Examining Human-Elephant Conflict in Southern Africa: Causes and Options for Coexistence

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Abstract

Though African elephants (*Loxodonta africana*) are listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN), efforts to protect and conserve the species have been complicated by human-elephant conflict (HEC). Land conflicts may be the greatest long-term threat to elephant conservation because as people and elephants inhabit the same areas and share scarce resources, there will be more pressure to encroach on elephant habitat for human uses, and this will get worse as human populations continue to grow. This paper looks at factors that contribute to HEC and examines measures that are being taken to reduce conflict. The paper focuses on two field studies: an analysis of Elephant Pepper Development Trust's (EPDT) use of chilli peppers in Zambia to reduce incidents of elephant crop raiding and an assessment of farmers' experiences with HEC in the southern part of the Okavango Delta. This paper is intended to provide an overview of the social, economic, and environmental dynamics of HEC and the resulting management implications for African elephant conservation.

Contents

Foreword

In the fall of 2006, I enrolled in Dr. Daniel Janzen's course, "Humans and their Environment." For my final paper, I began researching human-elephant conflict (HEC) in Africa. I was intrigued by the complexity of this issue and determined to research the topic further for my capstone project. In the fall of 2007, I went to Botswana and Zambia to research the extent and impact of HEC and mitigation methods to reduce HEC. While there, I had the opportunity to gain a better understanding of the social, economic, and environmental dynamics of HEC and to develop ideas about future lines of research.

My paper is organized into three major sections. The first section is a literature review that provides an overview of HEC in areas of Africa that have elephant populations. The second section focuses on my research in Zambia. It presents an assessment of the Elephant Pepper Development Trust's protocol for using chillis as a deterrent for crop raiding. The third section examines HEC in the Okavango Delta of Botswana. It begins with a general overview of the conditions that contribute to HEC in the delta. The remainder of this section focuses on the research I conducted while in Botswana.

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Acronyms

AfESG	African Elephant Specialist Group
BDF	Botswana Defense Force
CBNRM	Community Based Natural Resource Management
CITES	Convention on the International Trade in Endangered Species of Wild Fauna and Flora
DWNP	Department of Wildlife and National Parks
EPDT	Elephant Pepper Development Trust
HEC	Human-Elephant Conflict
IUCN	International Union for the Conservation of Nature and Natural Resources
KZTfCA	Kavango-Zambezi Transfrontier Conservation Area
NG32, 35	Ngamiland Districts 32 and 35
NGO	Non-Governmental Organizations
ODMP	Okavango Delta Management Plan
OKMCT	Okavango Kopano Mokoro Community Trust
PAC	Problem Animal Control
WMA	Wildlife Management Area
ZAWA	Zambian Wildlife Authority

Literature Review

Introduction

For those who are in a position of privilege and have the luxury to care, elephants often conjure up majestic images: visions of elephants trumpeting as they loaf near a watering hole in the savanna or tramping through dense rainforests. But for many who have little and must share their inhabitance with these hulking animals, elephants inspire fear and frustration and are deemed “pests” to be controlled or extinguished if their behavior infringes on the livelihoods or security of the humans around them. Survival of these magnificent and powerful mammals depends on their ability to coexist peacefully with people; therefore, conservation of the species is manifestly connected to addressing the well being of the humans who interface with elephants.

In Africa, humans and savanna and forest elephants (*Loxodonta africana africana* and *Loxodonta africana cyclotis*) have not coexisted peacefully through history. Before the dawn of technologies that enabled humans to control elephants’ habitats and population density, these animals, with their sheer size and strength, overpowered humans when they interfered with elephant survival. In pre-colonial Africa, elephants were a major obstacle to establishing agriculture (Parker and Graham 1989a; Barnes, R.F.W. 1996). In savanna and forest areas that were part of elephant migration routes, agriculture was probably only successful in large, well-defined villages (Laws *et al.* 1975). Colonial records indicate small-scale farmers suffered tremendous losses from elephant depredation (Schweitzer 1922), and it was not until Europeans and Arabs began moving in to Africa in the nineteenth and early twentieth centuries that human-elephant dynamics changed (Hanks 1979; Eltringham 1990). There were several reasons for this change: firearms made it easier to kill elephants and contributed to a decrease in elephant populations (Lee and Graham 2006); colonial governments expanded throughout the continent;

agriculturalists began producing cash crops; mortality rates were reduced with control of tsetse fly populations and better medical care; and ivory became a precious commodity with a high monetary value (Hoare 1999b).

In addition, elephants were slaughtered in large numbers because of the ivory trade; these mass hunting operations peaked during the "ivory crisis," which began in the early 1970s and continued through the early 1990s. During this period ivory was used to fuel wars (Draulans and Krunkelsven 2002), to finance local development, and to generate wealth for individuals. When the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) took effect in 1989, African elephant populations had a chance to rebound as poaching pressure declined and action was taken to implement better management strategies. However, political instability, ongoing wars, and a global market for ivory products have continued to fuel the demand for illegal ivory, especially savanna elephants in Central Africa and forest elephants in West Africa (Blanc *et al.* 2003).

Blanc *et al.* (2003) assessed the population status of elephants by region and country and determined there are between 420,000 and 660,000[1] compared to pre-poaching estimates of 1.6 million (Douglas-Hamilton 1987). The majority of Africa's elephants live in Southern Africa with estimates ranging from 197,000 to 214,000, and 50% of these elephants are said to live in Botswana (DGEC 2003). Only 5% of the total African elephant population resides in West Africa—most populations already have less than 200 elephants and in many cases the effective population is less than 50 because males have been hunted (Barnes, R.F.W. 1999). Many of the African elephant populations that have declined over the last 30 years are in countries suffering

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[1] Lee and Graham (2006) suggest 660,000 is a "speculative" number.

from "civil war and/or breakdown in political and institutional governance" (Lee and Graham 2006).

Though poaching continues to reduce the number of individuals in a population, the overall decline in elephant range and population density (Said *et al.* 1995) has not diminished conflict between elephants and agriculturalists throughout rural Africa (Brown 1968; Kinloch 1972; Parker 1983; Parker and Graham 1989b; Eltringham 1990; Barnes, R.F.W. 1996). In fact, land conflicts may be the greater long-term threat because as people and elephants inhabit the same areas and share scarce resources, there will be more pressure to encroach on elephant habitat for human uses, and this will get worse as human populations continue to grow. Increasing populations can even put pressure on areas that have been designated as protected areas. For example, when Ghana's Bia National Park was established in 1974, it originally covered 305 km^2, but after being downgraded and logged it now covers 70 km^2(Martin 1991). Wildlife agencies are typically underfunded and governments have other priorities; therefore, it is likely that there will be more human encroachment into protected areas.[2] It is important to note too that protected areas alone are inadequate for sustaining elephants, and whether humans purposely or inadvertently create barriers to elephant movement, these barriers impact the species' ability to thrive by limiting access to critical food and water sources made scarce by seasonal climate changes and by interfering with genetic exchange among populations (Lee and Graham 2006).

Because humans and elephants often compete for land, food, and water, conflict occurs almost everywhere elephants come into contact with humans, regardless of whether the elephants are protected (Hoare 2000). Though measures have been taken to ameliorate human-elephant

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[2] R.F.W. Barnes (1999) describes this as "creeping unofficial declassification…as hungry eyes turn towards the island of uncultivated soil or standing timber in a sea of over-exploited farmland."

conflict (HEC), it persists for several reasons, including limited resources, technical solutions that are inefficient in deterring elephants, lack of commitment and cooperation from affected farmers, and the socio-economic cost of living with wildlife (Osborn and Parker 2003b).

Factors Contributing to HEC

Elephants have increased contact with humans due to changes in land-use (i.e., fragmentation of habitats because land is converted for crop cultivation, settlement, and livestock grazing) (Nelson *et al.* 2003). The human landscape has expanded into areas that were previously occupied by wildlife for several reasons. In some areas, state-sponsored and voluntary settlement programs were enacted to encourage pastoralists to take permanent residence in areas that were not being used by human populations. Since these areas are often environmentally marginal, agriculture has been rather unproductive. Farms have become more isolated in these areas as localized soil degradation has compelled farmers to plant in scattered mosaics farther from villages (Nelson *et al.* 2003). As a result, the human-elephant interface expands and creates a land-use pattern conducive to elephant foraging (Lahm 1996; Hoare and du Toit 1999). There has also been human migration as rural residents move to more urban areas in search of employment. When they abandon their fields, they leave a configuration of farmland scattered with early successional forests that attract elephants (Houghton 1994). Other rural areas have had greater interaction with elephants because they have altered the environment—artificially maintained water sources attract elephants during times of drought (Sukumar 1990; Thouless 1994; Sutton 1998), and logging brings elephants in closer proximity to humans because elephants forage on the secondary vegetation that moves in after the disturbance (Barnes, R.K. *et al.* 1991; Lahm 1996). Additionally, canals and cattle fences have blocked traditional migration routes (Kangwana 1995, C. VanderPost pers. comm.), and humans have settled along the boundaries of protected areas. Though the area of interface is expanding, modern socio-economic conditions have reduced human tolerance to elephant presence (Naughton *et al.*, 1999).

Since natural wildlife habitat has been lost, measures have been taken to create protected areas, but local people have not always met this decision favorably. National parks created under colonial governments were established to exclude local people and protect the areas as wildlife sanctuaries. As a result, these landscapes "became frozen in time." This exclusion led to local people resenting wildlife, especially dominant wild species like elephants, because native people thought animals enjoyed economic, land-use, and political advantages that were unavailable to them (Anderson and Grove 1987). This has contributed to "determinedly hostile" attitudes towards elephants (Lee and Graham 2006). Though only 20% of elephants' range is legally protected (Said *et al.* 1995), to reduce tensions regarding protected areas, local people sometimes are given farmland in areas that had previously been elephant habitat. The habitat is disturbed as the people cut forest trees to establish farmland, which may actually be within the boundaries of a park. Elephants, already in confined habitats, come under increasing pressure as the human population makes use of scarce resources for firewood and construction materials (Yeager and Miller 1986).

For example, in Kenya, the Maasai people graze their cattle within the boundaries of national parks, especially Amboseli National Park. There are disputes over access to the park's vegetation, timber, and water. As water has become increasingly available via boreholes, livestock herds have grown, and tensions have mounted as herders, farmers, and wildlife depend on the same resources (Hart and O'Connell, 1998). This also holds true for the East Caprivi region of Namibia where as many as 5000 elephants can be found in the dry season, reaching a maximum density of 3 elephants/km^2 (Rodwell *et al.* 1995). The elephants range beyond the parks, competing with local communities for food, space, and water resources that are at a premium (O-Connell-Rodwell *et al.* 2000). In fact, competition with humans for water and land resources is one of the reasons why incidents of HEC are among the highest in the region (Lindeque 1993).

As conflicts over land-use persist, it is clear that land-use decisions affect elephant density. Though Parker and Graham (1989a and 1989b) argue that elephant abundance depends on human abundance, and elephant densities decline linearly as human density increases, Hoare and du Toit (1999) assert elephant and human density does not have a linear relationship; rather, the condition of the natural habitat is the more significant factor in determining elephant density. When human density reaches a threshold of about 15.6 persons/km^2 it upsets the critical balance between agricultural land cover and natural habitat—it is at this point that about 40-50% of the land is used for human activity. At this threshold, elephant density declines sharply, not because elephants are dying *in situ*, but because they must leave in search of less disturbed habitats. The threshold hypothesis is significant because it implies that converting land for human use could lead to a "more precipitous and less reversible local decline in elephant density" than previously predicted when relying on the linear model. Hoare and du Toit caution, however, that though the threshold hypothesis can be applied to savanna elephants, it cannot necessarily be extrapolated to forest elephants because ecological requirements and human land-use differs in forested regions.

Ecological Role of Elephants

To sustain their large bodies, adult elephants must ingest approximately 160 L of water and between 100 to 300 kg of vegetation per day. They are generalist browsers and grazers that spend 70 – 90% of their time foraging (NRP 2007). They consume plant species, including forbs, grasses, sedges, shrubs, and trees, the proportions of which vary seasonally and regionally, depending on availability. They also eat bulbs, fruits, plant bases, and roots. In both forested and savanna habitats, elephants browse throughout much of the year, and turn to grazing when rainfall increases grass production (Ulrey *et al.* 1997). Elephants graze more when grass is early in its growth cycle, but as the grasses become drier, more fibrous, and less nutritious, elephants will return to browse (NRP 2007). Adult elephants take in about 1 to 1.5% of their body weight daily in dry biomass. The amount of dry biomass consumed is influenced by environmental circumstances, digestibility, and productive functions (i.e., growth, maintenance, and lactation) (Ulrey *et al.* 1997).

Elephants are a keystone species that influence the greater ecological fitness of their environment (Owen-Smith 1988; Western 1989). While feeding, elephants may uproot, break, or knock over trees, which opens up the area of vegetation and changes the habitat conditions for other species of animals. When elephants remove trees, shrubs and grasses are able to regenerate in their place, which provides smaller herbivores foliage for consumption (Owen-Smith 1989) and may help to maintain savanna grasslands (Barnes, M.E. 1999). This process also accelerates the rate at which nutrients are recycled (Botkin *et al.* 1981).

Though human inhabitants may feel too much land is devoted to wildlife, not having enough area for elephants can affect the ecology of the area. When elephants are compressed into protected areas, which essentially become islands of isolation, biodiversity can decline (Caughley 1976; Western 1989; Cumming *et al.* 1997). Moderate elephants densities (<4 per km^2) may contribute to vegetative biodiversity; whereas, low and high densities contribute to simplified savanna vegetation. For example in Kenya’s Amboseli basin, in areas with low and high elephant densities, there are fewer plant species than in areas of moderate densities where there are two to three times as many species present. In areas with low densities, yellow-barked acacia (*Acacia xanthophloea*) dominates, and as the woodland groves become dense, the understory plants receive little light, so only a few shade tolerant plants dominate the herbaceous layer. Conversely, moderate numbers of elephants can open up the savanna canopy, enabling many species to exist in the light gaps. In fact, there is evidence that elephants protect against woody invasion in savannas and dry forest ecosystems, providing a more nutritious mix for browsing and grazing animals, which benefits subsistence herders and commercial ranchers (Western 1989).

Elephant browsing is also advantageous in tropical forests where elephants create forest gaps that facilitate a “more productive and varied” herbaceous layer, which supports other vertebrates, including bongo (*Tragelaphus eurycerus*), buffalo (*Syncerus caffer*), bush pigs (*Potamochoerus porcus*), duiker (*Cephalophus spp.*), forest hogs (*Hylochoerus meinertzhageni*), and gorillas (*Gorilla spp.*). At low densities, elephants do not create significant forest gaps, and at high densities they thin too much of the forest, which allows secondary forest vegetation to dominate. Kortlandt (1984) speculated that the simplified forests of the central Congo Basin are the result of “the absence of rejuvenation owing to the extermination of elephants,” which may portend that other diverse forests of Africa are in danger of species loss if elephants are eliminated. In addition, as elephants clear vegetation, they create pastures for other species, including livestock. In Amboseli, elephants create swamp and swamp-edge pasture for other herbivores when they feed on and trample tall sedges that can edge out better quality grasses (Western 1989).

Elephants also act as seed dispersal agents, especially for large, tough tree seeds, which would decline without them. In Botswana, M.E. Barnes (1999) found that acacia (*Acacia spp.*)

seeds dispersed in elephant dung will germinate more quickly than seeds that remain uneaten. Alexandre (1978) determined 21 of 71 species in the Tai Forest, Ivory Coast have selected for elephant dispersal. With the loss of elephants, African savannas and forests could experience tree species extinction similar to those that occurred in Central America after the mega-faunal extinctions during the Pleistocene (Janzen and Martin 1982). Owen-Smith (1988) builds on this theory of extinction with his “keystone herbivore hypothesis,” which asserts smaller mammals died off as their habitats were eliminated because larger mammals were no longer there to open up the vegetation. A modern analog is found in the Hluhluwe-Umfolozi Game Reserve in South Africa where elephants were eliminated in the late nineteenth century. With elephants no longer present to maintain the forest mix, woody vegetation invaded the area, which coincided with local extinctions of three grazers and significant declines in wildebeest and waterbuck populations (Western 1989). Because elephants have far-reaching ecological functions, elimination of elephants due to HEC could have sweeping effects for natural ecosystems and human landscapes.

Crop Raiding

Crop raiding is the most prevalent example of HEC. Much research has focused on “problem elephants” and the causes for and patterns of crop raiding behavior. Problem elephants are identified as those that extend their range into areas inhabited by humans, usually to feed on cultivated crops, but they may also damage water installations, food stores, village structures, and may, on occasion, injure or kill people (Hoare 1999b). Several studies examining problem elephants and their crop raiding behavior have drawn similar conclusions, namely that elephants consume cultivated crops because of spatial constraints and because they seek the nutrients provided by those crops. The following is a discussion of the research[3] concerning spatial and temporal patterns of crop raiding, the demographics of crop raiders, the economic value of the crop depredation, and implications for conservation.

Elephant damage is not evenly distributed within a given area, and there is broad inter-year variation—an area that sustains a large amount of damage one year may not experience a similar level of damage the next (NRP 2007). Though elephants may cause significant damage at the local level (Dudley *et al.* 1992), their regional impact on agriculture is insignificant compared to other vertebrate and invertebrate pests.[4] Communities and/or farms near a forest or protected area boundary, a migration route, or a water source suffer a disproportionate amount of damage (Naughton *et al.* 1999; Mosojane 2004). In fact, elephants have shown they have a strong sense of spatial awareness and are able to distinguish between "safe" forest and "dangerous" farmland. Elephants are more likely to raid along boundaries rather than going deep into farming areas because the risk of detection is lowest in areas that serve as a buffer between protected areas and areas cleared for cultivation (NRP 2007). Mosojane (2004) found the percentage of the field damage decreased as the area of cultivation increased. He attributes this to an "edge effect"—elephants penetrate the entire field because these smaller agricultural patches are surrounded by and may blend in with the natural vegetation. In larger patches elephants generally raid only those crops closest to the edge, and the crops in the middle are less vulnerable.

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[3] Research methods for gathering and assessing the data included: indirect measures of elephant dung characteristics (Chiyo and Cochrane 2005), monitoring field disturbance and mapping damage (Naughton-Treves 1998; Naughton *et al.* 1999; Barnes, R.F.W. 1999; Mosojane 2004; Osborn 2004; Chiyo *et al.* 2005; Marchais 2005), counting and examining spoors (Mosojane 2004; Osborn 2004), talking with local residents and governmental authorities and reviewing reports from local agricultural services (Tchamba 1996), and questionnaires, informal interviews and community meetings in conjunction with the use of global positioning system (GPS) to locate crop damage and graphical information systems (GIS) to map the locations (Nchanji and Lawson 1998).

[4] The term "pests" typically refers to any insect, bird, or animal that consumes crops at any time during the agricultural cycle—from planting to storage after harvest (Porter and Shepard 1998).

As elephant populations reach unsustainable densities (Lahm 1996) and their range decreases due to greater human activity, there is an increase in crop raiding (Sukumar 1991; Barnes, R.F.W. *et al.* 1995), which suggests a relationship between problem elephant behavior and land transformation that excludes elephants. For instance, in Uganda's Kabarole District, where Kibale National Park is located, wildlife habitat is comprised of islands and corridors surrounded by cultivated fields. Where agricultural settlements were once isolated within wildlife habitat, beyond the park's boundaries, wildlife habitat is now disappearing rapidly. Even though wildlife habitats are severely limited, farmers within 1 km of the park complain vehemently about crop loss. Near the park, the greatest predictor of crop damage was proximity to the forest edge (Naughton *et al.* 1999). In Laikipia District in northern Kenya, the spatial occurrence of crop raiding was based on distance from permanent water sources and protected areas. Raiding was most intense in sites with minimal to medium levels of crop cover and less intense in areas with maximum crop cover. Thus, small-scale farmers with "patchy" cultivation, which is usually due to inhospitable climate conditions, are more vulnerable to crop depredation than those who have fields with some sort of barrier (Lee and Graham 2006).

Though there is not a great deal of research concerning crop raiding in forest and savanna zones in West Africa[5], crop raiding is particularly intense in this region because most elephant protected areas are encircled by dense human populations (Barnes, R.F.W. 1999). The Banyang-Mbo Wildlife Sanctuary in Cameroon is a prime example of an isolated protected area, with 44 villages in close proximity to the sanctuary (Naughton *et al.* 1999). Nchanji and Lawson (1998) studied crop raiding in three of these villages. They found elephants preferred to raid specific fields and villages because the fields were close to the sanctuary or because they preferred the

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[5] Less scientific research has been conducted on elephants in West Africa than other parts of the continent (Bossen 1998).

vegetation surrounding the location: 67% of the fields were over 3 km from the village, and 70% were at the edge of the secondary forest or were actually enclaves within the forest. Overall, the damage was highly localized at the village and field level. Thus, it seems fields closest to a protected area, especially those with preferred vegetation, are most likely to be raided (Naughton *et al.* 1999).

In some areas, there are seasonal fluctuations in crop raiding that coincide with food availability and crop maturity—the greatest amount of crop damage is sustained when crops approach maturity (NRP 2007). Foods consumed by wild elephants have been determined to be lower in minerals and protein than cultivated crops (Sukumar 1989; Osborn 1998). As optimal foraging theory predicts "animals will maximize the quality of their nutrient intake whenever possible" (Begon *et al.* 1986); therefore, it is plausible that elephants raid crops to supplement diets deficient in required nutrients (Rode *et al.* 2006). Elephants may also be prompted to raid crops because secondary chemical compounds influence elephant food preferences (Omondi 1995; Seydack *et al.* 2000; Milewski 2002) and crops are more highly digestible than wild forage (Rode *et al.* 2006).

Osborne (2004) found a seasonal pattern to crop raiding in the Sebungwe region of Zimbabwe when elephants appeared to select food based on nutritional quality rather than availability. Crop raiding coincided with the period when elephants were transitioning from grass to browse at the end of the late wet season. During this transitional period, the moisture content of wild grasses decreases, and they become more coarse and fibrous—when these desiccated grasses are ingested, they wear down the teeth more quickly and lower digestive efficiency. Similarly, in Botswana in the Okavango Panhandle and the southern part of the delta, there is a general trend of raiding when the cultivated crops approached maturity at the end of the rainy season (Mosojane 2004, Marchais 2005). When elephants damaged fields early in the wet season it was due to trampling as they sought watermelon intercropped with millet (*Pennisetum glaucum*), beans (*Tylosema esculentum*), and maize (*Zea mays*) (Mosojane 2004). These studies indicate crop raiding may begin around this time because cultivated crops maintain their nutritional quality and are less fibrous while the quality of the grasses is declining.

Chiyo *et al.* (2005) studied elephants' responses to bananas (*Musa paradisiaca*) and maize to determine temporal raiding patterns. Banana plantations yield fruit throughout the year, but the maize is only available when it ripens at the beginning of the dry season. Though there was no fluctuation in the level of banana raiding, maize and other annual crops were raided after they matured in the dry season, which is, incidentally, a period when food availability is lower and the quality of natural forage declines and may even fall below levels necessary for maintaining body weight. Nutritional stress is not, however, the only factor influencing crop raiding patterns—elephants are also drawn to the ripe crops.

In tropical forests, forage quality is lowest in the wet season and highest during the dry season when new leaves and fruit are prevalent (Nchanji and Lawson 1998). Consequently, peaks in crop raiding in Central and West Africa occur at the end of the wet season when mature crops are ready to be harvested (Tchamba and Seme 1993; Lahm 1996; Tchamba 1996). Nchanji and Lawson (1998) found elephants typically raid crops during the rainy season—84% of the incidents reported happened between November and May. The seasonal raiding occurs because crops mature and trees fruit during the rainy season at a time when food availability within the sanctuary is low.

Crop raiding also relates to the social structure of the elephant herd. Since elephant breeding herds usually consist of females, their offspring, and their siblings, females are less likely to raid crops because this risk-taking behavior could jeopardize the lives of vulnerable juveniles in the herd (Chiyo and Cochrane 2005). For example, when electric fences were installed around fields in Kenya, incidents of female crop raiding decreased (Thouless and Sakwa 1995). However, young males start to become peripheral members of their natal families at six to eight years of age and spend up to a quarter of their time with older males. When males break away from their maternal family units, they begin to search for new foraging areas, which may lead them to cultivated areas (Chiyo and Cochrane 2005).

Males have been shown to gather near boundaries between protected areas and human settlements, especially when crops are typically at maturity (Osborn 1998). Some male elephants may be quite tolerant of human disturbance (Barnes, R.F.W. 1999); in fact, some bulls have been identified as habitual fence breakers (Thouless and Sakwa 1995) or crop raiders (Lahm 1996; Osborn 1998). Chiyo and Cochrane (2005) found repeated raiding by the same individuals was common and incidences of repeated raiding increased with animal age. Therefore, an area housing a few regular crop raiders may report approximately the same number of incidents as an area where many elephants raid on different occasions (Barnes, R.F.W. 1999).

In Kibale National Park, Chiyo and Cochrane (2005) determined crop raiding elephants were predominantly males, 20-24 years of age, which is also the period when they are postpubertal (20-25 years) and begin to enter sexual maturity (Poole 1994). The crop raiding may be related to reproductive preparation when the young male’s “exploratory drive” increases; they begin to engage in more risk-taking behavior, and they boost their caloric intake to sustain their growth during the pubertal period (Spear 2000; Macri *et al.* 2002; Romeo *et al.* 2002). The nutritional value of the crops, which is higher than wild forage (Sukumar 1989; Osborn 1998), may benefit the males in terms of greater body mass and longer musth[6] periods, making the raiding bulls more competitive over non-raiders as they seek a mate (Poole 1989). Elephants may also be adhering to an "optimal foraging strategy" because crop raiding maximizes nutrition and energy use: elephants can take in more calories in a short time in a cultivated field while reducing energy and time needed to travel to quality forage (Sukumar 1989; Osborn 1998). Young males may learn to raid crops through associations with older, more experienced raiders. Then once the young males become accustomed to raiding behavior and the nutritional pay-off, the raiding may become their primary means of obtaining nutrition, which is reinforced by their drive to maximize growth and maintain longer periods of musth (Chiyo and Cochrane 2005).

Crop raiding is a particular problem for elephant conservation because when elephants expand their range into human settlements, they are at greater risk of predation or maltreatment by humans (Barnes, R.F.W. 1999). Farmers living near protected areas seek redress from elephant damage, and without it, they seek ways to retaliate, including killing the problem elephants themselves (Naughton *et al.* 1999). To some degree, however, crop raiding is a way of expanding shrinking habitats. Naughton-Treves (1998) found that only 4-6% of crops were lost in fields cultivated within 500 m of Kibale National Park. The area of greatest loss was less than 200 m from the forest boundary, but this buffer area supplements elephant habitat with an "extra" 3000 ha of forage. Nevertheless, there are about 4000 people who live in this zone of heavy depredation, and farmers become frustrated because their options are limited in terms of repelling the elephants. Though people cannot be removed from their land, by exploring and

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[6] Musth is characterized by aggressive behavior, almost constant secretions from and enlargement of the temporal glands on the sides of the head, and continuous dribbling of urine. Post-pubertal males enter musth typically for a period of two to three months. Musth is accompanied by an increase in testosterone levels and heightened sexual activity, which indicates entering musth may play a role in reproductive success. Though musth has been compared to rutting behavior in ungulates, musth periods are not synchronized and can occur any time in the year (Poole and Moss 1981).

implementing different land-use strategies, humans and elephants could benefit from reduced conflict and maximized elephant forage, but this will take cooperation from those living near elephant habitats.

Impacts and Perceptions of Crop Raiding

Changes in the socio-economic structure in rural African villages have made farmers more vulnerable to elephant depredation and have contributed to hostility towards elephants. Farmers can reduce vulnerability through either “individualist self-insurance” (i.e., guarding their property, scattering fields, or diversifying crops) or through “social reciprocity between households” (i.e., sharing fields and labor and assisting neighbors in need). Many farmers are forced to practice self-insurance or risk individual loss (Carter 1997) because traditional farming strategies, which are rooted in communal property and kin networks, are eroding, and there is a trend towards private landholdings. Under the new agricultural model, collective coping mechanisms are no longer in place, which means the community does not absorb losses as a whole (Naughton *et al.* 1999), and communal guarding practices have deteriorated because there are fewer guards—more men are migrating to cities in search of employment and more children are attending school (Goldman 1996; Lahm 1996).

If a farmer suffers crop damage due to elephant raiding, it can be devastating for an individual household. With the disintegration of collective farming, subsistence farmers are especially vulnerable because their landholdings are usually small; they have no land to buffer them from contact with wildlife; and they cannot afford to hire guards for their fields (Bell 1984; Naughton unpublished data in Naughton *et al.* 1999). Farmers who own relatively large farms of greater than 5 ha are best able to cope with incidents of crop raiding because their entire field will not be damaged during a crop raiding incident (Mosojane 2004); the size of their plots enables them to plant less palatable crops near the forest, which serves as a buffer zone; or they can lease the most vulnerable land closest to the forest. Those who have small fields (<1 ha) and grow crops along the border of the forest on land are the most vulnerable and experience crop losses more often (Naughton-Treves 1998). Therefore, calculating the percentage of crops lost does not provide a good framework for determining the impact of depredation because some farmers can absorb greater losses than their neighbors (Naughton *et al.* 1999).

Though crop raiding is a real problem, HEC may not be on the rise. Rather, this may be a common misperception because the problem is receiving more political and media attention, or because there are more human-elephant interfaces, so the frequency of raiding is increasing, but the intensity per unit area is not (Hoare 1999b). It may be most accurate to describe HEC as "dynamic and dependent on the local temporal and spatial extent of interactions" (Lee and Graham 2006). Based on systematic data gathering, Dublin and Hoare (2004) concluded there is a wide gap between perceived and actual levels of conflict and elephant damage.

In fact, it often difficult to quantify the extent of the problem because monitoring systems can be flawed. For example, Hanks (2006) identified several problems with current methods for monitoring and evaluating HEC in Southern Africa:

- Data quantifying the extent of crop damage are often unreliable, which may be due in part to difficulty in distinguishing crop damage from poor production during droughts;
- Monitoring systems are not sufficiently supervised or focused enough to gather data well suited for comparative statistical analysis or land use planning;
- Field staff often have low numeracy skills causing them to incorrectly report monthly and annual statistics and summaries, or relatively poorly-educated field staff have difficulty with overly complicated reporting methods and structures;
- Farmers tend to exaggerate the extent of their losses because they see reporting damage as an opportunity to express frustration or anger about their helplessness in dealing with conflicts with wildlife; and
- In some areas, HEC is underestimated because each crop raiding event may not be reported and/or reports may lack pertinent information such as the age, sex, and number of elephants involved in the depredation.

Even if subsistence farmers in semi-arid savanna regions did not have to contend with elephants and other pests, the climate would not be suitable for crop production. In rainforests, crop yield can also be quite low because the cultivated plots are often poorly managed and small; thus, the actual economic impact due to elephant crop raiding on subsistence farmers is correspondingly small (Hoare 2000). It is also quite difficult to measure losses because farmers generally plant polycultures with varying yields and densities within poorly defined areas. Furthermore, farmers do not tend to maintain records concerning their planting regime (Naughton *et al.* 1999). Nevertheless, farmers may be inclined to base their perception of elephant damage on rare though extremely destructive events that are highly localized rather than looking at average losses. Researchers may also have a role in overstating the impact of crop raiding. They often exaggerate crop damage by extrapolating results from “hotspots” to larger areas and rarely compare farmers’ reports to actual scientific field data (Naughton *et al.* 1999).

National surveys of crop-raiding events (Lahm 1994) or studies conducted several kilometers from a protected area (Hawkes 1991) are actually more apt to identify rodents and birds as major crop raiders than farms close to protected areas (Balakrishan and Ndhlovu 1992; Plumptre and Bizumuremyi 1996). For example, Naughton *et al.* (1999) found livestock caused two-thirds of crop damage (albeit on a smaller-scale and usually by animals from neighboring farms), and the damage from these domestic raiders was persistent. But farmers do not complain as much about these losses because they have “institutionalized modes of restitution,” and livestock is perceived to provide economic benefits for the community (Naughton-Treves 1998). Similarly, on the outskirts of Banyang-Mbo Wildlife Sanctuary, it was not elephants that caused the majority of the crop damage, rather domestic goats (*Capra hircus),* grasshoppers, and large rodents, such as cane rats (*Thryonomys swinderianus*). Naughton-Treves (1998) found redtail monkeys (*Cercopithecus ascantus*) were responsible for 51.8% of the crop foraging events, followed by cows (*Bos taurus*) and goats (combined 17.7%), and baboons (*Papio cynocephalus* – 9.6%), but in terms of total area, baboons caused the most damage (24%), followed by elephants (21%) then livestock (16%). However, the local communities complained[7] the most about elephants on the basis that they could destroy an entire field in one night (Naughton-Treves 1998; Nchanji and Lawson 1998), and they can be dangerous and have, on occasion, attacked humans (Tchamba 1995; Naughton *et al.* 1999).

Since the central government has taken ownership of wildlife and prohibited hunting, local human populations are not as tolerant of crop damage due to wildlife (Naughton-Treves 1997). Villagers often resent the elephants' protected status because farmers feel the government emphasizes the elephants' lives over the people's interests and security (Naughton *et al.* 1999). The farmers believe the government or conservationists should protect their fields from the elephants and should supply the material and fences needed to exclude them—a common belief is "nothing should interfere with their farming" (Naughton *et al.* 1999). This exaggeration and distortion probably originates from feelings of disenfranchisement and helplessness. The impoverished local citizenry is most likely seeking solutions to the limitations of their undeveloped rural economies (Dublin and Hoare 2004), and their complaints may come out of concern or annoyance about constraints on resource use imposed by conservation or government authorities (Madden 2004).

In general many people living in rural communities suffer the costs of living with wildlife, but do not realize the benefits from it (O-Connell-Rodwell *et al.* 2000). People's perceptions of wildlife are significant because in areas where HEC occurs, a reduction in

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[7] In Nchanji and Lawson (1998) complaints were most intense when they were in community meetings or when conservation authorities were present as opposed to during individual interviews.

elephant range often follows (Barnes, R.F.W. 1999; Hoare 2000). Conservationists and wildlife managers must recognize there are opportunity costs that go beyond crop damage, including competition for water sources, restricted human activity, and the need to guard agricultural fields, which may impact the amount of sleep a farmer gets, school attendance, opportunities for employment, and exposure to malaria (Hoare 2000). If people are asked to tolerate too much, they will seek solutions that could jeopardize the long-term security of elephant populations even if these elephants inhabit protected areas.

Conflict Reduction Measures

In addition to traditional deterrent methods, there has been a range of solutions that have been implemented to reduce HEC and assuage frustrations. The goal of these measures is to facilitate a more peaceful coexistence between humans and elephants. Some of these measures include: culling or controlled animal shooting, translocation, passive barrier systems, land use management strategies, and disturbance and repellent methods. The following is a discussion of the merits and disadvantages of these measures.

Traditional methods are locally varied self-defense actions farmers take to safeguard their crops (Hoare 2001). These measures include: guarding crops at night and alerting the community if elephants approach; making loud noises to deter elephants, such as beating drums or cracking a whip to mimic gun fire; setting fire to field boundaries or at field entry points; launching “missiles” ranging from sticks and stones to spears and tinder, which is often fatal for both the humans and elephants involved; clearing field boundaries to provide a buffer zone; providing a decoy of fruit or an unpalatable substance to steer elephants away from fields; taking aggressive measures, such as lining elephant paths with sharp stones or nails (Hoare 2001) or shooting elephants with small caliber weapons (Tchamba 1996), which can result in the elephants being wounded and eventually dying from infection (Nelson *et al.* 2003). Traditional methods, however, can be problematic because elephants may become habituated to them rather easily, which diminishes their effectiveness (Barnes, R.F.W. 1999; Hoare 1999a; O-Connell-Rodwell *et al.* 2000). Nevertheless, a level of deterrence can be achieved by combining a number of these methods (Nelson *et al.* 2003).

Killing problem elephants has been and continues to be a "quick-fix" solution for reducing HEC, but these practices have been criticized because "from a moral and economic perspective, it is not appropriate to destroy large and economically valuable mammals such as elephants when the value of the damaged crop (to the overall economy) is relatively small" (Tchamba 1996). Though culling enables wildlife managers or local authorities to use aggressive measures that placate local communities that have suffered depredation (Nelson *et al.* 2003), there is no evidence that destroying problem elephants reduces the magnitude of damage from crop raiding (Balakrishnand and Ndhlov 1992). Identifying the correct culprit is challenging because most crop raiding takes place at night, and often the wrong animal is identified (Nelson *et al.* 2003). Since elephants are not being taken out of their home ranges, culling does not significantly affect their movements (Whyte 1993). Though meat is a major benefit of culling and could be provided to those who have suffered damage, it may not get to the local people. Tchamba (1996) found that the local communities in Cameroon did not receive meat as compensation because it was shared among administrative, military, political, and wildlife authorities. Additionally, Tchamba found that even though the local communities were appeased, the amount of crop damage did not decrease. This is evidence that culling does not provide a solution and may create greater animosity and aggression towards elephants.

There is also the psychological impact of controlled shooting to consider. The structure of elephant society has been damaged over the years by poaching, habitat loss, translocation, and culling to control elephant populations. In areas where poaching is prevalent or where culling operations take selected individuals, elephants may exhibit aberrant behavior. Young elephant calves normally stay with their mothers for the first eight years of their lives. But in cases where young elephants are orphaned, they mature without the traditional support system that is part of elephant society, without female caregivers ("allomothers") or older bulls that help to control younger males. Elephants from herds that have been torn apart may exhibit behavior similar to humans who suffer from post-traumatic stress disorder, with symptoms including: "abnormal startle response, unpredictable asocial behavior, inattentive mothering, and hyperaggression" (Siebert 2006). Therefore, reckless culling programs could actually create greater disturbance for both the elephants and the humans who live in their vicinity.

Despite the possible negative impacts, a controlled culling program could be combined with trophy hunting if the programs are carefully designed for minimal animal disturbance. This could work during the season when crop raiding is at its peak because it could actually reduce the total number of elephants shot each year (Taylor 1993). For example, Zimbabwe has initiated a selective culling regime in the form of regulated safari hunts for problem animals, which has been somewhat constructive because it replaces an unsuccessful compensation scheme (Hoare 1995) by returning some of the hunting revenue to farmers who have suffered crop damage (Hoare 1999b). Under such a scheme only males would be culled, which has less impact on the demographics of the population than removing a female because it is less disruptive to child rearing (Sukumar and Gadgil 1988; Sukumar 1991). However, hunting practices would need to be vigilantly supervised to ensure quotas are not manipulated or abused (Nelson *et al.* 2003) and to avoid culling or hunting so intense that elephants cause even greater damage to crops because smaller herds join thus creating larger more destructive groups (Southwood 1977). This is a management technique that should be assessed on a case-by-case basis because problem elephants in a population could easily be replaced by other individuals if underlying problems persist (Nelson *et al.* 2003).

Translocation may appeal more to conservation organizations because, theoretically, it has a number of advantages, including saving elephants from being killed, replenishing populations that have been diminished by poaching, and taking obvious action that satisfies local communities and conservation organizations. In practice, translocation requires trained specialists and is logistically complicated and costly (Nelson *et al.* 2003). Once again it is difficult to identify the problem animal (Hoare 1999b; Hoare 2001), and capturing and transporting the elephants is stressful (Njumbi *et al.* 1996; Hoare 1999a). For example, in Kenya, 26 elephants were part of the Mwea-Tsavo translocation, but five of the animals died from drug-related stress (Njumbi *et al.* 1996). In addition, translocation is not effective if the conflict involves migratory elephants like those that are only present in Kaélé, Cameroon during the wet season (Tchamba 1995). Fisher and Lindenmayer (2000) reviewed 180 animal translocations and concluded translocations meant to solve conflicts between animals and humans failed in general. Nevertheless, translocation can play a roll in elephant conservation by replenishing herds whose numbers become too small to remain genetically viable.

Passive systems are barriers designed to control elephant movement and keep them out of agricultural areas. These systems include electric, stone or wooden fences, trenches, and other barriers such as thorn branches. Since fence construction can be very expensive, as an alternative, stone walls and trenches have been constructed with acceptable short-range results.

But over time, stone walls do not tend to work on their own because elephants can break them with their chests. Stone walls can be made more effective if reinforced with concrete or an electric wire along the top (Thouless and Sakwa 1995). In Namibia's Caprivi region, creating steep-sided trenches reduced elephant access to crop fields for a time, but eventually the elephants created bridges to negotiate the trenches. In some areas the trenches were reinforced with concrete, but this would not be practical or feasible on a larger-scale, which is what would be needed to surround the conservancy area (Hart and O'Connell, 1998). Similarly, the Aberdares and Mount Kenya in the Laikipia District of Kenya, were surrounded by moats and trenches, but the elephants quickly learned to break the walls down and climb through (Thouless and Sakwa 1995).

Of the passive barriers, it seems electric fences are the most enduring exclusionary measure. A study conducted by O-Connell-Rodwell *et al.* (2000) compared the effectiveness of electric fences powered by solar panels, trip alarms that activated a siren, and elephant warning calls that were played back for breeding herds and bulls. Compared to the trip alarms, which worked for the short term, and distress calls, which proved ineffective, the electric fences were the most successful solution over a period of time. They found electric fences were the only large-scale deterrents that reduced losses due to wildlife intrusion, and those made of steel wire were the most durable, but also the most expensive to install.

Passive systems could be particularly effective in combination with other methods. For instance, they could demarcate a boundary to warn that going beyond the barrier could be dangerous (Nelson *et al.* 2003). But the initial effectiveness of these systems depends on the design of the barrier and the materials used as well as elephants' reaction to the barrier (Osborn and Parker 2003b). Over the long-term though, fence construction is not as important as the maintenance; the demography of the elephant population, specifically the number of males; and the species of crops within the fence and their distribution (Thouless and Sakwa 1995). Thus, solutions made possible through donor-funding are often unsustainable because the donor agencies are unwilling to assist with maintenance costs over time (Osborn and Parker 2003b). With electric fences, maintaining the voltage is crucial. It must be maintained at a high enough level to deter the elephants—often fences that are poorly maintained will have a low voltage that is more of an irritant, and the elephants will simply destroy sections of the fence in addition to raiding the crops (Hoare 2001).

Though barriers have proven effective, they can be a problematic solution. As elephants become habituated to these fences, an "expensive arms race" can ensue between wildlife managers and the elephants (Osborn and Parker 2003b). Thouless and Sakwa (1995) have shown that shooting elephants that are the first to break a fence may be a deterrent over the long-term, and since males are typically fence breakers, the impact on reproductive rates would be minimal, but, once again, this could cause psychological disturbance. Another major problem with these defenses is that farmers tend to rely on the barriers and do not guard their fields at night when most raiding occurs; whereas, if farmers sleep at their fields, they can react quickly when animals approach. For example, Osborn (1998) determined 85% of crop raiding incidents took place in fields that were unattended. However, obtaining farmers' commitment to guard and defend their fields is complicated by the fact that they identify such activity as the responsibility of wildlife managers (MZEP 2001), and if fences have been installed, they may feel guarding is unnecessary. In addition, fences are often economically impractical because the cost of construction is more than the value of the crops they are protecting (Osborn and Parker 2003b).

In planning a fence, Hoare (2001) provides a general rule: "the smaller the project, the less it costs and the better it works."

Deterrence measures that are more low-impact for elephants and sometimes less financially onerous include disturbance calls, adaptive land-use, and repellent methods. Elephant vocalizations have been used to deter other elephants though the results have varied. For example, in a number of studies, recordings of postcopulatory rumbles attracted bulls (Poole *et al.*, 1988; Poole and Moss 1989; Langbauer *et al.*, 1991); while non-musth males were repelled by musth rumbles (but females and musth males were not) (Poole, unpublished in Osborn and Rasmussen 1995). Using other elephant vocalizations has proven challenging because these cries are not as well understood, and they are made at such low frequencies that they require specialized and expensive recording equipment to play the calls back (Osborn and Parker 2003b).

Thoughtful land-use strategies can be used alone or to complement barrier methods, which is an important consideration because the effectiveness of a fence can be undermined if palatable crops are grown within or too close to the fence (Nelson *et al.* 2003). One land use strategy that has shown potential to decrease the human-elephant interface is forest buffer zones, created by moving fields closer to human settlements and not clearing secondary vegetation close to protected areas. Near Banyang-Mbo Wildlife Sanctuary, villagers were able to reduce elephant raiding by changing their planting strategies; they repositioned fields closer to their village and away from the high-risk zones near the sanctuary. Moving the fields also reduced farmers' travel time and energy spent getting to the fields (Naughton *et al.* 1999).

Another strategy is making cultivated areas undesirable to elephants. The Chiyo *et al.* (2005) study, which found elephants are drawn to ripe crops, provides support for planting unpalatable crops to deter elephants from going into areas they could damage. If economically feasible and if environmental conditions permit, farmers could plant a buffer zone of non-preferred crops (i.e., crops high in secondary compounds) (Ebregt and Greve 2000), such as tea (*Camellia sinensis*), cowpeas (*Vigna unguiculata*), tobacco (*Nicotiana tabacum*), Irish potatoes (*Solanum tuberosum*), and coffee (*Coffea spp.*) (Chiyo *et al.* 2005; Rode *et al.* 2006). Ideally, these unpalatable crops would be near sub-optimal elephant habitat (Osborn and Parker 2003b) to increase the distance between the cultivated crops and prime elephant habitat. In addition, crops with a higher tannin concentration, such as cocoa (*Theobroma cacao*), sorghum (*Sorghum spp.*), and other fruits (Gu *et al.* 2004) could help to diminish the total amount of crops consumed (Rode *et al.* 2006). Since elephants also seek cultivated crops for their sodium content, salt blocks could be used to influence elephants to stay within their natural habitats and away from forest edges or close to human settlements (Rode *et al.* 2006).[8]

Chillis (*Capsicum spp.*), members of the nightshade family *Solanaceae*, have also been used to control movement. Chillis act as a repellent because they contain capsaicinoids, a combination of capsaicin (8-methyl-N-vanillyl-6-nonenamide) and several related chemicals, which are responsible for their heat intensity when consumed (Wikipedia 2008). They are particularly irritating to olfactory mucosa in an elephant's trunk—the entire trunk is coated with mucus membranes, so even small amounts of atomized capsicum stimulate the trunk (L. Osborn interview with Neilson 2006).

Capsicum-based repellents have been tested on elephants as a means of conditioning them. In Zimbabwe, Osborn and Rasmussen (1995) studied wild elephants' reaction to the aversive stimulus. When elephants exhibited unwelcome behavior, they were exposed to the

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[8] To encourage sustainable use of foraging resources, the blocks would need to be moved frequently to prevent the elephants from depleting the vegetation in the surrounding areas (Rode *et al.* 2006).

capsicum via aerosol spray with the hope that they would associate adversity (i.e. burning sensation in the trunk, itchy skin, and watering eyes) with the unwelcome behavior of destroying crops. Theoretically, if elephants continued to make these associations, they could be deterred from foraging in cultivated areas. In the Transmara District of Kenya, Sitati and Walpole (2006) tested a variety of deterrent methods and found that elephants were deterred when farms were encircled by rope barriers covered with chilli grease. Burning capsicum may also be an option. Dung bombs—ground up peppers in dry elephant dung, which enhance the effects of the burning dung—have been used in the Democratic Republic of Congo (Hillman-Smith *et al.* 1995) and South Africa where the program seems to be working. The spicy smoke is an olfactory irritant that can drive groups of elephants away for hours at a time (Neilson 2006).

Though a number of these control and deterrent measures have proven some effectiveness, much of the literature suggests greatest effectiveness is achieved through a combination of methods.

Community Based Natural Resource Management

If a conservation program brings economic benefits, there is a greater likelihood that it will be successful. It has been suggested that negative perceptions about wildlife can be dispelled if local people are allowed to become custodians of wildlife and make decisions about wildlife "use" (Barbier 1992; Metcalf 1994). Therefore, instead of focusing solely on limiting the extent of crop raiding, the focus should shift to benefiting from living with elephants and other wildlife. Community based natural resource management (CBNRM) projects are designed to facilitate rural development, based on wildlife or other biological resources, in areas that are not designated as protected habitats (IUCN 1997; Adams 1998; Adams and Hulme 2001). These projects are similar to Janzen's (1998) wildland garden concept in which wildland nature is "relabeled" and viewed as having "all the traits that we have long bestowed on a garden—care, planning, investment, zoning, insurance, fine-tuning, research, and premeditated harvest." Key elements of CBNRM projects include securing local community participation and highlighting the link between the costs and benefits of elephant persistence (Nelson *et al.* 2003). CBNRM programs could assist with elephant conservation by keeping unprotected areas in the elephants' range available and relatively free of competing land uses. Communities involved in CBNRM projects are believed to "have a strong sense of ownership of elephants and a positive attitude towards conserving them" (DGEC 2003). However, the efficacy of any CBNRM projects depends on how well it is managed and whether the entire community feels the benefits of the program.

In CBNRM, rural communities have rights over the elephants and other wildlife, but these rights are part of a larger conservation plan that focuses on sustainable use of natural resources. Under the auspices of a CBNRM project, elephants are viewed as an economic asset, and farmers also have the right to use the elephants in a "nonconsumptive" form, such as tourism (Barnes, J.I. 1996) and enjoy "spin-off benefits" like employment and revenue-sharing from areas set aside as protected habitat. In addition, if an elephant dies or is killed in accordance with a pre-arranged (and minimally disturbing) hunt or culling operation, the local people have access to ivory and meat for the community's benefit (Barnes, J.I. 1996; Lewis and Alpert 1997). Success from non-consumptive use could change the perception local communities have about wildlife—they may begin to value the possibility of generating revenue as their tolerance for conflict increases and as they become more willing to cooperate with responsible management strategies.

Namibia established a conservation policy in 1995 that gave rural communities conditional rights over wildlife. The hope in implementing this policy was that local people would be motivated to conserve wildlife resources outside of protected areas and deter others from poaching. The people would then have an opportunity to base their local economy on the wildlife resources, especially in the Caprivi region, which offers great potential for CBNRM schemes (Barnes, J.I. 1995; Ashley and LaFranchi 1997). Though it is important to provide revenue from wildlife resources to local communities, it is also important to address the causes and outcomes of HEC because benefits to the community will not necessarily translate into compensation to individuals who have suffered losses due to wildlife (Ngure 1995). One of the biggest misconceptions about community-based utilization is that modern rural communities function as units. To make a community model work, the local people will need to commit to comprehensive crop protection systems or move from subsistence farming to a wildlife resources-based economy (O-Connell-Rodwell *et al.* 2000).

Local wildlife programs in Southern Africa, have benefited financially when elephants have been present (Bond 1994). The prospect of tourism in other countries could be a significant inducement for farmers, and it could do much to maintain existing herds because tourists place value on viewing wildlife in its natural environment. Creating a tourism industry could, however, require a movement away from such activities as farming, safari hunting, and wildlife ranching because these activities could detract from the tourist experience (Barnes, J.I. 1998). Though prospects for tourism are good in a number of African countries, tourism would not necessarily be a solution for all areas with elephant populations. For instance, in West Africa wildlife resources are not as abundant as in other parts of the continent and revenue from current tourism activities seldom offsets the cost of crop raiding (Barnes, R.F.W. 1999). If a cost-benefit analysis is conducted, the benefits derived from having elephants persist beyond protected areas (i.e., conservation of other wild species, sport hunting, tourism revenue) should outweigh the costs of having elephants persist (i.e., conflict with humans, costs of managing elephant impacts such as crop raiding) (Hoare 2000).

Finding economically viable nonconsumptive uses for animals will be important because "with the human population doubling every 30 years, wildlife areas that do not contribute to human economic welfare inevitably will be converted to uses that directly contribute to human development" (Barnes, J.I. 1998). Community-based utilization could be detrimental, however, if wildlife "use" is not controlled through effective institutions and management programs and thus becomes unsustainable. Few of these conservation mechanisms have been established, and there is not much published research into the long-term impacts on conservation problems related to elephants (Lee and Graham 2006). But if wildlife managers and conservationists can maximize benefits while minimizing costs, there is a greater chance that elephants will be able to share human habitats or at least coexist in proximate areas.

Investigating Chillis as a Deterrent to Crop Raiding

Within the conservation community, chillis are being lauded as a promising method for reducing incidents of elephant crop raiding. To investigate these techniques further and to assess the efficacy of this solution, I worked with the Elephant Pepper Development Trust (EPDT) located in Livingstone, Zambia. EPDT has developed a protocol for reducing elephant pressure in crop production areas. The protocol consists of six features: erecting a chilli string fence, applying chilli grease to the fence, burning chilli briquettes, planting a chilli buffer, creating a non-vegetative buffer zone, and practicing vigilance, especially during high periods of elephant activity.[9] My goal was to learn more about how the protocol is being implemented, to assess farmers' attitudes towards the protocol, and to evaluate its success in reducing crop raiding.

Image 1. Visual of the EPDT Protocol displayed at a demonstration farm near Livingstone

Study Area and Methods

In November 2007, I visited farms in the Mukuni, Kazungula, and Musokotwane areas (Figure 1). These visits occurred during the dry season when crop production is limited by the amount of water that can be gotten from nearby sources or from wells. All watering must be done manually; therefore, the farms visited were more representative of small-scale garden farming, rather than the larger-scale farming that takes place during the wet season.

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[9] Though the EPDT was developed primarily to deter elephant encroachment in cultivated plots, some elements of the protocol can also deter other species of problem animals, including birds (M. Karidozo pers. comm.).

Prior to my farm visits, I had developed a data form (presented in the Appendix) to assess the individual farmers' experiences with the EPDT protocol and to evaluate the degree to which the farms are successfully implementing the protocol. I completed an assessment of nine farms, which were selected because they are in various stages of implementing the protocol. For most of the farms, this is the first growing season in which they are employing the protocol; however, I did have the opportunity to see two farms that had been participating in the program since 2005.[10]

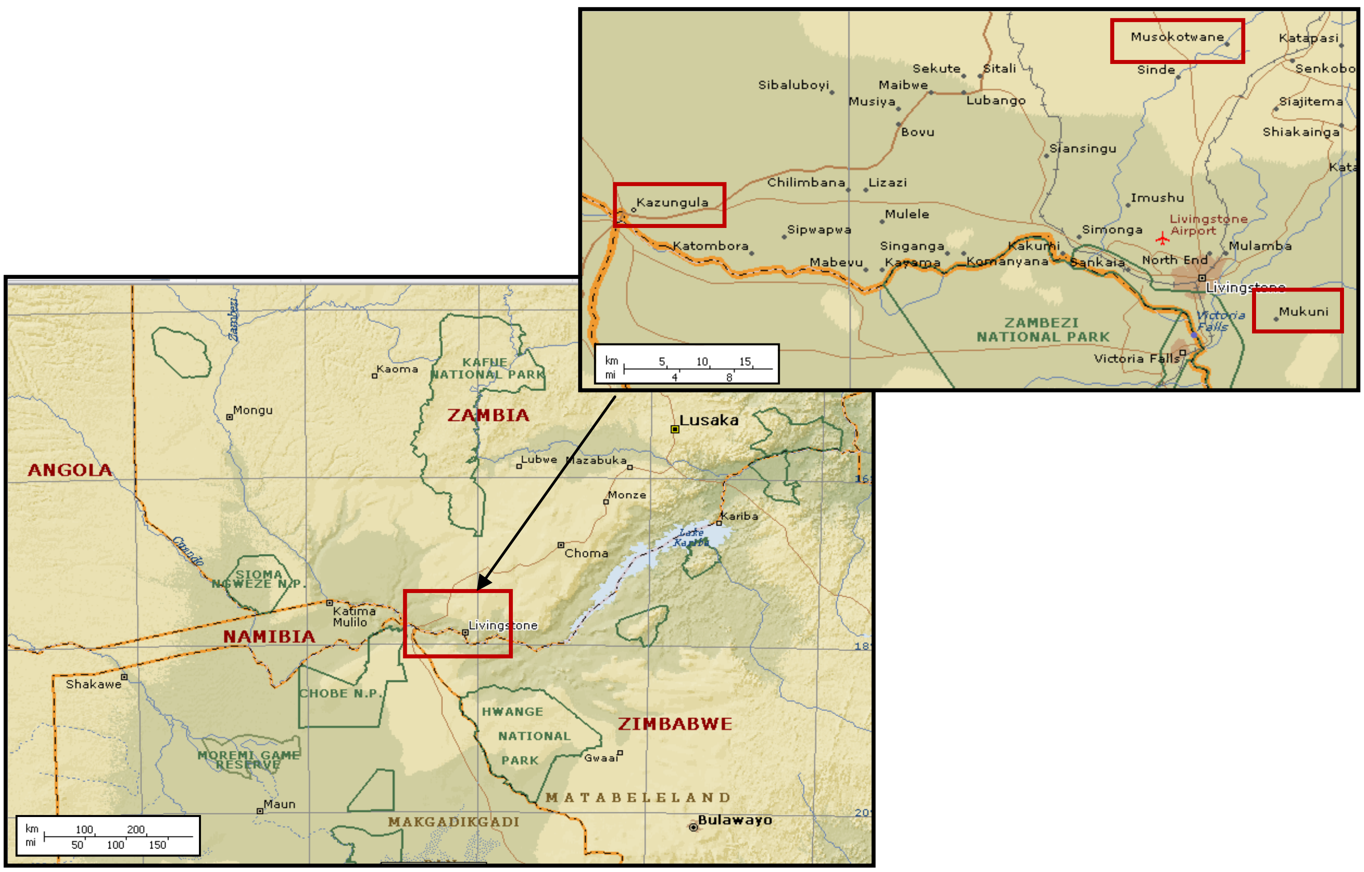


Figure 1. Study area for EPDT Protocol assessment (Source: Microsoft MapPoint)

[10] The information gleaned during the assessment has been recorded in an Excel file (presented in the Appendix) that can be added to when EPDT conducts future assessments. This database can be used to track changes at farms that are assessed on an annual or semi-annual basis.

Results

Response to the program was positive. The farmers all felt that using chillis is an effective method for deterring elephant encroachment in cultivated areas. One farmer said, “When you burn the bricks, it’s like someone is shooting at the elephants—they run.” Some of the farmers did say elephants came in or near their fields since starting the EPDT protocol; however, the elephants did not raid crops that were in chilli-protected areas even though they may have taken crops in unfenced areas or damaged the fence itself.

Though farmers seemed to have a positive attitude about the protocol, my overall impression was most farms are not implementing all six features of the protocol simultaneously. Perhaps this is because they feel they do not have the time, resources, or adequate supplies to keep up with the protocol or because they feel that implementing only some of the features of the protocol will be sufficient to deter elephants. Since most of the farms I visited are only in their first growing season, it would be unrealistic to expect the farms to have a chilli buffer along the fence. In fact, several of the farmers received nursery-grown chilli seedlings the day I conducted the assessment; therefore, the chilli buffer would not be in place for about three months (towards the end of the rainy season). Nevertheless, several farmers were not fully implementing protocol features that are not dependent on the growing season.

Image 2. Chilli seedlings grown in a nursery bed—they will be transplanted to create a chilli buffer

Most of the farmers had the chilli string fence in place, but in a number of cases the fences did not surround the entire perimeter of the field. Several of the farmers appeared to have a non-vegetative buffer zone, but in some cases I could not tell if it was intentional or not. Some farmers were not burning the chilli briquettes, or they were not doing it on a regular basis. A few reported that they only burned the briquettes when they actually detected the elephants. One farmer said he was burning only the chillis themselves rather than making the longer-burning briquettes. (This farmer also said he did not have an adequate supply of chillis for the entire growing season.) On most of the fences, the chilli grease still appeared to be effective (i.e., oily to the touch) though some did not emit a detectable odor. But farmers seemed to have difficulty specifying their application schedule. Being unclear on the schedule could prove to be problematic for determining when to do future applications.

Image 3. Chilli grease fence surrounding demonstration farm

Image 4. A recent application of chilli grease

Image 5. The remains of a burned chilli briquette

Discussion

There were some reporting constraints that may have affected the accuracy of the data I gathered. When I arrived at a farm, I would speak to one person for a single fenced area. Though some of the farms are run by an individual farmer, several are managed by a collective and/or had paid laborers. If it was a collective farm, I would interview one representative from the farm. In some cases, I did not speak directly to the owner; rather, I spoke to a representative for that farmer (e.g., a laborer or the farmer's child). Additionally, when I asked the farmer to quantify time or amounts, it was often difficult for him/her to do so. For instance, if I asked the farmer when the chilli grease was last applied and how often he/she was applying the grease, it was hard to determine whether the farmer had an accurate sense of the timing of these events.

Not being a member of EPDT enabled me to provide an outsider's perspective, but it also may have influenced my individual assessments. Since I do not speak the local language, I had to conduct my assessments in English. Most of the farmers were able to speak English (though in some cases James Mwanza, a Zambian native and EPDT employee, helped with translation); however, they may have been able to communicate more freely or precisely in their native language. In addition, my presence as a white person may have given the false impression that I was visiting the farm in an aid-capacity. When farmers described their constraints, they may have exaggerated them in an effort to seek some sort of assistance. For example, several farmers said they did not have enough string, chilli briquettes, and/or grease to implement the protocol properly. Perhaps they said this in the hope of procuring additional materials.

Since a researcher will inevitably encounter some limitations, I have tried to describe and account for them when analyzing the results of the assessment in order to reduce bias in the results. Despite the limitations, I believe I was able to get a sense of how things are working "on the ground" and to identify challenges in implementing the EPDT protocol. Though the sample size was quite small (too small for scientific analysis), these visits enabled me to see how the various farmers are using EPDT's methodology.

Vigilance appears to be the weakest area of enforcement. Most of the farmers said they would not be close to their fields at night even though some of them did have a shelter erected near the field. I was unable to determine if the farmers would have been closer to their farms if they were not using the chillis to protect their crops. Though vigilance should remain a priority, it seems farmers might be inclined to be less vigilant once the other features of the protocol are in place. Vigilance is probably the most demanding aspect of the protocol, and it is understandable that farmers may not want to stay near their fields at night, especially if they live more than 500 m from the farm. However, farmers will need to maintain vigilance even if there have not been any recent crop raiding events because a lack of human presence could increase the risk of vulnerability (Osborn and Parker 2003b), especially if farms are located in areas susceptible to crop raiding.

Studies have shown the potential of chillis to reduce elephant encroachment on farmland (Osborn and Rasmussen 1995; Parker and Osborn 2006; Sitati and Walpole 2006); however, it seems that having local farmers fully adopt these methods will be part of the challenge moving forward. EPDT is working to help farmers change their perspective to understand that agriculture does not have to compete with conservation. But this is not easily accomplished when the farmers are poor and often do not have the benefit of a strong education.

Currently, farmers appear to see the value of the program but may be reluctant to take ownership of it. With full ownership would come a greater responsibility for maintaining the structures necessary for the protocol, and it might mean farmers become less dependent on

EPDT for support. The problem could be compounded if other non-governmental organizations (NGOs) in the region provide support without the expectation that the aid recipient will also need to make a contribution or without making provisions for moving toward self-sustainability.

Farmers are expected to develop a long-term vision that will enable them to become self-sustainable after one season of support from EPDT. This could be onerous for farmers until implementing these measures becomes a matter of common practice, especially during the first year when returns may be limited. In addition, farmers may be somewhat resistant to taking greater ownership because they do not value the elephants and see the animals as the "government's problem." If farmers are looking for outsiders to take responsibility for protecting their crops, they may not want to invest too heavily in a solution that eliminates the need for or possibility of future assistance (MZEP 2001).

Farmers who were not following the entire protocol often attributed these lapses to lack of supplies or money to purchase supplies. For example, a farmer said he had not applied the chilli grease to the fence because he did not have the oil needed for the next treatment. Using lack of supplies as an excuse could go back to the ownership issue. Having adequate supplies will require the farmer to spend money (about $50 USD over five or six months), which does require a commitment to the program that goes beyond simply carrying out the chilli-protection activities. The farmers may feel they should not have to spend any money if they view the protocol only as a means of keeping the elephants away from their farms rather than as a means of ensuring a good harvest. It is an investment in their farms, and, initially, this may be a rather unwelcome or foreign concept.

Recommendations

Changing farmers' perspective of wildlife encroachment may come if farmers enjoy the benefits of implementing the EPDT protocol. However, because elephants may devise ways to bypass barriers to their crop raiding behavior or may opportunistically seek cultivated crops during the course of migration or when moving to water sources, farmers will need to make concerted efforts to reduce the likelihood of depredation. To assist farmers in doing this, I recommend using the data form, or a revised version of it, to monitor the farms participating in the EPDT program. Through monitoring, EPDT will be able to determine which farmers are most at-risk and to evaluate how well the protocol works when it is applied in varying degrees. This will help with data gathering and analysis because results can be quantified based on the degree to which the protocol was followed.

Further research is required to test the efficacy of the EPDT protocol. Though the farms implementing the protocol can provide anecdotal evidence of the chillis' deterrent properties, it will be important to also have scientific data that quantify the degree to which the chillis prevent crop raiding. Hanks (2006) suggests performing "rigorously designed field trials on mitigation methods running over several seasons." These trials should involve test plots that implement the EPDT protocol to varying degrees (i.e., some plots will implement a single feature of the protocol, some will do a combination of several features, and some will incorporate all of the features). The trials could also test influence of land use by having test plots at varying distances from protected areas and human settlements.

In addition, the extent of HEC in Zambia should be quantified. EPDT worked with the Zambian Wildlife Authority (ZAWA) to develop a database to track reports of human-wildlife conflict between May 27, 2004 and March 6, 2006. For that period, there were 283 elephant incident reports, which was more than the number of reports for all of the other species combined. Though elephants may indeed present the greatest wildlife threat, these results should be interpreted with caution. The high number of elephant reports could also be related to a desire to meet community needs. For example, communities may perceive elephants as the greatest risk because traditional methods for dealing elephant encroachment only have limited success, or an elephant may be shot as a result of a report to ZAWA with local people then benefitting from the meat (Klebelsberg 2006). Therefore, incident reports should continue to be tracked in the database, but to ensure the validity of these reports, an objective enumerator should verify the information contained in the incident report before it is entered into the database.

HEC in the Okavango Delta, Botswana

Elephant Population

It is thought that at the beginning of the nineteenth century there might have been as many as 400,000 elephants distributed throughout of Botswana (Campbell 1990). Their range diminished as large-scale commercial hunting for ivory became more prevalent and as water sources dried up. The remaining populations were restricted to the northern part of the country, but the populations began to rebound after measures were put in place to control hunting with the Wildlife Conservation and National Parks Act of 1992 (DGEC 2003).

Today, estimates for elephant populations in Botswana vary from year to year. The Department of Wildlife and National Parks's (DWNP) aerial survey data[11] for the dry seasons from 2001 to 2006 show a general growth trend, but in some years population numbers decline

[11] The surveys were based on a stratified systematic transect sampling method (Norton-Griffiths 1978), and data were collected around the same time of year though the length of the survey periods varied.

(Table 1). According to these data, elephant populations are clustered in the Okavango Delta and along the border of Zimbabwe (Figures 2-7). In terms of growth, the 2001 population estimate was 116,988, and by 2006 the estimate was 154,658, but over the seven year period, the low range estimates were between 95,196 and 133,404, and high range estimates were between 138,779 and 175,911 with 95% confidence limits. Chase and Griffin (2005) estimate annual growth rates to be about 5% per year. Though it is difficult to determine the exact number of elephants, Junker *et al.* (2008) have concluded that "elephant numbers in northern Botswana have begun to stabilize despite the high growth rate noted previously."

Table 1. Dry season aerial survey data for Botswana's elephant population from 2001 to2006 (Source: DWNP 2001-2006).

Year	Sampling Dates	No. of Elephants	Range*
2001	July 30 to Oct. 10	116,988	95,196 - 138,779
2002	July 29 to Oct. 6	123,152	106,000-140,304
2003	July 29 to Sept. 24	109,471	91,028-127,914
2004	Aug. 6 to Oct. 17	151,000	130,995 - 171,004
2005	Aug. 8 to Oct. 6	88,626	71,634 - 105,619
2006	Sept. 3 and Sept. 26	154,658	133,404-175,911

* within 95% confidence limits

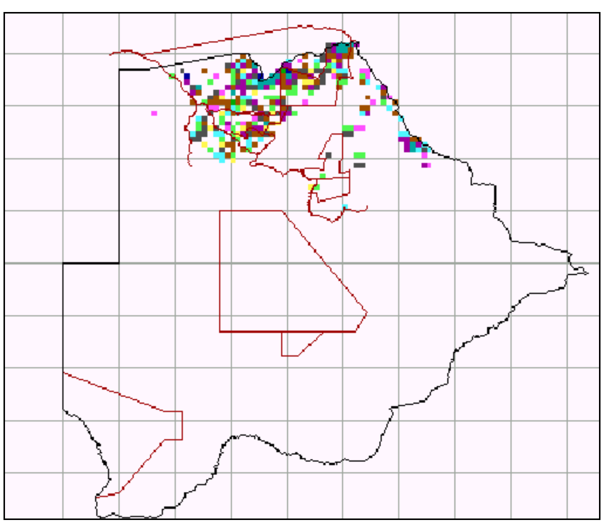


Figure 2. Elephant distribution, 2001 dry season (Source: DWNP 2001-2006)

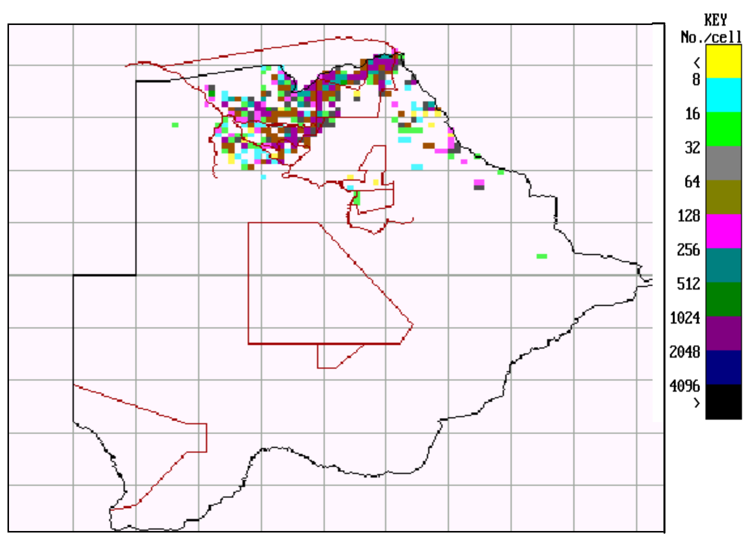


Figure 3. Elephant distribution, 2002 dry season (Source: DWNP 2001-2006)

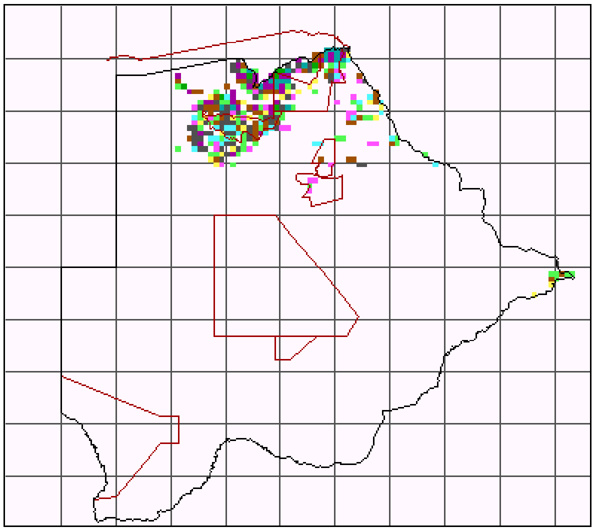


Figure 4. Elephant distribution, 2003 dry season (Source: DWNP 2001-2006)

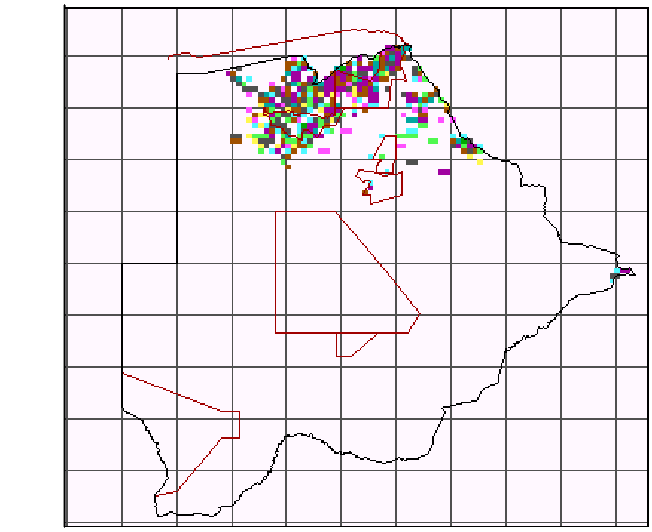
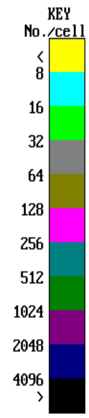


Figure 5. Elephant distribution, 2004 dry season (Source: DWNP 2001-2006)



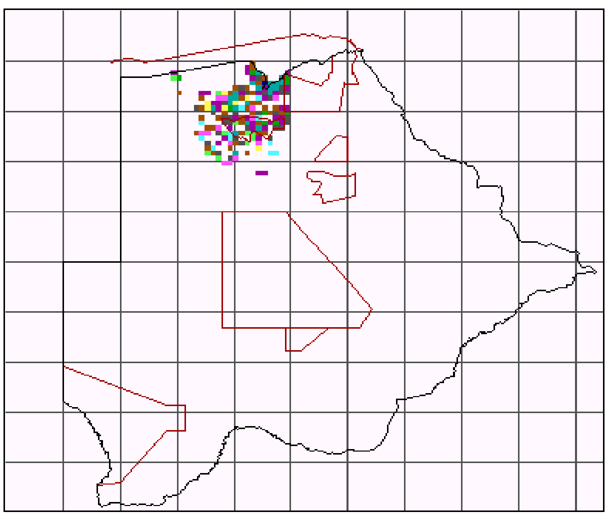


Figure 6. Elephant distribution, 2005 dry season (Source: DWNP 2001-2006)

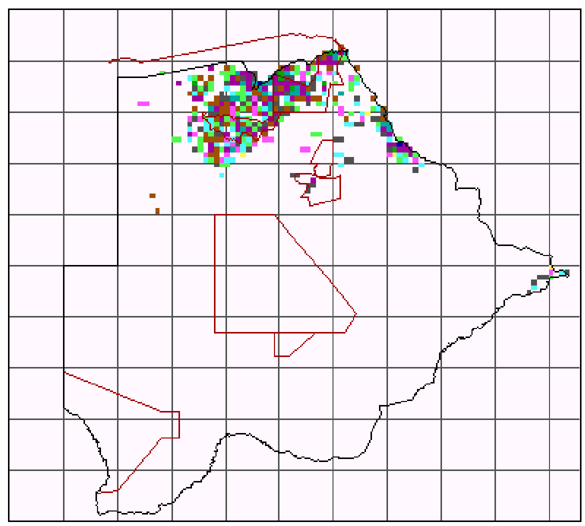


Figure 7. Elephant distribution, 2006 dry season (Source: DWNP 2001-2006)

Economic Activity

In the Ngamiland region, the area in and around the Okavango Delta, the principal economic activities are: flood recession and rain-fed farming, livestock management, hunting, fishing, gathering of veld[12] products from uncultivated areas, employment in the tourism industry

[12] Veld is a "Southern African term for natural vegetation, usually grassland or wooded grassland, typically containing scattered shrubs or trees" (Mampye 2005).

for the government or in the private sector, and small scale commercial enterprise such as selling crafts, food or beverages. Though crop production is risky and yields are often poor, the majority of households in Ngamiland are involved in some form of agriculture. Perhaps because farming is a high-risk activity, farmers have not expanded or intensified their cultivation of arable land over time—the human population increased more than tenfold between 1968 and 2002, but the area under cultivation remained rather static (Figure 7) (Bendsen and Meyer 2002).

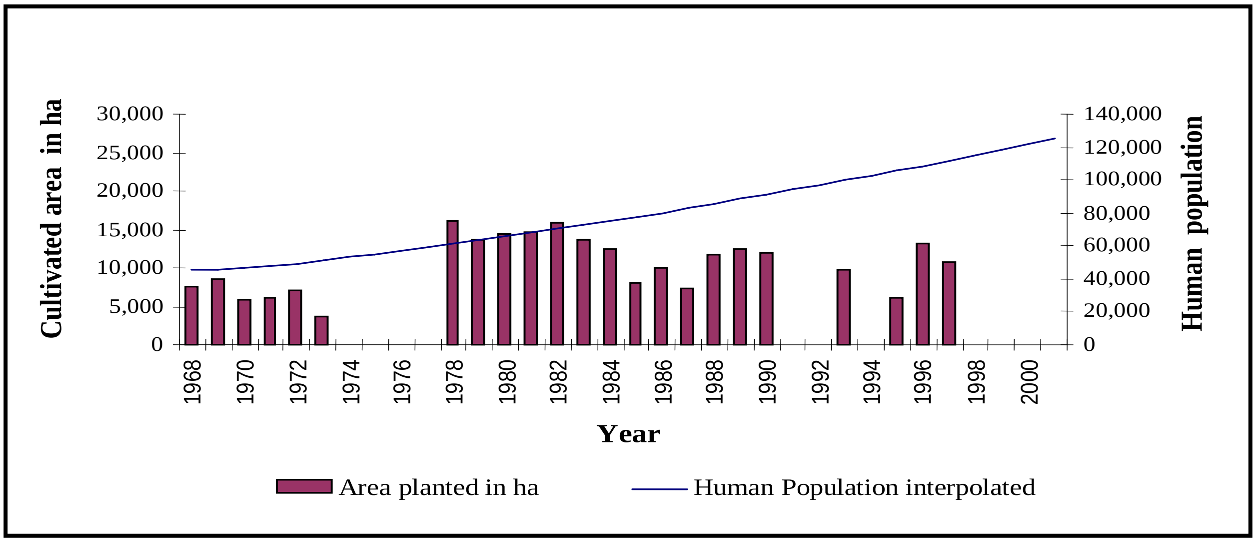


Figure 8. Cultivated area in Ngamiland in comparison to demographic changes – no statistical reports were produced for the years showing a data gap (Source: Agricultural Statistics Unit 1968-2002).

On average, only about 10,000 ha of the total arable area are cultivated during the cropping season (ASU 2002). Using remote sensing techniques Meyer *et al.* (2002) determined the total area cleared for cultivation in Ngamiland is about 48,900 ha. Traditional arable farming is divided into two types of farming: dryland farming and molapo or floodplain cultivation, which occurs in areas that are seasonally inundated. Though yields in the fertile molapo areas are typically higher, only 25% of the fields are located in floodplains; the rest of the farming occurs in dryland fields (Bendsen and Meyer 2002).

Most crop production is undertaken on a small scale and is mainly for subsistence. The average area plowed per household annually is 2.1 ha (ASU 2002). The majority of part-time farmers plow only enough area to meet subsistence needs and do not expand farming activities to produce marketable surpluses (Dorloechter 1989). However, Ndozie *et al.* (1999) determined only 10% of farmers actually reach full subsistence and are able to live primarily from their own crop production.

Image 6. A farmer in Boro in the Ngamiland District prepares her field for seeding

On average, farmers are able to harvest only 40% of the total area cultivated at the end of the cropping season—in some years, the ratio between the area planted and harvested is even lower (ASU 2002). These figures demonstrate the variability of crop-farming, with high failure rates attributable to “drought or erratic rainfall patterns, flooding (in flood-recession farmland) and crop losses or crop damage by livestock, wildlife, birds (particularly quelea), rodents, and pests.” For example, in addition to long-term, gradual changes in flood distribution patterns, Ngamiland experienced extreme flooding from 1978-79 and droughts from 1964-65, 1982-88, and in 1995. Because the rate of total crop failure is quite high, yield figures are usually based on the area that could be harvested rather than the total area planted (Bendsen and Meyer 2002).

Traditional arable farming generally involves minimal inputs with fair to low returns; yields are largely determined by unpredictable environmental conditions that are beyond farmers’ control. Since cropland irrigation is not commonly practiced, yields are based on annual rates of precipitation and rainfall distribution patterns during the cropping season. In addition, soil fertility where dryland farming is practiced is declining, and farmers are no longer using some areas that had previously been cleared for cultivation (Kirkels 1992). In an effort to reduce soil degradation, farmers will often rotate their crops with the area they have cleared for cropping, but there is no discernable model for fallowing the land (Bendsen and Meyer 2002).

Over the last 40 years, in Ngamiland traditional agricultural practices have declined in their overall economic significance. This is largely because local communities have access to alternative employment in the tourism industry or in related support services, which often provide a more reliable source of income. Though the percentage of the population involved in the agricultural sector is declining, subsistence agriculture remains an important livelihood activity because it absorbs those individuals who are not able to compete in the formal labor market. And with tourism's seasonal nature, farming is a fallback economic activity that enables households to diversify their family income (Bendsen and Meyer 2002). Nevertheless, in terms of the larger economic picture, benign tourism is a key source of revenue for Botswana, with elephants being one of the primary targets for game-viewing (DGEC 2003). In fact, a cost-benefit analysis shows the losses communities suffer due to elephant crop raiding are outweighed by the economic benefits derived from wildlife through CBNRM arrangements (NRP 2007).

Extent of and Factors Contributing to HEC

Though many people farm in Ngamiland, attitudes toward agriculture in the delta are ambivalent—communities exhibit a lack of intensity toward farming (NRP 2007) and a tendency to rely more heavily on government assistance when farming is minimally productive (Bendsen and Meyer 2002). Because Ngamiland has repeatedly experienced natural disasters, the government provides food for "destitute" households (NRP 2007). Also, as part of concession agreements through CBNRM schemes, safari operators provide some communities with a tractor for plowing at the beginning of the cropping season. Though farmers accept this assistance, they do not necessarily plow more land in an effort to increase production (Bendsen and Meyer 2002). In addition, while there seems to be a strong commitment to maintaining their livestock heritage, cultivation is not as highly regarded and is not as high of a priority. The lower status of farming coupled with government subsidies may foster a situation in which farmers are less motivated to pursue high yield production on their farms (NRP 2007).

Despite the ambivalence towards farming and the environmental conditions that make farming difficult and often relatively unproductive, farmers often point to elephant depredation as one of the greatest challenges they face in crop production. Though environmental factors influence conflict between humans and elephants, with the primary factors being access to water and rainfall patterns, land use planning is at the core of this problem (NRP 2007). Seventeen percent of Botswana is comprised of protected areas (i.e., national parks, game reserves, and wildlife management areas), but a large portion of these areas are inhospitable to elephants; therefore, while there are large elephant populations living in parks and reserves, 70% of Botswana's elephants live in unprotected areas where they may encounter human settlements (DGEC 2003). With the high rate of human population growth, people have spread out into elephant ranges, fragmenting and transforming the land for crop production and competing for resources (DGEC 2003; Hanks 2006). Thus, crop raiding should not be seen as a "perverse behavior," rather as "an inevitable consequence of [elephants'] isolation in a human-dominated landscape" (Barnes, R.F.W. 2002).

Though it inarguable that elephants are responsible for a portion of the crop raiding in Botswana, the extent of the problem is still relatively uncertain. Mosojane (2004) states conflicts between humans and elephants have been occurring for a long time, and there is no evidence that these conflicts are on the rise; whereas, Masunga (2007) asserts HEC is increasing because elephant populations are growing and expanding their foraging range at the same time that human settlements are moving into previously uninhabited areas. Determining the extent of HEC is further complicated because it is unclear how much of the problem can be attributed to elephant population growth and how much can be attributed to expanding human settlements. In addition, the problem may be compounded because cultivation is taking place in areas where farming is "illegal." Farmers cultivate crops on land for which they have no formal land tenure, and they regularly cultivate within 150 m of rivers and other water sources, which is a violation of the Environmental Conservation Act.[13] This illegal cultivation means they are operating outside of any established land use plan and may be farming in areas that are traditional elephant migration paths (NRP 2007). There is evidence, however, that areas in which people and elephants overlap are relatively limited (Figure 9), and the number of incidents is determined more by the number of people than elephant density (DGEC 2003).

In a report prepared for the Okavango Delta Management Plan (ODMP), it was determined that there are three areas in the delta that are "hotspots" for HEC: the eastern panhandle (the Seronga area), the western panhandle (from Shakawe to Gumare), and Maun south (from Maun to Shorobe) (Masunga 2007; NRP 2007). These hotspots were identified by: examining incident reports recorded over a three year period in the problem animal control (PAC) book maintained by the Department of Wildlife and National Parks (DWNP), determining where the PAC unit spends the majority of its time, and speaking to local inhabitants (NRP 2007).

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[13] Though many farmers in the panhandle do not have legal land tenure, they may still make a claim for compensation if depredation occurs (NRP 2007).

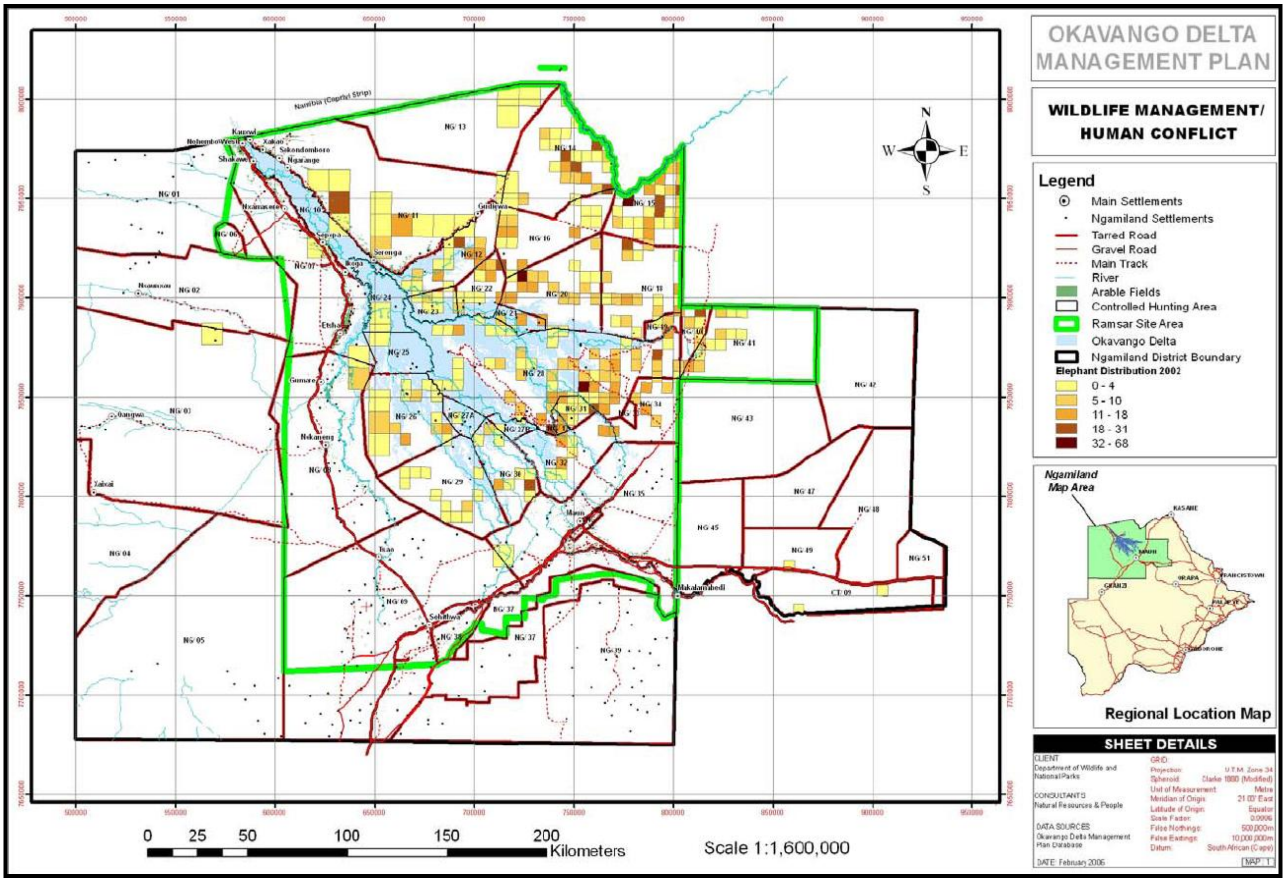

Figure 9. 2002 elephant distribution in relation to human settlements (Source: NRP)

Though these methods are helpful in identifying hotspots, these data may not present an entirely accurate picture for several reasons. The majority of the incident reports from 1997 to 2002 were generated by a few hundred people—there were 136 individuals in the database with two or more separate reports, accounting for about 45% of the reports for that five year period (DGEC 2003). The incident reports may also be influenced by which individuals are able to report a crop raiding incident, which may depend on the resources available to an individual. In remote areas where wildlife conflict is most prevalent, people had trouble reporting damage by the deadline[14] because there is often no wildlife office nearby and public transportation is limited. In addition, some farmers do not attempt to place a claim because the cost of traveling to

[14] Farmers have one week to report a crop raiding incident (Bendsen 2005).

a wildlife office is greater than the expected payout (Bendsen 2005). It must be noted as well that these hotspot determinations would be influenced by whether the PAC unit distinguished between HEC and other human-wildlife conflict, which was not made clear in the report.

Nevertheless, human settlements along the panhandle may be especially vulnerable to crop raiding because elephants pass through this area during the dry season to reach the river. In fact, agricultural expansion in the western panhandle is progressively moving into areas that elephants have traditionally used for passage between the hinterland and the river (Mosojane 2004). Additionally, a number of families in Seronga are living in clearly defined elephant movement corridors. Elephants move daily from the panhandle to the dry bushvelds in the east, which may be an indication that these animals have been displaced by people, so they spend their time in sub-optimal habitats during the day and move to the delta at night to feed and drink (NRP 2007).

Though elephants tend to avoid areas that have been altered by humans (Parker and Graham 1989a and 1989b; Hoare and du Toit 1999; Mosojane 2004), as human activities continue to expand, it is likely that their future range will be further compressed (DGEC 2003). The DWNP's aerial data indicate that in the last few decades elephant populations were clustered around areas with permanent water sources in the Okavango Delta and the Linyanti-Kwando and Chobe River Systems (Masunga 2007). In addition, the construction of veterinary or buffalo fences in parts of northern Botswana and a rapidly growing human population have led to high concentrations of elephants with restricted patterns of dispersal, which has affected the natural environment (Hanks 2001).

Availability of surface water is one of the major factors that restricts elephant movement and regulates distribution, especially at the end of the dry season (Hoare 2004). The elephants' range changes seasonally, and animals expand their range when water is widely available (DGEC 2003). During the wet season, water is not a limiting factor, and large breeding herds and bulls expand their grazing range to areas that do not have permanent water sources (Mosojane 2004). When seasonal water pools dry up during the dry season, elephants return to areas with permanent water sources, which leads to a concentration of elephants in critical habitats (Masunga 2007).

Due to the intense feeding pressure from the elephants, these habitats can undergo changes; for example, the dense woodlands in parts of Moremi Game Reserve, the northeastern panhandle, and Chobe National Park have been transformed into scrublands (Masunga 2007). Habitat modification has been an issue of concern since 1965 (Child 1968; Sommerlatte 1976; Moroka 1984; Lugoloobi 1993), and changes in natural environments could have a secondary effect on other species that share the habitat. In fact, it is possible that these habitats may become unable to support elephants themselves, which could lead to a population crash similar to that of Kenya’s Tsavo ecosystem (DGEC 2003).

The elephant population in northern Botswana is actually part of a larger population that extends from Namibia to Zimbabwe (DGEC 2003). In 2003, the ministries responsible for tourism in Angola, Botswana, Namibia, Zambia, and Zimbabwe agreed to establish the Kavango-Zambezi Transfrontier Conservation Area (KZTfCA). This contiguous transfrontier area would span 278,000 km^2 of rivers, wetlands, savanna, and woodlands in the Okavango and Upper Zambezi River Basins, and priority activities for this area would be conservation, tourism development, and sustainable development (Hanks 2006). Once the KZTfCA is established and new movement corridors are available to elephants, it is highly probable that elephants from Botswana will be able to move north into Angola and Zambia, which should: reduce the environmental impact of the highly concentrated elephant populations of Botswana and the Caprivi Strip, ease conflicts with human populations (Chase and Griffin 2005), and facilitate genetic exchange (Lee and Graham 2006). Though the KZTfCA may relieve elephant pressure on undeveloped areas, it may not directly benefit farmers affected by crop raiding who may be more concerned with seeking reparation for lost crops than in preserving and maintaining wildlife habitat.

Compensation

Throughout Africa, in areas where human-wildlife conflict exists, compensation schemes have been used to remunerate farmers and local communities that have suffered losses due to wildlife depredation. Reparations can also be a means of ameliorating situations in which water installations or food storage facilities are destroyed. Compensation is not always monetary—sometimes essential foodstuffs are distributed to those who can demonstrate life-threatening crop losses (Nelson *et al.* 2003). However, developing a good compensation scheme that upholds conservation goals is challenging because at its foundation, it is designed to address the effects of the conflict rather than the causes (Nelson *et al.* 2003; Hanks 2006; NRP 2007). In addition, there may be problems with corruption through inflated or false claims, inadequate payments or inability to pay all claims, unequal distribution of funds among those who have suffered from depredation, and expenses associated with creating a bureaucracy to deal with the claims (Nelson *et al.* 2003). Another major problem with these schemes is they could be used as a means to seek redress for grievances unrelated to wildlife depredations (i.e., poverty or lack of social benefits) (Gillingham 1998).

To reduce the impact of wildlife on people, the government of Botswana established a compensation scheme that is administered by the DWNP. In Botswana, compensation is based on a standardized payout system: farmers receive P250 (Botswana pula) per hectare regardless of the types of crops damaged. However, farmers have not been satisfied with the current compensation system. They complain the period between when an incident occurs and when a compensation claim is settled is too long (Mosojane 2004)—some farmers reported waiting a year or more to receive compensation (NRP 2007). In addition, because fields are often smaller than one hectare, payments can be a low as P10 (Mosojane pers. com. in Hanks 2006), which is often unacceptable to farmers.

The amount paid out since 2002 has been increasing, but communities are still dissatisfied and feel the compensation is inadequate (NRP 2007). The DWNP contends that payouts for damages are designed to "alleviat[e] the impacts caused by the problem animals" and are not meant to replace losses entirely (Hanks 2006).[15] Essentially, the compensation system is flawed because it does not address the problem at the root—it is simply an instrument to appease some individuals (Mosojane 2004), and it has the potential to be easily exploited and corrupted. In fact, DWNP staff members have said they felt like they were "trying to implement a flawed system," and "compensation and PAC is political" (NRP 2007).

Though the DWNP's wildlife compensation scheme does not appear to be working for farmers or the government, livestock compensation practices have been more successful and have helped to diffuse tensions around crop raiding by livestock. In a focus group conducted for the ODMP report, community members said livestock also damage their fields, but the damage is less severe and not as frequent as damage done by wildlife.[16] These assertions may be

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[15] Because of this distinction, in the DWNP policy regarding compensation, the word *compensation*, which means "replacement of the value," will be changed to the term *ex gratia*, which means "out of kindness" (Bendsen 2005).
[16] In Ngamiland, the main areas for livestock management are Maun/Shorobe, Toteng/Sehithwa/Tsau, Nokaneng/Gumare, Shakawe, and Seronga (Bendsen and Meyer 2002); three of these areas, Maun South, the western panhandle, and the eastern panhandle were also identified as HEC "hotspots" (NRP 2007; Masunga 2007).

influenced by the fact that communities usually have a traditional compensation scheme for livestock damage. The field owner estimates the cost of plowing the field, and the livestock owner pays the plowing cost. Or if the fencing around the field has been damaged, the livestock owner will either repair the fence or pays the cost of repairing the fence. The majority of the people were satisfied with this flexible system, which leaves room for negotiation and provides a sense of empowerment for both parties. Therefore, it seems policies that establish compensation systems within the context of a CBNRM model would be preferable and more economically effective than a compensation system that relies on payouts from the central government (NRP 2007).

Study Area and Methods

In 2007, I evaluated HEC in the Okavango Delta in an area located between Maun and Shorobe. The Okavango Delta is one of the world's largest Ramsar sites. The delta is fed by the Nqoga and Maunachira channels of the Okavango River. The Okavango's waters originate in the mountains of Angola and bring alluvial deposits to the delta, which is characterized by wetlands and a rolling landscape. There are four discrete sub-environments in the delta: the panhandle region, permanent swamp areas, areas with seasonal swamps that receive the permanent swamps' overspill when the seasonal flood waters advance, and islands (McCarthy *et al.* 1998).

My study area is in the Ngamiland District of Botswana in the villages of Ditshipi in NG 32 and Boro, Daonara, Morutsa, and Xharaxao in NG35 (Figures 10 and 11). These villages are located in the southern part of the delta and are part of the seasonal swamp sub-environment. I chose this area because it is part of a larger area that has been identified as one of the three hotspots for HEC in Botswana (Masunga 2007; NRP 2007).

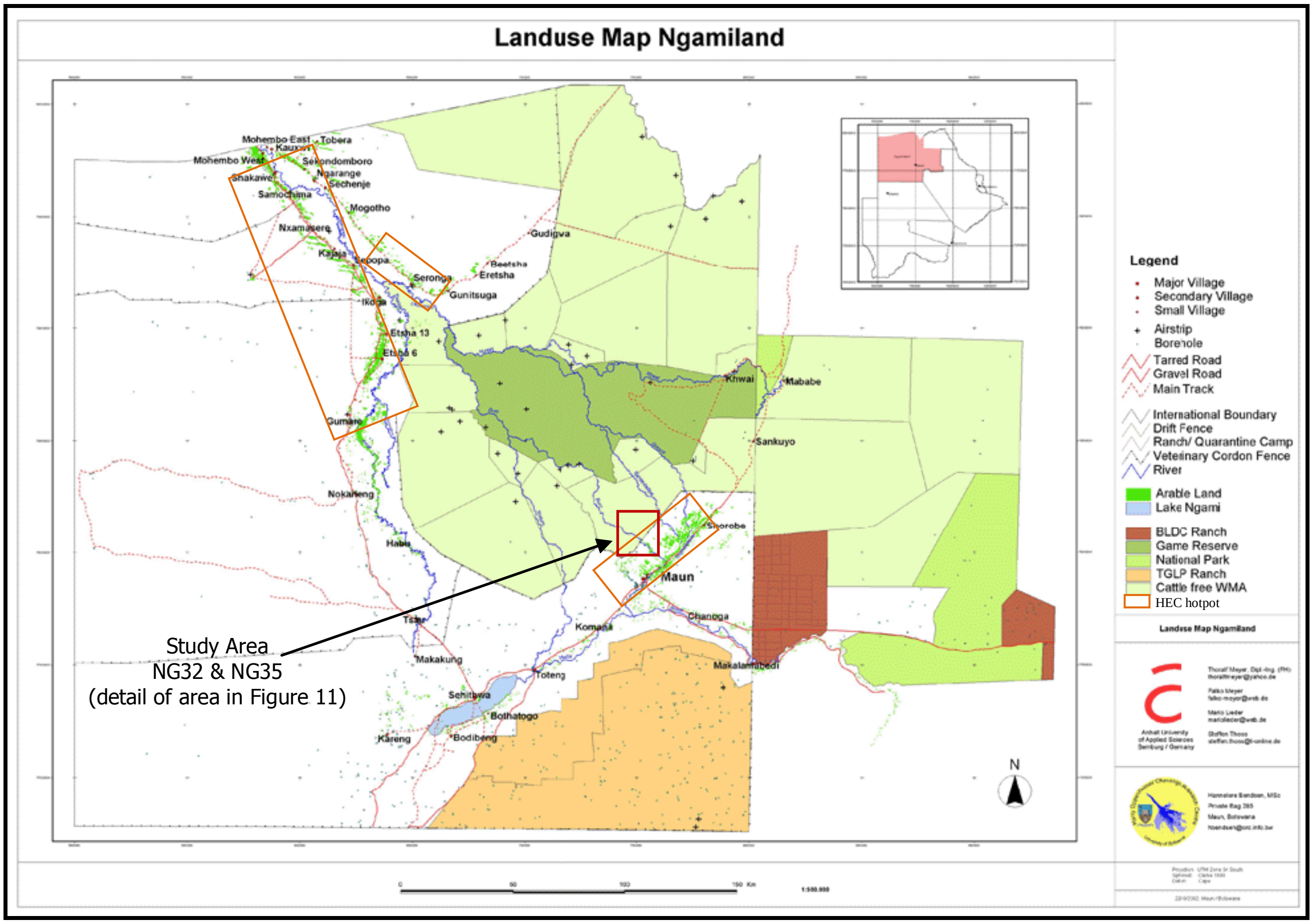

Figure 10. Land use in the delta, study area highlighted (Source: Harry Oppenheimer Okavango Research Center, University of Botswana)

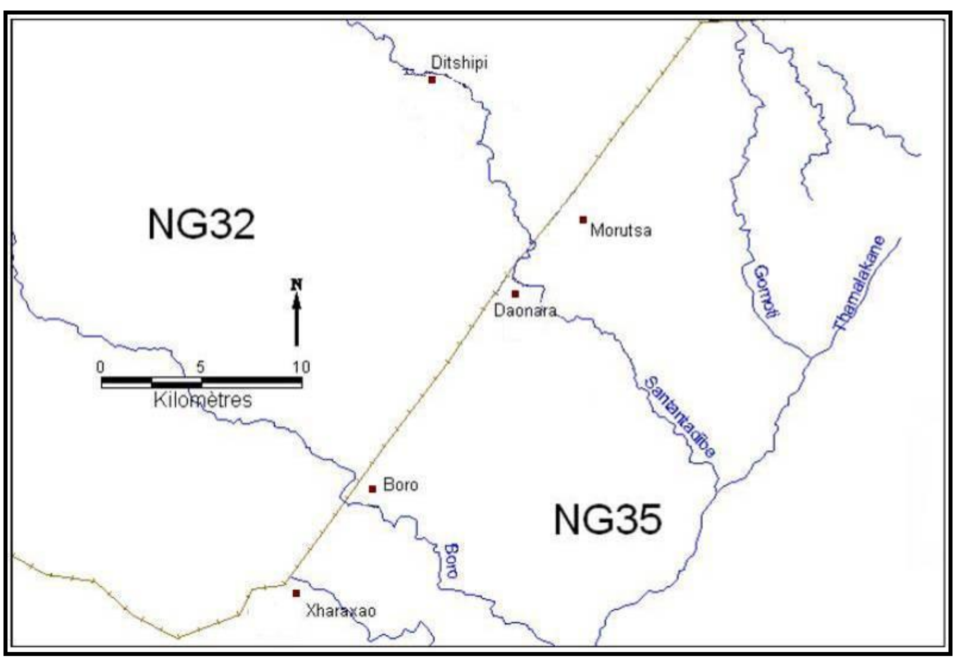

Figure 11. The five villages of the study area (Source: Marchais 2005)

These villages are managed by the Okavango Kopano Mokoro Community Trust (OKMCT), an administrative body for implementing a CBNRM scheme with the objective of managing the area's natural resources sustainably and in a manner that generates income for the villagers through photographic and hunting safaris (Marchais 2005). The NG32 area is part of a buffer zone or wildlife management area (WMA) between Moremi Game Reserve and the southern buffalo fence, and NG35 lies just south of the buffalo fence.

A large percentage of the inhabitants of the villages within the OKMCT practice subsistence agriculture. The average size of fields established for cultivation is about one hectare (Marchais 2005). Though villagers practice both dryland farming and molapo cultivation, more people engage in dryland farming, which means they are dependent on rainfall to feed their crops. Mean annual rainfall for the area is about 430 mm, but rainfall is regional and unpredictable, taking the form of localized showers and thunderstorms. The summer is the rainy season with the majority of the rain beginning in November, peaking in January, and ending in March. The driest part of the year occurs during the winter from May to August (Facts on Botswana 2005). The cropping season typically runs from January to June when the rains begin to taper off. Crop raiding coincides with the dry season—it usually begins between February and May, depending on the rain, and ends between June and August (Marchais 2005).

Image 7. A molapo field in Boro is plowed after the river water has receded

To understand better the impact of crop raiding for the villages within the OKMCT, I surveyed farmers during the 2007 plowing season. My survey was designed to evaluate: farmers' experiences with elephants and other problem animals, the mitigation techniques they currently employ, government response to HEC, the degree to which they receive economic benefits from farming and tourism, and environmental factors that affect farming. The survey (presented in the Appendix) was limited to 15 questions to avoid repetition and to limit the amount of time required from each farmer. Given my limited financial means, I was unable to conduct enough interviews for a statistically significant study. Therefore, I designed an open-ended survey that would allow farmers to describe their individual experiences. I was then able to use their answers to perform a qualitative analysis that could be compared to Marchais's (2005) field assessment conducted in the same area from January to June 2004.

The majority of the farmers spoke only Setswana though some did have a limited understanding of English. To enable the farmers to express themselves freely in their native language, I hired research assistants from each of the villages who had been recommended by the OKMCT. Each of the assistants spoke English fluently and had family members who farmed in one of the villages. When possible, interviews were accompanied by field observations. Interviews were conducted in December 2007.

Results

I conducted 27 interviews: seven in Boro, five in Dianora, seven in Ditshipi, three in Marutsa, and five in Xharaxao.[17] The number of interviews was limited by the number of farmers available to talk on the days we visited the villages. In these villages, farming tends to be more of a female occupation, which was reflected when the surveys were divided along gender

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[17] The full responses to the survey can be found in the Appendix.

lines—I interviewed 19 females and eight males. Farming also tends to be an activity for older members of the community. The median age of the farmers was 50.5, and 20 of the 27 individuals surveyed were 40 or older.

All of the farmers grew maize, and almost all grew watermelon (*Citrullus vulgaris*) (89%), which is often intercropped with maize. The other crops grown by the majority of the farmers included sorghum (*Sorghum vulgare* – 74%), pumpkins (*Cucurbita spp.* – 81%), and beans (74%). Farmers also grew sweet reed (*Sorghum bicolor* – 41%), millet (26%), and groundnuts (*Vigna subterranean* – 26%) in addition to a small number who grew (33% combined) sweet potatoes (*Dioscorea spp.*), melon (*Cucumis metuliferus*), and/or wheat (*Triticum spp.*). About two-thirds of the farmers had fields that were grouped with other farmers' fields; while, the rest of the cultivated fields were in isolated areas.

Image 8. Young maize plant

Image 9. Watermelon ready for harvesting

When farmers were asked if elephants had come to their fields during the last productive growing season,[18] 89% said their fields had been raided. The amount of damage varied: 26% said their entire field was damaged during the raiding event; 40% said they sustained no or very little damage or damage only along the edge of the field; 22% said between one quarter and one half of the field was damaged, and 11% were unable to estimate the amount of damage. Farmers also had problems with other wild animals raiding their fields: baboons (63%), vervet monkeys (*Cercopithecus aethiops* – 67%), porcupines (*Hystrix africaeaustralis* – 67%), and black-backed

[18] This was defined as the last season in which they had viable crops. Because of a drought in 2006-07, some farmers' crops did not germinate. Therefore, the last productive season may have been 2005-06.

jackals (*Canus mesomelas* – 44%). In addition, 33% of the farmers mentioned having trouble with one or more of the following species: hippopotamus (*Hippopotamus amphibious*), common duiker (*Sylvicapra grimmia*), reedbuck (*Redunca arundinum*), waterbuck (*Kobus ellipsiprymnus*), springhare (*Pedetes capensis*), hornbill species (*Tockus spp*.), and red-billed francolin (*Francolinus adspersus*). Domestic animals damage farmers' fields as well—26% of farmers said livestock raided their fields.[19] In addition to problem animals, farmers said environmental conditions pose challenges and limit their yields; farmers cited lack of rain or unreliable rainfall patterns (67%) and pests and diseases (11%). Farmers also complained about the shortage of farming equipment and having a late start on plowing (22%).[20]

Farmers were asked if they thought HEC was increasing in the area, and 96% thought it was. However, when asked to provide evidence of escalation, farmers had difficulty identifying specific examples to support this assertion. Forty-eight percent of the farmers said things like, "There are too many;" "Their numbers are increasing;" or "They come often." Other farmers mentioned that elephants eat more than other animals that come or destroy the fences around their fields, but these responses do not indicate an actual increase in HEC.

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[19] This percentage might have been higher, but in the early stages of my interviews, it was not clear whether farmers were including livestock when describing problem animals. In the later stages of the surveying process, I specifically mentioned livestock as a potential problem species. When I did, the majority of the farmers said livestock do cause crop damage.

[20] A concession agreement reached by the OKMCT and one of the safari operators in the area, stipulates the operator will provide plowing services for the local farmers. This operator provides this service for at least two community trusts, but there is only one tractor. Therefore, if villagers are unwilling or unable to plow using mules, they have limited control over when the plowing is done.

Image 10. Thorn fence to deter livestock in Xharaxau

Image 11. Plastic bags are hung in the field to keep wildlife out

To keep elephants out of their fields, 71% of farmers engage in some form of passive or active mitigation: 18% have built a thorn fence (passive), though the farmers who did this said this is more to prevent livestock from entering fields; 33% have erected a palm frond fence lined with plastic bags and/or cans in the field (passive), which produces an unnatural sound if the elephants touch them or if the wind blows; and 37% drum or clap their hands when animals approach (active), but this is only effective if they are present when the elephants are there, which is usually during the night.[21] Only 11% of farmers said they stay in their fields during the growing season. Though farmers use these techniques, few of them thought they were very effective. Farmers said, “They only work part of the time;” “It helps, but it’s not very effective;” “They don’t really work;” “The thorn fences are ineffective for elephants—they push it, and it falls;” and “Bulls are less likely to be affected by the plastic.”

In addition to the prevention methods farmers are already employing, they had suggestions for measures that would help to reduce elephant pressure. Most of these proposals would involve outside assistance. Erecting an electric fence was the most common suggestion (55%). Some elaborated further, stating the villagers’ fields should be grouped; then an electric fence should surround the perimeter of the entire cultivation area. Others wanted a fence that

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[21] These percentages add up to more than 71% because some farmers use more than one method of mitigation.

would control the movement of the elephants. Twenty-two percent said the DWNP or the Botswana Defense Force (BDF) should patrol the area and chase the animals away or should shoot problem animals. A few farmers said they would be content with adequate compensation.

Since the DWNP currently compensates farmers who have experienced crop damage due to wildlife, farmers were asked if they had ever sought compensation for elephant damage. Seventy-eight percent said they had applied for compensation. Of those who applied for compensation, 65% were not satisfied with the outcome. Several said a DWNP official did not come at all, or when an official came, he/she did not authorize a payout. When farmers were paid, many felt they did not receive enough money[22] to cover the cost of the loss or the cost of plowing. One person was told she would not receive compensation because she had plowed too close to the river, which violates the rule that cultivated fields must be at least 150 m from the river (NRP 2007).

The economic importance of farming and tourism was also assessed. Sixty-seven percent of farmers said farming was their only source of income; however, 30% received additional income from working in tourism or selling agricultural products (e.g., crops, home-brewed beer, reeds). Though the majority of the farmers did not work in tourism, 59% had at least one family member who was employed in the industry, most commonly at one of the safari camps in the WMA.

Because tourism provides an important source of income for families, farmers were asked if they thought the concession area[23] was beneficial to them—78% believe it is. The majority of the farmers said the concession attracts tourists and brings money into the area. Villagers either

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[22] The range was between P25 and P400.

[23] The concession area is located in NG32—the part of the WMA managed by the Okavango Kopano Mokoro Community Trust. Benefits from the concession area are shared among the villages in NG32 and NG35.

receive the direct benefit of working in tourism or receive indirect benefits when the OKMCT disburses funds for debt relief, family emergencies, or community development projects, such as digging a borehole or providing assistance with plowing. Nevertheless, there were some concerns raised about how the OKMCT manages the community funds. One farmer said, “Some people benefit from the concession, but the executive members benefit more than the rest of the people.” Another said, “The community trust is beneficial if they use all of the money to give to the locals, but if they misuse the money, there's no benefit.”

Discussion

It is important to note that my survey was designed to assess the farmers’ experiences with HEC, and their responses may not fully reflect the reality of the situation. Roche (1999) observes “people may deliberately or accidentally not tell the truth or omit information,” and this should be taken into consideration when using participatory tools to assess impact. When relying on interviews with farmers it is crucial to watch for inconsistencies and overstatement. Complaints can be exaggerated or politicized to reflect a broader frustration about wildlife issues (e.g., prohibitions on grazing in protected areas), and complaints can be disproportional to the actual amount of crop damage because individuals are projecting “opportunity costs” (i.e., restrictions to movements and activities and fears about food and personal security) (DGEC 2003). For example, when asked about the amount of damage caused by elephants, farmers made estimates based on their memory of the event. Since this information could not be verified by an outside enumerator, the farmer could have exaggerated the amount of damage to make the problem seem worse. To expand on the results of this study and to measure the extent of HEC in Botswana, it would be necessary to conduct a quantitative analysis of the frequency of crop raiding events and the actual amount of damage sustained by individual farmers.

Though the farmers' responses may not be entirely factual, they do provide insight into the farmer's perspective and experience. Their responses, however, must be viewed within the socio-economic context of their lives. Their descriptions of HEC may mask deeper socio-economic problems, such as lack of employment opportunities, inequity in distributing revenue from tourism, and poor agricultural conditions and yields (Marchais 2005). Many of the farmers are older and have limited economic opportunities, especially because they often have not attended school or only attended until a young age (J. Marchais pers. comm.).[24]

These farmers are part of the informal employment sector, which means their "job" as a farmer is an extension of their household enterprises and production is more for subsistence than for profit. They cannot afford to lose crops, so they may experience greater frustration and a sense of helplessness because their productivity is largely based on factors they cannot control (i.e., environmental conditions and depredation by wildlife). Even if farmers have a good harvest, opportunities to move beyond subsistence are impeded because it is hard to secure transport to sell the crops and market prices for crops are low. Interestingly, the farmer with the largest farm of those surveyed (5 ha) said lack of farming equipment was his greatest challenge because with the proper equipment, he can plow a larger area and absorb losses from crop-raiding elephants. This man appeared to be in a better financial position than the other farmers I surveyed, and with that financial security, he may be able to examine the issue of HEC from a different perspective.

In addition to socio-economic limitations, environmental conditions hamper farming productivity: rainfall is highly variable, soil conditions are poor, and the land on which people are farming is often marginal (Bendsen and Meyer 2002). When asked about their greatest

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[24] In Ngamiland, the level of education is relatively low compared to the rest of Botswana—illiteracy in Ngamiland is 43% while it is only 30% for the whole of Botswana (Bendsen and Meyer 2002).

challenge as a farmer, many farmers initially talked about inadequate rainfall but then said the elephant problem is worse. Perhaps this is because it would seem humans can take measures to control elephants; whereas, environment conditions are less controllable. Almost as a contradiction, however, nearly all of the farmers said they would have a good harvest if there was no crop raiding, but then a number later qualified this by saying they would need sufficient rain to make the harvest fruitful.

Today farmers are not as free to use wildlife and the natural environment (i.e., collecting plants for construction, game hunting, medicine). Consequently, farmers may perceive elephant crop raiding as increasing because their access to the environment changed with shifts in management decisions—the Moremi Game Reserve was taken over by the DWNP in 1979, the buffalo fence was erected in 1982, and a CBNRM policy was instituted in 2000 (Marchais 2005). In addition, the delta area within the fence boundaries was declared a cattle-free zone, which meant local farmers were no longer able to graze their livestock in the delta as they had traditionally done in the past (Bendsen and Meyer 2002). During the survey a number of farmers expressed a sense of vulnerability because they have less influence on elephant activity. One farmer said, “Before the elephants weren't coming to the people because the people were shooting them, now they can't shoot and the elephants come.” Another said, “If we could shoot them, they'd go away.”

Along with these changes, many farmers view elephants as government property (Marchais 2005), and as an extension of this, they believe the government should be accountable for elephant movement and crop raiding. This belief may lead to frustration with the government around compensation, specifically the rules governing payouts. Farmers are not supposed to cultivate inside the buffalo fence, and though there has been tacit agreement between the government and the farmers to overlook crop production in this area, these farmers are not entitled to compensation. One farmer even said she was afraid the government would forbid them to plow within the WMA in the future. Furthermore, compensation levels are based on a formula—P250 per hectare—that reflects the actual amount of damage. Since most fields are one hectare or less, farmers may miscalculate the amount of damage because visually the area looks greater. In these cases, compensation is likely to be minimal, and the small payout could lead to dissatisfaction and more negative feelings about elephants.

Though farmers focus on elephants as one of their major problems, other wild animals can also cause a great deal of crop damage. Baboons, vervet monkeys, and porcupines may cause more damage, but because they are not as physically imposing as elephants and do not cause as much damage in a single raiding incident, farmers may perceive them as less destructive than elephants and minimize their impact. Farmers said these species eat crops and can damage the whole field, but this occurs over time and only if the animals come regularly. Baboons and vervet monkeys usually come during the day, so when farmers are working in their fields, they can chase them away rather easily. Farmers expressed more frustration about porcupines because they come at night, and farmers did not discover the damage until the next morning. However, unlike elephants, these species can also "eat for many days without destroying the entire field." Additionally, location may influence which species are deemed most destructive —farmers who had fields near the river's edge actually complained that hippos cause more damage than elephants. In terms of the livestock that eat crops, farmers may be less likely to complain about the damage because livestock provide tangible benefits (Naughton-Treves 1998) and communities have devised compensation schemes that they control and deem fair (NRP 2007).

When farmers were asked what could be done to reduce the elephant pressure, they said they wanted the government to erect an electric fence around their fields or electrify the buffalo fence. This response echoes responses from other communities in other regions in Africa that suffer from crop raiding (DeBoer and Ntumi 2001; Nelson *et al.* 2003). But an electric fence may not solve the problem, and it presents its own challenges because it can be expensive to construct, and if the fence is not properly maintained, it will not be an effective deterrent (Thouless and Sakwa 1995; Hoare 2001; Osborn and Parker 2003b). However, farmers already participate in little conflict management compared to other regions in Africa (NRP 2007), and in calling for a fence, it further releases them from being accountable for mitigation. In fact, farmers may contribute to the problem if their fields are located in isolated areas (Mosojane 2004).

As much as farmers express negative feelings towards elephants, their responses were equivocal when asked about the elephants' value to the community. A number of the farmers may not work in tourism themselves, but they do have family members in the industry. Farmers acknowledged that "elephants are beneficial because they attract tourists." Since most of the farmers said the OKMCT was beneficial (the OKMCT exists to manage the WMA), it seems farmers may enjoy the benefits of elephants and other wildlife, but they do not want to incur any of the opportunity costs of living with wildlife. This issue may be further complicated by the fact that some community members do not benefit from tourism, but they still bear the burden of wildlife conflict (Marchais 2005). As time goes on, however, attitudes may shift because the younger generation seems to have an unfavorable opinion of farming (Kirkels 1992; Marchais 2005) while interest in employment opportunities in tourism has grown (Marchais 2005).

Management Implications, Recommendations, and Future Research

Elephant persistence is now related to the species' interactions with the humans who live in their range and to the ability of the two species to coexist peacefully through proper management (Dublin *et al*. 1997). It is necessary to emphasize the "social ecology, where resources are seen as one component in a natural system which incorporates human communities" (Hart and O'Connell 1998). As human populations grow, people must adopt behavioral patterns that are based on appropriate management and use of natural resources. Thus, there is not a single panacea for reducing HEC; rather, local communities, wildlife managers, and conservation organizations should explore what Hoare (2001) calls a "synergy of options."

A compensation scheme could be used sparingly and in conjunction with a conservation framework. For instance in areas where there are known elephant populations, a secondary forest buffer zone could be established, and only damage sustained outside of the buffer would be compensated; this would entail limiting agricultural production and small-scale logging for firewood within the buffer zone, and it might involve redistributing land to some extent. In addition, compensation could be revoked if a village allowed hunters or poachers to have access to elephant herds. Finally, compensation should be based on a reasonable assessment of damages provided by trained professional assessors, a measure that could provide employment for members of the community as well. Compensation payouts should be set at a fair market rate for the percentage of the crops destroyed, which would essentially amount to paying the local community to tolerate some amount of damage (Naughton *et al.* 1999), but this would also require an accurate quantification of the damage and could not be based on the farmer's assessment alone.

Though there are problems with the structure of the compensation scheme in Botswana, it could be made more effective by developing a valid means of tracking crop raiding incidents. This would necessitate quantifying damage through a standardized data collection process. African Elephant Specialist Group (AfESG)[25] has developed a management "tool" that benefits the local community, in which members of the community are trained to gather data on HEC in their immediate area. The benefits of this scheme are threefold: local people become involved in wildlife management; data are more precise and are not based on anecdotal evidence that may be incomplete or flawed, and it is a source of viable employment in areas that often lack formal employment. If such a data collection scheme were established, data could be gathered at regular intervals, which would allow for more analysis and valid comparisons, and local people could serve as enumerators, which would provide a more affordable and reliable reporting system meant to track crop raiding incidence over a large area (Hoare and Mackie 1993). It is important to note, however, that the study would need to be conducted for a minimum of three years in a designated area to accurately portray inter-year variations (Dublin and Hoare 2004), and in selecting enumerators it would be essential to choose individuals with an appropriate level of education and the skill set required to meet the data collection goals.

An alternative to compensation for crop losses would be to institute a system of "self-insurance" similar to the programs being implemented in the Kunene and Caprivi regions of Namibia as part of a communal conservancy management philosophy. Essentially, the system is designed to weigh individual losses against the economic benefits of wildlife in the conservancy. Only farmers who are registered members of the conservancy can receive a payout, and the

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[25] AfESG, part of the International Union for the Conservation of Nature and Natural Resources (IUCN), is a body of 70 members from 37 countries (the elephant "range states") that has been established to address six issues that are part of elephant survival: "law enforcement, poaching, and the ivory trade; habitat loss; local overpopulation of elephants; improved elephant surveys, and human-elephant conflict" (Hoare 2000).

payout is given only if certain conditions are met. If the farmer sustains damage after making reasonable efforts to reduce losses, he/she is paid a portion of the total value of the damaged crops: claim limits range between N$120 (Namibian dollars), which is less than the value of one 50 kg bag of maize, to a maximum of N$480 for severe depredation. Since the farmer does not receive the full market value of the crops, the likelihood of fraud is reduced because the farmer's income from harvesting the crops would outweigh any compensatory award. These conditions are meant to encourage better land management practices, to increase tolerance of and appreciation for wildlife by limiting the powerlessness farmers feel when they come into conflict with wildlife, and to promote equitable distribution of the benefits derived from having wildlife in the conservancy (Hanks 2006).

Effective and sensible land-use near elephant habitat is perhaps one of the most important actions that can be taken to mitigate HEC. Elephants' ability to coexist with humans is probably based more on the spatial arrangement of cultivated fields and human settlements than the actual amount of elephant habitat that has been converted. If human land-uses do not vastly transform the land cover and if elephants are not constantly harassed, relatively high densities of humans and elephants can co-exist in the same ecosystem. However, there is a critical point at which natural elephant habitat interspersed with a human cultivation mosaic is transformed to an altered state in which patches of elephant habitat are part of a human settlement matrix. The "size and connectivity" of these patches of habitat determine whether elephants can persist or must move to more hospitable environs (Hoare and du Toit 1999). Habitat corridors between larger protected areas, could help to maintain healthy elephant populations by providing protection between patches of natural habitat with minimal conflict with humans (Osborn and Parker 2003a) and by enabling elephants to access seasonally distributed resources, such as high-quality browse and water (Lee and Graham 2006). Therefore, continuing efforts to establish the KZTfCA could reduce elephant pressure on habitats and lessen the area of interface between humans and elephants.

Since habitat preservation is more important than focusing on protection status (Hoare and du Toit 1999), especially if protection status does not contribute to effective management, land-use policies and planning are the most important tools for developing compromises for coexistence (Hoare 2000). Therefore, land use policies should not contribute to high conflict situations, such as allowing smallholder settlements in close proximity to protected areas (Naughton *et al.*1999). Rather than trying to rigidly control management issues, conservationists must try to "raise general tolerance of wildlife among the farmers, enhance their methods of defense, and lessen the impact of severe losses by elephants" (Naughton-Treves 1998). And, an added benefit of developing effective conservation initiatives designed for elephants is these measures will help to conserve the other species that fall under their "conservation umbrella" (Dublin and Hoare 2006).

The impact of elephant crop raiding could also be reduced if farmers were willing to make collective land-use decisions, such as grouping crops together in large plots (Chiyo *et al.* 2005). This could provide a greater degree of protection for individual farms—since elephants typically raid crops along the edge of the field, larger patches are likely to be less vulnerable (Mosojane 2004). Though developing a collective management system poses some challenges as farmers move away from traditional communal farming practices to private land management (Bell 1984; Lahm 1996), if it is feasible, cooperative fields could be established as part of the CBNRM practices already in place. This would lessen the impact of raiding for any single farmer who sustains damage to his/her crops (Naughton *et al.* 1999). Nevertheless, responsibility for protecting agricultural areas should be decentralized to the farmers because the more responsibility they have, the more they will invest in making their conflict avoidance measures successful (Osborn and Parker 2003b). Therefore, farmers should be encouraged to take responsibility for actively protecting their crops rather than depending on compensation after crops have been damaged.

In addition, existing land use policies must be enforced, including prohibitions on cultivating along stream banks and in established elephant movement corridors. The government must address the issue of illegal farming and settlements, particularly in hotspot areas (NRP 2007). Though it is not currently common practice, the authorities at the land board should consult with the DWNP when allocating land to communities in areas susceptible to crop raiding (Mosojane 2004). The land board has the power to permit land uses that do not clash with overall land use objectives for WMAs. If approval is granted for expanded agriculture in these areas, it would violate the stated objectives for WMAs, namely that these areas were established to utilize wildlife sustainably and to provide a buffer between wildlife preservation areas and more intensive agriculture in order to reduce conflicts between people and wildlife (DGEC 2003).

Though HEC is an issue of concern for both conservationists and those whose livelihoods depend on agriculture, more quantitative research is required to determine the extent of the problem, and viable options for amelioration should be tested in areas where humans and elephants come into contact. Before committing to a specific, and perhaps expensive, strategy for reducing conflict, it is crucial to ascertain the degree to which elephant activity is creating problems and then establish “tolerance limits” for areas where there is conflict. It must be made clear whether perception of the problem is an accurate reflection of the realities of HEC (DGEC 2003).

It will be important to evaluate the degree to which elephants actually affect crop yields. Therefore, it would be helpful to track variations in environmental factors (i.e., amount of rainfall, soil conditions, and crop reactions to environmental conditions) to determine reasonable expectations for yields given production conditions. In addition, to determine the effect of elephants on crop yields, it would be helpful to know the exact amount of crop loss due to elephant depredation versus other wildlife species and livestock.

In areas identified as hotspots, it would be beneficial and more cost effective to set up experimental plots to test various mitigation strategies, such as use of chillis and buffer zones. Authorities in Botswana would like to use chillis, especially in hotspots, to repel elephants, as recommended in the ODMP report (G. Masunga pers. comm.). Currently, the extent of chilli use is limited to a few farms that are being monitored by the DWNP. Before employing this mitigation method throughout the entire delta, it will be necessary to test the efficacy and the appropriateness of chilli-based repellants. This would require field trials over at least two growing seasons that would test the results of using the chillis at varying levels and in areas that are vulnerable to elephant depredation, such as known movement corridors and cultivation areas near water sources. Trials could combine test plots assessing chillis and buffer zones to minimize costs and maximize efficiency.

In the hotspots, research on elephant movement patterns has been minimal. To predict future elephant depredation events and to assist with land use management decisions, further investigation should focus on how human land use affects elephants' ability to persist and thrive. This would involve examining how land use (especially land conversion for agricultural uses) and habitat fragmentation impact elephant populations, specifically their movement patterns and habitat choices. This would provide an opportunity to determine if there are seasonal patterns of movement, if movement is influenced by the availability of surface water, and if movement is related to the distribution of vegetation. This information would also enable researchers to evaluate how compressed elephant populations affect the vegetation and the general health of the ecosystem.

Conclusion

There will always be individuals who do not benefit from protecting elephants, but elephant persistence can be quite advantageous to local communities. However, in attempts to conserve elephants, humans must not be made to feel that their needs are somehow less important than those of the animals being protected. Solutions that reduce fear of and animosity towards elephants will meet with more success. Even with sound management programs, there will still be those who sustain losses due to elephant presence. For those negatively impacted, actions should be taken to facilitate resource-sharing among community members, to assist individuals to develop livelihoods based on sustainable use of natural resources available because of elephant persistence, and to encourage self-reliance and vigilance, so economic activities are not disrupted by elephant depredation. If endeavors to ameliorate HEC are to be lasting and conservation goals are to be met, solutions cannot be imposed; rather, local people need to be enlisted to cooperate with and become invested in wildlife management and preservation. With a strong commitment from all parties involved, HEC should not be an obstacle to elephant conservation.

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Appendix

Data sheet used for EPDT Protocol Assessment

Date ______________________ **Farmer's Name** ______________________

Village ______________________ Commercial ☐ Subsistence ☐ Mixed ☐

Elephant Pepper Protocol

Chilli String Fence

Chilli string fence in place Yes ☐ No ☐

Fence around the entire perimeter Yes ☐ No ☐

Fence condition Good ☐ Fair ☐ Poor ☐

Chilli Grease

Chilli grease has been applied Yes ☐ No ☐

Grease is still effective Yes ☐ No ☐

Application frequency 2 weeks ☐ 2-3 weeks ☐ Monthly ☐ >Monthly ☐

Last applied ______________________

Chilli Briquettes

Farmer is burning chilli briquettes Yes ☐ No ☐

Frequency Upon detection ☐ Daily ☐ 2-4x/week ☐ <2x/week ☐ >Weekly ☐

Does the farmer have an adequate supply for the entire growing season? Yes ☐ No ☐

Chilli Buffer

Chilli buffer crop is in place Yes ☐ No ☐

Distance from the fence <1m ☐ 1m ☐ >1m ☐

Location of chilli buffer Inside ☐ Outside ☐

Buffer Zone

Surrounding vegetation Crops ☐ Grass/shrubs ☐ Fruit trees ☐ Non-fruit trees ☐

Farmer has buffer between crops and uncultivated vegetation Yes ☐ No ☐

Width of buffer <3m ☐ 3-5m ☐ >5m ☐

Vigilance

How far is the farmer's residence from the field?

<100m ☐ 100-300m ☐ 300-500m ☐ >500m ☐

Farmer will be close to field at night Yes ☐ No ☐

Farmer has a shelter erected Yes ☐ No ☐

What other PAC methods is the farmer using in conjunction with the Elephant Pepper protocol?

Drumming ☐ Creating Noise ☐ Whips ☐ Gunfire ☐ Fireworks ☐ Other ______________________

The Farm

Field Size ______________

Crops:					
Bananas ☐	Butternut Squash ☐	Cabbage ☐	Cucumbers ☐	Eggplant ☐	Guavas ☐
Impwa ☐	Leaf Vegetables ☐	Lettuce ☐	Mangos ☐	Maize ☐	Okra ☐
Peppers ☐	Pumpkin ☐	Rape ☐	Sugarcane ☐	Tomatoes ☐	Watermelon ☐

Other ______________________

Farmer's Experience

How long has the farmer been implementing the Elephant Pepper protocol? ______________________

Does the farmer think the program is effective? Yes ☐ No ☐

Have elephants raided the crops since the protocol was first implemented? Yes ☐ No ☐

If PAC methods have been applied, what was the reaction of the elephant(s)? ______________________

____

Describe any constraints the farmer may be experiencing ______________________

____

____

Farmer's general comments ______________________

____

Results of the EPDT Protocol assessment. The data file has been re-created for ease of reading.

ID	Village	Farmer	Type of Farming	Crops	Size of Field
1	Siajoba	Eustice Mushabati	Subsistence	maize, bananas, lemons, rape	25m x 50m
2	Kamwi	Chihebule Bonface	Mixed	cabbage, leaf vegetables	50m x 50m
3	Sirkalebwe	Moscow Siatembo	Subsistence	tomatoes, cabbage, onions, rape	1 ha
4	Mukemu	Ishmael Kambole	Subsistence	maize, bananas, mangos, guava, sugar cane	25m x 50m
5	Old Showground	Roy Kaanga	Mixed	maize, green pepper, pumpkin, impwa, vegetable rape, chillis	50m x 75m
6	Libuyu	Victor Himbayi	Mixed	cucumbers, peppers, eggplant, watermelon, butternuts, tomatoes, lettuce, impwa	1 ha
7	Songa	Mavis Sibuku (Women's Collective)	Mixed	maize, chillis (intercropping), okra, tomatoes	50m x 50m
8	Kazuni	Mokama Kanatu	Subsistence	tomatoes, impwa, vegetable rape, maize	75m x 100m
9	Kapalota	Felix Munyeme	Subsistence	maize, tomatoes, vegetable rape	50m x 100m

	Chilli String Fence			Chilli Grease			
ID	Fence in Place	Entire Perimeter	Appearance	Applied	Date Applied	Effective	Application Frequency
1	Yes	No	Fair	Yes	September	Yes	no schedule
2	Yes	No	Poor	No			
3	Yes	No	Good	Yes	October	Yes	2 weeks
4	Yes	Yes	Good	Yes	October	No	2-3 weeks
5	Yes	Yes	Good	Yes	last week	Yes	2 weeks
6	Yes	No	Good	Yes	last week	Yes	2 weeks
7	Yes	Yes	Fair	Yes	October	Yes	2 weeks
8	Yes	Yes	Good	Yes	October	Yes	monthly
9	Yes	Yes	Poor	Yes	September	No	no schedule

ID	Chilli Briquettes Burning Briquettes Regularly	Frequency	Adequate Supply	Chilli Buffer Buffer Crop	Distance from Fence	Placement
1	No-chillis/no brick	Upon elephant detection	No	No		
2	No		No	No		
3	Yes	2-4x/week	No	No		
4	No		Yes	No		
5	Yes	Daily	Yes	No		
6	Yes	Daily	Yes	Yes	1m	Outside
7	Yes	Daily	No	Yes	25 cm	Inside
8	Yes	weekly	Yes	No		
9	Yes	Upon elephant detection	Yes	No		

ID	Buffer Zone Surrounding Vegetation	Buffer Present	Width	Vigilance Distance of Residence	Night Presence	Shelter Erected	Other PAC Methods
1	trees	Yes	<3 m	>500m	Yes	Yes	drumming, shouting
2	trees (scattered)	Yes	3-5 m		No	No	drumming, fire
3	stream (no gap with field), road	No		300-500 m	No	No	N/A
4	stream (no gap with field), road	No		300-500 m	No	No	drumming, clapping, whip
5	trees (scattered)	Yes	3-5m	<100m	Yes	No	N/A
6	stream, trees	Yes	3-5m	200m	No	Yes	N/A
7	trees, grasses	Yes	>10 m	300-500 m	No	No	fireworks
8	grass, trees (scattered)	Yes	3-5m	>500m	No	No	N/A
9	grass, trees (scattered), crops	No		>500m	No	Yes	N/A

Survey questions for farmers in NG32 and NG35

1. What types of crops do you grow?
2. Are your fields near other farms (grouped) or a distance from other farms (isolated)?
3. Were your fields raided during the last productive growing season (i.e., the last season in which you had viable crops)?
4. How much of your field was damaged (estimation)?
5. Do you have a problem with other animals in your fields (i.e., baboons, vervet monkeys, porcupine, jackals, bat-eared foxes, common duiker, kudu, livestock)?
6. Is the problem with elephants increasing in the area? What evidence is there of an increase?
7. What are you doing to prevent elephants from entering your fields?
8. Are these methods effective?
9. What measures would help to reduce elephant pressure?
10. Have you ever sought compensation for elephant damage to crops from the DWNP? If so, what was the result?
11. Do you or members of your family work in tourism?
12. Do you have another source of income besides farming? If so, how much of your income comes from farming?
13. Is the concession area beneficial to the community? Why or why not?
14. What is the worst problem you face as a farmer? How does this compare to elephant damage?
15. Would you have a good harvest if you did not have problems with crop raiding? (I should have qualified this question by asking, “If the physical conditions/environment were the same, would the fields be productive?”)

Results of survey in NG32 and NG35

ID	Village	Sex	Age	Crops Grown: Sorghum	Millet	Maize	Watermelon	Pumpkins	Beans	Sweet Reed	Groundnuts	Other†	Fields Grouped
1	Boro	F	22	1*	1	1	1	1	1	0	0	0	1
2	Boro	F	38	1	1	1	1	1	1	0	0	0	1
3	Boro	F	43	1	0	1	1	1	1	0	0	0	1
4	Boro	F	44	1	0	1	1	1	1	1	1	1	1
5	Boro	F	46	1	0	1	1	1	1	1	1	1	1
6	Boro	F	49	1	0	1	1	1	0	1	1	0	1
7	Boro	F	54	0	1	1	1	1	1	1	0	0	0
8	Dianora	M	60	1	0	1	1	0	0	1	0	0	0
9	Dianora	M	62	0	0	1	1	1	1	0	0	1	0
10	Dianora	M	79	0	0	1	1	1	1	0	0	1	0
11	Dianora	F	85	0	0	1	1	0	0	0	0	1	0
12	Dianora	F		1	0	1	1	1	1	0	0	0	1
13	Ditshipi	M	27	1	0	1	0	1	0	1	1	0	1
14	Ditshipi	F	39	0	0	1	1	1	1	1	0	0	1
15	Ditshipi	M	40	0	0	1	1	1	0	1	1	0	1
16	Ditshipi	F	42	0	0	1	1	1	1	1	1	0	1
17	Ditshipi	F	52	1	0	1	1	0	1	1	0	0	1
18	Ditshipi	F	59	1	0	1	0	1	1	0	0	0	1
19	Ditshipi	F	65	1	0	1	0	0	0	0	0	0	1
20	Marutsa	M	25	1	0	1	1	0	0	0	0	1	1
21	Marutsa	M	27	1	0	1	1	1	1	0	1	1	1
22	Marutsa	M	55	1	0	1	1	1	1	1	0	0	0
23	Xharaxao	F	24	1	0	1	1	1	1	0	0	0	0
24	Xharaxao	F	55	1	1	1	1	1	1	0	0	0	0
25	Xharaxao	F	57	1	1	1	1	1	1	0	0	1	0
26	Xharaxao	F	60	1	1	1	1	1	1	0	0	1	0
27	Xharaxao	F	60	1	1	1	1	1	1	0	0	0	0
		Ave age	48.8	# 20	7	27	24	22	20	11	7	9	16
		Median Age	50.5	% 74%	26%	100%	89%	81%	74%	41%	26%	33%	59%

* 1 = yes, 0 = no
† sweet potato, melon, wheat

ID	Elephant raiding	Amt of Damage	Other Problem Animals						
			Baboons	Vervet Monkeys	Porcupines	Jackals	Livestock	Other†	Other Problem Animal - Comments
1	1	entire field	1	1	0	0	0	0	can damage the whole field over time
2	1	entire field	1	1	1	1	0	0	they destroy whole farm when they come, but elephants are worse
3	1	entire field	1	1	1	0	1	0	monkeys eat maize and watermelon; baboons are not as big of a problem; livestock destroy maize and eat it
4	1	none	1	1	1	0	1	1	they can spend the night and destroy the whole field if you don't chase them away
5	0	none	1	1	0	0	1	0	they destroy the whole field when they come regularly
6	0	none	0	1	0	0	1	1	they destroy the whole field when they come regularly
7	0	none	0	1	1	1	1	0	they can destroy half of the field if they come regularly
8	1	none	1	0	0	0	0	0	they eat maize & watermelon; can do a lot of damage if not chased away quickly (move in big groups)
9	1	unsure	1	1	1	0	0	0	porcupines can damage whole field because they come at night - they're worse than monkeys and baboons
10	1	entire field	1	1	1	0	0	0	they eat more than elephants
11	1	entire field	1	0	1	0	0	0	can chase baboons away before they do damage, porcupines come at night, elephants do most damage
12	1	edge	1	0	1	1	0	1	reedbuck - feed on young maize; porcupines and jackals eat watermelon
13	1	not much	1	1	1	0	0	0	porcupines feed on watermelons and pumpkins, baboons and monkeys eat maize and watermelon
14	1	edge	1	0	0	0	0	0	very destructive - feed on maize and watermelon, come more often than elephants
15	1	<½ of field	1	0	0	0	0	1	baboons don't come that often & can be chased away; hippos are a big problem (field ~300m from river)
16	1	edge	1	1	1	0	0	1	baboons do a lot of damage, but the others aren't as bad because they can be chased away with a torch
17	1	½ of field	1	0	0	0	0	1	they damage a lot if they aren't driven off; hippos are worse than elephants
18	1	unsure	0	1	0	0	0	1	hippos do much damage; last year monkeys ate small plants
19	1	½ of field	1	0	1	1	0	0	baboons feed on maize & do a lot of damage because they travel in big groups and can eat much; jackals feed on watermelons; porcupines feed on maize and do a lot of damage at night
20	1	unsure	0	1	0	1	0	1	they eat the crops, but not sure how much damage they do
21	1	~¼ of field	1	0	1	1	0	1	they eat watermelon and destroy much (~1/4 of field)
22	1	edge	0	0	1	1	0	0	feed on watermelons, no problem with livestock because the field is fenced
23	1	edge	0	1	1	1	0	0	elephants cause more damage in one visit
24	1	entire field	0	1	1	1	1	0	wild animals eat the fruit and leave the plants, but unlike elephants they can eat for many days without destroying the entire field; livestock take crops but don't destroy as much as elephants
25	1	½ of field	0	1	1	1	0	0	jackals eat watermelon; porcupines and monkeys cause a lot of damage because they come often
26	1	½ of field	0	1	1	1	0	0	jackals eat watermelon; porcupines and monkeys cause a lot of damage because they come continuously
27	1	entire field	0	1	1	1	1	0	wild animals eat the fruit not the plants, can eat for many days without destroying the entire field unlike elephants; livestock don't destroy as much as elephants
#	24		17	18	18	12	7	9	
%	89%		63%	67%	67%	44%	26%	33%	

ID	HEC Increasing	Evidence	Prevention Methods	Effectiveness	Future Assistance
1	1	they eat a lot	none		electric fence
2	1	they break the fence	none		compensation equal to the money she spent to plow
3	1	they spent 1 night & destroyed entire field; other animals don't destroy entire field	hang plastic in the field	scares the elephants	wants DWNP to patrol and chase the elephants
4	1	there are more elephants now	none		electric fence and fence that will control movement of wild animals to keep them away from people
5	1	there are more elephants now than before	none		electric fence
6	1	there are too many compared to before	none		electric fence
7	1	the elephants are nearer to buffalo fence & they cross it – they're moving from Moremi into concession area	none		electric fence
8	1	some people's fields are totally destroyed	none		village should group farms in an open space then the government can fence whole area with electric fence
9	1	they don't get compensation anymore	drumming	only works part of the time	the elephants should be culled
10	1	elephants are increasing in number	clap hands	nothing happens	wants the government to chase elephants inside the buffalo fence and make them stay there
11	0	no change over the years	palm frond/plastic bag fence	they don't really work	BDF should chase the elephants
12	1	eat a lot of the fields, number of elephants is increasing (sees more elephants)	palm frond/plastic bag fence	it helps, but not very effective	wants an electric fence around fields
13	1	before they didn't have problems with elephants coming, now they come every year	drumming, palm frond/plastic bag fence	keeps them away most of the time, but bulls less affected by plastic	find an open place where everyone can farm together and government could fence the entire area with electric fence; move farms away from river
14	1	they destroy the fields after they plow	drumming, palm frond fence with plastic & bells	it helps, but not very effective	not sure what would help, wants compensation if elephants destroy crops
15	1	getting worse because they have no way of inflicting pain on the elephants; if they could shoot them, they'd go away	drumming	doesn't help much because elephants come back	wants to be paid a lot of money because the government said they shouldn't shoot the elephants; wants an electric fence around the fields
16	1	the number of elephants is increasing - she sees more elephants	drumming, palm frond/plastic bag fence	they don't really work	wants an electric fence around fields

ID	HEC Increasing	Evidence	Prevention Methods	Effectiveness	Future Assistance
17	1	now that elephants know about the crops, they smell them and go straight there; the number of elephants is increasing (too many elephants)	drumming, stays in the field at night	it helps	government should fence the fields and electrify the fence
18	1	they come every year, but she can't remember a time when they didn't come	drumming; palm frond/plastic bag fence; goes to fields at night	they don't really work	wants compensation if animals destroy crops
19	1	this year when she plows, she's afraid elephants will come	drumming; palm frond/plastic bag fence; goes to fields at night	they don't really work	DWNP should shoot the elephants; an electric fence around the fields
20	1	they come often	put bells around the field during the growing season	the bells keep the elephants out	
21	1	more damage comes from elephants than from other animals	none		wants government assistance, but not sure what form it should take
22	1	before the elephants weren't coming to the people because the people were shooting them, now they can't shoot and the elephants come; there are too many now	drumming, walk into the wind (elephants smell human scent and leave)	doesn't help much	government should allow them to shoot the elephants so they will go away like in the past
23	1	killed cattle in Tsutsubega, village 40-50 min. away (not reported to DWNP or documented)	fence the field	fence ineffective for elephants	electrify the buffalo fence and make it taller
24	1	they come every day (there was no evidence of elephants)	livestock fence	fence ineffective for elephants	government should help with an extra fence for their field
25	1	elephants started coming in 2002, before they didn't come	thorn fence (more for livestock)	fence ineffective for elephants-they push it and it falls	electric fence around the field-wants government to help because animals belong to the government
26	1	elephants started coming in 2002, before they didn't come	thorn fence (more for livestock)	fence ineffective for elephants-they push it and it falls	electric fence around the field-wants government to help because animals belong to the government
27	1	they come every day (there was no evidence of elephants)	livestock fence	fence ineffective for elephants	government should help with an extra fence for their field
	96%				

ID	Compensation Sought	Compensation Result	Work in Tourism	Who/Position	Other Sources of Income
1	1	DWNP came and said elephants didn't destroy much	1	uncle-Elephant Back Safaris	none
2	1	DWNP came and assessed the damage, she received P70, but she spent more than that to plow	0		none
3	0		0		street vendor-sells her crops
4	0		0		none
5	0		1	brother-Elephant Back Safaris	none
6	0		0		none
7	0		1	son-cook (Kwanda Safaris)	hawker, but makes more from farming
8	1	he's gotten compensation many times	1	son at hunting safari in NG32	mokoro poler & specialist guide (makes more than from farming)
9	1	last time he received a payment was in the 1990s	0		none
10	1	they report, but they don't get a payment	1	son - escort guide	none
11	1	she has gotten money in the past, but now nothing happens when they contact DWNP	0		none
12	1	DWNP came once and paid P200, on a second occasion paid P300	1	daughter at Stanley's; son used to work at the hunting camp	yes - cut reeds & sell them
13	1	mother went to DWNP 2x, but they didn't come to assess the damage	1	brother-Baines camp chef	mokoro poling, cut grass and sell it
14	0		1	guide, maintenance, cooks, waitress	none
15	1	DWNP came to see damage but didn't do anything	1	son at Stanley's	mokoro poler
16	1	tried to get compensation, but they didn't pay after they assessed the damage	0		none
17	1	game wardens come to see damage, but don't do anything about it	1	son at Baines	selling home-brewed beer
18	1	DWNP didn't pay because they plowed next to the river (rule states you must plow a certain distance from the river) - hasn't moved field because she wants to be close to others	1	daughter - mokoro poler	none
19	1	husband went to DWNP 3x, the first 2x they didn't come, the last time they did an assessment but didn't pay	1	daughter at Stanley's; daughter at Wilderness	none
20	1	contacted DWNP, and they were paid	1	guide at Stanley's	none
21	1	has gotten compensation every time he reports, payment based on amount of damage	1	himself - escort guide (checks for illegal activities)	earns more from tourism than farming
22	1	he went 2x, first time when elephants damaged fence he received P400, second time DWNP didn't come	0		yes
23	1		0		none
24	1	2005 given P200, not enough to buy food	1	skinner	none
25	1	DWNP measured the field, they received P25	0		none
26	1	DWNP measured the field, they received P25	0		none
27	1	2005 given 200P, not enough to buy food	1	skinner	none
		21		16	None = 18
		78%		59%	67%

ID	Feelings about Concession	Worst Farming Problem	No animals/ productive farming	Additional Comments
1	it stops wild animals--it's a buffer between Moremi and the villages	pests and disease, but elephants are worse because they can destroy the whole field in one night	yes	elephants are beneficial because they attract tourists
2	not beneficial	animals	yes	last year the elephants came many times but just passed by the fields; she doesn't protect the fields because she's scared of the elephants
3	beneficial because the DWNP helps them chase wild animals	animals like monkeys, lack of rain	yes, if there is enough rain	
4	concession area attracts tourists and brings income to the area	sun destroys crops - the sun is worse than elephant, lack of rain is also a problem	yes	never had elephant damage
5	beneficial because it provides employment	cattle – the cattle and elephants are equally bad	yes	elephants are beneficial for tourism
6	not beneficial	animals taking crops and pests	yes	
7	beneficial because the villages benefit from tourism, it brings money into the community	last year it was unreliable rainfall and pests and diseases	yes	even though she's never had elephants come, she said elephants do more damage than pests and disease
8	money from the trust can help people with debt and money to start a business; people can work in tourism and gather reeds in the protected area	lack of rain, lack of machines for farming, but elephants are a problem because they kill people	yes - if there were enough rain	
9	some people benefit from the concession, but the executive members benefit more than the rest of the people	lack of rainfall and animals - they're equal	yes	no market for crops
10	they get money for the land inside the fence	lack of rain and animals - rainfall is worse than the animals, there's also a shortage of farming machines	yes	no market for crops
11	concession benefits her through the OKMCT	lack of rainfall, but animals destroying crops is worse	yes	sometimes they can harvest, but there's no transport to sell the crops, so it is only subsistence farming
12	concession is good because members of the community get money for funerals or if someone gets sick, and people make money from jobs in tourism	baboons, elephants, porcupines	yes	if the field were fenced with an electric fence, everything would be OK
13	having wildlife is a great thing and good for the concession	elephants not a big problem, but the farmers need enough rain and farming equipment	yes - if there were enough rain and no animals	people may say elephants are a big problem because they're lazy about looking after their fields
14	concession is good because some people benefit from tourism	lack of rain - if there's not enough rain, the elephants take the small crops that have germinated		
15	government gave them the trust, so they get benefits from that; they move independently in the area; people pay to see the elephants, so elephants are good for tourism	can't complain about lack of rain because that's natural; guy who plows is late; if it rains a lot the elephants go away and don't come back until after the harvest	yes	he wants the elephants culled because they kill people and destroy fields

ID	Feelings about Concession	Worst Farming Problem	No animals/ productive farming	Additional Comments
16		lack of rain - if it rains enough, elephants migrate away to higher ground	yes	she wants government to help them sell their crops rather than keeping them for subsistence
17	make money from tourism, only locals can work at camps, the locals can use the land still and it's open to the people	elephants and other animals	farming would be good without problems with animal	tourism is better than farming, but the work isn't consistent
18	concession is good because people can get jobs in tourism	water is unpredictable, lack of rain is equal to problem of elephants (worst animals: elephants, porcupines, hippos)	yes	she's afraid the government won't let them plow anymore because they're in the wildlife management area; last year plants didn't germinate because of lack of rain
19	concession is good because land is used for safaris	lack of rain - crops don't germinate, but elephants are also a problem because they eat the crops before they are ripe and until they are ripe	farming still difficult because they can get too much or not enough rain	
20	concession is good because people can work there, and there are patrols to keep the elephants in the wildlife area	shortage of plowing machines	no	
21	economic benefit from concession area - the elephants are good for the concession area	animals and lack of rainfall - his farm is totally dependent on rain	yes	he's heard of people digging trenches around their fields, but that would be very labor intensive
22	community trust is beneficial if they use all of the money to give to the locals, but if they misuse the money, there's no benefit	lack of farming equipment, which leads to plowing later in the season, this year there's enough rain, but no equipment; elephants are not as bad as lack of equipment because if there's enough equipment, he can plow more and absorb the losses from the elephants	good harvest even though govt. does not have good prices for the food	
23	brings income when tourists come to see the animals			
24	animals should be farther away; benefit from OKMCT-they dug boreholes and they plow	they are afraid they'll meet the elephants when they go to get water (they're competing for water from a stream that's drying up)		
25	before community trust was established, there were no problems with elephants because tourists and hunters could hunt; now they can't kills the elephants	lack of water-cart water from borehole ~2km away; elephants also a problem because they are a threat to personal security		
26	before community trust was established, there were no problems with elephants because tourists and hunters could hunt; now they can't kills the elephants	lack of water-cart water from borehole ~2km away; elephants also a problem because they are a threat to personal security		
27	animals should be farther away; benefit from OKMCT-they dug boreholes and they plow	they are afraid they'll meet the elephants when they go to get water (they're competing for water from a stream that's drying up)		