Solutions for elephant *Loxodonta africana* crop raiding in northern Botswana: moving away from symptomatic approaches

Tim P. Jackson, Sibangani Mosojane, Sam M. Ferreira and Rudi J. van Aarde

Abstract Conflict between people and elephants in Africa is widespread yet many solutions target the symptoms, rather than the underlying causes, of this conflict. To manage this conflict better the underlying causes of the problem need to be examined. Here we examine factors underlying spatial use by elephants and people along the Okavango Panhandle in Ngamiland, northern Botswana, to provide ways to address the causes of the conflict between elephants and people. We found that (1) elephant spatial use was a function of season, (2) spatial use did not differ between breeding herds and bull groups, (3) spatial use by elephants and people only overlapped significantly at night, during the dry season, (4) crop raiding by elephants was a function of season and social grouping, and (5) crop raiding by elephants had social and economic implications. Based on these results we suggest measures to manipulate elephant spatial use to reduce the causes of this conflict. We also reflect on present compensation measures for elephant crop damage and advocate that a more direct performance payment approach may benefit both the Botswana Government and local farmers.

Keywords Botswana, compensation, crop raiding, human-elephant conflict, land-use planning, performance payment, spatial use.

Introduction

Conflict between people and wildlife is a global conservation issue (Woodroffe *et al.*, 2005). Typically, conflict occurs outside protected areas, where the ranges of people and wildlife overlap. For example, 70% of the range of African elephant *Loxodonta africana* occurs outside protected areas (Blanc *et al.*, 2007). Conflict with people therefore seems inevitable. Presently, elephant numbers are increasing in some areas, and their ranges may also be expanding (Blanc *et al.*, 2005). Consequently, human-elephant conflict is increasingly reported, particularly where people's livelihoods are affected (Hoare & du Toit, 1999; Sitati *et al.*, 2003).

Numerous studies promote symptomatic treatments to mitigate human-elephant conflict, although many of these efforts meet with limited success (Hoare, 1999; Osborn & Parker, 2003; Graham & Ochieng, 2008), possibly because they deal with the consequences of people and elephants living together. To manage this conflict better an approach is needed that deals with the underlying causes, and not the consequences, of the problem (Hoare, 1999; Barnes, 2002). The present understanding of human-elephant conflict is fragmented, as factors underlying human-elephant conflict appear to be site-specific and unpredictable. In part this may be due to the spatial scale at which analyses are conducted and the unpredictable behaviour of individual elephants (Hoare, 1999; Sitati *et al.*, 2003). Only when the underlying causes of human-elephant conflict have been identified can a non-symptomatic management approach be applied.

Here we examine a key factor underlying human-elephant conflict (the overlap in spatial use between elephants and people), while conceding that other factors such as the nutritional quality of crops for elephants also need to be examined (Osborn, 2004). For elephants, the availability and distribution of water and food underlie patterns of spatial use (Grainger *et al.*, 2005; de Beer *et al.*, 2006; Harris *et al.*, 2008). Elephants remain close to permanent water during the dry season but with the onset of the rainy season may move away and rely instead on rain water that collects ephemerally in natural depressions scattered across the landscape (Owen-Smith, 1996; Verlinden & Gavor, 1998).

When the distribution of people and elephants overlap conflict appears to be correlated to spatial factors such as human population density, the transformation of land through agriculture, distance from roads, and proximity to daytime elephant refuges (Hoare & du Toit, 1999; Parker & Osborn, 2001; Sitati *et al.*, 2003). Changes in the seasonal distribution of elephants and people

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could explain patterns of human-elephant conflict. In the dry season, when water is limiting, elephants and people may compete for this resource. In other instances, however, human-elephant conflict is reported as elephants shift their ranges between seasons (Tchamba, 1996) or occupy wet season ranges (Thouless, 1994) where they encounter people and agriculture.

In savannah ecosystems, problem elephant activity shows a seasonal peak, usually at the end of the wet season (Hoare, 1999). This is a period when water becomes limiting as seasonal supplies dry up, presumably forcing elephants to return to more permanent water bodies. The period also corresponds to the time when savannah elephants destroy ripening crops (Hoare, 1999).

Here we examine the spatial-temporal distribution of elephants and people and the manner in which this may underlie patterns of crop raiding along the Okavango Panhandle in northern Botswana. The regional elephant population across northern Botswana has apparently stabilized (Junker *et al.*, 2008), while the human population continues to grow (Central Statistics Office Botswana, 2002). Given our present understanding of elephant spatial use and human-elephant conflict, we will show how season determines elephant spatial use, that spatial use does not differ between bulls and breeding herds, and that crop damage is a consequence of elephant spatial use and its overlap with people and their livelihoods. Finally, based on our findings, we examine the present scheme used by the Botswanan Government to compensate farmers for crop damage, and suggest a more direct performance payment method to reward farmers effectively for the ecological services they provide.

Study area

Our study area forms part of the Ngamiland District of north-west Botswana. For administrative purposes the area is commonly referred to as NG11. It extends over a controlled hunting area of 5,952 km^2. The Okavango River, which forms a Panhandle to the Okavango Delta, marks the southern and western boundaries of NG11 (Fig. 1). The international boundary with Namibia, which is fenced, delineates the northern boundary, and NG11 adjoins NG13 to the east. Rain falls predominantly during the summer (November-April) and the area receives a mean annual rainfall of 500 mm (Department of Meteorological Services Botswana, 2004). We defined the period from November to April as the wet season and May to October as the dry season.

NG11 is inhabited by *c.* 13,000 people (Central Statistics Office Botswana, 2002). Seronga is the largest village, with a population of 3,000, and small settlements and cattle posts occur between villages. Soil is largely deep Kalahari sands, and mopane *Colophospermum mopane*

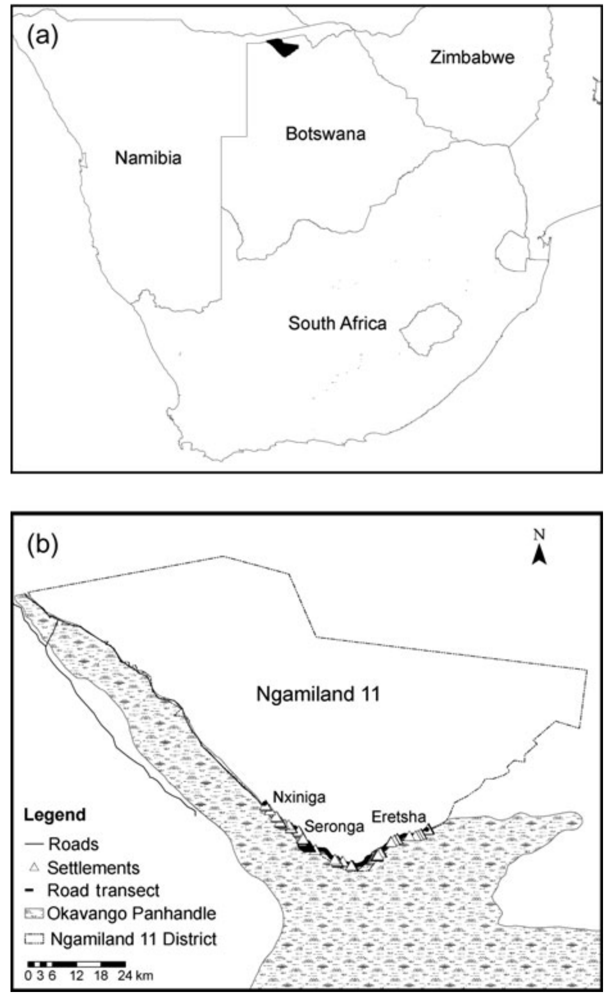

Fig. 1 (a) The location of Ngamiland District 11 in north-west Botswana. (b) NG11 borders the eastern side of the Okavango Panhandle. The road that runs parallel to the edge of the Panhandle served as a survey transect (see text for details).

woodlands occur throughout. Fertile soils support subsistence agriculture, mostly in areas adjacent to the Okavango Panhandle. Both people and elephants rely on the Okavango River for water during the dry season when there is no other perennial water (McCarthy, 2006). Farming is small-scale, and fields are 0.2–6.0 ha in size. Cultivation occurs in the rainy season when farmers plant maize, groundnut, millet and watermelon, which are harvested in April-June.

Methods

Elephant spatial use: aerial surveys

We used a Cessna 206 aircraft to conduct two fixed-wing aerial surveys of the entire area of NG11.These surveys took place over a period of 4 days at the end of the dry

(September 2003) and wet (April 2004) seasons. We used strip transects (Buckland *et al.*, 2001) and defined 67 north-south transects, at one nautical mile (*c.* 2 km) intervals. We flew these transects at an altitude of 300 ft (*c.* 90 m) (measured with a conventional altimeter) and a speed of 100 kt (*c.* 185 km h^{-1}). We sampled using calibrated strip widths fixed to 400 m on each side of the aircraft (following Norton-Griffiths, 1978). These strips covered 40% of the study area. Two observers conducted each transect, and a survey coordinator sat next to the pilot and used a hand-held global positioning system (GPS) to record the positions of elephants. Each observer used a digital camera to record 2-5 images at each elephant sighting from which we later counted the number of elephants in each herd. We examined numbers at a local scale by dividing our study area into four strata defined by distances to the Panhandle (0-10, 10-20, 20-30 and >30 km). These strata covered areas of 1,716, 1,377, 985 and 626 km^2, respectively. Using fixed-width transects of variable length facilitated the application of Jolly's Method II (Jolly, 1969) to estimate population sizes and their variances for each of the strata. We estimated elephant density for a stratum as the mean value for the transects within that stratum.

Elephant spatial use: satellite tagging

We placed GPS satellite collars (Africa Wildlife Tracking, Pretoria, South Africa) on 10 elephants. We immobilized individuals by darting from a helicopter; a veterinarian was present to supervise all collaring and sedation procedures, which adhered to the standards and conditions set by the Animal Ethics Committee of the University of Pretoria (permit number AUCC-040611-013). During October 2003 we fitted collars on four adult females in separate breeding herds and two adult bulls. We present hourly data from these individuals, collected over a 3-day period during October 2003. However, as four of these collars failed within a month we attached a further four collars, on three adult females and an adult male, during June 2004. The collars collected positional data at 24-hour intervals. To reduce bias towards any specific time of day, we advanced the data collection time by two hours each week. We used data collected from September 2004 to August 2005 and global information system software to calculate the distances of individuals' locations to the Okavango Panhandle.

Elephant spatial use: spoor counts

We used a public road that runs parallel to the Panhandle as a survey transect. This 50 km transect stretched from Nxiniga, via Seronga, eastwards to Eretsha (Fig. 1). We counted fresh spoor from elephants that crossed from the Panhandle to the hinterland, daily over 06.00–10.00 for 7-13 days each month from October 2003 to May 2004. To prevent recounting old spoor, we cleared this spoor after each survey by dragging a tyre tied to our survey vehicle. We distinguished the spoor of bulls from that of breeding herds, which comprise adult females, their offspring and some males. We divided the survey transect into 100 segments, each 500 m long. We used a χ^2 test on 2 * 2 contingency tables to test whether the segments where elephants crossed were associated with the presence or absence of human settlements.

Human spatial use

We used a hand-held GPS unit to determine the position of human settlements along the road transect. The area away from the road is mostly uninhabited and our survey along the road therefore included a relatively complete record of spatial settlement. For each segment of our line transect 50 m each side of the road was sampled as 500 * 100 m (5 ha) quadrats, in each of which we recorded the number of settlements, and questioned inhabitants to estimate the number of people living in these settlements.

Crop raiding by elephants

Each month 40 agricultural fields were randomly selected along the road transect to record crop age and type, area damaged by elephants and the status of these elephants (bulls, breeding herds). To quantify the financial implications of elephants damaging crops we related the area damaged to expected crop production and income using market-related values. Using these data we predicted the income after raids and the actual income after compensation from the Botswana Government, using the compensation standard of BWP 250 per ha damaged. Separate to this, we accompanied personnel from the Botswana Department of Wildlife and National Parks to verify reported elephant damage to crops.

Results

Season and elephant spatial use

The dry season elephant population estimate was 3,579 (95% confidence limit, CL, 2,975–4,183), which is a density of 0.71 elephants km^{-2} (95% CL = 5.1–9.2; Fig. 2, Table 1). The wet season population estimate was 1,060 (95% CL 810–1,310), i.e. a density of 0.21 elephants km^{-2} (95% CL 1.0–3.2). This suggests a 70.4% reduction

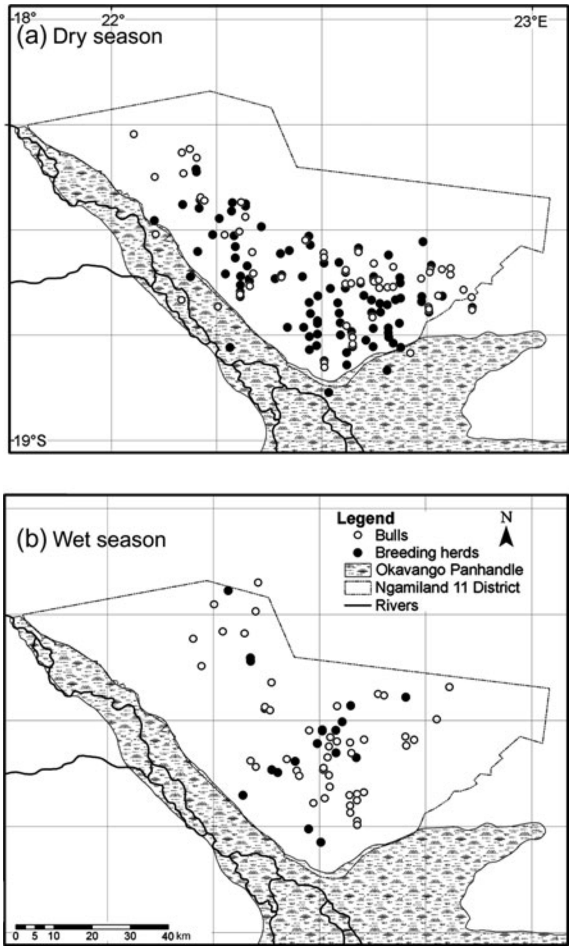

Fig. 2 Distribution of elephant bulls and breeding herds across the NG11 section of Ngamiland (Fig. 1), during aerial censuses conducted in (a) October 2003 (dry season) and (b) April 2004 (wet season).

in elephant number from the dry to the wet season. The distribution of elephants also changed with season (Fig. 2), with greater proportions of elephants occurring closer to water in the dry season (Table 1). Individuals were only recorded >30 km from permanent water during the wet season (Table 1).

The distance that satellite-tracked individuals ranged from the Okavango Panhandle varied during the year (Fig. 3). Elephants were closest to the Panhandle in September, but most distant in April. During the dry season, from June to October, most individuals remained within 10 km of the Panhandle. At this time elephants remained closer to the Panhandle than from November to May, during the wet season, when most elephants moved further away (Fig. 3). In April the furthest elephant from the Panhandle was an average of 60.2 ± SE 0.7 km away (n = 26 GPS fixes). Human settlements were situated 197 ± SE 11 m (n = 305) from the Panhandle. Overall, there appeared to be little overlap in spatial use between elephants and people, as elephants tended to use areas further from the Panhandle than people.

Herd type and elephant spatial use

Both bull and breeding herd numbers close to the Panhandle declined during the wet season when more elephants were recorded in more distant strata (Table 2). From October 2003 to May 2004 we recorded 881 incidences of breeding herds and 861 of bull groups crossing the 50 km road transect. Breeding herds and bulls crossed the transect at as many segments with human settlements as expected during both the dry and wet season (breeding herds, wet season: $\chi^2 = 2.3$, df = 1, P = 0.13; dry season: $\chi^2 = 0.0$, df = 1, P = 0.99; bulls, wet season: $\chi^2 = 0.1$, df = 1, P = 0.72; dry season: $\chi^2 = 0.0$, df = 1, P = 0.99; Table 3). However, both breeding herds and bulls apparently avoided areas with human settlements, assuming that crossings are independent (Table 4). They did so by crossing the transect at a higher frequency than expected in segments with no human settlements (breeding herds, wet season: χ^2 = 40.7, df = 1, P <0.001; dry season: χ^2 = 82.9, df = 1, P <0.001; bulls, wet season: χ^2 = 57.5, df = 1, P <0.001; dry season: χ^2 = 26.8, df = 1, P <0.001).

Human spatial use

We recorded 5,544 people, 2,686 homes and 111 agricultural fields along the 50 km transect (Fig. 1). Of the 100 survey quadrats, 31 were not inhabited or used for agriculture, and consisted primarily of mopane woodland.

Crop raiding in relation to season and herd type

Crop raiding occurred as crops ripened towards the end of the rainy season, from March until May. This was reflected in both our randomly sampled fields and in fields where farmers reported crop damage (Table 5). The increase in crop raiding during April coincided with the time of our aerial census, when we recorded few elephants within 10 km of the Panhandle. This suggests the increase in crop raiding may be independent of elephant numbers. Raids took place at night, and more bull groups than breeding herds were involved (Table 5).

Financial implications of elephant activity

Farmers applied to the Botswana Department of Wildlife and National Parks for financial compensation for crop damage by elephants (Table 6). Due to the small size of their fields compensation was low, up to a maximum of

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Table 1 Mean estimates ± SE of elephant numbers and densities from fixed-wing aerial surveys conducted in October 2003 (dry season) and April 2004 (wet season), with 95% confidence interval in parentheses, in the NG11 section of Ngamiland, Botswana (Fig. 1).

Distance from Okavango Panhandle (km)	Number of transects		Elephant number		Elephant density (km^{-2})	
	Dry	Wet	Dry	Wet	Dry	Wet
0-10	66	67	1,710 ± 418 (1,225-2,195)	95 ± 50 (37-153)	0.97 ± 0.21 (0.56-1.38)	0.08 ± 0.04 (0.00-0.16)
10-20	61	62	1,609 ± 287 (1,275-1,942)	369 ± 167 (172-562)	1.00 ± 0.21 (0.58-1.42)	0.26 ± 0.12 (0.00-0.55)
20-30	46	47	261 ± 85 (1.62-360)	391 ± 115 (257-524)	0.23 ± 0.09 (0.05-0.40)	0.32 ± 0.11 (0.00-0.55)
>30	28	29	0	205 ± 53 (142-268)	0	0.24 ± 0.11 (0.03-0.45)
Total			3,579 ± 514 (2,975-4,183)	1,060 ± 215 (810-1,310)	0.71 ± 0.10 (0.51-0.92)	0.21 ± 0.06 (0.10-0.32)

BWP 250 (*c.* USD 38) per month. The actual income farmers made following compensation was on average 11% lower than their projected income if elephant raids had not taken place. Considering we recorded 111 fields along our 50 km transect, and that the entire length of the road along the eastern border of the Panhandle through NG11 is 120 km long, we expect 266 fields to be at risk from elephants in NG11. Given an average field size of 1.5 ha (Mosojane, 2004), and a compensation rate of BWP 250 per ha, this suggests that the Botswana Government would be obliged to compensate the farming community a total of *c.* USD 10,000 per year if crops were totally destroyed by elephants in NG11.

Social implication of elephant activity

We examined hourly variation in spatial use by elephants during the dry season, when elephants were present at their highest densities along the Panhandle. Elephant movements over a 3-day period during this season confirmed they were only present on the Panhandle after dark, moving to areas further away during daytime (Fig. 4). This pattern suggests that these elephants drank at 1–3 day intervals. Thus, while elephants in general were situated further from the Panhandle than people, the highest probability of encountering elephants was at night as they moved onto the floodplain.

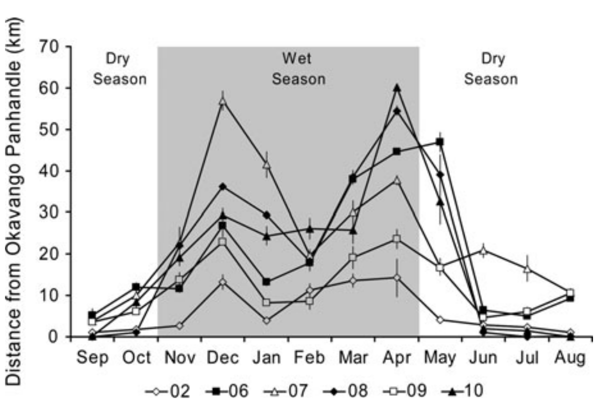

Fig. 3 Mean ± SE of monthly distances at which six GPS-satellite collared elephants were recorded from the Okavango Panhandle. The shaded area indicates the wet season. During the dry season, from June to October, most individuals remained within 10 km of the Panhandle. These distances were closer to the Panhandle than from November to May, mostly during the wet season, when most elephants moved away.

Discussion

This study shows that one aspect of human-elephant conflict, crop raiding, was greatest at the transition from the wet to the dry season, during periods of darkness, and dominated by bulls. Elephant spatial use clearly varied with season: they used areas close to the Panhandle during the dry season, moving away at the onset of the wet season. Thus when the distribution of water is limited, dry season refugia played an important role in dictating elephant spatial use. Conversely, during the wet season when the distribution of water is less limiting, elephants tended to range away from perennial water.

Unlike elephants, the spatial distribution of people in NG11 does not vary seasonally, as most people live along the edge of the Panhandle and close to permanent water. Thus, while people and elephants are separated spatially during the wet season, they occur more closely together through the dry season. Even so, elephants tended to remain further away from the Panhandle than

Table 2 Number (with percentage in parentheses) of elephant bull groups and breeding herds observed within distance strata during aerial surveys in October 2003 (dry season) and April 2004 (wet season) in the NG11 section of Ngamiland (Fig. 1).

Distance from Okavango Panhandle (km)	Bulls		Breeding herds	
	Dry	Wet	Dry	Wet
0-10	22 (40)	2 (4)	44 (43)	4 (13)
10-20	27 (49)	21 (46)	50 (49)	9 (29)
20-30	6 (11)	16 (16)	9 (8)	14 (45)
>30	0 (0)	7 (15)	0 (0)	4 (13)

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Table 3 Number of segments along a line transect in which we recorded crossings (with expected number of crossings in parentheses) by elephant breeding herds and bulls in October 2003 (dry season) and April 2004 (wet season), in relation to the presence or absence of human settlements.

	Dry season			Wet season		
	Crossed	Did not cross	Total	Crossed	Did not cross	Total
Breeding herds						
Settlements	27 (27)	10 (10)	37	13 (17)	24 (20)	37
No settlements	46 (46)	17 (17)	63	32 (28)	31 (35)	63
Total	73	27	100	45	55	100
Bulls						
Settlements	29 (29)	8 (8)	37	19 (18)	18 (19)	37
No settlements	49 (49)	14 (14)	63	30 (30)	33 (33)	63
Total	78	22	100	49	51	100

people, at least during the day. Critically, elephants moved onto the Panhandle at night, when they also raided fields. Our results thus show the importance of both time and space in determining the likelihood of conflict (Hoare & du Toit, 1999).

Unexpectedly, our study did not show a distinct separation in the distances of bulls and breeding herds from water (Stokke & du Toit, 2002). Nor did our results suggest breeding herds or bull groups react differently to human settlement patterns, in comparison to Hoare (1999) who recorded bull elephants significantly closer to human settlements than cows. Despite these differences with other studies, the patterns of elephant spatial use that we recorded are, however, consistent with our prediction that crop raiding would be seasonal.

Given our findings, we suggest several management options to reduce crop raiding by elephants in this area. The most obvious approach would be to modify elephant spatial use. This may be achieved using physical barriers, including various fencing schemes, which are sometimes used to restrain elephant movement (Osborn & Parker, 2003). Rudimentary fencing using cut branches around fields in our study area were ineffective in excluding elephants. In other areas, chemical deterrents such as chilli peppers may discourage elephants (Sitati & Walpole, 2006).

Alternatively, the spatial distribution of elephants may be manipulated by providing mineral licks as forage, as soils and water high in sodium are known to attract elephants (Holdo *et al.*, 2002). Manipulating the spatial distribution of water during the dry season by creating waterholes away from areas where people live is another way to reduce the spatial overlap of elephants and people. We do not, however, advocate the establishment of permanent water supplies throughout NG11, as this could have deleterious consequences for vegetation (van Aarde *et al.*, 2006). We also do not support the culling of elephants to reduce numbers, as this does not address the underlying causes of human-elephant conflict (van Aarde & Jackson, 2007).

From a human perspective, settlement patterns need to be considered relative to elephant spatial use. Land-use planning is known to influence human-elephant conflicts (Fernando *et al.*, 2005). Given the recent increase in human numbers in NG11 (Central Statistics Office Botswana, 2002) land-use and zonation must be carefully planned to ensure that future patterns of human settlement avoid areas that are well used by elephants.

While these ideas require substantial development, farmers in Botswana currently receive government compensation when elephants damage their crops. Despite the goals of relieving social and economic hardships, this type of compensation may be detrimental to conservation efforts (Bulte & Rondeau, 2005). Such schemes are often cumbersome and expensive to administer (Hoare, 1995), and the cost of government bureaucracy to process claims almost certainly exceeds the total value of claims by farmers in NG11.

Table 4 The number of times that elephant breeding herds and bulls crossed 500 m segments of a line transect (with expected number of crossings in parentheses) in October 2003 (dry season) and April 2004 (wet season) as a function of the presence or absence of human settlements.

	Number of segments	No. of times segments crossed by breeding herds		No. of times segments crossed by bulls	
		Dry	Wet	Dry	Wet
No settlements	63	409 (338)	299 (217)	386 (329)	281 (214)
Settlements	37	127 (198)	46 (128)	136 (193)	58 (125)
Total	100	536	345	522	339

Table 5 The incidence and type of elephant groups involved in crop raiding along the Okavango Panhandle from October 2003 to May 2004. Reported refers to incidents reported by farmers to the Botswana Department of Wildlife and National Parks, and Random refers to incidences assessed while inspecting 40 randomly selected fields each month.

Month	Breeding herds	Bull groups	Total
Reported			
Oct.	0	0	0
Nov.	0	0	0
Dec.	0	0	0
Jan.	0	0	0
Feb.	0	0	0
Mar.	3	10	13
Apr.	2	17	19
May	5	17	22
Total	10	44	54
Random			
Oct.	0	0	0
Nov.	0	0	0
Dec.	0	0	0
Jan.	0	0	0
Feb.	0	0	0
Mar.	0	5	5
Apr.	7	18	25
May	8	18	26
Total	15	41	56

Critics argue that as farmers know they will be compensated for damage, there is no incentive for them to adopt new or revise current practices to reduce crop raiding: the so-called moral hazard of compensation schemes (Nyhus *et al.*, 2005). In addition, the costs of compensation schemes run well beyond damage payments and include search and information costs (needed to verify the damage costs) as well as decision making costs (associated with disputes that arise from claims; Schwerdtner & Gruber, 2007).

An alternative approach is a payment in advance, or performance payment, to farmers (Nyhus *et al.*, 2005; Schwerdtner & Gruber, 2007). Effectively, this approach rewards farmers for living with elephants rather than compensating individuals for losses incurred through elephant activity. This direct payment approach is more cost-efficient than indirect incentives such as compensatory payments for crop damage (Ferraro & Kiss, 2002).

Performance payments are beneficial to farmers, who are effectively rewarded for the ecological services they provide (Ferraro, 2001; Bulte & Rondeau, 2005), such as sharing space with elephants. From a financial perspective, performance payments do not detract from farmers attempting to maximise crop yield, as any harvested crops will count over and above the performance payment they will receive. The approach relieves farmers from some of the social costs they endure such as sleepless nights or the dangers associated with trying to ward off elephants, knowing they will receive some reward for living with elephants. This may therefore culture a more positive attitude towards elephants, as is presently the case in Namibia's Caprivi Region (G. Owen-Smith, pers. comm.).

Nationally, the fiscal impact of human-elephant conflict to farmers in NG11 is small. At USD 10,000 annually this is less than the license fee to hunt an elephant in Botswana (USD 15,000; Sharp, 2007). The income generated from hunting one elephant would more than cover payments to every farmer should a performance payment scheme be introduced. Similarly, revenue generated from problem elephant control in Zimbabwe went some way to replacing dysfunctional crop damage compensation schemes (Hoare, 1995).

In conclusion, we have outlined, based on our examination of the spatial-temporal distribution of elephants and people, a new approach that could be developed to help alleviate the causes of elephant crop raiding in north-west Botswana, and recommended that a more direct performance payment approach may jointly benefit government, local farmers and elephant conservation. Based on our recommendations the Botswana Department of Wildlife and National Parks (District Office, Maun, Botswana, pers. comm.) has agreed to present the performance payment approach for consideration to communities affected by human-elephant conflict in northern Botswana. This follows the integration of areas of northern Botswana into the Kavango-Zambezi Transfrontier Conservation Area, for which a Botswana government unit was recently established to coordinate activities, and that will include our call for a performance payment approach.

Table 6 Financial implications of crop damage by elephants raiding fields along the Okavango Panhandle from January to May 2004.

Month	No. of affected farmers	Expected income before raids (BWP)	% of field raided	Predicted income after raids (BWP)	Compensation (BWP)	Actual income with compensation (BWP)
Jan.	0					
Feb.	0					
Mar.	11	714	29	507	140	647
Apr.	17	652	36	417	155	572
May	20	918	37	578	250	828

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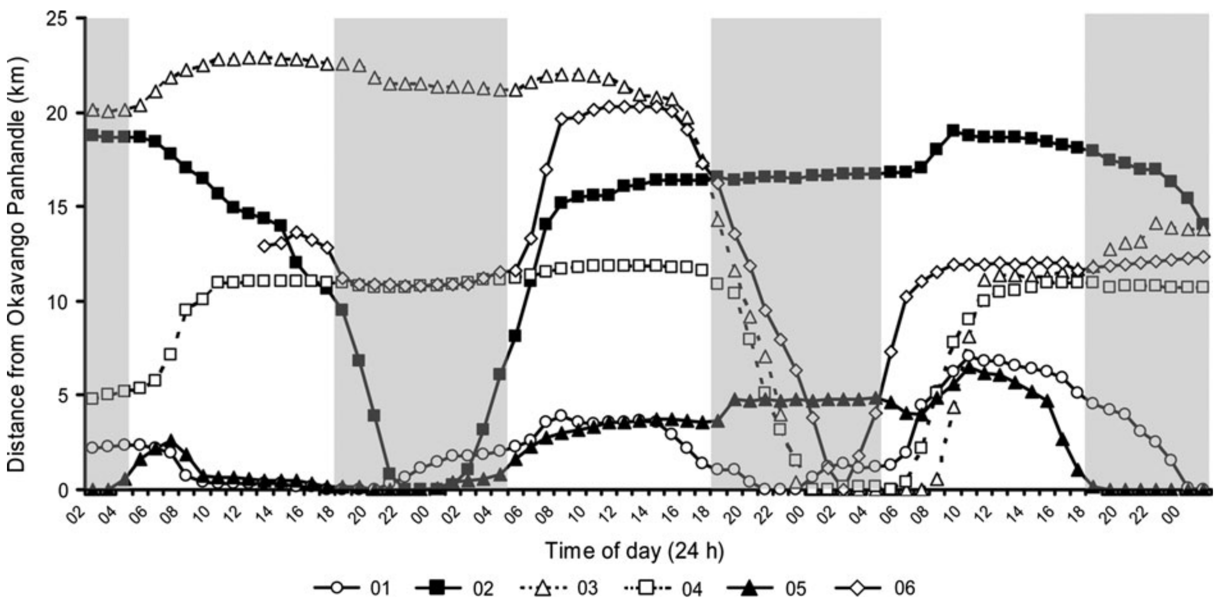

Fig. 4 The distances six GPS-satellite collared elephants were recorded from the Okavango Panhandle over a 3-day period in October 2003, during the dry season. Shaded areas indicate hours of darkness. Elephants visited the Panhandle during hours of darkness only and at intervals of 1–3 days, remaining further away from the Panhandle during the day.

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