Dual season crop damage by elephants in the Eastern Zambezi Valley, Zimbabwe

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ABSTRACT

An elephant focused crop damage reporting scheme was developed and tested in Muzarabani district for two consecutive years, with the objective of producing information to 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 lower 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 food is scarce during the dry months. The system of crop damage reporting developed in this study provided objective and practical management information for the local district council.

INTRODUCTION

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

In the savannah range 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 the maturing of crops. The majority of crop raiding incidents involve elephants destroying mature food crops (Kangwana, 1995; Tchamba, 1995), as they are most palatable during their mature phase (Bell, 1984). There is some evidence for elephant crop damage during the dry season in Zimbabwe (Osborn, 1998), but it is considered an unusual phenomenon.

Crop damage is a major problem in farm land adjacent to wildlife areas. Bell (1984) described these border farms as the "front line", because he found crop damage incidents concentrated along the boundary, but declined with increasing distance from the wildlife area. 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 further away were unaffected. Elephants generally require a large wilderness refuge for survival, and tend to make 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 whom 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 limited resources at their disposal. Muzarabani is a CAMPFIRE district in the eastern Zambezi valley of northern Zimbabwe. In 1997 Muzarabani RDC expressed a need for more information about its elephant population in order 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 own unique characteristics. The development of a straightforward and management orientated 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 rapidly assess a large area, at low cost to the management authority.

Frequency and distribution measurements are commonly used in crop damage assessment schemes (Hoare, 1999), and provide useful indicators as to the geography of the crop raiding problem. There can be considerable variation in the severity of crop damage, particularly when considering incidents over a large area. A measure of severity was developed in this study, as it was considered important when prioritising human-elephant conflict at a macro scale.

STUDY AREA

Muzarabani district encompasses an area of 2,774 km^2 in the eastern Zambezi Valley, northern Zimbabwe (31^o 05’ E, 16^o 25’ S) (Figure 1 (A)). The district is divided into three distinct geographical regions: the flat Zambezi Valley to the north (350-500 m), the broken mountainous plateau of the highveld to the south (800-1,300 m), and a ten kilometre wide band of escarpment mountains (900-1,650 m) that 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 (1,000 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, Musengezi and the Hoya (Cunliffe, 1992) (Figure 1 (B)). The Zambezi valley is dominated by mopane-terminalia woodland (*Colophospermum mopane* and *Terminalia stulhmani*) and mopane-combretum woodland (*Colophospermum mopane and Combretum apiculatum*), with dense riverine thicket of mixed species along the major rivers. In the escarpment there is a mixture of escarpment woodland and miombo (*Brachystegia* spp. and *Julbernadia* spp.) woodland (Cunliffe, 1992).

Muzarabani district comprises communal farmlands, large-scale commercial farm land, and the Mavuradona Wilderness Area (MWA), a formally protected wildlife area. The MWA 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 in the Zambezi Valley. Cultivation in the communal lands occurs mainly along water courses 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 dry land cultivation and the main wet season crops include maize *Zea mays,* and cotton *Gossypium hirsutum.* These rain-fed 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, due to the profitability of cotton and the associated clearance of new land, and to resettlement of people from other parts of the country. The elephant population is centred around the MWA, but elephants move extensively through the communal farm lands, 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) (Figure 1(A)).

MATERIALS AND METHODS

Crop damage reports were collected across the entire district area by ten local enumerators, each one 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 a communal farmers' crops. The format for the reports was modified from those used by Osborn (1998).

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 standardise data collection techniques and to minimise the risk of false or biased reporting.

Two year's data 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 categorised the season of each incident by the type of crop affected. Incidents affecting rain fed 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 categorisation, 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 (Figure 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 were compared.

Crop damage incidents were displayed first in map form (Figure 1 (B)). A seasonal trend of distribution was found among the incidents, which was explored further. The relationship between wet season incidents and the MWA were examined first, with each incident being categorised in terms of its distance from the borders of the MWA. Distance was measured using one-kilometre wide bands up to a total of 5 km from the borders. A graph of the number of incidents in each distance class was plotted (Figure 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 borders of MWA (Figure 1(B)). Beyond 5 km crop damage may have been caused by elephants from other areas, so these incidents were considered separately.

The same methodology was used to examine the relationship between dry season incidents and the major rivers of the district. Each incident was allocated to a one-kilometre band up to 5 km from the closest major river, and the number of incidents per distance class was plotted (Figure 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 may be unrelated to the river systems in question, and these were considered separately.

The severity of each incident was measured using two indicators. The first, the 'extent' indicator, measured the proportion of the field damaged by pacing the total field and the damaged portion, and calculating the percentage area of damage. 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 was a subjective measure of the intensity of damage to the crops within the damaged area, and 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 'grade 3' intensity incidents were typified by serious plant damage (fruit destroyed, broken stems and uprooting). 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 'intensity' scoring, using the matrix. The severity categories were 'low', 'medium' and 'high', and the percentage of incidents in each category were presented for each season in tabular form (Table 2).

RESULTS

In Muzarabani district elephant crop damage was a dual season phenomenon, affecting 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. The duration of damage to wet season crops was 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 (Figure 2).

Two percent of incidents involving wet season crops occurred at the seedling stage, 23% of incidents occurred at the intermediate stage, and 75% occurred when crops were at the mature stage. Dry season crops were affected similarly: no incidents occurred at the seedling stage, 7% occurred at the intermediate and 93% of crop damage incidents occurred when crops were at the mature stage.

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

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

Fifty nine percent of wet season crop damage incidents were classified as low severity, 26% were medium, and only 15% were high severity. In comparison dry season incidents exhibited greater severity: only 29% were low, 40% were medium, and 30% were classed as high severity (Table 2).

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 for 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. Crop damage along the boundary of MWA was caused by elephants resident in the MWA raiding crops in fields close to the boundary, making short trips from the refuge. The rapid decrease in incidents with distance from the refuge may reflect increased risks of venturing deeper into the farming land.

Incidents occurring more than 5 km from the 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 & 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 with distance from the major rivers may be linked to the decreasing potential for agriculture as one moves further away from the main river bed, 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 utilise riverine areas in the dry season because water is available at a time of year when it is generally scarce. They may also be attracted by fruiting trees, specifically the *masawu* (*Zisiphus mauritiana*) tree, which grows extensively along the river lines and produces a sweet fruit that elephants feed on during the months of June-September (Funkhauser, 1999). Thick riparian vegetation provides browse, and also concealment and shade for elephants during daylight hours. Elephants may be attracted by a range of resources, and raid vegetable gardens opportunistically once they are there. 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. Fields were actively defended by farmers during the rains, and crop raiding elephants were frequently chased away. Dry season vegetable plots in the river beds 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 farmer's 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. Food stores at homesteads may also be targeted by elephants, and these incidents affect food security for the farmer until his 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, forms a useful tool for the prioritisation of crop damage incidents.

By studying crop damage over a large land area at it was possible to identify the broad seasonal patterns that existed within Muzarabani district. The information yielded was designed to assist the RDC with macro-scale management issues, including future land use planning, the deployment of Problem Animal Control units, the distribution of wildlife revenues according to conflict, and the placement of 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, in order 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 a few trained enumerators covering a wide area. The major cost is associated with the time and effort required to train and supervise the enumerators, to ensure the information collected is of high quality, and ultimately comparable.

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TABLES

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

	Extent				
Intensity	**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

Table 2. Severity of crop damage incidents in each season, displayed as percentages.

	Severity		
Season	**Low**	**Med**	**High**
Wet season	59	26	15
Dry season	29	40	30

Figure 1. Map of Muzarabani district, showing major rivers, cultivation and the Mavuradonha Wilderness Area. Wet season crop damage incidents are displayed as black dots, and dry season incidents are shown as circles. In areas with many crop damage incidents the symbols are overlaid.

Figure 1 (A)

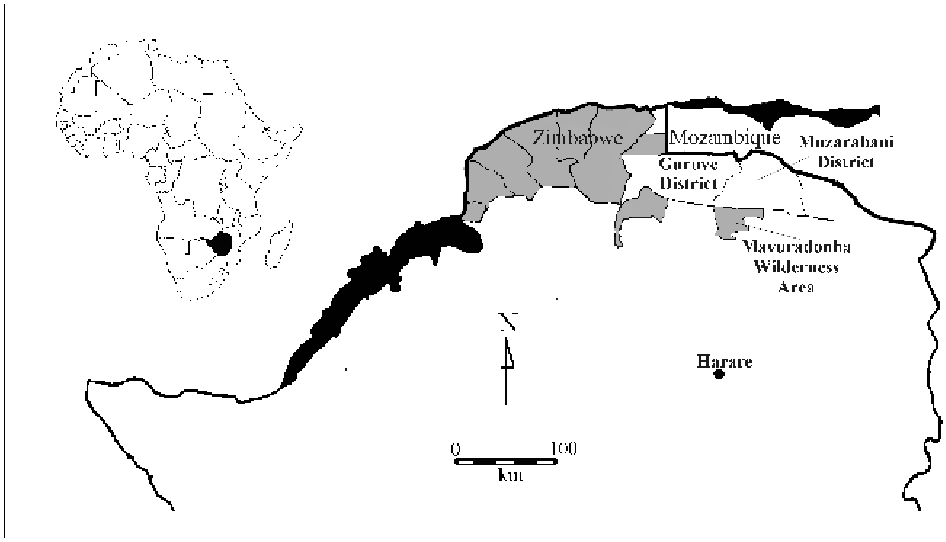

Figure 1 (B)

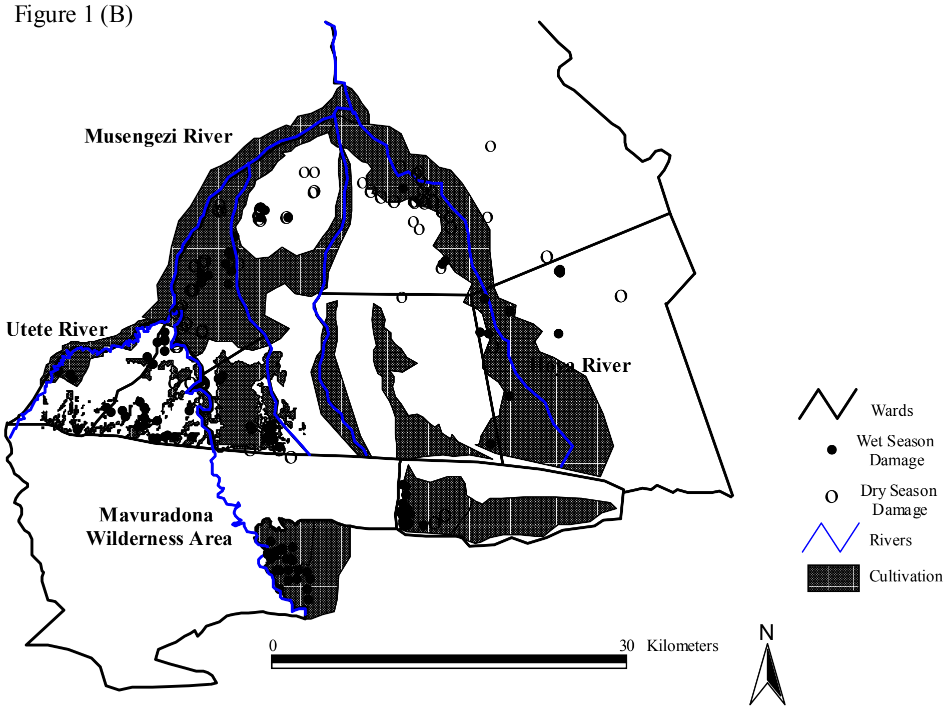

Figure 2. The number of crop damage incidents per month in Muzarabani district. Wet season crops are displayed as black bars, and dry season crops as grey bars.

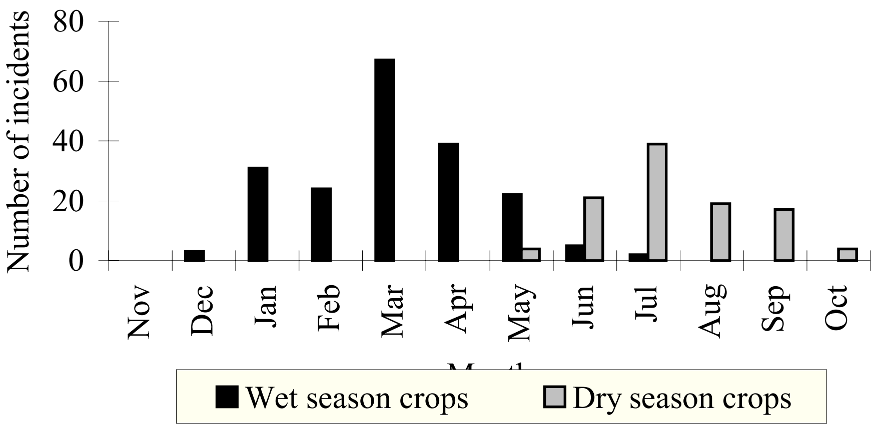

Figure 3. The number of wet season crop damage incidents per distance band from the MWA is displayed as black bars. Each bar represents the number of incidents for each distance class. The solid black line represents the non-linear regression model for the wet season data.

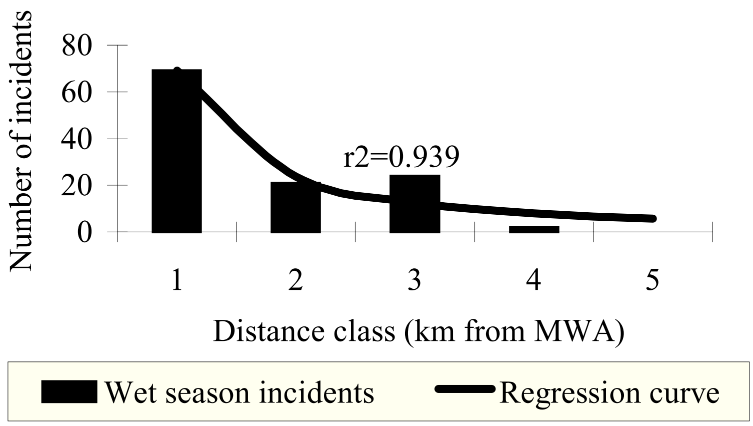

Figure 4. The number of dry season incidents per distance band from the major perennial rivers is displayed as grey bars, with each bar representing the number of incidents for each distance class. The solid black line represents the non-linear regression model for the dry season data.