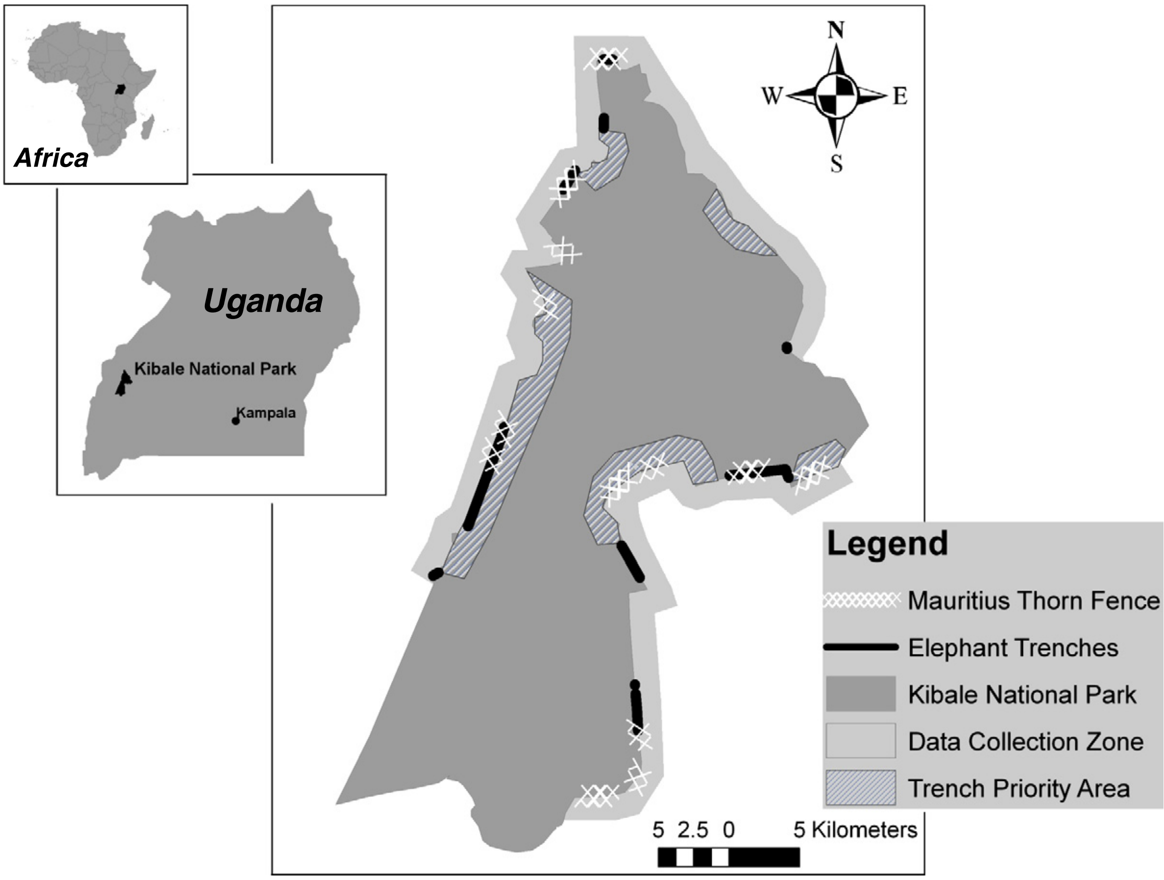

Fig. 1. Kibale National Park Uganda and passive crop raiding defenses.

Local people live in villages of about 100 households, led by a village chairperson. A village is defined by the spatial extent of households associated with a village name under the leadership of one village chairperson. Twenty-five study villages were chosen, located approximately 5 km apart in the data collection zone (Fig. 1), based on village members cultivating land adjacent to the park. These same villages participated in a study of illegal resource extraction from KNP (MacKenzie et al., in press). Therefore, village locations are not identified, as this could led to retribution by the wildlife authority (Robbins et al., 2006).

2.2.1. Household survey

All village households were Global Positioning System (GPS) located while noting the construction standard of primary dwellings. The number of households per village ranged from 41 to 242, with households located between 15 and 3300 m from the park boundary. Within each village 24 households were surveyed, representing 24% of all village households. Households were chosen by random stratified sampling, with stratification based on house construction standard, a proxy for wealth (Ellis and Bahiigwa, 2003). The survey was administered in July and August 2009 by four Ugandan assistants, in two local languages (Rutoro and Rukiga).

Respondents were asked whether they experienced crop raiding, how troubled they perceived their household to be by this raiding, and to estimate the fraction of five staple crops (maize (*Zea mays*), matoke (*Musa* spp), cassava (*Manihot esculenta*), sweet potato (*Ipomea batatas* L) and yams (*Dioscorea* spp)) that had been lost in the last growing season. Matoke is a starchy cooking banana similar to plantain. Beans (*Phaseolus vulgaris* L) were not included as a prior study in Uganda found beans were not as vulnerable to crop raiding (Hill, 1997). Using picture cards of wild and domestic animals, respondents were asked to identify which species raided their crops and to rank animals by frequency of raids and damage caused (Hill, 1997). They were then asked to identify the worst months for crop raiding and whether they used any crop raiding defenses. If they identified human guarding as a defense, they were asked how many days per week men, women and children guarded in high and low raiding seasons.

Two survey variables were used for statistical analysis: i) the perceived trouble of crop raiding measured on a 5-point scale (1 = none, 2 = a little, 3 = some, 4 = considerable, 5 = a lot), and ii) the estimated fraction of crop production lost, calculated as the mean estimated loss of the five staple crops, with the fraction of loss attributed to domestic animals removed. Neither of these variables was normally distributed, so non-parametric statistics were used.

Demographic and socio-economic data were also collected in the survey. The village-mean number of people per household was multiplied by the number of households in the village and by the total area of village lands to calculate village population density. Whether the household head had been born in the village was used to determine the percent of households that migrated to the village in the last generation. As recommended by Ellis and Bahiigwa (2003), capital asset wealth of the household was calculated as the total local market value of assets owned, including land, buildings, livestock, radios, cell phones, bicycles and motorcycles. Respondents were also asked if the household engaged in income-generating activities, had members employed outside the household, the years of education completed by each adult, and household tribal affiliation.

2.2.2. Six Month Study

The frequency of visits was identified as critical to capture evidence of damage, because greater than two weeks between visits allowed for replanting and further crop raiding (Hill, 2000). Due to the challenge of reaching 25 villages every week, a local assistant was trained in each village (Naughton-Treves, 1997; Sitati et al., 2005) to physically verify damage, identify which crops were damaged, measure the damaged area, and count the number of damaged plants. Using a standardized guide, the assistant identified which species of animal caused the damage based on tracks, scat and bite marks (Kagoro-Rugunda, 2004; Naughton-Treves, 1998). Verification continued weekly for six months (August 2009 to January 2010), capturing parts of both dry seasons and a wet season. We visited each village at least once per month to collect and review data. Unfortunately, data from one village had to be discarded due to apparent data fabrication.

Six separate households participated in the physical verification per village (n = 150), of which 90 also participated in the household survey. The six households were located along the park border and along a village track traveling away from the park (up to 1314 m), to capture spatial variation.

Statistical analysis was based on three variables: i) number of wild animal raiding incidents per household, ii) area damaged, and iii) financial loss incurred. A crop raiding incident was defined as a single foray by a single species to a single household. These variables were not normally distributed so non-parametric statistics were used. Since these three variables and the fraction of crop production lost and perceived trouble of crop raiding from the survey were covariant, model selection based on Akaike (AIC) and Bayesian (BIC) Information Criteria (Burnham and Anderson, 2002) was used to identify the best explanatory variables.

Financial losses were calculated as the value of the crop/m^2 multiplied by the area damaged (Naughton-Treves and Treves, 2005). Crop value was equal to yield multiplied by local market price (Kagoro-Rugunda, 2004). Yield was based on average farmer estimates from at least six locations around the park to allow for variation in geographic location or farming methods. Calculated yield was checked against national yield statistics (European Commission, 2010), and was typically within 10%. The national yield was used for rice (*Oryza sativa*) and Artemisia (*Artemisia* L) as these are grown in very limited areas around the park. Local market prices, collected early in 2009, were derived from six to 18 trading centers around the park, depending on how widely the crop was cultivated. Loss value was converted to US dollars using an exchange rate of 2250 Ugandan shillings/US Dollar.

A cost–benefit analysis was performed for each village to determine if elephant trench construction could be justified based on measured losses. Using Ugandan rates (Bank of Uganda, 2011) for food crop inflation (38.8%) and lending (23.34%), the benefit to each village of a trench was compared with the cost of excavating (US $2000/km) and annually maintaining (10% of excavation cost) the trench along the village-park boundary,[1] compounded over a five year time horizon. The annual benefit of a trench was equal to the estimated efficiency of a trench against a specific species, multiplied by the average household cost of damage caused by that species, multiplied by the number of village households reporting raiding by that species[2] in the survey; summed over all raiding species.

2.2.3. Focus Groups

The perceived problems of crop raiding were collected in focus groups, conducted in 15 study villages (60%) in June and July 2008. Focus groups often grew beyond those invited, resulting in the number of people present ranging from 16 to 51. Women, the primary cultivators of food crops (Naughton-Treves, 1997), were in attendance at 14 of the focus groups, where they represented 6 to 65% of the participants. Comments were coded based on whether the problem related to direct financial loss, opportunity costs, food insecurity, education, health, or physical injury. Issues raised by focus groups were statistically tested against the household survey using Chi-squared analysis,

[1] Trench length was defined as the length of park boundary shared with the village based on GPS data, plus an additional ½ km on either end to protect households living at the edge of the village.

[2] Equal to the village percent of survey households reporting raiding by that species times the total number of households in the village.

comparison of means, and correlation testing to check for significant relationships that might warrant further investigation.

2.2.4. Supplementary Scholastic Data

Concerns about children missing school to guard crops were raised in 60% of the focus groups. Since children's scholastic achievement had not been collected in the survey, a supplementary study was conducted with 12 primary schools located near study villages from October to December 2009. The catchment area of these schools included the study village, adjacent to the park, and villages farther from the park where crop raiding by park-protected animals is rare. In each of the school years, P1 to P7, the average achieved grade for study village students was compared with the average achieved grade for all other students. This comparison was done separately for boys and girls. Pairing data by school year and gender permitted the scholastic achievement of study village students to be directly compared with their peers without having to separately control for age, gender, or quality of school.

The average grade achieved by study village students was modeled by linear regression to determine if crop raiding influenced scholastic achievement. The most influential determinants of scholastic achievement in rural Africa are the child's academic ability, gender, and absenteeism (Liddell et al., 1997). The percent of female study village students in each school was recorded, but we did not measure scholastic aptitude. The time a child spends in school is often defined by the household need for child labor (Reynolds, 1991). We are hypothesizing that school absenteeism is influenced by the level of crop raiding, represented by the village-mean perceived trouble of crop raiding, and the percent of village households permitting children to guard crops more than 2 days per week, and hence having to miss school.

School quality, varying due to teacher training, student–teacher ratios, and infrastructure, is also a strong determinant of scholastic achievement (Kasirye, 2009). In Uganda, children write a standardized primary leaving examination (PLE). The PLE score of each school was used to represent school quality in the regression model.

Weaker determinants of scholastic achievement are socio-economic status (Liddell et al., 1997; Simmons and Alexander, 1978), education achieved by fathers (Heyneman, 1977; Kasirye, 2009), belonging to the dominant ethnic group (Heyneman, 1977), family size (Liddell et al., 1997), and how far the child travels to school (Boomier and Lambert, 2000). These factors were included in the model using the following variables: village-mean capital asset wealth, the percent of village men completing primary school, the percent of village households affiliated with the dominant tribe, the village-mean number of children in a household, and the straight line distance from the village to the school.

3. Results

3.1. Crop Raiding Landscape

Thirty-three percent of households relied solely on subsistence agriculture for their livelihood, while 67% also engaged in income-generating activities such as making honey, charcoal, bricks, and gin, and cash crop production. Thirty percent of households had members employed outside the household. Household capital asset wealth varied from US$119 to over US$132,000, but skewed toward lower values resulting in a median of US$5033. Only 24% of adults had completed primary school (men 34%, women 12%). Village population densities ranged from 70 to 611 people/km^2 (mean 241 people/km^2), with in-migration ranging from 21% to 91% (mean 56%).

In all focus groups, crop raiding was identified as a problem of living next to KNP and 73% of survey respondents experienced crop raiding. Respondents felt crop raiding troubled their household considerably, on average losing 30% of their five staple crops. Specifically, households reported 45% of their maize was lost to park-protected animals, more than typical maize loss to animal pests in Africa (20%; Oerke et al., 1994). The perceived burden of crop raiding and the estimated fraction of production lost from the survey were correlated ($r_{Spearman}=0.621$, $p<0.001$, $n=591$), and varied around the park (Fig. 2a,b). During the six month verification study, 77% of households were raided, experiencing, on average, eight raids (range 1–35), 1638 m^2 of damage (range 0–24,000 m^2), valued at US$74 per household (range 0–US$632), with the highest losses along the western and central eastern boundary (Fig. 2c,d). The survey and six month study were compared in the overlapping 90 households. On average 20% of the household area cultivated was verified as damaged, suggesting the respondent estimated 30% loss of production may be overstated. The number of baboon raids recorded in the six month study and the perceived trouble of crop raiding correlated ($r_{Spearman}=0.217$, $p=0.040$, $n=90$), suggesting frequent baboon raiding may be shaping the opinions of farmers.

Crops were primarily raided by baboons and elephants, but redtail, vervet, and colobus monkeys, bushpigs, chimpanzees, and civets also raided crops (Table 1). Baboon raiding was prevalent around much of the park, while elephant, small primate and bushpig raiding was more localized (Fig. 3). The maximum raiding distance from the park in the six month study varied by species (bushpig = 1314 m, baboon = 924 m, elephant = 895 m, small primate = 846 m, chimpanzee = 523 m), but survey data indicated all species had raided up to 3 km from the park. Chimpanzee raids were recorded in villages close to habituated troops. The most frequent raider was baboon, followed by elephant and small primates (Table 1). Elephant raiding caused more area to be damaged overall and per household; however, due to the frequency of baboon raids on higher value crops, the financial loss was highest for baboons. Villages experiencing more elephant raiding had more area damaged ($r_{Spearman}=0.493$, $p=0.014$, $n=24$).

Crop raiding tends to be worse at the end of dry seasons (Naughton-Treves et al., 1998), when crops are harvested (May–July and November–January). These crop raiding cycles were also identified by survey respondents (Fig.4). The six month study covered one of these cycles and confirmed a peak in November when crops are ready for harvesting, followed by a steep decline. Baboon raiding was consistent with this temporal pattern; however, elephant raiding steadily declined from the beginning of the six month study.

Crop raiding has been escalating around PAs due to increased human settlement and recovering animal populations (Thouless and Sakwa, 1995; Tweheyo et al., 2005; Weber et al., 2007). Human population density within 5 km of the boundary of KNP increased 35% from 1990 to 2000 (SEDAC, 2008). In addition, long-term data for KNP suggests that baboon populations are both increasing and expanding their range northwards, and elephant numbers have increased (Colin Chapman, personal communication). The percent of households reporting crop raiding increased closer to the park (Fig. 5), with 90% of verified damage occurring within 530 m of the park. Households closer to the park reported higher crop production losses ($r_{Spearman}=-0.413$, $p<0.001$, $n=596$), verified by area damaged during the six month study also increasing closer to KNP ($r_{Spearman}=-0.282$, $p=0.001$, $n=143$).

Although there is some overlap between study villages, my research extends over considerably more of the park boundary than prior studies around KNP (Naughton-Treves, 1998; Naughton-Treves and Treves, 2005), potentially influencing comparisons between our results. Even so, crop raiding conflict does seem to be escalating. The spatial extent of raiding, defined as the distance within which 90% of the damage had occurred, is extending 300 m farther from the park, and the percent of crop production lost has increased, as has the percent of farmers raided by elephant (+66%). Bushpig raiding has decreased 55% and redtail monkey raiding has decreased 59%. Baboons are now the most frequent primate raider, with baboon

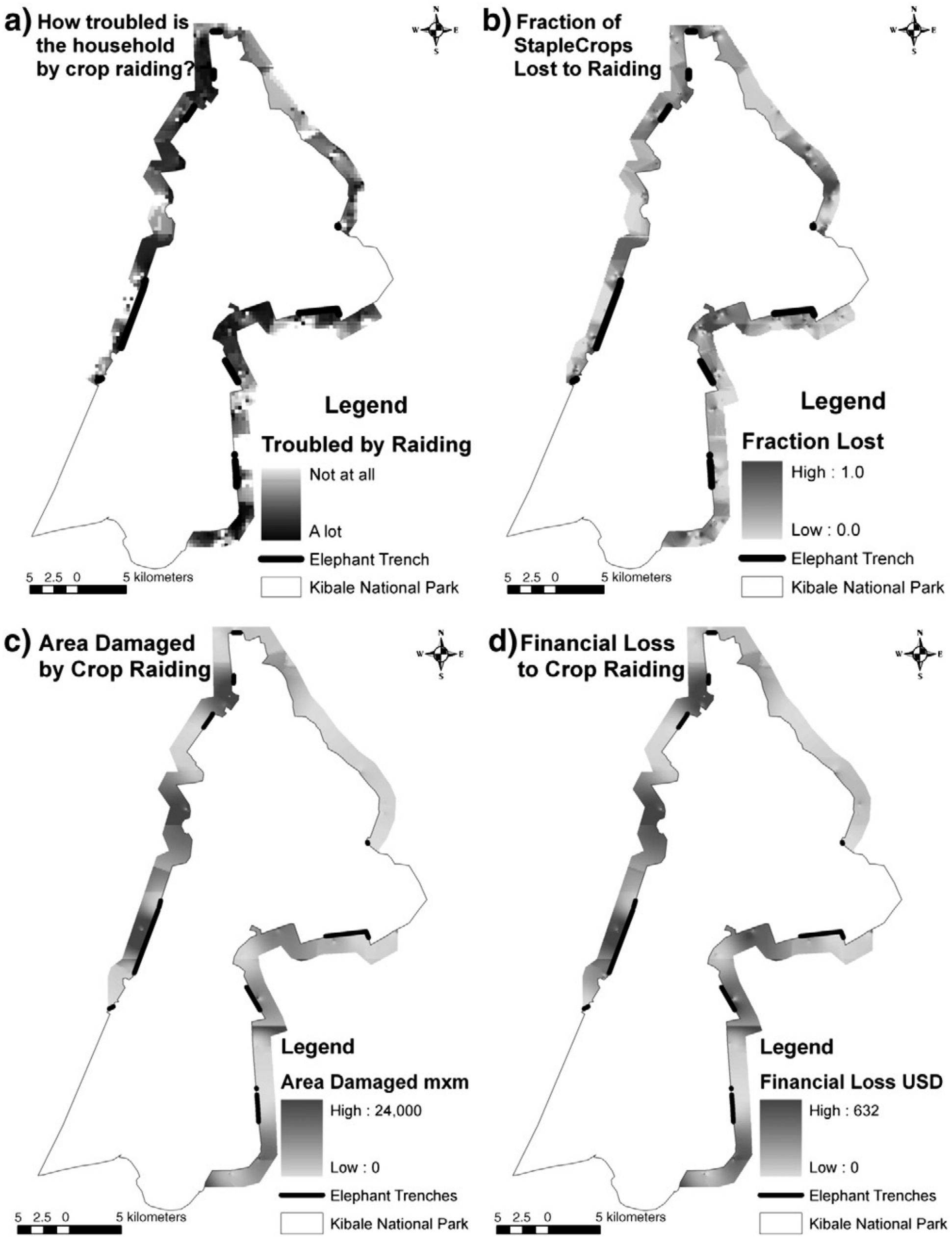

Fig. 2. Spatial distribution of crop raiding around Kibale National Park. (a) Perceived trouble, (b) Fraction of production lost, (c) Area damaged, (d) Financial loss. (a) and (b) Survey data n = 596, (c) and (d) Six month physical verification data n = 143.

and elephant accounting for 93.5% of all area damaged by wild animals.

3.2. Barriers to Crop Raiding

The highest losses were reported within 300 m of the park boundary (>45%), and reduced to typical African animal pest crop losses (Oerke et al., 1994) beyond 1100 m from the park. Households with more than two houses between them and the park had less area damaged (Mann–Whitney $p = 0.006$). However, village population density did not correlate with crop raiding levels ($r_{Pearson} = 0.022$, $p = 0.920$, $n = 24$). As per Batoro custom, immigrants to the village, typically Bakiga, are allocated land closer to the park (Mann–Whitney $p = 0.001$), creating a crop raiding buffer for Batoro farmers (Aluma et al., 1989; Naughton-Treves and Treves, 2005). Therefore Bakiga households lost more to raiding than their Batoro neighbors (Mann–Whitney $p = 0.023$).

Twenty-four different crops were raided by wild animals during the six month study. Most frequently raided were maize (39%), cassava (14%), beans (10%), matoke (10%), and sweet potato (8%); crops grown by over 90% of households (Table 2). Since cultivated area was not recorded by crop species, it is not possible to specify whether crops were preferentially sought by wild animals. To mitigate losses, some households employed planting strategies; planting closer to the house (41%), planting as far from the park as possible (27%), stopped planting crops animals prefer (17%), planting crops they knew animals did not like (10%), planting tea as a buffer crop (not palatable to animals, 9%), while 10% of households reported abandoning land as a result of crop raiding.

Households used numerous methods to defend their crops (Table 3); the most common were human guarding, burning fires, and beating drums to scare animals away. The average time spent guarding per week by men (5.2 days), women (3.9 days) and children (1.5 days) during high crop raiding months was twice that

Table 1
Crop raiding damage by species around Kibale National Park, Uganda and its estimated financial cost.

Raiding species	Household survey			Six month physical validation study									
	Percent reporting	Frequency rank	Damage rank	Percent raided	Incidents			Area damaged (m^2)			Financial loss (USD)		
					Total	Mean	Max	Total	Mean	Max	Total	Mean	Max
Baboon (*Papio cynocephalus*)	85%	1	2	60%	470	3.3	25	78,714	550	8996	$3809.20	$26.24	$312.67
Elephant (*Loxodonta africana*)	79%	2	1	50%	190	1.3	12	87,183	610	23,396	$3515.21	$24.58	$603.25
Redtail Monkey (*Cercopithecus ascanius*)	69%	3	3	21%	77	0.5	10	3052	21	722	$163.49	$1.14	$84.64
Vervet Monkey (*Cercopithecus aethiops*)	42%	5	5	14%	45	0.3	8	3008	21	894	$175.93	$1.23	$32.77
Bushpig (*Potamochoerus procus*)	42%	4	4	9%	53	0.4	10	4153	29	2238	$250.91	$1.75	$97.61
Colobus Monkey (*Colobus* spp)	10%	6	7	9%	21	0.1	3	151	1	62	$70.26	$0.49	$34.19
Chimpanzee (*Pan troglodytes*)	15%	7	6	7%	14	0.1	3	1102	8	338	$134.25	$0.94	$88.99
African Civet (*Civettictis civetta*)	0%	NR	NR	2%	8	0.1	3	18	0.1	7	$0.53	$0.00	$0.21

spent at other times of the year. Sixty percent of survey households reported children under the age of 18 guarding crops. Since guarding more than two days per week requires the child to miss school, most respondents said children only guarded on holidays and weekends. However, 89 households reported children guarding three to seven days/week during high raiding seasons (May–July and November–January), and 80% of these households were located within 1 km of the park boundary. The best model (AIC = 726, BIC = 736) of the person days spent guarding crops ($R^2 = 0.362$, $F = 163.636$, $p < 0.001$) resulted when the estimated fraction of production lost ($\beta_{Standardized} = 0.411$, $p < 0.001$) and the number of people in the household ($\beta_{Standardized} = 0.392$, $p < 0.001$) were used as predictor variables, suggesting households were investing available human resources based on the raiding risk to which the household was exposed.

Elephant raiding incidents were similar in villages with and without elephant trenches (Mann–Whitney $p = 0.786$). However, trenches appear to have been built in areas most troubled by elephants, potentially reducing elephant raiding to background levels for the park. Focus group participants in villages with trenches said trenches, if maintained, were 65% effective against elephants, 100% effective against bushpig, but did not stop primates. Applying these efficiencies resulted in an average village benefit from trench excavation of US$52,418 over five years (range 0 to US$509,818). Excavation and maintenance costs averaged US$18,807 over the same five year period (range US$9783 to US$32,802). Ten villages had a net benefit, indicating that five areas of the park boundary should be prioritized for trench excavation (Fig. 1). Households protected by Mauritius thorn (5.7%), experienced the same number of raiding incidents as households without thorn fence (Mann–Whitney $p = 0.684$), even though they rated its effectiveness quite highly (Table 3).

3.3. Social Implications

Household financial losses averaged US$74 over the six month study, a substantial loss given the median household capital asset wealth was US$5033. In 87% of focus groups, participants wanted cash compensation for lost crops. If cash could not be given, they suggested compensation should be: access to the park to harvest trees, provision of tree/coffee/tea seedlings, or maize flour and beans to feed their families. Some villagers went so far as to ask "Can we sue in civil court to get compensation from the government?" (11/6/08). The lack of compensation left many expressing a desire for revenge; "If a thief pays for his sins, then animals should be speared and killed if there is no compensation" (16/7/08).

Although some farmers saw the sharing of park revenues as a substitute for direct compensation, there was confusion whether the money would come as cash or a community project that many feared would not benefit those who actually lost crops. The revenue disbursed through the revenue sharing program over the last 10 years, has funded community projects and equates to about US$1 per household per year (MacKenzie, in press); far less than the crop raiding losses incurred.

Focus group participants claimed that crop raiding lead to lost opportunity costs; "Men and women are guarding so they have no opportunity to do income-generating activities" (3/7/08), and "unemployment is high because we cannot guard our crops all night and then work all day" (6/7/08). However, the number of income activities was higher for households experiencing crop raiding (Mann–Whitney $p = 0.002$), and no correlation was found between the percent of adults employed in the household and the fraction of crops lost ($r_{Spearman} = 0.000$, $p = 0.995$, $n = 593$). In an average household, ten adult person-days per week were spent guarding crops. At the minimum local wage of US$1/day, paid for agricultural labor, the household is potentially forgoing US$10/week. However, employment opportunities in the area are few and the lack of employment is more probably linked to the regional economy than crop raiding. Although income generation could potentially be higher if people did not guard crops, raiding was not restricting households from engaging in income-generating activities nor being employed, making the claim of lost opportunity costs invalid. However, local people do perceive crop raiding as a barrier to development; "How can we make money with crop raiding going on?" (11/6/08). Claiming they had to abandon land near the park and telling us that "local farmers take out loans to invest in their farms but then lose it all when they are crop raided and then are imprisoned for defaulting on the loans" (22/6/08).

Crop raiding can have serious consequences for food security. In 60% of focus groups participants said that, "when crops are raided, there is not enough food" (22/6/08) and that, "sometimes due to crop raiding we fail to feed our children" (11/6/08). In the survey, 19% of respondents reported a period of food insecurity in the prior year. Food insecure households had lost higher fractions of their staple crops to wild animals than households not reporting food insecurity (Mann–Whitney $p = 0.002$), specifically losing more maize (Mann–Whitney $p = 0.024$), yams (Mann–Whitney $p = 0.005$) and cassava (Mann–Whitney $p = 0.004$).

Although primary education is now free in government schools, private schools are perceived to provide a better education and charge fees to attend (US$130 to over US$500 per year). Even in

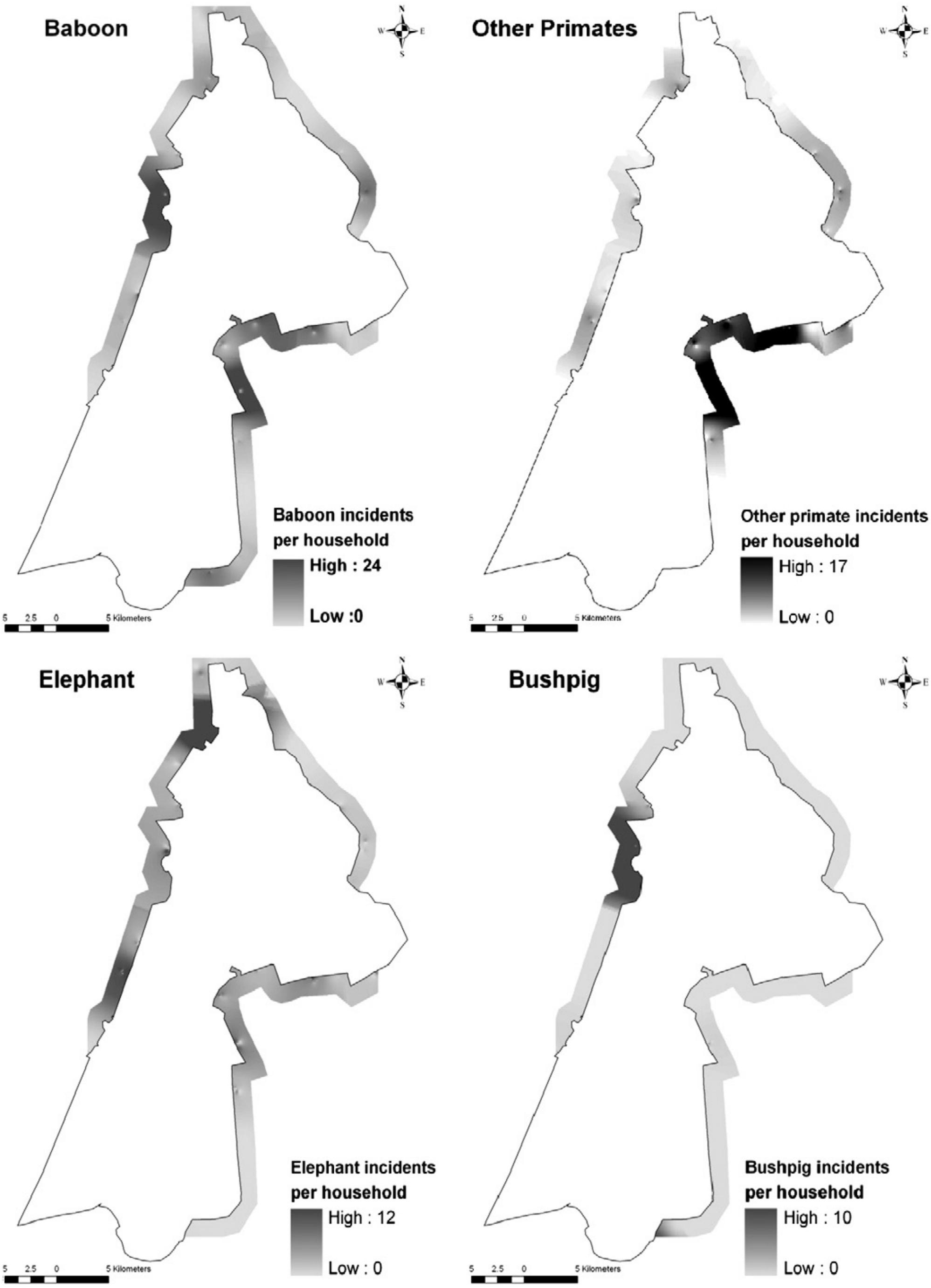

Fig. 3. Spatial distribution of crop raiding by species around Kibale National Park, Uganda.

government schools, parents pay for uniforms, school supplies, examination fees and lunches. Focus group participants asked, "How can parents send children to school and have to pay for fees, books and uniforms, when they cannot even feed their children?" (22/6/08). Failure to pay fees or provide food for school lunches typically results in a child being turned away from school. In addition, many hold their children back from school; "Our children cannot spend time in school because they have to guard the crops" (1/7/08). In the 12 primary schools studied, children from study villages tended to have lower grade averages than their peers from other villages (paired *t*-test, $p<0.001$, $n=122$). In three schools, study village students did better or equal to their peers living farther from the park (0–18% higher), while in nine schools, they attained lower grades (2–40% lower).

In the model of scholastic achievement of study village students (Table 4), the perceived trouble due to crop raiding and the percent of households allowing child guarding more than 2 days per week were more influential than wealth, ethnicity, family size and distance traveled to school. In this village-school aggregate analysis, crop raiding was as influential as gender, and school quality, indicating crop raiding should be considered in future studies of scholastic achievement for children living near PAs.

Focus groups reported that, "crop raiding brings diseases that spread to humans and livestock" (1/7/08). Survey respondents were asked to self-report if household members had suffered certain health problems within the last five years. Households reporting crop raiding were more likely to report malaria ($\chi^2=9.53$, $p=0.002$), worms and parasites ($\chi^2=13.64$, $p<0.001$), dysentery ($\chi^2=8.11$,

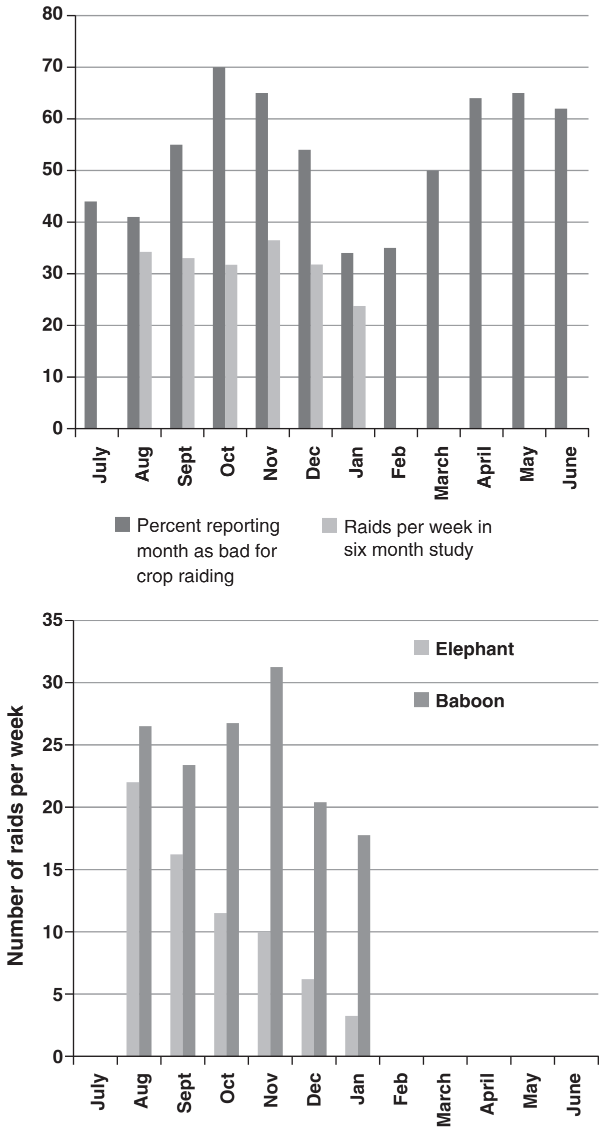

Fig. 4. Temporal variation in crop raiding.

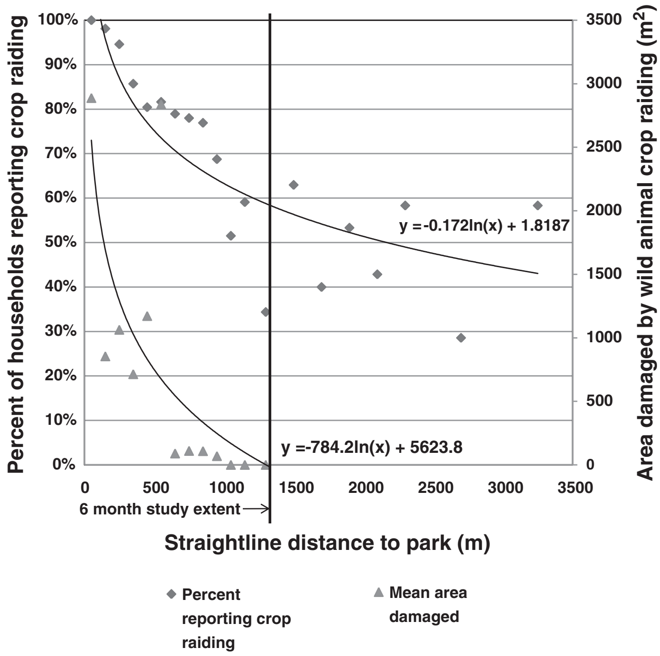

Fig. 5. Crop raiding as a function of distance from park.

p = 0.004), and pneumonia ($\chi^2 = 7.64$, p = 0.006). Focus group participants explained that, "disease is transmitted from animals in the park to people by insects" (11/6/08), but that more "malaria is contracted due to spending nights outside guarding the crops" (3/7/08). Bacterial genetic similarity has been found between humans, livestock and non-human primates in and near forest fragments adjacent to KNP (Goldberg et al., 2008). Although specific transmission mechanisms are still being identified, the primary determinant of bacterial transmission was spatial and ecological overlap between human, livestock, and non-human primate habitats due to human disturbance inside the forest fragments, crop raiding by primates, and livestock grazing in and near the fragments.

Among households where livestock was owned, the following livestock diseases were more likely to be reported by households experiencing crop raiding: tick-borne disease in goats ($\chi^2 = 4.37$, p = 0.037), lumpy skin disease in goats ($\chi^2 = 6.77$, p = 0.009), east coast fever in goats ($\chi^2 = 4.48$, p = 0.034) and pigs ($\chi^2 = 7.55$, p = 0.006), and Fascioliasis in cows ($\chi^2 = 5.01$, p = 0.025). Most of these diseases are transmitted by ticks, and not animal to animal transmission. Therefore transmission is either due to crop raiding animals leaving ticks in farmers' fields, to livestock grazing on low brush inside the park boundary where crop raiding animals hide prior to raiding and where ticks thrive (T.L. Goldberg, personal communication), or when livestock are intentionally, but illegally, grazed inside the park as frequently occurs in the south of KNP.[3]

In one third of focus groups people expressed their fear of elephants; "We are scared of being killed when guarding against elephants, because they charge and kill" (1/7/08). Twenty-three percent of survey respondents reported a household member being attacked by wild animals. During the course of the six month study, one man lost the use of a hand after a baboon attack, and a juvenile elephant chased and injured one woman. Households reporting attacks by wild animals tended to have lost more crop production to wild animals (Mann–Whitney p = 0.002) and invested more person-days to guard crops (Mann–Whitey p = 0.001), therefore exposing themselves to potential injury.

4. Discussion

Consistent with other studies, the distance to the park was the primary predictor of crop raiding damage (Hill, 1997; Linkie et al., 2007; Naughton-Treves, 1998; Naughton-Treves and Treves, 2005). Therefore, farmers restricted to cultivating directly adjacent to the boundary are most vulnerable, and having other households between a given household and the park reduced the area damaged (Hill, 1997). Baboon raiding increased just before the harvest (Hill, 2000; Naughton-Treves et al., 1998), and guarding investment increased as the risk of raiding rose (Hill, 2000). Elephant raids have been reported to decrease from July to December (Chiyo et al., 2005), although the reason for this decline is unknown. Therefore, elephant raiding in this study may be under reported as no data were recorded in July.

Human guarding, drums, and fire, the most effective means of reducing crop raiding losses (Sitati et al., 2005), were the most frequently employed defense strategies around KNP. Residents near

[3] In-park grazing of livestock is illegal and if caught the perpetrator is fined US$10 to US$35. Eight percent of survey respondents admitted grazing cattle in the park; this activity was not valued.

Table 2
Crops grown by study households and raider crop preferences near Kibale National Park, Uganda.

Crop	Percent of households growing crop	Percent all crop raiding incidents	Percent elephant incidents	Percent baboon incidents	Percent redtail monkey incidents	Percent vervet monkey incidents	Percent bushpig incidents	Percent colobus monkey incidents	Percent chimpanzee incidents	Percent African civet incidents
Beans (*Phaseolus vulgaris* L)	97%	9.5%	8.4%	10.4%	6.6%	12.5%	13.6%	9.5%	0.0%	0%
Sweet potato (*Ipomea batatas* L)	97%	7.8%	5.1%	8.9%	6.6%	12.5%	13.6%	14.3%	6.7%	0%
Maize (*Zea mays* L)	96%	39.4%	30.7%	40.9%	61.8%	47.9%	40.7%	71.4%	6.7%	100%
Matoke (*Musa spp*)	91%	10.0%	13.6%	9.4%	2.6%	10.4%	0.0%	0.0%	20.0%	0%
Cassava (*Manihot esculenta*)	90%	14.4%	19.6%	12.6%	6.6%	6.3%	22.0%	0.0%	0.0%	0%
Fruit (*Passiflora* spp, *Persea Americana*)	82%	1.3%	2.0%	1.1%	0.0%	0.0%	0.0%	4.8%	0.0%	0%
Irish potato (*Solanum tuberosum* L)	82%	2.1%	0.9%	3.5%	1.3%	0.0%	0.0%	0.0%	0.0%	0%
G nuts (*Arachis hypogeal*)	76%	2.1%	1.6%	2.9%	2.6%	2.1%	0.0%	0.0%	0.0%	0%
Doodo (*Amaranthus dubious*)	72%	0.2%	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Yams (*Dioscorea spp*)	71%	2.7%	2.4%	2.2%	1.3%	8.3%	8.5%	0.0%	0.0%	0%
Millet (*Eleusine corocana* L)	71%	2.7%	5.3%	1.1%	5.3%	0.0%	0.0%	0.0%	0.0%	0%
Eggplant (*solanum spp*)	71%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Pumpkin (*Cucurbita spp*)	69%	1.1%	0.4%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Sorghum (*Sorghum bicolor* L)	61%	0.8%	0.4%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Sugarcane (*Saccharum officinarum* L)	41%	3.0%	3.3%	1.8%	5.3%	0.0%	0.0%	0.0%	60.0%	0%
Pineapple (*Ananas comosus*)	37%	0.4%	0.2%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Coffee (*Coffea* spp)	29%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Green Pepper (*Capsicum* spp)	24%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Tomato (*Lycopersicon esculentum*)	20%	0.3%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Cabbage (*Brassica oleracea* L)	19%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Tobacco[a] (*Nicotiana tabacum*)	13%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Tea seedlings[a,b] (*Camellia sinensis*)	9%	0.5%	0.2%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%
Rice (*Oryza sativa*)	7%	0.6%	1.1%	0.3%	0.0%	0.0%	1.7%	0.0%	0.0%	0%
Artemisia[a] (*Artemisia* L)	1%	0.5%	1.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0%

[a] Not consumed by elephants, but was destroyed by trampling.
[b] Tea was not consumed by baboons. They picked the seedling out of the ground to look for food below ground level before throwing the seedling away.

the park wanted elephant trenches, because trenches limit the locations where human guarding is required. Trenches were described as 'like the wall of a house', where guarding now only had to be done at the windows and doors, areas where elephants were more likely to cross. The construction of elephant trenches are financially justified, but only in areas with high losses to elephant and bushpig. Revenue sharing funds should be spent on trenches in these areas, and UWA should pursue conservation NGOs to supplement funds for trench excavation.

There was a perception in villages without trenches, that trenches would be effective against baboons. This is not so and could lead to expectations not being met when trenches are excavated. Adult baboons jump across trenches and juveniles bend trees above the trench until they can jump over. Effective defenses against baboon have still to be developed. UWA have authorized baboon culling in one area, but culling was not effective long-term, as baboons returned to raid within a month of the cull. Since conclusions of long-term population studies for baboon and elephant are still incomplete, it is premature to consider culling as a defense mechanism. However, 85% of households experienced baboon crop raiding, and six month losses to baboon averaged US$26 per household, totaling US$109,600 per year for the villages included in this study alone. We believe this loss justifies the funding of research into baboon raiding deterrents.

Table 3
Crop raiding defense mechanisms used around Kibale National Park, Uganda.

Defense mechanism	Household survey (n = 596)				Six month study: overlap households with survey (n = 90)			
	Percent of households using defense	Mean effectiveness rating	Mean rating for 'troubled by crop raiding'	Mean fraction of production lost	Percent of households using defense	Mean number of incidents	Mean area damaged (m^2)	Mean financial loss (USD)
Human guarding	64.9%	2.08	4.62	0.43	83.0%	7.6	1624	$79.88
Fire	53.5%	2.10	4.66	0.45	71.1%	7.9	1771	$85.19
Beating drums	53.4%	2.08	4.61	0.44	71.1%	8.2	1878	$92.24
Scare shooting by UWA rangers	27.2%	2.17	4.66	0.43	44.4%	9.4	2229	$106.47
Elephant trench	14.4%	2.07	4.56	0.45	20.0%	9.3	2543	$95.63
Dogs	10.9%	2.11	4.28	0.42	16.7%	11.0	2855	$137.76
Spread dung on maize	8.1%	2.27	4.4	0.41	13.3%	14.0	2558	$146.50
Live fence (Mauritius thorn)	5.7%	2.29	4.59	0.49	12.2%	8.0	1638	$73.02
Set traps for animals	1.2%	1.86	4.57	0.52	2.2%	18.0	5757	$204.70
Fences	0.8%	2.20	5	0.54	2.2%	16.5	1304	$57.38
Chili rope	0.3%	1.50	4.5	0.48	0.0%	–	–	–
Shallow trenches around gardens	0.2%	1.00	5	0.60	0.0%	–	–	–
Other	4.4%	2.00	4.31	0.42	6.7%	8.0	1471	$56.37
Do not try to stop crop raiding	6.2%	–	4.38	0.31	6.7%	3.3	431	$25.45

Effectiveness rating: 3 = works well, 2 = works sometimes, 1 = does not work.
Troubled rating: 5 = a lot, 4 = considerably, 3 = somewhat, 2 = a little, 1 = not at all.
Other includes: Shouting or other noise (9), throwing burning firewood at animals (3), burning plastic or bicycle tires (3), hanging clothes to scare animals (2), burning chili and cow dung (1), burning peppers in the fire (1), hire Bakonjo tribe to kill baboons (1), grow tobacco (1), scare shooting by a local (1).
Survey data collected July–August 2009 and six month study data collected August 2009–January 2010.

Table 4
Linear regression model of the scholastic performance of study village students.

Predictor variables	Mean	Range	β Standardized	Significance
Quality of school (PLE score)[a]	25.9	21.9 to 30.9	−0.789	0.064
Percent of study village students who are female	47	37 to 55	−1.294	0.083
Percent of households permitting children to guard crops >2 days per week	16	4 to 29	−2.621	0.045
Village-mean perceived trouble due to crop raiding	3.8	2.2 to 4.7	−0.796	0.039
Village-mean capital asset wealth (USD)	7287	4163 to 13,401	0.517	0.142
Percent of men in village who completed primary school	34	24 to 61	−2.105	0.042
Percent of households in village affiliated with the dominant tribe	87	25 to 100	0.259	0.178
Village-mean number of children per household	3.4	2.6 to 4.3	−0.131	0.503
Straight line distance from village to school (kms)	2.6	1.1 to 4.6	0.921	0.454

Dependent variable = Study village student's mean achieved grade.
Adjusted $R^2 = 0.936$, $F = 18.914$, Sig = 0.051
[a] Due to the method of scoring the primary leaving exams (PLE), a low score represents a good school and a high score represents a poor school.

This study found Mauritius thorn, a highly invasive species imported from Asia, was not effective as a crop raiding defense. IUCN cautiously recommended it be tried because it was already in use elsewhere in Uganda (Chhetri et al., 2004). Ten years after its introduction, forest ecologists in KNP find Mauritius thorn grows uncontrollably, often reaching 3 m tall, penetrating over 5 m into the forest, with new stems found far from where the original seedlings were planted (Colin Chapman, personal communication). In addition, once the plants reach the mid-canopy, only large stems are left near the ground, allowing baboons and bush pigs to easily pass under the plants. Further planting of Maurtius thorn is therefore not recommended.

Residents local to KNP definitely want compensation for crop losses. Lack of compensation has been called unjust, especially since mitigation efforts by local farmers are restricted by conservation policy (Laudati, 2010). However, in Uganda, like many African countries, compensation programs would not be sustainable, since conservation efforts attempt to recover animal numbers and human population growth results in more farmers near PAs, leading to ever increasing human-wildlife conflict (Nyhus et al., 2005). Even in African countries where compensation exists (Jackson et al., 2008), programs are expensive, and compensated farmers still incur an 11% income loss relative to farmers who are not raided.

Compensation schemes are complicated to implement and fraught with pitfalls. Programs have to guard against fraudulent claims (Bulte and Rondeau, 2005), verify damage was caused by protected animals (Nyhus et al., 2005), and guard against 'moral hazard'; a situation where the farmer looses the incentive to protect their crops, because all are equally compensated for losses (Bulte and Rondeau, 2005; Nyhus et al., 2005). Setting up compensation schemes can also run counter to conservation objectives by providing incentive to put more land into agriculture and promote in-migration by people seeking access to compensation (Bulte and Rondeau, 2005), and since over half the survey households in this study had migrated to the boundary of KNP, a known human-wildlife conflict area, it is debatable whether compensation for these households is warranted. Given the issues involved with compensation programs and their inherently unsustainable nature, we recommend that any funding found to address crop losses be applied to developing better crop raiding defenses, an activity that is typically underfunded (Thouless and Sakwa, 1995).

Many authors acknowledge the social implications of guarding against raiding animals (Haule et al., 2002; Hill, 2000; Kagoro-Rugunda, 2004; Naughton-Treves, 1997; Tchamba, 1996). Reducing crop raiding could also address these indirect costs, such as loan defaults, food insecurity, poor educational performance, health problems, and injury from park-protected animals. Without exception, participants in the focus groups held around KNP stated that the costs of living near the park far outweighed any benefits received as a result of conservation. Although the perceived opportunity costs might not be recovered due to few employment opportunities in the area, many of the other issues could be mitigated by directing development aid, such as the Ugandan National Agricultural Advisory Services program (NAADS, 2011), to households closer to the park. Rather than providing a new incentive that might attract more migration toward the park boundary, expansion of existing NAADS projects is preferred, because the yield and marketing advantages offered would then be equal for farmers near and far from KNP.

Data collected from schools near Kilombero Game Controlled Area in Tanzania, found 88.4% of pupils reported guarding crops and 60% missed classes to guard (Haule et al., 2002). Around KNP, many focus group attendees voiced concern about having to choose between food to eat and their child's education. Our study confirms children living in villages directly adjacent to the park have poorer scholastic achievement, and that this is partially tied to their parent's perceptions of crop raiding risk. The need to guard crops instead of going to school could be addressed by existing school-based Non-Government Organizations providing extra tutoring to those living closest to the park.

Given the self-reported nature of health data in the survey, a more rigorous study is required to confirm the relationship between disease and crop raiding. However, if true, whether or not a household is troubled by crop raiding will need to be considered when planning health programs, particularly malaria prevention. Bed-nets will not be effective if people live in fields instead of their house in high guarding season. The potential for animal to human transmission (Goldberg et al., 2008), coupled with higher disease self-reporting rates in crop raided households, supports the need for further research to fully understand crop raiding implications for human and livestock health.

The financial and social costs of crop raiding require additional focus on crop loss mitigation by conservation organizations. This study indicates that funding to improve deterrents to crop raiding, as well as development programs to lessen the social burden borne by local residents are justified.

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References

Aluma, J., Drennon, C., Kigula, J., Lawry, S.W., Muwanga-Zake, E.S., Were, J., 1989. Settlement in Forest Reserves, Game Reserves and National Parks in Uganda. Makerere Institute of Social Research, Kampala.
Archibald, K., Naughton-Treves, L., 2001. Tourism revenue-sharing around national parks in western Uganda: early efforts to identify and reward local communities. Environmental Conservation 28, 135–149.

Bank of Uganda, 2011. Inflation and Lending Rates. 2011Retrieved November 2011 from http://www.bou.or.ug/bou/home.
Boomier, A., Lambert, S., 2000. Education demand and age at school enrollment in Tanzania. Journal of Human Resources 35, 177–203.
Bulte, E.H., Rondeau, D., 2005. Research and management viewpoint: why compensating wildlife damages may be bad for conservation. Journal of Wildlife Management 69, 14–19.
Burnham, K.P., Anderson, D.R., 2002. Model selection and Multimodel Inference: a Practical Information-Theoretic Approach, second edition. Springer Science & Business Media, Inc, New York.
Chapman, C.A., Lambert, J.E., 2000. Habitat alteration and the conservation of African primates: case study of Kibale National Park, Uganda. American Journal of Primatology 50, 169–185.
Chhetri, P.B., Barrow, E.G., Muhweezi, A., 2004. Securing Protected Area Integrity and Rural People's Livelihoods: Lessons from Twelve Years of the Kibale and Semliki Conservation and Development Project. International Union for Conservation of Nature and Natural Resources, Nairobi.
Chiyo, P.I., Cochrane, E.P., Naughton, L., Basuta, G.I., 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.
Ellis, F., Bahiigwa, G., 2003. Livelihoods and rural poverty reduction in Uganda. World Development 31, 997–1013.
European Commission, 2010. Average Yield (kg/Ha) 2003–2010. Retrieved March 2010 from Post Harvest Losses Information System: http://www.aphlis.net/.
Goldberg, T.L., Gillespie, T.R., Rwego, I.B., Estoff, E.L., Chapman, C.A., 2008. Forest fragmentation as cause of bacterial transmission among nonhuman primates, humans, and livestock, Uganda. Emerging Infectious Diseases 14, 1375–1382.
Haule, K.S., Johnsen, F.H., Maganga, S.L., 2002. Striving for sustainable wildlife management: the case of Kilombero Game Controlled Area, Tanzania. Journal of Environmental Management 66, 31–42.
Heyneman, S.P., 1977. Relationships between primary school community and academic achievement in Uganda. The Journal of Developing Areas 11, 245–259.
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.
Hill, C.M., 2000. Conflict of interest between people and baboons: crop raiding in Uganda. International Journal of Primatology 21, 299–315.
Jackson, T.P., Mosojane, S., Ferreira, S.M., van Aarde, R.J., 2008. Solutions for elephant *Loxodonta africana* crop raiding in northern Botswana: moving away from symptomatic approaches. Oryx 42, 83–91.
Kagoro-Rugunda, G., 2004. Crop raiding around Mburo National Park, Uganda. African Journal of Ecology 42, 32–41.
Kasirye, I., 2009. Determinants of learning achievement in Uganda. Centre for the study of African Economics Conference Proceedings.
Laudati, A.A., 2010. The encroaching forest: struggles over land and resources on the boundary of Bwindi Impenetrable National Park, Uganda. Society and Natural Resources 23, 776–789.
Liddell, C., Lycett, J., Rae, G., 1997. Getting through grade 2: predicting children's early school achievement in rural South African schools. International Journal of Behavioral Development 21, 331–348.
Linkie, M., Dinata, Y., Nofrianto, A., Leader-Williams, N., 2007. Patterns and perceptions of wildlife crop raiding in and around Kerinci Seblat National Park, Sumatra. Animal Conservation 10, 127–135.
MacKenzie, C.A., in press. Trenches like fences make good neighbours: Revenue sharing around Kibale National Park, Uganda. Journal for Nature Conservation, doi: 10.1016/j.jnc.2011.08.006.
MacKenzie, C.A., Chapman, C.A., Sengupta, R., in press. Spatial patterns of resource extraction in Kibale National Park, Uganda. Environmental Conservation 38, doi:10.1017/S0376892911000282.
NAADS, 2011. Uganda National Agricultural Advisory Services Program. 2011Retrieved November 2011 from http://www.naads.or.ug.
Naughton-Treves, L., 1997. Farming the forest edge: vulnerable places and people around Kibale National Park, Uganda. Geographical Review 87, 27–46.
Naughton-Treves, L., 1998. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. Conservation Biology 12, 156–168.
Naughton-Treves, L., Treves, A., 2005. Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa. In: Woodroffe, R., Thirgood, S., Rabinowitz, A. (Eds.), People and Wildlife: Conflict or Coexistence. Cambridge University Press, Cambridge, pp. 252–277.
Naughton-Treves, L., Treves, A., Chapman, C., Wrangham, R., 1998. Temporal patterns of crop-raiding by primates: linking food availability in croplands and adjacent forest. Journal of Applied Ecology 35, 596–606.
Newmark, W.D., Manyanza, D.N., Gamassa, D.-G.M., Sariko, H.I., 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.
Nyhus, P.J., Osofsky, S.A., Ferraro, P., Madden, F., Fischer, H., 2005. Bearing the cost of human-wildlife conflict: the challenges of compensation schemes. In: Woodroffe, R., Thirgood, S., Rabibowitz, A. (Eds.), People and Wildlife: Conflict or Coexistance. Cambridge University Press Cambridge, pp. 107–121.
Oerke, E.C., Dehne, H.W., Schonbeck, F., Weber, A., 1994. Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops. Elsevier, Amsterdam.
Osborn, F.V., Parker, G.E., 2003. Towards an integrated approach for reducing the conflict between elephants and people: a review of current research. Oryx 37, 80–84.
Reynolds, P., 1991. Dance Civet Cat: Child Labour in the Zambezi Valley. Zed Books, London (UK).
Robbins, P., McSweeney, K., Waite, T., Rice, J., 2006. Even conservation rules are made to be broken: implications for biodiversity. Environmental Management 37, 162–169.
SEDAC, 2008. Gridded Population of the World (GPWv3). International Earth Science Information Network, United Nations Food and Agriculture Programme and Centro Internacional de Agricultura Tropical . Columbia University, New York.
Sifuna, N., 2005. Providing compensation for damage caused by wildlife: a case study of Kenya with particular reference to elephants. Journal of Social Development in Africa 20, 7–39.
Simmons, J., Alexander, L., 1978. The determinants of school achievement in developing countries: a review of the research. Economic Development and Cultural Change 26, 341–357.
Sitati, N.W., Walpole, M.J., 2006. Assessing farm-based measures for mitigating human-elephant conflict in Transmara District, Kenya. Oryx 40, 279–286.
Sitati, N.W., Walpole, M.J., Leader-Williams, N., 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.
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.
Thouless, C.R., Sakwa, J., 1995. Shocking elephants: fences and crop raiders in Laikipia District, Kenya. Biological Conservation 72, 99–107.
Tweheyo, M., Hill, C.M., Obua, J., 2005. Patterns of crop raiding by primates around Budongo Forest Reserve, Uganda. Wildlife Biology 11, 237–247.
Uganda Wildlife Statute, 1996. FAOLEX. Retrieved March 25, 2008, from Food and Agriculture Organization of the United Nations Legal Office. http://faolex.fao.org/docs/texts/uga9000.doc.
Warren, Y., Buba, B., Ross, C., 2007. Patterns of crop-raiding by wild and domestic animals near Gashaka Gumti National Park, Nigeria. International Journal of Pest Management 53, 207–216.
Weber, A.D., Hill, C.M., Reynolds, V., 2007. Assessing the failure of a community-based human-wildlife conflict mitigation project in Budongo Forest Reserve, Uganda. Oryx 41, 177–184.