Dual-season crop damage by elephants in eastern Zambezi Valley, Zimbabwe

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Abstract

An elephant-focused crop-damage reporting scheme was developed and tested in Muzarabani District, Zimbabwe, for two consecutive years, to produce information that would improve elephant management. The scheme assessed wet- and dry-season crop damage, identifying spatial and temporal patterns, and developing a measure of severity for each incident. Within Muzarabani the majority of elephant crop-raiding incidents occurred during the wet season. Dry-season crop damage, considered an unusual phenomenon, was found to be common. Wet-season crop damage occurred primarily in farmland along the edge of a protected wildlife area, and dry-season crop damage occurred along the major rivers of the district. Although fewer in number, dry-season incidents were generally more severe than wet-season incidents. Crop damage in the dry season may have a greater impact on rural farmers as that is when food is scarce. The system of crop-damage reporting developed in this study provided objective and practical management information for the local district council.

Résumé

On a mis au point un système pour rapporter les dommages causés aux cultures par les éléphants, et on l'a testé dans le District de Muzarabani, au Zimbabwe, pendant deux ans de suite, pour disposer d'informations qui amélioreraient la gestion des éléphants. Ce système a évalué les dommages causés aux cultures en saison sèche et en saison des pluies, en précisant les schémas spatiaux et temporels, et en mettant au point une mesure de la gravité pour chaque incident. A Muzarabani, la majorité des incidents survenaient pendant la saison des pluies. Les dégâts aux cultures survenant en saison sèche, que l'on considérait comme un phénomène inhabituel, se sont avérés communs. Les dommages en saison des pluies affectaient principalement les fermes situées le long d'une aire protégée pour la faune, et ceux qui avaient lieu en saison sèche survenaient le long des principales rivières du district. Moins nombreux, les incidents de saison sèche étaient cependant généralement plus graves qu'en saison des pluies. Les dommages causés aux récoltes pendant la saison sèche peuvent avoir un plus fort impact sur les fermiers parce que c'est alors que la nourriture est plus rare. Le système mis au point par cette étude pour rapporter les dommages aux récoltes a fourni au *District council* local des informations objectives et pratiques pour une bonne gestion.

Introduction

The destruction of crops by elephants is a major conservation concern across Africa. Farmers and elephants are increasingly coming into conflict as elephant habitat is converted to farmland. Crop damage can have a serious impact on subsistence farmers' livelihoods. In some semi-arid rural farming areas of Zimbabwe and Kenya, elephant damage to food crops accounts for 75 to 90% of all incidents by large mammal pest species (Hoare and Mackie 1993; Waithaka 1993).

In the savanna, elephant crop raiding is usually considered a wet-season problem, with a defined peak of activity at the end of the season that coincides with crop maturation. The majority of crop-raiding incidents involve elephants destroying mature food crops (Kangwana 1995; Tchamba 1995), as the crops are most palatable when they are mature (Bell 1984). There is some evidence for elephant crop damage during the dry season in Zimbabwe (Osborn unpubl.), but it is considered an unusual phenomenon.

Crop damage is a major problem in farmland adjacent to wildlife areas. Bell (1984) described these border farms as the 'front line', because he found crop-damage incidents were concentrated along the boundary and declined as the distance from the wildlife area increased. A study by Hawkes (1991) documented that only those villages at the boundary of a national park were affected by elephant crop raiding, and communities farther away were unaffected. Elephants generally require a large wilderness refuge for survival and tend to make only brief trips to settled areas to raid crops (Bell 1984).

The management of human–elephant conflict is a complex and logistically challenging problem. In Zimbabwe the responsibility increasingly falls to rural district councils (RDCs), many of which have managed their wildlife since 1990 under a national programme called CAMPFIRE (Communal Areas Management Programme For Indigenous Resources). Often administering large areas of land, the RDCs struggle to ameliorate the problem of widespread crop raiding with the limited resources at their disposal. Muzarabani is a CAMPFIRE district in the eastern Zambezi Valley of northern Zimbabwe. In 1997 Muzarabani RDC wanted more information on its elephant population to improve management strategies, with crop raiding being identified as a high priority. In response, the Mid Zambezi Elephant Project (MZEP) designed and established a district-wide crop-damage reporting system. The major objective was to identify spatial and temporal patterns of crop damage in the wet and the dry seasons.

General patterns of crop raiding have been documented in a number of studies, but every site has its unique characteristics. The development of a straightforward and management-oriented data collection system that describes site-specific characteristics, but that may also contribute to the general understanding of human–elephant conflict, is considered important. This scheme aimed to assess a large area rapidly, at low cost to the management authority.

Frequency and distribution measurements are commonly used in crop-damage assessment schemes (Hoare 1999), and they provide useful indicators of the geography of the crop-raiding problem. The severity of crop damage can vary considerably, particularly when considering incidents over a large area. A measure of severity was developed in this study, as it was considered important when setting priorities about human–elephant conflict at a macro scale.

Study area

Muzarabani District encompasses an area of 2774 km^2 in the eastern Zambezi Valley, northern Zimbabwe (31^o 05' E, 16^o 25' S) (fig. 1a). The district is divided into three distinct geographical regions: the flat Zambezi Valley to the north (altitude 350–500 m), the broken mountainous plateau of the highveld to the south (800–1300 m), and a 10-km band of escarpment mountains (900–1650 m), which runs east–west and separates the two.

Rainfall in the Zambezi Valley is low (650–850 mm per year), falling between December and mid-March. The rainfall of the highveld is greater (1000 mm) and falls in a longer wet season from November to mid-March. There is a long dry season from April to November. Most rivers within the district drain north from the escarpment towards Mozambique. The major rivers, which are a perennial source of water for humans and wildlife, are the Utete, the Musengezi and the Hoya (Cunliffe 1992) (fig. 1b). The Zambezi Valley is dominated by mopane-terminalia woodland (*Colophospermum mopane* and *Terminalia stuhlmanii* and mopane-combretum woodland (*Colophospermum mopane* and *Combretum apiculatum*), with dense riverine thickets of mixed species along the major rivers. In the escarpment there is a mixture of escarpment woodland and miombo (*Brachystegia* spp. and *Julbernardia* spp.) woodland (Cunliffe 1992).

Muzarabani District comprises communal farmlands, large-scale commercial farmland, and the Mavuradona Wilderness Area (MWA), a formally protected wildlife area. It covers 650 km^2 of the escarpment mountains and is bordered to the south by commercial farms on the highveld, to the east and west by communal farms in the mountains, and to the north by a near-continuous boundary of communal farms

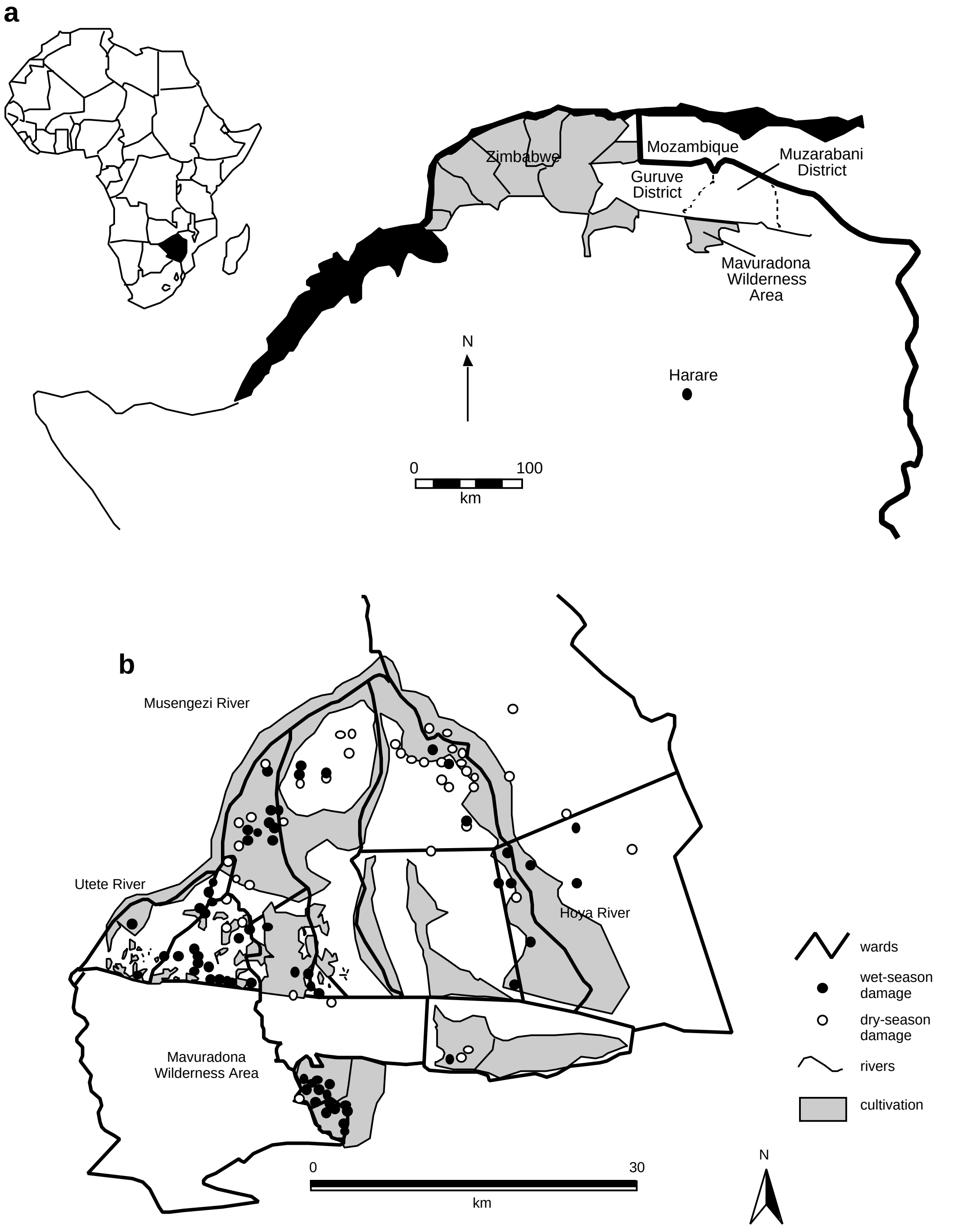

Figure 1. Muzarabani District, showing major rivers, cultivation and the Mavuradona Wilderness Area. Wet-season crop-damage incidents are shown as black dots and dry-season incidents as circles. In areas with many crop-damage incidents, the symbols are overlaid.

in the Zambezi Valley. Cultivation in the communal lands occurs mainly along watercourses and in areas with fertile soils. In the escarpment these correspond to the flat terrain where deeper soils have developed. In the Zambezi Valley, cultivation occurs on the colluvial soils along the base of the escarpment and the alluvial soils bordering the major rivers (Cunliffe 1992). As a result, the district comprises a mosaic of cultivation and bush. Most farming is small-scale dryland cultivation, and the main wet-season crops include maize (*Zea mays*) and cotton (*Gossypium hirsutum*). These rainfed crops are planted extensively in November and harvested between April and June. During the dry season small-scale bucket-irrigated gardens are established along the rivers. Assorted vegetables and green maize are planted in small plots in April and May and harvested up until October.

Agricultural activities are expanding rapidly, because of the profitability of cotton and the associated clearance of new land, and people from other parts of the country are being resettled here. The elephant population is centred around MWA, but elephants move extensively through the communal farmlands, making use of dense thickets as temporary refuges. The elephant population of Muzarabani District is contiguous with populations in the neighbouring Guruve District to the west, and Magoe District in Mozambique to the north (MZEP and ZamSoc 2000) (fig. 1a).

Materials and methods

Crop-damage reports were collected across the entire district area by 10 local enumerators, each representing an administrative area called a ward. The enumerators were trained and supervised by MZEP to record every incident of elephant crop damage within their area. An incident was defined as an occasion where an elephant or elephants caused damage to communal farmers' crops. The format for the reports was modified from those used by Osborn (unpubl.).

The probability of data error increased with the number of people collecting data. MZEP conducted regular and intensive field supervision throughout the two-year period to standardize data collection techniques and to minimize the risk of false or biased reporting.

Data covering two years were analysed, as large between-year variation is common in crop-damage studies (Taylor 1999). The data were pooled, as similar seasonal patterns were exhibited in both years of research. We categorized the season of each incident by the type of crop affected. Incidents affecting rainfed crops (mainly maize and cotton) were considered wet-season crop damage, and those affecting bucket-irrigated crops (vegetables and green maize) were considered dry-season crop damage. The separation of season by crop type was considered more accurate than a time-based categorization, as some overlap in the period of cultivation of these crops occurred.

The crop-damage incidents were plotted along a 12-month time series to study the temporal distribution (fig. 2). Incidents were separated into those affecting wet-season crops and those affecting dry-season crops. Each crop-damage report detailed the life stage of the crops affected as seedling, intermediate or mature. The percentage of incidents involving each life stage was compared.

Crop-damage incidents were displayed first in map form (fig. 1b). A seasonal trend of distribution was found among the incidents, which was explored further. The relationship between wet-season incidents and MWA was examined first, with each incident categorized by its distance from the MWA borders. Distance was measured using 1-km bands up to a total of 5 km from the borders. A graph of the number of incidents in each distance class was plotted (fig. 3). A non-linear negative regression was fitted to the data as a tool to describe the shape of the graph. The strength of the fit reflected the similarity between the graph (frequency of crop-damage incidents in each distance class) and the regression model. A distance of 5 km was selected as it captured all incidents immediately associated with the MWA borders (fig. 1b). Beyond 5 km, crop damage may have been caused by elephants from other areas, so these incidents were considered separately.

The same method was used to examine the relationship between dry-season incidents and the major rivers of the district. Each incident was allocated to a 1-km band up to 5 km from the closest major river, and the number of incidents per distance class was plotted (fig. 4). A negative non-linear regression was fitted to the data to describe the shape of the graph. It was decided that any incidents occurring more than 5 km from the major rivers might be unrelated to the river systems in question, and these were considered separately.

The severity of each incident was measured using two indicators. For the first, the 'extent' indicator, the proportion of the field damaged was measured by pacing both the total field and the damaged portion and

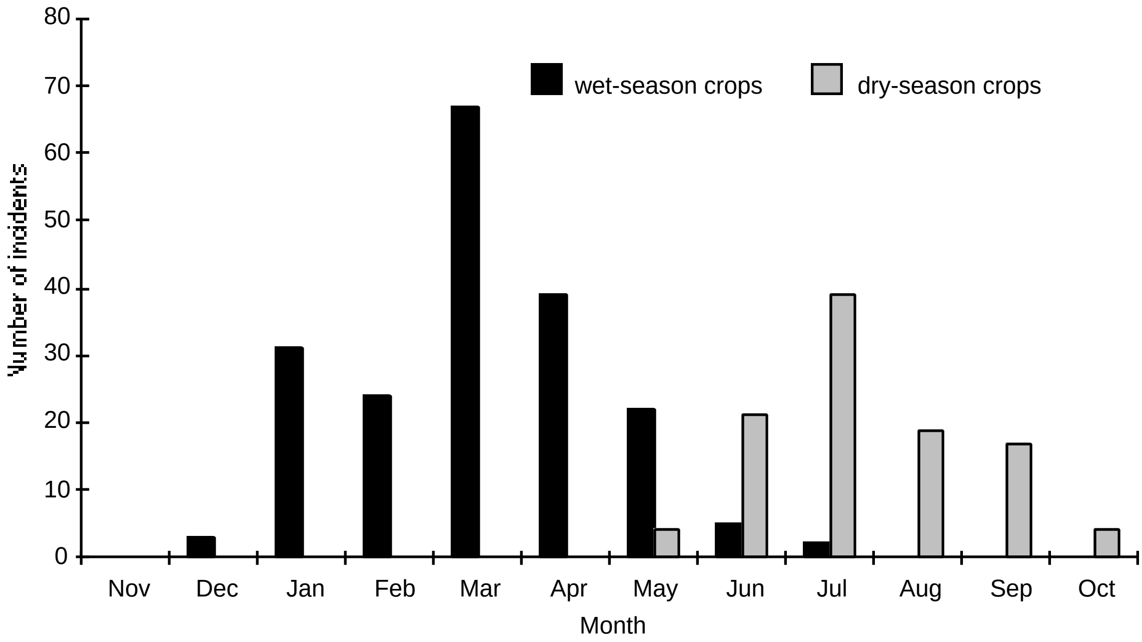

Figure 2. The number of crop-damage incidents per month in Muzarabani District.

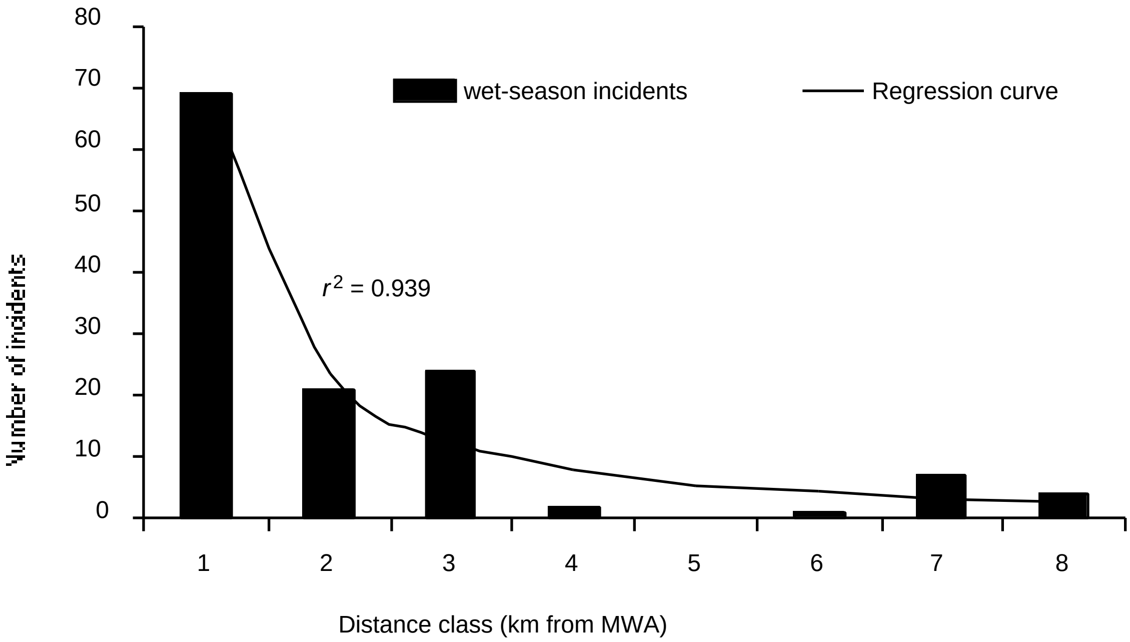

Figure 3. The number of wet-season crop-damage incidents per distance band from the Mavuradona Wilderness Area. The solid black line represents the non-linear regression model for the wet-season data.

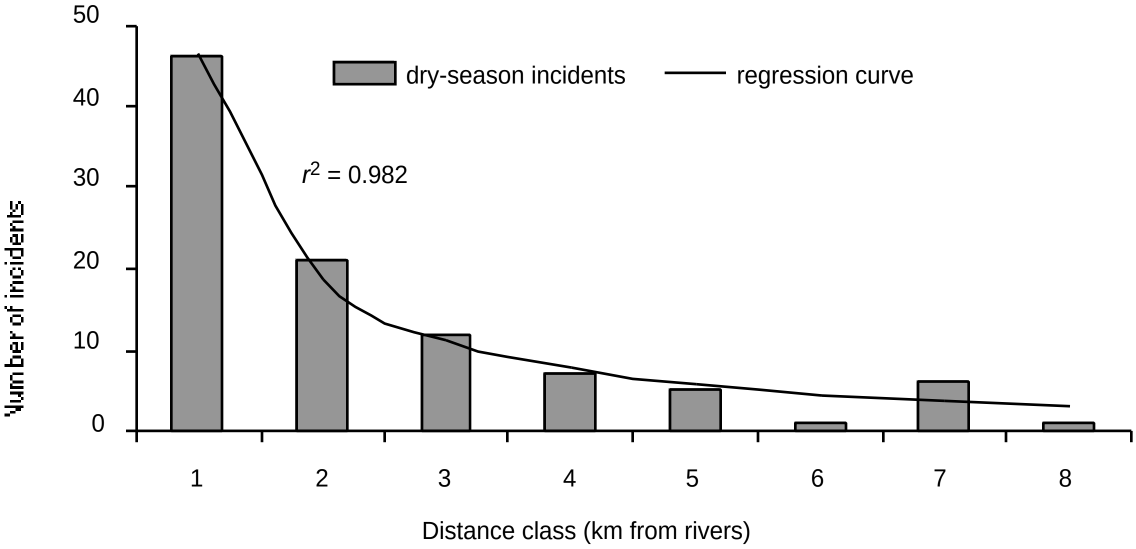

Figure 4. The number of dry-season incidents per distance band from the major perennial rivers. The solid black line represents the non-linear regression model for the dry-season data.

calculating the percentage of the damaged area. Each incident was placed into one of five categories, based on percentage of damage: 0–10%; 11–25%; 26–50%; 51–75% and 76–100%. The second indicator, a subjective measure of the intensity of damage to the crops within the damaged area, was assessed visually. Grade 1 intensity indicated that the damage was not critical to the survival of the plants (some leaf and fruit damage), grade 2 intensity involved some critically damaged plants (some fruit destroyed and stems broken), and incidents of grade 3 intensity were typified by serious plant damage (fruit destroyed, stems broken and plants uprooted). Both measures were used to construct a matrix (table 1). Each crop-damage incident was placed into a severity category based upon a combination of its 'extent' and its 'intensity' scoring, using the matrix. The severity categories were low, medium and high, and the percentage of incidents in each category was presented for each season.

Table 1. Severity matrix showing the level of severity assigned to each combination of 'extent' and 'intensity'

Intensity	Extent (%)				
	0–10	11–25	26–50	51–75	76–100
1	low	low	low	med	high
2	low	med	med	med	high
3	low	med	high	high	high

Results

In Muzarabani District, elephant crop damage was a dual-season phenomenon, affecting both wet- and dry-season crops. Of the 312 crop-damage incidents in total, 204 incidents affected wet-season crops and 108 incidents affected dry-season crops. Damage to wet-season crops occurred over seven months, beginning in December, peaking in March and ending in July. Damage to dry-season crops lasted six months, starting in May, peaking in July and ending in October (fig. 2).

With wet-season crops, 2% of the incidents occurred at the seedling stage, 23% at the intermediate stage, and 75% when crops were mature. Dry-season crops were affected similarly: no incidents occurred at the seedling stage, 7% occurred at the intermediate and 93% when crops were mature.

Grouped around the northern and eastern borders of MWA, 58% of the wet-season incidents occurred within 5 km of the area. There was a strong negative non-linear relationship between distance classes and frequency of incidents (corrected $r^2 = 0.939$), indicating that the number of incidents decreased rapidly with increasing distance from the border (fig. 3). Grouped mainly along the western boundary of the district with some incidents were scattered on the eastern side, 42% of wet-season incidents occurred outside the 5-km limit.

Occurring within 5 km of the major rivers were 82% of the dry-season incidents, grouped mainly along the Musengezi River and the northern section of the Hoya River. There was a strong negative non-linear relationship between distance classes and frequency of incidents (corrected $r^2 = 0.982$), indicating that the number of incidents rapidly decreased with increasing distance from a river (fig. 4). Outside the 5-km limit, only 18% of the incidents occurred, these being scattered widely to the east of the river systems and to the south of the district in the mountains.

Classified as low severity were 59% of wet-season crop-damage incidents, 26% as medium, and only 15% as high severity. In comparison, dry-season incidents exhibited greater severity: only 29% were low, 40% were medium, and 30% were classed as high.

Discussion

In Muzarabani District the rapid expansion of agricultural activities and the existence of a stable and mobile population of elephants are conducive to the occurrence of human–elephant conflict. During this study, elephant crop damage was common and widespread, occurring in 11 months of the year and affecting both wet- and dry-season crops.

Wet-season patterns of crop damage agreed closely with those documented in recent research. The peak of crop-raiding activity observed during March corresponded to the maturing period of cotton and maize crops. Elephants resident in MWA damaged crops along the boundary by raiding fields close by in short trips from the refuge. The rapid decrease in incidents with distance from the refuge may reflect increased risks of venturing deeper into farming land.

Incidents occurring more than 5 km from MWA along the western boundary of Muzarabani District may be attributable to elephants moving from Guruve District. Large-scale movements of elephants between the two districts have been identified in the wet season (MZEP and ZamSoc 2000), and elephants may use small thickets as refuges within the communal lands at this time. The broad distribution of incidents reflects widespread cultivation and large-scale elephant movements during the wet season.

Dry-season crop damage exhibited a peak of activity that corresponded to the maturing period of vegetables and green maize. Most crop-raiding incidents occurred along the major rivers, reflecting the fact that dry-season agriculture is limited to the beds of the major rivers and their tributaries, where alluvial soils and water are available. The rapid decrease of incidents at a distance from the major rivers may be linked to the decreasing potential for agriculture as one moves farther away from the main riverbed, or it may reflect increasing risks associated with moving greater distances from the main riverine refuges. Few incidents occurred more than 5 km from the major rivers, indicating that in the dry season the geographical extent of crop damage is more limited than during the wet season.

Elephants may use riverine areas in the dry season because water is available there at a time of year when it is generally scarce. They may also be attracted by fruiting trees, specifically the *masawu* (*Ziziphus mauritiana*) tree, which grows extensively along the river lines and produces a sweet fruit that elephants feed on during the months of June to September (Funkhauser unpubl.). Thick riparian vegetation provides browse and also concealment and shade for elephants during daylight hours. A range of resources may attract elephants, and once they are nearby they opportunistically raid vegetable gardens. Alternatively the vegetable gardens may attract elephants to riverine areas in the first place. At this stage it is impossible to state the relative attractive values of each resource, but this may be the subject of further research. However, dry-season crop damage may be more common in Muzarabani District that other areas because of the abundance of fruiting masawu trees, which are uncommon elsewhere in Zimbabwe.

Incidents of crop damage in the wet season were generally less severe than those during the dry season. Farmers actively defended fields during the rains, and crop-raiding elephants were frequently chased away. Dry-season vegetable plots in the riverbeds were not actively defended and so were often heavily damaged or destroyed. In addition, wet-season fields were large, and the proportion of damage in a single crop-raiding incident was generally low. Dry-season cultivation areas were small, and the proportion of damage in a single incident was therefore generally higher.

Dry-season crop damage may affect communal farmers' livelihoods to a greater degree than wet-season damage, as dry-season crops supplement the farmers' diet at a time of year when food is scarce. Elephants may also target food stores at homesteads, and these incidents affect food security for the farmer until the crops are harvested the following year. To determine whether dry-season crop damage has a greater effect upon the farmer than wet-season damage, a detailed socio-economic study would be required.

The severity measure developed in this study adds a further dimension to the assessment of crop-damage incidents. It gives an indication of the actual impact of crop raiding upon the farmer, and when combined with 'frequency' and 'distribution' measures, it forms a useful tool for determining priorities of crop-damage incidents.

By studying crop damage over a large land area, it was possible to identify the broad seasonal patterns that existed within Muzarabani District. The information yielded was designed to assist the rural district council with macro-scale management issues, including planning future land use, deploying problem animal control units, distributing wildlife revenues according to conflict, and placing conflict amelioration projects. This study represents the first phase of ongoing research within Muzarabani District. Crop-damage information continues to be collected in the most heavily affected wards of the district, to update management decisions and to evaluate crop-damage intervention projects.

The methods developed in this study have been adopted and used by the AfESG Human–Elephant Conflict Task Force as a basis for its crop-damage data collection protocol across Africa (Hoare 2000). The data collection system is practical and straightforward, and ideal for large-scale assessments. It is also efficient, as it requires only a few trained enumerators to cover a wide area. The major cost is associated with the time and effort required to train and supervise the enumerators, to ensure that the information collected is of high quality and ultimately is comparable.

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References

Bell, R.H.V. (1984) The man–animal interface: an assessment of crop damage and wildlife control. In: Bell, R.H.V., and McShane-Caluzi, eds., *Conservation and wildlife management in Africa:* US Peace Corps Seminar, Malawi.

Cunliffe, R.N. (1992) *An ecological resource survey of the communal lands of Centenary District.* WWF MAPS Project Paper No. 26. World Wide Fund for Nature Programme Office, Harare, Zimbabwe.

Funkhauser, S. (unpubl.) Local community tree management of *Ziziphus mauritiana:* an exploratory study from the mid-Zambezi Valley, Zimbabwe. MSc thesis, 1999, Michigan State University, USA.

Hawkes, R.K. (1991) *Crop and livestock losses to wild animals in the Bulilimangwe Natural Resources Management Area.* CASS Research Paper 1-91, University of Zimbabwe.

Hoare, R.E. (1999) Determinants of human–elephant conflict in a land-use mosaic. *Journal of Applied Ecology* 36, 689–700.

Hoare, R.E. (2000) Project of the Human–Elephant Conflict Task Force (HETF): results and recommendations. *Pachyderm* 28, 73–77.

Hoare, R.E., and Mackie, C.S. (1993) *Problem animal assessment and the use of fences to manage wildlife in the communal lands of Zimbabwe.* WWF MAPS Project Paper No. 39. World Wide Fund for Nature Programme Office, Harare, Zimbabwe.

Kangwana, K.F. (1995) Human–elephant conflict: the challenge ahead. *Pachyderm* 19, 11–14.

MZEP and ZamSoc (2000) *Elephant research and management in Muzarabani District and the mid-Zambezi Valley.* Zambezi Society, PO Box HG 774, Highlands, Harare, Zimbabwe. 18 p.

Osborn, F.V. (unpubl.) The ecology of crop-raiding elephants in Zimbabwe. Ph.D. thesis, 1998, University of Cambridge, UK.

Taylor, R.D. (1999) *A review of problem elephant policies and management options in southern Africa.* AfESG Human–Elephant Conflict Task Force (HETF) Report. IUCN/SSC African Elephant Specialist Group, Nairobi, Kenya.

Tchamba, M. (1995) The problem elephants of Kaele: a challenge for elephant conservation in northern Cameroon. *Pachyderm* 19, 23–27.

Waithaka, J. (1993) The elephant menace. *Wildlife Conservation* 96, 14–17.