Systematic recording of human–elephant conflict: a case study in south-eastern Tanzania

Cyprian Malima,[1] Richard Hoare[2] and J. Julian Blanc[3]*

[1] World Wide Fund for Nature, Tanzania Programme Office, PO Box 63117, Dar es Salaam, Tanzania;
email: cmalima@wwftz.org
[2] TAWIRI Wildlife Veterinary Programme, PO Box 707, Arusha, Tanzania;
email: richard@messerlifoundation.org; *corresponding author
[3] African Elephant Specialist Group, PO Box 68200, City Square 00200, Nairobi, Kenya;
email: julian.blanc@ssc.iucn.org

Abstract

A standardized data collection system recommended by the African Elephant Specialist Group to record and assess human–elephant conflict was used in subsistence agricultural areas to the east of the Selous Game Reserve in Tanzania. Nine enumerators were recruited, trained and supervised to collect primary data on elephant damage incidents in 38 rural villages widely spaced throughout an area of 30,000 km^2. Losses were suffered over a small total area of cultivation that covered only 1% of potential elephant habitat. In the first year of recording 1239 incidents occurred, of which 973 were assessed as crop raids. Sixteen categories of food crops were damaged, representing loss to both wet- and dry-season produce. Elephants killed two people and people killed 25 elephants. One year of a proposed three-year study already highlights the usefulness and cost-effectiveness of simple, inexpensive recording schemes, operated principally by people within affected communities and producing rapid results relevant to local wildlife management and community-based conservation. Further assessments of the economic value of losses, the selectivity of crops by elephants and tests of causative factors in human–elephant conflict will be made once the data of the three years become available.

Résumé

On a utilisé un système standardisé de récolte des données recommandé par le Groupe Spécialiste des Eléphants d'Afrique pour rapporter et évaluer les conflits hommes–éléphants dans des zones d'agriculture de subsistance à l'est de la Réserve de Faune de Selous, en Tanzanie. On a recruté neuf compteurs qui ont été formés et supervisés, pour qu'ils récoltent les données de base sur des incidents de dégâts aux cultures dans 38 villages ruraux distribués sur une superficie de 30.000 km^2. Les pertes ont été constatées sur une petite surface de culture dont le total ne couvrait que 1 % de l'habitat potentiel des éléphants. Au cours de la première année, on a rapporté 1239 incidents et 973 d'entre eux ont été considérés comme des dégâts aux cultures. 16 catégories de récoltes ont été endommagées, représentant des pertes de produits de saison sèche et des pluies. Les éléphants ont tué deux personnes et les gens ont tué 25 éléphants. Une seule année de cette étude qui devrait durer trois ans a déjà mis en évidence l'utilité et la rentabilité de programmes de rapport simples et peu coûteux, réalisés principalement par des personnes des communautés affectées, qui donnent des résultats rapides intéressant la gestion locale de la faune sauvage et la conservation communautaire. Des évaluations plus poussées de la valeur économique des pertes, de la sélectivité exercée par les éléphants et des tests de facteurs de causalité dans les conflits hommes–éléphants seront faites dès que les données récoltées pendant ces trois ans seront disponibles.

Introduction

Established during the colonial era, the Selous Game Reserve (SGR) in south-eastern Tanzania is the largest protected area (50,000 km^2) south of the Sahara under a single management unit. The primary purpose at the time of gazetting the large tract of land was to conserve elephants, which were thought to be fast disappearing (Matzke 1976). In the 1940s some of the sparse human settlements in the area were abandoned due to severe crop damage by elephants, and the vacated land was annexed to SGR (Nicholson 1969).

After independence in 1961 the Tanzania government, realizing the earning potential of wildlife populations within the reserve, initiated a programme in which hunting safaris by tourists were given access to the reserve under strictly controlled conditions (Nicholson 1969). In Tanzania, national parks are fully protected, allowing only non-consumptive tourism, but in game reserves limited offtake of trophy animals is permitted through annual quotas.

When figures were first produced in 1976 the Selous elephant population was estimated at 110,000—one of the largest on the African continent. Rampant poaching in the 1970s and 1980s, however, reduced the population to about 30,000 by 1989. Today the elephant population in the greater Selous ecosystem (105,000 km^2 of surveyed elephant range) is recovering strongly and is estimated to have reached around 70,000 (Blanc et al. 2003). Of these, about 25% are thought to be found outside the various protected areas, but the number fluctuates depending on season and the intensity of the expanding human activity in that area encroaching on elephant habitats and movement routes—agriculture, settlement, hunting, fishing, uncontrolled fires, etc. (Mpanduji et al. 2002). Conflict between humans and wildlife, particularly elephant, hippopotamus, bush pig and wild carnivores, is a continuing serious issue in areas surrounding the SGR.

Previous efforts to mitigate elephant damage to crops in the area have largely depended on centralized problem animal control (PAC) units of government-employed wildlife personnel. Due to logistical constraints similar to those experienced elsewhere in Africa (Osborn and Parker 2002) and the recurring nature of the problem, these units have had little lasting effect. Reliance on PAC units has recently diminished due to cutbacks in government spending under the country's economic adjustment programme. Thus the problem of managing elephants, as is increasingly the case in many African countries, is now de facto largely in the hands of rural communities that interface with elephant range. But local communities and farmers lack the capacity to deal with the problem effectively, so their support for any conservation initiative is jeopardized.

In response to the need to evaluate and compare vastly differing human–elephant conflict (HEC) situations across Africa (Dublin and Hoare 2004), some years ago the African Elephant Specialist Group (AfESG) developed a standardized data collection and analysis protocol for HEC situations (Hoare 1999a). This protocol and its associate, a training package for enumerators of elephant damage (Hoare 1999b), were adopted and tested in this study. The project was designed to generate baseline information on HEC levels as such information is an essential first step towards more local management of the conflict problem. This paper describes the performance of the first year of the standardized reporting scheme and discusses benefits of using such a model elsewhere in the African elephant range.

Study area

The study was carried out around villages in Rufiji, Kilwa and Liwale Districts in south-eastern Tanzania, situated in nine administrative wards: three in each district. These wards border SGR's eastern zone with the exception of Kikole Ward of Kilwa District, which was chosen because elephants occur locally the year round (fig. 1). The total area covered by the incident-reporting scheme was 30,000 km^2, containing 38 villages with an estimated human population of 52,880 people (Tanzania Census 2002).

The vegetation is predominantly miombo-dominated (*Brachystegia* spp.) woodland with undulating topography. The area receives rainfall biannually with an average annual total of 800 mm. 'Short rains' fall in November and December and 'long rains' may last from February to May.

Human communities are primarily artisanal peasants and hunters. Most local people continue to carry out shifting cultivation. A wide variety of crops is cultivated: in the wet season the staples maize, rice and millet are grown, while in the dry season people also rely on various fruits and vegetables. Communities that live adjacent to oxbow lakes or large rivers such as the Rufiji, Mbwemkuru, Kilombero or Ruaha practise fishing. Livestock keeping has never been

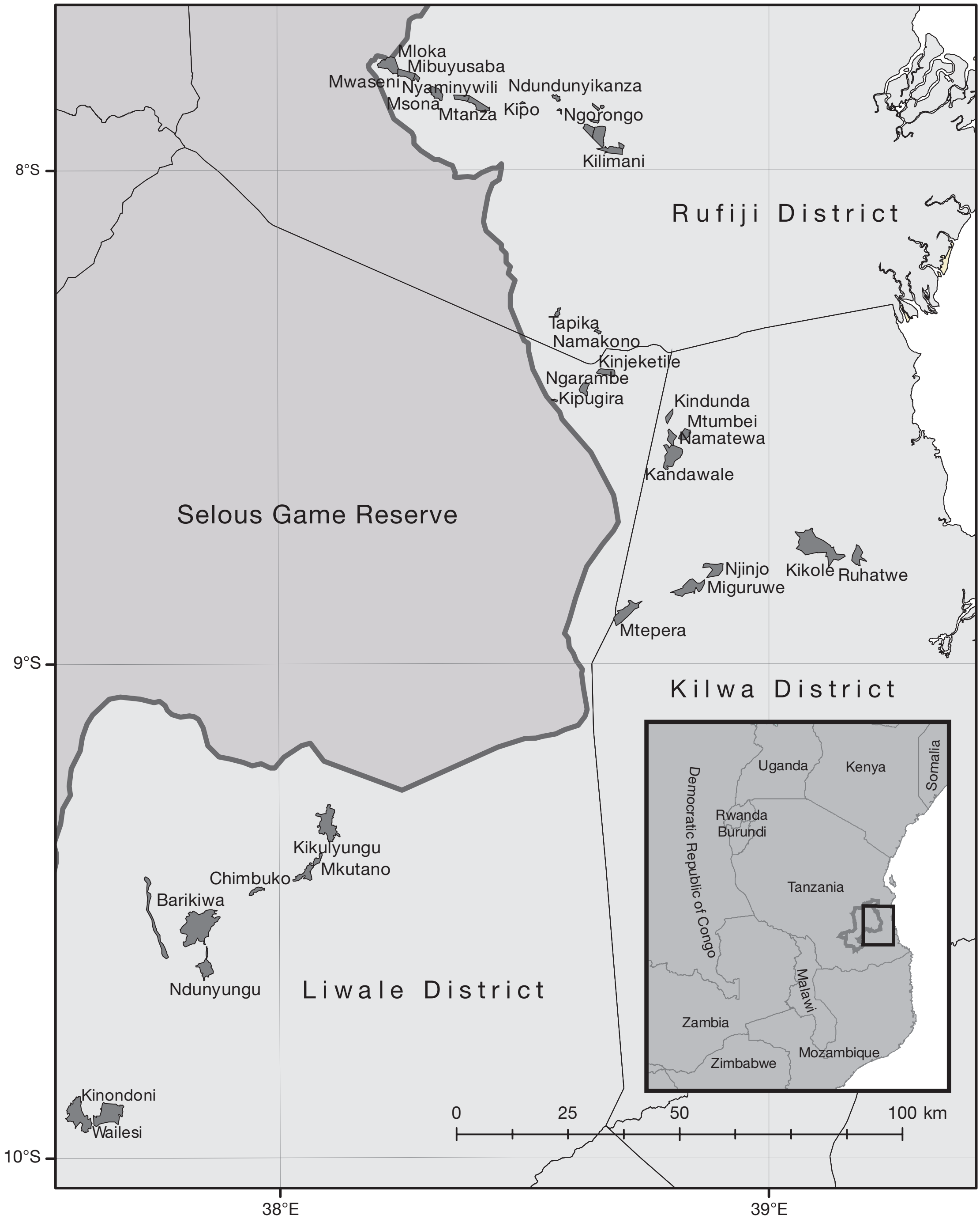

Figure 1. Human–elephant conflict study area between the Selous Game Reserve and the Indian Ocean.

successfully carried out in the area because of the high prevalence of trypanosomiasis. Ethical taboos and religion have historically had an influence on controlling the consumptive use of some wildlife including elephants.

Methods

A standardized HEC data-collection protocol was followed to collect baseline data (Hoare 1999a). This protocol was developed and is endorsed by AfESG and has been successfully used in several other HEC situations in Africa (Hoare 1999c; Parker and Osborn 2001; Sitati et al. 2003). Its aim is to quantify the distribution, frequency and severity of HEC incidents over large areas, do so reasonably cheaply, and achieve data of quality sufficient for local management of the problem. In this study, nine local enumerators were recruited and trained to capture primary data from conflict zones around the remote villages. Their training was carried out by the supervisor (C. Malima) in accordance with an AfESG-endorsed training package (Hoare 1999b) that is closely associated with the data protocol.

When elephant damage occurs, the local HEC enumerator is informed through existing local communication networks. To maximize acceptance of the scheme among local communities, enumerators were assigned to collect HEC data only from the ward of their origin. The enumerator visits the incident site as soon as possible after the occurrence, travelling on foot or by bicycle. Enumerators discuss particulars of the incident with the affected people and quantify the property damage using standardized procedures. To avoid the problems associated with the use of paper maps, each enumerator was trained to use a GPS unit to record incident locations accurately.

Apart from necessary particulars of date, location, farmers' names and so on, the primary quantitative data captured from each incident are what crops the elephants damaged, how badly they damaged them, and if possible the group composition (age and sex) of problem elephants involved. The scheme began in July 2003 and the data presented here are those collected for one year, up to June 2004. Data collection in both wet and dry seasons monitored elephant damage to both seasonal and perennial crops.

The seriousness of each crop-damage incident was subsequently further quantified by the supervisor, using a simple secondary data analysis based on the age, quality and damage level to the crop (Hoare 1999a). Crop damage by elephants was assigned to three levels—low, medium and high—by combining scores for the age of the crop and the quality and extent of the damage. Age categories for crops were given 1, 2 and 3 points for seedling, intermediate and mature growth stages. Quality categories of crops were given 1, 2 and 3 points for poor, medium and good. Damage was assigned to six categories (1–6 points) based on percentage of crop-growing area damaged as assessed by the enumerator (≤5%; 6–10%; 11–20%; 21–50%; 51–80%; >80%). The supervisor regularly checked a sample of incidents in situ, to minimize assessment bias by enumerators.

The higher the score of combined points (age + quality + damage) for an incident, the more serious the damage suffered. All incident scores were then assigned to low (≤5 points), medium (6–8 points) or high (≥ 9 points) damage classes. Other categories of serious incident like human death or injury, damage to food stores or water sources and retaliatory killing of problem elephants were also recorded. The annual summary of many different conflict incidents gives a picture of the distribution, frequency and severity of the HEC problem in each ward and district.

To quantify the proportion of farms affected by elephants, ideally all farms at risk should be mapped. In the prevailing conditions, however, this was not possible for a number of reasons: the very large number of individually owned plots; the extensive practice of shifting cultivation, and the limits of the workforce employed. Instead, locations (GPS waypoints) on the periphery of arable farming areas were recorded every 50 m and the total cultivated area used by village (including some fallow) was calculated by a computer program (ArcGIS 9.0 Desktop, ERSI 2004, Redlands, CA, USA). This was done in 26 of the villages.

Results

Types of incident

In the 12-month period, 16 types of food crops were raided by elephants in 973 separate incidents (table 1). Farms commonly have mixed crops and during a raid elephants frequently damaged more than one crop type. Other conflict types identified (no. of cases in brackets) included:

- people killed (2) or injured (1) by elephants
- elephant damage to water sources (17)
- elephants shot dead (25) by both wildlife officers and villagers
- interference with people's daily travel schedules such as obstructing children from attending school or restricting farmers moving to and from their fields (4)

Table 1. Elephant crop damage incidents in agricultural fields, July 2003–June 2004

		Dry season			Wet season			
	Rank	Rufiji	Kilwa	Liwale	Rufiji	Kilwa	Liwale	Totals
Maize	1	20	4	0	122	4	25	175
Millet	2	5	0	2	36	45	51	139
Cashew nut	3	21	24	89	—	3	—	137
Mixed crops	4	34	23	15	17	3	26	118
Banana	5	46	30	2	10	1	1	90
Cassava	6	0	4	70	—	—	8	82
Rice	7	—	—	—	44	5	12	61
Mango trees	8	7	45	1	—	—	—	53
Peas	9	3	23	5	—	3	2	36
Sugar cane	10	9	16	3	2	—	—	30
Coconut trees	11	—	18	—	—	2	—	20
Vegetables	12	9	0	1	2	—	—	12
Sweet potato	13	0	6	1	—	—	—	7
Orange trees	14	0	5	0	—	1	—	6
Pawpaw	15	2	2	0	—	—	—	4
Simsim	16	—	—	—	1	2	—	3
Totals		156	200	189	234	69	125	973

The discrepancy in totals with tables 2 and 3 is due to multiple farms being damaged in some raids, non-assessment of some incidents, and counting of incidents other than crop raiding.

Destruction of food stores by elephants, sometimes commonly encountered in other HEC zones in Africa, was not recorded during the reporting period.

Seasonality of crop destruction by elephants

Elephants seldom raided fields with crops at seedling stage. Raiding intensified in regularity and severity towards an annual peak as the harvest period approached for rainfed crops (June and July). Wet-season crop raiding damaged more annual crops like maize and rice, especially in the wetter Rufiji District. Faster-growing, more drought-resistant crops such as millet were damaged in the drier farming conditions of Kilwa and Liwale Districts.

In the Rufiji Valley basin and to a lesser extent in Kilwa District, farmers carry out valley-bottom farming, growing mixed crops composed of maize, vegetables and peas on isolated farms. These areas were prone to dry-season elephant raids. In the dry season, farms with fruiting trees—cashew nut, mango, coconut and banana—were vulnerable to elephant invasion. Elephants debarked trees, broke branches to eat leaves or shook trees to dislodge fruit (especially cashew nut, mango and coconut). Perennial cassava, grown mostly in Liwale District, suffered dry-season damage.

Level of elephant damage

The year's data were summarized by frequency (tables 1, 2) and severity (fig. 2) of incidents. Overall elephants caused relatively few cases of heavy losses in the three districts (5.8% wet season and 23.3% dry season). These high-level damage incidents often occurred in small and isolated agricultural fields, especially when they were raided by large groups of elephants. Most of the damage was in the medium-loss category (64.7% wet season and 56.3% dry season). Low-loss cases ranked intermediate (29.5% wet season and 20.4% dry season).

Raiding group composition

Raiding group size usually ranged from 3 to 10 but occasionally bigger groups of up to 40 animals were involved. Elephant mixed herds (bulls, cows and calves together) were the group type responsible for most of the crop raiding (table 3). Male groups (usually two to three animals) and lone bulls also caused considerable amounts of damage. In very few cases were cow–calf groups involved. These results should be interpreted with some caution, however, as data on the sexing of nocturnally active (and therefore mostly unseen) groups of raiders from their footprints are subject to error.

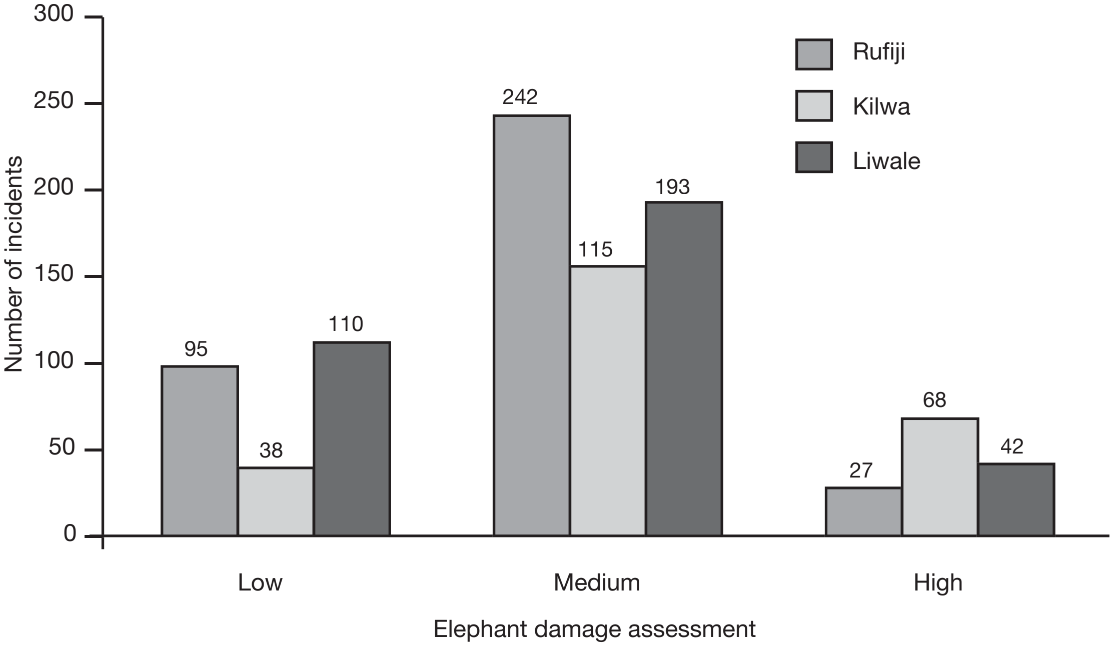

Figure 2. Elephant crop damage levels assessed in the three districts, July 2003–June 2004.

Variation between areas affected by elephants

Elephant raids occurred in all nine wards and all but one out of 37 village areas (table 2). The worst crop damage was concentrated in Kikulyungu, Mloka, Chimbuko, Ngarambe and Miguruwe villages. These villages either border the SGR or are located in densely vegetated riverine habitats where elephants can easily take refuge.

In Ngorongo Ward of Rufiji the relatively high level of elephant raiding in Kipo, Kipugira, Nyamnywili and Ndundunyikanza was possibly related to abandonment of fields following 32 human deaths caused by lions between October 2002 and April 2004—probably the most intense human–carnivore conflict in Africa (G. Packer, pers. comm. 2005). Wet- and dry-season raids in Kikole village showed little difference. This village does not border the SGR but areas nearby harbour resident elephants year round. The low level of raiding in Kandawale Ward villages, which are also near the SGR, appears to coincide with elephant avoidance of the area as yet unexplained.

Variation in the severity of elephant crop raiding can be judged by ranking villages. The simplest index is the number of incidents (table 2). But as many incidents may not be serious, a more meaningful ranking for management priority is the number of raids in the high (or high and medium) damage categories. No meaningful relationship existed between size of area cultivated around villages (range 0.7–35 km^2) and the number of elephant raids therein (range 0–137) (table 2; fig. 3, $R^2 = 0.2112$). Therefore a better ranking index to compare raiding intensity between villages could be: the size of the village area cultivated / number of raids (that is, raids per km^2 of cultivation per year (Hoare 1999a). The range for raiding intensity in villages was also very wide at 0–25 incidents/km^2 per year (table 2). In all villages combined, the overall raid intensity (1239 elephant ‘problem incidents’ in about 300 km^2) was 4.1 incidents per km^2 per year.

Discussion

The data presented here are from the first year of a study that is scheduled for three years, to capture between-year variation of this conflict. But even this first year’s results have successfully tested the principle and logistics of collecting primary data through an independent third party (the village-level enumerator), rather than from affected people’s verbal accounts

Table 2. Incident totals and ranking of elephant raids per village, July 2003–June 2004

District and ward	Village	Dry-season incidents	Wet-season incidents	Total incidents	Ranking by no. incidents[a]	Ranking index[b]
Rufiji						
Ngorongo	Ngorongo	25	21	46	10	8.2
	Nyaminywili	23	14	37	12	4.9
	Kilimani 1	23	24	47	9	4.9
	Kipo	0	9	9	24	2.6
	Kipugira	0	4	4	28	—
	Ndundunyikanza	0	8	8	22	5.0
	Kilimani 2	0	24	24	16	22.4
Mwaseni	Mloka	73	62	135	2	12.7
	Mwaseni	8	21	29	14	5.3
	Mibuyusaba	21	13	34	13	25.2
	Mtanza	11	7	18	18	—
	Msona	6	16	22	17	3.8
Utete	Ngarambe	31	49	80	4	21.4
	Tapika	11	0	11	22	8.3
	Nyamakono	0	1	1	29	1.4
Kilwa						
Kandawale	Kandawale	0	0	0	30	0
	Kindunda	2	7	9	24	—
	Kinjeketile	0	7	7	26	1.5
	Mtumbei	4	3	7	26	—
	Namatewa	0	4	4	28	—
Kikole	Kikole	42	12	54	6	1.6
	Mbunga	7	5	12	19	—
	Nanyati	15	10	25	15	—
	Ruhatwe	3	5	8	25	1.1
	Migelgele	0	1	1	29	—
Zinga-Miguruwe	Miguruwe	69	5	74	5	5.6
	Mtepera	37	16	53	7	4.3
	Naking’ombe	28	19	47	9	—
	Njinjo	39	1	40	11	4.8
	Zinga-Kibaoni	4	7	11	22	—
Liwale						
Barikiwa	Barikiwa	26	27	52	8	2.0
	Chimbuko	75	36	111	3	—
	Ndunyungu	8	2	10	23	1.0
Kikulyungu	Kikulyungu	56	81	137	1	6.8
	Mkutano	5	8	13	21	1.4
Mpigamiti	Kinondoni	10	4	14	20	0.6
	Wailesi	28	17	45	11	2.0
Totals: 9 wards	**37 villages**	692	547	1239		

The discrepancy in totals with tables 1 and 2 is due to multiple farms being damaged in some raids, non-assessment of some incidents, and counting incidents other than crop raiding.

[a] no. of raids

[b] no. of raids per km^2 of cultivated area

— area not measured; therefore not ranked

Table 3. Elephant group type damaging crops, July 2003–June 2004

Group type	Wet season		Dry season	
	no.	%	no.	%
Mixed herd	271	56	435	63
Lone bulls	108	22	94	13
Bull group	84	18	150	22
Cow–calf	21	4	12	2
Totals	484		691	

The discrepancy in totals with tables 1 and 2 is due to multiple farms being damaged in some raids, non-assessment of some incidents, and counting incidents other than crop raiding.

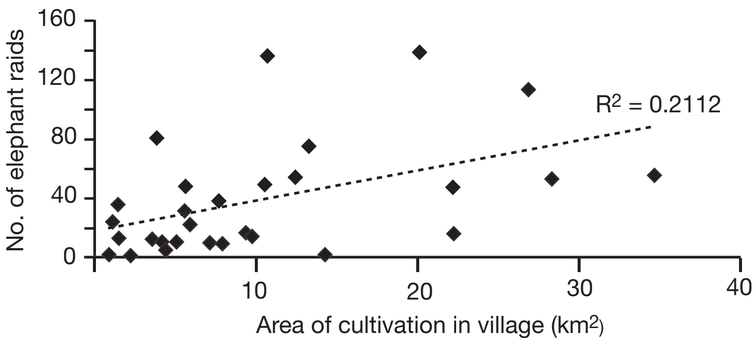

Figure 3. Elephant raids in the different size cultivated areas around 26 villages, July 2003–June 2004.

or from employees of a national wildlife authority. With both the latter, data are often inconsistent or biased (Hoare 2001a).

This study operated over probably the largest area ever covered by a wildlife conflict reporting scheme of its kind (30,000 km^2). Villages are widely spaced and the proportion very small of the area actually occupied and cultivated (1%)—and therefore in which HEC actually occurred. Situations where small, scattered pockets of human habitation exist in a large matrix of natural habitat containing elephants are fast disappearing in Africa (Hoare and du Toit 1999), so this conflict assessment gives a possible first-time indication of the HEC scenario in historic times, for which only anecdotal accounts exist.

Despite what appear to be high raiding figures, actual economic losses were probably quite small and, in keeping with the pattern of this problem elsewhere in Africa, showed a gradient of seriousness. Elephant damage can be devastating to an individual farmer but its actual impact up the spatial scale through village and ward decreases progressively, until at district level its material impact is minor. Further assessments involving the economic value of losses (Tchamba 1996) at these scales, the seasonal selection of crops by elephants, and hypotheses tests of causative factors in HEC will be done once the data of three years are available.

Eastern Selous showed differences when compared with other areas where HEC has been systematically recorded (Parker and Osborn 2001; Sitati et al. 2003). Here the highest number of incidents was caused by mixed herds as opposed to the more usual bull-only groups in fairly similar southern African woodland ecosystems (Hoare 1999c, 2001b; Osborn 2003). Also, the medium category of elephant damage was highest, rather than the low category—usually found most numerous elsewhere (Hoare 1999c; Parker and Osborn 2001). High-category damage incidents were relatively few, which agrees with findings elsewhere (Hoare 1999c; Parker and Osborn 2001; Sitati et al. 2003).

The number of elephant raids per village showed a very weak positive relationship to the area of cultivation around villages, and the area-based index of raiding intensity varied widely. One such significantly positive relationship has been shown in very different land use in Kenya (Sitati et al. 2003). But generally, quantitative associations with raid intensity are hard to find in the study of HEC, suggesting alternative hypotheses that other spatial factors like habitat or crop type (Parker and Osborn 2001), farmers' defences (Osborn and Parker 2002), and individual elephant behaviour (Hoare 1999c; 2001b) are more likely determinants of conflict levels.

With only one year's data, specific factors significant in the damage pattern in the study villages are speculative but may include the isolation of many of the agricultural fields, the common practice of shifting cultivation, the severe damage to fruit trees and vegetable plots, cultivation in the riverine habitats that elephants favour, and elephants moving in relatively large groups, which in turn may be due to human harassment.

A valuable finding was the relatively large number of elephants (25) that were killed in the conflict zone during the year. There is suspicion that HEC is sometimes being used as a pretext for illegal killings as some elephants were hunted by people from outside the area and meat was taken away to other parts of the country. Without the activities of an organized scheme systematically gathering data, it is doubtful that these killings would have been fully recorded in this large and remote area. This has important implications for other elephant ranges, especially sites involved in the CITES MIKE programme (www.citesmike.org), where collecting information exclusively on illegal activity may prove difficult; any activity that is perceived as helping people in conflict with wildlife has few opponents.

The recording scheme proved cost efficient: it cost the equivalent of a little over USD 1000 to employ one enumerator for the year (USD 9180 to employ the nine enumerators for one year). Additional project costs were a small workshop to train enumerators and vehicle transport for regular field visits by the supervisor. The latter was outside the project budget but was met by the World Wide Fund for Nature International (WWF-International), who employed the supervisor, also responsible for other conservation work in the SGR. Most recording schemes using this model in smaller conflict zones can be run with six enumerators or fewer, and may cost less in other countries. The total area each enumerator can cover is dependent on terrain and land use, but in the past in the more common subsistence farming systems with scattered agriculture, 150–200 km^2 per enumerator has been achieved (Hoare 1999c; Parker and Osborn 2001; Sitati et al. 2003).

As the management of problem elephants is increasingly becoming de facto the responsibility of communities affected by them, it is especially important to quantify a conflict situation as much as possible, so as to be able to place it in a local conservation context (Hoare 2001a). The common research practice of using attitudinal questionnaire surveys (Kaltenborn et al. 2003; Holmern et al. 2004) is insufficient to understand wildlife conflict situations, as a clear disjunction has been shown to exist between perceived and actual problems (Languy 1996; Gillingham and Lee 2003). The scheme described here quantifies actual conflict incidents rapidly, impartially, cheaply and sufficiently accurately in rural African situations to be useful for local-scale wildlife management and land-use planning. For effective mitigation measures to be planned in any HEC situation (Hoare 2001a), initial collection of baseline information similar to that recorded in this study should be attempted.

Acknowledgements

We would very much like to thank Dr PJ Stephenson of WWF-International for encouragement and for soliciting funds for this study. WWF-Tanzania Programme Office Country Representative Dr Hermann Mwageni and Conservation Director Mr Stephen Mariki are sincerely thanked for their advice and support. Mr Leo Niskanen is thanked for his competent administrative support through the AfESG. We also appreciate the contribution and advice given by Mr Charles Mdoe, Assistant Director, Development, of the Wildlife Division. Enumerators who collected the field data were Messrs Abdallah Nnungu (Mpigamiti Ward), Adinani Rajabu (Zinga-Miguruwe Ward), Idd Ngajaja (Mkutano Ward), Juma Mpule (Barikiwa Ward), Mussa Maimbanya (Kikole Ward), Rajabu Lipanjanga (Kandawale Ward), Ramadhan Mneka (Ngorongo Ward), Said Kagoma (Utete Ward) and Saidina Malenda (Mwaseni Ward). We also thank the Wildlife Division district game officers, Messrs Eniyoye J. John (Rufiji District), Chande M. Ligibu (Kilwa District) and Said Kabanda (Liwale District) for working very closely with the enumerators. Three anonymous reviewers made useful comments on the manuscript and Mr Simon Mwansasu assisted with data for the map.

The corresponding author thanks his employer, the Messerli Foundation of Switzerland, for the use of their facilities while writing the paper.

References

Blanc JJ, Thouless CR, Hart JA, Dublin HT, Douglas-Hamilton I, Craig CG, Barnes RFW. 2003. *African elephant status report 2002: an update from the African Elephant Database*. IUCN/SSC African Elephant Specialist Group, Gland, Switzerland.

Dublin HT, Hoare RE. 2004. Searching for solutions: an integrated approach to understanding and mitigating human–elephant conflict in Africa. *Human Dimensions of Wildlife* 9:271–278.

Gillingham S, Lee PC. 2003. People and protected areas: a study of local perceptions of wildlife crop damage conflict in an area bordering the Selous Game Reserve, Tanzania. *Oryx* 37(3):316–325.

Hoare RE. 1999a. Data collection and analysis protocol for human–elephant conflict situations in Africa. IUCN African Elephant Specialist Group, Nairobi, Kenya, and www. iucn.org/afesg. 37 p. Also in French.

Hoare RE. 1999b. *Training package for enumerators of elephant damage.* IUCN African Elephant Specialist Group, Nairobi, Kenya, and www. iucn.org/afesg. 17 p. Also in French.

Hoare RE. 1999c. Determinants of human–elephant conflict in a land-use mosaic. *Journal of Applied Ecology* 36:689–700.

Hoare RE. 2001a. *A decision-support system for managing human–elephant conflict situations in Africa.* African Elephant Specialist Group, Nairobi, Kenya**,** and www. iucn.org/afesg. 104 p. Also in French and Portuguese.

Hoare RE. 2001b. Management implications of new research on problem elephants. *Pachyderm* 30:44–48.

Hoare RE, du Toit JT. 1999. Coexistence between people and elephants in African savannas. *Conservation Biology* 13(3):633–639.

Holmern T, Johannesen AB, Mbaruka J, Mkama S, Muya J, Roskaft E. 2004. *Human–wildlife conflicts and hunting in the western Serengeti, Tanzania.* Norwegian Institute for Nature Research (NINA) Project Report No. 26. Tungasletta 2, NO-7485 Trondheim, Norway, and www.nina.no

Kaltenborn BP, Nyahongo JW, Mayengo M. 2003. *People and wildlife interactions around Serengeti National Park, Tanzania.* Norwegian Institute for Nature Research (NINA) Project Report No. 22. Tungasletta 2, NO-7485 Trondheim, Norway, and www.nina.no

Languy M. 1996. Suivi et attenuation de l'impact des éléphants et autres mammifères sauvage sur l'agriculture au Gabon. Rapport final, WWF Programme pour le Gabon.

Matzke G. 1976. The development of the Selous Game Reserve. *Tanzania Notes and Records* No. 79 and 80.

Mpanduji DG, Hofer H, Hildebrandt TB, Goeritz F, East ML. 2002. Movement of elephants in the Selous–Niassa wildlife corridor, southern Tanzania. *Pachyderm* 33:18–31.

Nicholson BD. 1969. The Selous Game Reserve. Unpublished mimeograph copy of a speech to 2nd annual meeting of Game Conservation International, San Antonio, Texas, USA.

Osborn FV, Parker GE. 2002. Community-based methods to reduce crop losses to elephants: experiments in the communal lands of Zimbabwe. *Pachyderm* 33:32–38.

Osborn FV. 2003. Seasonal influence of rainfall and crops on home-range expansion by bull elephants. *Pachyderm* 35:53–59.

Parker GE, Osborn FV. 2001. Dual-season crop damage by elephants in the eastern Zambezi Valley, Zimbabwe. *Pachyderm* 30:49–56.

Sitati NW, Walpole J, Smith RJ, Leader-Williams N. 2003. Predicting spatial aspects of human–elephant conflict. *Journal of Applied Ecology* 40:667– 677.

Tanzania Census. 2002. *Population and housing census general report.* Central Census Office, National Bureau of Statistics, Dar es Salaam.

Tchamba MN. 1996. History and present status of the human–elephant conflict in the Waza–Logone region, Cameroon. *Biological Conservation* 75:34–41.